



Essentials of Obstetrics

Lakshmi Seshadri • Gita Arjun



Wolters Kluwer

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Preface

A medical student is on a journey of discovery. Every day of his or her progress through medical education is crowded with, overwhelming amount of information. The young student struggles hard to not only acquire and assimilate knowledge but also reproduce that knowledge in examinations. An ideal textbook, therefore, should help him or her on both counts; it should make knowledge easy to acquire and exciting, and also help the student replicate it in an examination.

In the course of our medical education, some textbooks will always stand out in our minds. A book that introduces us to a completely new subject and fans the embers of curiosity to explore and learn more, is priceless. The authors have clearly poured their passion into the book and succeeded in bringing alive all the intricacies of the subject.

For students of Medicine, learning never stops. It is a lifelong process that involves years of dedication to the gathering of knowledge from textbooks, journals, and from clinical experiences. Both the novice student and the practicing clinician can be overwhelmed by the vast amount of information that is currently available. Information is easily assimilated only when it is put together in a concise, simple, and easy-to-read format.

Authoring a textbook with an undivided focus on the student and his or her needs is daunting. As authors, the onus is upon us to make sure that the facts presented to the student are evidence based and clinically applicable. To this end, we have researched every piece of information before including it in the text. On the other hand, it is imperative that the book spurs the student to learn more without being intimidated by the subject matter.

A student cannot grow to become a good practitioner without a thorough understanding of the pathophysiology of diseases. Skills in diagnostic evaluation and management must follow. We have ensured this pattern in the book so that the subject is presented in a cogent fashion. Clinical guidelines which are tailored to the needs of the population we deal with have been emphasized and included at appropriate places.

Each chapter begins with a commonly seen clinical case scenario pertaining to the topic of the chapter and goes on to introduce the topic, explain and illustrate the relevant concepts, and closes with self-assessment. The questions based on the case scenarios are answered at the end of the chapter.

Keeping in mind that examinations are a major challenge in a student's life, the details are presented in Boxes, Tables, Flowcharts, and Figures (line illustrations and clinical images). Figures have simple explanations placed along with the captions. These visuals are of immense help during revision. Besides, the Key Points section at the end of the chapter presents the entire chapter in a nutshell—this feature too is useful in quick recapitulation of essentials.

The Boxes and Tables introduced in the sister volume, *Essentials of Gynecology* (authored by Prof Lakshmi Seshadri), have been a huge success with students. Naturally, we have retained these features in this book as well.

The book is a joint effort by the two of us but with unstinting and generous help and support from our family, colleagues, former and current students, and friends. We are indebted to the editorial team at Wolters Kluwer for their professional inputs.

**Lakshmi Seshadri
Gita Arjun**

Acknowledgements

Essentials of Obstetrics has been a collaborative effort between the two of us. Our greatest inspiration and motivation for writing this book has come from the widespread appreciation of *Essentials of Gynecology* by undergraduate and postgraduate students, teachers, and colleagues and, of course, a request for the companion volume.

We would like to place on record our sincere thanks to those who have supported, encouraged, and helped us in several ways. We would like to thank Dr S Suresh and his team at Mediscan Systems, Chennai, for their generous contribution of ultrasonographic images. The colorful clinical photographs are from our former student, Dr Rajnish Samal, Bangalore, and also from the team at Seethapathy Clinic and Hospital, Chennai. Some of the laparoscopic images were provided by Dr Sandip Datta Roy. The cardiotocography traces, partographs, and images were provided by Dr Santosh Benjamin and the postgraduate students of Christian Medical College, Vellore. We gratefully acknowledge their help.

Dr Padmini Jasper, Dr Alice George, and other faculty members from the Department of Obstetrics and Gynecology, Christian Medical College Hospital, Vellore, have gone through the chapters and have given their constructive comments for which we are thankful.

Our respective husbands, Dr M.S. Seshadri and Dr Arjun Rajagopalan, have been patient and tolerant of our late working hours, our labile moods, and have managed to survive our ignoring them for long periods of time. They have been our most supportive critics, have read through many of our chapters, and given their expert inputs (at the risk of marital disharmony).

The team at Wolters Kluwer: Mrs P Sangeetha, Manager, Commissioning; Dr Vallika Devi Katragadda, Consultant; and Mrs Pooja Chauhan, Manager, Prepress; has worked tirelessly to make this book a possibility and a dream come true. We are indebted to them for their support and contribution. We are thankful to Mr P Saravanan and his team at Digiprezz Media Solutions, for excellent composition and to Mr S Kartikeyan, for beautiful illustrations. Their co-operation and hard work are truly appreciated.

Lakshmi Seshadri

Gita Arjun

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Section 1

Basic Science in Obstetrics

1

Anatomy of the Female Reproductive Tract

Case scenario

Mrs. AV, 24, primigravida was admitted to labor room at term. Labor was augmented with oxytocin for dysfunctional labor. Second stage of labor was prolonged; therefore, baby was delivered by forceps after pudendal block. There was a fourth degree perineal laceration. Consultant obstetrician was called in to perform an accurate anatomical perineal repair.

Introduction

A comprehensive knowledge of the anatomy of the reproductive tract, changes in the anatomy in pregnancy, the anatomy of the bony pelvis, different pelvic configurations, and the anatomy of the fetal skull is essential for understanding the mechanism of labor and managing problems that arise during pregnancy and labor.

Anterior abdominal wall

Consists of the following layers:

- Skin
- Subcutaneous fascia
- Rectus sheath

- Muscles
- Peritoneum

Skin

Skin of the anterior abdominal wall stretches in pregnancy. There is pigmentation along the midline forming linea nigra. Stretch marks that develop in pregnancy are known as *striae gravidarum*. The Langer's lines or dermal fibers are arranged transversely.

Subcutaneous tissue

Consists of superficial fatty layer or Camper's fascia and deep membranous layer or Scarpa's fascia.

Rectus sheath

Rectus sheath is formed by the aponeurosis of external and internal oblique and transverse abdominis muscles. This sheath covers the rectus abdominis muscle. Midway between umbilicus and pubic symphysis is the arcuate line. The formation of the rectus sheath is different above and below the arcuate line. Above the arcuate line, the internal oblique aponeurosis splits into two layers: the anterior layer fuses with the external oblique aponeurosis and the posterior layer fuses with transverse abdominis aponeurosis to form the anterior and posterior rectus sheath, respectively. Below the arcuate line, the aponeuroses of the internal oblique and transverse abdominis fuse with the external oblique aponeurosis anteriorly to form anterior rectus sheath (Fig. 1.1).

Muscles

The muscles of the anterior abdominal wall are:

- External oblique
- Internal oblique
- Transverse abdominis
- Rectus abdominis
- Pyramidalis

The fibers of the internal oblique and transverse abdominis become aponeurotic more medially than external oblique. Therefore, these muscle fibers may have to be cut laterally while making a transverse incision. The rectus

abdominis muscles lie on either side of midline. Transverse incisions for cesarean section are usually extended up to the lateral border of these muscles. Pyramidalis is visualized when the anterior rectus sheath is dissected from the muscle near the pubic symphysis. These small muscles may be left attached to the rectus sheath.

Peritoneum

This is part of the parietal peritoneum that covers the abdominal cavity.

Blood supply

Blood supply is from branches of femoral and external iliac arteries (Box 1.1).

The superficial epigastric vessels are encountered during transverse (*Pfannenstiel*) incision in the subcutaneous tissue. The inferior epigastric vessels are larger and lie posterior to the rectus muscle. These have to be identified and ligated or cauterized.

Box 1.1 Blood supply of the anterior abdominal wall

- Branches from femoral artery
 - Superficial epigastric
 - Superficial circumflex iliac
 - External pudendal
- Branches from the external iliac artery
 - Deep (inferior) epigastric
 - Deep circumflex iliac

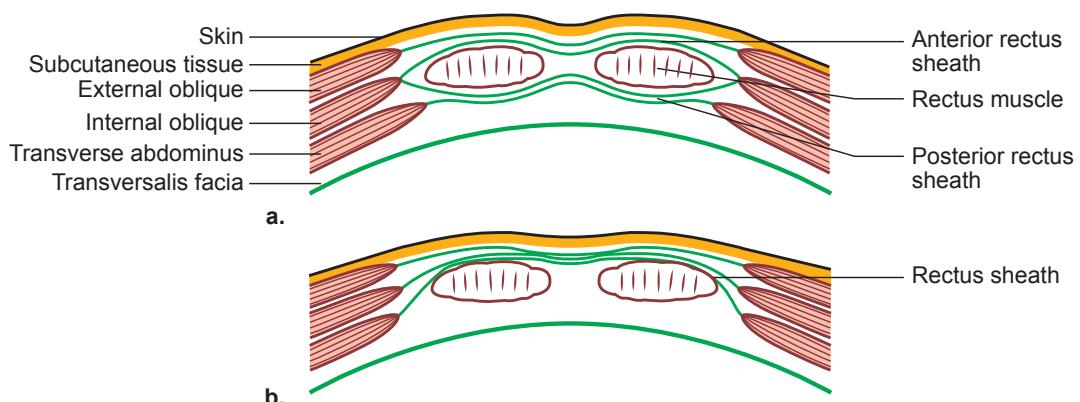


Figure 1.1 The rectus sheath. **a.** Above the arcuate line. The internal oblique aponeurosis splits into two layers. **b.** Below the arcuate line. The aponeuroses of internal oblique and transverse abdominis fuse with external oblique aponeurosis.

Clinical implications

Incisions on the abdominal wall for cesarean section may be vertical midline or Pfannenstiel. Vertical incisions are associated with more postoperative pain and higher risk of incisional hernia; hence, transverse incisions are preferred. Other clinical implications (advantages and surgical anatomy) of *transverse incision* are given below.

- Advantages
 - Performed along Langer's lines
 - Cosmetically better
 - Less pain
 - Less risk of hernia
- Surgical anatomy
 - Lateral extent of transverse incision
 - Up to lateral border of rectus abdominis
 - Inferior epigastric vessels
 - Lie under rectus muscles
 - Must be clamped/cauterized
 - Ilioinguinal/Iliohypogastric nerve fibers
 - May be entrapped/divided in transverse incision

Nerve supply

Innervation is by T7-T12 and L1. Abdominal wall at the level of the umbilicus is supplied by T10. Ilioinguinal and iliohypogastric nerves (L1) supply the suprapubic area, lower abdomen, and mons pubis. These nerve fibers run between the layers of rectus sheath lateral to the rectus

muscle and may be entrapped or divided if the transverse incision extends too far laterally.

External genitalia (vulva)

Vulva or the external genitalia consists of anatomical structures listed in Box 1.2 (Fig. 1.2).

Mons pubis

This is the triangular area anterior to the pubic bones; it is continuous with the abdominal wall above and with the labia below. It is filled with adipose tissue and covered by hairy skin.

Box 1.2 External genitalia (vulva)

- Mons pubis
- Labia majora
- Labia minora
- Clitoris
- Vestibule
- Urethral orifice
- Vaginal orifice
- Hymen
- Bartholin's glands
- Skene's glands
- Vestibular bulbs

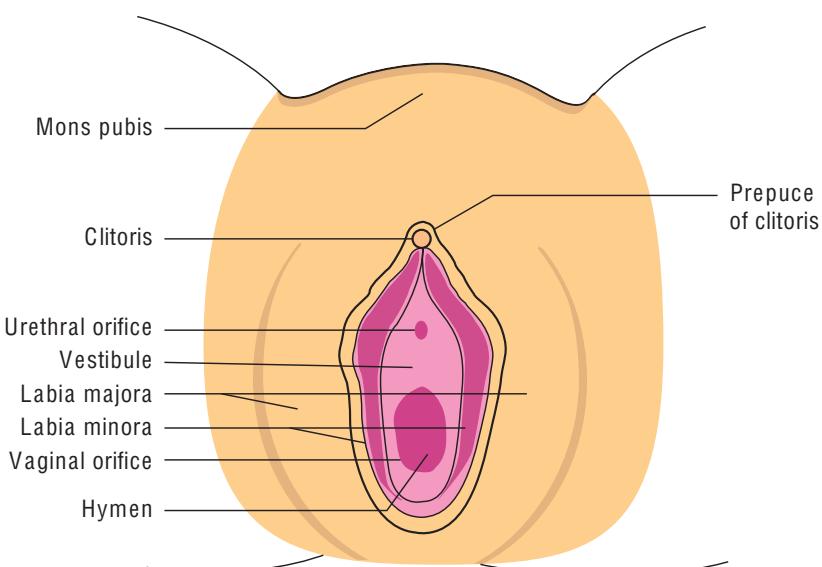


Figure 1.2 Structures in the vulva.

Labia majora

These are folds of fatty tissue covered by skin that extend from mons pubis to perineum to meet in front of the anus, forming the posterior fourchette. The skin on the lateral aspect of labia majora is pigmented and covered by hair. Inner aspect is smooth and shiny and contains apocrine, sweat, and sebaceous glands.

Labia minora

Labia minora are folds of skin that lie medial to the labia majora, encircling the urethral and vaginal orifices. Posteriorly they fuse with the posterior fourchette but anteriorly they divide to form a hood or prepuce and a frenulum for the clitoris.

Clitoris

Clitoris is the homologue of the penis in men and is formed by two corpora cavernosa and erectile tissue. It is about 1.5–2 cm in length and is located anterior to the urethral orifice between the anterior folds of labia minora.

Vestibule

The area between the labia minora is referred to as the vestibule. This is perforated by the urethral and vaginal orifices.

The urethral orifice (meatus) is a vertical opening above the vaginal orifice. The ducts of Skene's (paraurethral) glands open just inside or outside the meatus.

Urethral orifice

This is otherwise known as *external urethral meatus* and is located in the anterior part of the vestibule.

Vaginal orifice

This lies between the labia minora and is partially covered by a thin membrane called *hymen*. The ducts of the Bartholin's glands open into the vaginal orifice laterally between the hymen and labia minora.

Hymen

Hymen is the thin membrane that covers the vaginal orifice. This ruptures during the first intercourse and remains as small rounded tags.

Bartholin's glands

These are small glands located on the postero-lateral aspect of vaginal orifice, beneath the bulbospongiosus muscle, at 4 o'clock and 8 o'clock positions. The glands are about 1 cm in size and not palpable normally. The ducts are 2 cm long and open into the vaginal orifice, superficial to the hymen. The glands are compound racemose and lined by cuboidal epithelium. Ducts are lined by cuboidal epithelium proximally and transitional epithelium distally. The secretions provide lubrication during sexual intercourse.

Skene's glands

These are paraurethral glands that are homologous of the prostate and are located on either side of the distal urethra. The ducts open into the urethra, close to the external meatus.

Vestibular bulbs

These are elongated masses of erectile tissue located beneath the bulbospongiosus muscle on either side of the vaginal orifice. They meet anteriorly as a narrow strip.

Changes in pregnancy

Vulva becomes soft in pregnancy and varicosities may develop. Vulval edema may develop in severe preeclampsia.

Clinical implications

Clinical implications of *changes in vulva during pregnancy* are given below.

- Varicose veins of the vulva
 - Bleeding during delivery
- Vulval edema
 - Difficulty in episiotomy
 - Impaired healing

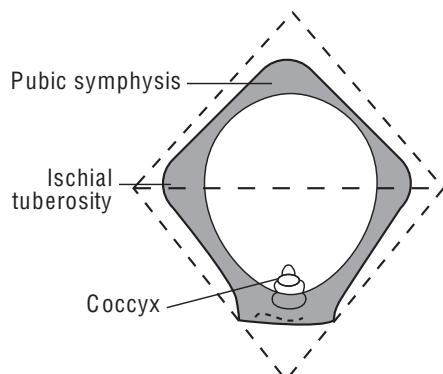


Figure 1.3 The anatomical perineum. This is a diamond-shaped area that extends from the pubis anteriorly to the coccyx posteriorly and the ischial tuberosities laterally.

The perineum

The anatomical or true perineum is a diamond-shaped area that extends from pubis anteriorly to coccyx posteriorly and the ischial tuberosities laterally (Fig. 1.3). This is divided by an imaginary line between the two ischial tuberosities into *anterior or urogenital triangle* and *posterior or anal triangle*.

The urogenital triangle

The urogenital triangle forms the anterior triangle of the perineum.

Boundaries

- Anterior: Subpubic angle
- Posterior: Superficial transverse perinei muscles
- Lateral: Ischiopubic rami and ischial tuberosities (Fig. 1.4)

Contents

The contents of the urogenital triangle are listed in Box 1.3.

Box 1.3 Contents of the urogenital triangle

- Vulva and its contents
- Urogenital diaphragm
- Superficial perineal muscles
- Deep perineal muscles
- Blood vessels, nerves, and lymphatics

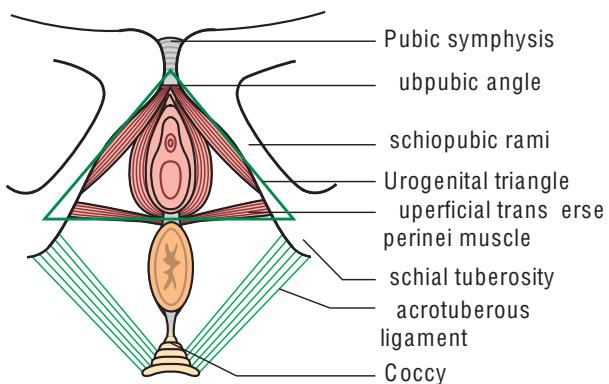


Figure 1.4 The urogenital triangle. The boundaries are subpubic angle anteriorly; superficial transverse perinei muscle posteriorly; ischiopubic rami and the ischial tuberosities laterally.

Box 1.4 Muscles of the perineum

- Superficial perineal muscles
 - Ischiocavernosus
 - Bulbospongiosus
 - Superficial transverse perinei
- Deep perineal muscles
 - Deep transverse perinei
 - Urethral sphincter

Muscles of the perineum

They fall into two groups—superficial and deep—as demarcated by the perineal membrane (Box 1.4; Fig. 1.5).

Superficial perineal muscles

The *ischiocavernosus* muscles run along the ischiopubic rami, originate at the ischial tuberosity and are inserted into the ischiopubis. The *bulbospongiosus* muscles are medial and lie over the vestibular bulbs. They originate at the perineal body and are inserted into the clitoris. The *superficial transverse perinei* muscles are attached to the ischial tuberosities laterally and perineal body medially (Box 1.5).

Deep perineal muscles

The *urethral sphincter* consists of a sheet of muscle that arises from the ischiopubis and is inserted into the urethra and vagina. This muscle functions along with deep transverse perinei, puborectal fibers of the levator ani, and bulbospongiosus

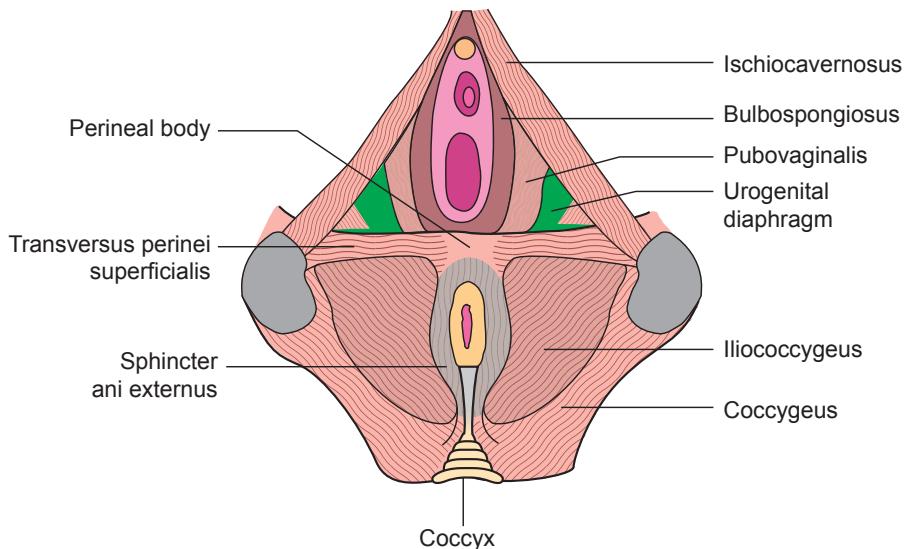


Figure 1.5 Muscles of perineum. Superficial muscles of the perineum are seen.

Box 1.5 Superficial and deep perineal muscles

Muscle	Origin	Insertion
Ischiocavernosus	Ischial tuberosity	Ischiopubis
Bulbospongiosus	Perineal body	Clitoris
Superficial transverse perinei	Ischial tuberosity	Perineal body
Urethral sphincter	Ischiopubis	Urethra and vagina
Deep transverse perinei	Ischium	Lateral vaginal wall

muscles to aid the bladder muscles in closing the urethra. The *deep transverse perinei* muscles are located above the perineal membrane, arise from the ischial bone, and are inserted into the lateral vaginal wall.

Perineal membrane

Perineal membrane is a dense triangular condensation of fascia that stretches between the two ischiopubic rami and is pierced by the urethra and vagina. This membrane separates the superficial from the deep compartment of the perineum. The perineal membrane and the deep transverse perinei muscles attach the lower vagina and urethra to pubic rami and provide support to these structures.

The anal triangle

Boundaries

- Anterior: Superficial transverse perineal muscles
- Posterior: Coccyx
- Lateral: Ischial tuberosities and sacrotuberous ligaments (Fig. 1.6)

Contents

Contents of anal triangle are listed in Box 1.6.

Anal canal

Anal canal extends from the anorectal junction to the anal verge and is approximately 4 cm in length. The dentate line is located 2 cm from the anal verge. The canal is lined by columnar epithelium above the dentate line and squamous epithelium below the dentate line.

The anal sphincters

There are two anal sphincters—external and internal. The *external anal sphincter* is made of skeletal

Box 1.6 Contents of anal triangle

- Lower end of anal canal
- Anal sphincters
- Anococcygeal body (raphe)
- Ischiorectal fossae
- Blood vessels, lymphatics, and nerves

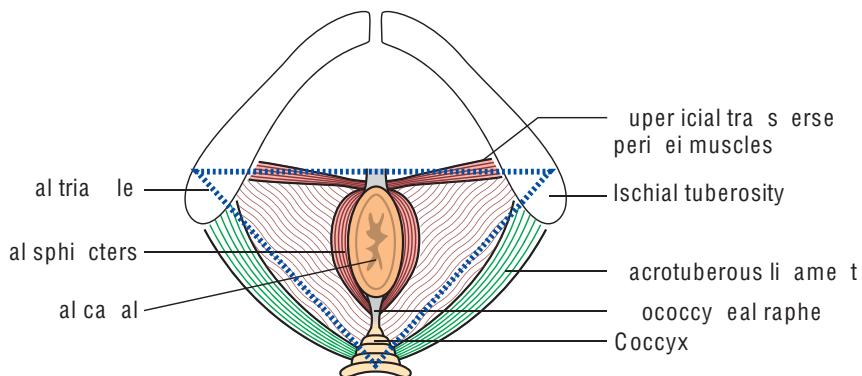


Figure 1.6 The anal triangle. The boundaries are superficial transverse perineal muscles anteriorly; coccyx posteriorly; ischial tuberosities and sacrotuberous ligaments laterally.

muscle and has three parts—subcutaneous, superficial, and deep. The fibers of external anal sphincters merge with each other and are attached to perineal body anteriorly and to puborectalis and anococcygeal body posteriorly.

Anococcygeal body is a fibromuscular structure located between the anus and coccyx. The fibers of the levator ani and anal sphincters are attached to it.

Ischiorectal fossae

These lie on either side of the anal canal. They are wedge-shaped, fat-filled spaces. Boundaries and contents of the fossae are given in Box 1.7 and Fig. 1.7.

Perineal body

Perineal body is a fibromuscular structure that forms the center point of the perineum and is situated between the anus and lower vagina. Several muscles are inserted into it (Box 1.8; Fig. 1.8).

Box 1.7 Boundaries and contents of ischiorectal fossa

- Boundaries
 - Base: Perineal skin
 - Apex: Point where obturator and anal fascia meet
 - Lateral: Ischial tuberosity, obturator internus muscle, obturator fascia
 - Medial: Sphincter ani internus, levator ani
 - Posterior: Gluteus maximus, sacrotuberous ligament
- Contents
 - Ischiorectal pad of fat
 - Inferior rectal nerve and vessels
 - Pudendal canal and its contents
 - Posterior labial nerve, perineal branch of fourth sacral nerve, cutaneous branch of S2, S3

Pelvic floor

The pelvic organs are supported in the upright position by a fibromuscular floor that includes the pelvic diaphragm, muscles of the deep perineal compartment, and the perineal membrane.

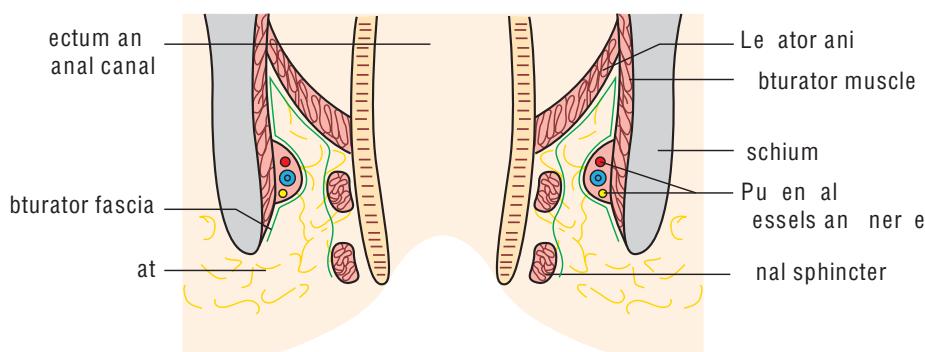


Figure 1.7 Coronal section of the ischiorectal fossae. These are wedge-shaped spaces on either side of the anal canal.

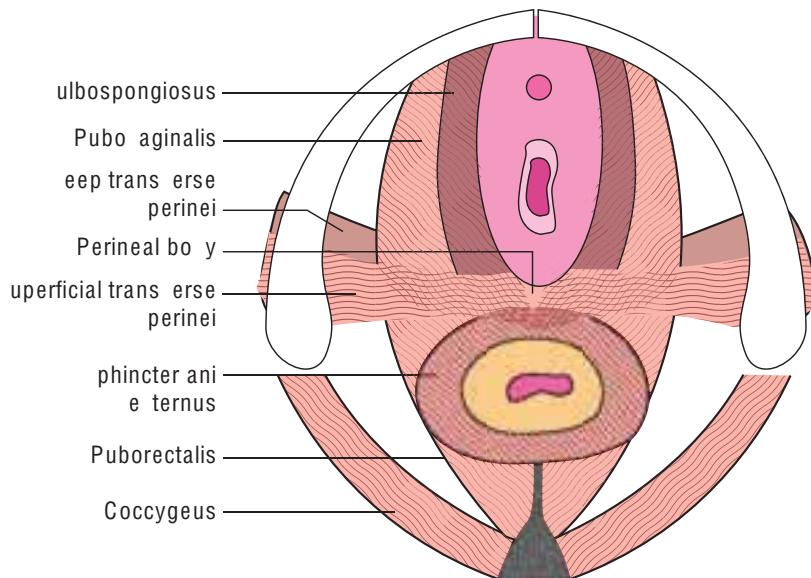


Figure 1.8 Muscles that form perineal body.

Box 1.8 Muscles inserted into perineal body

- Sphincter aniexternus
- Bulbospongiosus
- Superficial transverse perinei
- Deep transverse perinei
- Levator ani
 - Pubovaginalis
 - Puborectalis

Box 1.9 Components of levator ani

- Pubococcygeus
 - Puborectalis
 - Pubovaginalis
- Iliococcygeus

Clinical implications

Perineal body stretches during delivery and the muscles are involved in perineal tears. Damage to perineal body causes a deficient perineum, gaping of the introitus with resultant sexual problems, and loss of support for lower one-third of vagina. Third and fourth degree tears lead to anal incontinence. Surgical incision on the perineum to enlarge the introitus to facilitate delivery is known as *episiotomy* (see Chapter 15, *Management of normal labor and delivery*).

Pelvic diaphragm

Pelvic diaphragm consists of levator ani muscle covered by pelvic fascia. The muscle covers the space from the pubic bone to coccyx and from one pelvic side wall to another forming a funnel-shaped support. The muscle has two components (Box 1.9; Fig. 1.9). The coccygeus, formerly called *ischiococcygeus*, extends from the ischial spine to coccyx but is not a part of levator ani.

The muscle fibers of the levator ani muscles arise from the *arcus tendineus or white line* which is a thickening of the fascial covering of the obturator internus muscle and extends from the pubic bone to ischial spine (Fig. 1.10). The fibers of levator ani pass backwards and medially to be inserted into perineal body, rectal wall, anococcygeal raphe, and coccyx. In addition, the medial and anterior fibers that arise from the pubis (pubovaginalis) cross the lateral vaginal wall between the middle and lower third and are inserted into the vaginal wall and perineal body. Some fibers decussate behind the urethra as well. They form a sling around the urethra, vagina, and rectum, pulling these structures anteriorly toward the pubis. When the muscle contracts, the urethra, vagina, and rectum are kinked and narrowed. The uterus and vagina lie horizontally on the pelvic floor. The contraction of the levator ani also maintains the vagina in its horizontal position at rest.

The coccygeus, also called *ischiococcygeus*, though not part of the levator ani, also forms the posterior part of the pelvic floor and pelvic

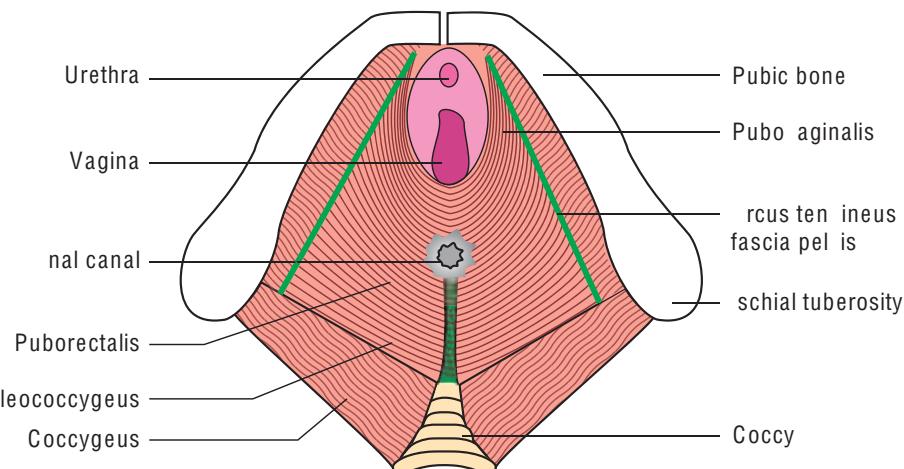


Figure 1.9 Components of levator ani muscle—puborectalis, pubovaginalis, and iliococcygeus.

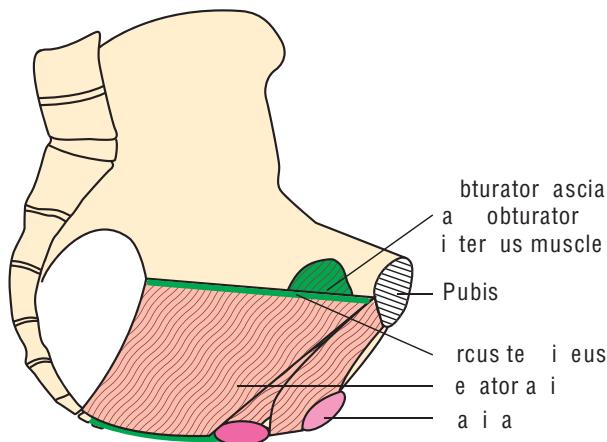


Figure 1.10 Arcus tendineus fascia pelvis. It extends from the pubic bone to the ischial spine.

Clinical implications

The *location, attachments, and functions of the levator ani muscle* have several clinical implications.

- The levator ani muscle has a resting tone that keeps the pelvic floor closed and prevents herniation of the uterus and cervix.
- The shape of the levator ani muscle and the direction of the fibers play a major role in internal rotation of the presenting part in labor.
- Puborectalis contributes to anal continence.
- Injury to levator ani muscle, detected by ultrasonography and magnetic resonance imaging, occurs during vaginal delivery and causes pelvic organ prolapse.

support. It originates from the ischial spine and sacrospinous ligament and is inserted into the lateral part of the lower sacrum and coccyx.

Box 1.10 Internal genital organs

- Vagina
- Uterus
- Fallopian tubes
- Ovary

Internal genital organs

The internal genital organs are listed in Box 1.10 and elaborated in the following text.

Vagina

Vagina is the fibromuscular tube that extends from vestibule to uterine cervix (Box 1.11).

The attachment of vagina to the cervix is at its middle (Fig. 1.11). Therefore, a gutter is formed all around the cervix, between it and the vagina,

Box 1.11 Vagina

- Fibromuscular tube from vestibule to cervix
- Axis horizontal
- Closely applied
 - Anteriorly
 - Bladder
 - Urethra
 - Posteriorly
 - Posterior cul-de-sac
 - Rectum
 - Anal canal
 - Perineal body
- Anterior and posterior walls in apposition

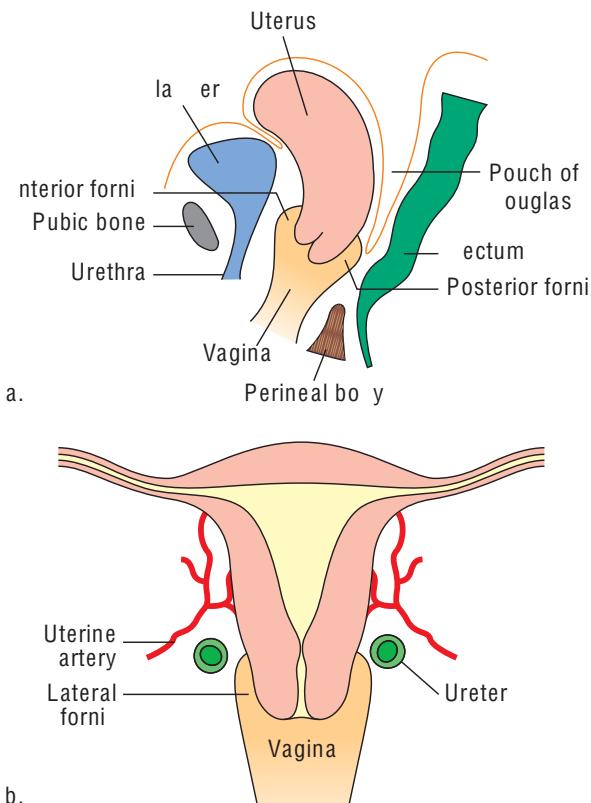


Figure 1.11 a. Sagittal section of the vagina showing the axis of the vagina, the anterior and posterior fornices, and its relationship to bladder and urethra. b. Coronal section of the vagina showing the lateral fornices and their proximity to ureters.

called *fornices*. Ureter and uterine artery are in close proximity to lateral fornices. The posterior attachment is at a higher level making the posterior fornix deep. The anterior wall of the vagina is, therefore, shorter than the posterior wall. The opening at the vestibule is partially covered by hymen. The vaginal walls have rugae which allow stretching during parturition. The axis of the vagina is horizontal.

Structure of vagina

Vaginal wall is composed of three layers (Box 1.12).

Changes in vagina during pregnancy

There is increased vascularity and bluish discolouration of the vagina, described as Chadwick's sign. Increase in glycogen-containing cells results in lowering of pH due to increase in lactic acid. This offers protection from infection.

Box 1.12 Structure of vagina

- Mucosa
 - Stratified squamous epithelium
- Subepithelial connective tissue
- Muscle layer
 - Outer longitudinal
 - Inner circular
- Condensed endopelvic fascia

Clinical implications

Clinical implications of *changes in vagina during pregnancy* are given below.

- Bluish discolouration of vulva
 - Diagnosis of pregnancy
- Lowering of vaginal pH
 - Protection against vaginal infections

Uterus

Uterus is a pear-shaped hollow viscus located between the bladder and rectum. It is divided into *cervix* and *uterine corpus*, the dividing line being the internal os.

Cervix

The attachment of the vagina divides the cervix into upper supravaginal cervix and lower portio vaginalis (Fig. 1.12). It has an external os and internal os, and a cervical canal in between. Total length of cervix is 2.5–3 cm. The external os is circular in the nullipara but becomes a transverse slit after childbirth. Anatomical features of cervix are given in Box 1.13.

Box 1.13 Anatomical features of the cervix

- Cervix divided into
 - supravaginal cervix
 - portio vaginalis
- Consists of
 - external os
 - internal os
 - endocervical canal between the two
- Structure includes
 - fibromuscular wall
 - endocervical canal—columnar epithelium
 - ectocervix—stratified squamous epithelium
 - glands—secrete mucus

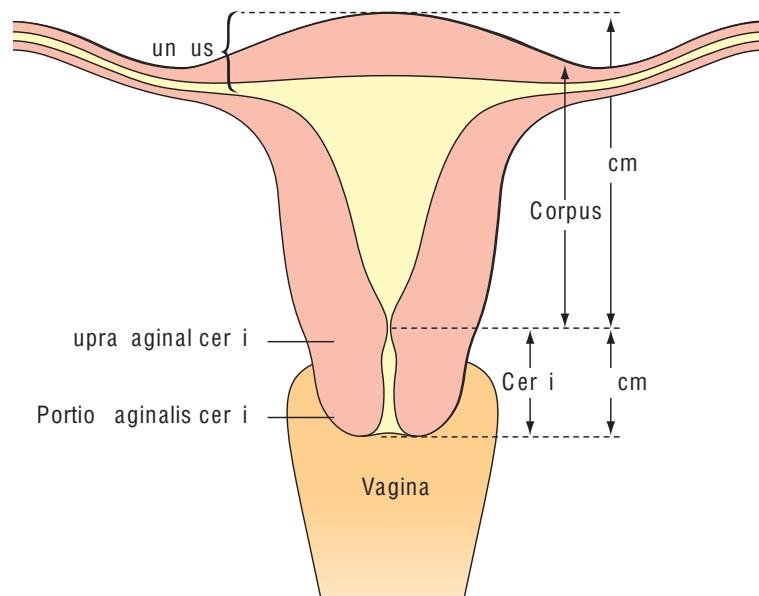


Figure 1.12 Uterus and cervix. Uterine fundus is the part above the line of attachment of the fallopian tubes. The part of the cervix above the attachment of the vagina is supravaginal cervix and below this is portio vaginalis cervix.

Changes in cervix during pregnancy

Cervix undergoes changes in pregnancy. In the first trimester of pregnancy, the lower part of the uterus softens, while the fundus and cervix are firmer. This softening of the lower segment is described as Hegar's sign (see Chapter 7, *Clinical manifestations and diagnosis of pregnancy*). The cervix remains closed in pregnancy till onset of labor. Endocervical epithelium proliferates and gives rise to ectropion. There is also plenty of mucus production and a mucous plug forms in the cervical canal, which is expelled at the onset of labor along with bloody discharge known as *show* (see Chapter 14, *Normal labor: Mechanics, mechanism, and stages*). During labor, cervix undergoes effacement and dilatation to allow the passage of fetus.

Early effacement and dilatation occurs in some women, leading to recurrent pregnancy loss or preterm labor.

Uterine corpus

The size and shape of the uterus changes with changes in hormone levels associated with puberty and pregnancy. The dimensions of nulliparous uterus are given in Box 1.14. The uterus is normally anteverted and anteflexed. Flexion is the angle between the uterus and cervix and version is the angle between the uterus and vagina.

Clinical implications

Clinical implications of *changes in cervix during pregnancy* are given below.

- Hegar's sign
 - Diagnosis of pregnancy
- Mucous plug
 - Protects against ascending infection
- Show
 - Sign of first stage of labor
- Effacement and dilatation
 - Normal labor
- Dilatation before term
 - Preterm labor
 - Pregnancy loss

Box 1.14 Uterus

- Pear shaped
- Length: 7 cm
- Anteroposterior thickness: 2.5 cm
- Length of cavity: 6 cm
- Body: Cervix ratio
 - At birth: 1:1
 - Adult: 2:1
- Corpus is divided into
 - Isthmus: Just above the internal os
 - Cornu: At insertion of fallopian tube
 - Fundus: Above the level of cornu

Structure of uterus

The uterine wall consists of three layers—inner endometrium, outer serosa, and a middle layer composed of smooth muscles called *myometrium*. The endometrial cavity is continuous with that of the tubes, cervix, and vagina. The endometrium, including glands and stroma, is very sensitive to estrogen and progesterone and undergoes changes during menstrual cycle and pregnancy.

The myometrium consists of three layers. These layers are more distinct during pregnancy.

- Outer longitudinal
- Middle interlacing, crisscross
- Inner circular

The outer longitudinal fibers of myometrium are continuous with those of the tubes. The middle layer of interlacing fibers is important for uterine contraction and retraction. The blood vessels pass through this layer and the contraction of the fibers in this layer occludes the vessels, forming *living ligatures* and stopping the bleeding after parturition. The inner circular layer is thin and insignificant (Fig. 1.13).

The serosa or peritoneum covering the uterus stops at the uterovesical junction anteriorly but extends down to form the *cul-de-sac* or pouch of Douglas posteriorly (Box 1.15). The *cul-de-sac* is the most dependent part of the pelvis, and therefore, fluids, pus, and blood collect here to form abscess or hematocoele. This can be easily accessed through the posterior fornix.

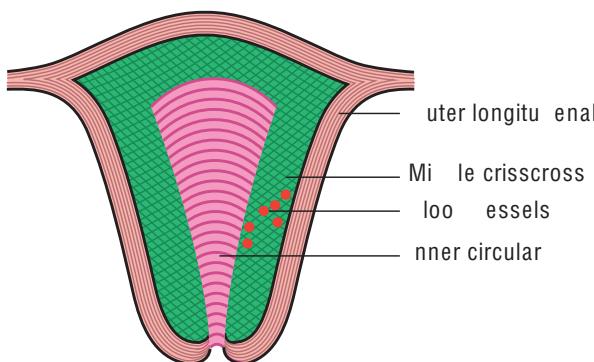


Figure 1.13 Diagrammatic representation of the muscle layers of the uterine myometrium. The myometrium consists of outer longitudinal, inner circular, and middle interlacing crisscross fibers. The blood vessels pass through the middle layer.

Box 1.15 Histology of uterus

- Endometrium
 - Columnar epithelium
 - Cellular stroma
 - Glands
 - Specialized stroma
- Myometrium
 - Inner circular
 - Middle interlacing
 - Outer longitudinal
- Serosa (peritoneum)
 - Incomplete anteriorly
 - Complete posteriorly

Changes in uterus during pregnancy

Major anatomical changes take place in the uterus during pregnancy.

a. Changes in size and shape

In the prepregnant state, uterus is a pear-shaped organ, which weighs about 100 g, measures $10 \times 5 \times 2.5$ cm, and has a cavity of about 10 mL. Rapid growth in pregnancy is due to hyperplasia and hypertrophy. By term, uterus weighs 1000 g and has a capacity to hold 5 L or more. Shape of the uterus changes with advancing pregnancy from pear shaped to spherical at 20 weeks and elongates toward term, becoming longitudinally oval (Box 1.16).

b. Formation of lower segment

The lower segment develops from the isthmus and is about 10 cm in length by term. The difference between the two segments becomes more obvious as pregnancy advances. The junction between the two segments is at the level of the pubic symphysis and is marked by the level at

Box 1.16 Changes in the uterus during pregnancy

- Size
 - Increase in uterine size
 - More at the fundus
 - Due to hypertrophy and hyperplasia
- Shape
 - Spherical by 12 weeks
 - Longitudinally oval by term
- Volume
 - Increases to 5 L or more

which the peritoneum becomes loosely adherent to the anterior uterine wall.

c. Changes in blood flow

Blood flow to the uterus and cervix increases steadily to 500 mL/min, which is five times more than the nonpregnant state. Uterine vessels enlarge gradually and become tortuous.

d. Changes in myometrium

The three layers become distinct and the middle layer becomes prominent.

e. Uterine activity

Spontaneous contractions called *Braxton Hick's contractions* begin at about 20 weeks and continue till term. This uterine activity facilitates the development of lower segment and softens the cervix.

Fallopian tubes

The tubes are about 10 cm in length and extend laterally from the cornual ends of the uterus into the peritoneal cavity. Each tube is divided into four regions (Box 1.17; Fig. 1.14). The infundibulum has fimbriae with cilia to aid in ovum pickup. Fertilization takes place in the tube, and the blastocyst is transported to the uterine cavity where implantation takes place.

The structure of the tube is given in Box 1.18. The tube has three layers—inner mucosa, outer serosa, and muscularis layer between the two.

Clinical implications

Clinical implications of *changes in uterine anatomy during pregnancy* are given below.

- Changes in size, shape, position
 - Accommodates growing fetus
- Changes in myometrium
 - Uterine contraction in labor
 - Retraction and hemostasis in third stage
- Formation of lower segment
 - Facilitates labor
- Thinning of lower segment
 - Predisposes to rupture uterus
- Formation of retraction ring
 - Indicates obstructed labor

Box 1.17 Fallopian tubes

- Length: About 10 cm
- Four regions
 - Interstitial: Narrowest, within the uterine cornu
 - Isthmus: Narrow, close to uterine cornu
 - Ampullary: Broader, thin walled, lateral to isthmus
 - Infundibulum: Funnel shaped, ends in fimbriae
- Functions
 - Ovum pickup
 - Site of fertilization
 - Transport of fertilized ovum

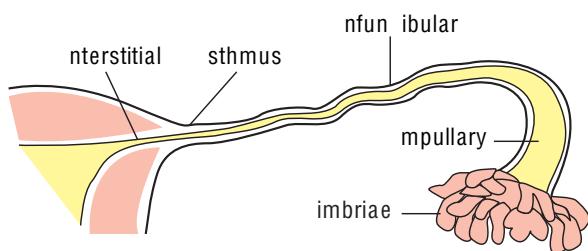


Figure 1.14 The fallopian tube. The tube is narrow at the isthmus and broad at the ampullary part.

Box 1.18 Structure of the fallopian tube

- Mucosa
 - Ciliated columnar epithelium
- Muscularis
 - Outer longitudinal
 - Inner circular
- Outer
 - Serosa

Clinical implications

When implantation of fertilized ovum takes place in the fallopian tube, ectopic pregnancy results. It can rupture leading to hemoperitoneum, shock, and pelvic hematocole.

Ovaries

The tube and ovary together are referred to as *adnexa*. The ovaries are the female gonads. The size of the ovaries varies with age, sex, steroid hormone levels, and certain medications. The ovaries are located on either side of the uterus, close to the infundibulum of the tubes. They are connected to the uterine cornu by the ovarian ligaments and to the broad ligament by mesovarium.

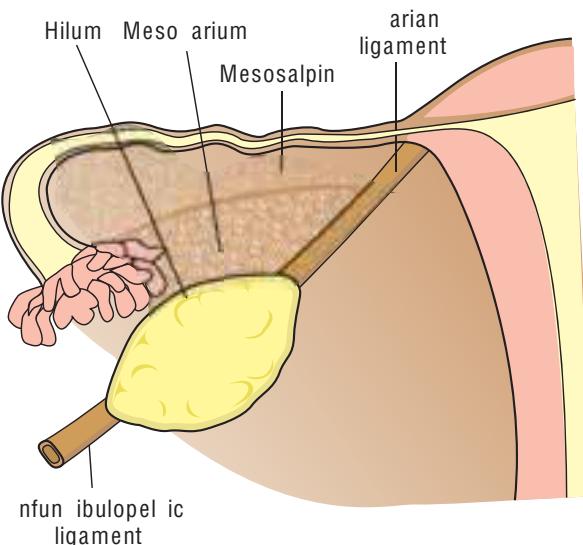


Figure 1.15 Attachments of the ovary. Infundibulopelvic ligament attaches the ovary to the lateral pelvic wall and ovarian ligament to the ovary. Mesovarium lies between the ovary and the broad ligament.

Box 1.19 Ovaries

- Size
 - 3 x 2 cm
- Connected by
 - mesovarium (mesentery) to posterior surface of broad ligament
 - ovarian ligament to uterine cornu
 - infundibulopelvic ligament to lateral pelvic wall

(Fig. 1.15). The ovarian vessels are carried in a fold of peritoneum, called the *infundibulopelvic ligaments*, from the lateral pelvic wall to the ovary (Box 1.19).

Structure

The ovary is divided into an outer cortex and inner medulla (Box 1.20). The cortex contains the specialized stroma and the follicles and is responsible for the important functions of ovulation and steroid hormone production.

Changes in ovaries during pregnancy

Ovaries enlarge and become vascular. The corpus luteum continues to grow and secrete hormones till 7–8 weeks and begins to degenerate at 12 weeks when placenta takes over.

Box 1.20 Structure of the ovary

- Cortex
 - Cuboidal surface epithelium
 - Specialized stroma
 - Follicles
- Medulla
 - Fibromuscular tissue
 - Blood vessels

Ligaments of the uterus and cervix

The endopelvic fascia condenses in some areas to form ligaments that support the uterus and other pelvic structures (Box 1.21; Fig. 1.16).

Cardinal or Mackenrodt's ligaments

These extend from the lower part of the uterus, supravaginal cervix and lateral vaginal fornix to the lateral pelvic wall. The loose cellular tissue in this area is referred to as *parametrium*. The

Box 1.21 Ligaments of the uterus and cervix

- Cardinal ligaments
- Pubocervical ligaments
- Uterosacral ligaments
- Round ligaments
- Broad ligaments
- Ovarian ligaments
- Infundibulopelvic ligaments

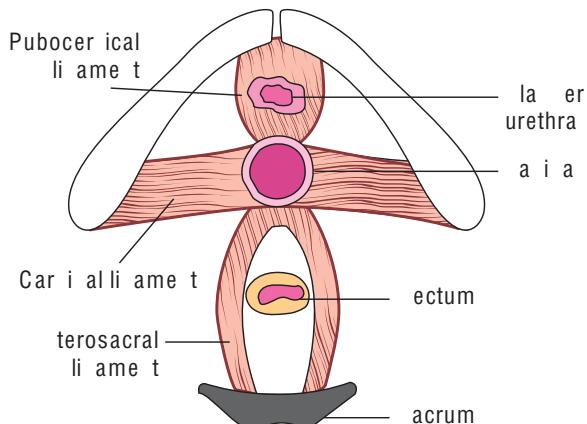


Figure 1.16 Ligaments attached to the lower uterus and cervix—cardinal, uterosacral, and pubocervical ligaments.

ureter, before entering the bladder, traverses this ligament and is encased in a fascial sheath called *ureteric tunnel* which lies 2 cm lateral to the cervix. The uterine artery crosses to the uterus above the ureter at this point. The descending cervical branch of the uterine artery courses through this ligament.

Pubocervical ligaments

This condensation of the pubovesicocervical fascia passes from the anterolateral aspect of the cervix to the posterior surface of pubic bone. Some fibers extend from the bladder and the pubis and form the bladder pillars. Pubocervical ligaments merge posterolaterally with the cardinal ligaments.

Uterosacral ligaments

These ligaments extend from the posterior part of the supravaginal cervix to the sacrum. They lie on either side of the rectosigmoid. Anterolaterally they merge with cardinal ligaments. Frankenhauser's plexus of nerves are located mainly along these ligaments.

Round ligaments

These are vestiges of the gubernaculum and are made of fibromuscular tissue. They extend laterally from the uterine cornu extraperitoneally, enter the inguinal canal, and finally merge with the skin and connective tissue of the mons pubis and labia majora.

Broad ligaments

The peritoneum on the anterior and posterior surface of the uterus spreads out laterally toward the pelvic wall to form the broad ligaments. Between the two layers of peritoneum is the pelvic cellular tissue containing ureter and the plexus formed by the anastomosis of uterine and ovarian vessels. The round ligaments, tubes, and ovarian ligaments are covered by the peritoneum of the broad ligament and are contained in its upper part.

Ovarian ligaments

They pass from the medial pole of the ovaries to the uterine cornu posterior to the attachment of the tubes.

Infundibulopelvic ligaments

These are lateral extensions of the broad ligaments between the ovary and pelvic wall. They contain the ovarian vessels.

Pelvic ureters

The ureters are located retroperitoneally and run from the renal pelvis to urinary bladder. The abdominal segments lie on the psoas muscle and run downwards and medially. They enter the pelvis by crossing the common iliac vessels from lateral to medial aspect at their bifurcation just medial to the ovarian vessels (Fig. 1.17a and b). They can be found attached to the medial leaf of the posterior peritoneum during dissection. At the level of the ischial spines, they turn forward and medially toward the base of the broad ligament. They then enter the ureteric canal in the cardinal ligament, crossing under the uterine vessels. Here they are 2 cm lateral to the cervix. The ureters run medially and enter the bladder close to the anterior vaginal wall (Box 1.22).

Box 1.22 The course of the pelvic ureters

- Cross the common iliac at bifurcation
- Lie attached to the posterior peritoneum
- Reach the level of uterosacral ligaments
- Turn forward at ischial spine
- Enter the base of broad ligaments
- Cross under the uterine vessels
- Enter ureteric canal in cardinal ligaments
- Run forward to enter the bladder
- Lie close to anterior vaginal wall

Clinical implications

Due to the close proximity to other structures in the pelvis, the ureter is prone to injury during various surgical procedures. *Points at which ureter is prone to injury* are listed below.

Site	Procedure
Pelvic brim	Clamping of infundibulopelvic ligaments
Bifurcation of common iliac	Internal iliac artery ligation
Broad ligament	Uterine artery ligation
Cardinal ligament	Dissection of ureteric tunnel
Upper vagina	Clamping of cardinal ligament
	Clamping of vaginal angle

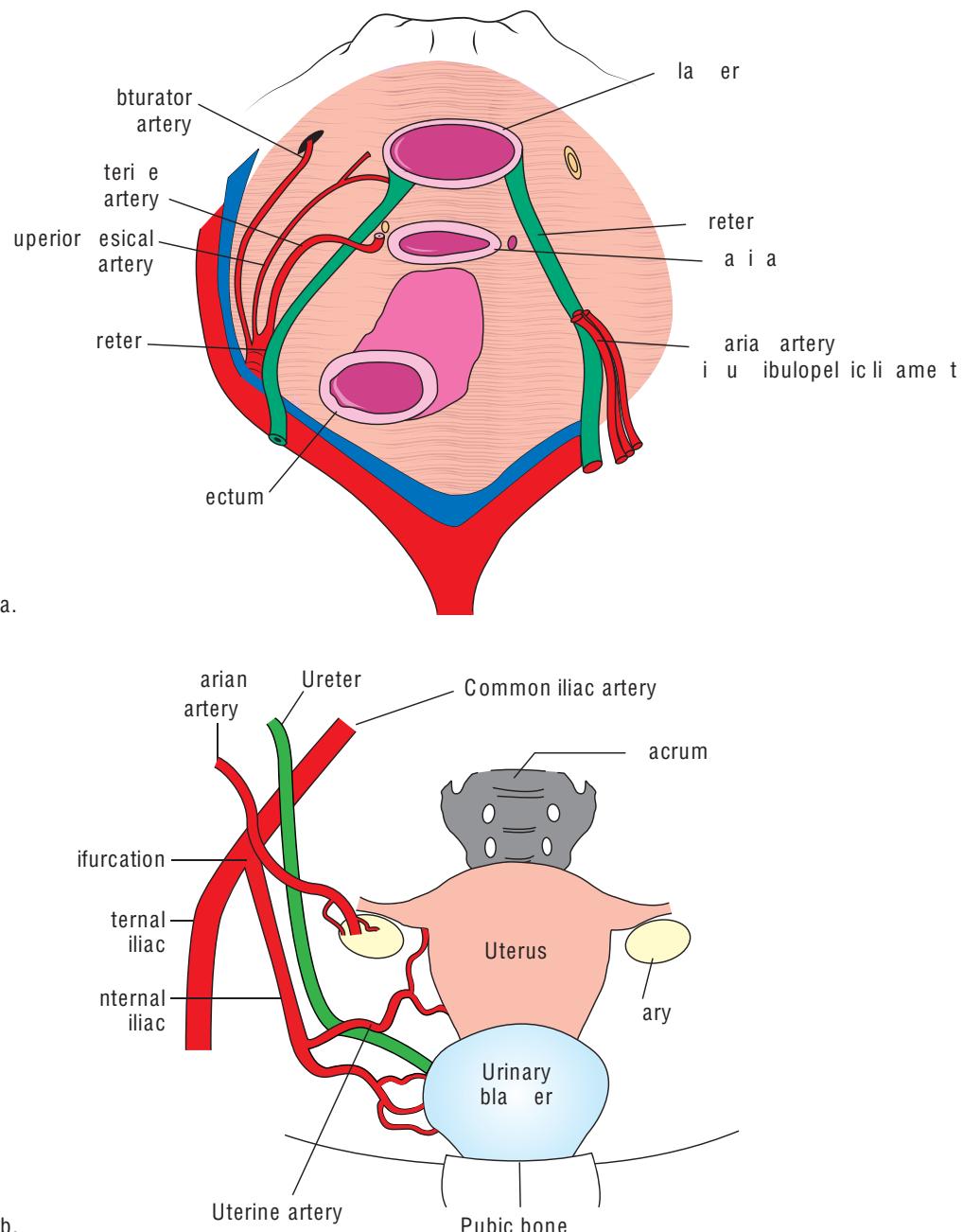


Figure 1.17 The pelvic ureters. **a.** The course of the ureters. **b.** The relationship of the pelvic ureters. The Ureters enter the pelvis by crossing the common iliac artery at its bifurcation, turn forward to enter the ureteric canal crossing under the uterine vessels.

The ureters receive rich blood supply from all the blood vessels in the pelvis. These vessels anastomose to form a plexus on the adventitia of the ureters before entering it. Therefore, the ureter is protected from devascularization unless it is skeletonized.

Urinary bladder and urethra

The urinary bladder and urethra are in close proximity to the anterior surface of uterus and vagina. The proximity and susceptibility to injury varies with the amount of urine in the bladder.

Clinical implications

Since the urinary bladder lies just anterior to lower uterine segment, injuries to the bladder are common during surgery. The bladder or urethra may be compressed between the fetal head and pubic bone in obstructed labor, leading to pressure necrosis and urinary fistulae.

Obstetric injuries of the urinary bladder

- Rupture uterus
- Cesarean section
 - While entering peritoneum
 - While incising uterovesical peritoneum
 - While pushing bladder down
 - Downward extension of uterine incision
- Vaginal delivery
 - Rotational forceps
 - Destructive operations
- Obstructed labor
 - Pressure necrosis and fistula

The superior surface of bladder is adjacent to the anterior uterine surface. Base of the bladder is located adjacent to the anterior vaginal wall. Bladder neck and urethra lie anterior to the anterior vaginal wall. The space between the bladder and pubic symphysis is called *space of Retzius*.

Blood supply

The internal and external genitalia have a rich blood supply in order to allow for the needs of pregnancy and labor.

The ovarian vessels

The ovaries are supplied by ovarian vessels. The ovarian arteries arise from the aorta just below the renal vessels. They descend retroperitoneally, cross the ureter anteriorly, and enter the infundibulopelvic ligaments. After supplying the ovary, they give off branches to supply the fallopian tube and finally anastomose with the ascending branch of uterine artery near the uterine cornu in the broad ligament. The right ovarian vein drains into the inferior vena cava but the left ovarian vein joins the left renal vein.

Internal iliac (hypogastric) vessels

The aorta bifurcates into common iliac arteries at the level of L4 vertebra. Common iliacs divide

into external and internal iliacs at the sacroiliac joints. The ureters cross the common iliacs at their bifurcation.

The internal iliac (hypogastric) artery lies posteromedial to the external iliac vessels. The ureter is anterior and the internal iliac vein is posterior to the artery. The artery on each side divides into anterior and posterior divisions. The posterior division exits the pelvis and does not give off any visceral branches. The anterior division gives rise to several branches which supply the internal and external genitalia (Box 1.23; Fig. 1.18).

The obturator and superior vesical are the first two branches of the anterior division, followed by the uterine artery. The vaginal artery may arise from the uterine artery. After giving off these branches in the pelvis, the internal iliac artery continues as internal pudendal artery which hooks behind the ischial spines to enter the pudendal canal in the ischiorectal fossa. Here it gives off two more branches—the inferior rectal and perineal arteries. The vessel then ends as dorsal artery of the clitoris. The parietal branches supply the respective muscles and tissues.

Uterine arteries

The uterine arteries run medially and cross over the ureter about 2 cm lateral to the internal os in the broad ligament. At the lateral border of the uterus, they turn sharply upward and run along the side of the uterus as *arcuate artery* (Fig. 1.19). Before turning upward, they give off the descending cervical branches. The descending branch

Box 1.23 Branches of the anterior division of internal iliac artery

- Parietal branches
 - Obturator
 - Inferior gluteal
 - Internal pudendal
 - Inferior rectal
 - Perineal
 - Dorsal artery of the clitoris
- Visceral branches
 - Superior vesical (umbilical)
 - Uterine
 - Vaginal
 - Middle vesical
 - Middle rectal
 - Inferior vesical

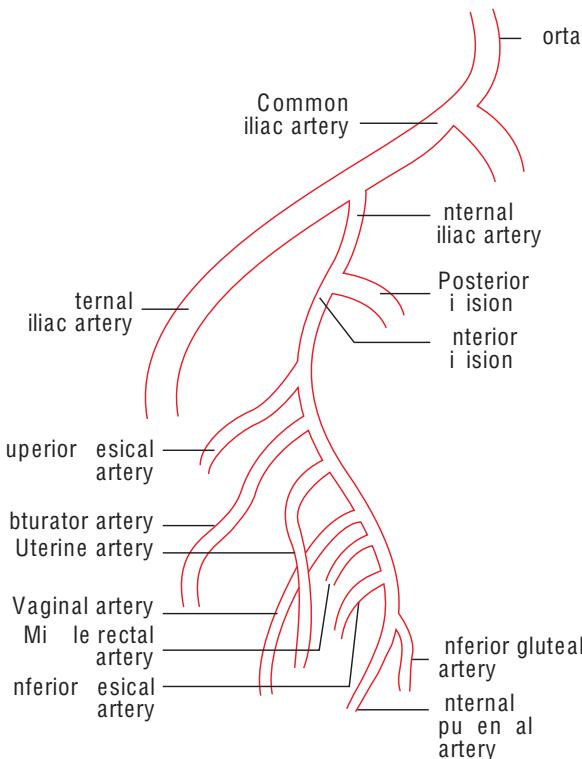


Figure 1.18 Internal iliac artery and its branches.

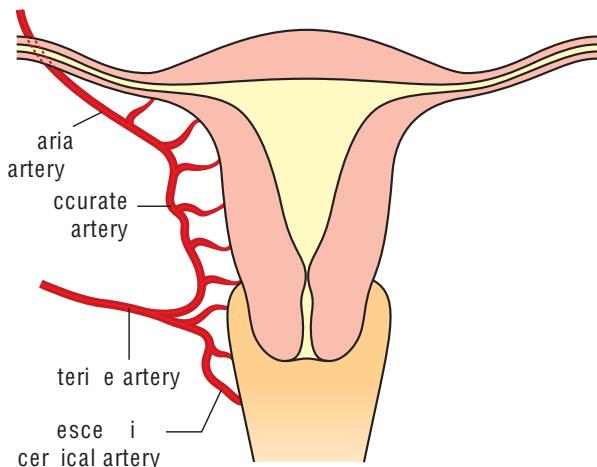


Figure 1.19 The uterine artery and its branches. The uterine artery runs upwards lateral to the uterus as arcuate arteries, give off branches called radial arteries and anastomose with branches of the ovarian artery.

runs in the cardinal ligament to supply the cervix and vagina. The arcuate arteries give off several branches to the uterus that run transversely, called *radial arteries*. The terminal part of the uterine artery ultimately anastomoses with the ovarian vessels and gives off branches to supply the fallopian tube.

Changes in the blood supply to pelvic organs in pregnancy

The blood supply to the uterus increases manifold in pregnancy. The internal iliac, uterine, descending cervical, and arcuate arteries are enlarged and dilated. In addition there is rich collateral circulation.

Clinical implications

Clinical implications of *changes in the blood supply to pelvic organs during pregnancy* are given below.

- The increase in blood supply is essential for placental blood flow and supply of oxygen and nutrients to the fetus.
- Ligation of the vessels supplying the uterus reduces the pulse pressure without causing a vascular changes in the uterus. This is used to arrest bleeding in postpartum hemorrhage.
 - Ligation of internal iliac artery
 - Ligation of uterine artery at the base of the broad ligament
 - Stepwise devascularization: Ligation of the radial arteries in the broad ligament as they enter the uterus
 - Ligation of the anastomosing vessels of the uterine and ovarian arteries at the uterine cornu

Blood supply to the vulva

The vessels that supply the structures of the vulva are as listed in Box 1.24. The internal pudendal artery hooks around the ischial spine to enter the *pudendal (Alcock's) canal* in the lateral wall of the ischiorectal fossa and reaches the perineum (Fig. 1.20). Here it lies close to the pudendal nerve. Once the vessel enters the perineum, it gives rise to several branches to supply the muscles of the perineum, vestibular bulb, lower urethra, and

Box 1.24 Blood supply to the vulva

- Branches of the internal pudendal artery
 - Inferior rectal artery
 - Perineal arteries
 - Urethral artery
 - Artery of the bulb
 - Deep artery of the clitoris
 - Dorsal artery of the clitoris
- Branches of the femoral artery
 - External pudendal artery

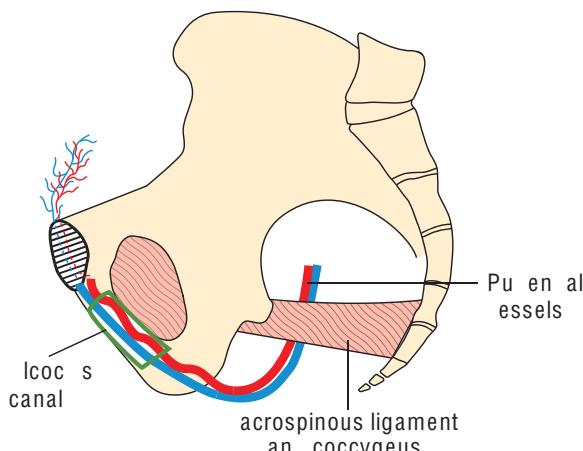


Figure 1.20 The course of pudendal artery.

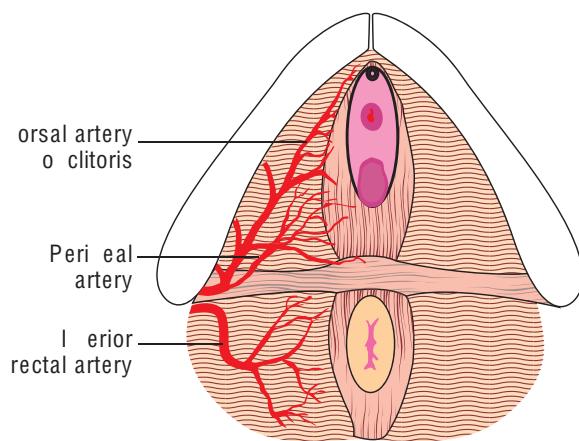


Figure 1.21 The course of perineal artery.

Clinical implications

The pudendal vessels are in close proximity to the pudendal nerve as they hook round the ischial spine to enter the pudendal canal. The vessels can get punctured during injection of local anesthetic into the nerve (pudendal block).

clitoris (Box 1.24; Fig. 1.21). In addition, external pudendal artery arising from the femoral artery supplies the pubic area and labia majora.

Lymphatic drainage

Lymphatic drainage is usually along the veins that drain the organs. There are groups of lymph nodes along all the major vessels—inguinal, external, internal and common iliac, and para-aortic (Fig. 1.22).

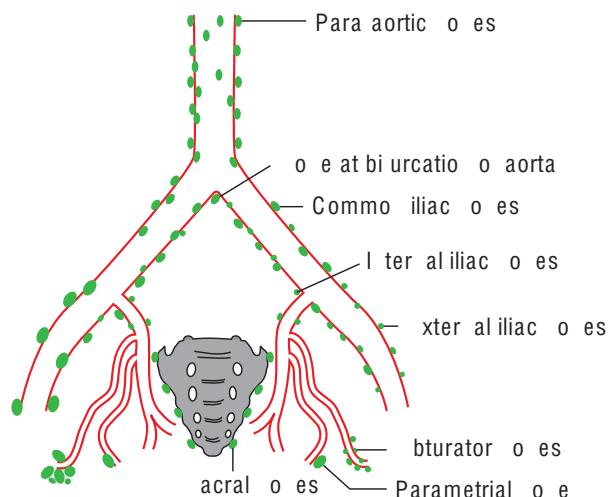


Figure 1.22 Lymph nodes of the pelvis that drain the genital organs.

Nerve supply

The pelvis is supplied by somatic nerves and the autonomic nervous system (Fig. 1.23).

Somatic innervation

Somatic innervation of genital tract and perineum is from T12 to S4 through the following nerves:

- Lumbosacral trunk
- Obturator
- Pudendal
- Iliohypogastric
- Ilioinguinal
- Genitofemoral
- Posterior femoral cutaneous

The lumbosacral trunk, obturator, and pudendal nerves supply the muscles of the pelvis, gluteal region, thigh, obturator muscle, pelvic and urogenital diaphragm, and perineal muscles. The sensory nerve supply to the mons pubis and labia majora are from the ilioinguinal and genitofemoral nerves. Perianal area, perineum, vestibule of the vagina, and clitoris are supplied by the pudendal nerve.

Autonomic innervation

The autonomic nervous system controls the contraction and relaxation of the smooth muscles of the uterus, bladder, rectum, and the

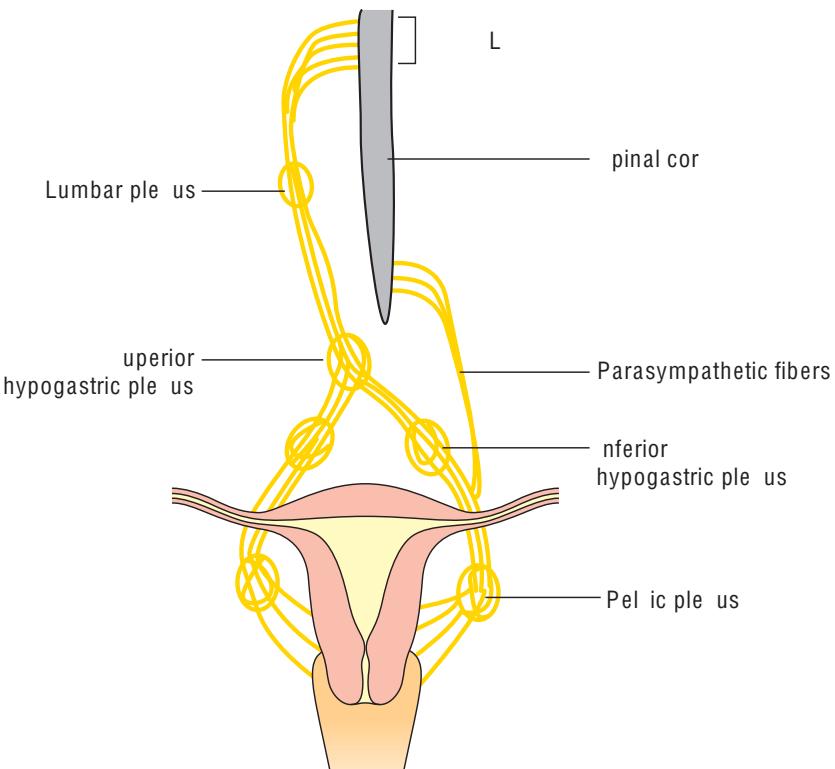


Figure 1.23 Autonomic innervations of the reproductive tract. The sympathetic nerves arise from T10–L2, form the superior and inferior hypogastric plexuses; they are joined by parasympathetic fibers from S2, S3, S4 to form pelvic plexuses.

blood vessels. *Sympathetic system* stimulates contraction and *parasympathetic system* causes relaxation.

Sensory nerve fibers from the uterus, bladder, and rectum travel via the sympathetic and parasympathetic fibers to reach the spinal cord and cranial ganglia. They transmit visceral sensations such as bladder and rectal distension, and pain of cervical stretching and uterine contractions. Pain from the perineum, labia, clitoris, and anus are transmitted through the pudendal nerve to spinal segments S2–S4.

Sympathetic system

The sympathetic nerve supply arises from T10 to L2. The sympathetic ganglia are located in the lumbar and sacral regions. The *lumbar sympathetic plexus* lies along the aorta. This continues downward to form the *superior hypogastric plexus*. Nerves from this plexus descend to form the *inferior hypogastric plexus* at the bifurcation of the common iliac. As they continue downward, they are joined by the parasympathetic fibers from S2, S3, and S4 to form the *pelvic plexuses* at

the base of the broad ligament. Nerves from the pelvic plexus form the *Frankenhauser's plexus* along the uterosacral and cardinal ligaments. These two plexuses together supply the uterus, cervix, vagina, anus, rectum, and urinary bladder. Ovary is supplied by ovarian plexus which is derived from nerves from the renal plexus.

The afferent sensory fibers from uterus, cervix, and vagina traverse through the Frankenhauser's plexus, pelvic plexus, inferior and superior hypogastric plexus, and finally the lumbar and thoracic plexus to enter the spinal cord at T10–L2.

Parasympathetic system

The efferent parasympathetic nerve supply to the pelvis emerges along with the ventral rami of S2–S4 as myelinated, preganglionic nerves and joins the sympathetic fibers from the hypogastric plexus to form the pelvic plexuses (Box 1.25). As already mentioned, these pelvic plexuses have an inhibitory effect on rectum, bladder, and erectile tissue of the clitoris and cause vasodilatation of the ovarian and uterine vessels.

Box 1.25 Sensory pathway of the genital tract

- Uterus, cervix, and upper vagina
 - Frankenhauser's plexus
 - Pelvic plexus
 - Inferior hypogastric plexus
 - Superior hypogastric plexus
 - Lumbar plexus
 - Spinal cord, T11–L2
- Lower vagina, perineum, labia, and clitoris
 - Pudendal nerve
 - Spinal cord S2–S4

Clinical implications

Clinical implications of *nerve supply to pelvis* are given below.

- Pain of uterine contractions felt at T12–L2 level.
- Epidural/spinal analgesia relieves pain of cervical dilatation and uterine contraction.
- Pudendal block provides analgesia to perineum, labia, and lower vagina.

Key points

- The anterior abdominal wall consists of skin, subcutaneous tissue, rectus sheath, muscles, and peritoneum.
- The rectus sheath has no posterior layer below the arcuate line.
- Transverse incisions for cesarean section should be extended up to the lateral border of rectus muscles.
- Blood supply to the abdominal wall is from branches of femoral and external iliac arteries. Inferior epigastric vessels lie under the rectus muscles and must be identified, clamped, and ligated during transverse incisions.
- The reproductive tract consists of external and internal reproductive organs.
- The external reproductive organs include the structures of the vulva and perineum.
- The vulva becomes soft in pregnancy and varicosities may develop.
- The anatomical perineum is a diamond-shaped area which extends from pubis to coccyx. This is divided into anterior and posterior triangles by an imaginary line between the two ischial tuberosities.
- The contents of the anterior triangle include vulva, urogenital diaphragm, perineal muscles, blood vessels, nerves, and lymphatics.
- Muscles of the perineum are separated by the perineal membrane into superficial and deep muscles.
- Deep perineal muscles are the sphincter urethrae and deep transverse perinei muscles. They compress the urethra and support the lower vagina, respectively.
- The contents of the posterior triangle include anal canal, anal sphincters, anococcygeal body, ischiorectal fossae, lymphatics, blood vessels, and nerves.
- The perineal body is a fibromuscular structure that forms the center point of the perineum. It stretches during delivery and may be damaged in perineal tears. Surgical incision of the perineum to enlarge the introitus is known as *episiotomy*.
- The pelvic diaphragm is made of the two components of levator ani. The shape of this muscle and the

direction of its fibers play a major role in rotation of the presenting part in labor.

- Internal genital organs consist of the vagina, uterus, fallopian tubes, and ovaries.
- There is increase in vascularity, bluish discoloration, and lowering of pH of the vagina in pregnancy.
- There is softening of cervix in pregnancy. The mucous plug that is formed during pregnancy is expelled in first stage of labor. Cervix effaces and dilates in labor to facilitate delivery of the fetus.
- The size and shape of the uterus change markedly in pregnancy. The myometrium plays a major role in contraction during parturition and contraction and retraction after delivery. The lower segment of the uterus is formed in labor.
- Fertilization of the ovum takes place in the fallopian tube and the fertilized ovum is then transported to the uterine cavity.
- The ovaries become more vascular in pregnancy. They house the corpus luteum which provides the hormonal support for the developing fetus till 12 weeks of gestational age.
- The pelvic ureter is closely related to the ovarian and uterine vessels during its course in the pelvis. There are several points where it is prone to injury. Care should be taken to avoid injury to the ureter during pelvic surgeries.
- The lymphatics that drain the various parts of the genital tract lie along the respective blood vessels.
- The pelvic structures are supplied by somatic nerves and autonomic nervous system. The sensory motor nerve supply is through the lumbosacral trunk, pudendal, ilioinguinal, and genitofemoral nerves from T12 to S5.
- Sensory pain fibers from the uterus and cervix traverse along the sympathetic nerve fibers, through the pelvic, hypogastric, and lumbar ganglia to join the spinal cord at T11–L2 levels. Pain from lower genital tract is transmitted to S2–S4 levels of the spinal cord.

Self-Assessment

Case-based questions

Case 1

Mrs. AK, 24, primigravida, was admitted to labor room at term. Second stage was prolonged; therefore, baby was delivered by forceps under pudendal block. There was a fourth degree perineal laceration. Consultant obstetrician was called in to perform an accurate anatomical perineal repair.

1. What is pudendal block? Where is it given?
2. Where do the sensory fibers along the pudendal nerve enter the spinal cord?
3. What are the structures involved in fourth degree perineal tear?
4. What is the blood supply to the perineum?

Case 2

Mrs. AN, multigravida, was delivered by cesarean section. Following the delivery, there was profuse bleeding from the angles of the uterine incision.

1. What causes profuse bleeding from the angles of the uterine incision?
2. How will you manage this?
3. If the bleeding vessel cannot be clamped due to poor visibility, what is the next step?
4. What are the branches of the internal iliac artery?

Answers

Case 1

1. Pudendal block is the injection of local anesthetic agent into and around the pudendal nerve. This is given at the point where the pudendal nerve curves round the ischial spine before it enters the pudendal canal in the ischiorectal fossa.
2. At S2–S4 level.

3. The vaginal mucosa, muscles of the perineum—superficial transverse perinei, bulbospongiosus, deep transverse perinei, and external anal sphincter—and anal mucosa.
4. This is from the perineal artery, a branch of internal pudendal artery.

Case 2

1. The bleeding is from the uterine artery, which turns medially at the level of the internal os and ascends between the layers of the broad ligament and lies close to the lateral angle of the uterine incision.
2. By ligating the uterine artery, taking care not to injure the ureter which lies close to the vessel.
3. Ligation of the internal iliac artery from where the uterine artery arises.
4. Parietal branches are obturator and internal pudendal arteries. Visceral branches are superior vesical, uterine, vaginal, middle rectal, and middle and inferior vesical arteries.

Sample questions

Long-answer questions

1. Describe the course of the pelvic ureter. What is its significance in obstetrics?
2. Discuss the anatomy of internal reproductive organs and the changes in pregnancy.

Short-answer questions

1. Perineal body
2. Levator ani
3. Anatomy of the internal iliac artery
4. Internal iliac artery ligation
5. Innervation of the reproductive tract

2

Anatomy of the Bony Pelvis and Fetal Skull

Case scenario

Mrs BN, a second gravida at 39 weeks of pregnancy, was admitted to labor room with pains. She had gone to a local hospital for delivery but was told that the passage was inadequate for the baby and was referred to a tertiary care center. On abdominal examination, contractions were every 5 minutes lasting for 40 seconds. On vaginal examination, cervix was 5-cm dilated and the pelvic shape was abnormal. The husband was informed that delivery had to be by cesarean section.

Introduction

The anatomy of female pelvis is of special importance in obstetrics since the fetus has to pass through this before being born. Its shape, size, and configuration can affect the course of labor. The fetal skull and its diameters are equally important. The obstetrician must be aware of the normal anatomy and its variations for appropriate management of normal labor and diagnosis and management of abnormal labor.

The bony pelvis

The bony pelvis is of great importance in obstetrics since the fetus has to pass through the

pelvis and negotiate its diameters at various levels before it is born. The pelvis is made of sacrum, coccyx, ilium, ischium, and pubis. The latter three are fused together to form the innominate bone. The ischium is joined to sacrum at the two sacroiliac joints and the pubic bones are joined to each other at the pubic symphysis (Fig. 2.1).

The bony pelvis is divided into true and false pelvis by an oblique plane passing through the sacral promontory, arcuate line, pectenial line, pubic crest, and pubic symphysis. This plane is called the *linea terminalis* or *pelvic brim* (Fig. 2.1).

False (greater) pelvis

This lies above the linea terminalis and is bounded by the lumbar vertebrae posteriorly,

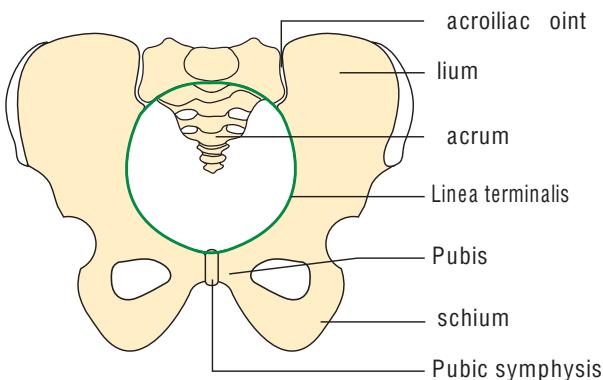


Figure 2.1 Bones and joints of the bony pelvis and the linea terminalis. Anterior view of the pelvis showing bones of the pelvis and the two joints—sacroiliac joint and pubic symphysis. Linea terminalis or pelvic brim is marked in green.

iliac fossae laterally, and abdominal wall anteriorly. This part of the pelvis is not of obstetric importance.

The true (lesser) pelvis

This part of the bony pelvis is of great importance in obstetrics. This is bounded posteriorly by sacrum, laterally by ischium and sacrosciatic notches, and anteriorly by pubic bones, obturator foramen, and ischiopubic rami. True pelvis is divided into four planes.

- Plane of the pelvic inlet
- Plane of the pelvic outlet
- Pelvic cavity—between the inlet and the outlet. It has two planes:
 - Plane of least pelvic dimensions
 - Plane of greatest pelvic dimensions

Plane of the pelvic inlet

Essential features of the plane of the pelvic inlet are given in Box 2.1 and Figure 2.2.

The transverse and oblique diameters are larger than the anteroposterior diameter. The transverse diameter lies 4 cm anterior to the sacral promontory. The oblique diameter is measured from the sacroiliac joint to the iliopectenial eminence. The right and left oblique diameters extend from the right and left sacroiliac joints respectively. There are three anteroposterior diameters (Fig. 2.3).

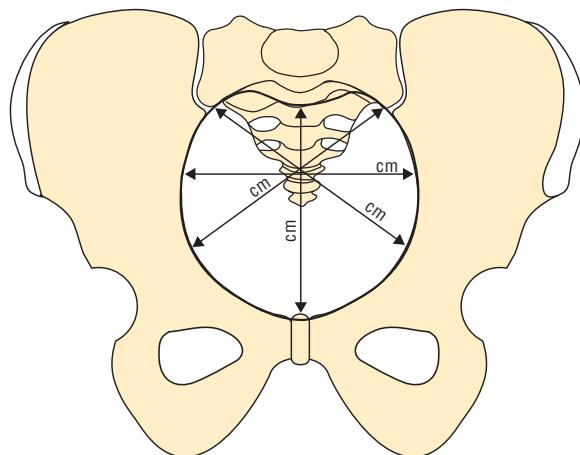


Figure 2.2 Diameters of the pelvic inlet. The three important diameters of the inlet are anteroposterior, transverse, and oblique diameters.

Box 2.1 Plane of the pelvic inlet

Boundaries

- Posterior: Sacral promontory, sacral alae
- Lateral: Pectenial and arcuate lines
- Anterior: Pubic ramus and pubic symphysis

Shape

- Round

Diameters

- Anteroposterior
 - True conjugate: 11 cm
 - Obstetrical conjugate: 10 cm
 - Diagonal conjugate: 12 cm
- Transverse: 13.5 cm
- Oblique: 12.5 cm

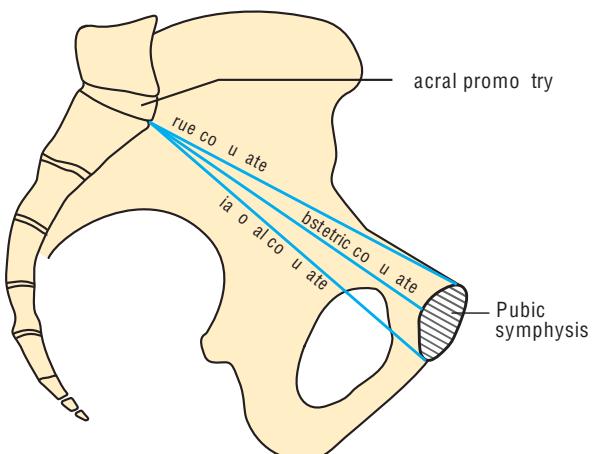


Figure 2.3 Anteroposterior diameters of the plane of pelvic inlet. The three anteroposterior diameters extend from sacral promontory to three different points on the pubis.

Anatomical (true) conjugate

This is the distance from the sacral promontory to the upper border of pubic symphysis. It is referred to as the anteroposterior diameter of the pelvic inlet and is usually 11 cm.

Obstetric conjugate

This is the distance between the sacral promontory and the most prominent point on the posterior surface of the pubic bone. It is the diameter that the fetal head has to negotiate and is the shortest diameter at the inlet (10 cm). This diameter is obtained by subtracting 1.5–2 cm from the diagonal conjugate.

Diagonal conjugate

This is the anteroposterior diameter that can be clinically measured. It is the distance between the sacral promontory and the inferior border of the pubic symphysis (12 cm). This is measured by inserting the index and middle fingers into the vagina, tipping the sacral promontory with the middle finger, and marking off the point of contact on the radial border of the hand with the inferior border of pubic symphysis (Fig. 2.4).

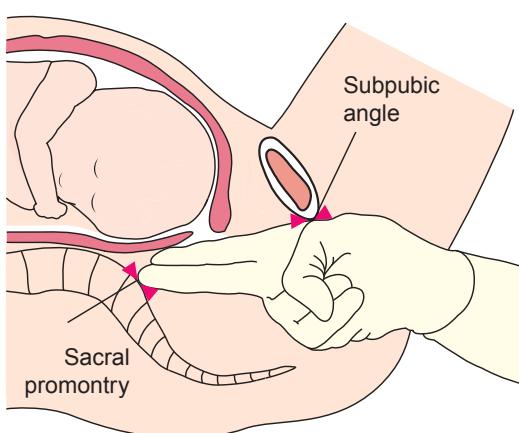


Figure 2.4 Measurement of diagonal conjugate. The diagonal conjugate is the distance between the tip of the middle finger which touches the sacral promontory and the point of contact with the undersurface of pubic symphysis, on the radial border of hand.

Plane of the pelvic outlet

The features of pelvic outlet are given in Box 2.2 and Fig. 2.5.

The anteroposterior diameter of the plane of pelvic outlet is from subpubic angle to the tip of

Box 2.2 Features of the plane of the pelvic outlet

Boundaries

- Posterior: Tip of sacrum
- Lateral: Sacrosciatic ligaments, ischial tuberosities
- Anterior: Subpubic arch, ischiopubic rami

Shape

- Diamond shaped
- Two triangles with common base
- Separated by a line joining ischial tuberosities

Diameters

- Anteroposterior: 12 cm
- Transverse: 10.5 cm
- Posterior sagittal: 7.5 cm

the sacrum (Fig. 2.5). This is the largest diameter of the outlet. Transverse diameter runs between the ischial tuberosities. Posterior sagittal diameter is the part of the anteroposterior diameter that lies posterior to the line joining the ischial tuberosities. This diameter compensates for a narrow subpubic angle which pushes the fetal head posteriorly. All diameters of the outlet can be measured clinically.

Pelvic cavity

This is the part of the pelvis between the inlet and outlet. It is shaped like a truncated cylinder (Box 2.3; Fig. 2.6). The anterior wall is shallow and is formed by the pubic bone; the posterior wall is deep and concave and is formed by the sacrum.

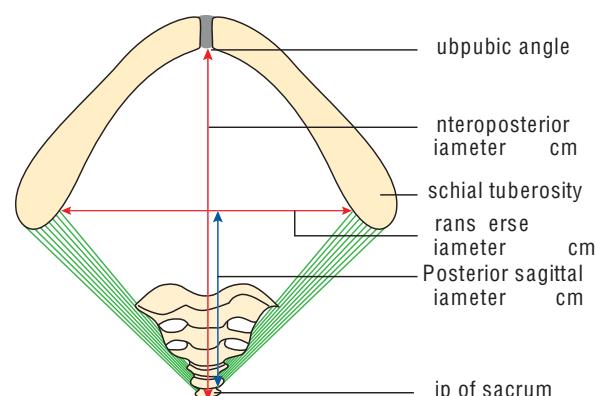


Figure 2.5 Diameters of the pelvic outlet. The important diameters of the pelvic outlet are anteroposterior, transverse, and posterior sagittal diameters. The posterior sagittal diameter is that part of the anteroposterior diameter that lies posterior to the transverse diameter.

Box 2.3 Features of the pelvic cavity

- Shape: Truncated cylinder
- Plane of greatest pelvic dimensions
 - At the level of second and third piece of sacrum
 - Not of obstetric significance
- Plane of least pelvic dimensions
 - At the level of
 - ischial spines
 - fourth and fifth piece of sacrum
 - Interischial diameter
 - Measures 10 cm
 - Smallest diameter of the pelvis
 - Of great obstetric significance

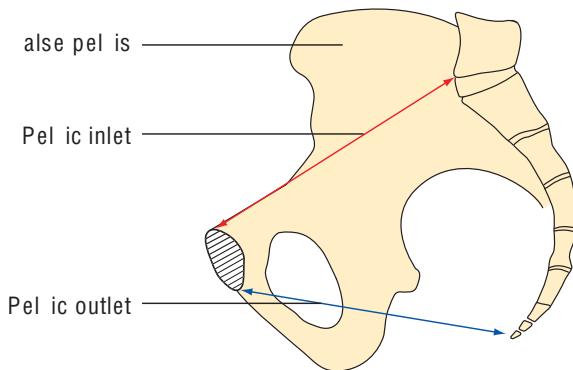


Figure 2.6 Pelvic cavity: Lateral view.

Plane of greatest pelvic dimensions

This part of the cavity is roomy and has the largest dimensions. It is at the level of the second and third sacral vertebrae posteriorly and posterior surface of the pubis anteriorly. The anteroposterior diameter is 12.5 cm and transverse diameter is 13 cm. This plane has no obstetric significance.

Plane of least pelvic dimensions

As the name implies, this is the plane of smallest diameters. It is at the level of ischial spines and the fourth and fifth sacral vertebrae. The interischial spinous diameter (transverse diameter) is the smallest diameter that the fetal head has to pass through (10 cm) (Fig. 2.7). The anteroposterior diameter is 11.5 cm and posterior sagittal diameter is 5 cm.

It should be noted that the transverse diameter is the widest at the inlet and the anteroposterior diameter is the widest at the outlet. Hence, the fetal head normally enters the pelvis with the

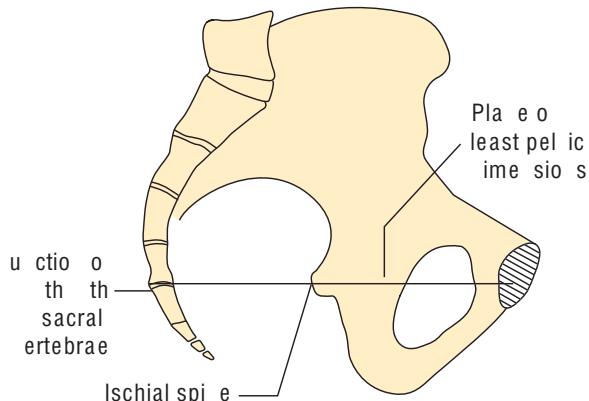


Figure 2.7 Plane of least pelvic dimensions. The plane of least pelvic dimensions is at the level of ischial spines and the 4th and 5th sacral vertebrae.

engaging diameter in the transverse or oblique diameter of the inlet and has to rotate through 90 degrees or more to bring the engaging diameter to the anteroposterior diameter at the outlet for normal delivery to occur. This is achieved through the cardinal movements of labor (see Chapter 14, *Normal labor: Mechanics, mechanism, and stages*).

The diameters of the pelvis are summarized in Box 2.4.

The axis of the pelvis

The axis of the pelvis is downward and backward in the upper half and downward and forward in the lower half. The *anatomical axis* is represented by the *curve of Carus*, which is a line joining the midpoints of the anteroposterior diameters at the inlet, outlet, and cavity. The shape of

Box 2.4 Diameters of the pelvis

- Inlet
 - Anteroposterior
 - Anatomical conjugate: 11 cm
 - Obstetric conjugate: 10 cm
 - Diagonal conjugate: 12 cm
 - Transverse: 13.5 cm
 - Oblique: 13 cm
- Outlet
 - Anteroposterior: 12 cm
 - Transverse: 10.5 cm
 - Posterior sagittal: 7.5 cm
- Plane of least pelvic dimensions
 - Anteroposterior: 11.5 cm
 - Transverse: 10 cm
 - Posterior sagittal: 5 cm

the curve corresponds to the sacral curvature. The *obstetric axis* is, however, slightly different. The presenting part moves downward and backward initially and turns abruptly forward at the ischial spines (Fig. 2.8).

Waste space of Morris

While the head is being delivered, it passes through the pelvic outlet between the ischiopubic rami, behind the subpubic angle. The space between the subpubic angle and the circumference of the fetal head is normally <1 cm. When the subpubic angle is narrow as in an android pelvis, the head emerges more posteriorly, increasing the space to >1 cm. This is the waste space of Morris (Fig. 2.9). This has to be compensated by an adequate posterior sagittal diameter for the head to deliver. A liberal episiotomy is necessary in this situation to avoid deep perineal lacerations.

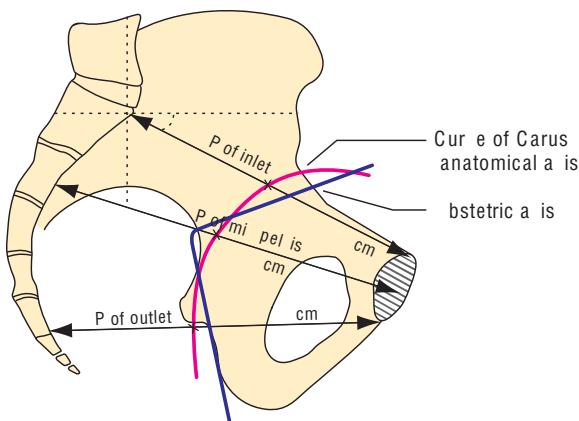


Figure 2.8 The anatomical and obstetric axis of the pelvis.

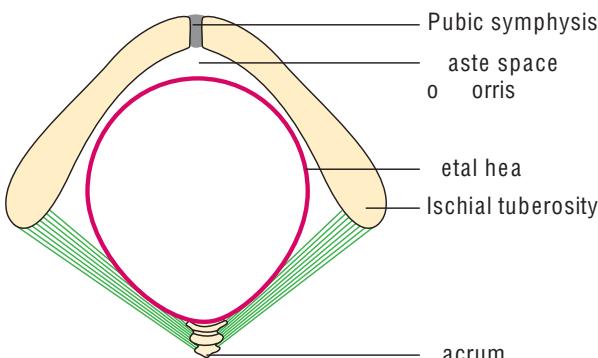


Figure 2.9 Waste space of Morris. This is the space between the fetal head and subpubic angle.

Changes in pelvis during pregnancy

Pelvic joints relax due to the hormones of pregnancy. There is an increase in the width of the pubic symphysis. The mobility of the sacroiliac joints also increases, especially in lithotomy position. This results in an increase in the anteroposterior diameter at the brim.

Clinical implications

The clinical implications of anatomy of pelvis and changes in pelvis during pregnancy are given below.

- The transverse diameter is more at the pelvic inlet; therefore, the fetal head engages in the transverse diameter.
- The anteroposterior diameter is more at the outlet; therefore, the fetal head has to rotate through 90° to achieve delivery.
- The interspinous diameter is the smallest. Malrotation, nonrotation, and arrest of descent occur at this level.
- The direction of descent of the fetal head is along the axis of the pelvis. This must be followed in instrumental deliveries.
- Relaxation of the pelvic joints increases the diameter of the pelvis and helps in descent of the fetal head and delivery.
- Relaxation of pubic symphysis causes pain in the pubic region.
- Backache is common in pregnancy and is partly due to the relaxation of sacroiliac joints

Pelvic shapes

Pelvic shape can influence fetal presentation, position and course of labor. Maternal body structure, nutritional status, and deformities of the spine and hip can affect pelvic shape. However, four parent types of pelvis have been described.

Caldwell–Moloy classification

Caldwell and Moloy have classified pelvis into four types, based on the shape, transverse diameter of the inlet, and character of the anterior and posterior segments of the pelvis. The four types of pelvis and their percentage of occurrence in women are as follows (Fig. 2.10):

- Gynecoid (typical female): 50%
- Android (typical male): 20%

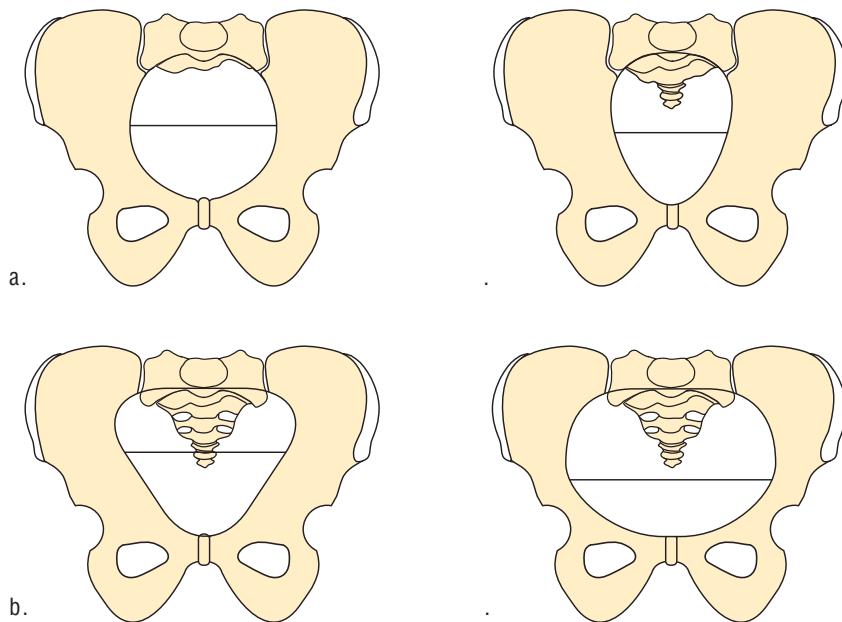


Figure 2.10 Types of pelvis. **a.** Gynecoid. **b.** Android. **c.** Anthropoid. **d.** Platypelloid. The four types of pelvis according to configuration (Caldwell–Moloy classification) are diagrammatically represented.

- Anthropoid (oval): 25%
- Platypelloid (flat): 5%

The gynecoid pelvis

Gynecoid pelvis is the typical female pelvis and is most favorable for normal labor and delivery. The inlet is round, the sacral promontory is not prominent, sacrum is concave and well curved, the sacrosciatic notch is wide and admits two fingers, pelvic sidewalls are straight and parallel, the forepelvis is wide and rounded, ischial spines are not prominent, subpubic angle is wide and >90 degrees, and interischial tuberous diameter is adequate and admits four knuckles. Fetal head engages in transverse diameter, cardinal movements take place, vertex rotates anteriorly and is delivered by extension.

The android pelvis

Android pelvis is the typical male pelvis. The inlet is heart shaped due to the prominent sacral promontory, the sacrum is flat, the sacrosciatic notch is narrow and does not admit two fingers, pelvic sidewalls converge downward, forepelvis is narrow and beaked, ischial spines are prominent making the transverse diameter smaller, subpubic angle is narrow and <80 degrees, and

transverse diameter of the outlet is less than normal. The fetal head engages in occipitoposterior position and does not rotate beyond the ischial spines, leading to deep transverse arrest and obstructed labor.

The anthropoid pelvis

The anthropoid pelvis is anteroposteriorly oval; therefore, anteroposterior diameters are more than the transverse diameters at all levels. The sacral promontory is not prominent, sacrum is curved, sacrosciatic notch is wide and deep, side walls are straight, forepelvis is wide, ischial spines are not prominent, subpubic arch is medium (about 90 degrees), and transverse diameter of the outlet is average. The fetal head engages as occipitoposterior, short posterior rotation takes place (since anterior rotation is difficult with a slightly reduced interspinous diameter), and head delivers as face to pubis.

The platypelloid pelvis

The platypelloid or flat pelvis is the least common type of pelvis and is transversely oval. The transverse diameters are more than the anteroposterior diameter at all levels. The sacral promontory is prominent, reducing the anteroposterior

Table 2.1 Distinctive features of the four types of pelvis

	Gynecoid	Android	Anthropoid	Platypelloid
Shape	Rounded	Heart shaped	Anteroposteriorly oval	Transversely oval
Inlet				
Transverse D (cm)	13.5	<12	<12	13.5
Anteroposterior D (cm)	11	11	>12	10
Forepelvis	Wide	Narrow (beaked)	Straight	Divergent
Cavity				
Sidewalls	Straight and parallel	Convergent	Straight	Straight and wide
Sacrosciatic notch	Wide	Narrow	Wide	Short
Ischial spines	Not prominent	Prominent	Not prominent	Not prominent
Outlet				
Subpubic arch	Wide	Narrow	Medium	Wide
Transverse D (cm)	10.5	<10	10.5	>10.5

diameter at the brim. Sacrum is flat, sacrosciatic notch is wide and shallow, sidewalls are straight, forepelvis is wide and rounded, ischial spines are not prominent, subpubic angle is wide and >90 degrees, and transverse diameter of the outlet is also wide. The narrow anteroposterior diameter at the brim acts as the fulcrum at the fetal biparietal diameter and the head undergoes extension and face presentation results. Alternatively, asynclitic engagement takes place so that the biparietal diameter can negotiate the anteroposterior diameter.

Pelvis may have mixed characteristics as well and classification into a distinct type may be difficult.

The distinctive features of the four types of pelvis are listed in Table 2.1.

Clinical implications

Clinical implications of the shape and type of pelvis on labor are given below.

- The gynecoid pelvis is the most favorable—the vertex engages in the transverse or oblique diameter and labor progresses normally.
- The android pelvis is the least favorable. Occiputoposterior positions and deep transverse arrest are common with this type.
- The anthropoid pelvis favors occipitoposterior position and face-to-pubis delivery.
- Asynclitic engagement and face presentations are the problems encountered in platypelloid pelvis (see Chapter 40, *Abnormal labor: Abnormalities in passage and powers*).

Fetal skull

The fetal skull consists of several bones joined at the sutures. The bones of the face are joined together firmly while those of the vault of the skull are joined at sutures that are soft and membranous. The bones of the vault are as follows:

- Two frontal bones
- Two parietal bones
- Two temporal bones
- One occipital bone

The two frontal bones are joined to each other at the frontal suture and attached to the parietal bones at the *coronal suture*. The parietal bones meet at the *sagittal suture* (parietoparietal suture) and they are attached to the occipital bone at the *lambdoid suture* (occipitoparietal) (Fig. 2.11).

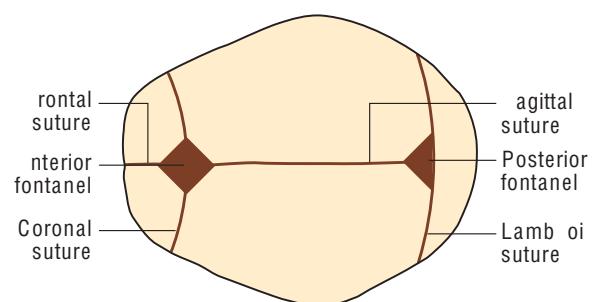


Figure 2.11 Sutures of fetal skull and fontanelles. Coronal, sagittal, lambdoid and frontal sutures and anterior and posterior fontanelles are seen in the superior view of the fetal skull.

Box 2.5 Features of the two fontanelles*Anterior fontanel or bregma*

- Diamond shaped
- Junction of
 - coronal suture
 - sagittal suture
 - frontal suture
- Four sutures radiate from the fontanel
- Felt easily if the head is deflexed or extended

Posterior fontanel or lambda

- Triangular
- Junction of
 - sagittal suture
 - lambdoid suture
- Three sutures radiate from the fontanel
- Felt easily when the head is flexed
- Used to identify position of the vertex

Two fontanelles are formed at the junction of the various sutures. These are areas covered by membranes, as the sutures are not firmly united.

This allows sliding of bones under each other, thus reducing the diameters of the skull. This is known as *molding* (see Chapter 14, *Normal labor: Mechanics, mechanism, and stages*). The two fontanelles are described in Box 2.5.

Landmarks of the fetal skull

Practice of obstetrics and management of labor is not possible without a thorough understanding of the landmarks of the fetal skull (Fig. 2.12). These are listed in Box 2.6.

Diameters of the fetal skull

The diameters of the fetal skull are listed in Box 2.7 and shown in Figure 2.13. There are four anteroposterior or engaging diameters and three transverse diameters.

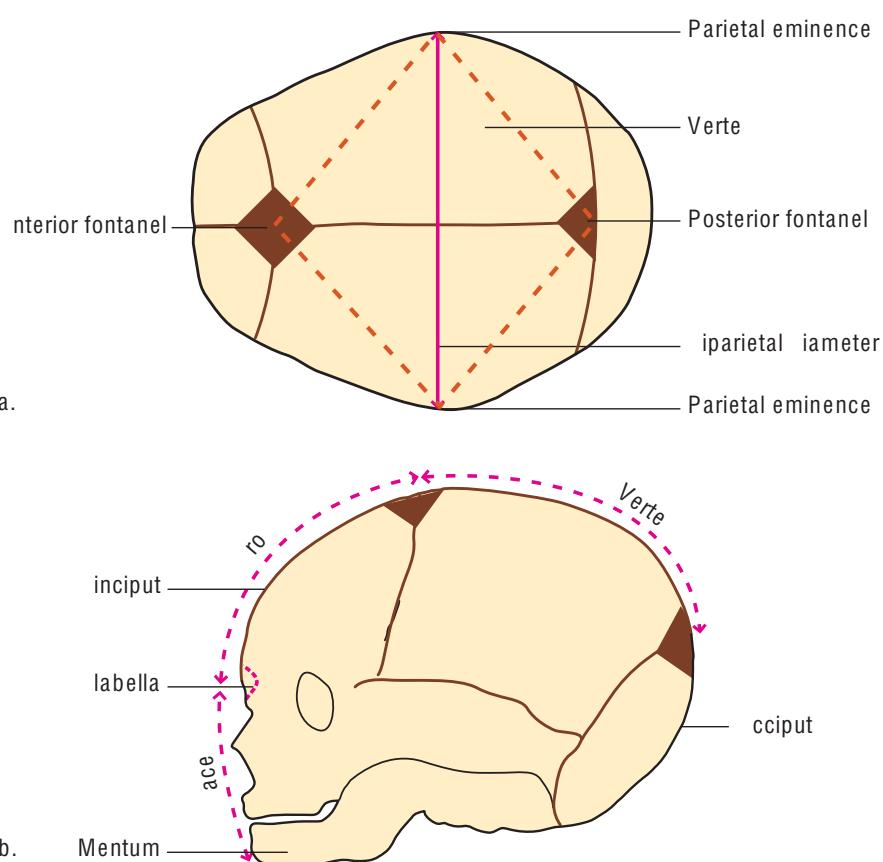


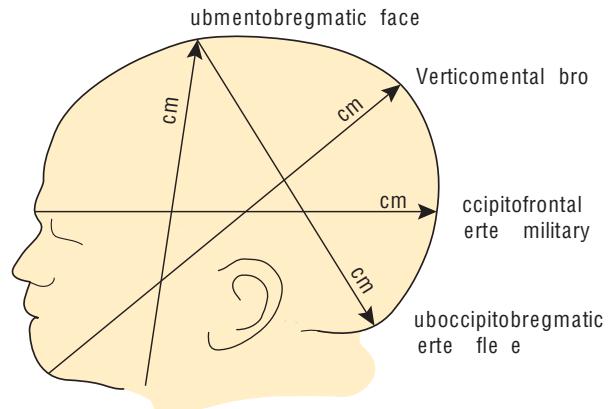
Figure 2.12 Landmarks of the fetal skull. **a.** Vertex and biparietal diameter. Vertex is the diamond-shaped area bounded by anterior and posterior fontanelles and two parietal eminences. **b.** Other landmarks include three bony points (occiput, sinciput, and mentum) and three areas (face, brow, and vertex).

Box 2.6 Landmarks of the fetal skull

- Vertex: Diamond-shaped area
 - Boundaries
 - Anterior: Anterior fontanel
 - Posterior: Posterior fontanel
 - Lateral: Parietal eminences
- Face: Chin to glabella
- Brow: From anterior fontanel to orbital ridges
- Glabella: Between the orbital ridges
- Occiput: Prominent area behind and below the posterior fontanel
- Sinciput: Prominent part of the frontal bone above glabella
- Mentum: Chin

Box 2.7 Diameters of the fetal skull

- Suboccipitobregmatic (9.5 cm): From a point below occiput where it meets the neck to the center of anterior fontanel (bregma)
- Occipitofrontal (11 cm): From occipital protuberance to glabella
- Verticomental (13.5 cm): From midpoint of vertex to chin (mentum)
- Submentobregmatic (9.5 cm): From a point where neck meets lower jaw to the center of anterior fontanel (bregma)
- Biparietal (9.5 cm): From one parietal eminence to the other
- Bitemporal (8 cm): From one temporal bone to the other
- Subparieto-supraparietal (8.5 cm): From a point above one parietal eminence to a point below the other parietal eminence.

**Figure 2.13** The anteroposterior diameters of fetal skull.**Box 2.8 Terminology in obstetrics**

- Presenting part: Part that is first felt on vaginal examination.
 - Vertex
 - Brow
 - Face
- Attitude: Degree of flexion or extension of the fetal neck
 - Complete flexion: Vertex
 - Deflection: Occipitoposterior
 - Partial extension: Brow
 - Complete extension: Face
- Denominator: Bony point on the presenting part for the particular presentation
 - Used as reference point
 - Occiput
 - Mentum
 - Frontum
- Position: Relationship of the denominator to the pelvic quadrants
 - Left anterior /posterior
 - Right anterior/posterior

Terminology used in obstetrics

These are summarized in Box 2.8.

The cephalic presentations, fetal attitudes, engaging diameters, and denominators are summarized in Table 2.2.

Clinical implications

The clinical implications of *landmarks and diameters of fetal skull* are given below.

- The sutures and fontanelles are used for the identification of presentation and position of the fetus.
- The engaging diameter is an important factor that determines the progress of labor.

Table 2.2 Cephalic presentations, engaging diameters, attitudes, and denominators

Presentation	Attitude	Engaging diameter (cm)	Denominator
Vertex	Complete flexion	Suboccipitobregmatic (9.5)	Occiput
Face	Complete extension	Submentobregmatic (9.5)	Mentum
Brow	Partial extension	Verticomental (13.5)	Frontum
Occipitoposterior (position)	Deflection	Occipitofrontal (11)	Occiput

Key points

- The bony pelvis is made of sacrum, coccyx, ilium, ischium, and pubis joined together by two sacroiliac joints and pubic symphysis.
- The bony pelvis is divided into a false pelvis above and true pelvis below. The false pelvis is not of any obstetric significance.
- The true pelvis has an inlet, cavity, and outlet. The cavity has two planes: the plane of greatest pelvic dimensions and the plane of least pelvic dimensions.
- The transverse diameter of the inlet is greater than the anteroposterior diameter; therefore, the fetal head engages in the transverse diameter of the inlet.
- There are three anteroposterior diameters at the inlet: the anatomical, obstetric, and diagonal conjugates. The diagonal conjugate can be measured clinically and obstetric conjugate can be deduced from this.
- The pelvic outlet is diamond shaped and divided into anterior and posterior triangles by a line joining the ischial tuberosities.
- The anteroposterior diameter is greater than the transverse diameter; therefore, the fetal head has to rotate by 90 degrees for delivery to occur.
- The plane of the greatest pelvic dimensions is of no obstetric significance.
- The interischial spinous diameter at the plane of the least pelvic dimensions is the smallest diameter of the pelvis.
- The axis of the pelvis is the line joining the midpoint of the anteroposterior diameters at all levels. It is curved with its concavity facing anteriorly and is called the *curve of Carus*.

- According to Caldwell–Moloy classification, there are four types of pelvis: gynecoid, android, anthropoid, and platypeloid.
- The gynecoid pelvis is the typical female pelvis and is most favorable for the cardinal movements of labor and normal delivery.
- Android pelvis is the typical male pelvis and has narrow interischial spinous diameter and forepelvis. Deep transverse arrest is common in this type of pelvis.
- The anthropoid pelvis is longitudinally oval and favors occipitoposterior position and face-to-pubis delivery.
- The platypeloid pelvis is transversely oval and favors face presentation and asynclitic engagement.
- The fetal head is made of face and vault. The bones of the vault of skull are frontal, parietal, temporal, and occipital.
- The sutures of the skull are coronal, sagittal, and lambdoid.
- There are two fontanelles: anterior and posterior. They are used for the identification of the position of vertex in labor.
- Vertex is the diamond-shaped area bounded by anterior and posterior fontanelles and two parietal eminences.
- Bony points of the skull used as landmarks are occiput, sinciput, face, brow, mentum and glabella.
- Attitude of the fetal head is the degree of flexion at the fetal neck. The presentation depends on flexion and extension of the head.
- The diameters of engagement also vary with the degree of flexion or extension.

Self-Assessment

Case-based questions

Case 1

A second gravida at 39 weeks of pregnancy was admitted to labor room with pains. On abdominal examination, contractions were every 5 minutes lasting for 40 seconds. On vaginal examination, cervix was 5-cm dilated and the pelvic shape was abnormal.

- What are the four major types of pelvis?
- What problems do you expect with android pelvis and why?
- What is ‘waste space of Morris’? In which type of pelvis is this seen and why?
- Why is asynclitic engagement common in platypeloid pelvis?

Case 2

A multigravida, at term, was admitted in labor. She had regular uterine contractions every 7–8 minutes. The head was four-fifth palpable; sinciput was at a lower level than occiput. On pelvic examination, the anterior fontanel was easily felt.

- What is the presentation likely to be? What other parts of the head should be identified?
- What is the attitude of the head and engaging diameter?
- If the head was fully extended what would the presentation be? What is the engaging diameter?
- What is “denominator”? What are the denominators in vertex and face presentations?

Answers

Case 1

1. Gynecoid, android, anthropoid and platypelloid.
2. The following problems can be expected:
 - a. Occiput posterior position: The bulky occiput occupies the broader posterior part of the pelvis since the forepelvis is narrow.
 - b. Deep transverse arrest: Internal rotation is difficult since the interischial spinous diameter is narrow.
 - c. Obstructed labor: Due to cephalopelvic disproportion and deep transverse arrest.
3. The space between subpubic angle and the circumference of the fetal head is the waste space of Morris. This space is more in android pelvis because the head emerges more posteriorly due to the narrow subpubic angle.
4. The anteroposterior diameter at the inlet is less in platypelloid pelvis and the biparietal diameter cannot negotiate this. The head tilts to one side bringing the subparieto-supraparietal diameter to negotiate the anteroposterior diameter of the pelvis.

Case 2

1. When the sinciput is lower than the occiput, the head is extended. When anterior fontanel is easily felt with an extended head, the presentation is brow. The frontal bones and orbital ridges should also be felt to confirm brow presentation.

2. Attitude is incomplete extension. Engaging diameter is verticomental.
3. When the head is completely extended, the presentation is face. The engaging diameter is submento-bregmatic.
4. The denominator is a reference point on the presenting part used to identify position. It is occiput in vertex and mentum in face presentations.

Sample questions

Long-answer questions

1. Discuss the classification of pelvis, their salient features, and their influence on labor.

Short-answer questions

1. Sagittal suture
2. Diagonal conjugate
3. Diameters of the fetal skull
4. The fontanelles of the fetal skull
5. Anthropoid pelvis
6. Waste space of Morris

3

Maternal Physiology in Pregnancy

Case scenario

Mrs. KT, 20, a primigravida at 32 weeks of pregnancy, came to the clinic for routine antenatal checkup. She was quite troubled by minor but multiple problems such as pedal edema, which was obvious by evening, constipation, backache, and breathlessness on walking. She wanted to know if these would affect her pregnancy and labor. Her husband, a 25-year-old software engineer, was equally concerned and needed reassurance.

Introduction

Extensive anatomic, physiological, and biochemical changes occur in the mother during pregnancy. These are intended to prepare the mother to meet the demands of pregnancy, labor, and puerperium and to protect the fetus. Some of these changes give rise to symptoms which can be troublesome. Many of the changes are brought about by the physiological hormonal changes of pregnancy. All the organ systems return to prepregnancy state after delivery and lactation. The process takes about 6 weeks. Some of these changes would be considered abnormal in the nonpregnant state and may be interpreted as disease if one is not aware

of maternal physiology in pregnancy. A knowledge and understanding of the changes during pregnancy is, therefore, absolutely essential for management of normal pregnancy and recognition of abnormality.

Changes in body water and electrolytes

Retention of sodium and water due to the increased levels of progesterone during pregnancy leads to an increase in total body water (volume overload). Total body water increases by 6–8 L which is distributed as shown in Box 3.1.

Box 3.1 Distribution of additional body water in pregnancy

- Maternal blood volume: 1500–1600 mL
 - Plasma volume: 1200–1300 mL
 - Red cell volume: 300–400 mL
- Uterus and breasts:
- Extravascular fluid: }
- Intravascular fluid: } 1500–2500 mL
- Adipose tissue:
- Fetus, placenta, and amniotic fluid: 3500 mL

Box 3.2 Factors contributing to increase in body water in pregnancy

- Increased levels of progesterone
- Increased sodium retention by kidneys
- Increase in renin-angiotensin-aldosterone system
- Sodium retention and changes in osmolality
- Altered secretion of arginine-vasopressin
- Increase in atrial natriuretic peptide (ANP)

Increase in total body water is due to sodium retention, changes in osmoregulation, and changes in vascular tone brought about by factors listed in Box 3.2.

Increase in total body water affects all organ systems and contributes to other changes in pregnancy.

Clinical implications

The clinical implications of *increase in body water* are given below.

- Maternal weight gain
- Hemodilution
- Physiological anemia of pregnancy
- Increase in cardiac output, stroke volume
- Pedal edema
- Laxity of joints
 - Intervertebral joints
 - Pubic symphysis
- Gingival edema
- Tracheal edema

Sodium metabolism and osmoregulation

Increase in total body water results in a fall in plasma osmolality by 8–10 mOsm/kg in pregnancy. This occurs by 10 weeks and continues till postpartum period. The increased circulating

blood volume, through stimulation of baroreceptors and volume receptors, leads to increased secretion of *arginine-vasopressin* by posterior pituitary and this contributes to the fall in osmolality. Further, thirst is experienced at a lower osmolality than in the nonpregnant state, leading to increased water consumption.

Sodium is an important determinant of body water. During pregnancy, sodium balance is maintained by factors that increase sodium levels and those that decrease the levels. Despite additional retention of sodium, water retention exceeds sodium retention, resulting in fall in serum sodium levels by 3–4 mmol/L. Factors that alter renal tubular absorption of sodium are listed in Box 3.3.

enin angiotensin aldosterone system

A four-to-five fold increase in renin, renin substrate (angiotensinogen), and angiotensin levels occurs in pregnancy which, in turn, increase vascular tone and play a role in maintaining normal blood pressure. Aldosterone levels rise in response to increase in angiotensin levels and this leads to increased sodium and water retention. As pregnancy advances, there is refractoriness to the pressor effects of angiotensin II. Women who are not refractory to the pressor effect develop gestational hypertension.

Atrial and brain natriuretic peptides

These are secreted by the cardiomyocytes in the left atrium and ventricles in response to a stretch induced by the increased blood volume. Atrial natriuretic peptide (ANP) is secreted by atria

Box 3.3 Factors that alter sodium balance

- Sodium retention
 - Renin-angiotensin-aldosterone system
 - Deoxycorticosterone
 - Estrogen
 - Progesterone
- Sodium excretion
 - Atrial and brain natriuretic peptides
 - PGE₂

P prostaglandin E₂.

and B-type or brain natriuretic peptide (BNP) by the ventricles and brain. They cause natriuresis or sodium loss in the urine. The increased body water coupled with natriuresis accounts for the fall in osmolality and mild decrease in serum sodium observed in pregnancy.

Other electrolytes and minerals

There is very little change in metabolism of most minerals. Small amounts required for the growth of the fetus may be retained. Changes in iron metabolism are discussed in Chapter 49, *Hematological disorders pregnancy*. Dietary requirements of other minerals are discussed in Chapter 9, *Preconceptional and antenatal care*.

Changes in potassium, calcium, and magnesium metabolism during pregnancy are given in Box 3.4.

Box 3.4 Changes in potassium, calcium, and magnesium metabolism during pregnancy

- Potassium
 - Increased retention
 - Increase in tubular reabsorption
 - Increase in total body potassium
 - Increased plasma volume
 - Mild decrease in serum potassium
- Calcium
 - Required for fetal skeleton
 - Increased demand in pregnancy
 - Increased intestinal absorption
 - Increased intake and supplementation required
- Magnesium
 - Mild decrease in serum magnesium levels

Clinical implications

Clinical implications of *changes in rennin-angiotensin-aldosterone system and electrolyte metabolism* are given below.

- Increased sensitivity to angiotensin II
 - Predictor of hypertension
- Calcium deficiency
 - Implicated in
 - gestational hypertension
 - preeclampsia
 - preterm labor

Maternal weight gain

Weight gain is usually 11–16 kg. Maternal body water, fat, fetus, amniotic fluid, placenta, breast changes, blood volume, and extracellular fluid contribute to this. The average weight gain is about 0.5 kg per week in the second and third trimesters. In the first trimester, women may lose about 2–3 kg due to distaste for food and vomiting.

Metabolic changes

Several metabolic changes occur in pregnancy due to increase in caloric requirements and endocrine changes.

Energy requirement

The mother and growing fetus require extra energy in pregnancy. The total requirement varies between individuals. The requirement increases gradually from the end of the first trimester (Box 3.5). The additional caloric requirement averages to 300 kcal/day through the entire pregnancy.

Carbohydrate metabolism

Several changes take place in carbohydrate metabolism in pregnancy. Glucose is the primary energy source for the fetus. There is a continuous and increasing transport of glucose to the fetus as pregnancy progresses. The mother's fasting glucose levels are lower due to continuous fetal utilization of maternal glucose. The mother, on the other hand, tends to use fatty acids and amino acids as energy source. The mother therefore has a tendency for fasting hypoglycemia and ketosis (**accelerated starvation**).

The increase in levels of some hormones and other diabetogenic substances listed in Box 3.6 leads to increased insulin resistance.

Box 3.5 Energy requirement during pregnancy

- Total energy requirement: 80,000 kcal
- Average additional requirement: 300 kcal/day
 - First trimester: No increase
 - Second trimester: 350 kcal/day
 - Third trimester: 450 kcal/day

Box 3.6 Substances causing increase in insulin resistance in pregnancy

- Human placental lactogen
- Cortisol, prolactin
- Estrogen and progesterone
- Tumor necrosis factor- α
- C-reactive protein
- Interleukin-6

Box 3.7 Changes in glucose metabolism in pregnancy

- Fasting hypoglycemia
- Mother prone to ketosis
- Increase in insulin resistance
- Increase in postprandial glucose levels
- Increase in insulin response to glucose
- Increase in hepatic glucose output

Increase in peripheral resistance to insulin, caused by these factors, leads to a diabetogenic state. The predominant changes in glucose metabolism are listed in Box 3.7.

Levels of diabetogenic hormones are significantly elevated by 24–28 weeks. Screening for gestational diabetes is therefore performed at this period of gestation.

Changes in glucose metabolism are discussed in Chapter 48, *Diabetes*.

Protein and fat metabolism

Dietary requirement of proteins increases in pregnancy from 0.8 g/kg/day to 1 g/kg/day. This is due to an increase in demand due to the fetus, placenta, uterus, breasts, and increase in maternal production of hemoglobin and plasma proteins. Amino acids are required by the mother as an energy source and by the fetus for growth. Circulating level of amino acids in the pregnant mother falls due to placental transfer and utilization of amino acids by the mother's liver for gluconeogenesis.

Fat is also used as a source of energy between meals by the mother. Therefore, circulating levels of fatty acids increase. Serum levels of triglycerides and low-density (LDL) and high-density (HDL) lipoproteins increase in pregnancy. Elevated levels of estrogen, progesterone, and human placental lactogen are probably causative (Box 3.8).

Box 3.8 Protein and fat metabolism during pregnancy

- Protein metabolism
 - Increase in dietary requirement
 - Proteins utilized by
 - fetus
 - placenta
 - breasts
 - uterus
 - hemoglobin
 - plasma proteins
 - Fall in maternal amino acid levels due to
 - placental transfer to fetus
 - maternal gluconeogenesis
- Fat metabolism
 - Increase in
 - triglycerides
 - fatty acids
 - low- and high-density lipoproteins

Clinical implications

Clinical implications of *metabolic changes during pregnancy* are given below.

- Screening for gestational diabetes to be done at 24–28 weeks.
- Ketosis occurs readily in pregestational diabetes.
- Insulin requirements increase in pregnancy.

Changes in the cardiovascular system

Important anatomical and physiological changes take place in the cardiovascular system as discussed below.

Anatomical changes

Elevation of the diaphragm due to the upward enlargement of the uterus and changes in the shape of the rib cage lead to the anatomical changes described in Box 3.9. The heart is displaced upward and to the left and apex beat is felt in the fourth intercostal space, lateral to the midclavicular line. Due to the hemodynamic changes in pregnancy, functional systolic murmurs in the aortic and tricuspid areas, functional ejection systolic murmur in pulmonary area can be heard. Increased blood flow through the mammary vessels may give rise

Box 3.9 Anatomical changes in the heart during pregnancy

- Examination
 - Heart displaced upward and to the left
 - Apex beat shifted upward and laterally
 - Fourth intercostal space lateral to midclavicular line
- Auscultation
 - Split first heart sound
 - Appearance of physiological third heart sound
 - Functional murmurs
 - Ejection systolic murmur in pulmonary area
 - Continuous murmur
 - Venous hum if patient is anemic
 - Mammary vessels

to continuous murmurs along the sternal border. A third heart sound may be heard and first sound may be split. Unless one is aware of these physiological changes, they may be mistaken for organic cardiac disease.

Symptoms and signs that mimic cardiac disease are listed in Box 3.10.

There are changes in ECG and chest radiography, as listed in Box 3.11.

Therefore, a diagnosis of cardiac disease should be made only if symptoms and signs given in Box 3.12 are present.

Box 3.10 Symptoms and signs that mimic cardiac disease in pregnancy

- Breathlessness
- Palpitation
- Lightheadedness and syncope
- Easy fatigability
- Pedal edema
- Increase in pulse volume

Box 3.11 ECG and chest radiographic findings in pregnancy

- ECG
 - Left axis deviation
 - Nonspecific ST-T changes
 - ST depression
- Chest X-ray
 - Apparent cardiomegaly (inadequate inspiration)
 - Apparent straightening of left heart border
 - Prominent pulmonary conus

Box 3.12 Symptoms and signs of cardiac disease in pregnancy

- Dyspnea on mild activity
- Dyspnea at rest/orthopnea
- Paroxysmal nocturnal dyspnea
- Hemoptysis
- Pedal edema up to the knees
- Edema not subsiding with overnight rest
- Grade III or IV systolic murmurs
- Murmurs associated with thrill
- Diastolic murmurs

Physiological changes

The physiological changes in cardiovascular system during pregnancy are multiple and profound. These are meant to maximize oxygen delivery to the fetus.

Cardiac output

Cardiac output increases by 30%–50% in pregnancy, due to an increase in stroke volume and heart rate. It begins to increase by 5 weeks, and reaches a peak at 25–30 weeks. Changes in heart rate, stroke volume, and cardiac output are given in Box 3.13.

In labor, with pain and associated catecholamine release, the heart rate increases further. The increased venous return as a result of pumping of blood from uterus during contractions increases the cardiac output further. Vigorous pushing efforts in second stage increase the cardiac output even further.

Box 3.13 Changes in heart rate, stroke volume, and cardiac output in pregnancy

- Heart rate
 - Starts increasing by 5 weeks
 - Peaks at 32 weeks
 - Increases by 15–20 beats
- Stroke volume
 - Starts increasing by 8 weeks
 - Peaks by 20 weeks
 - Increases by 20%–30%
- Cardiac output
 - Product of heart rate and stroke volume
 - Starts increasing by 5 weeks
 - Reaches a peak by 25–30 weeks
 - Increases by 30%–50%

Cardiac output in pregnancy depends on maternal position; it is more in the lateral and knee chest positions. In the supine position, pressure exerted by the gravid uterus on inferior vena cava reduces venous return and hence cardiac output. Renal and placental blood flow are also decreased in the supine position.

Systemic vascular resistance

Systemic vascular resistance (SVR) falls in pregnancy and remains low till term. This is largely responsible for the fall in blood pressure during pregnancy. Reduction in SVR is caused by the following:

- Progesterone-mediated relaxation of smooth muscles
- Increase in nitric oxide (NO), which decreases vascular responsiveness to pressors like angiotensin II.

Blood pressure

Blood pressure should be measured in the sitting position and disappearance of Korotkoff sounds should be used to determine diastolic pressure. Blood pressure falls during pregnancy and is position dependent, being lower in lateral recumbent position. Diastolic pressure falls more than the systolic pressure. Overall, the decrease in mean arterial pressure and diastolic pressure is between 5–10 mm Hg (Box 3.14). Fall in blood pressure starts by 8 weeks, reaches a nadir by 24–26 weeks and returns to prepregnancy levels by term.

In about 10% of pregnant women, compression of vena cava by gravid uterus in supine

Box 3.14 Changes in S and blood pressure

- SVR
 - Decreases
 - Due to smooth muscle relaxation
 - Caused by
 - progesterone
 - nitric oxide
- Blood pressure
 - falls by 8 weeks
 - nadir at 24–26 weeks
 - returns to normal by term
 - is lower in lateral recumbent position

S = systemic vascular resistance.

position causes marked fall in blood pressure, leading to supine hypotension manifested as dizziness, nausea, and sometimes syncope. These changes are more pronounced after 24 weeks.

enous pressure

Pressure on the inferior vena cava by the gravid uterus causes an increase in venous pressure in the lower half of the body. This leads to pedal edema, varicose veins, and less commonly hemorrhoids can also predispose to venous thrombosis in the lower limbs.

Cardiovascular changes in labor

Labor has several effects on cardiovascular system (Box 3.15).

Box 3.15 Effects of labor on cardiovascular system

- Effects of pain
 - Increase in heart rate and stroke volume
 - Increase in mean arterial pressure
 - Further increase in cardiac output
- Immediate postpartum (10–30 minutes after delivery)
 - Fall in heart rate
 - Further increase in cardiac output
 - Increase in stroke volume
- Postpartum 1 hour
 - Fall in cardiac output

Clinical implications

Cardiovascular changes in pregnancy have important clinical implications as listed below.

- *Anatomical and physiological changes*: Misinterpreted as cardiac disease
- *Increase in heart rate especially in labor*: Risk of pulmonary edema in valvular disease
- *Increase in cardiac output*: Congestive cardiac failure (CCF) in valvular disease
- *Third trimester fall and later rise in blood pressure*: Misdiagnosed as pregnancy induced hypertension (PIH)
- *Muscular smooth muscle relaxation and increase in venous pressure*: Varicose veins, pedal edema and hemorrhoids
- *Pressure of gravid uterus on vena cava in supine position*: Supine hypotension, fetal heart decelerations, hypotension during epidural/spinal anesthesia
- *Changes in labor*: Increased risk of pulmonary edema, CCF in labor and immediate postpartum

Hematological changes

The physiological changes in pregnancy, involving the hematological system, are important for the mother and fetus.

Blood volume

Blood volume increases by 40%–50%. This starts in first trimester (6 weeks), reaches a peak by 32–34 weeks, and plateaus thereafter. Plasma volume increases by 50% but red cell volume increases by 30%. This gives rise to ‘physiological hemodilution’ or ‘physiological anemia’ of pregnancy. The increase in red cells is due to increase in erythropoietin levels, begins at 10 weeks and continues till term.

The increase in blood volume is meant for

- extra blood flow to uterus and placenta;
- filling the expanded vascular system;
- protection against blood loss at delivery.

In addition to changes in blood volume, there are other hematological changes which are given in Box 3.16.

Box 3.16 Changes in blood cells and inflammatory markers

- Blood cells
 - Decrease in hemoglobin
 - Increase in white cell count
 - To 12,000–14,000 in pregnancy
 - To 20,000–30,000 in labor
 - Decrease in platelets (gestational thrombocytopenia)
- Inflammatory markers
 - Increase in
 - CRP
 - complement factors C3 and C4
 - ESR

C P C-reactive protein; S erythrocyte sedimentation rate.

Coagulation system

Pregnancy is a hypercoagulable state caused by an increase in coagulation factors and a decrease in inhibitors of coagulation and fibrinolytic activity (Box 3.17). The commonly used coagulation tests (bleeding time, clotting time, prothrombin time, and activated partial thromboplastin time) are unaffected.

Box 3.17 Changes in coagulation system during pregnancy

- Increase in all clotting factors except XI and XIII
- Decrease in plasminogen activator
- Increase in plasminogen-activator inhibitor
- Decrease in protein S

Clinical implications

Clinical implications of *hematological changes in pregnancy* are given below.

- Increase in blood volume
 - Coping mechanism against blood loss
 - Diagnosis of hemorrhagic shock may be delayed
 - Increases risk of congestive cardiac failure (CCF) in valvular disease
 - Hemodilution
 - Anemia in women with low iron reserve
 - Leukocytosis
 - Cannot be used for diagnosing infection
 - Thrombocytopenia
 - Mistaken diagnosis of idiopathic thrombocytopenic purpura (ITP)
 - Elevated erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP)
 - Cannot be used for diagnosing infection
 - Increase in clotting factors }
 - Decrease in fibrinolysis }
- Risk of venous thrombosis

Changes in respiratory system

Significant changes occur in anatomy of the respiratory system and pulmonary functions during pregnancy.

Anatomical changes

Anatomical changes in the respiratory tract are given in Box 3.18.

Box 3.18 Anatomical changes in respiratory tract

- Hyperemia and edema of mucosa of respiratory tract
- Increased secretion of mucus
- Expansion of chest
 - Relaxation of ligaments attaching ribs to sternum
 - Upward displacement of diaphragm: 4 cm
 - Increase in chest circumference: 5–7 cm
 - Increase in transverse diameter of chest: 2 cm

Clinical implications

Clinical implications of *changes in respiratory system during pregnancy* are given below.

- Congestion and edema of mucosa
 - Nasal stuffiness
 - Epistaxis
 - Difficulty in intubation and difficulty in placing nasogastric tube
- Low maternal PaCO₂
 - Chronic respiratory alkalosis
- Increase in oxygen consumption
 - Increased susceptibility to effects of respiratory infection and hypoxia during intubation

Pulmonary function

There are changes in pulmonary function as well (Box 3.19). Increase in progesterone levels and elevation of diaphragm contribute to these changes. Chronic hyperventilation and the resultant drop in PaCO₂ help in creating a gradient and facilitating carbon dioxide transfer from fetus to mother. Maternal oxygen consumption increases in pregnancy by 20%–40%, and there is a further increase in labor. This increased demand for oxygen is met by increase in minute ventilation.

Changes in urinary system

Being close to the enlarging uterus, several significant changes occur in the urinary system in pregnancy.

Box 3.19 Changes in pulmonary function during pregnancy

- Respiratory rate unchanged
- Decrease in lung volumes at resting state
 - Functional residual capacity
 - Residual volume
 - Total lung capacity
- Bronchial flow unaltered
 - Forced expiratory volume
 - Peak expiratory flow rate
 - Maximum breathing capacity
- Chronic hyperventilation leads to
 - increase in
 - tidal volume
 - minute ventilation
 - PaO₂
 - decrease in
 - PaCO₂

Anatomical changes

Anatomical changes take place in the kidneys, ureters, and urinary bladder during pregnancy. These are listed in Box 3.20. The dilatation of the renal pelvis and ureters is due to the following reasons:

- Mechanical pressure by gravid uterus
- Progesterone-induced relaxation of smooth muscles

These changes begin by the second month of pregnancy and are maximal at midpregnancy. They revert to normal after delivery. The dilatation is more on the right and this is attributed to the following:

- Dextrorotation of uterus
- Cushioning and protection of left ureter by sigmoid colon
- Pressure on the right ureter by engorged right ovarian vein complex

Changes in bladder and urethral pressure also occur. These cause stress incontinence.

Changes in renal function

Changes in renal hemodynamics and renal function begin by 5–7 weeks of pregnancy and continue till term (Box 3.21). They revert to normal postpartum.

Box 3.20 Anatomical changes in the urinary tract during pregnancy

- Kidneys
 - Increase in size and weight
 - Increase in renal vasculature
 - Increase in interstitial volume
 - Pelvicalyceal dilatation
- Ureter
 - Dilatation: More on right than left
- Bladder
 - First trimester
 - Compression by gravid uterus
 - Second trimester
 - Elevation of trigone
 - Hyperemia of bladder wall
 - Labor
 - Pressure by presenting part
 - Edema
 - Congestion

Box 3.21 Changes in renal function during pregnancy

- Renal hemodynamics
 - Increase in renal plasma flow by 75%
 - Increase in glomerular filtration rate (GFR) by 50%
 - Causes reduction in
 - serum creatinine
 - blood urea nitrogen
 - uric acid
 - Increase in creatinine clearance to 150–200 mL/min
 - Increase in urine volume
 - Nocturia
- Renal tubular function
 - Glycosuria
 - Conservation of potassium
 - Increase in
 - protein and albumin excretion
 - amino acid excretion
 - calcium excretion
 - bicarbonate excretion

Creatinine clearance is used as a measure of glomerular filtration rate (GFR). Increase in renal plasma flow and GFR are thought to be due to the effect of nitric oxide (NO). Serum creatinine and blood urea nitrogen decrease gradually throughout pregnancy. However, serum uric acid, which shows a decrease up to 24 weeks, increases thereafter due to increased renal tubular function. Glycosuria occurs due to increase in GFR and reduced tubular reabsorption of glucose.

Glycosuria is not related to plasma glucose levels and can be intermittent. It is extremely common and should not be misdiagnosed as gestational diabetes. When glycosuria is persistent, screening for diabetes is indicated.

Clinical implications

The *changes in urinary system* have several clinical implications as given below.

- Pelvicalyceal dilatation
 - Increase in risk of pyelonephritis mistaken for obstructive uropathy
- Increased vascularity of bladder
 - Hematuria
- Glycosuria
 - Mistaken diagnosis of diabetes
- Increased bicarbonate excretion
 - Compensates for respiratory alkalosis

Changes in gastrointestinal system

Changes occur in all parts of the gastrointestinal system including oral cavity, stomach, intestines, liver, and gall bladder.

Anatomical changes

Anatomical changes in the gastrointestinal tract are mainly due to upward displacement by enlarging uterus. The appendix is displaced superiorly and reaches the right flank.

Gums become hypertrophic and hyperemic and may bleed, commonly known as *gingival hypertrophy of pregnancy*.

Physiological changes

Appetite increases in pregnancy except in first trimester. Craving for unusual foods (pica) may be present in some. Secretion of saliva and other gastrointestinal secretions increases. Progesterone causes relaxation of the smooth muscles of the entire gastrointestinal tract. This leads to decrease in gastric and intestinal motility, constipation, and stasis of contents in gall bladder (Box 3.22).

Box 3.22 Changes in gastrointestinal system during pregnancy

- Anatomical changes
 - Upward displacement of stomach and intestines
 - Gum hypertrophy
 - Change in the position of appendix
- Physiological changes
 - Due to smooth muscle relaxation by
 - progesterone
 - estrogen-mediated release of NO
 - Decrease in gastric tone and motility
 - Increase in gastroesophageal reflux
 - Gastric compression by gravid uterus
 - Relaxation of gastroesophageal sphincter
 - Decreased intestinal motility
 - Stasis of contents of gall bladder
 - Increase in biliary cholesterol content

nitric oxide.

Clinical implications

Clinical implications of *changes in gastrointestinal system* are given below.

- Change in position of appendix
 - Difficulty in diagnosis of appendicitis
- Gastroesophageal reflux
 - Heart burn and dyspepsia
- Delayed intestinal emptying
 - Constipation
- Gall bladder stasis and increase in cholesterol content in bile
 - Formation of biliary sludge, gall stones
- Increase in hormone-binding proteins
 - Increase in total hormone levels
 - Decrease in free hormone levels
- Increase in portal venous pressure
 - Formation of hemorrhoids

Changes in liver functions

No anatomical or histological changes are seen in the liver. Spider naevi and palmar erythema appear due to increased estrogen levels and disappear after delivery. Total serum protein and serum albumin show a modest progressive decrease due to hemodilution. However, levels of fibrinogen, hormone-binding proteins, transferrin, and ceruloplasmin increase. Serum alkaline phosphatase increases but the main source is placenta and not the liver. Changes in liver function are listed in Box 3.23.

Box 3.23 Changes in liver function during pregnancy

- Fall in
 - serum total protein
 - serum albumin
- Increase in
 - binding proteins
 - fibrinogen
 - transferrin
 - ceruloplasmin
 - alkaline phosphatase
- Increase in portal venous pressure

Changes in endocrine system

The endocrine changes play a major role during pregnancy, labor, and puerperium.

Pituitary gland

Pituitary gland enlarges in pregnancy. Prolactin-secreting tumors also increase in size. Due to the increase in size, pituitary gland is more susceptible to ischemia when SVR falls in postpartum hemorrhage (Sheehan's syndrome).

Changes in pituitary hormones are given in Box 3.24. Prolactin-secreting cells in the pituitary increase in number and secrete large amounts of the hormone. Suppression of follicle-stimulating hormone and luteinizing hormone is due to feedback inhibition by estrogen, progesterone, and inhibin. Placental production of growth hormone suppresses the pituitary growth hormone but the serum growth hormone level increases.

Thyroid gland

Moderate increase in size of the thyroid gland occurs in pregnancy to meet the need for increased thyroid hormone production. There is glandular hyperplasia and increase in vascularity. The gland enlarges more in iodine-deficient women. Iodine requirement increases in pregnancy.

Changes in thyroid function are listed in Box 3.25.

The increased estrogen levels in pregnancy cause stimulation of thyroid-binding globulin production by the liver. This leads to a transient fall in free T₃ and T₄, which, in turn, leads to increased production of T₃ and T₄ by the thyroid, such that the serum total T₃ and T₄ increase and free T₃ and T₄ are restored to values near the

Box 3.24 Changes in pituitary hormones during pregnancy

- Anterior pituitary hormones
 - Prolactin
 - Begins to increase by 5–8 weeks
 - Marked increase prior to labor
 - Prepares breast for lactation
 - FSH/LH
 - Markedly decreased
 - Growth hormone
 - Decreased
- Posterior pituitary hormones
 - Oxytocin
 - Increases markedly in third trimester
 - Peak levels in labor

S = follicle-stimulating hormone; LH = luteinizing hormone.

Box 3.25 Changes in thyroid function during pregnancy

- Increase in thyroid-binding globulin
- Increase in total T3 and total T4
- Slight increase in free T3 and free T4
- Transient decrease in TSH in first trimester

S thyroid-stimulating hormone.

upper limit of the normal range. Placental hCG is the principal thyroid stimulator in the first trimester. The serum thyroid-stimulating hormone is therefore transiently suppressed in the first trimester. In hyperemesis gravidarum, twin pregnancy, and molar pregnancy, where the serum hCG levels are very high, there may be transient thyrotoxicosis.

Fetal thyroid begins to function from the 12th week of gestation. The fetus is dependent on placental transmission of maternal T4 for early development (up to 12 weeks). In women with autoimmune thyroid disease such as Grave's disease and Hashimoto's thyroiditis, maternal thyroid-stimulating and inhibiting immunoglobulins may cross the placenta and cause fetal hyper- or hypothyroidism. Iodine in maternal circulation crosses the placenta with ease and the fetal thyroid avidly takes up iodine. Therefore, excessive iodine intake or radioactive iodine should be avoided in pregnancy since they can cause fetal hypothyroidism.

Adrenal glands

Even though there is no net increase in the size of the adrenals in pregnancy, there is selective increase in the size of the zona fasciculata which secretes glucocorticoids.

Changes in adrenal function

corticosteroids

The placenta produces large amounts of a placental corticotrophin-releasing hormone (pCRH) which in turn stimulates adrenocorticotrophic hormone (ACTH) production by the maternal pituitary. This leads to an increase in maternal serum cortisol levels. The increase in cortisol-binding protein (CBP) from maternal liver also contributes to the increase in cortisol

levels. Elevated cortisol levels cause weight gain, increase in plasma glucose, and striae. This is termed *physiological hypercortisolism*.

mineralocorticoids

The increased aldosterone levels along with the high cortisol levels tend to cause sodium and water retention and oppose the natriuretic effects of ANPs.

Adrenal androgens

Most of the circulating maternal dehydroepiandrosterone is derived from the fetal adrenals and serves as the precursor for maternal adrenal hormone production.

Changes in adrenal function are summarized in Box 3.26.

Box 3.26 Changes in adrenal function during pregnancy

Increase in

- Placental CRH
- Maternal ACTH
- Corticosteroid-binding globulin
- Total cortisol
- Free cortisol
- Aldosterone
- Deoxycorticosterone

AC adrenocorticotrophic hormone; C corticotrophin-releasing hormone.

Parathyroid glands

Parathyroid hormone is secreted in response to low calcium levels. Calcium utilization, and therefore, requirement increases since it is required for formation of fetal bones. Maternal levels of ionized calcium are unchanged in pregnancy. Most of the calcium required for fetal skeleton formation is obtained from increase in maternal intestinal calcium absorption, but some calcium resorption from maternal bones occurs. In countries like India, where dietary calcium intake may be insufficient, calcium reserves decrease. Supplementation with 1000–1300 mg of calcium/day is, therefore, recommended for all pregnant women. Parathormone levels remain unchanged throughout pregnancy according to recent studies (Box 3.27). Similarly, serum vitamin D levels are also unchanged

Box 3.27 Changes in parathyroid function and levels of calcium and vitamin D during pregnancy

- No change in levels of
 - parathyroid hormone
 - serum calcium
 - vitamin D
- Mild increase in bone resorption

Clinical implications

Clinical implications of *changes in endocrine system during pregnancy* are given below.

- Enlargement of pituitary
 - Susceptibility to infarction after postpartum hemorrhage
- Increase in prolactin
 - Preparation for lactation
- Increase in oxytocin in labor
 - Uterine contraction
- Elevated total T3 and T4
 - Over diagnosis of hyperthyroidism
- Stimulation of thyroid by human chorionic gonadotropin (hCG)
 - Gestational thyrotoxicosis, thyrotoxicosis of hydatidiform mole
- Increased cortisol secretion
 - Hyperglycemia, weight gain, striae gravidarum
- Increase in calcium demand
 - Calcium supplementation required

except when the maternal intake of vitamin D is poor and exposure to sunlight is inadequate. Routine screening for vitamin D deficiency and supplementation in pregnancy are not required except in populations with deficiency.

Skeletal system

Lumbar lordosis helps to shift the center of gravity backward and relaxation of pubic and sacroiliac joints may increase pelvic diameters during labor. These changes are associated with backache and pain in the sacroiliac and pubic joints (Box 3.28).

Box 3.28 Changes in skeletal system during pregnancy

- Lumbar lordosis
 - Shifts center of gravity
 - Causes backache
- Relaxation of sacroiliac joint
 - Causes backache
- Relaxation of pubic symphysis
 - Increases pelvic diameter
 - Causes pubic pain

Key points

- Extensive anatomic, physiological, and biochemical changes occur in the mother during pregnancy to prepare the mother to meet the demands of pregnancy.
- Total body water increases by 6-8 L due to increase in progesterone, renin-angiotensin-aldosterone, sodium retention, and increase in atrial natriuretic peptide. Increase in body water contributes to hemodilution, increase in cardiac output, pedal edema, and maternal weight gain.
- Water retention exceeds sodium retention leading to fall in serum sodium levels.
- There is increase in renin, angiotensin and aldosterone levels which increase vascular tone.
- There is increased demand for calcium in pregnancy necessitating calcium supplementation.
- Additional caloric requirement averages to 300 kcal/day through the entire pregnancy.
- There is increased insulin resistance caused by diabetogenic hormones. Fasting plasma glucose levels are lower but postprandial levels are higher. The pregnant woman is more prone to development of glucose intolerance and diabetes.
- Dietary requirements of proteins also increases. Fat is broken down and is used as a source of energy.
- Anatomical and physiological changes in cardiovascular system can mimic clinical features of cardiac disease. There is increase in cardiac output, stroke volume, and heart rate along with fall in systemic vascular resistance. Due to these changes, pregnant women with cardiac disease can deteriorate in pregnancy.
- Blood volume increases. The increase in plasma volume is more than the increase in red cell volume, resulting in physiological anemia.

(Continued)

Key points *Continued*

- Changes in coagulation system results in the hypercoagulable state of pregnancy.
- Anatomical and physiological changes in respiratory system leads to chronic respiratory alkalosis.
- Pelvicalyceal and ureteric dilatation occur. Renal blood flow and glomerular filtration rate increase. There is increase in susceptibility for urinary tract infection and pyelonephritis.
- Relaxation of smooth muscles of the gastrointestinal system leads to gastroesophageal reflux, constipation, and stasis of contents in the gall bladder.
- Increase in binding proteins results in increase in levels of total hormones but decrease in levels of free hormones.
- Pituitary gland enlarges and level of oxytocin increases in third trimester. Thyroid gland enlarges and there is transient increase in thyroid-stimulating hormone in first trimester.
- Zona fasciculata of adrenal gland increases in size and there is increase in cortisol and deoxycorticosterone leading to physiological hypercortisolism.

Self-Assessment

Case-based questions

Case 1

Mrs. KT, a 20-year-old primigravida, at 32 weeks of pregnancy came to the clinic for routine antenatal checkup. She was quite troubled by minor but multiple problems such as pedal edema, which was obvious by evening, palpitation, feeling tired, and breathlessness on walking

1. Are the symptoms suggestive of valvular heart disease?
2. What findings may be physiological but mimic cardiac disease?
3. What symptoms and signs would be suggestive of valvular disease?

Case 2

A 30-year-old second gravida, presented with loin pain and fever.

1. How will you evaluate?
2. What is your diagnosis?
3. Why is this condition common in pregnancy?
4. What are the changes in urinary tract in pregnancy?

Answers

Case 1

1. No, symptoms such as palpitation, breathlessness, and easy fatigability can occur in normal women in pregnancy due to the changes in cardiovascular system.
2. Findings on examination include pedal edema, shifting of apex beat to left, splitting of first heart sound, appearance of third heart sound, and functional systolic murmurs in tricuspid and aortic areas and continuous murmur indicating blood flow in mammary vessels.

3. Symptoms like dyspnea on mild activity, orthopnea, paroxysmal nocturnal dyspnea, and hemoptysis and clinical findings such as pedal edema up to the knees, grade III or IV systolic murmurs, murmurs associated with thrill, and diastolic murmurs.

Case 2

1. Urine microscopy, urine culture, and sensitivity.
2. Pyelonephritis.
3. Due to dilatation of the collecting system of the kidneys and stasis of urine in bladder due to incomplete bladder evacuation.
4. Pelvicalyceal and ureteric dilatation, compression of bladder by uterus in first trimester, elevation of trigone in second trimester, hyperemia of bladder wall, and compression by fetal head in labor.

These changes are due to progesterone effect on smooth muscles and pressure by enlarging uterus.

Sample questions

Long-answer question

1. Describe the changes in respiratory and cardiovascular systems, and hematological changes in pregnancy. What are the clinical implications of these changes?

Short-answer questions

1. Urinary tract changes during pregnancy
2. Hematological changes in pregnancy
3. Carbohydrate metabolism in pregnancy
4. Glycosuria in pregnancy
5. Cardiovascular changes in pregnancy

4

Fertilization, Implantation, and Fetal Development

Case scenario

Mrs. LN, 28, married for 4 years, came to the hospital with a history of three previous children with congenital anomalies and early neonatal death. She was advised preimplantation genetic diagnosis.

Introduction

An understanding of the biology of ovulation, fertilization, implantation, and development of the fetus is important when one deals with conditions like infertility, recurrent pregnancy loss and fetal anomalies. This is not only helpful in appropriate evaluation and treatment but is invaluable while counseling and discussing prognosis. For a discussion on physiology of menstruation and ovulation, the reader may refer to *Essentials of Gynecology* by Dr. Lakshmi Seshadri.

Ovulation

Ovulation occurs on Day 14 of a 28-day menstruation cycle and 14 days prior to the onset of menstruation in longer cycles. Luteinizing hormone (LH) surge begins 36 hours prior to ovulation and peaks 12 hours before ovulation. The LH surge can be detected by simple tests and is used as an indicator of ovulation and for determining

the timing of intrauterine insemination (IUI) or sexual intercourse (Box 4.1).

Immediately after the LH peak, the *primary oocyte* undergoes the first meiotic division. A space forms between the zona and vitelline membrane covering the oocyte, known as the perivitelline space. The *first polar body* is extruded into the *perivitelline space*. The *secondary oocyte*, which is haploid, is surrounded by the corona radiata and zona pellucida and moves toward the periphery of the follicle. The second meiotic division in the oocyte is arrested in metaphase. When the follicle ruptures and the oocyte is released with the surrounding cumulus, it is picked up by the fimbriae of the fallopian tube and directed into the tubal lumen (Fig. 4.1).

Fertilization

Fertilization is the fusion of the nucleus of the oocyte with that of the sperm. This takes place in the fallopian tube. For fertilization to occur,

Box 4.1 The process of ovulation*the process*

- LH surge begins 36 hours prior to ovulation
- LH surge peaks 12 hours prior to ovulation
- First polar body released soon after LH surge
- Second meiotic division arrested in metaphase
- Oocyte with surrounding cumulus released

Clinical application

- Tests for ovulation help in determination of
 - fertile period
 - timing of IUI

intrauterine insemination; luteinizing hormone.

Box 4.2 Fertilization*the process*

- Occurs in fallopian tube
- Fertile period
 - Begins 48 hours prior to ovulation
 - Ends 24 hours after ovulation

Clinical implications

- Couples with infertility
 - Planned intercourse during fertile period recommended
- Couples desirous of contraception
 - Avoidance of intercourse during fertile period recommended

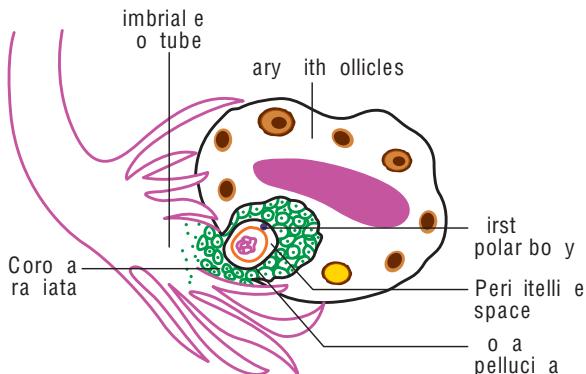


Figure 4.1 Ovulation. The secondary oocyte, with the first polar body in the perivitelline space surrounded by corona radiata, is released from the ovary and picked up by the fimbriae of the fallopian tube.

the sperm must enter the vagina <48 hours prior to ovulation. The oocyte can be fertilized up to 24 hours after ovulation. Thus, the window of

opportunity or the *fertile period* is from 48 hours prior to ovulation to 24 hours after ovulation. This has implications in planning or avoiding pregnancy (Box 4.2).

Several sperms penetrate the corona radiata and zona pellucida but only one pierces the vitelline membrane. Enzymes secreted by the oocyte immobilize the other sperms. Fusion of the nucleus of the oocyte and that of the sperm takes place, followed by completion of the second meiotic division. The *second polar body* is released into the perivitelline space (Fig. 4.2).

Preimplantation events

The fertilized ovum is now known as a *zygote* and is diploid. It divides by cleavage into 2 cells, then into 4 cells and so on. A ball of 16 cells, known

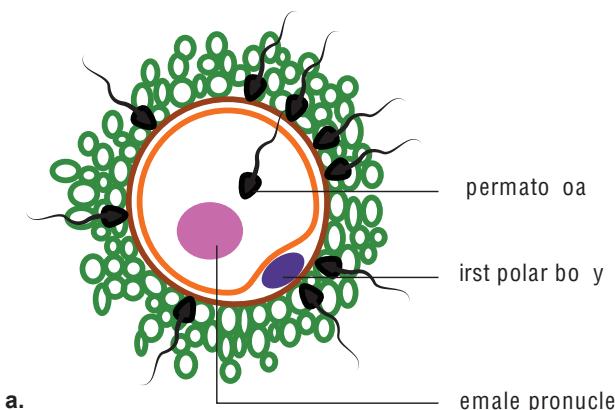
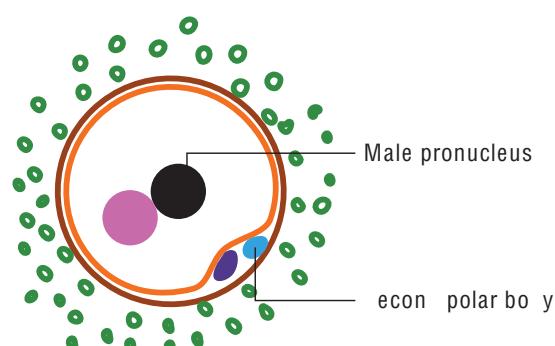


Figure 4.2 Fertilization. **a.** Penetration of zona pellucida by sperm. Though several sperms enter the zona, only one pierces the vitelline membrane. **b.** Fusion of the nucleus of the oocyte and sperm, completion of second meiotic division, and extrusion of second polar body.



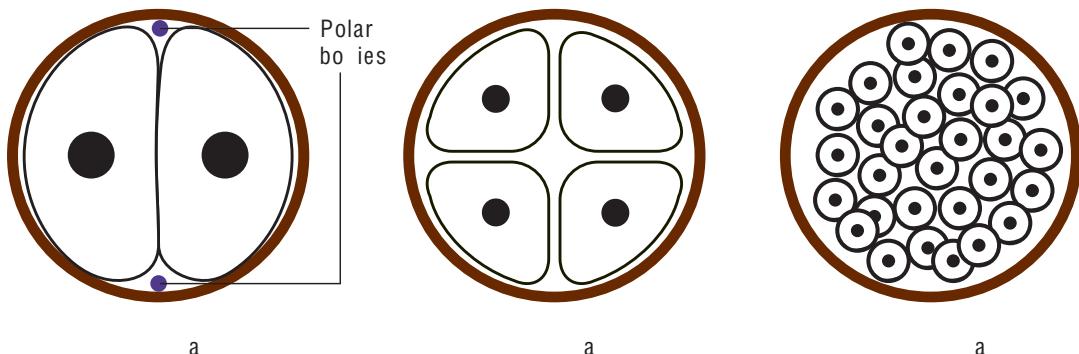


Figure 4.3 Formation of morula. The zygote is divided into 2 cells first, then into 4 cells and becomes a ball of cells known as the morula.

as a *morula*, is formed by Day 3 postfertilization (Fig. 4.3). The morula enters the uterine cavity and is covered by mucus and endometrial fluid at this stage. The endometrial fluid is absorbed by the morula and enters between the cells. The solid morula transforms into the *blastocyst* which contains a cavity (Fig. 4.4). By Day 4 or Day 5, the cells differentiate into an inner cell mass, known as the *embryoblast*, and cells arranged in the periphery, known as the *trophoblast* or *trophoblast*. Lytic enzymes from the blastocyst cause dissolution of the zona pellucida and the blastocyst is released, a process known as *zona hatching* (Fig. 4.5).

Preimplantation genetic diagnosis

In order to arrive at the diagnosis of a suspected heritable disease, one will need to remove cells

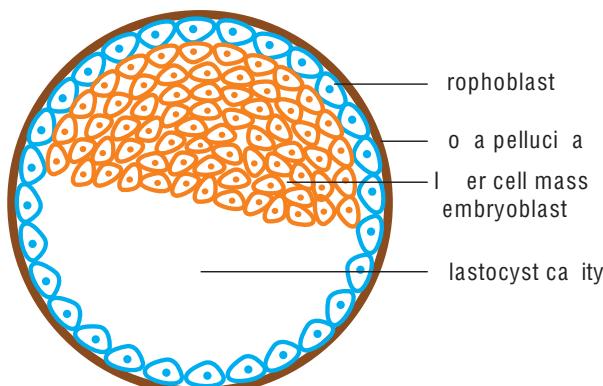


Figure 4.4 Blastocyst. The morula becomes a blastocyst when fluid enters between the cells and forms a cavity. The cells arrange themselves as an inner cell mass or embryoblast and an outer cell mass or trophoblast.

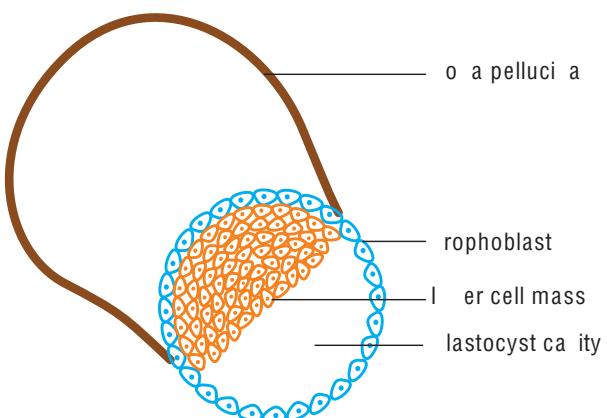


Figure 4.5 Release of blastocyst (zona hatching). The blastocyst is extruded from the zona pellucida.

Box 4.3 Preimplantation biopsy procedures and their timing

- Polar body biopsy
 - First polar body biopsy
 - Conducted on unfertilized oocyte
 - Second polar body biopsy
 - Shortly postfertilization
- Blastomere biopsy
 - Day 3 postfertilization
- Blastocyst biopsy
 - Day 5 postfertilization

from the oocyte, blastomere or blastocyst and subject them to genetic testing. These procedures are usually performed on Day 3 or Day 5 from fertilization, in assisted reproductive cycles (see Chapter 12, *Prenatal screening, prenatal diagnosis, and fetal therapy*). Different preimplantation biopsy procedures and their timing are given in Box 4.3.

Implantation

Successful implantation requires the appropriately timed arrival of a viable blastocyst into a receptive endometrium. The most receptive time period of the endometrium is from Day 20 to Day 24 of the menstrual cycle and this is known as the *implantation window*. Implantation of the blastocyst into the uterine decidua takes place 6–7 days postfertilization.

The process of implantation has three phases, as given in Box 4.4. Initially, the trophoblast lying over the embryoblast pole gets attached to the decidua. Following that, it gradually burrows into the stratum compactum and invades it further. By Day 10 postfertilization, the blastocyst is totally enclosed within endometrium. The process of implantation is a complex interaction between the trophoblast and decidua. This process is facilitated by progesterone, proteoglycans, integrins, and fibronectin.

Differentiation of trophoblast

By Day 6 following fertilization, the trophoblast cell layer multiplies rapidly and differentiates into (a) an outer layer of multinucleated syncytium without distinct cell walls, called *syncytiotrophoblast*, and (b) an inner layer of cells with distinct cell walls and nuclei, called *cytotrophoblasts* (Fig. 4.6). This differentiation is complete by Day 8.

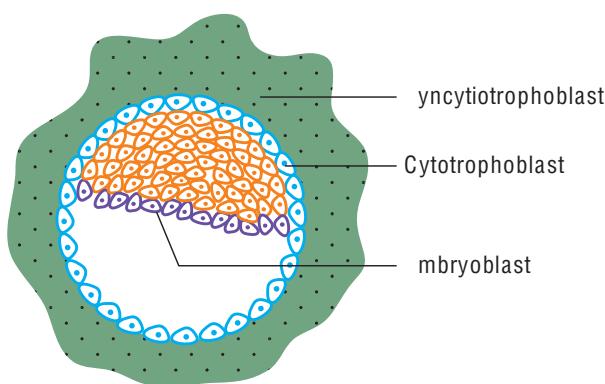


Figure 4.6 Differentiation of trophoblast. The trophoblast cell layer multiplies and differentiates into an outer layer of multinucleated syncytium without distinct cell walls, known as syncytiotrophoblast and an inner layer of cells with distinct cell walls and nuclei, known as cytotrophoblasts.

Box 4.4 Implantation

- Stage of apposition
 - Trophoblast covers the embryoblast pole
 - First contact between trophoblast and decidua
 - At the upper posterior wall of uterus
- Stage of adhesion
 - Stronger attachment of trophoblasts
 - Trophoblastic penetration of endometrium mediated by progesterone, proteoglycans, integrins, and fibronectin
- Stage of invasion
 - Further invasion of trophoblasts into endometrium
 - Firmer attachment

The trophoblasts work their way into the uterine decidua and later become part of the placenta. Complete penetration of the blastocyst into the endometrium takes place by Day 8 or 9 following fertilization. The maternal vessels are eroded by the trophoblast between Day 11 and Day 13. The trophoblasts further differentiate into villous and extravillous trophoblast. These are discussed in detail in Chapter 5, *Placenta, fetal membranes, and amniotic fluid*.

Abnormal implantation

The blastocyst may also get implanted in the fallopian tube, ovary, peritoneum, or cervix, resulting in an ectopic pregnancy. A tubal pregnancy is the most common type of ectopic pregnancy. The fallopian tube cannot distend to accommodate the pregnancy; therefore, it ruptures, resulting in intraperitoneal hemorrhage and shock. The pregnancy may also miscarry through the fimbrial end into the peritoneal cavity (see Chapter 30, *Ectopic pregnancy*).

Implantation in the lower uterine segment results in placenta previa. This causes antepartum hemorrhage, as discussed in detail in Chapter 39, *Antepartum hemorrhage*. Abnormalities of implantation are listed in Box 4.5.

Box 4.5 Abnormalities of implantation

- Ectopic implantation
 - Fallopian tube, ovary, cervix, or peritoneum
- Implantation in lower segment
 - Placenta previa

The decidua (endometrium of pregnancy)

The *decidua* is the specialized and modified endometrium of pregnancy. The process of decidualization of the secretory endometrium takes place under the influence of progesterone secreted by both the corpus luteum and the blastocyst. The process of decidualization is unique to hemochorionic placentae in which maternal blood comes in direct contact with the chorionic villi (described later in this chapter). The decidua is termed *decidua basalis*, *decidua capsularis*, or *decidua parietalis* depending on its location relative to the site of implantation (Fig. 4.7). Decidua basalis and decidua parietalis consist of three layers each. By 12–14 weeks' gestation, as the embryo enlarges to fill the uterine cavity, decidua capsularis and parietalis oppose and fuse. The uterine cavity is completely obliterated at this point.

Important features of decidua are summarized in Box 4.6.

Ovulation, fertilization, and implantation are shown in Figure 4.8.

Istology of decidua

Histologically, the stratum compactum consists of large polygonal cells (epithelioid cells)

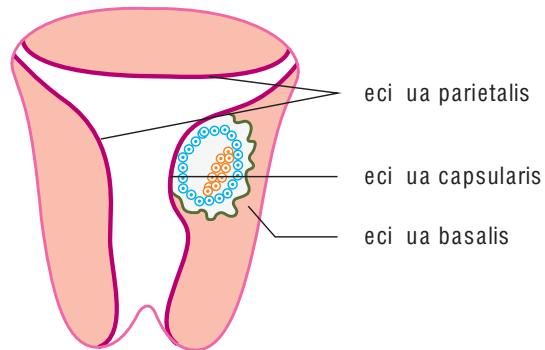


Figure 4.7 Decidua. The decidua covering the blastocyst is decidua capsularis; decidua lining the rest of the uterus is decidua parietalis; and the decidua invaded by trophoblast is decidua basalis.

Box 4.6 The decidua

- Modified, specialized endometrium of pregnancy
- Unique to hemochorionic placenta
- Develops under progesterone influence
- Consists of three parts:
 - Decidua basalis: Site of implantation
 - Decidua capsularis: Covers the embryo
 - Decidua parietalis (vera): Lines the rest of the uterine cavity
- Decidua basalis and decidua parietalis each have three layers:
 - Stratum compactum near the surface
 - Stratum spongiosum, the intermediate layer
 - Stratum basalis near the myometrium

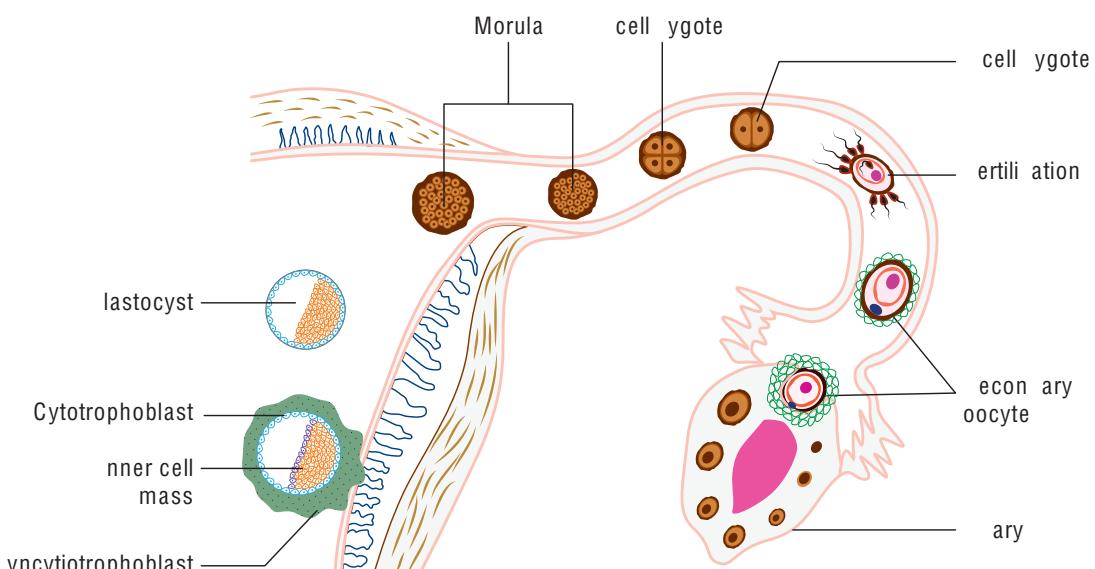


Figure 4.8 Ovulation, fertilization, and implantation. The process of ovulation, picking up of the ovum by the fimbriae, transfer to the tubal lumen, fertilization in the tube, development of zygote into morula and later into blastocyst, and implantation into the uterine decidua are diagrammatically represented.

Box 4.7 Histology of decidua

- Stratum compactum
 - Large polygonal cells with long processes
 - Natural killer lymphocytes
 - Leukocytic infiltration
- Stratum spongiosum
 - Large glands in early pregnancy
 - Glands disappear in late pregnancy
- Stratum basalis
 - Arteries and large veins
 - Invaded by trophoblasts

with long processes, lymphocytes called *natural killer (NK) cells*, and stroma. There is leukocytic infiltration as well. The stratum spongiosum contains large glands in early pregnancy that disappear by late pregnancy. The stratum basalis forms part of the basal plate of the placenta. It consists of arteries and dilated veins and is invaded by trophoblasts. Histology of decidua is summarized in Box 4.7.

The decidua produces large amounts of prolactin, under the influence of progesterone. Decidual prolactin plays a role in maintaining amniotic fluid volume, regulating immunological functions, and enhancing angiogenesis during implantation.

Development of the embryo

The conceptus is known as an *embryo* from the first mitotic division (fertilization) for a period of 8 weeks, that is, from the 3rd to 10th week of gestation. However, the critical period of organogenesis begins 2 weeks postfertilization; therefore, others consider this as the beginning of the embryonic period. Organogenesis continues through the embryonic period, till the end of the 8th week postfertilization. Cytotrophoblast secretes human chorionic gonadotropin (hCG) by Day 14 postfertilization and this is used for the diagnosis of pregnancy.

The inner cell mass of the blastocyst develops into the embryo. By Day 8 postfertilization, the cells arrange themselves in two layers adjacent to each other known as *epiblast* and *hypoblast*. The hypoblast layer is adjacent to the blastocyst cavity. The *amniotic cavity* develops as a fluid-filled space in the epiblast (Fig. 4.9). A layer of flattened cells originating from and continuous with the hypoblast forms a thin membrane on the inner surface of the cytotrophoblasts of the blastocyst. This is the *exocoelomic membrane*. The cavity lined by the membrane and hypoblast is now called the *primitive yolk sac*.

By Day 11 or 12, *extraembryonic mesodermal cells*, derived from the yolk sac cells, appear between the cytotrophoblasts and the exocoelomic

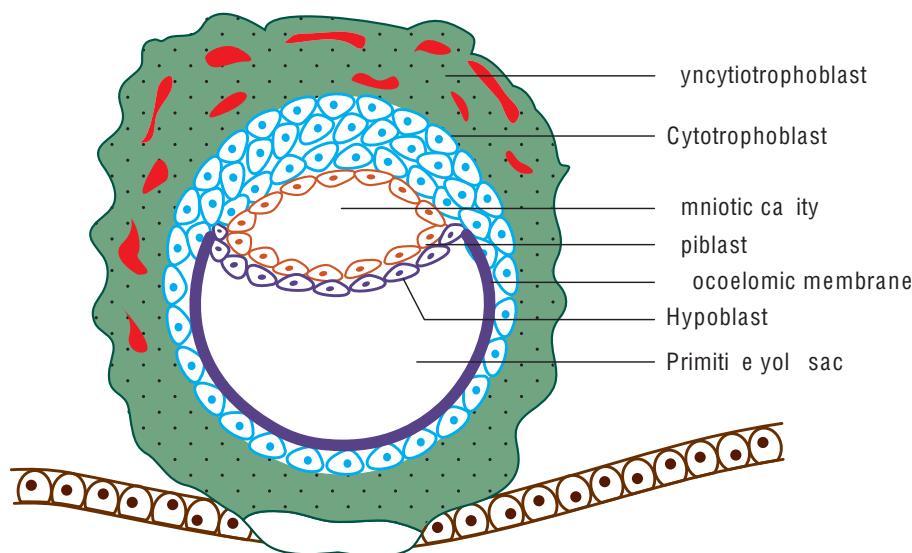


Figure 4.9 Development of epiblast, hypoblast, amniotic cavity, and yolk sac. The cells of the inner cell mass are arranged in two layers—epiblast and hypoblast. Amniotic cavity appears in the epiblast and the cells of the hypoblast line the blastocyst to form the primitive yolk sac.

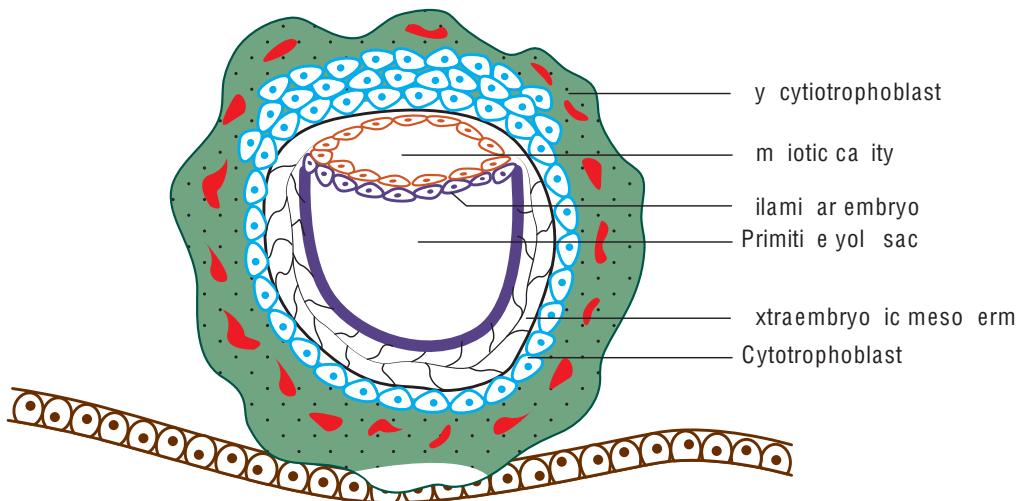


Figure 4.10 Formation of extraembryonic mesoderm. Extraembryonic mesodermal cells, derived from the cells of the primitive yolk sac, appear between the exocoelomic membrane and the cytотrophoblasts.

membrane (Fig. 4.10). These cells are loosely arranged with cavities in between. The cavities coalesce to form the *chorionic cavity*. Another layer of cells originates from the hypoblast to line the inner surface of the exocoelomic cavity and forms the *definitive yolk sac*, which is smaller than the primitive yolk sac (Fig. 4.11). The chorionic cavity expands and covers the definitive yolk sac and amniotic cavity. Extraembryonic mesodermal cells running between the yolk sac and chorion condense into the body stalk that later becomes the *umbilical cord*.

The embryonic disc is now known as the *bilaminar* disc and has two layers, namely, epiblast and hypoblast, and two cavities on either side—amniotic cavity dorsally and definitive yolk sac ventrally. The chorionic cavity surrounds the bilaminar disc, the amniotic sac, and the definitive yolk sac.

Gastrulation

Gastrulation is the process of formation of the three germ cell layers, namely, *ectoderm*, *endoderm*, and *mesoderm*. By the beginning of the

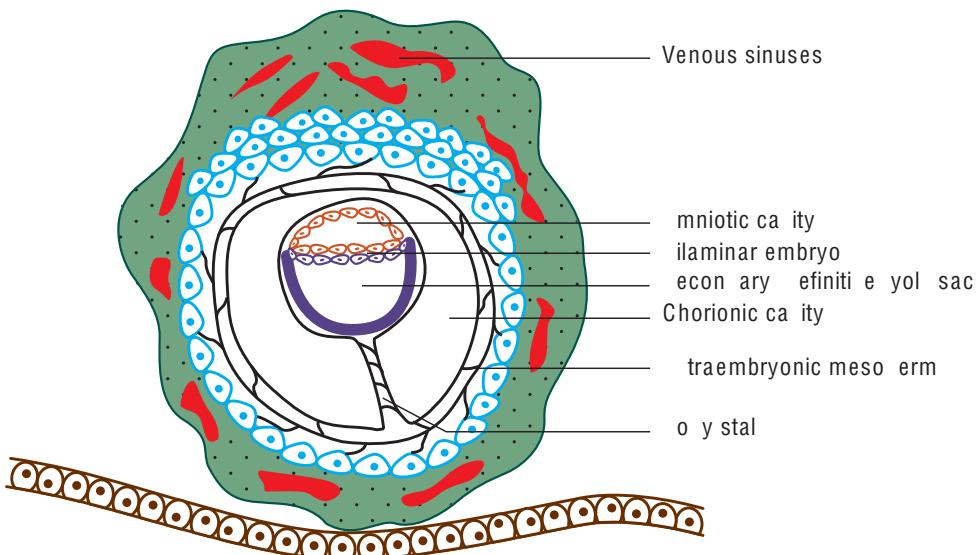


Figure 4.11 Formation of definitive yolk sac. Cells originate from the hypoblast and line the inner surface of the primitive yolk sac and form the definitive yolk sac. The cavities between the extraembryonic mesodermal cells have coalesced to become the chorionic cavity.

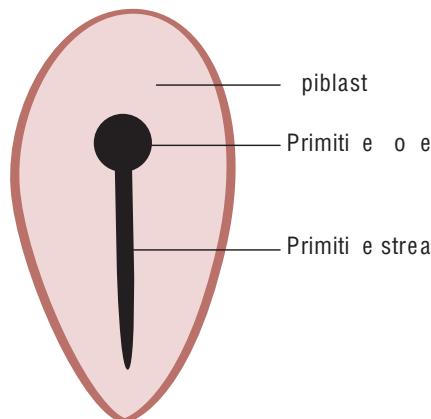


Figure 4.12 Primitive streak and node. Primitive streak appears as a thickening on the dorsal surface of epiblast. Primitive node is at the cephalic end of the primitive streak.

3rd week postfertilization, a thickening is noted on the dorsal aspect of the epiblast and this is called the *primitive streak*. The cephalic end of this streak is the *primitive node* (Fig. 4.12). The cells of the epiblast invaginate in the area of the primitive node and streak. Some cells displace the hypoblast and form a layer called the *endoderm*, and other cells that extend between the endoderm and epiblast become the *mesoderm*. The dorsal layer of epiblast forms the *ectoderm*. The embryo is now trilaminar with three layers—ventral endoderm, dorsal ectoderm, and a third layer between the two, the mesoderm (Fig. 4.13).

Organogenesis

Organogenesis or differentiation of cells into different organ systems begins after the formation

Box 4.8 Organogenesis

- Occurs during embryonic period
- Extends for 8 weeks from fertilization
- Formation of all organ systems
- Period most vulnerable to the effects of
 - drugs
 - radiation
 - infections
 - metabolic/endocrine abnormalities

of the three germ cell layers. It is almost completed by the end of the embryonic period (Fig. 4.14). The embryo measures about 40 mm in length; external genitalia are not developed at this time. A summary of organogenesis is presented in Box 4.8.

The three layers of the trilaminar embryo contribute to the development of organ systems with different functions (Box 4.9).

Fetal period

The fetal period begins 8 weeks after fertilization, or after 10 completed weeks' gestation, and continues until delivery. During this period, growth of various organs takes place (Box 4.10). The embryo grows laterally and longitudinally. The ends curve inward to assume the typical fetal shape. Further growth and development of the fetus to complete maturity depends on uteroplacental blood flow, fetal oxygenation, and genetic and environmental factors.

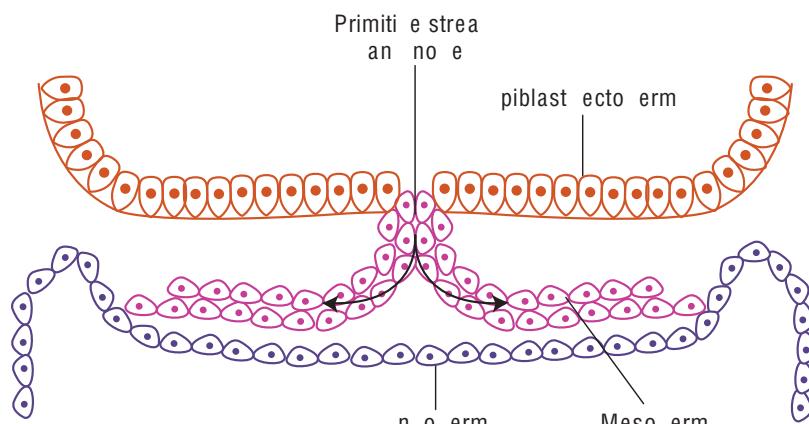


Figure 4.13 Trilaminar disc. The embryo has three layers. The cells of epiblast differentiate into dorsal ectoderm, ventral endoderm, and a layer of cells between the two, the mesoderm.

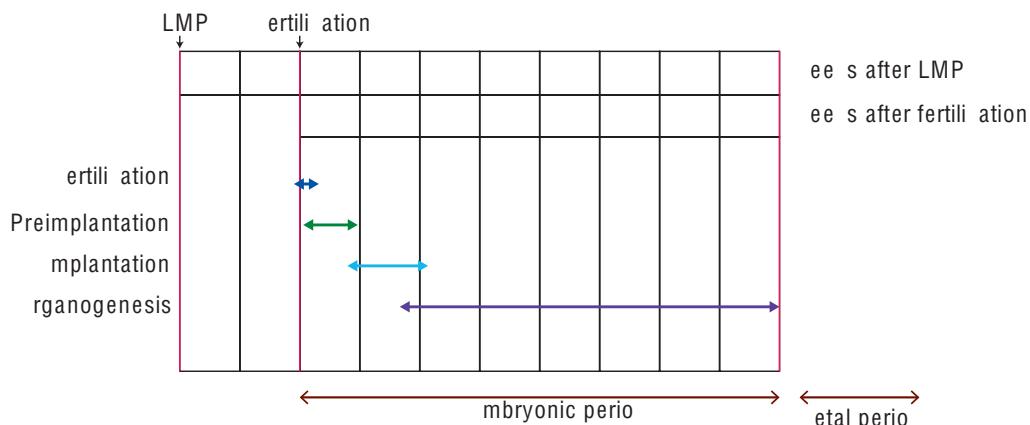


Figure 4.14 The embryonic and fetal period. Graph shows the embryonic and fetal period in weeks from the last menstrual period and from the day of fertilization.

Box 4.9 Organ systems developing from layers of embryo

Ectoderm	Endoderm	Mesoderm
<ul style="list-style-type: none"> Epidermis, nails, hair Central nervous system Peripheral nervous system Sensory epithelium of ear, nose, and eye Subcutaneous glands (pituitary, mammary, and sweat glands) 	<ul style="list-style-type: none"> Lining of gastrointestinal tract Liver, pancreas Lining of respiratory tract Thyroid/parathyroid Lining of lower urinary tract Lining of tympanic cavity and auditory tube 	<ul style="list-style-type: none"> All connective tissue Spleen Entire body musculature Blood/lymphatics Urogenital system and suprarenal cortex Skeletal system

Clinical implications

Clinical implications of events during fertilization are given below.

- Prior to organogenesis (from fertilization to Day 14)
 - Teratogens have no effect on the embryo
 - Severe insults cause miscarriage
- Secretion of human chorionic gonadotropin (hCG) by trophoblast by Day 14
 - Used for diagnosis of pregnancy
- Organogenesis (Day 14–Day 56)
 - Susceptible to teratogenic effects from
 - exposure to radiation/drugs and infections
 - poor glycemic control in diabetics

Development of fetal organ systems

The organ systems that are of relevance to the obstetrician are discussed in the following text.

Fetal cardiovascular system

In the cardiogenic plate, the heart develops initially as two tubular structures which fuse to form a single contractile tube and later into a four-chambered structure. The beating heart can be seen as cardiac activity on ultrasound scan by the 4th week after fertilization (6th week of gestation).

Box 4.10 Fetal period

- From the end of embryonic period till delivery
- Growth of organ systems affected by
 - uteroplacental blood flow
 - oxygenation
 - genetic factors
 - Environmental factors such as
 - smoking/tobacco
 - infections
 - Metabolic/endocrine milieu

fetal circulation

Fetal circulation differs from adult circulation for the following reasons:

- Oxygen and nutrients are supplied by the umbilical vein.
- Lungs are not functional and pulmonary circulation does not oxygenate the blood.
- Pulmonary vascular resistance is high.
- Deoxygenated blood is carried to the placenta by the umbilical arteries.

Fetal circulation is shown in Figure 4.15 and schematically represented in Figure 4.16.

The oxygenated blood from the placenta enters the fetus through the umbilical vein, which divides into the ductus venosus and portal sinus in the liver (hepatic circulation). Most of the blood flows through the ductus venosus to the inferior vena cava and reaches the right atrium. The portal sinus drains into the liver and the blood also reaches the right atrium through the hepatic vein. Deoxygenated blood from the lower half of the body (below the diaphragm) is also brought to the right atrium by the inferior vena cava.

Part of the blood from the right atrium is shunted into the left atrium through the foramen ovale and the rest flows into the right ventricle. Blood from the left atrium is pumped into the left ventricle and through the aorta supplies blood to the head and neck region. The deoxygenated blood from these regions returns through the superior vena cava to the right atrium. The blood that enters the right ventricle is pumped into the pulmonary artery. Almost 90% of this blood is shunted through the ductus arteriosus into the descending aorta and supplies the entire body distal to the left subclavian. Deoxygenated blood returns through the hypogastric artery (umbilical artery) to the placenta.

Changes in circulation at birth

Shortly after birth, the umbilical vein and ductus venosus collapse and close. Functional closure of foramen ovale and ductus arteriosus occurs

but fibrosis and complete occlusion occur few days later. The fibrosed ductus venosus becomes the ligamentum venosum. The lungs expand; the blood flows through the pulmonary circulation and gets oxygenated. The distal hypogastric arteries get obliterated and are called the *umbilical ligaments* (Box 4.11). The transition from intrauterine to extrauterine life is explained in more detail in Chapter 23, *The newborn*.

Fetal blood

Erythrocytes are produced initially by the yolk sac and later by the liver. By 18 weeks, bone marrow is formed. Fetal erythrocytes are nucleated and larger in size than adult erythrocytes. Erythropoiesis is controlled by fetal erythropoietin. Fetal hemoglobin or hemoglobin F has higher affinity for oxygen, making it easier for the fetus to extract oxygen from maternal circulation. The level of hemoglobin F decreases toward term, and it is gradually replaced by adult hemoglobin.

Platelets are produced in the yolk sac, and leukocytes are produced by the spleen and thymus. Immunoglobulin M (IgM) is produced by the fetus in response to infection. Maternal immunoglobulin G (IgG) crosses the placenta and can be detected in fetal circulation.

Fetal respiratory systems

The anatomical development of lungs begins by 25 weeks. Fetal breathing movements can be seen, but the lungs do not serve the function

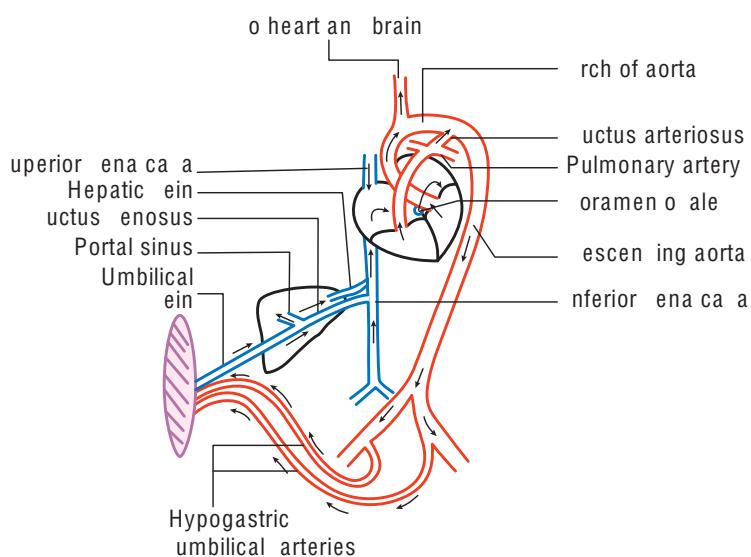


Figure 4.15 The fetal circulation, a diagrammatic representation.

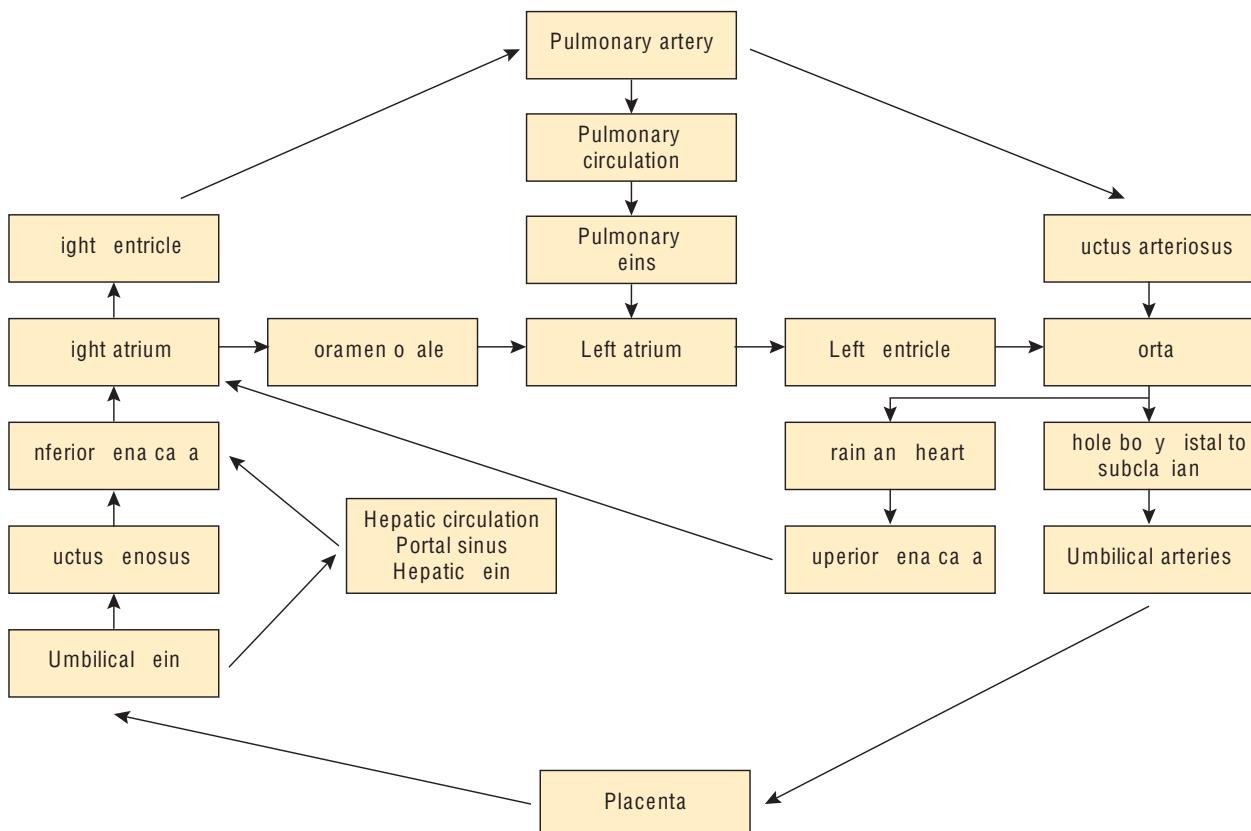


Figure 4.16 The fetal circulation, a schematic representation.

Box 4.11 Changes in circulation at birth

- Closure of
 - umbilical vein
 - ductus venosus
 - foramen ovale
 - ductus arteriosus
- Expansion of lungs
- Establishment of pulmonary circulation
- Obliteration of hypogastric arteries

of oxygenation until after birth. Type II pneumocytes produce *surfactants* which prevent alveolar collapse. Surfactants are made of glycerophospholipids, mainly lecithin. Lecithin may be dipalmitoylphosphatidylcholine, phosphatidylglycerol, or phosphatidylinositol. Lack of surfactant (in a premature neonate) results in respiratory distress syndrome (RDS). Levels of surfactants increase with gestational age and lung maturity. Corticosteroids induce production of surfactant and are used in preterm deliveries to accelerate pulmonary maturity and prevent RDS. Box 4.12 summarizes important features of the fetal respiratory system.

Box 4.12 Fetal respiratory system

- Development of lungs begins at 25 weeks
- Breathing movements seen at 12 weeks
- Oxygenation of blood begins at birth
- Type II pneumocytes produce surfactants
- Surfactants
 - Consist of glycerophospholipids such as
 - dipalmitoylphosphatidylcholine
 - phosphatidylglycerol
 - phosphatidylinositol
 - Prevent alveolar collapse
 - Are required to prevent RDS
 - Can be induced by corticosteroids

DS respiratory distress syndrome.

Fetal thyroid gland

Thyroid hormones are secreted by 12 weeks' gestational age. They play a major role in fetal growth and the development of organ systems, including the brain. Congenital hypothyroidism does not manifest as cretinism at birth because small amounts of maternal T4 cross the placenta. However, early neonatal screening using thyroid-stimulating hormone (TSH) levels must

be performed so that congenital hypothyroidism is diagnosed and treatment initiated immediately after birth to avoid mental retardation.

Thyroid-stimulating/-inhibiting immunoglobulins cross the placenta and can cause neonatal hyperthyroidism or hypothyroidism. Antithyroid drugs cross the placenta, and therefore, overtreatment of maternal hyperthyroidism can lead to fetal hypothyroidism, interfering with fetal growth and development.

The fetal thyroid has a greater affinity for iodine; therefore, administration of excess of iodide to the mother must be avoided. The use of radioactive iodine for treatment of the mother is contraindicated in pregnancy. Important features of fetal thyroid gland are listed in Box 4.13.

Fetal gastrointestinal system

Gastrointestinal peristaltic movements, fetal swallowing, and gastric emptying are seen by

Box 4.13 Fetal thyroid gland

- Fetal thyroid hormone
 - Secreted by 12 weeks
 - Plays major role in fetal growth and development
 - Affects development of brain
- Thyroid-stimulating/-inhibiting immunoglobulins
 - Cross the placenta
 - Can cause neonatal hyper-/hypothyroidism
- Fetal thyroid has high affinity for iodine

12 weeks' pregnancy. The contents of the fetal bowel, known as *meconium*, consist of undigested debris, lanugo hair, desquamated cells, secretions of glands, and swallowed vernix. The green color is due to biliverdin. Meconium passage occurs due to passage of bowel peristalsis which is normal at term. It can also occur in response to vagal stimulation and hypoxia. When aspirated, meconium causes chemical pneumonitis.

Key points

- Ovulation occurs on Day 14 of a 28-day cycle and 14 days prior to onset of menstruation in longer cycles, 36 hours after the beginning of the luteinizing hormone (LH) surge, and 12 hours after the peak. The first meiotic division of the oocyte takes place and the first polar body is released immediately after the LH surge.
- Fertilization is the fusion of the nucleus of the oocyte with that of the sperm. This takes place in the fallopian tube. The window of opportunity for fertilization, or the fertile period, extends from 48 hours prior to ovulation to 24 hours after.
- The fertilized ovum, known as the *ygote*, divides and becomes a morula in 3 days. This enters the uterine cavity.
- With accumulation of fluid, the solid morula becomes a blastocyst. The cells differentiate into the inner cell mass and peripheral trophoblasts.
- Zona hatching occurs and implantation of the blastocyst into the uterine wall takes place.
- The trophoblasts differentiate into inner cytotrophoblasts and outer syncytiotrophoblasts. They burrow into the decidua and later form the fetal component of the placenta.
- Implantation has three stages—apposition, adhesion, and invasion.
- The specialized endometrium of pregnancy is called *decidua*. Depending on its location in the uterus, the decidua is termed *decidua capsularis*, *basalis* and *parietalis*.
- The decidua has three layers—stratum compactum, spongiosum, and basalis. Stratum compactum consists of epithelioid cells and natural killer (NK) cells.
- The conceptus is known as *embryo* for a period of 8 weeks from fertilization and as *fetus* thereafter till birth.
- The inner cell mass, which develops into the embryo, arranges itself into two layers—the epiblast and hypoblast—by the 2nd week. The amniotic cavity and the yolk sac develop in the epiblast and hypoblast respectively.
- Extraembryonic mesoderm and chorionic cavity appear in the space between trophoblasts and yolk sac.
- The primitive streak and node appear in the epiblast. Cells from the epiblast invaginate at the streak and node to form mesoderm and endoderm. The dorsal layer of epiblast forms the ectoderm. The embryo now has three layers.
- The critical period of organogenesis begins 2 weeks after fertilization and extends till the end of the embryonic period. During the fetal period, only growth and development take place.
- From ectoderm, endoderm, and mesoderm various organ systems develop.
- Fetal circulation is different from the adult one in that the placenta supplies oxygen and nutrients, lungs are not functional, the umbilical vein carries oxygenated blood, a large amount of blood from the right atrium is shunted to the left atrium through the foramen ovale, and blood from the pulmonary artery is redirected to the descending aorta through the ductus arteriosus.

(Continued)

Key points *Continued*

- Surfactant is essential to prevent alveolar collapse and is secreted by type II pneumocytes. The production of surfactant increases with gestational age and pulmonary maturity.
- Fetal thyroid hormone is essential for fetal growth and development including development of the brain. Thyroid-stimulating and -inhibiting immunoglobulins cross the placenta. The fetal thyroid has a great affinity for iodine.
- Meconium is formed in the lumen of the intestines from debris, lanugo hair, vernix, and glandular secretions. Biliverdin gives the green color. Meconium passage occurs when the fetus is mature or due to hypoxia/vagal stimulation.

Self-Assessment

Case-based questions

Case 1

Mrs. LN, 28, married for 4 years, came to the hospital with a history of three previous children with congenital anomalies and early neonatal death. She was advised preimplantation genetic diagnosis.

1. Describe the preimplantation phase of embryonic period.
2. When are the first and second polar bodies released?
3. What is preimplantation genetic diagnosis?

Case 2

Mrs. NC, primigravida, presented at 14 weeks with hyperthyroidism under treatment with antithyroid medication.

1. Can the fetus be affected? How?
2. How will you manage this patient?
3. She was advised treatment with radioactive iodine just before she conceived. Will you proceed with it?

Answers

Case 1

1. Embryonic period begins with fertilization. The fertilized embryo or zygote becomes morula by mitotic division by Day 3. Fluid accumulates between the cells and this becomes a blastocyst. The cells in the blastocyst arrange themselves into inner cell mass and peripheral trophoblasts. Trophoblasts burrow into the decidua and implantation takes place.

2. First polar body is released immediately after luteinizing hormone surge, just before ovulation, while the second polar body is released immediately after fertilization.
3. Diagnosis of chromosomal or genetic disorders by sampling polar body, blastomere, or blastocyst, to select embryos which are not affected by abnormality.

Case 2

1. Fetus can be affected by the following:
 - a. Transplacental passage of thyroid-stimulating immunoglobulin, causing neonatal hyperthyroidism.
 - b. Transplacental passage of antithyroid medications, causing fetal hypothyroidism.
2. The patient can be managed by close monitoring of thyroid function tests and adjustment of dose of medications to avoid overtreatment.
3. The fetal thyroid has high affinity for iodine. Radioactive iodine treatment should not be given in pregnancy.

Sample questions

Long-answer question

1. Discuss the process of fertilization and implantation.

Short-answer questions

1. Implantation
2. Fetal circulation
3. Organogenesis
4. Surfactant

5

Placenta, Fetal Membranes, and Amniotic Fluid

Case scenario

Mrs. DK, 23, primigravida at 30 weeks of pregnancy, was referred to the outpatient clinic for evaluation of reduced amniotic fluid. Mr. and Mrs. DK were software engineers and the couple had been surfing the net for information regarding amniotic fluid. They wanted to know why the fluid was less, how the fluid is produced, and what were the clinical implications of reduced fluid.

Introduction

The human placenta is the anatomical and physiological connection between the fetus and mother. The fetal membranes are an integral component of the placenta and gestational sac. Amniotic fluid fills the amniotic cavity and surrounds the fetus. The placenta, membranes, and amniotic fluid play a key role in fetal nutrition, oxygenation, and maintenance of pregnancy through their many functions.

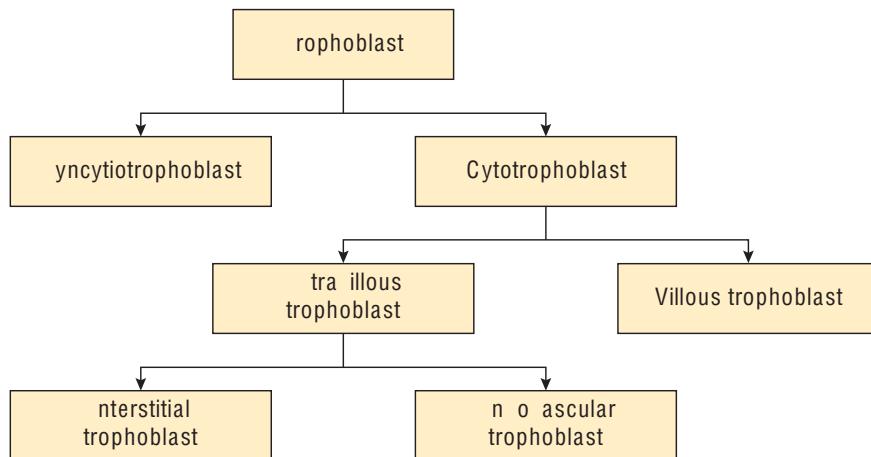
Development of the placenta

Placental development starts with implantation. At the time of implantation, the cells of the

blastocyst have differentiated into the inner cell mass or embryoblast and the outer cell mass or trophoblast (*see Chapter 4, Fertilization, implantation, and fetal development*). The trophoblast differentiates further, invades the decidua and develops into the placenta.

Differentiation of trophoblast

The trophoblast further differentiates into an outer multinucleated layer with no distinct cell walls, known as syncytiotrophoblast, and an inner layer of mononucleated cells, known as cytotrophoblast. The syncytiotrophoblast is formed by mitotic division and migration of cytotrophoblast cells. The cytotrophoblast further differentiates as shown in Figure 5.1. The differentiated trophoblast has specific functions which will be discussed later.

**Figure 5.1 Differentiation of trophoblast.**

Implantation of the blastocyst takes place at the embryonic pole; the trophoblast in this area develops into the fetal portion of placenta. By Day 9–10, vacuoles appear in the syncytiotrophoblast at the embryonic pole and coalesce to form large lacunae. The maternal capillaries are dilated to form sinusoids (Fig. 5.2). The lacunae and sinusoids merge to form *intervillous spaces* (Fig. 5.3). Blood from the maternal spiral arteries later enters the intervillous spaces.

Development of chorionic villi

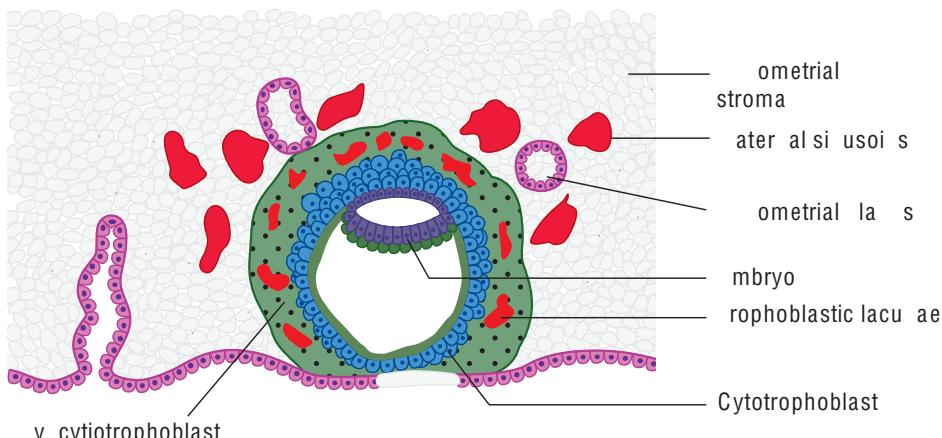
By Day 11–12, solid columns arising from the cytotrophoblast project into the decidua. These have an inner core of cytotrophoblasts covered by a layer of syncytiotrophoblasts and form the primary villi. The extraembryonic mesodermal

cells invade the villi and the villi are now known as secondary villi. Angiogenesis takes place in the mesoderm, giving rise to tertiary villi (Fig. 5.4a and b). Characteristic features of chorionic villi are presented in Box 5.1.

The tertiary villi protrude into the sinusoids and the fetal blood is separated from the maternal blood by the following four layers:

- Syncytiotrophoblast
- Cytotrophoblast
- Connective tissue of the villi
- Vascular endothelium

The human placenta is *hemochorial*, that is, the maternal blood (*hemo-*) comes in contact with chorionic villi (-chorial). The villous capillaries connect with vessels in the connecting stalk (umbilical cord) and later with intraembryonic

**Figure 5.2 Formation of trophoblastic lacunae and maternal sinusoids.** Vacuoles appear in the syncytiotrophoblast and coalesce to form lacunae. The maternal capillaries dilate to form maternal sinusoids.

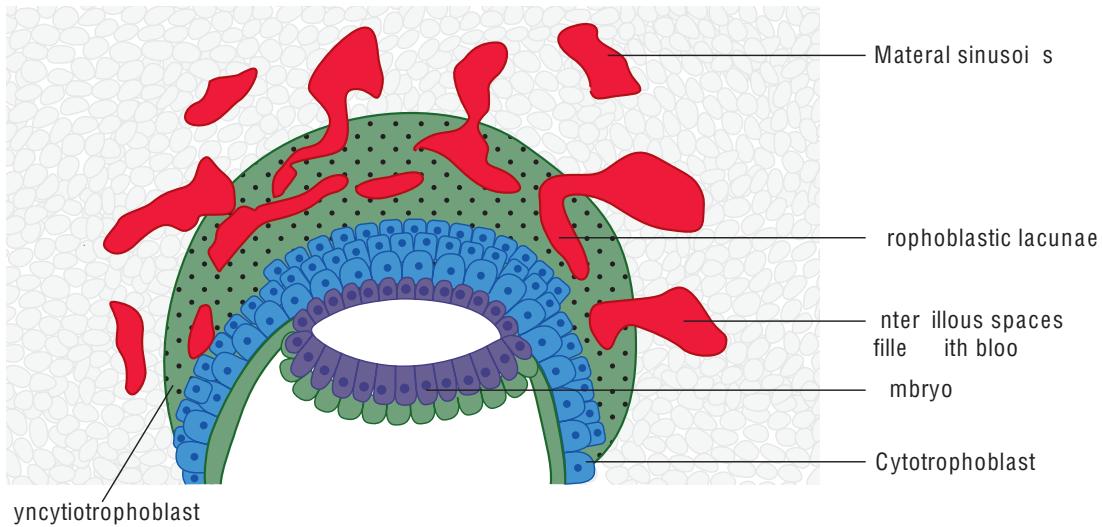


Figure 5.3 Formation of intervillous spaces. The lacunae and maternal sinusoids merge to form intervillous spaces.

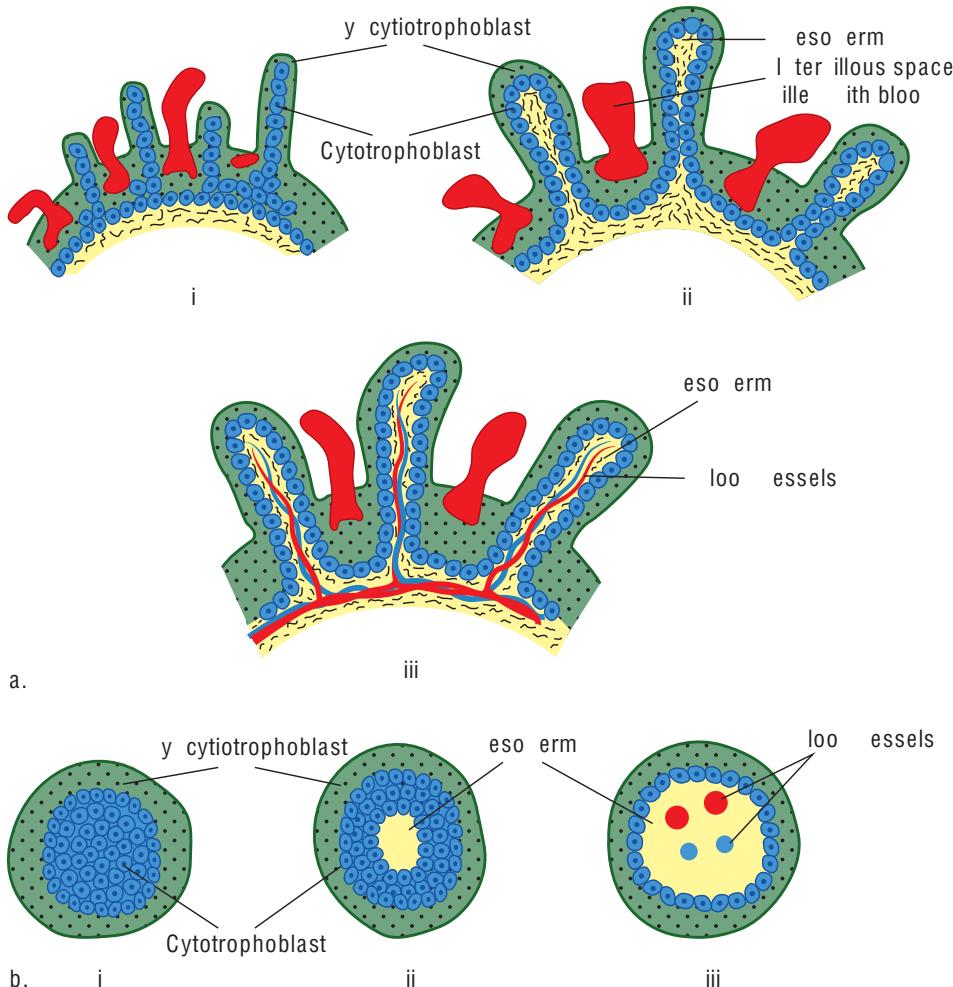


Figure 5.4 Structure of villi. **a.** Longitudinal section i. Primary villi lined by syncytiotrophoblast and cytotrophoblasts ii. Extraembryonic mesoderm extends into the secondary villi iii. Blood vessels are formed in the mesoderm in tertiary villi. **b.** Cross-section showing the trophoblast, mesoderm, and inner core of blood vessels i. Primary villi ii. Secondary villi iii. Tertiary villi.

Box 5.1 Chorionic villi

- Primary villi
 - Syncytiotrophoblast
 - Cytotrophoblast
- Secondary villi
 - Inner core of mesoderm
- Tertiary villi
 - Blood vessels in the mesoderm

blood vessels, thus establishing the fetoplacental circulation by the end of the 3rd week. The heart begins to beat by early 4th week and the circulation begins to function. Maternal blood enters the intervillous space in spurts from the

spiral arteries and exchange of nutrients and gases takes place between capillaries in the villi and maternal blood (Fig. 5.5).

The chorionic villi surround the entire blastocyst to begin with. The villi at the embryonic pole of the blastocyst proliferate further and are known as *chorion frondosum*. These later develop into the fetal side of the placenta. The villi covering the rest of the blastocyst (facing the uterine cavity) degenerate and are known as *chorion laeve* (Fig. 5.6). As the blastocyst expands to fill the uterine cavity, the amnion, chorion laeve and decidua capsularis fuse to form the *amniochorion*, which in turn fuses with the decidua parietalis and obliterates the uterine cavity (Fig. 5.7).

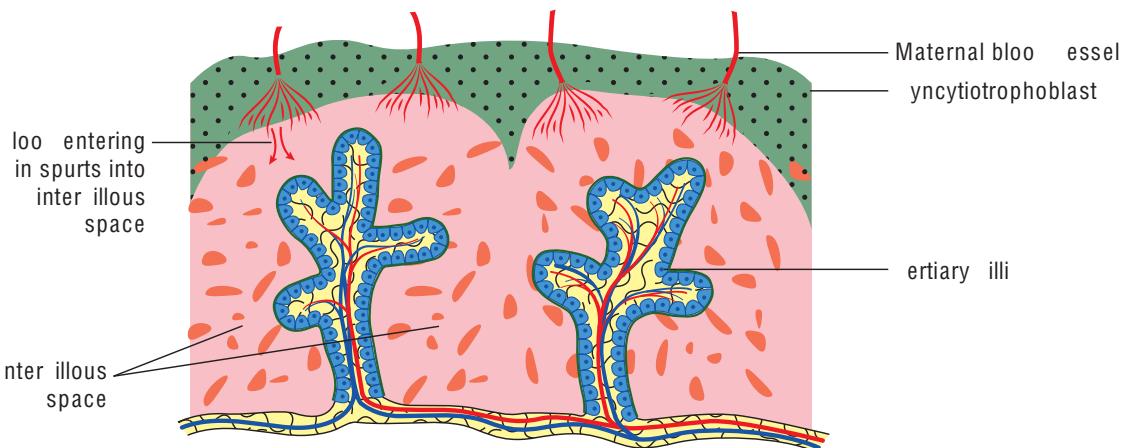


Figure 5.5 Hemochorial placenta. Maternal blood enters the intervillous spaces in spurts, bathing the chorionic villi to exchange nutrients and gases.

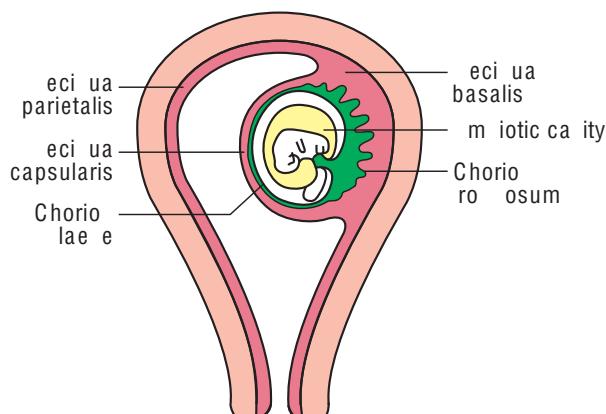


Figure 5.6 Chorion frondosum and chorion laeve. The chorionic villi at the embryonic pole of the blastocyst proliferate to form chorion frondosum and the chorionic villi covering the rest of the blastocyst degenerate to form chorion laeve.

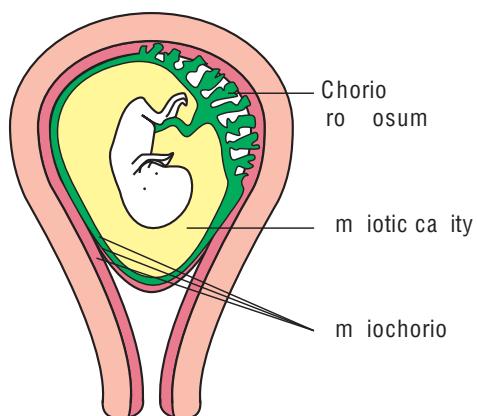


Figure 5.7 Formation of amniochorion. Amniotic sac, chorion laeve, decidua capsularis, and decidua parietalis fuse to form the amniochorion and obliterate the uterine cavity.

From the tip of some of the villi, cytотrophoblastic cells proliferate and attach themselves to the decidua basalis, forming the *stem villi* or *anchoring villi*. Smaller villi branch off from the side of the stem villi and float freely in the intervillous space. These are the *terminal villi*. Meanwhile, placental septae develop from the decidua and extend into the intervillous space between the main stem villi. Each main stem villus with its branches supplies one *cotyledon* (Fig. 5.8).

By 12–14 weeks, the cytотrophoblast cells and connective tissue of the villi disintegrate and the maternal blood is separated from the fetal blood by only two layers:

- Thinned out syncytiotrophoblastic layer
- Vascular endothelium

This further facilitates exchange of nutrients and oxygen.

Extravillous trophoblastic invasion

Meanwhile, the interstitial trophoblastic cells first invade the decidua basalis, inner third of the myometrium, and surround the spiral arteries.

In the myometrium, they fuse and form multinucleated giant cells known as placental bed giant cells. The interstitial trophoblast cells in the myometrium interact with cells of maternal immune system. The endovascular trophoblast cells penetrate the lumen of the spiral arteries and cause remodeling of the vessel wall. They initially form cellular plugs that are later displaced, allowing blood to flow through the spiral arteries. Eventually the musculature of the vessel wall is destroyed and replaced by fibrinoid material. This leads to the spiral arteries being converted into low-resistance vessels to facilitate blood flow (Fig. 5.9).

Trophoblastic invasion of spiral arteries occurs in two phases. The first phase occurs by 12 weeks after fertilization and extends into the decidua basalis. The second phase of invasion extends to the myometrium and is completed by 16 weeks postfertilization (Box 5.2). Failure of trophoblastic invasion of spiral arteries results in reduction in placental blood flow and is implicated in the causation of preeclampsia, fetal growth restriction, placental abruption, prelabor rupture of membranes, and preterm labor.

The syncytiotrophoblast, villous and extravillous trophoblasts serve different functions as listed in Box 5.3.

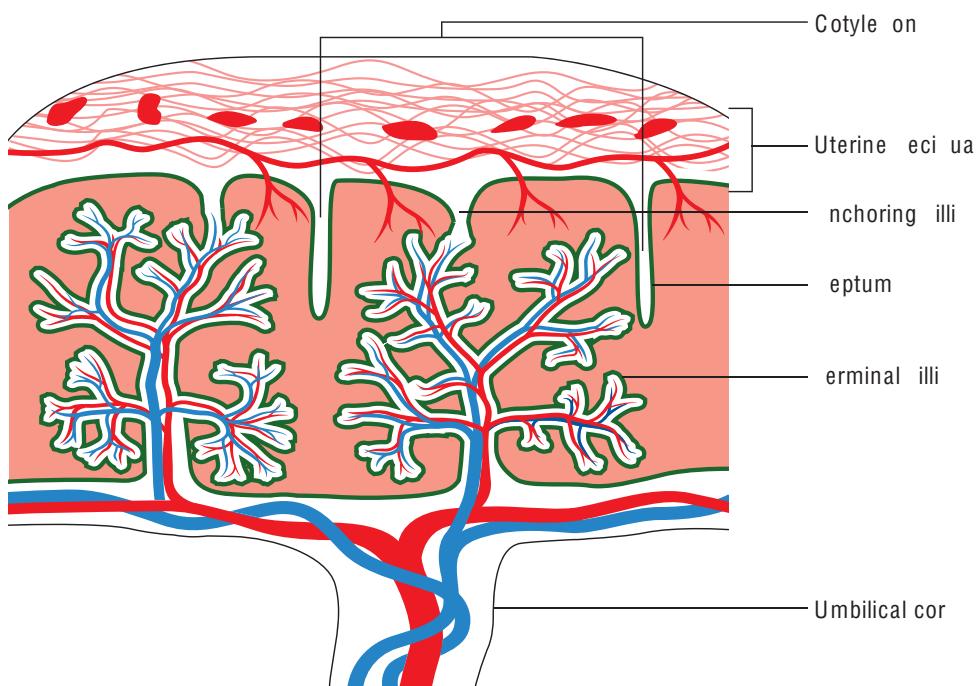


Figure 5.8 Formation of cotyledon. Placental septae extend between main stem villi. Each main stem villus with its branches separated by septae forms a cotyledon.

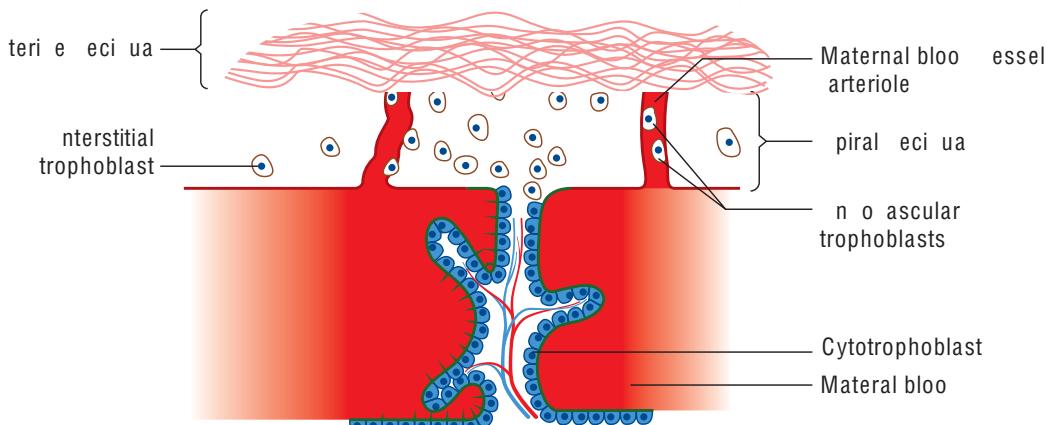


Figure 5.9 Extravillous trophoblastic invasion. The interstitial trophoblast invades the decidua and myometrium. The endovascular trophoblast penetrates the lumen of the spiral arterioles.

Regulation of trophoblastic invasion

Early trophoblastic invasion and later limitation of the same process are regulated by several substances produced by the placenta as listed in Box 5.4.

Box 5.4 Substances regulating trophoblastic invasion

- Matrix metalloproteinases
- Vascular endothelial growth factor (VEGF)
- Insulin-like growth factor 2 (IGF-2)
- Tissue inhibitors of metalloproteinases
- Oxygen
- Decidual natural killer cells (lymphocytes)

- insulin-like growth factor 2; vascular endothelial growth factor.

Box 5.2 Extravillous trophoblastic invasion

- Interstitial trophoblast
 - Invades decidua basalis and myometrium
 - Forms placental bed giant cells
- Endovascular trophoblast
 - Invades spiral arteries
 - First phase (by 12 weeks): Invades arteries in decidua
 - Second phase (by 16 weeks): Invades arteries in myometrium

Box 5.3 Functions of the trophoblasts

- Syncytiotrophoblast
 - Transports nutrients and gases
 - Secretes peptide and steroid hormones
- Villous trophoblast
 - Formation of villi
 - Transports of nutrients and gases
- Interstitial trophoblast
 - Interacts with cells of maternal immune system
- Endovascular trophoblast
 - Facilitates placental blood flow

The placenta

The placenta is well formed by 12 weeks and consists of *fetal portion* (chorion frondosum) and *maternal portion* (decidua basalis), with intervillous spaces between the two. The fetal surface is covered by chorion and amnion. The umbilical cord is attached to the fetal surface usually at a central location. *Decidual septae* extend from the decidua basalis toward the chorion and from grooves on the maternal surface of the placenta that separate the cotyledons. The septae do not reach the chorionic plate but stop short at the intervillous space so that blood flow between the cotyledons is uninterrupted. Fetal macrophages known as *Hofbauer cells* infiltrate the placental stroma. They have immunosuppressive function and secrete cytokines. The placenta enlarges as gestation progresses and covers 15%–30% of the uterine surface. At term, the placenta is 15–25 cm in diameter and weighs

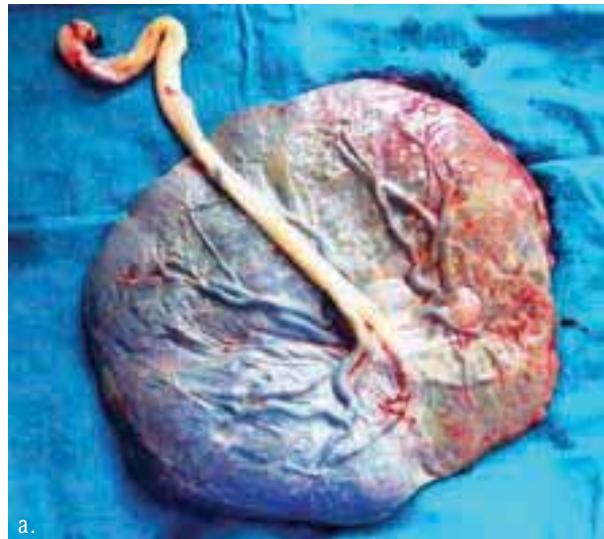
about 500–600 g (one-sixth the weight of the fetus) (Fig. 5.10). Some important features of the placenta are given in Box 5.5.

Development of the umbilical cord

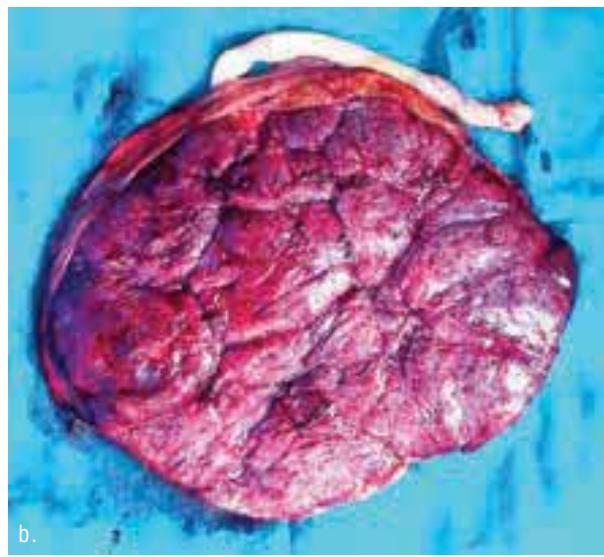
At 5–6 weeks after fertilization, the embryo lies between the amniotic cavity and yolk sac. The dorsal surface of embryo grows faster and the embryo curves ventrally as the dorsal surface bulges into the amniotic cavity. The yolk sac is incorporated into the body of the embryo; the

Box 5.5 The placenta

- Well formed by 12 weeks
- Term placenta
 - 15–25 cm in diameter
 - 500–600 g in weight
 - 3 cm in thickness
 - Covers 15%–30% of inner uterine surface
- Has two parts:
 - Fetal: Chorion frondosum
 - Maternal: Decidua basalis
- Maternal surface
 - Cotyledons
- Fetal surface
 - Covered by amnion and chorion
 - Blood vessels
 - Umbilical cord attachment (usually central)



a.



b.

Figure 5.10 Gross appearance of the placenta. **a.** Fetal surface with umbilical cord attached. **b.** Maternal surface showing cotyledons.

amniotic cavity enlarges and fuses with the chorion laeve. The body stalk is also covered laterally by the amnion and this is now known as the umbilical cord (Fig. 5.11).

The primitive umbilical cord contains part of the yolk sac, the allantois, vitelline duct, and loops of bowel. Later, the loops of bowel are gradually withdrawn, the allantois and vitelline duct are obliterated, the two umbilical arteries and one vein are covered by *Wharton's jelly*, which is in turn covered by the amnion (Fig. 5.12). Occasionally, obliterated vitelline duct and allantois may be present. The contents of the umbilical cord at term are listed in Box 5.6.

Box 5.6 Contents of the umbilical cord at term

- Covering epithelium
- Wharton's jelly
- Blood vessels
 - Two arteries
 - One vein
- Occasionally
 - Obliterated vitelline duct
 - Obliterated allantois

Fetal membranes

The two fetal membranes are amnion and chorion.

The chorion

The chorionic membrane is derived from chorion laeve. It is separated from the amnion initially

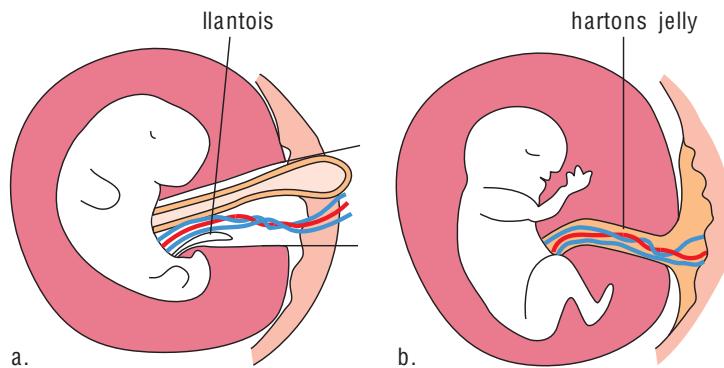


Figure 5.11 Formation of umbilical cord. **a.** At 10 weeks' gestation, the yolk sac, allantois, umbilical arteries, and vein are included in the umbilical cord. **b.** At 20 weeks' gestation, only the umbilical arteries and vein are present, covered by Wharton's jelly.

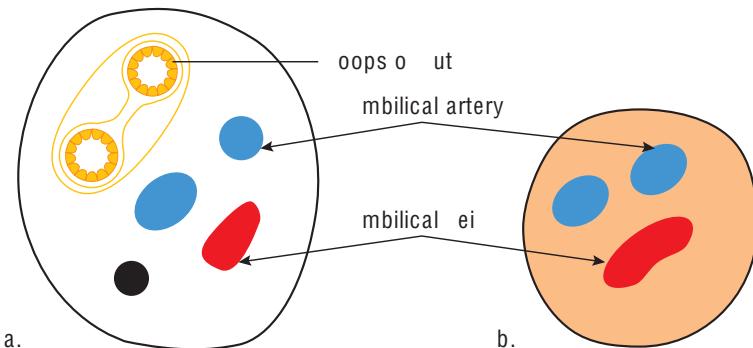


Figure 5.12 Cross-section of the cord. **a.** At 10 weeks' gestation, containing loops of gut, allantois, and umbilical vessels. **b.** At term, containing two arteries and a vein, covered in Wharton's jelly.

by the chorionic cavity but later, as the chorionic cavity disappears, fuses with the amnion (Fig. 5.7). There may be loose connective tissue between the amnion and chorion.

The amnion

The amnion is derived from fetal ectoderm and is a tough membrane that surrounds the fetus. It lines the fetal surface of the placenta and umbilical cord. The amnion has no blood vessels, nerves, or lymphatics. It has five layers:

- Inner layer of cuboidal epithelium
- Basement membrane
- Acellular compact layer made of collagen
- Fibroblast-like mesenchymal layer
- Outer layer of acellular, loose connective tissue between amnion and chorion

Functions of amnion

Amnion is not just a membrane forming a cavity to house the fetus. The epithelial cells synthesize fibronectin, prostaglandin, interleukin, vasoactive peptides such as endothelin and parathyroid hormone-related peptide (PTH-RP), and corticotropin-releasing hormone (CRH). The mesenchymal cells of the amniotic fibroblasts synthesize collagen, interleukin, and prostaglandins. The collagen provides remarkable tensile strength and does not break or rupture easily. It is elastic and expands to accommodate the growing fetus. Solute and water transport also takes place through the amnion (Box 5.7).

Amniotic fluid

Amniotic fluid fills the amniotic cavity and surrounds the fetus from early pregnancy.

Box 5.7 Functions of amnion

- Synthesis of substances
 - Epithelial cells synthesize
 - Fibronectin
 - Prostaglandin
 - Interleukin
 - Vasoactive peptides
 - Endothelin
 - Parathyroid hormone-related peptide
 - Corticotropin-releasing hormone
 - Mesenchymal cells synthesize
 - Collagen
 - Prostaglandin
 - Interleukin
- Mechanical functions
 - Collagen provides
 - tensile strength
 - elasticity
- Metabolic functions
 - Transport of water and solutes

Formation

Early in pregnancy, there are two cavities surrounding the embryo—the amniotic cavity surrounded by amnion, and the exocoelomic cavity (or chorionic cavity) surrounded by chorion and containing coelomic fluid, (see Chapter 4, *Fertilization, implantation, and fetal development*). The amniotic cavity gradually enlarges and the chorionic cavity decreases in size. By the 14th week of gestation, the amnion and chorion fuse

and the chorionic cavity disappears, leaving only the amniotic cavity filled with amniotic fluid.

Sources

Amniotic fluid is produced and cleared continuously. It has been estimated that the entire volume of amniotic fluid is replaced several times a day. The sources of amniotic fluid and routes of clearance are listed in Box 5.8 and also shown in Figure 5.13.

Major sources of production

Fetal urine production increases gradually from midtrimester and is about 1000–1200 mL/day at term. Maternal position and gestational age influence rate of urine production. Hourly urine production reduces 2 weeks prior to onset of

Box 5.8 Production and clearance of amniotic fluid

- Major sources of production
 - Fetal urine
 - Fetal lung fluid
- Major routes of clearance
 - Fetal swallowing
 - Intramembranous transfer to fetal blood
- Minor sources of production
 - Secretions from fetal oral–nasal cavities
- Minor routes of clearance
 - Transmembranous transfer to maternal blood

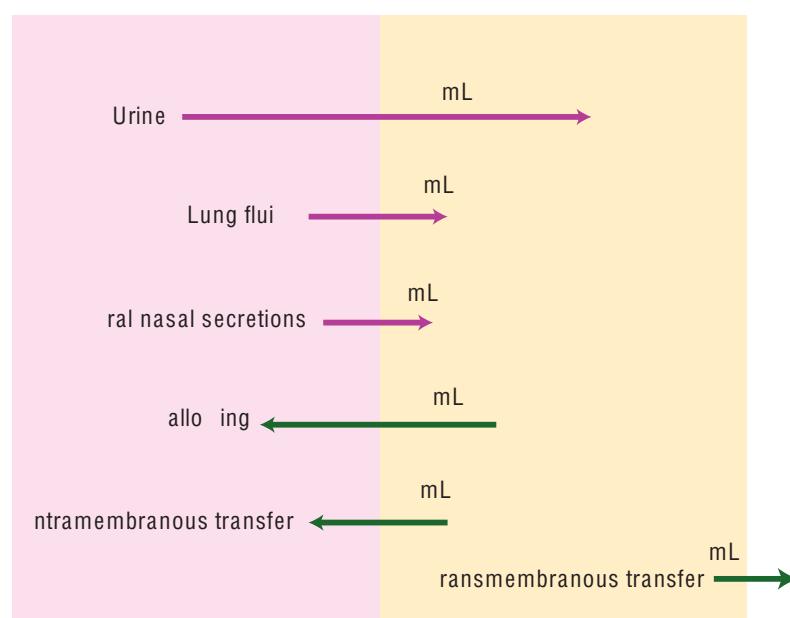


Figure 5.13 Diagrammatic representation of sources and routes of clearance of the amniotic fluid.

labor. Placental insufficiency, fetal cardiac failure, and outflow obstruction in the urinary tract cause marked reduction in urine production. This can result in oligohydramnios.

Fetal lung secretions fill the respiratory tract. The total volume secreted is about 400 mL/day. Fifty percent of the fluid exits through the mouth into the amniotic fluid and the other 50% is swallowed by the fetus. Lung secretions are reduced in fetal asphyxia and during labor.

Ma or routes of clearance

Fetal swallowing increases with gestational age and is about 500–1000 mL/day at term. Swallowing is much less in fetuses with esophageal or duodenal atresia and in neurologic abnormality such as anencephaly. This may result in polyhydramnios.

Intramembranous transfer occurs across the blood vessels on the fetal surface of the placenta. Water and solutes are transported to the fetus due to osmotic gradient between the amniotic fluid and fetal blood. About 400 mL of fluid is absorbed by this route.

Minor sources of production and routes of clearance

These are secretions from the nasal/oral cavities that account for about 25–30 mL of fluid. Transmembranous absorption of about 10 mL of amniotic fluid occurs through the decidua into the maternal circulation.

Composition

The amniotic fluid contains carbohydrates, proteins, peptides, lipids, urea, creatinine, uric acid, lactate, pyruvate, electrolytes, enzymes, and hormones. Glycerophospholipids in the amniotic fluid include lecithin, sphingomyelin, phosphatidylglycerol, and phosphatidylinositol. The presence of these components is used for diagnosis of fetal pulmonary maturity.

The hormones in amniotic fluid include estrogens, progesterone, cortisol, human chorionic gonadotropin (hCG), and insulin. Inhibin A and B are also present in the fluid. Levels of inhibin A, hCG, estriol, and alpha fetoprotein are used for prenatal screening for birth defects.

Several growth factors such as epidermal growth factor (EGF), transforming growth factors

(TGF) α and β , insulin-like growth factor-1 (IGF-1), erythropoietin, and granulocyte colony-stimulating factor (G-CSF) are also found in amniotic fluid. These factors are involved in the growth of various tissues and organs in the fetus.

Cells suspended in amniotic fluid are fetal epithelial cells, fibroblasts, amniocytes, pluripotent stem cells, and cells from the respiratory and urinary tract of the fetus. Fetal lanugo hair is also present. The fibroblasts obtained by amniocentesis are used for karyotyping and diagnosis of genetic and chromosomal disorders. Composition of amniotic fluid is given in Box 5.9.

Box 5.9 Composition of amniotic fluid

- Carbohydrates, proteins, lipids
- Urea, creatinine, uric acid, lactate, and pyruvate
- Electrolytes, enzymes, hormones
- Glycerophospholipids
 - Lecithin
 - Sphingomyelin
 - Phosphatidylglycerol
 - Phosphatidylinositol
- Growth factors
 - Epidermal growth factor
 - Transforming growth factors α and β
 - Insulin-like growth factor-1
 - Erythropoietin
 - Granulocyte colony-stimulating factor
- Cells
 - Fetal epithelial cells, fibroblasts
 - Amniocytes, stem cells

Characteristics

The pH of amniotic fluid is 7–7.5, which is much higher than the pH of the vagina (4–4.5). This change in pH is used as a test for rupture of membranes. The osmolality is 260–280 mOsm/L (Box 5.10). The fluid is clear in early gestation but becomes straw colored in the third trimester and bits of vernix appear by term.

Box 5.10 Characteristics of amniotic fluid

- pH: 7–7.5
 - Differentiates it from vaginal fluid
- Color
 - Early gestation: Clear
 - Third trimester: Straw colored, contains vernix
- Osmolality: 260–280 mOsm/L

Volume

The volume of amniotic fluid varies with gestational age. It has been estimated at different gestational ages using dye dilution technique. It increases progressively and rapidly from 8 weeks' gestation till 28 weeks' gestation, increases relatively slowly till 34 weeks, and remains more or less constant till 38 weeks. Thereafter, it reduces by 100 mL per week and is about 500 mL at 40 weeks (Box 5.11).

Box 5.11 Volume of amniotic fluid

- 12 weeks: 50 mL
- 16 weeks: 200 mL
- 28 weeks: 800 mL
- 34 weeks: 1000 mL
- 40 weeks: 500 mL

Clinical applications

Amniotic fluid analysis is performed for prenatal screening and diagnosis, and evaluation and management of certain clinical situations. The clinical applications are given in the Box 5.12.

Functions

Amniotic fluid surrounds the fetus and has several functions.

- Protects the fetus from trauma
- Prevents umbilical cord compression
- Supplies nutrients

Box 5.12 Clinical applications of amniotic fluid analysis and pH of vaginal fluid

- Second trimester
 - Karyotyping of fetal cells
 - Fetal gender for X-linked disorders
 - Chromosomal defects
 - Diagnosis of intrauterine infections
 - Rubella
 - Toxoplasma
 - Cytomegalovirus
 - Parvovirus
- Third trimester
 - Bilirubin: Rh alloimmunization
 - Lecithin/sphingomyelin }
– Phosphatidylglycerol }
Fetal pulmonary maturity
 - pH of vaginal fluid
 - Rupture of membranes

- Provides space for the growth and development of
 - Fetal skeleton
 - Lungs
 - Gastrointestinal systems
- Provides growth factors
- Has antibacterial properties
- Maintains even temperature
- Forms a hydrostatic wedge in labor
 - Helps in cervical dilatation

Placental circulation

Oxygenated maternal blood enters the intervillous space in spurts, under pressure, through the spiral arteries. It bathes the villi which are free floating, and exchange of gases and nutrients takes place. The pressure gradually decreases as the blood enters the maternal veins and returns to the maternal circulation (Fig. 5.14).

The oxygenated blood from the villi enters the umbilical vein and reaches the fetal heart. Less oxygenated blood is brought by the umbilical arteries to the villi as described in Chapter 4, *Fertilization, implantation, and fetal development*. About 750 mL of blood flows through the placenta every minute and the blood in the intervillous space is replaced 3–4 times/min. During uterine contractions, there is no arterial or venous blood flow (Box 5.13).

Box 5.13 Placental circulation

- Rate of blood flow: 750 mL/min
- Replaced 3–4 times/min
- No blood flow during uterine contractions

Functions of placenta

The placenta is a unique organ that has a short life span but performs multiple key functions. It transfers nutrients and oxygen to the fetus, secretes hormones and has immunological functions.

Placental transfer

Transfer of nutrients, gases, and other substances is an important function of the placenta. Placental transfer is influenced by several factors as given below:

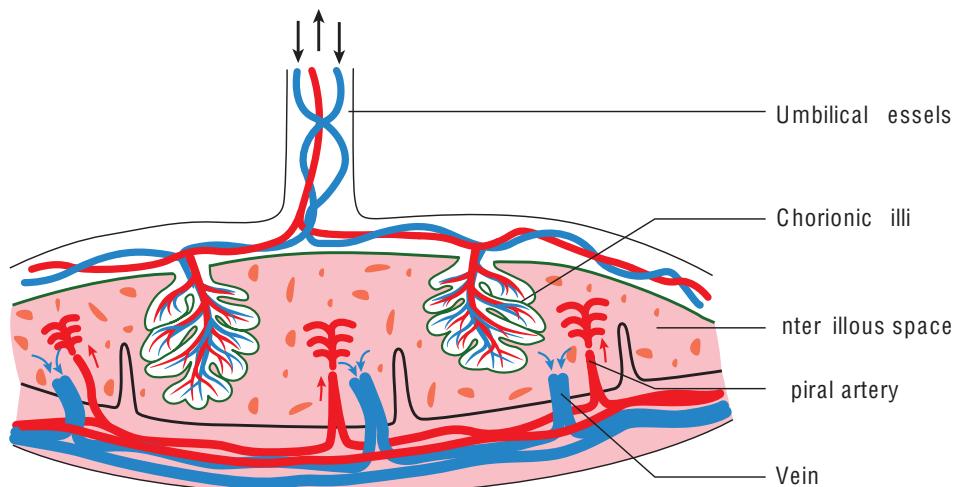


Figure 5.14 Placental circulation. Oxygenated blood from maternal blood enters the intervillous spaces through the spiral arteries. The blood returns to the maternal circulation through the veins.

- The concentration of the substance in maternal and fetal blood and the gradient between the two
- Proportion of bound and free forms of the substance
- Blood flow through placenta and villous capillaries
- Mechanism of transfer
- Area available for exchange of substance
- Amount of substance metabolized by placenta

Substances transferred across placenta by various mechanisms are listed in Table 5.1.

Metabolic functions

The placenta, in addition to transporting nutrients from the mother to fetus, also synthesizes glycogen to supply energy to the developing fetus, cholesterol as a precursor for steroid hormones and proteins for fetal nutrition. Lactate is produced as a waste product of metabolism (Box 5.15).

Mechanism of transfer

The mechanism of placental transfer of gases, nutrients and other substances is summarized in Box 5.14.

Box 5.14 Mechanism of placental transfer

- Simple diffusion
 - Passive transfer along concentration gradient
 - Transfers molecules of molecular weight <500 Da
- Facilitated diffusion
 - Active transfer against concentration gradient
- Endocytosis and exocytosis
 - Engulfing of substance in a vesicle and release of contents at the other end
- Carrier-mediated active transport
 - Uses ATP
 - Involves a carrier substance
- Bulk flow/solvent drag
 - Along hydrostatic/osmotic pressure gradient
 - Transfers water and dissolved substances
- Transfer through channels
 - Involves micropores in plasma membrane
 - Transfers small molecules

Endocrine functions

Placental hormones play a major role in maintenance of pregnancy, fetal and maternal

Table 5.1 Substances and their mechanisms of transport

Substances	Mechanism of transport
Oxygen	
Carbon dioxide	
Water	{ Simple diffusion
Electrolytes	
Anesthetic gases	
Ascorbic acid	
Iron	{ Facilitated diffusion
Lactate	
Glucose	
Amino acids	{ Carrier-mediated active transport
Calcium	
Fatty acids and triglycerides	
Proteins	{ Endocytosis and exocytosis

Box 5.15 Metabolic functions of placenta

Synthesis of the following:

- Glycogen
- Cholesterol
- Proteins
- Lactate

metabolism, and parturition. The corpus luteum secretes hormones, mainly estrogen and progesterone, in early pregnancy, but the placenta takes over as the major source of hormones by 7–9 weeks. Hormones secreted by the placenta are peptide hormones and steroid hormones. Placental hormones also serve autocrine or paracrine functions, that is, they act on the cells producing the hormone or on adjacent cells.

The peptide and steroid hormones secreted by the placenta are listed in Box 5.16.

Peptide and glycopeptides hormones

A number of peptide and glycopeptides hormones are produced by the placenta that play a crucial role in maintenance of pregnancy, glucose, fat and protein metabolism, and initiation of parturition.

Human chorionic gonadotropin

In the blastocyst stage, hCG, a glycoprotein, is produced by both cyto- and syncytiotrophoblast.

Box 5.16 Hormones secreted by the placenta

- Peptide hormones
 - Human chorionic gonadotropin
 - Human placental lactogen
 - Chorionic adrenocorticotropin
 - Relaxin
 - Parathyroid hormone-related peptide
 - Growth hormone variant
 - Releasing hormones similar to hypothalamic hormones
 - Gonadotropin-releasing hormone
 - Corticotropin-releasing hormone
 - Growth hormone-releasing hormone
 - Other peptide hormones
 - Leptin
 - Neuropeptide Y
 - Inhibin and activin
- Steroid hormones
 - Estrogens
 - Progesterone

After 5 weeks, it is produced by only the syncytiotrophoblast. It has two subunits: α and β . The α subunit is shared by LH, follicle-stimulating hormone (FSH) and thyroid-stimulating hormone (TSH), but the β subunit is characteristic and specific to hCG. Therefore, the β subunit is used in all measurements of hCG in pregnancy. Characteristics of hCG are given in Box 5.17.

Box 5.17 Human chorionic gonadotropin

- Glycoprotein
- Has α and β subunits
- β Subunit is specific to hCG
- α Subunit shared by LH, FSH, and TSH
- Secreted by syncytiotrophoblast
- Regulated by placental GnRH, inhibin, and activin

S follicle-stimulating hormone; n gonadotropin-releasing hormone; L luteinizing hormone; T thyroid-stimulating hormone.

hCG levels in maternal serum and urine

Human chorionic gonadotropin can be detected in maternal blood and urine 8–10 days after fertilization. The serum level is 100 mIU/mL at 2 weeks after fertilization, peaks to 100,000 mIU/mL at 10 weeks, and declines as shown in Fig. 5.15. By 16 weeks, a nadir is reached (20,000 mIU/mL) and maintained for the rest of the pregnancy (Box 5.18).

Box 5.18 Maternal serum human chorionic gonadotropin levels in pregnancy

- Detected by 7–10 days after fertilization
- Levels double every 48 hours
- Peaks by 8–10 weeks to 100,000 mIU/mL
- Begins to decline by 10–12 weeks
- Reaches a nadir by 16 weeks

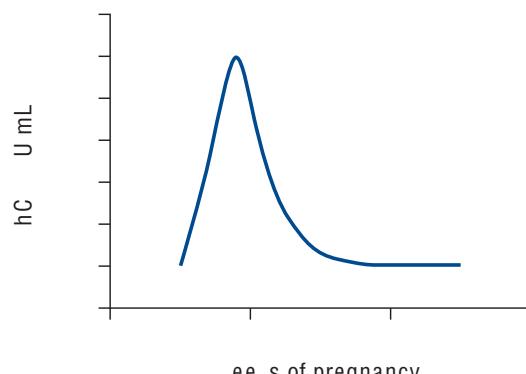


Figure 5.15 Serum human chorionic gonadotropin (hCG) levels in pregnancy. Level of hCG begins to rise by 7–10 days after fertilization, peaks by 8–10 weeks, and declines by 16 weeks.

Maternal urine contains the degradation product, namely, beta-core fragment. Levels in urine follow the serum levels.

Functions

Refer to Box 5.19.

Box 5.19 Functions of human chorionic gonadotropin

- Maintenance of corpus luteum
- Stimulation of
 - testicular testosterone in male fetus
 - maternal thyroid hormone production
 - relaxin secretion by corpus luteum

Clinical applications

Clinical applications of hCG are listed in the Box 5.20. The most important application is in the diagnosis of pregnancy. High levels ($>100,000$ mIU/mL) are found in multifetal pregnancy, gestational trophoblastic disease (GTD), Down syndrome, and erythroblastosis fetalis. Low levels are found in ectopic pregnancy and early pregnancy loss.

Box 5.20 Clinical applications of human chorionic gonadotropin (hCG)

Testing levels of hCG helps in the diagnosis of the following:

- Pregnancy
- Gestational trophoblastic disease
- Down syndrome
- Ectopic pregnancy
- Early pregnancy loss

Human placental lactogen

Also known as *chorionic somatomammotropin*, human placental lactogen (hPL) is secreted by syncytiotrophoblasts. The characteristics of this hormone are given in Box 5.21.

Box 5.21 Characteristics of human placental lactogen

- Polypeptide hormone
- Secreted by syncytiotrophoblasts
- Has a structure similar to prolactin
- Has plasma half-life of 20–30 s
- Levels depend on placental mass
- Stimulated by insulin and IGF-1
- Inhibited by PGE₂ and PGF_{2α}

- , insulin-like growth factor 1; P prostaglandin E₂; P prostaglandin F_{2α}

Human placental lactogen levels in maternal serum

Human placental lactogen can be detected 5–10 days after fertilization. Levels start rising by 10 weeks, continue rising till 34–36 weeks, and plateau thereafter (Fig. 5.16).

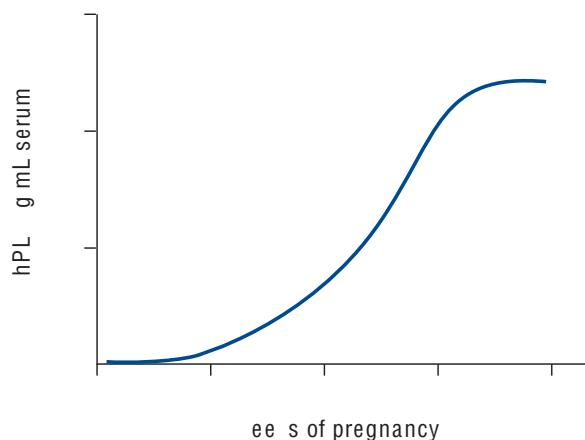


Figure 5.16 Serum human placental lactogen (hPL) levels in pregnancy. Human placental lactogen is detected 5–10 days after fertilization, continues to rise till 34–36 weeks, and plateaus thereafter.

Functions

Human placental lactogen is secreted mainly into maternal blood. It plays a major role in maternal carbohydrate and lipid metabolism (Box 5.22).

Box 5.22 Functions of human placental lactogen

- Lipolysis
- Acts as insulin antagonist
- Growth and differentiation of glandular tissue of breast
- Fetal angiogenesis

Other peptide hormones

Though hPL and hCG are the two most important peptide hormones, there are several others which also play a significant role in pregnancy. These are listed in Table 5.2.

Steroid hormones

Steroid hormones produced by the placenta are essential for the key events of pregnancy, including maintenance of uterine quiescence, preparation of the breasts for lactation, and initiation of parturition.

Table 5.2 Other peptide hormones of placenta

Hormone	Function
Chorionic adrenocorticotropin	Exact function not known
Relaxin	Uterine relaxation in pregnancy
PTH-RP	Calcium transport for fetal growth
hGH-V	Insulin resistance
GnRH	Regulation of hCG production
CRH	Placental ACTH secretion; initiation of parturition
Growth hormone-releasing hormone	Regulation of hGH-V production
Leptin	Fetal growth and development
Neuropeptide Y	Release of CRH
Inhibin	Inhibition of FSH and ovulation; inhibition of GnRH
Activin	Exact function not known

AC adrenocorticotrophic hormone; C corticotropin-releasing hormone; S follicle-stimulating hormone; n gonadotropin-releasing hormone; hC human chorionic gonadotropin; h - growth hormone variant; P - P parathyroid hormone-related protein.

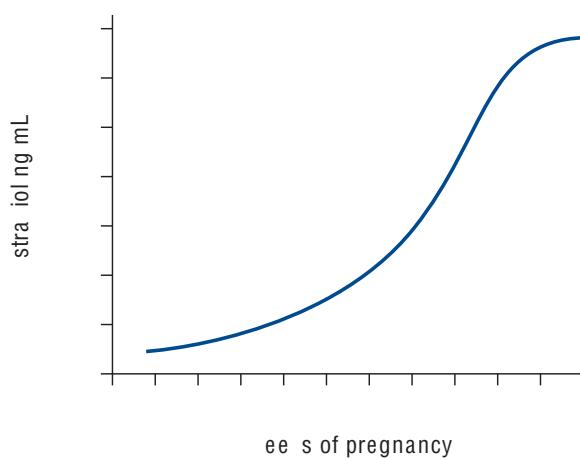


Figure 5.17 Serum estrogen level in pregnancy. Estrogen level begins to rise by 8 weeks, and remains elevated till the onset of labor.

Estrogens

Large amounts of estrogens are produced by the placenta throughout pregnancy (Fig. 5.17). During the first 6 weeks, the corpus luteum secretes estrogens, but this is taken over by the placenta by the 7th week. The ovary synthesizes estrogen from cholesterol or progesterone but the placenta lacks the enzymes required for this; therefore, dehydroepiandrosterone (DHEA) or

its sulfate (DHEAS) are used as precursors by the placenta (Fig. 5.18).

In pregnancy, the main source of the estrogen precursor DHEAS is the fetal adrenal gland, though the maternal adrenal gland also produces it in small amounts. Fetal liver and adrenal glands synthesize cholesterol from lipoproteins. This cholesterol is used as substrate for synthesis of DHEAS by fetal adrenal glands. The fetal adrenal glands have a prominent fetal cortical zone that secretes DHEAS; this is transported from the adrenal glands to the placenta, where it is converted to estrogens (Fig. 5.19).

Most of the estrogens produced by the placenta enter the maternal circulation. Three forms of estrogen are usually seen—estrone, estradiol, and estriol. Estriol is produced in small amounts in nonpregnant women but is the predominant form of estrogen in pregnancy. Hydroxylation of DHEA to 16(OH) DHEA, which is essential for estriol synthesis, occurs in fetal adrenal gland and final conversion to estriol occurs in the placenta. Additional 15-hydroxylation of DHEA in fetal adrenal gland/liver leads to synthesis of estetrol, which is unique to the pregnant state (Box 5.23).

Placental estrogen production is reduced in some conditions (Box 5.24).

Functions

Estrogen has many important functions in pregnancy and parturition (Box 5.25).

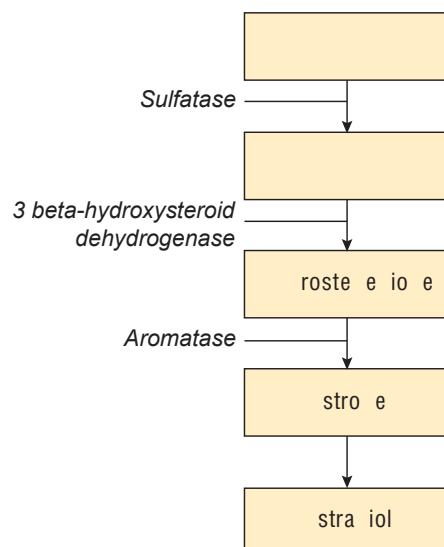


Figure 5.18 Placental estrogen synthesis. D A dehydroepiandrosterone; D AS dehydroepiandrosterone sulfate.

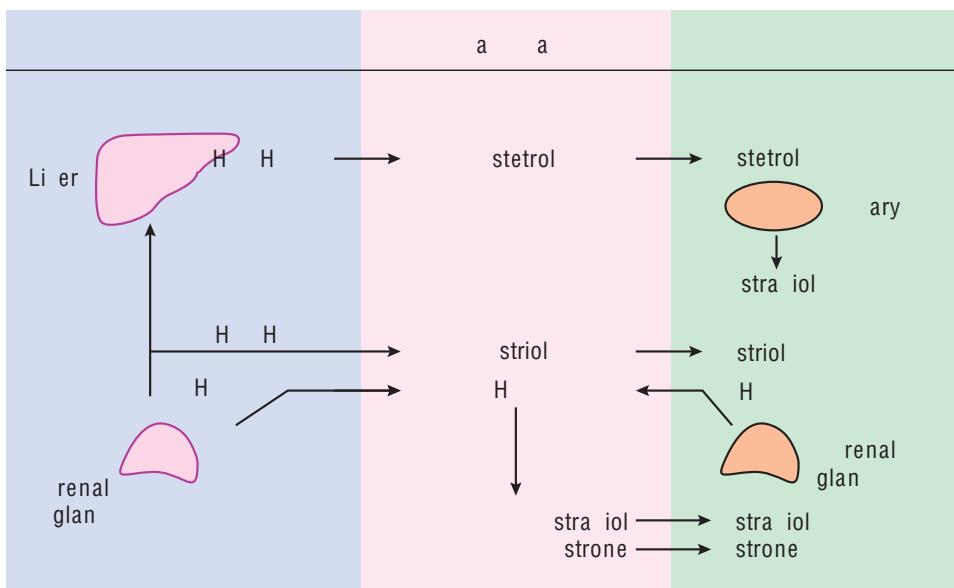


Figure 5.19 Synthesis of estriol and estetrol in the placenta.

Box 5.23 Placental estrogens

- Precursor of estrogens (DHEAS) is produced by
 - fetal adrenal gland
 - maternal adrenal gland
- Estrogens
 - Estrone
 - Synthesized from DHEAS
 - Estradiol
 - Synthesized from DHEAS
 - Estriol
 - Synthesized from 16(OH) DHEAS
 - 16-hydroxylation occurs in fetal adrenal
 - Is the predominant estrogen in pregnancy
 - Estetrol
 - Synthesized from 15, 16(OH) DHEAS
 - 15 hydroxylation occurs in fetal liver
 - Produced only in pregnancy

D AS dehydroepiandrosterone sulfate.

progesterone

As mentioned earlier, the corpus luteum is the main source of progesterone till 8–10 weeks. In pregnancies where exogenous progesterone support is considered necessary, it should be administered only up to 10 weeks. Beyond this period of gestation, the placenta takes over and produces large quantities of progesterone (Box 5.26; Fig. 5.20).

Functions

Functions of progesterone are listed in Box 5.27. Maintenance of pregnancy and uterine

Box 5.24 Conditions which reduce placental estrogen production

- Fetal conditions
 - Anencephaly
 - Fetal death
 - Adrenal hypoplasia
 - Deficiency in cholesterol synthesis
 - Down syndrome
- Placental
 - Sulfatase deficiency
 - Aromatase deficiency
- Maternal
 - Adrenal dysfunction
 - Gestational trophoblastic disease
 - Glucocorticoid therapy

Box 5.25 Functions of estrogen

- Increases uterine blood flow
- Prepares breast for lactation
- Stimulates hormone-binding globulin production in liver
- Increases fetal surfactant production
- Initiates parturition
 - By increasing prostaglandin production

Box 5.26 Placental progesterone

- Production begins by 8–10 weeks
- Precursor: LDL cholesterol from mother
- Rate of production: 250 mg/day
- Metabolized to pregnanediol

D low-density lipoprotein.

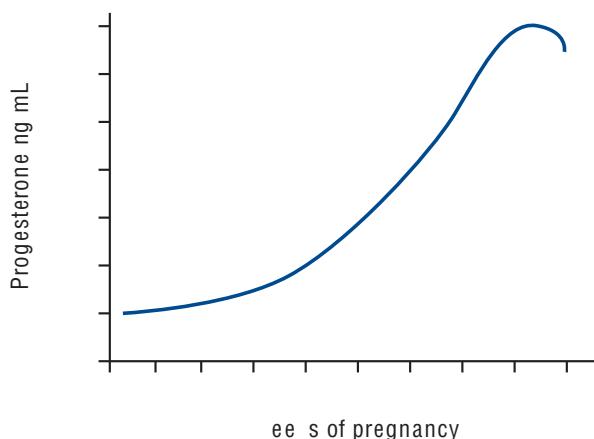


Figure 5.20 Serum progesterone level in pregnancy. The progesterone levels rise gradually from early pregnancy but fall toward term.

Box 5.27 Functions of progesterone

- Preparation of endometrium for implantation
- Maintenance of pregnancy
- Uterine relaxation
- Suppression of uterine contraction
- By inhibition of prostaglandin production
 - Stimulation of glandular proliferation in breast

P prostaglandin.

relaxation are important functions of progesterone. Deficiency of progesterone in early pregnancy can lead to miscarriage.

Other substances produced by the placenta

Vascular endothelial growth factor (VEGF), placental growth factor, epidermal growth factors (EGF), insulin-like growth factor 1 and 2 (IGF-1 and IGF-2), and fibroblast growth factor (FGF) are substances produced by syncytiotrophoblasts. They play a role in regulation of cell proliferation, cell differentiation, and angiogenesis in the villi.

Immunologic functions

Pregnancy can be considered an allograft. Several protective mechanisms are in place to prevent rejection of this allograft by the mother. It was believed that the placenta serves as an anatomic barrier between the mother and fetus, but now there is evidence that maternal cells come in contact with fetal cells. The placental immunological function is complex but crucial for normal fetal development and the continuation of pregnancy.

Key points

- Development of the placenta starts with implantation. The blastocyst differentiates into inner cell mass or embryoblast and trophoblasts.
- Trophoblasts differentiate into syncytiotrophoblasts and cytotrophoblasts.
- Implantation of the blastocyst takes place at the embryonic pole. Trophoblasts in this area develop into placenta. The decidua at the site of implantation develops into the maternal portion of the placenta.
- By Day 11 or 12, chorionic villi begin to develop. Primary, secondary, and tertiary villi are formed by trophoblasts, inner core of mesoderm, and angiogenesis.
- Further trophoblastic invasion into the decidua is by interstitial trophoblasts and into the spiral arteries by endovascular trophoblasts. This takes place in two phases.
- The fully developed placenta has fetal and maternal surfaces. The fetal surface is covered by chorion and amnion, with umbilical cord attached centrally. The maternal surface is divided into cotyledons.

- The term placenta weighs about 500–600 g and is 15–25 cm in diameter.
- The amniotic sac expands and fuses with the chorion laeve and lines the sides of the body stalk. This later develops into the umbilical cord.
- Placental circulation consists of oxygenated blood brought to the placenta by spiral arterioles and transport of nutrients and gases through the intervillous space into fetal vessels in chorionic villi; these nutrients and gases are then transported through the umbilical vein to the fetus. The less oxygenated blood from fetus is brought to the placental villi by umbilical arteries.
- Functions of the placenta include placental transfer and metabolic, endocrine, and immunological functions.
- Placental transfer of nutrients and gases takes place by simple diffusion, facilitated diffusion, active transport, bulk flow, endocytosis, and transfer through channels.
- Placenta also synthesizes glycogen, cholesterol, and some proteins.

Key points *Continued*

- Placenta produces peptide and steroid hormones. This is one of the major functions of placenta.
- The important peptide hormones are human chorionic gonadotropin (hCG) and human placental lactogen (hPL). The important steroid hormones are estrogen and progesterone.
- Human chorionic gonadotropin is required for maintenance of corpus luteum and for stimulation of fetal testosterone. Serum hCG is used for diagnosis of pregnancy, gestational trophoblastic disease, Down syndrome, and ectopic pregnancy.
- Human placental lactogen plays a major role in carbohydrate and lipid metabolism.
- Placenta produces estrone, estradiol, estriol, and estetrol from fetal and maternal precursors. Estrogen is essential for initiation of labor.
- Progesterone is the hormone that causes uterine relaxation and maintains pregnancy. This is produced by the corpus luteum in early pregnancy and by the placenta from 8 to 10 weeks.
- Placenta also has immunological functions which are complex but essential for continuation of pregnancy.

Self-Assessment

Case-based questions

Case 1

Mrs. DK, 23, primigravida, at 30 weeks of pregnancy, was referred to the outpatient clinic for evaluation of reduced amniotic fluid.

1. What are the major sources and routes of clearance of amniotic fluid?
2. What are the functions of amniotic fluid?
3. What is the volume of amniotic fluid at various gestational ages in the third trimester?
4. What are the clinical applications of amniotic fluid analysis?

Case 2

Mrs. AB, 32, multigravida, presented with vaginal bleeding at 8 weeks of pregnancy. She was asked to perform a blood test to estimate serum β hCG levels.

1. Where is β hCG produced in pregnancy? What is β hCG and what is its importance?
2. What are the functions of β hCG in pregnancy?
3. How does measurement of β hCG levels help in management of bleeding at 8 weeks' pregnancy?

Answers

Case 1

1. The major sources of amniotic fluid are fetal urine and fetal lung fluid. The major routes of clearance are fetal swallowing and intramembranous transfer across the blood vessels on the fetal surface of placenta.
2. Amniotic fluid protects the fetus, prevents cord compression, provides nutrients and growth factors, has antibacterial properties, and maintains even temperature. It also helps in cervical dilatation in labor.

3. Volume is about 800 mL at 28 weeks, 1000 mL at 34 weeks and reduces to 500 mL at term.

4. First trimester: For karyotyping for identification of fetal gender and chromosomal anomalies
Second trimester: Diagnosis of intrauterine infections
Third trimester: Measurement of bilirubin levels, lecithin/sphingomyelin ratio and phosphatidylglycerol levels.

Case 2

1. hCG is produced by the cytotrophoblast and syncytiotrophoblast of the placenta initially and only by the syncytiotrophoblast later. β hCG is a subunit which is produced only by the placenta and therefore specific to pregnancy.
2. It maintains the corpus luteum, stimulates relaxin production by corpus luteum, stimulates production of relaxin, thyroid hormone, and testosterone in the mother by the corpus luteum, thyroid gland, and testes respectively.
3. High levels indicate hydatidiform mole, low levels indicate failing pregnancy or ectopic pregnancy, normal levels indicate normal ongoing pregnancy.

Sample questions

Long-answer question

1. Discuss the development, structure, and functions of placenta.

Short-answer questions

1. Implantation
2. Human chorionic gonadotropin
3. Placental estrogens
4. Human placental lactogen
5. Placental circulation
6. Chorionic villi

6

Physiology of Labor

Case scenario

Mrs. KT, 25, primigravida, was brought to the labor room with history of watery vaginal discharge for 4 hours. Examination revealed a term-size uterus with the fetus in vertex presentation. There were no uterine contractions. On speculum examination, there was clear fluid draining and the cervix was long and closed. After discussion with the consultant, it was decided to induce labor.

Introduction

Labor is a complex process that ultimately results in the expulsion of the fetus and placenta through the birth canal. The physiology of labor has not been fully understood yet and varies with each species. Preparations for labor begin several weeks before the actual onset. Onset of labor is controlled by endocrine and paracrine signals from both mother and fetus.

Phases of labor

Four phases have been described, beginning with the quiescent phase (Box 6.1).

Box 6.1 Phases of labor

- Phase 1: Quiescent phase
- Phase 2: Activation phase
- Phase 3: Stimulation phase
- Phase 4: Involution phase

Phase 1 Quiescent phase

The quiescent phase starts even prior to implantation and continues till the onset of the activation phase, which begins 6–8 weeks before labor. The quiescence of the myometrium is essential to retaining the pregnancy inside the uterus. In this phase, which comprises 95% of

Box 6.2 Features and mediators of Phase 1 of labor

Features	Mediators
• Unresponsive myometrium	• Progesterone
• Cervical softening	• Relaxin
• Changes in the matrix	• Prostaglandin I ₂
• Changes in collagen	• Nitric oxide
	• PTH-RP

P - P, parathyroid hormone-related peptide.

In pregnancy, the uterine smooth muscle is unresponsive to natural stimuli. The cervix softens due to changes in matrix components and changes in collagen. The uterine unresponsiveness is mediated by several hormonal and nonhormonal inhibitors. The features of Phase 1 and its mediators are given in Box 6.2.

Phase 2 Activation phase

The activation phase begins about 6–8 weeks before term and ends with the onset of regular uterine contractions. Changes in the myometrium and cervix that are essential to this phase are regulated by the fetal hypothalamo–pituitary–adrenal axis, maternal hypothalamo–pituitary axis, and placental endocrine/paracrine factors.

Changes in the myometrium and cervix

The changes in the myometrium and cervix are preparatory to uterine contractions and cervical dilatation.

Changes in myometrium

Increase in uterine responsiveness and contractility is characteristic of this phase. The primary change responsible for the uterine responsiveness is an increase in the expression of contraction-associated proteins (CAPs), namely, oxytocin receptors, prostaglandin (PG) receptors, and connexin 43. Connexin 43 is a gap junction protein and its level increases due to an increase in the area of gap junctions in the myometrium. The increase in gap junctions between the myometrial cells permits electrical synchrony and allows effective coordination of contractions.

Box 6.3 Features and mediators of Phase 2 of labor

Features	Mediators
• Changes in the myometrium	• Estrogen
– Increase in contractility	• Progesterone
– Increase in uterine responsiveness	• CAPs
– Increase in gap junctions	• Glycosaminoglycans
• Changes in the cervix	• Proteoglycans
– Cervical ripening	• pCRH
▪ Changes in collagen structure	• Prostaglandins
▪ Increase in collagen solubility	• Cortisol
▪ Infiltration by inflammatory cells	• Interleukin-8
	• MMP

CAPs contraction-associated proteins; P matrix metalloprotease; pCRH placental corticotropin-releasing hormone.

Changes in the cervix

Changes in the cervix in Phase 2 include alteration in collagen structure and alteration in relative concentrations of matrix metalloproteases (MMP), glycosaminoglycans (GAGs), and proteoglycans. In addition, there is inflammatory cell infiltration, leading to an increase in inflammatory cytokines, especially interleukin-8. These changes result in extensive remodeling of the cervix known as *cervical ripening*. Cervical ripening takes place from 2 weeks to few days before labor, in preparation for effacement and dilatation with uterine contractions in labor.

The features of Phase 2 of labor and the mediators of this phase are given in Box 6.3.

Parturition cascade

The series of events at term, beginning with the removal of factors ensuring uterine quiescence and activation of factors promoting uterine contractions that take place in Phase 2 of labor, is known as the *parturition cascade*. It is a complex phenomenon involving the fetus, mother, and placenta.

Role of the fetus in the parturition cascade

In Phase 2, activation of the fetal hypothalamic–pituitary–adrenal axis takes place. This plays a major role in the initiation of uterine contractions.

The increase in secretion of fetal hypothalamic corticotropin-releasing hormone (CRH) stimulates fetal pituitary secretion of adrenocorticotrophic hormone (ACTH), which increases and stimulates the fetal adrenal gland. This leads to the production of dehydroepiandrosterone sulfate (DHEAS), which is converted into estradiol by the placenta. Some of the DHEAS undergoes 16-hydroxylation in the fetal liver to 16(OH) DHEAS. This is in turn converted to estriol by the placenta.

Placental estrogens act on the uterus and stimulate the production of prostaglandin F_{2α} (PGF_{2α}) and an increase in oxytocin receptors, PG receptors, and gap junctions. Fetal adrenals also secrete cortisol which, in addition to stimulating prostaglandin and oxytocin secretion by the placenta, causes the synthesis and release of large amounts of placental CRH (Fig. 6.1).

Role of placenta in the parturition cascade

The placenta actively participates in the process of labor through the production of estrogens, progesterone, placental corticotropin releasing hormone and other substances. Human placenta

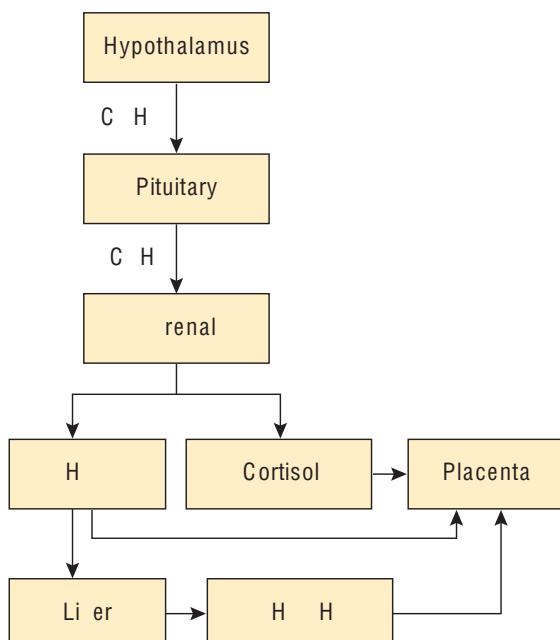


Figure 6.1 Fetal hypothalamic–pituitary–adrenal axis.
AC , adrenocorticotrophic hormone; C , corticotropin-releasing hormone; D AS, dehydroepiandrosterone sulfate; D AS, 16-hydroxy dehydroepiandrosterone sulfate.

lacks the enzyme 17α-hydroxylase unlike other mammalian placentae. Therefore, conversion of progesterone to estrogen does not take place in the placenta. However, placenta produces estrogens from DHEAS and 16(OH) DHEAS. These estrogens play an important role in Phase 2 of labor as mentioned earlier in the text.

estrogens

Estrogens in maternal blood are primarily from the placenta. DHEAS from the fetus is converted to estradiol and 16(OH) DHEAS to estriol. They stimulate uterine contraction by binding with estrogen receptors and thereby stimulating production of CAPs. The estrogen receptors in the uterus are suppressed by progesterone throughout pregnancy. At term, functional withdrawal of progesterone removes this suppression and uterine contractility increases.

progesterone

Progesterone plays an important role throughout pregnancy. It is secreted by the corpus luteum initially and after 7–9 weeks, by the placenta. It is responsible for maintaining uterine quiescence. The levels were thought to drop markedly before onset of labor. Current research, however, has shown that there is no actual fall in the level of progesterone, but there are changes in the relative expression of progesterone receptors leading to a ‘functional withdrawal’ or decrease in progesterone effect. The role of estrogens and progesterone in Phase 2 of labor is summarized in Box 6.4.

Placental corticotropin-releasing hormone

Placental corticotropin-releasing hormone (pCRH) is an important placental hormone produced in response to stimulation by fetal cortisol.

Box 6.4 Role of estrogens and progesterone in Phase 2 of labor

- Estrogens
 - Alter estrogen: Progesterone receptor ratio
 - Stimulate production of CAPs by placenta
 - Cause uterine contraction
- Progesterone
 - Causes uterine quiescence
 - Has anti-inflammatory effect on the myometrium
 - Undergoes functional withdrawal at term

CAPs, contraction-associated proteins.

It acts on fetal pituitary and adrenals and increases the production of ACTH and DHEAS, respectively; it also acts on the decidua and increases the production of prostaglandins that cause uterine contractions.

Other placental products

Contraction-associated proteins (CAPs) are released by the placenta in response to estrogen. Other substances produced by the placenta that are important in labor initiation are given in Box 6.5.

Box 6.5 Substances produced by placenta for labor initiation

- Estradiol: From fetal DHEAS
- Estriol: From fetal 16(OH) DHEAS
- CRH: In response to fetal cortisol
- CAPs
 - Oxytocin receptors
 - PG receptors
 - Gap junctions (connexin 43)
- Prostaglandins
- Oxytocin

CAPs contraction-associated proteins; C corticotropin-releasing hormone; D AS, dehydroepiandrosterone sulfate; P , prostaglandin.

Role of the mother in the parturition cascade

Maternal oxytocin secreted by the pituitary, along with prostaglandins produced in the decidua and fetal membranes, plays a pivotal role in labor initiation.

Oxytocin

In the nonpregnant state, oxytocin is secreted by the posterior pituitary gland in a pulsatile fashion. It has a short half-life of 3–4 minutes and is inactivated in the liver and kidney. Levels of oxytocin do not increase throughout pregnancy and in early labor but increase significantly in active labor (Phase 3) and the third stage of labor, puerperium, and during lactation. In active labor, secretion by the fetal pituitary gland, and to a lesser extent by the placenta, accounts for the rise in oxytocin levels. Oxytocin degradation during pregnancy is by placental oxytocinase (Box 6.6).

Oxytocin is the best known uterotonic. Though there is no rise in the level of oxytocin during pregnancy, the progressive increase in myometrial

Box 6.6 Oxytocin

- Secreted by
 - maternal posterior pituitary
 - fetal posterior pituitary
 - placenta
- Inactivated by
 - liver, kidney (nonpregnant state)
 - placental oxytocinase (in pregnancy)
- Best known uterotonic
- Binds to oxytocin receptors
- Contractile effect related to gestational age
- Plays a major role in
 - active phase of labor
 - third stage of labor
 - uterine involution

sensitivity to oxytocin is due to the marked increase in oxytocin receptors. Oxytocin receptors increase 100–200 fold toward term, in response to estrogens produced by the placenta. In addition, oxytocin also induces prostaglandin production in the decidua and fetal membranes. Uterine sensitivity is gestational age related, i.e., later the gestation, less the dose of oxytocin required to induce uterine contractions. Though oxytocin may not play a major role in the initiation of labor, it is an integral and essential uterine stimulant in active labor and the third stage of labor. It also contributes to uterine involution in the puerperium.

Prostaglandins

Prostaglandins are fatty acid derivatives that act locally (paracrine) unlike hormones which are secreted into the bloodstream to act at distant sites. They are produced in several organs in the body including the uterus. Most prostaglandins are uterotronics but some cause uterine relaxation. Prostaglandin F_{2α} (PGF_{2α}) causes uterine contractions. Prostaglandin E₂ (PGE₂) plays a major role in cervical ripening. Prostaglandins also increase oxytocin receptors in myometrium (Box 6.7).

Box 6.7 Prostaglandins

- Fatty acid derivatives
- Produced by several tissues
- High levels in decidua and fetal membranes
- Increase in oxytocin receptors
 - Uterotonins (PGF_{2α}, PGE₁, thromboxane)
 - Mediator of cervical ripening (PGE₂)
 - Uterine relaxant (PGI₂)

P prostaglandin E; P prostaglandin F; P prostaglandin I.

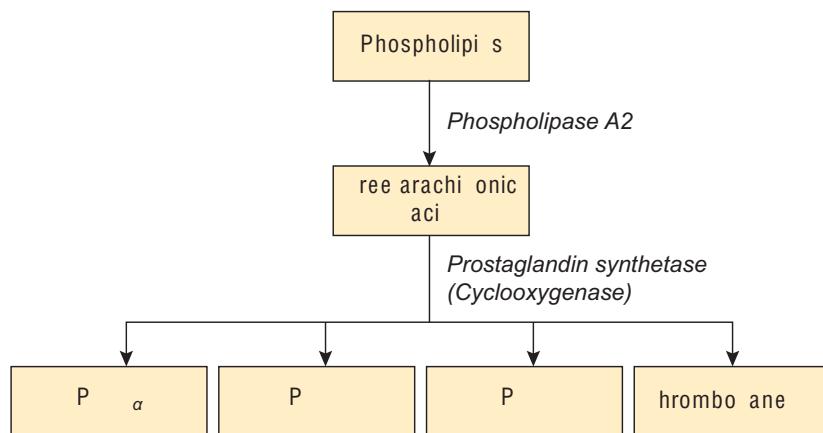


Figure 6.2 Prostaglandin synthesis. P prostaglandin E_2 ; P_α prostaglandin $F_{2\alpha}$; P prostaglandin I_2 .

Prostaglandins are synthesized from free (unesterified) arachidonic acid as shown in Figure 6.2. Fetal membranes and decidua contain *phospholipase* and *cyclooxygenase* enzymes. They are activated by local inflammatory reaction, trauma, stretch, estrogens, and progesterone. Arachidonic acid released from the phospholipids of the cell membranes is converted into prostaglandins. In turn, prostaglandins bind to myometrial PG receptors and exert their effects.

The roles of the fetus, placenta, and mother in Phase 2 of labor are pictorially represented in Figure 6.3.

Mechanical factors

Mechanical factors such as uterine distension due to the growing fetus and the resultant stretching of myometrial fibers also play a role in the initiation of labor.

Myometrial contraction

The ultimate goal of the parturition cascade is to stimulate myometrial contractions. The uterine myometrium is poorly innervated. Contraction

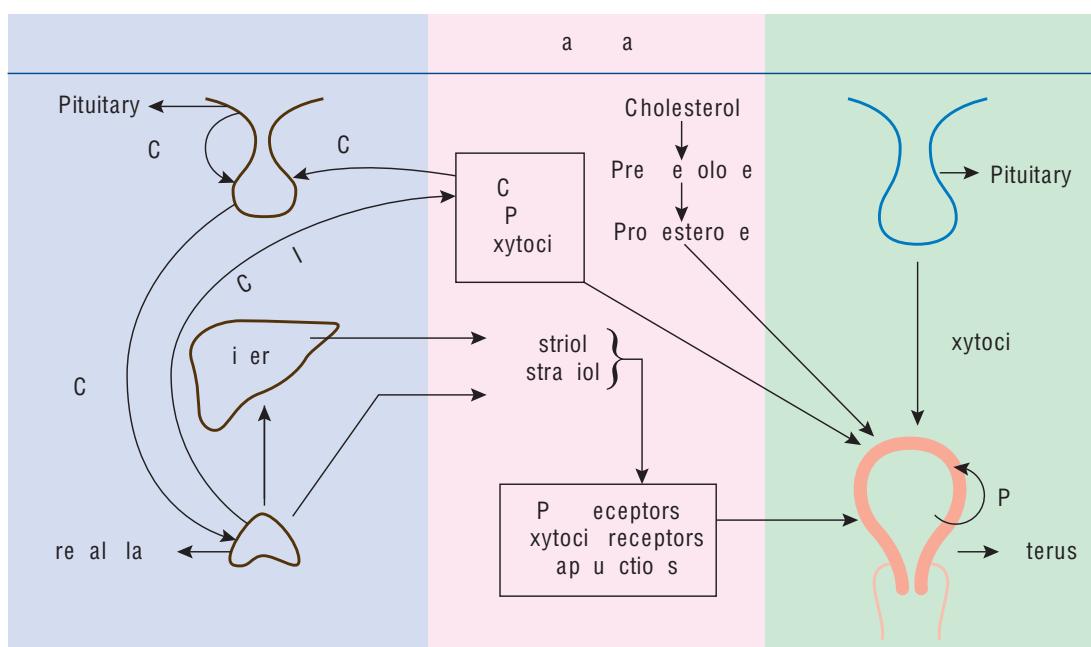


Figure 6.3 Role of fetus, placenta, and mother in Phase 2 of labor. AC , adrenocorticotrophic hormone; C , corticotropin-releasing hormone; $DHEA$, dehydroepiandrosterone sulfate; P , prostaglandin.

and relaxation are, therefore, mediated by hormones and other locally produced paracrine factors (such as prostaglandin) in the myometrium. There are myometrial surface receptors located on the cell surface. Hormones and prostaglandins exert their effect by binding to the receptors. The receptors are *upregulated* or *downregulated* by hormones, mainly estrogen and progesterone. At term, the receptors for uterotronics such as oxytocin and PGF_{2α} are upregulated by estrogen.

At the cellular level, myometrial contraction involves (a) interaction between the muscle proteins, actin, and myosin and (b) interaction between myometrial cells (Box 6.8).

Actin–myosin interaction is calcium dependent. Calcium moves from the extracellular compartment to the intracellular compartment and combines with calmodulin, a carrier protein, to form calcium–calmodulin complex. This activates the enzyme *myosin light chain kinase* which, in turn, catalyzes the phosphorylation of myosin. This ultimately leads to myosin–actin interaction and activation of ATP, resulting in myometrial contraction (Fig. 6.4). Entry of calcium into the cells to increase intracellular calcium is, therefore, an essential first step in the initiation of myometrial contraction.

The passage of signals, causing contraction or relaxation, between myometrial cells is through gap junctions (Fig. 6.5). These are channels formed by proteins, the most important one in labor being connexin 43. Ions, electric impulses, and metabolites pass through these gap junctions to cause synchronized contraction of the myometrium.

Box 6.8 Biology of myometrial contraction

- Actin–myosin interaction
 - Brought about by
 - calcium influx
 - calcium–calmodulin complex
 - myosin light chain kinase
 - myosin phosphorylation
 - activation of ATP
- Intermycocyte interaction
 - Gap junction proteins
- Myometrial receptors
 - Upregulation of oxytocin/PGF_{2α} receptors

A P adenosine triphosphate; P_{2α} prostaglandin F_{2α}.

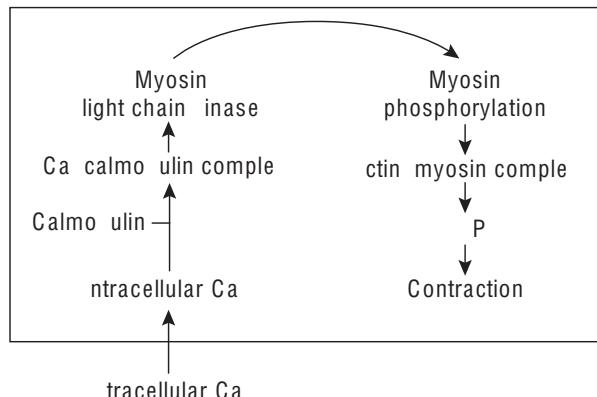


Figure 6.4 Cellular biology of myometrial contraction.

Figure depicts the series of events beginning with the movement of calcium to intracellular compartment to activation of ATP and myometrial contraction.

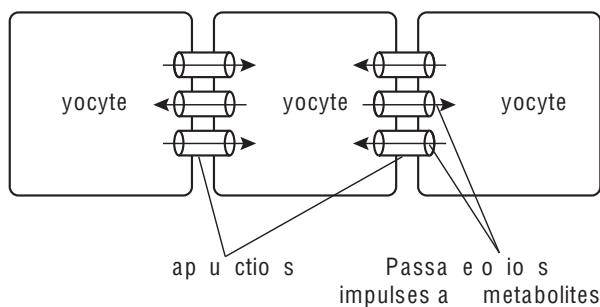


Figure 6.5 Passage of signals through gap junctions.

Gap junctions are channels between myometrial cells through which ions, metabolites, and electrical impulses are transmitted.

Phase 3 Stimulation phase

This is the phase during which active uterine contractions, cervical dilatation, descent of the presenting part, and expulsion of the fetus and placenta take place. Conventionally, this phase is divided into three stages.

First stage of labor

The first stage of labor begins with the onset of labor pains and extends till full dilatation of the cervix. This stage is characterized by progressive uterine contractions associated with effacement and dilatation of the cervix. Engagement and descent of the presenting part also occur in the first stage of labor.

Second stage of labor

The second stage extends from the time of full dilatation of the cervix to delivery of the fetus.

Third stage of labor

The third stage begins with delivery of the fetus and ends with expulsion of the placenta. Following placental separation and expulsion, the uterus contracts and retracts to achieve hemostasis.

The three stages of labor are discussed in detail in Chapter 14, *Normal labor: Mechanics, mechanism, and stages*. Continued uterine stimulation is maintained by the action of oxytocin and PGF_{2α}.

Features of Phase 3 of labor and the factors that mediate this phase are listed in Box 6.9. In addition to the increasing levels of oxytocin and prostaglandins in active labor, locally produced endothelin-1, epidermal growth factor, and platelet-activating factors also stimulate uterine contractions in this phase.

Box 6.9 Features and mediators of Phase 3 of labor

Features	Mediators
• First stage	
– Uterine contraction	– Prostaglandins
– Cervical effacement	– Oxytocin
– Cervical dilatation	– Endothelin-1
– Fetal descent	– Epidermal growth factor
• Second stage	– Platelet-activating factor
– Delivery of the fetus	
• Third stage	
– Separation of placenta	
– Expulsion of placenta	
– Uterine contraction and retraction	

Phase 4 Involution phase

The involution phase is described as the puerperium. The uterus and cervix shrink and return to their normal state and integrity during this phase. These changes take place over a period of 4–6 weeks. Multiple factors are responsible for uterine involution and return of the tissues to the prepregnant state. Local inflammatory processes resolve, production of glycosaminoglycans (GAGs) and proteoglycans ceases, and changes in the collagen and other tissues of the cervix regress.

Uterine involution is aided by oxytocin that is released in response to suckling. The

Box 6.10 Features and mediators of Phase 4 of labor

Features	Mediators
• Involution of uterus and cervix	• Oxytocin
• Responsiveness of endometrium to ovarian hormones	• Local factors

endometrium slowly becomes responsive to cyclical hormonal production by the ovary. The maternal hypothalamic–pituitary–ovarian axis starts functioning again in the normal cyclical fashion when lactation ceases. Features of Phase 4 and its mediators are listed in Box 6.10.

The phases of parturition and the factors involved are shown in Figure 6.6.

Clinical applications

A comprehensive understanding of the physiology of labor and the factors involved in the various phases has helped in the management of labor, induction of labor, and medical management of preterm labor. The clinical applications are given in Table 6.1.

Table 6.1 Clinical applications of physiology of labor

Physiological function	Application
Progesterone causes uterine quiescence	Used to prevent preterm labor
PGF _{2α} causes uterine contractions	<ul style="list-style-type: none"> Used to stimulate uterine contractions First and second trimester pregnancy termination Prevent and control PPH Antagonists used as tocolytics
PGF _{2α} is released by fetal membranes	Sweeping of the cervix for labor induction
PGE ₂ causes cervical softening	Used for cervical ripening
Oxytocin causes uterine contractions	Used for induction and acceleration of labor
Calcium is essential for myometrial contraction	Calcium channel blockers used as tocolytic
Magnesium competes with calcium	Magnesium sulphate used as tocolytic

P = prostaglandin; PP = postpartum hemorrhage.

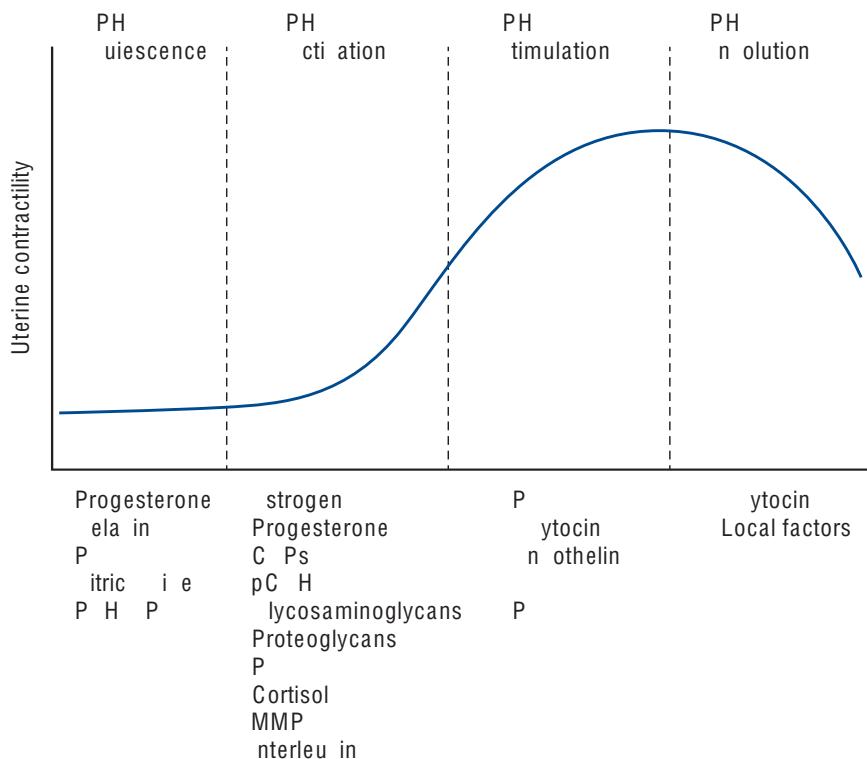


Figure 6.6 The four phases of parturition and their mediators. CAP, contraction-associated protein; EGF, epidermal growth factor; PGF, prostaglandin F; PA, platelet-activating factor; PC, placental corticotropin-releasing hormone; PGE, prostaglandin E; PGF_{2α}, prostaglandin F_{2α}; PTHrP, parathyroid hormone-related peptide.

Key points

- Labor is a complex process controlled by endocrine, paracrine, and other factors.
- Four phases of labor have been described: quiescent phase, activation phase, stimulation phase, and involution phase.
- Phase 1 or quiescent phase begins even prior to implantation and continues till the onset of labor. In this phase, the uterine myometrium is unresponsive and the cervix is softened.
- Phase 1 is mediated by progesterone, relaxin, prostaglandin I₂ (PGI₂), and other substances.
- Phase 2 or activation phase begins 6–8 weeks before term. The uterus becomes responsive to contractile stimuli and changes take place in cervical collagen.
- Phase 2 is mediated by several hormones and non-hormonal substances produced by the fetus, placenta, and mother.
- The fetal hypothalamic-pituitary-adrenal axis, placenta, and maternal hypothalamic-pituitary-uterine axis play major roles in phase 2. These events together are known as the *parturition cascade*.
- Oxytocin and PGF_{2α} are the most potent uterotonicics.
- Prostaglandins are synthesized in the fetal membranes and decidua and act on the uterus.
- The increase in oxytocin and PG receptors in the myometrium plays a key role in uterine contractions. Calcium influx into the myometrial cells in response to hormonal stimuli is the most important event in the initiation of contractions. Myometrial contraction during the parturition cascade is through actin and myosin interaction and interaction between myometrial cells via gap junctions.
- Phase 3 or stimulation phase includes the three stages of labor, begins with the onset of labor, and ends with the expulsion of the placenta and control of bleeding.
- Phase 4 or involution phase is known as the *puerperium*. The uterus and cervix return to the prepregnant state during this phase.
- The physiological processes involved in labor have important clinical applications.

Self-Assessment

Case-based questions

Case 1

Mrs. KT, 25, primigravida, was brought to the labor room with history of watery discharge per vaginum for 4 hours. Examination revealed a term-size uterus with fetus in vertex presentation. There were mild uterine contractions, once in 20–30 minutes, lasting for 10–15 seconds.

1. What further examination would you like to do to arrive at a diagnosis?
2. What phase of labor is she in?
3. What are the mediators of this phase?
4. Which prostaglandin will you use to soften the cervix?

Case 2

Mrs. MA, 23, multigravida, came to the emergency room with profuse vaginal bleeding following vaginal delivery. On examination, the patient was hemodynamically stable but the uterus seemed relaxed and vaginal bleeding was persistent.

1. What is the diagnosis?
2. What can you use to make the uterus contract?
3. How do these agents act?

Answers

Case 1

1. Speculum examination to visualize draining of amniotic fluid through the cervix and assessment of cervical effacement and dilatation.

2. In the activation phase.
3. Prostaglandin and oxytocin are the main mediators. Endothelin-1, platelet-activating factor, and epidermal growth factor also play a role.
4. Prostaglandin E₂ is used to soften the cervix.

Case 2

1. Atonic postpartum hemorrhage.
2. Oxytocin and prostaglandin F_{2α}.
3. Oxytocin binds to receptors and stimulates uterine contraction. It also induces prostaglandin production by the decidua and fetal membranes. Prostaglandin binds to its receptor and stimulates uterine contractions. Prostaglandin and oxytocin are the most effective uterotronics.

Sample questions

Long-answer question

1. What are phases of labor? Explain the parturition cascade.

Short-answer questions

1. Prostaglandins
2. Oxytocin
3. Myometrial contraction
4. Role of placenta in labor initiation

7

Clinical Manifestations and Diagnosis of Pregnancy

Case scenario

Mrs. AT, 24, had missed her period and wanted to confirm pregnancy. She came to the hospital at 45 days, amenorrhea and wanted to know if she was pregnant. She was fatigued. She had breast tenderness and nausea for 5 days.

Introduction

Knowing how to diagnose pregnancy, and familiarity with the early signs and symptoms of pregnancy, are essential for the practice of obstetrics. Pregnancy is usually suspected from the history and is confirmed by physical examination along with laboratory testing. In some cases sonographic confirmation may be required.

Gestational age versus conceptional age

In a woman with regular periods, conception usually occurs 14 days prior to the next expected period. However, in clinical practice, *gestational age* is calculated from the first day of the last menstrual period and not from the day of conception (*conceptional age*).

Duration of pregnancy

The normal duration of pregnancy is 280 days (40 weeks), calculated from the first day of the last menstrual period (corresponds to *conceptional age* of 266 days). This can also be expressed as 9 calendar months and 7 days. Pregnancy is divided into three trimesters:

- First trimester: 0–13 weeks
- Second trimester: 14–27 weeks
- Third trimester: 28–40 weeks

The trimesters are based usually on a pregnancy duration of 40 weeks. Sometimes, trimesters are based on a pregnancy duration of 42 weeks. Then the first trimester is considered to be 0–14 weeks, the second trimester is 15–28 weeks, and the third trimester is 29–42 weeks.

Symptoms and signs of pregnancy in the first trimester

Pregnancy is associated with characteristic symptoms and signs, which vary with each trimester.

Symptoms

Amenorrhea is the universal symptom which leads to the suspicion of pregnancy. Nausea and vomiting are more marked in the first trimester.

Amenorrhea

Amenorrhea is the fundamental symptom of early pregnancy. Whenever a woman in the reproductive age group misses a period, pregnancy should be suspected. The chances of pregnancy increase as the days past the missed period increase. If the woman has been sexually active without the use of contraception or has not consistently used contraception, the suspicion of pregnancy increases.

Amenorrhea is not always indicative of pregnancy; it can be a misleading symptom. In women with irregular periods, pregnancy may be difficult to diagnose just on the basis of a prolonged cycle. Even women with regular cycles may occasionally have prolongation of a cycle in spite of not being pregnant. In these situations, biochemical tests for pregnancy or the sonographic imaging of the pregnancy may be necessary.

Bleeding in normal pregnancy

Many women present with one or two episodes of bleeding during pregnancy (Box 7.1). Bleeding may occur 7–8 days after fertilization when the

Box 7.1 Bleeding in normal pregnancy

- In 10% of normal pregnancies
- In the first 8 weeks
- Around the time of expected periods
 - Implantation bleeding
 - Usually light
 - Stops on its own

blastocyst burrows into the decidua. Bleeding is usually light but can be mistaken for normal menses and the woman may not realize that she is pregnant.

Nausea with or without vomiting

Nausea with or without vomiting is perhaps the commonest symptom of pregnancy, found to affect about 50%–90% of pregnant women. It is also the most common reason for hospitalization in the first half of pregnancy. It tends to begin at 4–6 weeks, peaks at 8–12 weeks, and resolves by 20 weeks in 90% of women. The term *morning sickness* is a misnomer because the symptoms may occur at any time of the day. There is evidence that women with nausea and vomiting in early pregnancy have a lower rate of miscarriage than women without these symptoms.

The exact etiology of nausea and vomiting is poorly understood and is most probably multifactorial. The most likely etiology is the change in hormonal milieu during pregnancy. Rising levels of β human chorionic gonadotropin (β hCG) may have a role, as also estradiol. Vomiting can sometimes be excessive, leading to electrolyte disturbance and dehydration, and is referred to as *hyperemesis gravidarum* (see Chapter 28, *Hyperemesis gravidarum*).

Nausea and vomiting may be exacerbated by

- multiple gestation,
- hydatidiform mole,
- heartburn and acid reflux.

Fatigue and generalized malaise

One of the commonest symptoms reported by pregnant women is a sense of overwhelming tiredness, fatigue, and intense sleepiness. This usually occurs in the first trimester and generally resolves by the 4th month of pregnancy. It is thought to be due to the sleep-inducing property of the high level of circulating progesterone.

Breast enlargement and tenderness

Under the influence of hCG, the breast ducts undergo proliferation and enlargement. This may lead to an increase in size of the breasts and may also cause breast tenderness.

Increased frequency of urination without dysuria

The enlarging uterus presses on the bladder, especially over the trigone, and may lead to an increased urge to urinate. This is not associated with dysuria and may resolve after the 4th month of pregnancy.

Symptoms of pregnancy in the first trimester are summarized in Box 7.2.

Box 7.2 Symptoms of pregnancy in the first trimester

- Amenorrhea
- Nausea and vomiting
 - Begins at 4–6 weeks
 - Peaks at 8–12 weeks
 - Resolves by 20 weeks
 - Etiology multifactorial
 - Exacerbated by
 - multiple gestation
 - hydatidiform mole
 - heartburn and acid reflux
- Fatigue and generalized malaise
 - Due to high levels of progesterone
- Breast enlargement and tenderness
 - Due to increase in hCG and other hormones
- Increased urinary frequency
 - Due to pressure of uterus on trigone

hC human chorionic gonadotropin.

Signs

Enlargement of the uterus is the most important sign of pregnancy.

Uterine examination

The uterus begins to enlarge after the implantation of the blastocyst. Uterine examination may confirm the presence of an intrauterine pregnancy after the 6th week of pregnancy, that is, after 6 weeks' amenorrhea (see Chapter 8, *History taking and examination of the obstetric woman*). Prior to that, the uterine enlargement is difficult to ascertain. It is also easier to confirm the pregnancy by pelvic examination in a thin woman as compared to a woman with excess abdominal fat. It is important to have the woman empty her bladder before performing a pelvic examination to assess uterine size.

On physical examination, the pregnant uterus is soft, globular, and enlarged. The correlation

Box 7.3 Changes in the uterus and cervix in the first trimester

- Changes in the uterine shape and size
 - Becomes globular
 - Enlarges in size
 - *Hegar's sign*
 - Softening of lower uterine segment (isthmus)
 - Abdominal and vaginal fingers can be approximated
 - *Chadwick's sign*
 - Bluish appearance of the cervix
 - Due to increased vascularity
 - *Oodell's sign*
 - Marked softening of cervix

between uterine size and gestational age is learned by experience. The uterus and cervix feel softer than the nongravid uterus (Box 7.3).

Hegar's sign: At approximately 6 weeks gestational age, softening of the lower uterine segment occurs, just above the cervix. During bimanual (abdominal and vaginal) examination, when the uterus is compressed between the examining fingers, the uterine wall feels thin and the abdominal and vaginal fingers can be approximated (Fig. 7.1).

Chadwick's sign: Though not used routinely to confirm pregnancy, on a speculum examination the cervix will appear bluish-red due to the increased cervical vascularity in early pregnancy.

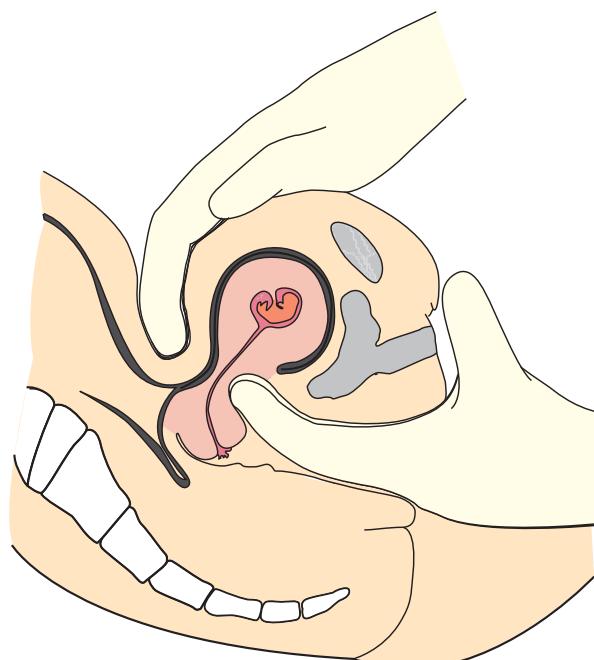


Figure 7.1 Hegar's sign.

Goodell's sign: The cervix is normally firm like the cartilage at the end of the nose. Goodell's sign is when there is marked softening of the cervix. This is present from 6 weeks' pregnancy.

The uterus remains a pelvic organ until approximately 12 weeks' gestation, when it enlarges enough to be palpable abdominally just above the symphysis pubis.

Problems in assessing uterine size

Uterine fibroids, obesity, a full bladder, a retroverted uterus, and multiple gestation may interfere with accurate assessment of the gestational age. The uterus might appear larger than is normal for the period of amenorrhea if the menstrual history is not accurate (wrong dates), and also in the presence of multiple pregnancy, molar pregnancy, and uterine fibroids (Box 7.4).

Box 7.4 Reasons for uterine size larger than period of amenorrhea

- Wrong dates
- Multiple pregnancy
- Molar pregnancy
- Uterine fibroids

Fetal heart tones

Handheld Doppler devices (Fig. 7.2) can usually detect fetal heart tones at 10–12 weeks' gestation. They are easier to detect in women who are thin. It might require persistence to detect the fetal heart tones before 11 weeks' gestation.

Symptoms and signs of pregnancy Second trimester

The symptoms of the first trimester decrease or disappear and the mother is more comfortable in this trimester.

Symptoms

Nausea and vomiting subside and there is a sense of well-being. Symptoms of the second trimester of pregnancy are listed in Box 7.5.



Figure 7.2 Handheld Doppler device.

Box 7.5 Symptoms in the second trimester

- Quickening or first fetal movements
 - At 16 weeks in multiparas
 - At 20 weeks in nulliparas
- Braxton Hicks contractions
 - Irregular, painless
 - No associated cervical changes

Fetal movements

The first fetal movements or *quickening* is perceived by 16–18 weeks by multiparas and by 18–20 weeks by nulliparas. Initial movements are like a flutter, but they become more definite and clear in 2–3 weeks. Active movements are perceived through the rest of pregnancy.

Braxton Hicks contractions

Irregular contractions of the uterus known as *Braxton Hicks contractions*, appear in the late second trimester. They are painless and do not cause any cervical changes. They become more prominent toward term.

Signs

In addition to uterine enlargement, other signs make their appearance in the second trimester.

uterine enlargement

The uterus remains a pelvic organ until approximately 12 weeks' gestation, when it enlarges enough to be palpable abdominally just above the symphysis pubis. At 16 weeks the fundus is palpable at one-third the distance between the pubic symphysis and the umbilicus, and at 20 weeks it is palpable at two-thirds the distance between the pubic symphysis and umbilicus.

Changes in the breast

The breasts enlarge further and the secondary areola is formed. Small protuberances called *Montgomery's tubercles* appear. Milk (colostrum) secretion may be noticed in some women. These changes occur due to high levels of estrogen and progesterone.

Skin changes

Increase s in pigmentation

Linea nigra: Most pregnant women develop some degree of skin pigmentation. Though the etiology is not clearly understood, one possibility is that estrogens and progesterone cause melanocytic stimulation. This is typically evident in the nipples and areola, umbilicus, axillae, and perineum. The linea alba, stretching from the umbilicus to the pubic symphysis, darkens and is termed *the linea nigra* (Fig. 7.3).



Figure 7.3 Linea nigra (yellow arrow) and striae gravidarum (white arrows).

Melasma: Facial darkening, also called *chloasma*, is a diffuse macular facial hyperpigmentation. As far as women are concerned, it is the most disturbing of all skin pigmentations occurring in pregnancy. The distribution is usually malar (over the cheeks) but can be central or mandibular. Because it is related to the hormones of pregnancy, it lessens after delivery.

Striae gravidarum: Stretch marks (*striae gravidarum*) appear on the abdomen and thighs (Fig 7.3).

Spi er angioma or nevi

A spider angioma or nevus consists of a central arteriole with radiating thin-walled vessels. Compression of the central vessel produces blanching and temporarily obliterates the lesion. When released, the thread-like vessels quickly refill with blood from the central arteriole. Spider nevi are caused by the increased circulating levels of estrogen.

almar erythema

Reddening of the palms occurs on both the thenar and hypothenar eminences and may be associated with itching.

Fetal parts and fetal movements

By 18–20 weeks, *fetal parts* can be appreciated within the uterus on palpation. Active fetal movements can also be felt by the examining physician.

External ballottement: With the woman lying in the dorsal position, the examining physician places both hands on either side of the uterus. When the uterus is tapped on one side, the fetal parts move and bounce back. This is called external ballottement. At this period of gestation, amniotic fluid volume is much more than the fetal size and the fetus can be moved freely within the fluid.

Fetal heart sounds

Fetal heart sounds are audible on auscultation from 20 weeks. In addition, soft murmurs or blowing sounds known as *uterine souffle* and *fetal souffle* can also be heard. These are due to increased blood flow through the uterine vessels and umbilical vessels, respectively.

Signs of the second trimester of pregnancy are summarized in Box 7.6.

Box 7.6 Signs of second trimester of pregnancy

- Changes in the breast
 - Enlargement
 - Formation of secondary areola
 - Formation of Montgomery's tubercles
 - Secretion of colostrum
- Changes in the skin
 - Pigmentation
 - Breast, abdomen
 - Linea nigra
 - Striae gravidarum
 - Chloasma
 - Spider nevi
 - Palmar erythema
- On abdominal palpation
 - Fetal parts
 - Fetal movements
 - External ballotment
- Fetal heart sounds
- Uterine and funic souffle

Box 7.7 Symptoms and signs in third trimester

- Symptoms
 - Uterine enlargement
 - Breathlessness
 - Palpitation
 - Pedal edema
 - Backache
 - Lightening near term
- Signs
 - Further uterine enlargement
 - Fullness of flanks
 - Shelving

Symptoms and signs of pregnancy Third trimester

The majority of the symptoms in the third trimester are due to the enlargement of the uterus.

Symptoms

The enlarging uterus causes obvious abdominal distension. Cardiovascular changes and splinting of the diaphragm can lead to palpitation and breathlessness. Pressure of the gravid uterus can cause pedal edema and backache. Toward term, when the fetal head enters the pelvis, the mother appreciates a decrease in the pressure on the diaphragm and lower ribs. This is called *lightening*.

Signs

Uterine enlargement in the second and third trimester is described in Chapter 8, *History taking and examination of the obstetric woman*. The flanks appear full, the uterus falls forward by 40 weeks and *shelving* occurs (Box 7.7).

Laboratory evaluation for the diagnosis of pregnancy

Pregnancy is often diagnosed by the characteristic symptoms and signs, but early in pregnancy, laboratory tests are required to confirm the diagnosis.

Several peptide and steroid hormones are secreted by the placenta (*see Chapter 5, Placenta, fetal membranes, and amniotic fluid*). Of these, the most commonly assayed hormone for the confirmation of pregnancy is the β subunit of hCG.

Human chorionic gonadotropin

- Human chorionic gonadotropin is a glycoprotein similar in structure to follicle-stimulating hormone (FSH), luteinizing hormone (LH), and thyroid-stimulating hormone (TSH). Human chorionic gonadotropin is composed of α and β subunits.
- Modern immunoassays for hCG, whether in urine or serum, specifically identify the β subunit of hCG.
- Human chorionic gonadotropin is detectable 8 days after conception in the serum of approximately 5% of women.
- More than 98% of women will have detectable levels in the serum by Day 11 after conception, that is, before the next period.
- At 4 weeks' gestation, the level of hCG in serum doubles approximately every 2 days.
- The level of hCG peaks at 10–12 weeks' gestation and then begins to decline rapidly. A more gradual rise begins again at 22 weeks' gestation, which continues until term.

Pregnancy tests

Pregnancy tests can be performed on the woman's urine or serum (Box 7.8).

Box 7.8 Laboratory testing for hCG (pregnancy tests)

- Urine
 - Qualitative
 - hCG highest in first morning urine specimen
 - False negative may occur due to high concentrations of hCG-βcf (core fragment)
 - Quantitative
 - Important to use same assay for serial tests
 - In a viable pregnancy, hCG usually doubles over 48 hours
 - Qualitative
 - Rapid but not as sensitive as quantitative
 - Should use quantitative if detection of pregnancy is critical
- Serum

hC human chorionic gonadotropin.

Urine pregnancy test

Urine pregnancy testing is the most common method for diagnosing pregnancy in the clinic or hospital and is the preferred method for home pregnancy tests. On an average, the result can be obtained in 5 minutes because it is a qualitative test.

Urine pregnancy tests are most commonly used in the week after the missed menstrual period (4th completed gestational week). The woman passes urine on the strip or dips it into urine and waits for 5 minutes. The strip has a plasma membrane containing three types of antibodies and dyes in three distinct test zones: *the reaction, test, and control zones*. The result is considered positive by the appearance of a line or dot in a designated color in the test zone.

Standard urine pregnancy tests used in clinical practice use the sandwich enzyme-linked immunosorbent assay (see page 95). These have a urine hCG threshold of 20–50 mIU/mL. A first morning specimen is recommended since hCG concentration in the urine will be the highest at that time. However, a random urine sample can also be used for testing. Since urine hCG values can be variable very early in pregnancy (values can range from 12 mIU/mL to >2500 mIU/mL), the home pregnancy test may show a negative

result if done too early. The home pregnancy kits claim to be very accurate but they are most sensitive after 45 days' amenorrhea. If it is done earlier and shows a negative result, it should be repeated after 1 week.

The results of a urine pregnancy test should be confirmed with a physical examination and, when still in doubt, with sonographic visualization of the intrauterine pregnancy (Box 7.9).

Box 7.9 Urine pregnancy test

- Most commonly used in the week after the missed menstrual period
- Most sensitive after 45 days' amenorrhea
- Should be confirmed by one of the following:
 - Physical examination
 - Sonographic visualization of pregnancy

Serum pregnancy test

The most sensitive method for detecting hCG in early pregnancy is a serum pregnancy test. Though both the qualitative (checking just for the presence of hCG) and quantitative (checking for the total amount of hCG present) methods can be used, serum hCG is almost always measured using the quantitative method (Box 7.8).

The sensitivity of methods used for serum hCG assay is high. Some methods can detect hCG levels as low as 2–20 mIU/mL. Serum pregnancy tests, therefore, are more sensitive than urine tests but are not routinely used for diagnosis or confirmation of pregnancy. They are used in women who undergo assisted reproductive technologies (ART), when ectopic pregnancy is suspected, or in the follow-up of hydatidiform mole.

It is important to remember that early in pregnancy a serum pregnancy test may be positive while the urine pregnancy test is still negative. This is due to the fact that in the first trimester, hCG is present in higher levels in serum than in urine.

In normal intrauterine pregnancy, the serum level of hCG doubles approximately every 48 hours. Failure to achieve this on serial monitoring is suggestive of ectopic pregnancy or an abnormal intrauterine pregnancy.

Methods of hCG assay

Several methods exist to assay for the presence of hCG (Box 7.10).

Box 7.10 Methods of hCG assay***adioimmunoassay***

- Sensitivity: 5 mIU/mL
- Gestational age when first positive: 3–4 weeks
- Time to complete: 4 hours

mmunoradiometric assay

- Sensitivity: 150 mIU/mL
- Gestational age when first positive: 4 weeks
- Time to complete: 2–30 minutes

n yme-linked immunosorbent assay SA

- Sensitivity: 25 mIU/mL
- Gestational age when first positive: 3.5 weeks
- Time to complete: 5–15 minutes

luoroimmunoassay A

- Sensitivity: 1 mIU/mL
- Gestational age when first positive: 3.5 weeks
- Time to complete: 2–3 hours

hC, human chorionic gonadotropin.

a ioimmunoassay

This method uses a radioactive plasma membrane receptor site containing anti-hCG antibodies to bind hCG, and in some cases, to react specifically with the β subunit of hCG. Radioimmunoassays are accurate and can detect pregnancy as little as 8 days after ovulation. However, they are expensive to conduct, rely on highly specialized equipment and medical personnel, and result in radioactive medical waste.

Immunora iometric assay

Both intact hCG and the free β subunit can be measured with this method. Samples, standards, and controls are incubated for 60 minutes at 37°C with two monoclonal antibodies, one labeled with I^{125} and the other covalently linked to magnetizable particles. After incubation, the unbound labeled antibody is removed by decanting after magnetic sedimentation or by centrifugation. The radioactivity in the washed precipitate is counted and the hCG concentration is calculated from the standard curve. The sensitivity of the assay is 150 mIU/mL.

n yme lin e immunoassay

Commonly, the sandwich enzyme-linked immunosorbent assay (ELISA) is utilized for testing urine/serum for the presence of the β subunit of hCG. A unique monoclonal antibody combination which is specific against β hCG is used.

The woman's urine/serum is allowed to react with the monoclonal antibody directed against hCG. A second antibody is then added to 'sandwich' the bound hCG. In some assays, the second antibody is linked to an enzyme, such as alkaline phosphatase.

If hCG is present in the urine/serum specimen, an antibody-hCG-antibody enzyme complex will be formed. When substrate to the enzyme is added, a color develops. The intensity of the color is proportional to the concentration of hCG present in the urine/serum specimen. Visual comparison of the intensity of the color with test specimen indicates the concentration of $hCG \geq 25 \text{ mIU/mL}$ of hCG in the test specimen.

luoroimmunoassay

The fluoroimmunoassay (FIA) technique uses an antibody tagged with a fluorescent label to detect serum hCG.

False-negative pregnancy test

The reasons for a false-negative test may be the following:

- Testing done too early (especially home pregnancy tests). The chance of a false negative test reduces if the test is done 1–2 weeks after the missed period.
- Wrong dates due to irregular periods.

False-positive pregnancy test

The reasons for a false-positive test may be the following:

- 'Biochemical' pregnancy, where there has been a pregnancy loss soon after implantation but the hCG levels are still detectable.
- hCG administered as part of infertility treatment may be detected. Exogenous hCG will still be present for 2 weeks after being given as an injection and this must be taken into consideration.
- hCG secretion from a tumor.

Abnormal rise of hCG level

In certain conditions, the level of hCG may not rise in the usual manner. The conditions resulting in either a slow rise or an accelerated rise are listed in Box 7.11.

Box 7.11 Abnormal rise of hCG levels

- Slow rise
 - Ectopic pregnancy
 - Failed pregnancy
- High or accelerated rise
 - Molar pregnancy
 - Multiple gestation
 - Chromosomal abnormalities

Box 7.12 Transabdominal versus transvaginal sonography

- Transabdominal sonography
 - Gestational sac visible 1 week later than by TVS
 - Difficult in obese women
 - Full bladder required
- Transvaginal sonography
 - Identifies gestational sac 1 week earlier than TAS
 - Useful in obese women
 - Full bladder not required
 - More accurate in early pregnancy

AS, transabdominal sonography; S transvaginal sonography.

Ultrasound confirmation of pregnancy

Sonographic examination of the uterus can be used to confirm the presence of a pregnancy and determine whether it is intrauterine or extrauterine (ectopic). It is also useful when the viability of the pregnancy has to be assessed.

First trimester sonograms can be performed via the transvaginal (TVS) and/or the transabdominal (TAS) route (Box 7.12). The accuracy of TVS is greater for early first trimester evaluation of the gestational sac, yolk sac, and developing embryo, while TAS may be unable to detect an intrauterine gestation, especially in an obese woman.

Using TVS, the gestational sac, yolk sac, and embryo can be identified and measurements taken for diagnosis of pregnancy and assessment of gestational age (Box 7.13).

The ultrasonographic diagnosis of pregnancy is discussed in greater detail in Chapter 10, *Obstetric ultrasound and other imaging*.

Box 7.13 Transvaginal sonography in early pregnancy

- Gestational sac
 - Is the first sign of intrauterine pregnancy
 - Visualized
 - At 4–5 weeks
 - When serum hCG is 1000–1500 mIU/mL
 - Eccentric in location
 - Double decidual sign by 5–5.5 weeks
- Yolk sac
 - Appears by 4–5 weeks
 - Present until 10 weeks
- Embryonic pole
 - Visible by 5–6 weeks
 - Grows at the rate of 1 mm/day
 - CRL accurate measure of gestational age
 - Cardiac activity visible
 - At 6 weeks
 - At CRL of 5 mm

C = crown–rump length; hCG, human chorionic gonadotropin.

Key points

- Pregnancy is usually suspected from the history and is confirmed by physical examination along with laboratory testing.
- Amenorrhea is the fundamental sign of early pregnancy.
- A uterine examination may confirm the presence of an intrauterine pregnancy after the 6th week of pregnancy. The correlation between uterine size and gestational age is learned by experience.
- The diagnosis of early pregnancy is based primarily upon laboratory estimation of human chorionic gonadotropin (hCG).
- Urine pregnancy testing is the most common method for diagnosing pregnancy in the clinic or hospital and is also the preferred method for home pregnancy tests.
- Almost all pregnant women will have a positive urine pregnancy test 1 week after the missed menstrual period.
- The most sensitive method of detecting hCG is a serum pregnancy test.
- The symptoms of pregnancy in the first trimester include nausea and vomiting, breast enlargement and tenderness, fatigue and generalized malaise, and urinary frequency.
- The signs of pregnancy in the first trimester include globular enlargement of the uterus, Hegar's sign (softening of the uterine isthmus), Chadwick's sign (bluish appearance of the cervix) and Goodell's sign (softening of the cervix).

(Continued)

Key points *Continued*

- In the second trimester, nausea and vomiting usually subside. The mother feels the first fetal movements (quickening). Braxton Hicks contractions start in the late second trimester.
- In the second trimester, the uterus can be felt abdominally and continues to grow. Fetal parts are felt. Skin manifestations start to appear: increased skin pigmentation (including linea nigra and chloasma), stretch marks, spider nevi, and palmar erythema. Fetal heart tones can be auscultated.
- In the third trimester, symptoms reflect the progressive enlargement of the uterus: breathlessness, palpitations, pedal edema, and backache.
- Sonographic examination of the uterus can be used to confirm the presence of a pregnancy and determine whether it is intrauterine or extrauterine (ectopic). It is also useful when the viability of the pregnancy has to be assessed.
- The gestational sac is the first ultrasound sign of an intrauterine pregnancy. It is usually visualized transvaginally when the serum hCG level has risen to 1500 mIU/mL.
- In early pregnancy, the identification of cardiac activity with transvaginal scan is a good sign of a viable pregnancy.

Self-Assessment

Case-based questions

Case 1

Mrs. AT, 24, presented with 8 weeks' amenorrhea and a positive home pregnancy test. She wanted her pregnancy confirmed.

1. What is the urine threshold of hCG at which a home pregnancy test will be positive?
2. Which is the most sensitive laboratory test for pregnancy?
3. What is Hegar's sign?
4. At what serum level of hCG should a gestational sac be visualized by transvaginal ultrasound examination?

Case 2

Mrs. KT, 28, second gravida, presented with 6 weeks' amenorrhea, nausea, and vomiting.

1. What causes nausea and vomiting in pregnancy?
2. What is hyperemesis gravidarum?
3. What can be suspected if the uterus is larger than the period of amenorrhea?
4. What structures will be visualized in the uterine cavity on transvaginal ultrasonography at this period of gestation?

Answers

Case 1

1. Urine hCG threshold of 20–50 IU/L.
2. The estimation of the serum level of hCG is the most accurate laboratory test for pregnancy and can detect hCG levels as low as 2–20 mIU/mL.

3. Hegar's sign is the softening of the lower uterine segment, just above the cervix (uterine isthmus). It occurs after 6 weeks' pregnancy.
4. A gestational sac should be visualized by transvaginal ultrasonography when the serum hCG is 1500 mIU/mL.

Case 2

1. The etiology of nausea and vomiting in pregnancy is probably multifactorial. Rising levels of β hCG and estradiol play a role.
2. Excessive vomiting leading to electrolyte disturbance and dehydration is referred to as hyperemesis gravidarum.
3. The uterus may be larger than the period of amenorrhea because of wrong dates, multiple gestation, molar pregnancy, or uterine fibroids.
4. At 6 weeks' gestation, a gestational sac, a yolk sac and an embryonic pole will be identified on TVS. Cardiac activity will be seen in a viable fetus.

Sample questions

Long-answer questions

1. How is pregnancy diagnosed? What are the laboratory methods of assessing hCG levels?
2. What are the signs and symptoms of pregnancy?

Short-answer questions

1. Hegar's sign
2. Chadwick's sign
3. hCG
4. Urine pregnancy test
5. Quantitative hCG assessment

Section 2

Antenatal Management

8

History Taking and Examination of the Obstetric Patient

Case scenarios

Mrs. TM, 24, was married 1 year ago and was 5 months pregnant. She was not sure if she could feel fetal movements and wanted to know if her pregnancy was normal.

Mrs. SS, 26, had come for a routine antenatal examination close to term. She wanted to know how the pregnancy was progressing and was anxious to know if the head was engaged.

Introduction

A detailed history and properly performed obstetric examination can give significant information regarding diagnosis of pregnancy, identification of risk factors, appropriate management and follow-up. Gestational age, fetal growth, presentation, and position of the fetus can be determined at different stages of gestation. Findings at physical examination can prompt appropriate investigations.

At the first and subsequent visits, the pregnant woman should be greeted and made to feel comfortable. All details of history and findings at each visit should be documented. A printed antenatal case record with a template is useful for this purpose.

History taking in the obstetric patient

History of an obstetric patient begins with the name of the woman, age, occupation, educational status, and income. An outline of the details to be obtained in history is given in Box 8.1.

Demographic data

Making the pregnant woman feel at ease is an important part of history taking. Starting off with personal information such as her name and age, her husband's name and age, and how

Box 8.1 History taking of the obstetric patient

- Demographic data—from both partners
 - Name
 - Age
 - Occupation/income
 - Educational status
- Menstrual history
 - Duration of flow
 - Interval between periods
 - Regular/irregular
- Marital history
- Obstetric history
 - Obstetric score
 - LMP, EDD, and gestational age
 - History of present pregnancy
- Presenting complaints
 - History of presenting complaints
- Contraception used prior to pregnancy
- Past medical history
 - Medical disorders
 - Medications
 - Past surgeries
- Family history
 - Diabetes
 - Hypertension
 - Multiple pregnancy
- Personal history
 - Smoking/alcohol/drugs
 - Diet

DD estimated date of delivery; *P* last menstrual period.

long they have been married helps to make her less nervous, and more comfortable with the obstetrician.

Age

There is an increased risk of obstetric complications at both ends of the age spectrum. Because of this, both a young gravida (<19 years) and an elderly gravida (>35 years) should be monitored carefully in pregnancy. Age-related obstetric risks are listed in Table 8.1.

Education, occupation, and income

History concerning education, occupation, and income helps to determine the woman's socio-economic status, level of comprehension, and risk factors associated with a particular occupation. A low socioeconomic status (class 3 or 4) is associated with anemia, preterm labor, and gestational hypertension, whereas obesity and

Table 8.1 Obstetric complications in the young gravida (19 years) and the elderly gravida (35 years)

Young gravida (19 years)	Elderly gravida (35 years)
Anemia	Chromosomal anomalies
Miscarriage	Miscarriage
Gestational hypertension/preeclampsia	Chronic hypertension/gestational hypertension/preeclampsia
Fetal growth restriction	Diabetes
Abnormal labor	Abnormal labor
• Dysfunctional labor	• Malpresentation
• Obstructed labor	• Obstructed labor
Cesarean section	Cesarean section
Perinatal mortality	Preterm labor
Psychological stress	Fetal macrosomia
	Perinatal mortality

diabetes are usually seen in women in socioeconomic class 1 or 2.

Menstrual history

The menstrual history is very important in a pregnant woman. Box 8.2 lists the questions to be asked regarding the woman's menstrual cycles. It is important to know the pattern of cycles prior to conception.

Women with irregular periods may conceive later in the cycle, usually 14 days prior to the expected date of menses. Corrected estimated date of delivery (EDD) has to be calculated by adding the number of days beyond 28 to EDD (e.g., if cycle length is 35 days [7 days beyond 28 days], corrected EDD = calculated EDD + 7 days). The gestational age in these

Box 8.2 Menstrual history

- Pattern of cycles prior to pregnancy
- Number of days of flow
- Interval between periods
- Last menstrual period (LMP)
 - First day of last period
 - Delayed or scanty period
 - Possibility of
 - implantation bleeding
 - ectopic pregnancy

women must be confirmed by an ultrasound examination.

In women who do not know the exact LMP, EDD may be calculated based on 'quickeening' (first perception of fetal movement).

- Primigravidas usually feel quickening at 18–20 weeks.
- Multigravidas can feel quickening as early as 16 weeks.

Ultrasonographic confirmation of gestational age is essential in these women as well.

It is also important to know whether the LMP was delayed, normal, or scanty. Some women may have a scanty period even after they have conceived (implantation bleeding), so there might be a discrepancy in the gestational age. A scanty period after conception may also occur with an ectopic pregnancy, so this history may be significant.

Marital history

It is important to know how long the couple has been married. If the duration of marriage is >2 years, check for a history of infertility. History must be obtained to find out if it was a spontaneous conception or assisted reproductive techniques (ART) were used. Assisted reproductive techniques for infertility is associated with a higher risk of multifetal pregnancy, miscarriage, and other complications.

Obtaining a history of consanguinity is important since consanguineous marriages are still prevalent in India. The risk of congenital and chromosomal abnormalities is higher in consanguineous marriages.

Obstetric history

Obstetric score

Certain terms used in obstetrics are defined in the next subsections.

Gravidity

Gravidity is defined as the number of times the woman has been pregnant, including the present pregnancy, regardless of whether the

pregnancy ended in a miscarriage/termination or resulted in a live birth. A gravida refers to a pregnant woman.

- *Gravida*: A woman who is pregnant
- *Nulligravida* or *gravida 0*: A woman who has never been pregnant
- *Primigravida* or *gravida 1*: A woman who is pregnant for the first time
- *Multigravida*: A woman who has been pregnant more than once and is currently pregnant
- *Elderly primigravida*: A woman in her first pregnancy, who is 35 years or older

Parity

Parity is defined as the number of pregnancies carried to viable gestational age. Viable gestational age varies in different countries. This depends on the neonatal facilities available to help the preterm baby survive. In the United States it is defined as 20 weeks. In the United Kingdom and Europe it is considered to be 24 weeks. In developing countries viability could be considered to be 24 or 28 weeks. In this book 24 weeks will be considered as a viable gestational age.

- *Para*: Number of >24-week births (including stillbirths); pregnancies consisting of multiples, such as twins or triplets, count as one birth
- *Nullipara* or *para 0*: A woman who has never carried a pregnancy beyond 24 weeks
- *Primipara*: A woman who has given birth after 24 weeks once before
- *Multipara*: A woman who has given birth to a viable fetus two or more times
- *Grand multipara*: A woman who has given birth to a viable fetus five or more times.

Examples

- *Gravida 2, para 1, living 1 (G2 P1 L1)*: Pregnant for the second time, one delivery after 24 weeks, and child alive
- *Gravida 3, para 0, abortion 2 (G3 P0 A2)*: Pregnant for the third time, two pregnancies ended in miscarriage (before 24 weeks)
- Multiple pregnancy
 - *Para 1, living 2 (P1 L2)*: One pregnancy and delivered twins after 24 weeks, currently not pregnant

LMP, EDD, and gestational age

The date of the first day of the LMP is very important information and should be obtained in all pregnant women. A provisional EDD can be calculated from the menstrual history in women with 28- to 30-day cycles by adding 7 days to the first day of the LMP and then subtracting 3 months (**Naegle's rule**). This is based on the fact that a normal pregnancy has a duration of roughly 280 days (40 weeks). Only 5% of women deliver on the calculated EDD.

Naegle's rule for calculating the EDD applies only to women who have regular 28- to 30-day cycles (Box 8.3). Gestational age is calculated from the LMP to the current date. This should be documented in completed weeks and days (e.g., 30⁺⁶ weeks).

It is important to determine the EDD because it helps in many aspects of diagnosis and decision making in pregnancy (Box 8.4).

History of present pregnancy

Details of the pregnancy from confirmation to the present must be obtained (Box 8.5). It is important to know whether she had received preconceptional advice (see Chapter 9, *Preconceptional and*

Box 8.3 Naegle's rule for calculating EDD (in women with 28- to 30-day cycles)

Add 7 days to the first day of LMP and subtract 3 months.

Example:

First day of LMP: February 21, 2014

Add 7 days: February 28, 2014

Subtract 3 months: November 28

EDD: November 28, 2014

Gestational age on August 10: 24⁺³ weeks

DD estimated date of delivery; *P* last menstrual period.

Box 8.4 Importance of estimated date of delivery

- Timing of investigations
 - First trimester screening for Down syndrome (aneuploidy screen)
 - Second trimester screening for Down syndrome (aneuploidy screen)
 - Screening for gestational diabetes
- Calculating preterm or postdates
- Timing of interventions
- Monitoring fetal growth

antenatal care), whether the pregnancy has proceeded normally so far, or whether there has been any maternal/fetal complications identified.

History of past pregnancies

A detailed obstetric history of past pregnancies is important (Box 8.6). Was the previous pregnancy full term or preterm? Did it end in a miscarriage or was there an induced abortion? The number of live children must be noted. Details of each delivery must be obtained with emphasis on any complication that occurred during the pregnancy or at delivery.

The past obstetric history has a bearing on the management of the current pregnancy since many obstetric complications (gestational hypertension, preterm labor, placental abruption) can recur in subsequent pregnancies.

Presenting complaint(s)

Most pregnant women who come for antenatal care may not have any specific complaints. However, they may have minor problems that are common in pregnancy such as backache, constipation, vomiting, or mild swelling of the legs. Physiological changes in the various organ systems in pregnancy and symptoms arising from these changes are discussed in Chapter 3,

Box 8.5 History of present pregnancy

- Preconceptional care received or not
- First trimester
 - Date of confirmation of pregnancy
 - Any bleeding/excessive vomiting
 - Fever/medications/exposure to radiation
 - Folic acid supplementation
 - Ultrasonography
- Second trimester
 - Date of quickening
 - Ultrasonography
 - Iron and calcium supplementation
 - Hypertension/diabetes
- Third trimester
 - History of bleeding
 - Hypertension
 - Preterm labor
 - Fetal movements
 - Fetal growth restriction
 - Any other complications

Box 8.6 Past obstetric history

umber of pregnancies

- Full term
- Preterm
- Miscarriage
- Abortion (induced)
- Ectopic pregnancy
- Living children
- Multiple gestation

or each delivery note the following:

- Date and place of delivery
- Gestational age at delivery
- Mode of delivery (vaginal/instrumental/cesarean)
- Indication for instrumental delivery/cesarean section
- Sex of child/children
- Birth weight
- Length of labor
- Analgesia or anesthesia used
- Outcome (miscarriage, ectopic, live birth, stillbirth)
- Complications of delivery (difficult forceps, tears, excessive bleeding)
- Complications of pregnancy (maternal/fetal)

Box 8.7 Symptoms that are not physiological in pregnancy

- Excessive vomiting (with weight loss)
- Bleeding in any trimester
- Abdominal pain
- Pedal edema present in the morning
- Dyspnea/orthopnea/hemoptysis
- Headache/visual disturbances/epigastric pain
- Decreased/absent fetal movements
- Watery vaginal discharge
- Dysuria/flank pain/fever

Maternal physiology in pregnancy. Women may also present with bleeding, watery discharge per vaginum, abdominal pain, or reduced fetal movements. Symptoms that are not physiological and may jeopardize the pregnancy are listed in Box 8.7.

istory of presenting complaint(s)

Details regarding the nature, duration, frequency, and severity of the complaints must be noted. Profuse bleeding in the first trimester indicates incomplete or inevitable abortion and requires admission, whereas mild spotting can be managed at home. Acute abdominal pain in the first trimester can be due to ruptured

Box 8.8 istory of presenting complaint(s)

- Duration
- Severity
- Frequency
- Other associated symptoms

ectopic pregnancy, whereas mild cramping can be associated with a threatened miscarriage. Intermittent abdominal pain associated with watery discharge in the third trimester may indicate preterm labor with rupture of membranes. Specific questions must be asked regarding the presenting complaints (Box 8.8).

Contraception prior to pregnancy

It is important to enquire whether the couple had been using contraception prior to the current pregnancy. This will indicate whether the pregnancy is due to failure of contraception or whether the couple had planned this pregnancy. Women who were on oral contraceptive pills may have a few irregular cycles after stopping the oral contraceptives and so their EDD should be calculated accurately.

Past medical surgical history

Past medical history may have obstetric implications (Box 8.9). A history of maternal diabetes, rheumatic valvular heart disease, hypertension, thyroid dysfunction, and epilepsy is important. A history of present and past medications should

Box 8.9 Past medical history

- Medical illnesses
 - Diabetes
 - Hypertension
 - Epilepsy
 - Thyroid dysfunction
 - Hereditary diseases
- Medications and allergies
- Past surgeries

be obtained since many drugs are contraindicated in pregnancy and may have to be stopped or changed. Allergies must be asked for and noted prominently on the antenatal card. Past surgical history should also be elicited.

Family history

Family history of medical disorders such as diabetes, hypertension, epilepsy, thyroid dysfunction, and hereditary diseases must be asked for. A history of multifetal pregnancies and chromosomal anomalies such as Down syndrome should also be noted.

Personal history

Smoking, addiction to alcohol, and drug abuse can affect the growing fetus and lead to complications. Women should be asked about these details and counseled accordingly.

Detailed information regarding the woman's diet is mandatory. This helps in identifying dietary deficiencies and excesses. Information regarding the woman's bowel and micturition habits should also be obtained.

Examination of the obstetric patient

General physical examination

Obstetricians are primary care physicians, and a first obstetric consultation is a good opportunity to perform a complete physical examination. It is customary clinical practice to have a nurse or trained birth attendant by the physician's side while doing the examination. A chaperone is essential if a male physician is examining a female patient.

On general examination, one should look for the following:

- Pallor
- Pedal edema

- Jaundice
- Lymphadenopathy
- Thyromegaly
- Gait

eight, weight, and BMI

The patient's height and weight are taken. The body mass index (BMI) is calculated (Box 8.10). The patient must be counseled on the optimal weight gain based on her prepregnancy BMI (Table 8.2).

A high BMI ($>30 \text{ kg/m}^2$) is associated with complications such as miscarriage, preterm labor, gestational diabetes, hypertensive disorders, and macrosomia. A low BMI of $<18 \text{ kg/m}^2$ along with inadequate weight gain is associated with low birth weight and preterm delivery (Box 8.11).

Pulse, blood pressure, cardiovascular and respiratory systems

The basal blood pressure is recorded with the patient in the seated position (Box 8.12). The respiratory and the cardiovascular systems are examined and the findings noted.

Examination of the breast

Breast examination is an integral part of examination of the pregnant woman (Box 8.13).

Box 8.10 Calculating BMI

The BMI is calculated as follows:

$$\text{BMI} = \frac{\text{Weight (kg)}}{\text{Height (m}^2\text{)}}$$

Example: kg m B of kg m

B = body mass index.

Table 8.2 Optimal weight gain based on BMI

Prepregnancy BMI	Weight gain recommended (kg)
<18.5	13–18
18.5–24.9	11–16
25–29.9	7–11
>30	5–9

B = body mass index.

Box 8.11 BMI and pregnancy outcome

- High B* kg m associated with
- Miscarriage
 - Preterm labor
 - Gestational diabetes
 - Hypertensive disorders of pregnancy
 - Macrosomia
 - Shoulder dystocia
 - Dysfunctional labor
 - Cesarean section
- Low B* kg m associated with
- Low birth weight
 - Preterm delivery

B = body mass index.

Box 8.12 Method of recording blood pressure in pregnancy

- Mercury sphygmomanometer recommended
- Aneroid or automated blood pressure recorders replacing mercury sphygmomanometers due to ban on mercury
- Seated position
- Left lateral recumbent position can be used, particularly during labor
- Large blood pressure cuff if upper arm circumference >33 cm
- Fifth (K5) Korotkoff sound used to define diastolic blood pressure

Inverted nipples should be looked for, and if present, the woman is counseled to draw the nipple out regularly during the antenatal period (*see Chapter 25, Lactation and breastfeeding*). Advice regarding breastfeeding and care of the breasts can also be given at this time.

Examination of spine

Presence of kyphosis, scoliosis, or pelvic deformity should be looked for. Spinal deformities may affect the shape of the pelvis. This may, in turn, have an impact on labor and delivery.

Obstetric examination

The obstetric examination is distinct from other examinations since the physician has to assess the health and well-being of two individuals—the mother and the fetus.

Box 8.13 Breast examination in pregnancy

- Asymmetry common
- Areola
 - Montgomery nodules (prominent sebaceous glands)
- Nipples
 - Normal
 - Flat
 - Inverted
 - Counseling regarding drawing nipple out
- Masses
 - Fibroadenoma
 - Fibrocystic disease

The mother might be sensitive about an obstetric examination and extra care and kindness are required to make it as comfortable as possible for her.

First trimester

Since the uterus is not felt abdominally in the first trimester, both an abdominal and a vaginal examination are required.

Abdominal examination

Abdominal examination is an integral part of the obstetric examination. The uterus is not palpable abdominally until 12 weeks. However, the uterus may be larger than the period of amenorrhea and may be felt abdominally in the following conditions:

- Wrong dates
- Uterine fibroids
- Multiple gestation
- Molar pregnancy

Vaginal (bimanual) examination

A vaginal examination is the most personal examination a woman will undergo and must be handled with sensitivity to her feelings. It should never be performed without

- a short explanation about the procedure she will be undergoing,
- asking permission to perform the examination,
- a clear indication for the examination (Box 8.14), and
- measures taken to maintain the modesty of the woman.

Box 8.14 Indications for a vaginal examination in the first trimester

- Diagnosis of pregnancy
- Assessment of the gestational age
- Detection of anatomical or pathological abnormalities of the lower genital tract
- Investigation of leucorrhea or bleeding per vaginum
- Examination of the cervix

A vaginal examination must always be preceded by an abdominal examination.

Procedure for a vaginal examination

Preparing the patient

In preparation for a vaginal examination, the following steps are followed:

- The patient is asked to empty her bladder because a full bladder may interfere with the assessment of the uterine size.
- The patient must be made aware of the subsequent procedure with a short explanation.
- The patient is placed in a dorsal position with her knees bent.
- The knees may be kept partially covered with a sheet or even part of her own clothing.
- If the examination is done gently, there is less chance of the patient tensing up her adductors and her abdominal muscles.
- Asking the patient to take deep breaths relaxes the abdominal muscles and also distracts the patient from the procedure.

Examination of the vulva

The vulva must be carefully inspected for any external abnormality.

- Congenital anomalies
- Genital warts (*condylomata acuminata*)
- Varicosities
- Ulcers
- Discharge

Bimanual pelvic examination

A bimanual pelvic examination is so named because both hands are required for the examination (Fig. 8.1).

Procedure

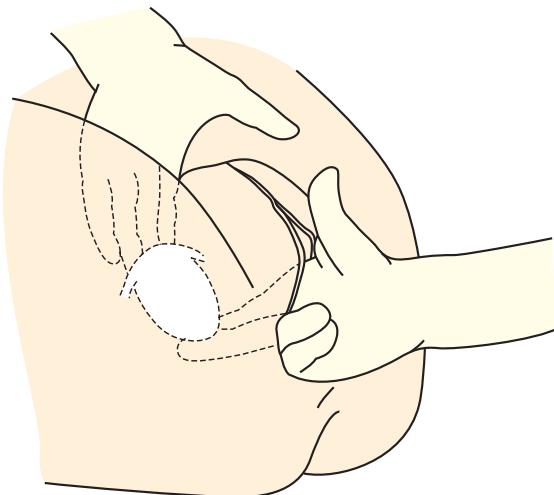


Figure 8.1 Bimanual pelvic examination.

The middle finger of the gloved right hand, after lubrication, is introduced into the introitus. When the patient relaxes a little more, the index finger is also introduced. The left hand is placed on the abdomen, on the suprapubic area.

The intravaginal fingers palpate the cervix and lift up the uterus. The size, shape, consistency, and contour of the uterus are noted. The fingers are first introduced into the right fornix and subsequently the left fornix, to palpate for any adnexal masses or tenderness. The abdominal hand feels the uterus and any other palpable pelvic mass (Box 8.15).

Box 8.15 Information obtained from a vaginal (bimanual) examination

- Cervix
 - Length
 - Firm or soft
 - External os closed or open
 - If external os open
 - whether internal os closed or open
 - Presence of discharge or bleeding
- Uterus
 - Size
 - Firm or soft
 - Anteverted or retroverted
 - Regular or irregular contour
- Fornices and adnexa
 - Presence of unilateral or bilateral adnexal masses

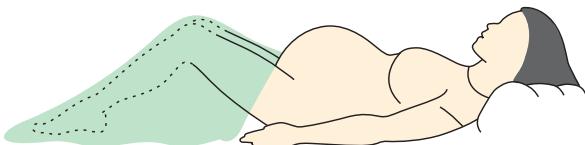


Figure 8.2 Position of the patient for abdominal palpation.

Box 8.16 Examination of the abdomen in the second trimester inspection

- Abdominal distension consistent with pregnancy
- Position of the umbilicus
- Flanks—usually not full
- Skin changes
 - Striae gravidarum
 - Linea nigra
- Presence of scars
 - Previous cesarean section
 - Any other surgery
- Presence of umbilical/incisional hernia

Second trimester

Abdominal examination

After having emptied her bladder, the pregnant woman is asked to lie comfortably on her back. Keeping her knees partly flexed helps relax the abdominal wall muscles (Fig. 8.2).

The pregnant woman should ideally be exposed from the pubic bone to just below her breasts. The obstetrician should stand on the woman's right side.

It is best to put the pregnant woman at ease by asking her a general question: How are you feeling today? Are you feeling any movements?

Inspection

Details to be noted on inspection of the abdomen are listed in Box 8.16.

Palpation

Palpation begins with measurement of fundal height. This is done with the patient's legs in the extended position.

Assessing fundal height

The fundus of the uterus is palpated by holding the hand in a 'chopping' position, with the medial (ulnar) aspect of the hand along the top of the uterus (Fig. 8.3). Usually the palpation is started slightly above the visible curve of the



Figure 8.3 Palpating the uterine fundus with the ulnar aspect of the hand.

Box 8.17 Uterine size by abdominal palpation

12 weeks	Uterus just palpable above the pubic symphysis
16 weeks	One-third the distance between pubic symphysis and umbilicus
20 weeks	Two-thirds the distance between pubic symphysis and umbilicus
24 weeks	At the level of umbilicus
28 weeks	One-third the distance between umbilicus and xiphisternum
32 weeks	Two-thirds the distance between umbilicus and xiphisternum
36 weeks	At xiphisternum
40 weeks	At 32 weeks but flanks full

uterus and then the hand is moved down till the top of the uterus is felt. Some obstetricians prefer feeling the top of the uterus with the palms of both hands.

After the 12th week of pregnancy, the uterus is just palpable above the pubic symphysis (Box 8.17). The distance between the pubic symphysis and the umbilicus is divided into three equal parts, corresponding to 16, 20, and 24 weeks. At 24 weeks, the uterus is at the level of the umbilicus. Again, the distance between the umbilicus and the xiphisternum is divided into three equal parts, corresponding to 28, 32, and 36 weeks. At 36 weeks, the fundus is at the level of the xiphisternum. After 36 weeks, the fundal height is lower, as the head may have descended into the pelvis and the uterus falls forward. At 40 weeks,

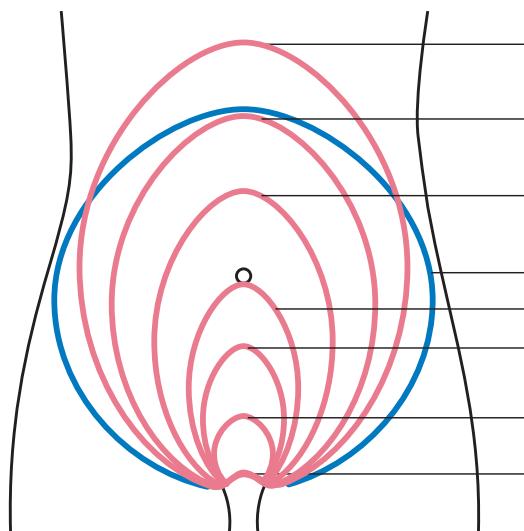


Figure 8.4 Fundal height at different weeks of pregnancy.

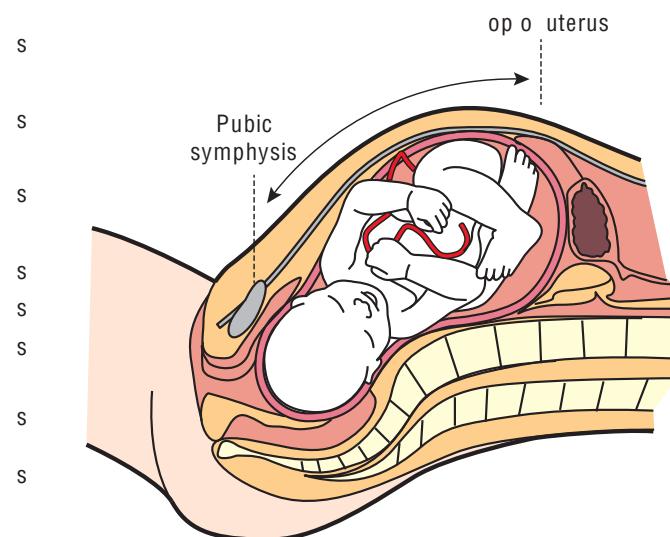


Figure 8.6 Landmarks for measuring the symphysio-fundal height.

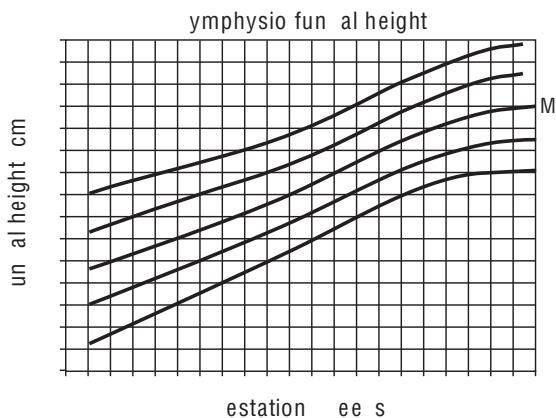


Figure 8.5 Metrogram or gravidogram for plotting symphysio-fundal height. *SD* standard deviation.



Figure 8.7 Measuring the symphysio-fundal height.

the fundus is at the same level as 32 weeks but the flanks are full (Fig. 8.4).

Measuring symphysio-fundal height

Measurement of fundal height can be used to estimate the gestation of the pregnancy. Between 20 and 32 weeks gestation, the fundal height (in cm) roughly corresponds to the weeks of gestation. For example, if the symphysio-fundal height (SFH) is 26 cm, it corresponds to 26 weeks' gestation. A difference of ± 2 cm is considered normal. A difference of ± 3 cm on a single measurement alerts one to the possibility of abnormality. Serial measurement of SFH should be plotted on a graph (metrogram

or gravidogram; Fig. 8.5). Persistent deviation above the 90th centile or below the 10th centile (or ± 2 SD) from the normal for the population needs further evaluation to exclude fetal macrosomia or growth restriction. This is a simple and inexpensive screening method for fetal growth restriction in low-resource countries and is recommended as a routine practice by the World Health Organization (WHO).

Procedure

The upper border of the pubic symphysis is palpated, and the distance between this and the top of the fundus is measured with a measuring tape (Figs 8.6 and 8.7).

Box 8.18 Reasons for discrepancy in the SFH measurements

Causes for higher-than-expected SFH measurement

- Wrong dates
- Macrosomia
- Multiple pregnancy
- Polyhydramnios

Causes for lower-than-expected SFH measurement

- Wrong dates
- Transverse lie
- Fetal growth restriction
- Oligohydramnios

SFH = symphysis-fundal height.

The reasons for a discrepancy in the SFH measurements are given in Box 8.18.

Auscultation of the fetal heart

In the second trimester, the uterus is felt above the pubic symphysis. Between 12 and 20 weeks, fetal heart tones will be difficult to identify with anything other than a handheld Doppler device. After 20 weeks, fetal heart tones may be picked up with a specialized obstetric stethoscope (fetoscope) or, with practice, with a regular stethoscope.

In the early months, fetal heart tones will usually be heard around the midline in the lower pole. As pregnancy progresses, they will be heard better on the side of the abdomen where the fetal spine is palpable.

Box 8.19 Objectives of abdominal and vaginal examination in the third trimester

- Abdominal examination
 - Fetal growth
 - Lie
 - Presentation
 - Attitude
 - Position
- Vaginal examination
 - Cervix
 - Effacement
 - Dilatation
 - Station of presenting part
 - Bony architecture of the pelvis

Third trimester

The objectives of the abdominal examination in the third trimester are to monitor fetal growth and, after 32–34 weeks, to determine the lie, presentation, and position of the fetus. The objectives of the vaginal examination in the late third trimester are to assess the cervix and the pelvis (Box 8.19).

Fetal lie, presentation, attitude, and position

Lie of the fetus

The lie of the fetus refers to the position of the long axis of the fetus in relation to the mother.

- *Longitudinal lie:* The long axis of the fetus and mother are parallel (Fig. 8.8a).

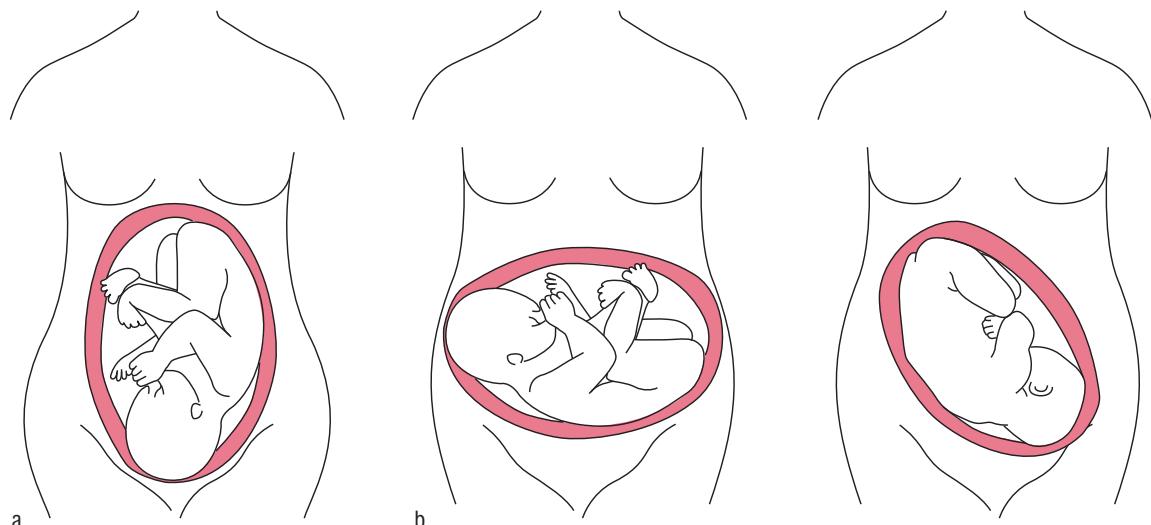


Figure 8.8 Fetal lie. **a.** Longitudinal lie. **b.** Transverse lie. **c.** Oblique lie.

- **Transverse lie:** The long axis of the fetus is perpendicular to the mother's long axis (Fig. 8.8b).
- **Oblique lie:** The long axis of the fetus lies at an oblique angle to the mother's long axis (Fig. 8.8c).

Presentation of the fetus

Presentation of the fetus is determined by the fetal lie and the presenting part:

- **Vertex or cephalic:** Longitudinal lie with the head in the lower pole
- **Breech:** Longitudinal lie with the breech in the lower pole
- Other presentations
 - Shoulder presentation (common in transverse lie)
 - Face presentation
 - Brow presentation

Fetal attitude

Attitude refers to the degree of flexion, deflexion, or extension of the fetal head. The fetal diameters presented to the birth canal increase with progressive deflection. A completely extended head is a face presentation which has the same presenting diameter as a flexed vertex presentation. The various attitudes described are as follows:

- **Flexion:** Vertex presentation (Fig. 8.9a)
- **Deflexion:** Vertex in occipitoposterior position (Fig. 8.9b)
- Extension
 - Partial: Brow presentation (Fig. 8.9c)
 - Complete: Face presentation (Fig. 8.9d)

Attitude of the fetal head is determined by abdominal examination (described later).

Position of the fetus

The position of the fetus refers to the relationship of a specific point of the fetal presenting part to the front, back, or sides of the maternal pelvis. The point referred to is called the reference point or denominator (Table 8.3).

Although the fetal position can be assessed by feeling for the position of the spine on abdominal examination, it is best determined by a vaginal examination, through a dilated cervix.

Fetal positions using vertex presentation as an example

Fetal positions using vertex presentation as an example are as follows (Fig. 8.10):

- **Left occipitoanterior (LOA):** The fetal occiput is in the left anterior quadrant of the maternal pelvis.
- **Right occipitoanterior (ROA):** The fetal occiput is in the right anterior quadrant of the maternal pelvis.
- **Occipitoanterior (OA):** The fetal occiput is directly behind the symphysis pubis.
- **Left occipitotransverse (LOT):** The fetal occiput is on the mother's left.
- **Right occipitotransverse (ROT):** The fetal occiput is on the mother's right.
- **Left occipitoposterior (LOP):** The fetal occiput is on the mother's left and pointing posterior.

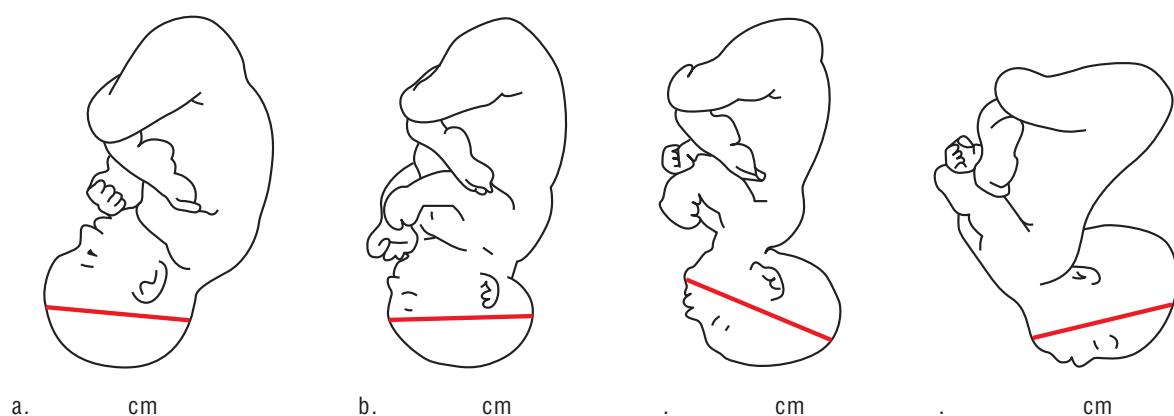


Figure 8.9 Fetal attitude. Note the increased diameters (red lines) presented to the birth canal with progressive deflection.
a. Flexed (vertex). **b.** Deflexed vertex ('military' position). **c.** Partially extended (brow). **d.** Fully extended (face).

Table 8.3 Reference point for determining fetal position in different presentations

Presentation	Attitude	Presenting part	Reference point
longitudinal lie			
Cephalic	Flexion	Vertex	Occiput
	Deflexion	Vertex	Occiput
	Partial extension	Brow	Frontum (forehead)
	Complete extension	Face	Mentum (chin)
re breech			
Complete	Flexed hips and knees	Buttocks	Sacrum
Frank	Flexed hips, extended knees	Buttocks	Sacrum
Footling (single, double)	Extended hips and knees	<ul style="list-style-type: none"> • Feet • Knees 	<ul style="list-style-type: none"> • Sacrum • Sacrum
transverse or oblique lie			
Shoulder	Variable	Shoulder, arm, trunk	Scapula

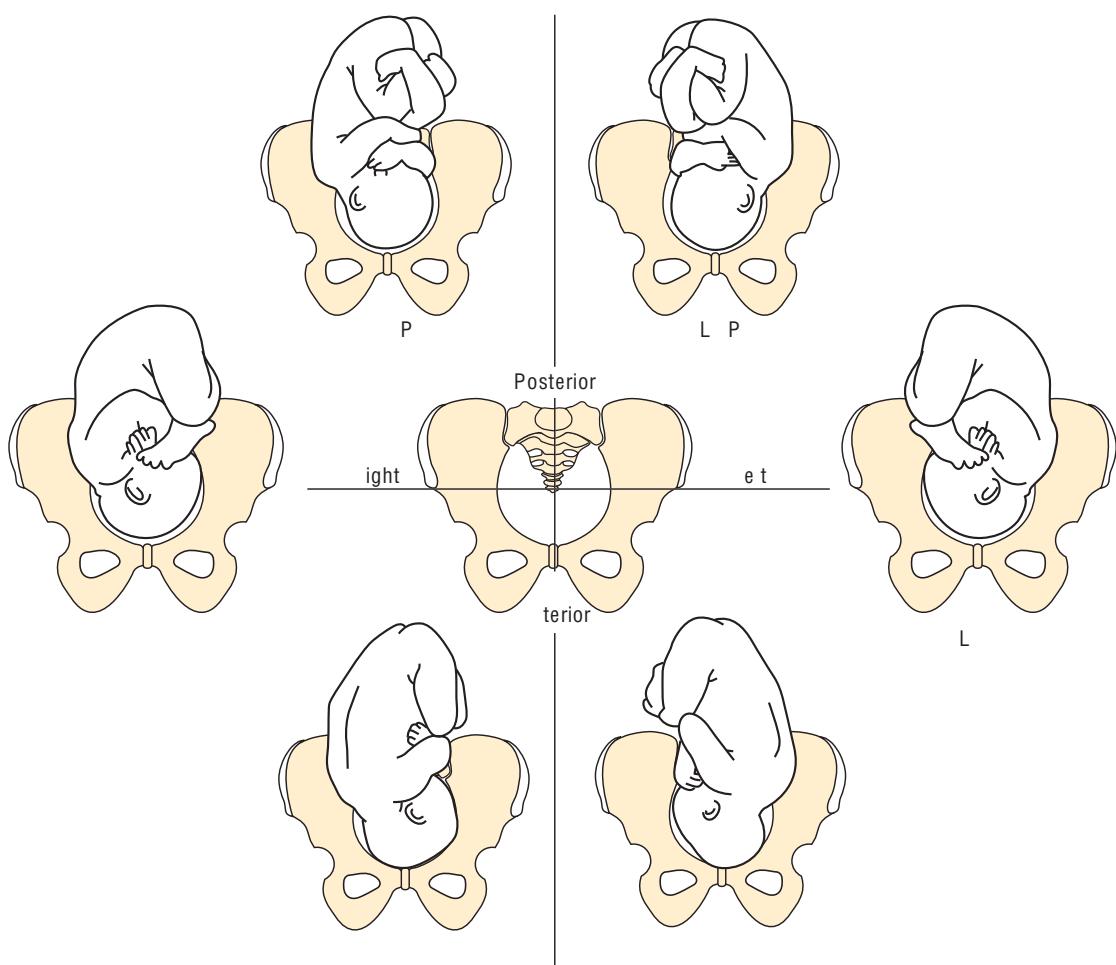


Figure 8.10 Fetal vertex (occiput) positions in relation to the maternal pelvis. A left occipitoanterior; P left occipitoposterior; L left occipitotransverse; A right occipitoanterior; P right occipitoposterior; L right occipitotransverse.

- *Right occipitoposterior (ROP)*: The fetal occiput is on the mother's right and pointing posterior.
- *Occipitoposterior (OP)*: The fetal occiput is directly in front of the sacrum.

Abdominal examination in the third trimester

Inspection

The details to be noted on inspection are as listed in Box 8.16. However, in the third trimester, special attention must be paid to the following additional details:

- Flanks—full after 38 weeks
- Uterine ovoid
 - Longitudinal—in cephalic and breech presentations
 - Transverse—in transverse and oblique lie

Shelving

Shelving occurs when the uterus falls forward at or after 38 weeks. The patient should be placed in a semirecumbent position at 45 degrees and shelving at the fundus should be noted (Fig. 8.11).

Palpation

Measuring fetal growth

After palpating the fundus of the uterus and identifying the top border of the symphysis pubis, the SFH is assessed or measured.



Figure 8.11 Shelving. It should be noted with the patient in a semirecumbent position.

Determining lie, presentation, and engagement

Lie, presentation, and engagement are determined by the *Leopold's maneuvers*, which are four specific steps in abdominal palpation of the uterus. These steps help determine the lie and presentation of the fetus. They also help identify whether engagement of the presenting part has occurred.

Leopold's maneuver 1 (fundal grip)

Leopold's maneuver 1 helps answer the following question:

What is in the fundus?

The examiner stands on the patient's right side, facing her head. The hands are placed at the fundus and an attempt is made to identify the fetal part at the fundus (Fig. 8.12). In most cases, the breech is palpated. The breech is less hard than the head and is not defined as easily. It is soft, broad, more irregular, and not independently ballotable. The breech is also in continuity with the fetal back with no intervening groove as is found with the head (Box 8.20).

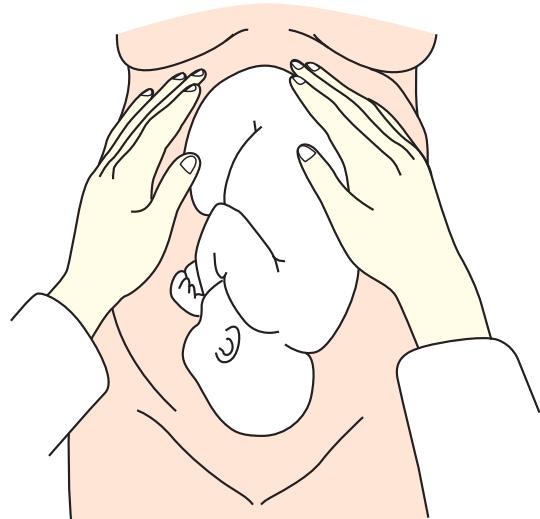


Figure 8.12 Leopold's maneuver 1.

Box 8.20 Identifying the breech

- Less hard than head
- Irregular
- Soft and broad
- Not independently ballotable
- In continuity with fetal back with no intervening groove

Leopold's maneuver 2 (umbilical grip)

Leopold's maneuver 2 helps answer the following question:

Where is the fetal spine?

The examiner continues to stand in the same position. The hands are placed on the sides of the abdomen, at the level of the umbilicus (Fig. 8.13). The location of the back and small parts is identified (Box 8.21). The back is identified by feeling the uniform resistance of the smoothly curving firm arch of the spine. On the other side, there will be small, irregular parts that represent the limbs. Movements of the limbs may be felt, confirming the diagnosis. Once the spine is identified, it is obvious that the occiput will be on the same side as the spine.

The fetal spine is felt easily and more anteriorly in occiput anterior positions. The spine is felt more posteriorly (toward the flank) and limbs felt easily and anteriorly in occiput posterior positions.

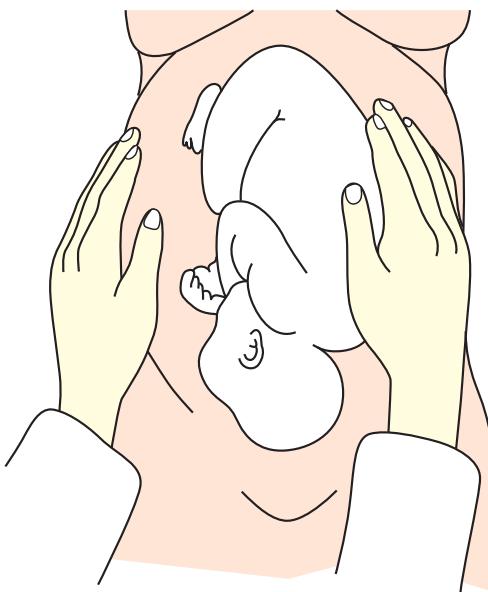


Figure 8.13 Leopold's maneuver 2.

Box 8.21 Identifying fetal spine and limbs

- Fetal spine
 - Uniform resistance
 - Smoothly curving
 - Firm arch
- Fetal limbs
 - Small, hard, irregular parts
 - On the opposite side of spine
 - Movements might be felt

Leopold's maneuver 3 (pelvic grip 1)

Leopold's maneuver 3 helps answer the following question:

What is the presenting part?

This maneuver is also called the Pawlik's grip. It is performed with the examiner still by the side of the patient, facing her head. The lower uterine segment is grasped between the thumb and fingers of one hand (Fig. 8.14), while the other hand steadies the uterus at the fundus. In most cases, the head will be in the lower pole of the uterus. It can be identified as a hard, globular smooth structure, which is in contrast to the less defined breech.

The head is then grasped and moved from side to side. If it moves freely, it is considered to be floating, that is, it has not yet descended into the bony pelvis. In contrast, if most of the head seems to have entered the bony pelvis, it may be engaged or fixed (see below). This is confirmed by the second pelvic grip. In late pregnancy, the lower uterine segment can be tender, so the first pelvic grip should be performed as gently and as quickly as possible.

This step also establishes the fetal lie and presentation. If the head is felt in the lower pole, it is then known that the fetus is in a longitudinal lie with a cephalic presentation.

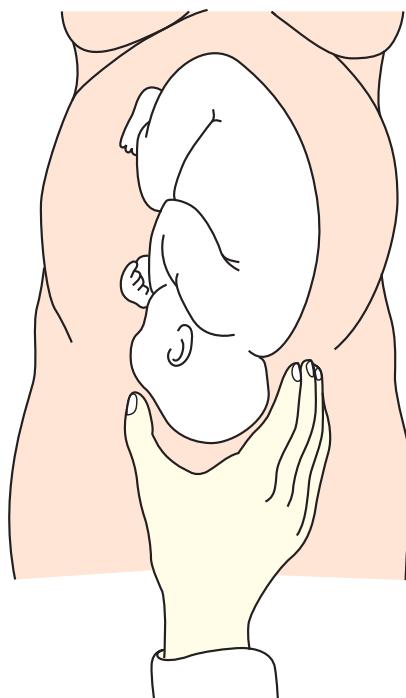


Figure 8.14 Leopold's maneuver 3.

Leopold's maneuver 4 (pelvic grip 2)

Leopold's maneuver 4 helps answer the following questions:

- What is the presenting part?
- Where is the cephalic prominence?
- What is the attitude of the fetal head?
- Is the head engaged?

The examiner still stands on the right side of the patient but now faces her feet.

The two hands are placed on either side of the uterus just below the level of the umbilicus (Fig. 8.15), and the tips of the fingers of each hand glide along the sides of the uterus toward the pubis ('walk down' with the fingertips).

- The presenting part is reconfirmed.
- The cephalic prominence is identified. It is the most prominent part of the fetal head that is felt on palpation. It may refer to the sinciput (forehead) or the occiput, depending on the attitude of the fetus. Feeling the cephalic prominence helps determine whether the head is flexed or extended. The cephalic prominence is identified by the resistance felt by one of the examining hands.
- The attitude of the fetus is determined. When the head is flexed, the sinciput is felt first and the occiput is lower (Fig. 8.16). The cephalic

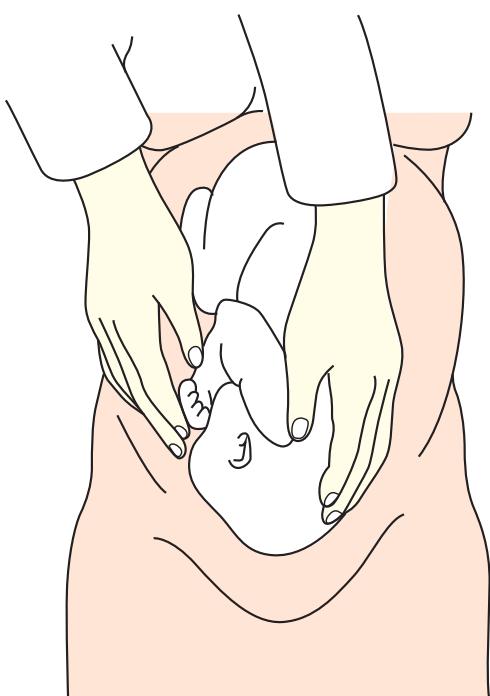


Figure 8.15 Leopold's maneuver 4.

prominence therefore will be on the same side as the small parts. When the head is extended and the fetus is in an extended attitude (face or brow presentation), the occiput will be felt first. In this case, the cephalic prominence will be on the same side as the fetal back. When the head is deflexed, the occiput and sinciput are felt at the same level (Box 8.22).

- Engagement of the presenting part is determined. When the widest diameter of the presenting part has passed through the pelvic inlet, engagement is said to have taken place (Fig. 8.17). If *engagement* has taken place, the leading bony presenting part is at or nearly at the level of the ischial spines.

Since the suboccipitobregmatic diameter and the biparietal diameter are at the same level, this diameter also enters the pelvic brim at the same

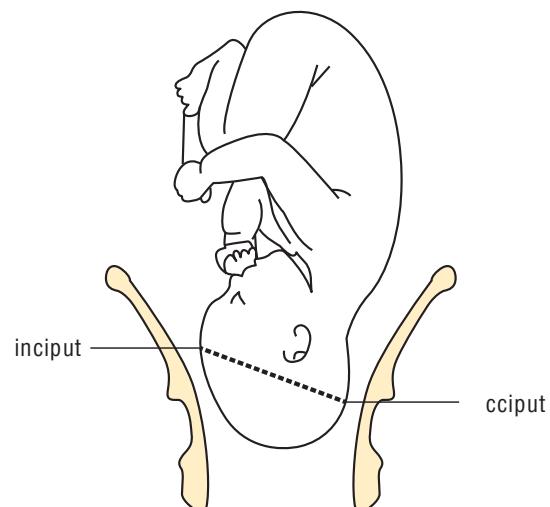


Figure 8.16 The sinciput is felt at a higher level in a well-flexed vertex presentation.

Box 8.22 Interpretation of findings on Leopold's maneuver 4

- Fetal vertex flexed
 - Sinciput (forehead) felt first
 - Occiput lower
 - Cephalic prominence same side as small parts
- Vertex deflexed (OP position)
 - Occiput and sinciput at the same level
 - Cephalic prominence on the same side as the back
- Fetal vertex extended (face or brow presentation)
 - Occiput felt first
 - Sinciput (forehead) lower
 - Cephalic prominence same side as fetal back

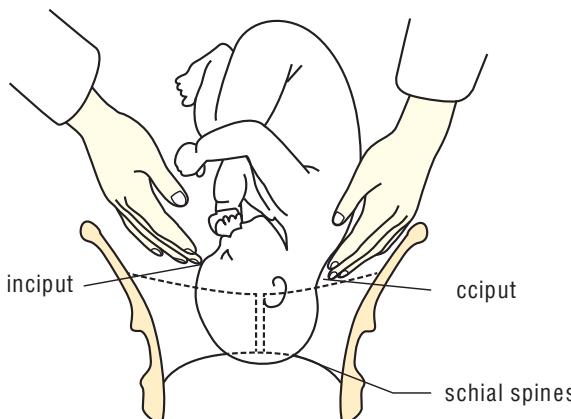


Figure 8.17 Engagement. Widest diameter of the fetal head has passed the pelvic inlet.

time. Therefore, on the second pelvic grip, in vertex presentation, when the head is engaged, only the sinciput is felt and the head is 1/5th palpable (Fig. 8.17; see Chapter 14, *Normal labor: Mechanics, mechanism, and stages*). The fingers of the examining hands diverge beyond this point.

Leopold's maneuvers are summarized in Box 8.23.

Box 8.23 Leopold's maneuvers

- Maneuver 1 (fundal grip)
 - Identifies fetal part in fundus
 - Fetal lie
- Maneuver 2 (umbilical grip)
 - Side of fetal spine
 - Fetal lie and presentation
- Maneuver 3 (pelvic grip 1)
 - Presenting part
- Maneuver 4 (pelvic grip 2)
 - Reconfirms presentation
 - Identifies cephalic prominence
 - Fetal attitude
 - Engagement of head

Auscultation

In the third trimester, in a vertex presentation, the fetal heart is usually heard below the level of the umbilicus, on the same side as the fetal spine, along the line connecting the umbilicus and anterior superior iliac spine (spinoumbilical line). It is heard just lateral to the midline in occipitoanterior positions and toward the flank in occipitoposterior positions. In a breech presentation it may be heard at or above the level of the umbilicus (Box 8.24). The normal fetal heart rate ranges between 120 and 160 bpm.

Box 8.24 Guidelines for locating the fetal heart

- Heard on the same side as fetal spine
- Vertex presentation
 - Below the umbilicus
 - OA—just lateral to midline
 - OP—toward the flank
- Breech presentation
 - Above the umbilicus

A occipitoanterior; P, occipitoposterior.

Vaginal examination in the late third trimester

A vaginal examination may be performed at or after 38 weeks' gestation. It provides information about the cervix, presenting part, membranes, and pelvis (Box 8.25).

Box 8.25 Indications for performing a vaginal examination at term

- Cervical effacement and dilatation
- Presenting part
 - Presentation
 - Position
 - Station
- Status of membranes
- Clinical pelvimetry to assess pelvic capacity

Procedure for vaginal examination at term

The procedure for vaginal examination at term consists of the following steps:

- A vaginal examination at term should be done with a sterile glove.
- Since the cervical os may be open or there may be a very small possibility of rupture of membranes at the time of examination, it is important to use sterile techniques to avoid ascending infection.
- The procedure is briefly explained to the mother so that she is at ease.
- She is placed in the dorsal position with her knees bent. She is asked to breathe deeply through her mouth, which helps her relax and makes the vaginal examination easier.
- Adequate lubrication should be used.
- The middle finger of the examining (right) hand is first inserted and then the index finger.
- The examination should be done gently because, at term, the vagina is very hyperemic and tender.

Contraindications to vaginal examination at term

Contraindications to vaginal examination at term are as follows:

- Suspected placenta previa
- Suspected ruptured membranes (in which case, a speculum examination must be done to confirm or rule out rupture of membranes)

Assessment of effacement and dilatation of the cervix

Assessment of effacement and dilatation of the cervix is discussed in Chapter 14, *Normal labor: Mechanics, mechanism, and stages*.

Evaluation of the presenting part

External presentation

Vertex (occiput) presentation

The fetal skull feels hard and rounded (Box 8.26). If the cervix is open, the coronal and sagittal sutures will be felt by gliding the examining fingers over the skull. The fontanelles can be identified as shallow spaces, which have a little give on gentle pressure. If the head is well flexed, only the triangular posterior fontanelle will be felt.

Box 8.26 Identifying the vertex on vaginal examination

- Skull feels hard and round
- Coronal and sagittal sutures felt
- Fontanelles identified as shallow spaces between suture lines

Identification of the breech, brow, and face presentations is given in the respective chapters (see Chapter 41, *Abnormal labor 2: Malposition and malpresentations* and Chapter 42, *Abnormal labor 3: Breech presentation and shoulder dystocia*).

External position

Vertex or cephalic presentation

The sagittal suture is identified. Once either the anterior or the posterior fontanelle is identified, the position of the fetus is recorded depending on the relation of the occiput to the maternal pelvis. The terms 'right' and 'left' refer to the

mother's right and left and not that of the examining physician (Box 8.27).

Box 8.27 Determining fetal position in vertex presentation

- Sagittal suture identified
- Anterior or posterior fontanelle located
- Occiput behind posterior fontanelle
- Relationship of occiput to maternal pelvis

Station of the presenting part

The station of the presenting part is described using the ischial spines as the reference point. When the presenting part is at the level of the spines, the station is '0.' Assessment of the station of the presenting part is discussed further in Chapter 15, *Management of normal labor and delivery*.

Assessment of the capacity of the bony pelvis (clinical pelvimetry)

It is good clinical practice to make a rapid assessment of the bony architecture of the pelvis. This may alert the obstetrician to the possibility of dystocia in labor. This is discussed further in Chapter 40, *Abnormal labor: Abnormalities in passage and powers*.

Procedure

Assessment of the pelvis or internal pelvimetry begins with palpation of the sacral promontory. The examination proceeds in the order described in Box 8.28.

At the end of the obstetric examination, the patient must be clearly informed about the findings, the progress of her pregnancy, and the fetal status.

Box 8.28 Assessment of the bony pelvis

- Sacral promontory
- Diagonal conjugate
- Curvature of the sacrum
 - Above downwards
 - Side to side
- Sacrosciatic notch
- Pelvic side walls
- Ischial spines
- Forepelvis
- Subpubic angle
- Transverse diameter of the outlet (intertuberous diameter)

Key points

History

- A detailed history from an obstetric patient can give significant information regarding diagnosis of pregnancy, identification of risk factors, appropriate management, and follow-up.
- The date of the first day of the last menstrual period (LMP) is a very important information and should be obtained in all pregnant women.
- Naegle's rule: A provisional expected date of delivery can be calculated from the menstrual history in women with 28- to 30-day cycles by adding 7 days to the first day of the LMP and then subtracting 3 months.
- Details of the present pregnancy from confirmation of pregnancy to date must be obtained.
- A detailed obstetric history of the past pregnancies is important.
- Past medical and surgical history, family history, and personal history should be elicited.

Examination

- A properly performed obstetric examination can give significant information for the diagnosis and follow-up of pregnancy.
- A vaginal examination must always be preceded by an abdominal examination.
- A vaginal examination is the most personal examination a woman will undergo and must be handled with sensitivity to her feelings.
- Gestational age can be assessed by recording the symphysio-fundal height. Between 20 and 32 weeks, each centimeter corresponds to 1 week.
- Leopold's maneuvers are four specific steps in abdominal palpation of the uterus. These steps help

determine the lie and presentation of the fetus. They also help identify whether engagement of the presenting part has occurred.

- The lie of the fetus refers to the position of the long axis of the fetus in relation to the mother. The fetus can be in longitudinal lie (cephalic or breech), transverse lie, or oblique lie.
- Presentation of the fetus is determined by the fetal lie and the presenting part. It could be cephalic, breech, shoulder, face, or brow.
- The position of the fetus refers to the relationship of a specific point of the fetal presenting part to the anterior, posterior, or lateral sides of the maternal pelvis. The point referred to is called the reference point or denominator.
- When the widest diameter of the presenting part has passed through the inlet, engagement is said to have taken place.
- In a vertex presentation, engagement of the fetal head is determined by evaluating the extent of the head palpable per abdomen, described in terms of fifths of the fetal head.
- A vaginal examination at term should be done with a sterile glove.
- Vaginal examination at term is contraindicated in suspected placenta previa and suspected ruptured membranes. In the case of suspected rupture of membranes, a speculum examination should be done to confirm or rule out rupture of membranes.
- Reasons for performing a vaginal examination at term include confirmation of the presenting part, assessment of station of the presenting part, assessment of the cervix for ripening (effacement and dilatation), and assessment of the capacity of the bony pelvis (clinical pelvimetry).

Self-Assessment

Case-based questions

Case 1

Mrs. TM, 24, was married 1 year ago and was 5 months pregnant. She was not sure if she could feel fetal movements and wanted to know if her pregnancy was normal.

1. How is EDD calculated?
2. When does a primigravida feel quickening?
3. Where will the uterine fundus be felt at 20 weeks' gestation?
4. Why is symphysio-fundal height important?

Case 2

Mrs. SS, 26, had come for a routine antenatal examination close to term. She wanted to know how the pregnancy was progressing and was anxious to know if the head was engaged.

1. What does Leopold's fourth maneuver achieve?
2. What is fetal lie?
3. Where will the fetal heart be best heard in a vertex presentation?
4. What is engagement?

Answers

Case 1

1. The EDD is calculated using Naegele's rule: Add 7 days to the first day of the LMP and then subtract 3 months. This is applicable to women with 28- to 30-day cycles.
2. A primigravida usually feels quickening at 18–20 weeks.
3. The uterine fundus will be felt two-thirds of the distance between the pubic symphysis and umbilicus, at 20 weeks' gestation.
4. The symphysio-fundal height is used to measure the uterine size. Between 20 and 32 weeks' gestation, the fundal height (in cm) roughly corresponds to the weeks of gestation.

Case 2

1. Leopold's fourth maneuver reconfirms presentation, identifies cephalic prominence, and determines fetal attitude and engagement of the head.
2. The lie of the fetus refers to the position of the long axis of the fetus in relation to the mother. The fetus can be in longitudinal lie (cephalic or breech), transverse lie, or oblique lie.

3. In a vertex presentation, the fetal heart is usually heard below the level of the umbilicus, on the same side as the fetal spine.
4. When the widest diameter of the presenting part has passed through the inlet, engagement is said to have taken place.

Sample questions

Long-answer question

1. Describe Leopold's maneuvers.

Short-answer questions

1. Gravidity
2. Parity
3. Fetal lie
4. Fetal attitude
5. Fetal presentation
6. Fetal position
7. Describe how engagement of the presenting part is determined

9

Preconceptional and Antenatal Care

Case scenarios

Mrs. YL, 25, had been married for a year. The couple was planning a pregnancy. She had a strong family history of diabetes mellitus. Before marriage she was diagnosed to have polycystic ovarian syndrome with mildly elevated blood sugars. The couple wanted to know what complications could occur during pregnancy and what precautions were necessary.

Mrs. HM, 23, was pregnant for the first time. At 32 weeks' gestation she was found to have hypertension. She wanted advice on managing her hypertension and what effect it would have on her baby.

Introduction

Childbearing is one of the commonest experiences that a woman in the reproductive age group will undergo. Improving the mother's preconceptional health can result in improved reproductive health outcomes, with the potential for reducing the economic burden on society. Preconceptional counseling and care has been shown to improve pregnancy outcomes, including low birth weight, premature birth, and infant mortality.

The antenatal period is an extremely important time during pregnancy and the care received during this time will have short- and long-term effects on both the mother and the fetus. It is well-recognized that good antenatal care improves

maternal, perinatal and neonatal outcomes, especially in developing countries such as India.

Preconceptional care

Preconceptional care is the process of identifying social, behavioral, environmental, and biomedical risks to a woman's future pregnancy outcome and then reducing these risks through appropriate intervention.

Goals of preconceptional care

Goals of preconceptional care include screening for risk factors, initiating preventive health

Box 9.1 Specific goals of preconceptional care

- Screening for risk
 - Personal and family history
 - Physical examination
 - Laboratory screening
- Preventive health
 - Nutrition and supplements
 - Weight and exercise
 - Vaccination
- Specific individual issues
 - Chronic diseases
 - Medications
 - Stop teratogenic drugs
 - Substitute safer drugs

measures, and identifying and addressing individual health issues (Box 9.1).

Opportunities to initiate preconceptional care

Most women do not consult the obstetrician for preconceptional advice prior to pregnancy. Therefore, all available opportunities should be utilized by the obstetrician/physician to initiate preconceptional care (Box 9.2).

Box 9.2 Opportunities to initiate preconceptional care

- Any visit to a doctor during reproductive years
- Annual health checkup
- Postpartum checkup
- A visit for a pregnancy test (especially if negative)
- Emergency visit
- Visit for infertility treatment
- Premarital counseling

Interventions in the preconceptional period

Specific preconceptional interventions are recommended to all women in the reproductive age group (Table 9.1). These interventions improve the outcome of pregnancy.

Several medical disorders may affect women before or during their pregnancy. These women need counseling regarding the effects on pregnancy, complications they are prone to, and the special precautions to be initiated. Therefore, women with specific risk factors require individualized, specific recommendations (Table 9.2).

Table 9.1 Recommended preconceptional interventions for all women

Intervention	Proven health benefit
Folic acid supplementation (400 µg); consider higher dose for women (a) taking antiseizure medications and other drugs that might interfere with folic acid metabolism, (b) who are obese, or (c) with a previous neural tube defect (NTD)	Reduces occurrence of neural tube defects by two-thirds
Hepatitis B vaccination for at-risk women	Prevents transmission of infection to the infant
HIV/AIDS screening and treatment	Allows for appropriate treatment and provides women (or couples) with additional information that can influence the timing of pregnancy and treatment
Screening and treatment of sexually transmitted diseases	(a) Reduces the risk of ectopic pregnancy, infertility, and chronic pelvic pain associated with <i>Chlamydia trachomatis</i> and <i>Neisseria gonorrhoeae</i> (b) Reduces the possible risk of fetal death, physical and developmental disabilities, including mental retardation and blindness
Rubella vaccination	Protects against congenital rubella syndrome
Optimizing weight in overweight and obese women	Reduces the risks of neural tube defects, preterm delivery, diabetes, cesarean section, and hypertensive disease
Smoking cessation	Prevents smoking-associated preterm birth, low birth weight
Eliminating alcohol use before and during pregnancy	Prevents fetal alcohol syndrome; other alcohol-related birth defects

A DS acquired immune deficiency syndrome;

human immunodeficiency virus.

Table 9.2 Recommended preconceptional interventions for women with specific risk factors

Risk factor	Intervention	Proven health benefit
Antiepileptic drug use	Changing to a less teratogenic treatment regimen	Decreases risk of fetal malformations
Diabetes mellitus	Achieving and maintaining hemoglobin- A1C <7%	Decreases congenital anomalies, length of neonatal intensive care unit admission, perinatal mortality, and long-term health consequences in infant; decreases miscarriage risk
Hypertension (HTN)	Avoid ACE inhibitors and ARBs. If long-standing HTN, then assess for renal disease, ventricular hypertrophy, and retinopathy	Decreases congenital anomalies, HTN complications, cesarean, FGR, placental abruption, preterm birth, perinatal death
Hypothyroidism	Thyroxine supplementation to maintain TSH level at <3.0 mU/L	Decreases infertility, preterm birth, low birth weight, fetal death, and possibly neurological problems in infant
Hyperthyroidism	Propyl thiouracil supplementation to maintain FT4 in high normal range, and TSH in low normal range	Decreases spontaneous pregnancy loss, preterm birth, preeclampsia, fetal death, FGR, maternal congestive heart failure and thyroid storm; neonatal Graves' disease
Asthma	Management with inhalation therapy (bronchodilators/ glucocorticoids)	Decreases infertility, preterm birth, low birth weight, preeclampsia, perinatal mortality
Systemic lupus erythematosus	≥6 months of quiescence on stable therapy	Decreases risk of HTN, preeclampsia, preterm birth, fetal death, FGR, neonatal lupus erythematosus

AC angiotensin converting enzyme; A Bs angiotensin receptor blockers; FGR fetal growth restriction; S thyroid-stimulating hormone.

Principles of teratogenicity

A prenatal visit is a good opportunity to screen for and educate the woman about exposure to teratogens. Any factor that alters normal intrauterine development can be considered a teratogen. This includes exposure to the following:

- Drugs
- Chemicals
- Radiation
- Maternal medical conditions
- Infectious agents
- Genetic factors

All or none period of embryogenesis

The first 2 weeks after conception is a remarkable period for the embryo. At this stage, exposure to teratogens can result in

- Complete loss of pregnancy (spontaneous miscarriage) due to severe cellular insult, or

- No damage at all because the pluripotent embryonic cells can replace the cells destroyed or damaged by the teratogen

This is referred to as the 'all or none' period of embryogenesis.

Fetal susceptibility to teratogens is largely dependent on the period of development. A particularly susceptible period is between *gestational days 15 and 60*. Different organs have different critical periods (Box 9.3).

The effect on the embryo/fetus also depends on the dose and duration of exposure to a

Box 9.3 Critical periods (weeks of gestation) of susceptibility for different fetal organs

- Heart: 3–4
- Limbs: 4.5–7.5
- Eyes: 4.5–8.5
- Ears: 4.5–9.5
- External genitalia: 8–9
- Brain and skeletal system: Beginning of week 3 to end of pregnancy

teratogen. Some teratogens may have a more deleterious effect in a single large dose than the same dose spread over several days, whereas another teratogen may be more harmful when exposure is prolonged instead of a single exposure.

Drug–drug interactions can also be important. Two drugs administered together may compound the effects, or one drug may protect against the teratogenic effects of the other. For example, folic acid is prescribed to prevent the increased risk of open neural tube defects in women who are prescribed antiepileptic drugs.

To minimize the potential risk of teratogenicity when prescribing drugs, it is important to

- Use drugs or drug classes known to be of low teratogenic potential
- Avoid prescribing drugs during critical periods of toxicity (e.g., during organogenesis for all drugs and near delivery for some drugs)

Drugs and teratogenicity in pregnancy

A preconceptional visit is an excellent opportunity to have an in-depth discussion regarding prescribed and over-the-counter medications that the patient may be on. Ingesting teratogenic drugs may result in congenital malformations or other negative fetal outcomes.

The most widely used tool for evaluating drug safety during pregnancy is the US Food and Drug Administration (FDA) safety rating system. The FDA system rates medication risk using categories A, B, C, D, and X, based on the available data in human and animal studies (Box 9.4).

Counseling for women on known teratogenic drugs

If a woman plans to become pregnant while taking a teratogenic medication for a known medical disorder, it is important to change the medication to a drug that is either not teratogenic or teratogenic to a lesser degree. However, it is important to not stop an essential drug. For example, although all antiepileptic drugs are known to be teratogenic to some degree, the patient should still receive medication to avoid seizures. Since valproic acid is the most teratogenic among antiepileptic drugs, it should definitely be avoided in pregnancy and,

Box 9.4 Safety rating system for drugs

Category A: Safety established

- Controlled studies in women show no risk to fetus in first trimester
- No evidence of a risk in later trimesters
- Possibility of fetal harm appears remote

Category B: Safety likely

- Animal studies show no fetal risk but no controlled studies in pregnant women *or*
- Animal studies have shown adverse effect but not confirmed in women in first or later trimesters.

Category C: Teratogenicity possible

- Studies in animals have revealed adverse effects on the fetus (teratogenic, embryocidal, or other) but no controlled studies in women *or*
- Studies in women and animals not available.
- These drugs should be given only if the potential benefit justifies the potential risk to the fetus.

Category D: Teratogenicity probable

- Positive evidence of human fetal risk, but the benefits from use in pregnant women may be acceptable despite the risk, if the drug is needed in
 - a life-threatening situation *or*
 - a serious disease for which safer drugs cannot be used or are ineffective

Category X: Teratogenicity likely

- Studies in animals and humans have demonstrated fetal abnormalities *and/or*
- There is evidence of fetal risk based on human experience *and*
- The risk of the use of the drug in pregnant women clearly outweighs any possible benefit
- Contraindicated in women who are or may become pregnant.

in addition, the patient should be placed on folic acid (Box 9.5).

In cases where the woman has conceived while on a teratogenic drug, a decision must be made to either continue the drug or change it for another one. The mother's anxiety must be understood and addressed. Since most drugs only marginally increase the risk of congenital malformations, termination of the pregnancy is usually not required. However, this decision must be based on the type, dose, and duration of medication ingested. Special monitoring or treatment may be warranted during pregnancy depending on the drug exposure. For example, fetal echocardiography may be indicated if a medication is known to cause fetal cardiac defects.

Box 9.5 Some teratogenic prescription drugs (Category X)

- Androgens and testosterone derivatives (e.g., danazol)
- Angiotensin-converting enzyme (ACE) inhibitors (e.g., enalapril, captopril) and angiotensin II receptor blockers
- Coumadin derivatives (e.g., warfarin)
- Carbamazepine
- Diethylstilbestrol
- Folic acid antagonists (methotrexate and aminopterin)
- Lithium
- Phenytoin
- Primidone
- Statins
- Streptomycin and kanamycin
- Tetracycline
- Thalidomide and leflunomide
- Trimethadione and paramethadione
- Valproic acid
- Vitamin A above recommended daily allowance (RDA), and its derivatives (e.g., isotretinoin, etretinate, and retinoids)

Exposure to radiation

In women who are planning pregnancy, diagnostic X-rays must preferably be done in the first 14 days of the menstrual cycle, to avoid inadvertent exposure to radiation.

Effect of radiation on the fetus

The human embryo and fetus are particularly sensitive to ionizing radiation. High radiation doses may lead to growth restriction, malformations, impaired brain function, and cancer. Fortunately, most common diagnostic radiological procedures will not expose the fetus to significant levels of radiation.

The effect on the fetus depends on the gestational age and the dose of ionizing radiation (Box 9.6).

Box 9.6 Effect of ionizing radiations on fetus

- First 14 days after conception, >0.1 Gy or 10 rad
 - Death of embryo or no effect (***all or none*** principle)
- At all gestational ages, <0.05 Gy or 5 rad
 - No adverse effect
- After 16 weeks, <0.50 Gy or 50 rad
 - No effect

The following imaging studies have no effect on the fetus:

- Diagnostic X-rays of the head, neck, chest, and limbs
- Ultrasound and magnetic resonance imaging (MRI)
- Dental X-rays
- CT scans not involving the abdomen or pelvis

Safety precautions

The pregnant woman should wear a lead apron to minimize fetal exposure whenever non-abdomino-pelvic radiological imaging is being carried out.

Women who work professionally with radiation should always wear a dosimeter to make sure that they are not exposed unnecessarily to high doses of radiation.

Antenatal care

The majority of women will have an uncomplicated pregnancy and deliver a healthy infant with minimal medical intervention. However, a significant number will develop medical or fetal complications. Antenatal care helps in recognition and appropriate intervention for the complications that may arise. The goals of optimal antenatal care are summarized in Box 9.7.

The first or booking visit

Ideally, the first or booking visit should be before 10 weeks' gestation. Regardless of when the woman presents for her first visit, a thorough history and physical examination must be carried out. Investigations specific to the first visit must be performed. Advice must be offered with emphasis

Box 9.7 Goals of antenatal care

- Early, accurate estimation of gestational age
- Identification of risk factors
 - Existing risks (e.g., diabetes)
 - Risks that develop during pregnancy (e.g., hypertension, fetal growth restriction)
- Regular evaluation of mother and fetus
- Anticipation of problems and intervention, if possible, to prevent or minimize morbidity
- Patient education and communication

on diet and nutrition, hematinics, exercise, travel, intercourse, and management of common signs and symptoms of pregnancy (Box 9.8).

History, physical examination, and gestational age assessment are discussed in detail in Chapter 8, *History taking and examination of the obstetric patient*.

Risk evaluation and risk categorization

During the initial antenatal examination, it is important to try and categorize the pregnant woman into a low- or high-risk group. Initial and ongoing evaluation of a woman's chance of giving birth normally is crucial in preventing

Box 9.8 First or booking visit

- History
 - Personal information
 - Menstrual and gynecological history
 - Obstetric history
 - Personal and family medical history
 - Psychosocial information
 - Past medical and surgical history
 - Genetic history
 - Current pregnancy history
 - Current medications and allergies
- Physical examination
 - Baseline blood pressure, weight, and height, body mass index (BMI)
 - Complete physical examination (including breasts)
 - Pelvic examination
 - Uterine size
 - Uterine shape
 - Evaluation of adnexae
- Gestational age assessment
 - Ultrasonography if discrepancy exists between uterine size by physical examination and that by dates
 - Assignment of expected date of delivery
- Risk evaluation for subsequent management
- Tests
 - Blood investigations
 - Aneuploidy screening
 - Screening for gestational diabetes/gestational hypertension
- Advice
 - Nutrition, including hematinics
 - Exercise
 - Travel
 - Work
 - Common symptoms and management

both maternal and perinatal complications, and adverse events. Risk categorization also helps in planning appropriate level of care.

The assessment of risk factors starts during antenatal care. Simple determinants (e.g., maternal age, height, and parity) and obstetric history of complications (e.g., previous stillbirth or cesarean section) will help place the woman in a low- or high-risk category. Subsequent visits might reveal abnormalities in the present pregnancy, such as hypertension, severe anemia, multiple pregnancy, antepartum hemorrhage, or abnormal lie.

The four combinations of risk categorization are listed in Box 9.9. The difficulty with risk assessment lies in group II where the baby is unexpectedly compromised. The likelihood of predicting all adverse outcomes is limited, and several scoring systems have been used but have failed to consistently identify this group.

A pregnant woman can be placed in the high-risk category based on maternal or perinatal factors (Table 9.3).

Box 9.9 Risk categories

- I. Low-risk mother with a low-risk fetus, for example, normal pregnancy, mother and baby well
- II. Low-risk mother with a high-risk fetus, for example, normal pregnancy, mother well but baby unexpectedly compromised
- III. High-risk mother with a low-risk fetus, for example, maternal asthma
- IV. High-risk mother with a high-risk infant, for example, severe hypertension with fetal growth restriction

Table 9.3 High-risk groups

Maternal factors	Perinatal factors
Hypertension	Previous adverse events
Renal disease	Recurrent pregnancy loss
Respiratory disease	Prematurity (including rupture of membranes and labor)
Cardiac disease	Rhesus disease
Hemoglobinopathy	Diabetes
Psychiatric conditions	Monozygotic multiple pregnancy
Infections (e.g., <i>aricella</i>)	Fetal anomaly
Drug misuse	Assisted conception
Extremes of age	
Obesity	

Tests and investigations at first booking

A standard panel of laboratory tests should be obtained on every pregnant woman at the first prenatal visit. Additional testing may be required in women at risk for specific conditions.

Standard panel of investigations

Hemoglobin, hematocrit, blood picture, and mean corpuscular volume

Tests for hemoglobin, hematocrit, blood picture, and mean corpuscular volume (MCV) are done to identify anemia. The MCV differentiates between iron-deficiency anemia ($MCV < 80 \text{ fL}$) and B_{12} -deficiency anemia ($MCV > 115 \text{ fL}$). Blood picture reveals microcytic hypochromic red cells in iron deficiency, and macrocytes in B_{12} and folic acid deficiencies (see Chapter 49, *Hematological disorders*).

Blood group and Rh typing

All pregnant women should have their blood group and Rh typing done and these should be documented. If a woman is identified as Rh(D) negative, her husband's/partner's Rh typing must be done to determine if he is Rh(D) positive. If he is Rh(D) positive, she could be at risk for Rh alloimmunization in pregnancy and her baby could have hemolytic disease of the newborn (see Chapter 38, *Red cell alloimmunization*). All Rh(D)-negative women should be tested for the presence of alloantibodies (Box 9.10).

Test for syphilis

Either the rapid plasma reagin (RPR) test or the Venereal Disease Research Laboratory (VDRL) test is done to rule out syphilis. Although syphilis is rare, the consequences of congenital syphilis are severe and so this test should be done for all women.

Box 9.10 Rh testing

- All women to be tested
- If Rh negative
 - Rh typing of husband/partner
- If husband/partner Rh positive
 - Test for alloantibodies
 - If positive
 - Risk of alloimmunization
 - Hemolytic disease of the newborn

Test for hepatitis B surface antigen

Hepatitis B antigen screening is recommended for all pregnant women to prevent perinatal transmission to the newborn (see Chapter 51, *Hepatic and gastrointestinal disorders*). Women who have been vaccinated should also undergo testing because no screening is done prior to vaccination to rule out carrier status.

Test for human immunodeficiency virus

Universal screening for human immunodeficiency virus (HIV) is recommended for all pregnant women (see Chapter 56, *Infections*) (Box 9.11). Screening is usually done with an enzyme-linked immunosorbent assay (ELISA) test for the presence of HIV antibodies. If this test is reported as positive, HIV infection is confirmed with the *Western blot* test. Confirmation can also be done with an *indirect fluorescent antibody* (IFA) test, which detects HIV antibodies using a special fluorescent dye and a microscope.

Polymerase chain reaction (PCR) test finds either the RNA of the HIV virus or the HIV DNA in white blood cells infected with the virus. PCR testing is done when a very recent infection is suspected. It is not done for routine screening in pregnancy.

Rubella susceptibility screening

The pregnant woman is tested for the presence of IgG antibody to rubella. If the test is positive, she is immune to rubella. If it is negative, she is susceptible to rubella. She will require vaccination in the postnatal period for the protection of future pregnancies.

Screening for TORCH infections

Routine screening for TORCH infections in pregnancy is **not** advised. The TORCH panel consists of serum tests for Toxoplasmosis, Other, Rubella, Cytomegalovirus and Herpes simplex. It is not

Box 9.11 Universal testing for HIV early in pregnancy

Advantages

- Informed decision to continue or terminate pregnancy
- Initiation of early treatment for mother
- Prevention of transmission to partner or identification of infected partner
- Measures to prevent vertical transmission to the newborn

indicated even with a history of recurrent pregnancy loss.

Screening for gestational diabetes

Screening for diabetes is performed at the booking visit for all Indian women since they are considered to be at an intermediate/high risk. If the first trimester screening test is negative, the test should be repeated at 24–28 weeks. Both fasting plasma glucose, and 75 g glucose followed by plasma glucose 2 hours later, are acceptable as screening tests. Screening for diabetes in pregnancy is discussed in detail in Chapter 48, *Diabetes*.

Screening for asymptomatic bacteriuria

Asymptomatic bacteriuria is an established risk factor for preterm delivery, low birth weight, and acute pyelonephritis. Identification and treatment of asymptomatic bacteriuria reduces the risk of such complications. It is usually offered at the booking visit.

The screening is done with a culture of a clean-catch urine specimen. In underresourced areas, this may not be possible. Nitrite dipsticks may be used and if positive, a urine culture may be done to confirm bacteriuria.

If the culture shows bacteriuria, appropriate antibiotics are prescribed (see Chapter 55, *Renal and urinary tract disorders*).

Screening for aneuploidy

Screening for Down syndrome should be offered to all women at booking, and the choice whether to have the screening test done or not, is left to the couple. The test that should ideally be offered is a first trimester screening (Box 9.12) done at 11 to 13⁺⁶ weeks (i.e., from the first day of the 11th week of gestation to the last day of the 13th week). The second trimester triple test or quadruple test

Box 9.12 First trimester screening for aneuploidy (Down syndrome [trisomy 21], trisomy 18, trisomy 13)

- 11–13⁺⁶ weeks
- Nuchal thickness
- Serum biochemistry
 - Pregnancy-associated plasma protein-A (PAPP-A)
 - Level reduced in Down syndrome
 - β human chorionic gonadotropin (βhCG)
 - Level raised in Down syndrome

is reserved for those women who book later in pregnancy.

Dietary and nutritional advice at the booking visit

Obtaining a good dietary history and giving proper dietary advice are essential at the booking visit (Box 9.13). It is an opportunity to set right the woman's misconceptions of food requirements in pregnancy. It also allows recommendation of weight gain goals that are appropriate for the individual.

Undernourished mothers (body mass index (BMI) <18 kg/m²), particularly low-income women, need special attention and dietary advice for meeting their dietary needs. Unless they gain adequate weight during pregnancy, they are at risk for preterm labor and delivering low birth weight infants (Box 9.14).

Women who gain excessive weight are at an increased risk for preeclampsia, failed induction, cesarean delivery, and a macrosomic infant. Women who gain more weight than the recommended amount during pregnancy are three times more likely to retain 5 kg or more at 1 year postpartum.

For those women whose BMI is >30 kg/m² at the initial visit, information on the complications of obesity on fetal and maternal well-being should be given (see Chapter 52, *Endocrine disorders*).

Box 9.13 Increased dietary requirements in pregnancy

- Calories: The recommended intake is an increase in daily caloric intake by
 - 300 kcal/day in the second trimester
 - 400 kcal/day in the third trimester
- Carbohydrate: The recommended daily allowance for carbohydrates
 - Pregnant women: 175 g/day
 - Nonpregnant women: 130 g/day
- Protein
 - Fetal/placental unit
 - Consumes approximately 1 kg of protein
 - Mostly in the last 6 months
 - Protein requirement in pregnancy
 - 1.1 g/kg/day
- Vitamins and minerals: These are provided by
 - ingestion of fresh fruits and vegetables
 - oral supplements essential

Box 9.14 Effect of weight gain on pregnancy outcomes

- Low weight gain
 - Associated with
 - preterm labor
 - low-birth-weight infants
- Excessive weight gain
 - Associated with
 - preeclampsia
 - failed induction
 - cesarean delivery
 - macrosomia
 - postpartum obesity

Box 9.16 Recommended dosage of folic acid

- 400 µg of folic acid daily to be started preconceptionally
- 4 mg of folic acid daily in women with a previous history of
 - neural tube defect
 - anticonvulsant therapy
 - pregestational diabetes

Advice on dietary supplements

Iron and folic acid

Iron and folate supplements must be given to all pregnant women since total iron loss associated with pregnancy and lactation is approximately 1000 mg.

In countries such as India where the prevalence of anemia is nearly 70%–80% among pregnant women, iron supplementation is routinely given (Box 9.15). Iron-deficiency anemia may be related to preterm birth and low birth weight. For further details about iron supplementation in pregnancy, see Chapter 49, *Hematological disorders*.

Box 9.15 Recommended dosage of iron

- 1 Tablet containing at least 60 mg of elemental iron and 500 µg of folic acid should be given 1–2 times daily
- The Government of India (Ministry of Health) recommends for all pregnant women
 - 100 mg of elemental iron (335 mg of ferrous sulfate) and 500 µg of folic acid
 - for 100 days
 - from 14 weeks' gestation
 - tablets of ferrous sulfate and folic acid are supplied free of cost by the Government of India
- If the Hb is <7.0 g/dL, the dose should be doubled
- The dose should be taken
 - on an empty stomach
 - with citrus juice
- The dose should not be taken with
 - calcium tablet
 - milk, tea, or coffee

Folic acid

Pregnant women should be informed that dietary supplementation with folic acid before conception and throughout the first 12 weeks' pregnancy reduces the risk of having a baby with a neural tube defect. The recommended dose is 400 µg/day (Box 9.16).

Patients who are at risk (previously have a baby affected by neural tube defect, on anticonvulsants, pregestational diabetes) should have 4 mg daily.

Calcium

Fetal skeletal development requires approximately 25–30 g of calcium during pregnancy, primarily in the last trimester. Most of this calcium can be mobilized from the maternal stores. Calcium absorption increases during pregnancy and allows progressive retention throughout gestation. The recommended dietary intake in pregnancy and lactation is 1000–1300 mg/day. Routine calcium supplementation is not recommended in pregnancy except for women with low dietary calcium intake (Box 9.17). Indian women with poor dietary calcium intake are advised calcium supplementation with calcium carbonate or calcium citrate.

Vitamin D

Severe maternal vitamin D deficiency causes neonatal hypocalcemia and seizures. There is also an association between milder forms of deficiency and preeclampsia, gestational diabetes, and impaired growth and skeletal problems in infancy (Box 9.18). Vitamin D

Box 9.17 Calcium supplementation (in women with low dietary calcium intake)

- 500 mg of elemental calcium twice daily
- Not to be taken with iron
- Taken after food

Box 9.18 Effects of vitamin D deficiency*maternal effects*

- Preeclampsia
- Gestational diabetes

neonatal and infant effects

- Low birth weight
- Impaired growth and skeletal problems in infancy
- Neonatal hypocalcemia and seizures

Box 9.19 Causes for vitamin D deficiency

- South Asian origin (includes Indians)
- Limited exposure to sunlight
 - Mostly housebound
 - Completely covered when outdoors
- Diet low in vitamin D
 - Women who consume no oily fish, eggs, meat
- Prepregnancy body mass index above 30 kg/m²

deficiency has a high prevalence in Indian pregnant women (Box 9.19) and coexists with other nutritional deficiencies, particularly calcium deficiency. There is no necessity for routine testing of vitamin D levels in pregnancy, but in women at high risk for vitamin D deficiency, 1000–2000 IU/day of vitamin D can be given as a supplement.

Fish oil capsules or docosahexaenoic acid supplements

The use of docosahexaenoic acid (DHA)-rich fish oil capsules during pregnancy does not improve cognitive and language development in the offspring during early childhood. Supplementation with DHA is not recommended.

Exercise in pregnancy

Exercise is safe for both mother and fetus during pregnancy, and women should therefore be encouraged to initiate or continue exercise to derive the health benefits associated with such activities. Women should be advised to walk briskly for 30–45 minutes in a day. Women who are involved in physical labor (light or heavy) should be reassured that it will have no ill effect on the fetus.

Women with complicated pregnancies are discouraged from excessive physical activity for fear of adverse impact on the underlying disorder or on maternal and fetal outcomes.

Immunization against tetanus

Tetanus kills an estimated 50,000 neonates/year, worldwide. A total of 5% of all maternal deaths are due to tetanus. If at least two doses of tetanus toxoid (TT) vaccination are given during pregnancy, neonatal deaths due to tetanus can be prevented (Box 9.20). Immunizing the mother allows tetanus antitoxin to be actively transported by the placenta to her fetus, providing passive protection against tetanus during the neonatal period and the following 1 or 2 months of life. TT schedule for women of childbearing age and pregnant women is given in Table 9.4.

Other advice at booking visit

Work

Women with uncomplicated pregnancies may be allowed to carry on their normal activities. Women can continue their employment till they go into labor.

Travel

Travel by a two- or three-wheeler vehicle, car, or train is safe in pregnancy. Most women are 'low risk' and can expect no problems with air travel during pregnancy, although long air travel is associated with an increased risk of venous thrombosis.

Box 9.20 Recommended dosage of tetanus toxoid

- First dose of tetanus toxoid (TT) at the booking visit
- Second dose after 4–8 weeks
- Third dose 6 months after the second injection
 - Provides protection for at least 5 years

Table 9.4 Tetanus toxoid (TT)/tetanus diphtheria (Td) vaccination schedule for women of childbearing age and pregnant women without previous exposure to TT/Td (WHO recommendation)

Number of earlier TT by history	When to give	Expected protection period
1	At first contact	None
2	At least 4 weeks after TT 1	1–3 years
3	At least 6 months after TT2/subsequent pregnancy	At least 5 years
4	At least 1 year after TT 3 or subsequent pregnancy	At least 10 years
5	At least 1 year after TT 4 or subsequent pregnancy	Through childbearing age and possibly longer

Sexual intercourse

Sexual intercourse in pregnancy is not known to be associated with any adverse outcomes. Sexual activity between 29 and 36 weeks does not increase the risk of preterm delivery.

Smoking and alcohol intake

Smoking should be discouraged. Pregnant women should be advised to avoid drinking alcohol in any part of pregnancy. Alcohol consumption may be associated with an increased risk of miscarriage, fetal alcohol syndrome and other congenital anomalies. There is no known safe amount of alcohol to drink while pregnant. There is also no safe time during pregnancy to drink and no safe kind of alcohol.

Further antenatal visits

Standard antenatal visits are usually scheduled

- Every month till 28 weeks
- Every 2 weeks from 28 to 36 weeks
- Every week from 36 weeks till delivery

In under-resourced areas, the World Health Organization recommends at least four visits during the pregnancy for low-risk women (first trimester, 26, 32, and 38 weeks). This improves compliance without increasing complications.

Interventions at subsequent antenatal visits

At subsequent visits, the uterine height, fetal heart sounds are documented and other required investigations are done.

- Assessment of the uterine size or fundal height to assess fetal growth
 - Symphysio-fundal height (see Chapter 8, *History taking and examination of the obstetric patient*)
- Documentation of fetal cardiac activity by auscultation
 - Fetoscope
 - Stethoscope
 - Handheld Doppler device
- Maternal blood pressure and weight
- Urine for protein and glucose
- Fetal presentation (in the third trimester)
- Follow-up of modifiable risk factors

Common symptoms and their management in pregnancy

The physiological changes in the various organ systems, along with the hormonal changes of pregnancy, result in some common symptoms. Other problems are caused by the growing gravid uterus causing pressure symptoms on maternal organs, especially the vena cava. The physiological basis for these symptoms has been discussed in Chapter 3, *Maternal physiology in pregnancy*. Some common symptoms and their management are summarized in Table 9.5.

Visits between 15 and 22 weeks

The mother feels more comfortable at this stage of pregnancy. She is offered the following tests and advice:

- Triple test or quadruple test for second trimester screening for Down syndrome should be offered if first trimester screening has not been

Table 9.5 Common symptoms and their management in pregnancy

Symptom	Management
Nausea and vomiting	<ul style="list-style-type: none"> Small frequent meals Low fat, bland food Avoidance of triggers Supportive therapy Medications
Heart burn	<ul style="list-style-type: none"> Avoidance of large meals Avoiding lying down for 2 hours after a meal Semi recumbent position when lying down Antacids
Pica (craving for unusual foods)	Correct iron deficiency
Ptyalism (excessive salivation)	Reassurance
Constipation	<ul style="list-style-type: none"> High fibre diet Mild laxatives
Hemorrhoids	<ul style="list-style-type: none"> Stool softeners Sitz bath
Varicosities	<ul style="list-style-type: none"> Rest, elevation of foot Elastic stockings
Backache	<ul style="list-style-type: none"> Proper posture Exercises Symptomatic therapy
Vaginal discharge (without itching)	<ul style="list-style-type: none"> Reassurance Personal hygiene

done (see Chapter 12, *Prenatal screening, prenatal diagnosis, and fetal therapy*).

- Detailed ultrasound examination for screening of fetal anomalies is offered between 18 and 22 weeks (see Chapter 10, *Obstetric ultrasound and other imaging*).
- The pregnant woman should be advised to start her antenatal exercises if she has not already done so. She should also be advised to walk briskly for 30–45 minutes each day.

Visits between 24 and 28 weeks

The following tests are recommended in visits between 24 and 28 weeks:

- Hemoglobin and hematocrit** are retested to assess anemia and to modify iron supplementation if needed.
- Screening for gestational diabetes** is offered for all women between 24 and 28 weeks unless they are pregestational diabetics or have

already been found to have diabetes by earlier screening (see Chapter 48, *Diabetes*).

- Antibody screening for Rh-negative women** is done at 28 weeks and if antibodies are absent, it is recommended that antenatal anti-D immunoglobulin be administered to nonsensitized Rh-negative women (see Chapter 38, *Red cell alloimmunization*).

Visits between 32 and 36 weeks

The following need to be done in visits between 32 and 36 weeks:

- The woman must be educated about signs of preterm labor and labor.
- A third trimester ultrasound is not required routinely. It may be indicated in the following situations (see Chapter 10, *Obstetric ultrasound and other imaging*):
 - Confirmation of abnormal fetal presentation
 - Suspected placenta previa or follow-up of placenta previa
 - Suspected small-for-gestational-age fetus or growth-restricted fetus
 - Suspected macrosomia
 - Suspected abnormalities of amniotic fluid (oligohydramnios or polyhydramnios)
 - Follow-up of multiple pregnancy
- Fetal presentation is confirmed at 36 weeks.
- External cephalic version (ECV) is offered to women with breech presentation at 36 weeks. ECV reduces the chance of breech births and cesarean section.
- Women must be taught to do a daily fetal movement count. The significance of decreased movements must be emphasized and explained to the pregnant woman.

Visits between 37 and 41 weeks

The following need to be done in visits between 37 and 41 weeks:

- The woman must be educated on signs of labor and when to seek help for labor.
- When a woman goes postterm, the plan for induction and the process of induction are discussed.
- Motivation for breastfeeding and a discussion of contraceptive options are also initiated.

Key points

- Preconceptional counseling and care has been shown to improve pregnancy outcomes, including low birth weight, premature birth, and infant mortality.
- Preconceptional care is the process of identifying social, behavioral, environmental, and biomedical risks to a woman's future pregnancy outcome and then reducing these risks through appropriate intervention.
- Most women do not consult the obstetrician for preconceptional advice prior to pregnancy. All available opportunities should be utilized by the obstetrician/physician to initiate preconceptional care.
- Antenatal care helps in recognition and appropriate intervention for the complications that may arise.
- Ideally, the first or booking visit should be before 10 weeks' gestation. Regardless of when the woman presents for her first visit, a thorough history and physical examination must be carried out.
- Several medical disorders may affect women before or during their pregnancy. Women with specific risk factors require individualized, specific recommendations.
- Exposure to teratogens in the first 2 weeks after conception can result in complete loss of pregnancy or no damage at all. This is referred to as the 'all or none' period of embryogenesis.
- The most widely used tool for evaluating drug safety during pregnancy is the US Food and Drug Administration (FDA) safety rating system. The FDA system rates medication risk using categories A, B, C, D, and X, based on the available data in human and animal studies.
- If a woman plans to become pregnant while taking a teratogenic medication for a known medical disorder, it is important to change the medication to a drug that is either not teratogenic or teratogenic to a lesser degree.
- The human embryo and fetus are particularly sensitive to ionizing radiation. High radiation doses may lead to growth restriction, malformations, impaired brain function, and cancer.
- Most common diagnostic radiological procedures will not expose the fetus to significant levels of radiation.
- Advice must be offered with emphasis on diet and nutrition, hematinics, exercise, travel, intercourse, and management of common signs and symptoms of pregnancy.
- The standard panel of investigations includes blood group and Rh typing, hemoglobin and hematocrit, testing for syphilis, hepatitis B surface antigen, human immunodeficiency virus, screening for rubella susceptibility, gestational diabetes, and asymptomatic bacteriuria.
- Screening of aneuploidy should be offered when available and includes ultrasound examination along with serum markers.
- Iron and folic acid supplements must be prescribed.
- Calcium supplements must be prescribed in women with low dietary calcium intake.
- Immunization for tetanus must be carried out to prevent neonatal tetanus.
- Subsequent antenatal visits are used to assess fetal growth.
- Maternal screening for anemia, gestational diabetes, and antibody screening in Rh-negative women is also carried out in the follow-up antenatal visits.
- The woman must be educated about signs of preterm labor and labor.

Self-Assessment

Case-based questions

Case 1

Mrs. YL, 25, married for 1 year, is planning a pregnancy. She has a strong family history of diabetes mellitus and has been under treatment for polycystic ovarian disease.

1. What preconceptional advice would you give her?
2. When will she need to be screened for diabetes in pregnancy?
3. If she was found to be a pregestational diabetic, what risks does her fetus face and how can they be avoided?

Case 2

Mrs. KT, 32, primigravida, presents at 10 weeks for confirmation of pregnancy. Her BMI is 30 kg/m².

1. What are the routine blood tests done in the booking visit?
2. What are the complications associated with a high BMI?
3. How much iron and folic acid supplementation does she require?
4. What is the recommendation for tetanus toxoid vaccination?

Answers

Case 1

1. She should be tested for impaired glucose tolerance or diabetes before she plans a pregnancy. She must be advised about diet and exercise since she is at the risk for developing diabetes in pregnancy.
2. She must be screened at the booking visit and if negative, then at 24–28 weeks.
3. If she is not euglycemic (normal blood sugars) at the time of conception, she is at risk for fetal anomalies particularly of the CVS and CNS. She is also at risk for fetal macrosomia and cesarean section. Strict control of blood sugar levels prior to pregnancy and during pregnancy can avoid these complications.

Case 2

1. The routine blood tests at the booking visit are hemoglobin, hematocrit, blood picture, and mean corpuscular volume, blood group and typing, tests for syphilis, hepatitis B, and HIV. Urine is tested for asymptomatic bacteriuria. Aneuploidy screening should be discussed.

2. Women with a high BMI are at increased risk for preeclampsia, failed induction, cesarean delivery, and a macrosomic infant.
3. 1 tablet containing at least 60 mg of elemental iron and 500 µg of folic acid should be given 1–2 times daily.
4. The first dose of tetanus toxoid (TT) is given at the booking visit, the second dose after 4–8 weeks, and the third dose can be given 6 months after the second injection.

Sample questions

Long-answer question

1. Describe in detail the aims of antenatal care.

Short-answer questions

1. Preconceptional counseling
2. Importance of antenatal care
3. 'All or none' period of embryogenesis
4. Dietary supplements in pregnancy
5. Immunization during pregnancy

10

Obstetric Ultrasound and Other Imaging

Case scenario

Mrs MP, 11-weeks pregnant, was a gravida 2, para 1, live 1. She had vaginal bleeding and was concerned about the pregnancy. She wanted assurance that the baby was doing fine. She was referred for an ultrasound examination.

Introduction

Ultrasonographic examination is the most common imaging technique used in pregnancy. Since its introduction in the 1970s, sonography has revolutionized the management of pregnancy. The capacity to image both the structure and the function of the fetus has improved the clinician's ability to bring about a decrease in perinatal morbidity and mortality. The introduction of sonography has also facilitated the ability to investigate the fetus with prenatal diagnostic techniques and treat the fetus with prenatal therapeutic procedures (see Chapter 12, *Prenatal screening, prenatal diagnosis, and fetal therapy*).

Basics of diagnostic ultrasound

The term 'ultrasound' denotes that the sound waves used for imaging have a frequency higher than the upper human auditory limit of 20 kHz. Obstetric imaging uses waves with a frequency ranging between 2 and 12 MHz.

Ultrasound transducers contain piezoelectric crystals. These crystals produce high-frequency ultrasound waves when electrically stimulated. Each transducer crystal transmits as well as receives mechanical energy. When the sound waves hit tissue, they bounce back depending on the density of the tissue encountered. The

Box 10.1 Physics of ultrasound imaging

- Frequency of sound waves
 - Higher than human auditory limit
 - 2–12 MHz
- Piezoelectric crystals
 - Are electrically stimulated
 - Produce ultrasound waves
 - Transmit and receive mechanical energy
 - Convert returning echoes into electrical energy
 - Display returning echoes as images

crystal converts the returning echoes into electrical energy. These returning electrical signals or echoes are displayed as images on the monitor of the sonography equipment (Box 10.1).

Transducers

Abdominal transducers are commonly used for obstetric ultrasound imaging. They have frequencies ranging from 3 to 5 MHz, which provide sufficient penetration and resolution. Curvilinear probes are preferred for obstetric scans (Fig. 10.1).

Transvaginal transducers (with a frequency of 5–10 MHz or higher) may be used in early pregnancy to better visualize the fetus (Fig. 10.2). Transvaginal probes are not useful in obstetrics beyond 12 weeks except to evaluate the cervix or localize a low-lying placenta. A condom is always used on a transvaginal probe to prevent transmission of infection from one woman to another.



Figure 10.1 Curvilinear transabdominal transducer. (Photo courtesy: Mediscan Systems, Chennai.)



Figure 10.2 Transvaginal transducer. (Photo courtesy: Mediscan Systems, Chennai.)

An **orientation marker** is located on the ultrasound transducer. It helps to orient the image on the screen with respect to the right and the left of the mother.

Gel is placed on the patient's skin for trans-abdominal scans and on the covered probe for transvaginal scans. This prevents air from coming between the transducer and the tissue. The gel also acts as a lubricant so that the ultrasound probe glides easily over the abdomen or along the vagina.

B-mode imaging

B-mode imaging, or brightness modulation, is used for imaging in obstetrics and gynecology. Different tissues will reflect sound waves with different intensities. Echoes with greater intensity are displayed with greater degrees of brightness. Fluid (e.g., urine in the bladder) will appear dark, whereas bone will appear white. The images are two-dimensional (2D).

Real-time imaging

Obstetric ultrasound uses real-time imaging, which is the rapid acquisition of images with the ability to evaluate movement as it is happening. These images are rapidly displayed in succession, thereby creating a video of the area being targeted. This allows evaluation not only of the structure but also of the function of an organ. That is why real-time ultrasound is especially useful in obstetrics where it enables the observation of the moving fetus and fetal cardiac activity.

M-mode imaging

M-mode imaging represents movement of structures over time. In obstetrics it helps in documenting fetal heart rate and movement of the valves.

3D sonography

Three-dimensional (3D) sonography provides 3D images of the fetus (Fig. 10.3). Special probes and software are needed to acquire and render the images. 3D sonography is especially useful for



Figure 10.3 3D sonography of fetal face. (Photo courtesy: Mediscan Systems, Chennai.)

delineating facial abnormalities and neural tube defects in the fetus.

4D sonography

4D sonography refers to 3D images that can be viewed in realtime. It is also called dynamic 3D sonography. It is useful in studying the fetal heart, fetal movement, and fetal behavioral states such as breathing.

Doppler ultrasound

Doppler ultrasound is used to study blood flow in the fetus and the placenta. It is discussed in detail later in this chapter.

Recommended ultrasound examinations in pregnancy

All pregnant women should be offered ultrasound examination and assessment of the fetus. The ideal time to undergo this examination is at

- 11–13⁺⁶ weeks (first trimester).
- 18–22 weeks (second trimester).

Third trimester ultrasound is done mainly to assess growth, placental localization and fetal well-being and in some cases to look for evolving abnormalities.

First trimester ultrasonography

Timing

First trimester ultrasonography is an ultrasound examination performed before 13⁺⁶ weeks' gestation. Ideally, to assess the anatomy, including nuchal translucency (NT), the examination is performed between 11 and 13⁺⁶ weeks' gestation.

Transabdominal versus transvaginal examination

Both transabdominal and transvaginal examinations can be performed in the first trimester. Transvaginal ultrasound is more useful in very early pregnancy (before 8 weeks), in obese women, for identifying anomalies and in measuring the NT.

Procedure

The woman is in the supine position for a transabdominal ultrasound and in the dorsolithotomy position for a transvaginal examination. The maternal bladder should be full when a transabdominal probe is used, to allow visualization of the early pregnancy. If a transvaginal probe is being used, the bladder should be emptied. First trimester ultrasonography is summarized in Box 10.2.

Indications for first trimester ultrasound

The indications for first trimester ultrasound examination are listed in Box 10.3.

Box 10.2 First trimester ultrasonography

- Done before 13 weeks +6 days
- Transabdominal examination
 - Performed with a full bladder
- Transvaginal examination
 - Performed with an empty bladder
 - More useful
 - in early pregnancy (before 8 weeks)
 - in obese women
 - for identifying anomalies
 - for measuring nuchal translucency

Box 10.3 Indications for first trimester ultrasound

- Location and documentation of pregnancy
- Assignment of gestational age by measuring
 - gestational sac
 - crown-rump length
- Documenting cardiac activity
- Number of viable fetuses
 - Amnionicity, chorionicity
- Identification of fetal anomalies
 - Acrania/anencephaly
 - Alobar holoprosencephaly
 - Major abdominal wall defects
 - Gross limb reduction defects
- Uterine anatomy and adnexae
 - Uterine anomalies
 - Presence of fibroids
 - Ectopic pregnancy
 - Adnexal masses
- Screening for aneuploidy (chromosomal abnormality)
 - Nuchal translucency
 - Combined with biochemical screening

Location and documentation of pregnancy

A transabdominal or transvaginal probe is used to look for a gestational sac in the uterus (intrauterine pregnancy), cervix, or adnexae (ectopic pregnancy). The location of the gestational sac is documented using ultrasonography.

Assignment of gestational age

The gestational age is assigned by measuring the crown-rump length (CRL). Measuring the CRL at 8–14 weeks is the most accurate method of dating pregnancy. It predicts the expected date of delivery (EDD) to within 3–5 days. Accurate assessment of gestational age in the first trimester is especially important in high-risk pregnancies (e.g., with hypertensive disorders or diabetes), where delivery before term may be required.

Once assigned, the gestational age is not changed in subsequent scans. The assigned gestational age forms the basis for the following:

- EDD
- Assessment of fetal growth
- Timing of invasive procedures
- Labor induction at or before term as indicated

valuation o gestational sac

The gestational sac is a small anechoic fluid collection surrounded by an echogenic ring that represents trophoblasts and decidual reaction. The earliest the gestational sac can be identified by transvaginal ultrasound is 4 weeks and 3 days of gestation, when the mean sac diameter is 2–3 mm (Box 10.4). Before the appearance of the embryo, the mean sac diameter can be used to calculate the gestational age. The mean sac diameter (in mm) +30 will give the gestational age in days. For example, using a sac size of 10 mm, the calculated age would be 40 days ($10 + 30$) or 6 weeks. An intrauterine gestational sac, being embedded in the endometrium is eccentrically located (Fig. 10.4) and, is surrounded by two concentric rings of decidua (double decidual sac sign).

The gestational sac is evaluated for the presence or absence of a yolk sac and embryo. In early pregnancy (before 5 weeks' gestation), the embryo may not be identified. In that case the mean sac diameter may be recorded to calculate the gestational age. The embryo is identified as a 1- to 2-mm structure by 5.5 weeks' gestation.

Box 10.4 Gestational sac

- Seen by transvaginal ultrasound at 2–3 mm size
- Clearly visible at 4.5–5 weeks
- Gestational age (days) = mean sac diameter (in mm) + 30
- Eccentric in location
- Surrounded by two rings of decidua



Figure 10.4 Gestational sac. The sac (arrow) is seen lying eccentrically in the cavity and demonstrates the double decidual sac sign (double arrows). (Photo courtesy: Mediscan Systems, Chennai.)

In the presence of an ectopic pregnancy, intrauterine fluid collection could also mimic a gestational sac (pseudogestational sac). A pseudogestational sac is centrally located in the endometrial cavity and is not surrounded by a double decidual ring.

Yolk sac

The yolk sac is the first structure that appears within the gestational sac. It should be visible when the mean sac diameter is 20 mm by transabdominal scan or 8–10 mm by transvaginal scan (5 weeks). The presence of the yolk sac is indicative of an intrauterine pregnancy. The normal yolk sac size is <6 mm (Fig. 10.5) and a larger yolk sac may be indicative of an abnormal pregnancy. As pregnancy advances, the yolk sac disappears and cannot be identified on ultrasound by 14 weeks.



Figure 10.5 Gestational sac, yolk sac, and fetus at 7 weeks.
(Photo courtesy: Mediscan Systems, Chennai.)

Crown rump length

The crown rump length (CRL) is the longest straight-line measurement of the length of the embryo or fetus (excluding the limbs and yolk sac). It is the measurement from the top of the head (crown) to the bottom of the buttocks (rump).

The CRL of the embryo (Fig. 10.6) provides the most accurate estimate of gestational age and should be used to determine EDD. The CRL at 7–10 weeks predicts the due date with an accuracy of ± 3 days. Between 11 and 14 weeks, the accuracy of the CRL falls slightly to ± 5 days (Box 10.5).

Cardiac activity

Presence or absence of cardiac activity should be documented. With transvaginal scans, cardiac



Figure 10.6 Crown–rump length at 10 weeks' gestation.
(Photo courtesy: Mediscan Systems, Chennai.)

Box 10.5 Crown rump length

- Most accurate for pregnancy dating
- Best measured between 7 and 10 weeks
 - Accuracy ± 3 days
- Can be measured between 11 and 14 weeks
 - Accuracy ± 5 days

motion should be present at 6 weeks' gestation when the embryo is 5 mm or greater in length. Absence of cardiac motion beyond that fetal length raises the suspicion of a miscarriage.

Number of fetuses

The number of fetuses is documented. In case of multiple gestation, zygosity, amniocitity and chorionicity should be reported if possible in the first trimester. The presence of 2 placentas clearly indicates dizygotic twins. The ultrasound signs for defining amniocitity and chorionicity in monozygotic twins are given in Box 10.6.

The twin peak sign and T sign are accurately assessed between 11 and 14 weeks and are described in Chapter 32, *Multifetal pregnancy*.

Fetal anatomy

Embryonic or fetal anatomy should be assessed according to gestational age. Some fetal anomalies (acrania/anencephaly, alobar holoprosencephaly, gross limb reduction defects) may be identified in the first trimester.

Box 10.6 Ultrasound imaging in twin pregnancy

- 2 placentas
 - Dizygotic twins
 - Dichorionic, diamniotic
- Single placenta
 - Monozygotic twins
 - Dichorionic twins
 - 2 sacs visible
 - Dividing membrane >2 mm thick
 - Monochorionic diamniotic twins
 - Thin membrane
 - Difficult to see in first trimester
 - Monochorionic monoamniotic twins
 - Single amniotic cavity

Box 10.7 Measurement of nuchal translucency (NT)

- Between 11 and 13⁺⁶ weeks
- Fetus in midsagittal plane
- Fetal neck in neutral position
- Image magnified to fill screen with
 - fetal neck
 - head
 - upper thorax

uterine anatomy and adnexae

The uterus should be evaluated for obvious anomalies (e.g., bicornuate uterus). The presence of any fibroids should be documented, including their size and location. The presence, location, and size of adnexal masses should be documented.

Screening for aneuploidy (chromosomal abnormality)

Nuchal translucency is the anechoic strip at the posterior fetal neck (Fig. 10.7). It is measured according to the established guidelines (Box 10.7).

Increased NT is associated with trisomy 21, Turner syndrome, and other chromosomal defects as well as fetal cardiac anomalies.

Nuchal translucency is combined with maternal biochemical testing to screen for chromosomal



Figure 10.7 Nuchal translucency. The translucent nuchal space (anechoic strip) is seen over the posterior fetal neck. (Photo courtesy: Mediscan Systems, Chennai.)

abnormalities (see Chapter 12, *Prenatal screening, prenatal diagnosis, and fetal therapy*).

Ultrasoundographic evaluation of first trimester complications

Vaginal bleeding in early pregnancy should raise suspicion of one of the following first trimester complications:

- Miscarriage
- Hematoma
- Ectopic pregnancy
- Molar pregnancy

Miscarriage

Miscarriage can be threatened, inevitable, incomplete, or complete (see Chapter 29, *Miscarriage and recurrent pregnancy loss*). Ultrasound plays an important role in identifying the type of miscarriage.

- *Threatened miscarriage*: Fetal cardiac activity is identified on ultrasound.
- *Inevitable miscarriage*: Ultrasound shows an open cervix with the pregnancy lying low in the uterine cavity or in the cervical canal.
- *Incomplete miscarriage*: Only some products of conception are seen in the uterine cavity with a previous ultrasound having shown a pregnancy.
- *Complete miscarriage*: The uterine cavity is empty, with a previous ultrasound having shown a pregnancy.
- *Missed miscarriage*: This may be an anembryonic pregnancy or early fetal demise.

In addition

- The diagnosis of *blighted ovum* or *anembryonic pregnancy* (early pregnancy loss

without the formation of an embryo) is made when

- mean sac diameter is >8 mm without a yolk sac or
- mean sac diameter is >16 mm without an embryo
- When there is no cardiac activity in an embryo >5 mm by transvaginal ultrasonography, a diagnosis of embryonic demise is made.

ematoma

Intrauterine hematomas are blood accumulations that are *subchorionic*, *retroplacental*, or both. Intrauterine hematomas do not have a deleterious effect on pregnancy outcome even in women with recurrent miscarriage.

Ectopic pregnancy

Implantation of the fertilized ovum outside the uterine cavity is called ectopic pregnancy. It is estimated that 95% of ectopic pregnancies occur in the fallopian tube. A combination of a serum test for human chorionic gonadotropin (hCG) and transvaginal ultrasound is used for diagnosing ectopic pregnancy (see Chapter 30, *Ectopic pregnancy*). Failure to detect an intrauterine gestational sac by transvaginal ultrasound when the hCG value exceeds 1000–2000 mIU/mL indicates an increased risk for the presence of ectopic pregnancy.

The criteria for ultrasound diagnosis of ectopic pregnancy are given in Box 10.8.

Box 10.8 Criteria for ultrasound diagnosis of ectopic pregnancy

Uterine findings

- Diagnostic signs
 - Absence of gestational sac in uterine cavity
 - Absence of embryo/its parts in uterine cavity
- Suggestive signs
 - Enlarged uterus
 - Thick endometrium
 - Pseudodecidual sac

Adnexal findings

- Diagnostic signs
 - Ectopic gestational sac with/without living embryo
 - Mixed solid and cystic mass
- Suggestive sign
 - Free fluid in the cul-de-sac

Molar pregnancy

When molar pregnancy is suspected due to vaginal bleeding associated with abnormally raised hCG values, ultrasonography can help with the diagnosis. Transvaginal sonography will show multiple fluid-filled vesicles in the uterine cavity without detecting an embryo/fetus/its parts.

Second trimester ultrasonography

Timing

Second trimester ultrasonography is an ultrasound examination performed between 18 and 22 weeks' gestation. An ultrasound done at this time has become part of routine obstetric care.

- This gestational age is an optimum time where a fetus can be labeled as 'normal' with a good degree of accuracy. Approximately 70% of major anomalies and 45% of minor anomalies can be detected at this time.
- It is the time when dating of the pregnancy can be done with accuracy to within ± 7 days.

Procedure

The woman is in the supine position for a transabdominal ultrasound. At 18–22 weeks, a full bladder is not needed to visualize the fetus. At this stage of pregnancy, a transvaginal scan is indicated only for the evaluation of the cervix for cervical insufficiency (incompetence) or for localization of the placenta.

Indications for second trimester ultrasound

The various indications for second trimester ultrasound are listed in Box 10.9.

Estimation of gestational age

If a gestational age has not been assigned in the first trimester, it is calculated in the second trimester. Gestational age calculated in the second trimester is accurate up to ± 7 days.

Box 10.9 Indications for second trimester ultrasound

Transabdominal examination

- Fetus
 - Estimation of gestational age
 - Fetal biometry
 - Number
 - Evaluation of multiple gestation
 - Screening for fetal anomalies
 - Evaluation of fetal growth
- Amniotic fluid
- Placenta
- Adjunct to prenatal diagnostic procedures
 - Amniocentesis
 - Chorionic villus sampling
 - Fetal blood sampling

Transvaginal ultrasound

- Evaluation of cervical insufficiency
- Placental localization

fetal biometry

Fetal biometry (imaged transabdominally) measures four fetal parameters. Gestational age is calculated based on the following parameters:

- Biparietal diameter (BPD)
- Head circumference (HC)
- Abdominal circumference (AC)
- Femur length (FL)

Once these measurements are obtained, the gestational age is assigned according to standardized charts.

Biparietal diameter

The BPD is the widest transverse diameter of the fetal head. When measured between 14 and 20 weeks' gestation, it can predict gestational age within ± 7 days.

The correct plane for the measurement of the BPD and the HC must include the cavum septum pellucidum, thalami, and the falx cerebri (Fig. 10.8). Once the measurement is obtained, the gestational age is assigned according to standardized charts.

Head circumference

The HC is measured at the same level as the BPD, around the outer perimeter of the fetal skull. It is the most accurate measurement for the prediction of fetal age. This measurement is not affected by head shape and is therefore more accurate



Figure 10.8 Measurement of the biparietal diameter (BPD) and the head circumference. (Photo courtesy: Mediscan Systems, Chennai.)

than BPD when the shape of the head is round (brachycephaly) or elongated (dolichocephaly).

Abdominal circumference

A transverse section of the abdomen is obtained to measure the AC (Fig. 10.9). It is measured at a level where the transverse section includes the portal vein (intrahepatic portion of the umbilical vein), the stomach, and a true cross-section of the spine with three ossification centers. The image should be circular in shape.



Figure 10.9 Measurement of abdominal circumference. It is done at the level where the spine, stomach, and portal vein are visualized. (Photo courtesy: Mediscan Systems, Chennai.)

The measurement of the AC is crucial in detecting growth disorders in the fetus. In a growth-restricted fetus, the AC will be less than the other three biometric values. This happens because of (a) depletion of abdominal adipose tissue and (b) decreased hepatic size as a result of reduced glycogen storage in the liver (see Chapter 33, *Fetal growth disorders: Growth restriction and macrosomia*).

Femur length

Measurement of the FL is an important part of fetal biometry. The femoral shaft is seen as a slightly curved, brightly echogenic structure that produces an acoustic shadow (Fig. 10.10). The FL is measured by aligning the long axis of the femur to the transducer. Only the osseous portion of the diaphysis and the metaphysis of the proximal femur are measured. The gestational age is assigned according to standardized charts.



Figure 10.10 Measurement of femur length. (Photo courtesy: Mediscan Systems, Chennai.)

Other biometric measurements

In addition to the four biometric measurements mentioned above, there are other less commonly used ones. They include the following:

- Length of long bones of the extremities
- Intraorbital and interorbital diameters
- Transverse cerebellar diameter
- Clavicle length
- Foot length

These additional measurements are used while evaluating specific system anomalies especially skeletal defects.

Calculating gestational age using fetal biometry

The four biometric values (BPD, HC, AC, and FL) are the standard parameters used for estimating gestational age in the second and third trimesters. Standardized charts are available that predict gestational age using these four values. The charts may need to be modified according to ethnic background; for example, the value for an Indian fetus will be different from that for a Western fetus. Therefore, appropriate charts should be used for calculating the gestational age in different populations.

The range of error in predicting delivery dates by ultrasound examination increases as pregnancy progresses. While the range is $\pm 5\text{--}7$ days in the first and second trimesters (before 20 weeks), it can be up to $\pm 21\text{--}28$ days in the third trimester. Sonographic assignment of fetal age is therefore best done before 20 weeks. Table 10.1 shows the range (in days) with which accuracy of dating decreases as pregnancy progresses.

Table 10.1 Correlation of accuracy of fetal age estimation with weeks of pregnancy

Parameter used	Gestational age (weeks) at which the fetal age estimation is done	Accuracy of fetal age estimation (range in days)
Mean sac diameter	4.5–6	$\pm 5\text{--}7$
Crown-rump length	7–10	± 3
Crown-rump length	11–14	± 5
BPD, HC, FL, AC	14–20	± 7
	21–30	± 14
	>30	$\pm 21\text{--}28$

AC abdominal circumference; BPD biparietal diameter; FL femur length; HC head circumference.

Discrepancy between LMP-derived and ultrasound-derived fetal age

In a woman who has irregular periods or is uncertain of her last menstrual period (LMP), ultrasound assignment of fetal age is done and the expected date of delivery (EDD) is assigned according to that. In some women, there might be a discrepancy in the fetal age obtained by ultrasound and the one calculated by the LMP. In such a situation, a decision has to be made to reassign a new EDD. The sonographically derived gestational age is used to calculate EDD only if it differs from that calculated using LMP by

- >7 days before 16 weeks
- >10 days between 16 and 22 weeks
- >14 days between 22 and 28 weeks
- >21 days after 28 weeks

Screening for fetal anomalies

Apart from fetal biometry, an ultrasound examination done between 18 and 22 weeks is essential for identifying fetal anomalies.

Targeted or detailed scan

An ultrasound done for fetal anatomical survey is called a *targeted* or *detailed* scan. At this gestational age (18–22 weeks), fetal organ development is optimal to identify approximately 70% of major anomalies and 45% of minor anomalies.

The following anatomical landmarks are evaluated in detail during the targeted scan.

ea

The midline falx and the cavum septum pellicidum are imaged. The lateral ventricles are measured at the level of the atria. Dilatation of the lateral ventricles signifies ventriculomegaly. The cerebellar hemispheres, vermis, and cisterna magna are identified. Nuchal fold thickness is important for the diagnosis of chromosomal and other anomalies. The posterior fossa should be evaluated for cysts (Dandy–Walker malformation) and abnormal anterior curvature of the cerebellum ('banana sign').

ace

The orbits, nose and nasal bone, and the mouth including the lips are imaged.

Spine

The spine and sacrum are examined for ossification centers, cervical widening, and sacral tapering. Spines should be evaluated in the sagittal, coronal, and transverse planes.

hora

A four-chamber view of the heart is obtained, and the heart's position in the chest cavity is documented. The outflow tracts are imaged to rule out anomalies such as tetralogy of Fallot. The lungs are homogenously echogenic. Intrathoracic masses or cysts should be ruled out. The diaphragm should be imaged to rule out diaphragmatic hernia.

Ab omen

In the upper abdomen, the stomach is identified and its position with reference to the heart is noted (*situs*). The liver and the portal vein are imaged. In the mid-abdomen, the kidneys and small bowel are evaluated. Dilated, fluid-filled bowel loops could indicate obstruction or atresia. In the lower abdomen, the bladder, two umbilical arteries, and the genitalia are identified.

The genitalia will define the gender of the fetus. In certain anomalies such as bladder outlet obstruction, identifying the fetus as male will confirm posterior urethral valves that occur only in males. Ambiguous genitalia is commonly seen in congenital adrenal hyperplasia. Sex determination, for a non-medical reason, is prohibited by law in India.

tremities

All four limbs must be evaluated. The extremities are evaluated for abnormalities in size, morphology, and number.

Box 10.10 lists the essential components of a targeted or detailed fetal anatomical scan.

Fetal environment

The placenta, amniotic fluid, and umbilical cord comprise the fetal environment.

Placenta

The placenta is assessed in terms of location, with specific reference to its lower edge and its distance from the internal os (to rule out placenta previa). If placenta previa is diagnosed in

Box 10.10 Components of a targeted or detailed fetal scan

- Head and neck
 - Midline falx and cavum septi pellucidum
 - Lateral cerebral ventricles and choroid plexus
 - Ventriculomegaly
 - Cerebellar hemispheres, vermis, and cisterna magna
 - ‘Banana sign’
 - Dandy-Walker malformation
 - Nuchal fold thickness
- Face
 - Orbita
 - Nose and nasal bone
 - Mouth including lips
- Spine
 - Ossification centres
 - Cervical widening
 - Sacral tapering
- Thorax
 - Heart
 - Four-chamber view
 - Outflow tracts
 - Lungs
 - Intrathoracic masses or cysts
 - Diaphragm
 - Diaphragmatic hernia
- Abdomen
 - Stomach (presence, size, and situs)
 - Liver
 - Kidneys and bladder
 - Bowel
 - Umbilical cord insertion site into the fetal abdomen
 - Umbilical cord vessel number
 - Genitalia
- Extremities
 - Size, morphology, and number

the second trimester, a repeat scan must be done in the third trimester to confirm whether the placenta has migrated away from the os or not.

Amniotic fluid

The amniotic fluid can be assessed by the subjective method, single deepest pocket, or amniotic fluid index (AFI). Subjective assessment of liquor is done in the 18–22 week scan (*see Chapter 11, Antepartum fetal surveillance*).

Umbilical cord

Examination of the umbilical cord should be an integral part of the second trimester ultrasound scan. The number of vessels in the cord should be

documented. If only two vessels are seen (instead of three), a thorough search for fetal structural and chromosomal anomalies must be made.

Evaluation of cervical insufficiency

Routine cervical length measurement is not recommended in low-risk pregnancies. When cervical insufficiency is suspected, serial evaluation of the cervical length may identify those at increased risk of primary or recurrent preterm birth. The length of the cervix is measured by a transvaginal or transperineal scan. A high-risk woman with a cervical length of 2.5 cm or less is considered to be at risk for preterm labor. The internal os is examined for *funneling* which is a sign of cervical insufficiency.

Ad unct to prenatal diagnostic procedures

Ultrasound may also be done to guide prenatal diagnostic procedures such as amniocentesis, chorionic villus sampling, or fetal blood sampling (*see Chapter 12, Prenatal screening, prenatal diagnosis, and fetal therapy*).

Third trimester ultrasonography

Third trimester ultrasonography is not done routinely. The indications for a third trimester ultrasound examination are enumerated in Box 10.11.

Doppler in pregnancy

Doppler ultrasound is an indispensable tool in evaluating pregnancies at risk for conditions such as preeclampsia, fetal growth restriction, fetal anemia, and umbilical cord abnormalities. Pulsed wave Doppler and color Doppler are used in obstetric practice.

Assessment is done using Doppler of the following:

- Umbilical artery
- Middle cerebral artery (MCA)
- Uterine artery
- Ductus venosus

Box 10.11 Indications for a third trimester ultrasound examination

- Significant discrepancy between uterine size and clinical dates
 - Evaluation of fetal growth
- Assessment of fetal well-being
 - Amniotic fluid
 - Biophysical profile
 - Doppler evaluation
- Vaginal bleeding
 - Suspected placental abruption
 - Suspected placenta previa
- Multiple gestation
- Suspected fetal death
- Preterm rupture of membranes
- Fetal well-being in an obese parturient
- Estimation of fetal weight
- Fetal presentation
- Guidance for external cephalic version
- Follow-up evaluation of fetal anomaly
- Women registering late for antenatal care

Doppler studies are invaluable in the management of complications arising from preeclampsia and fetal growth restriction.

Doppler ultrasonography is a noninvasive technique used to assess

- Presence or absence of blood flow in a vessel
- Direction of flow
- Flow characteristics such as
 - velocity of flow during phases of the cardiac cycle
 - impedance to flow during diastole

Principle

Ultrasound images of flow in fetal and maternal vessels are obtained from measurements of movement of blood flow. The transducer transmits a series of pulses to detect movement of blood. Echoes from moving objects (red blood cells) exhibit slight differences in the frequencies of the echoes received. These differences are termed as the 'Doppler shift' and can be heard as audio signals. These frequencies are then processed to produce either a Doppler waveform or a color flow display (Fig. 10.11). Color Doppler depicts blood flow in red and blue. Red color signifies flow **toward** the probe, and blue color signifies flow **away** from the probe.

Doppler waveform

A Doppler waveform is a graphic representation of flow velocities throughout the cardiac cycle (Fig. 10.12).

- Systolic waveform represents the cardiac pump
 - In uterine artery waveform: Maternal heart
 - In umbilical artery waveform: Fetal heart
- Diastolic waveform represents the status of the placental vascular bed

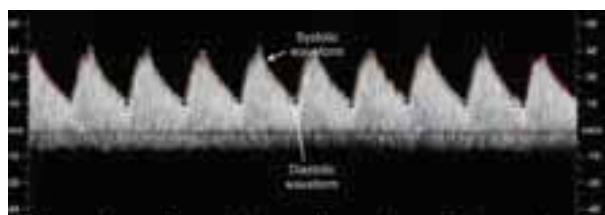


Figure 10.12 Umbilical artery velocity waveforms. (Photo courtesy: Mediscan Systems, Chennai.)

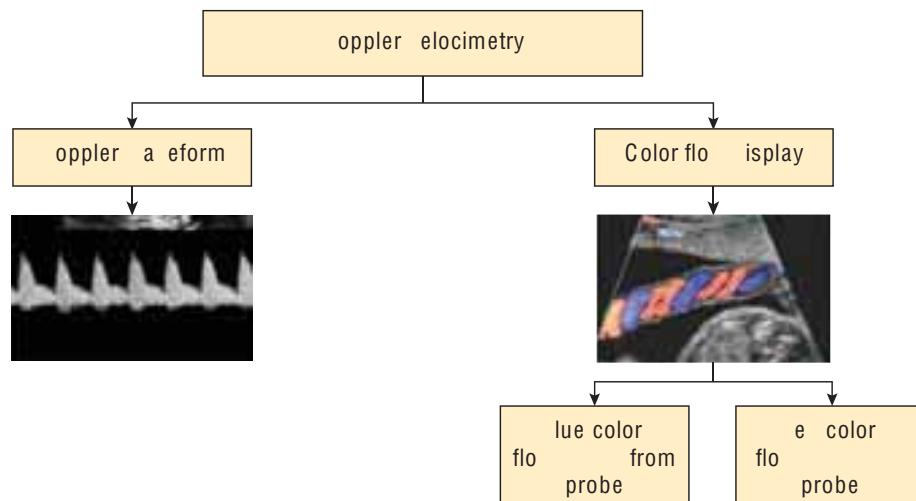


Figure 10.11 Doppler velocimetry in obstetrics.



Figure 10.13 Sample waveform marked for systolic (S) and diastolic (D) measurements. (Photo courtesy: Mediscan Systems, Chennai.)

Box 10.12 Indications for Doppler studies in obstetrics

First trimester

- Screening for aneuploidy
- As a marker for congenital heart disease
- Screening for preeclampsia

Second trimester

- Screening for preeclampsia
- Identification of fetal anemia
- Evaluation of vascular malformations in the fetus and placenta
- Identification of cardiac and renal anomalies and diaphragmatic hernia

Third trimester

- Evaluation of a growth-restricted fetus
- Assessment of fetal hypoxia

Doppler indices

The peak systolic velocity (S), the end-diastolic velocity (D), and the mean velocities are measured in the Doppler waveform (Fig. 10.13). From these measurements three Doppler indices are calculated that give a measure of the resistance of the vascular bed which are as follows:

- Systolic/diastolic ratio (S/D ratio)
- Resistance index (RI; also called resistive index or Pourcelot's index)
 - RI = (peak systolic velocity – end diastolic velocity)/peak systolic velocity or $(S - D)/S$
- Pulsatility index (PI)
 - PI = (peak systolic velocity – end diastolic velocity)/peak systolic velocity or $(S - D)/\text{mean}$

Indications for Doppler in obstetrics

The indications for Doppler in obstetrics are enumerated in Box 10.12.

The use of Doppler in evaluating fetal well-being is described in detail in Chapter 11, *Antepartum fetal surveillance*.

Nuclear imaging modalities in obstetrics

In certain circumstances, pregnant women may be required to undergo imaging with modalities other than ultrasonography.

X-rays and CT scans

A single diagnostic X-ray does not result in radiation exposure adequate enough to cause damage to the embryo or fetus and is not an indication for therapeutic abortion (see Chapter 9, *Preconceptional and antenatal care*). It is best to avoid imaging where multiple doses of ionizing radiation will be delivered to the fetus. CT scans are preferably avoided in pregnancy. In such situations, magnetic resonance imaging (MRI) may be useful.

Magnetic resonance imaging

With MRI, instead of ionizing radiation, magnets that alter the energy state of hydrogen protons are used. This technique is useful for diagnosis and evaluation of fetal central nervous system anomalies and placental abnormalities such as placenta previa and accreta. MRI is not associated with adverse fetal effects. However, cost restricts its routine use in pregnancy.

Nuclear medicine

Rarely, nuclear studies such as pulmonary ventilation-perfusion, thyroid, bone, and renal scans may be required in pregnancy. When pulmonary embolism is suspected during pregnancy, a ventilation-perfusion scan may be performed. The amount of radiation to which the fetus

is exposed is extremely small (approximately 50 mrad).

Radioactive iodine readily crosses the placenta and has an adverse effect on the fetal thyroid, especially if used after 10–12 weeks' gestation. Radioactive isotopes of iodine used for treatment of hyperthyroidism are contraindicated during pregnancy.

Contrast agents

Oral and intravascular contrast agents are used for better imaging with X-rays, CT scans, and MRIs. Most radiopaque agents used with CT and conventional radiography contain derivatives of iodine and have been associated with neonatal hypothyroidism. These are therefore best avoided unless absolutely essential.

Safety guidelines for imaging modalities in pregnancy

The safety guidelines for imaging modalities in pregnancy are summarized in Box 10.13.

Box 10.13 Safety guidelines for imaging modalities in pregnancy

- X-ray exposure not harmful to fetus in case of
 - single diagnostic procedure
 - exposure <5 rads
- Diagnostic X-ray procedures may be performed
 - when medically indicated
- Multiple diagnostic X-rays
 - Dosimetry should be calculated
- Ultrasonography or MRI safer than X-rays
- CT scans to be avoided
- Radiopaque and paramagnetic contrast agents to be avoided
- Radioactive isotopes of iodine contraindicated

Key points

- Ultrasonographic examination is the most common imaging technique used in pregnancy.
- The sound waves used for imaging have a frequency higher than the upper human auditory limit of 20 kHz. Obstetric imaging uses waves with a frequency ranging between 2 and 12 MHz.
- Abdominal transducers are commonly used for obstetric ultrasound imaging. They have frequencies ranging from 3 to 5 MHz.
- Transvaginal transducers (with a frequency of 5–10 MHz or higher) may be used in early pregnancy to better visualize the fetus.
- B-mode imaging, or brightness modulation, is used for imaging in obstetrics and gynecology. Different tissues will reflect sound waves with different intensities. Echoes with greater intensity are displayed with greater degrees of brightness.
- Obstetric ultrasound uses real-time imaging, which is the rapid acquisition of images with the ability to evaluate movement as it is happening.
- M-mode imaging helps in documenting fetal heart rate and movement of the valves.
- 3D sonography is useful for delineating facial abnormalities and neural tube defects in the fetus.
- 4D sonography refers to 3D images that can be viewed in realtime. It is useful in studying the fetal heart, fetal movement, and fetal behavioral states such as breathing.
- The ideal time to undergo ultrasonographic examination is between 11 and 13⁺⁶ weeks (first trimester) and between 18 and 22 weeks (second trimester). Third trimester ultrasound is done for evaluation of growth, placenta, liquor, and fetal well-being.
- In the first trimester, gestational age is assigned by measuring the gestational sac or the crown–rump length (CRL).
- Measuring the CRL at 7–14 weeks is the most accurate method to date pregnancy and predicts the expected date of delivery (EDD) to within 3–5 days.
- Presence or absence of cardiac activity should be documented.
- Some fetal anomalies (acrania/anencephaly, alobar-holoprosencephaly, gross limb reduction defects) may be identified in the first trimester.
- Nuchal translucency (NT) is measured according to established guidelines. Increased NT is associated with trisomy 21, Turner syndrome, and other chromosomal defects as well as fetal cardiac anomalies.
- Vaginal bleeding in the first trimester is investigated with ultrasonography, which helps in the diagnosis of miscarriage, hematoma, ectopic pregnancy, or molar pregnancy.
- The fetus is evaluated for number, viability, and age, and a targeted scan is done to rule out fetal anomalies.
- Fetal biometry measures four fetal parameters: biparietal diameter, head circumference, abdominal

(Continued)

Key points (*Continued*)

- circumference, and femur length. Gestational age is calculated based on these parameters.
- In the second trimester, the estimated date of delivery can be calculated with an accuracy of ± 7 days.
 - An ultrasound done for fetal anatomical survey is called a targeted or detailed scan. At 18–22 weeks, 70% of major anomalies and 45% of minor anomalies can be identified.
 - The placenta, amniotic fluid, and the umbilical cord comprise the fetal environment and are evaluated during a second trimester scan.
 - Doppler ultrasound is an indispensable tool in evaluating pregnancies at risk for conditions such as preeclampsia, fetal growth restriction, fetal anemia, and umbilical cord abnormalities.
 - Assessment is done using Doppler of the umbilical artery, middle cerebral artery, uterine artery, and ductus venosus.
 - Pulsed wave Doppler and color Doppler are used in obstetric practice.
 - Of the other imaging modalities available, magnetic resonance imaging is useful and has no deleterious effect on the fetus. However, cost restricts its use.

Self-Assessment

Case-based questions

Case 1

Mrs. MP, 27 years old, is a gravida 2, para 1, live 1. She is 11 weeks pregnant. She presented with vaginal bleeding and mild lower abdominal pain. The ultrasound showed a fetus corresponding to 11 weeks' gestation. Cardiac activity was seen.

- How accurate is fetal age determination at 11 weeks?
- What are the ultrasound findings in an inevitable miscarriage?
- What are the ultrasound signs of molar pregnancy?
- What are anembryonic pregnancy and early fetal demise?

Case 2

A 31-year-old primigravida presented at 33 weeks' gestation with hypertension. The uterine size appeared smaller than the gestational age.

- Which are the biometric parameters used for determining fetal age?
- Which is the parameter most useful for predicting fetal growth restriction?
- Why is Doppler of the fetal umbilical artery indicated in fetal growth restriction?

Answers

Case 1

- The accuracy of the CRL between 10 and 14 weeks is ± 5 days.
- Ultrasound will show an open cervix with the pregnancy lying low in the uterine cavity or in the cervical canal.

- In the presence of molar pregnancy, transvaginal sonography will show multiple fluid-filled vesicles in the uterine cavity without detecting an embryo/fetus/its parts.
- An anembryonic pregnancy is early pregnancy loss without the formation of an embryo. The ultrasound scan will show a gestational sac >8 mm with no yolk sac or >16 mm with no embryo. Early fetal demise is diagnosed when an embryo with CRL of 5 mm reveals no cardiac activity.

Case 2

- Fetal biometry measures four fetal parameters: biparietal diameter, head circumference, abdominal circumference, and femur length. Gestational age is calculated based on these parameters.
- Abdominal circumference measurement is most useful for determining fetal growth restriction.
- The diastolic portion of the waveform represents the status of the placental vascular bed. Placental insufficiency leading to fetal growth restriction will be diagnosed by reduced, absent, or reversed flow in the umbilical artery.

Sample questions

Long-answer question

- Discuss the usefulness of ultrasound imaging in pregnancy.

Short-answer questions

- Ultrasonography in the first trimester
- Estimation of gestational age using ultrasound
- Nuchal translucency

11

Antepartum Fetal Surveillance

Case scenario

Mrs. BG, 34, was pregnant for the first time after 8 years of marriage. She was found to have high blood pressure in the 28th week of pregnancy. At 32 weeks, the fetus was found to be smaller than expected (fetal growth restriction). She was referred by the local doctor to a tertiary center for evaluation of the mother and fetus, and further obstetric management.

Introduction

The aim of antepartum fetal surveillance is to prevent fetal demise. In the presence of risk factors that may affect fetal well-being, antepartum fetal surveillance gives information about the intrauterine status of the fetus. Fetal heart rate assessment, real-time ultrasonography, and Doppler velocimetry are commonly used to evaluate fetal well-being. Antepartum fetal surveillance techniques are useful in assessing the risk of fetal death in pregnancies complicated by preexisting maternal conditions (e.g., hypertension) as well as those in which complications have developed (e.g., fetal growth restriction). When an antepartum fetal test is abnormal, it is called a *nonreassuring* test.

Tests of fetal well-being

Several tests are in use to assess fetal well-being in utero. Biochemical tests (e.g., estimation of urinary estriol) were used in the past but have now been replaced by biophysical tests. The tests for fetal well-being include the following:

- Fetal movement count
- Cardiotocography (CTG) or electronic fetal monitoring (EFM)
 - Nonstress test (NST)
 - Vibroacoustic stimulation
 - Contraction stress test (CST)
- Ultrasonography
 - Amniotic fluid assessment

- Biophysical profile (BPP), which combines ultrasonography and CTG
 - Fetal breathing
 - Fetal movement
 - Fetal tone
 - Amniotic fluid index (AFI)
 - NST
- Doppler studies
 - Fetal umbilical artery
 - Fetal middle cerebral artery (MCA)
 - Fetal ductus venosus

The indications for antepartum fetal surveillance are listed in Box 11.1.

Box 11.1 Indications for antepartum fetal surveillance

Previous obstetric history

aternal

- Hypertensive disorder of pregnancy
- Placental abruption
- et al*
- Fetal growth restriction
- Stillbirth

Current pregnancy

aternal

- Postterm pregnancy
- Hypertensive disorders of pregnancy
- Diabetes
 - Pregestational diabetes
 - Gestational diabetes requiring insulin
- Antiphospholipid antibody syndrome
- Advanced maternal age (elderly gravida)
- Vaginal bleeding
- Prelabor rupture of membranes
- Pregnancy after assisted reproductive technologies
- et al*
- Decreased fetal movement
- Fetal growth restriction
- Oligohydramnios/polyhydramnios
- Multiple pregnancy (with significant growth discrepancy)
- Preterm labor

pregnancy. There is no gestational age cutoff at which it should be initiated.

Initiating testing at 32–34 weeks' gestation is appropriate for most high-risk pregnancies. If the mother reports decreased or absent fetal movements in the third trimester, then antepartum surveillance is immediately initiated. If there has been an adverse event in the previous pregnancy (e.g., stillbirth), then the testing is initiated 2 weeks before the gestational age at which the adverse event occurred in the previous pregnancy. In a postdated pregnancy, non-stress test (NST) and amniotic fluid assessment are started at 40 weeks' gestation. Antepartum testing in insulin-dependent or insulin-requiring pregnancies that are well controlled and otherwise uncomplicated should begin at 34–36 weeks' gestation. Fetal surveillance in a hypertensive pregnancy is started at 34 weeks' gestation or even earlier if it was early onset hypertension of pregnancy or if the woman had been hypertensive prior to pregnancy (chronic hypertension). When fetal growth restriction is diagnosed, a baseline surveillance is done and then it is repeated for follow-up. The initiation and suggested frequency for fetal testing are given in Box 11.2.

Box 11.2 Initiation and frequency of antepartum fetal surveillance

Initiation

- Decreased or absent fetal movement
 - Immediate
- Previous adverse event
 - 2 weeks before gestational age at which adverse event occurred
- Insulin-dependent diabetes in pregnancy
 - 34–36 weeks
- Postdated pregnancy
 - 40 weeks
- Hypertension in pregnancy
 - 32 weeks
- Fetal growth restriction
 - At the time of diagnosis
 - For follow-up

Frequency

- Usually 1–2 times per week
- Twice weekly in high-risk pregnancies
- Every 24–48 hours in preterm cases where every day gained increases the chance of neonatal survival

Initiation of antepartum fetal surveillance

Antepartum fetal surveillance is individualized and initiated depending on the severity of the risk factor or factors associated with the

Fetal movement counting ationale

A pregnant woman usually starts perceiving fetal movements at approximately 20 weeks' gestation, although a multigravida may perceive movements at an earlier gestational age (Box 11.3). In the presence of fetal hypoxia and placental dysfunction, the fetus decreases gross body movements to conserve oxygen. Decreased fetal movements may precede intrauterine fetal death. Early recognition of decreased fetal movement makes it possible to initiate interventions at a stage when the fetus is still compensated, and thus prevent progression to fetal death.

Fetal movement counting is an easy method of fetal surveillance because most women can be taught to recognize and note their baby's movements. Even healthy pregnant women without risk factors for adverse perinatal outcomes should be educated about the significance of fetal movements in the *third trimester* and asked to perform a fetal movement count. **Women should be instructed on any one method of counting fetal movements (Box 11.4) and advised to report decreased movements.**

Box 11.3 Fetal movements

- Felt first at approximately 20 weeks
- Felt earlier by parous women
- Decreased movements
 - Fetal hypoxia may be present
 - May precede intrauterine death

Box 11.4 Methods of counting fetal movements

- Cardiff kick chart: Movements counted over 12 hours and noted on a chart
 - 10 movements or more in 12 hours: *eassuring*
- Counting distinct movements while lying on the side for 2 hours
 - 10 movements or more in 2 hours: *eassuring*
- Counting movements for 1 hour every day
 - At least 4 movements within an hour: *eassuring*
- Counting movements for 1 hour 3 times/week
 - Equals or exceeds the woman's previously established baseline count: *eassuring*

Evaluation of decreased fetal movements

If the pregnant woman reports decreased fetal movements, the following evaluations are carried out:

- CTG
 - To record the fetal heart rate
 - To perform an NST
 - The presence of accelerations (see below).
- Ultrasound evaluation
 - To demonstrate fetal movements to the mother
 - To assess amniotic fluid volume
 - To perform a BPP, if needed (see below)

The advantages and disadvantages of fetal movement count are listed in Box 11.5.

Box 11.5 Advantages and disadvantages of fetal movement count

- Simple and inexpensive
- Approximately 20% of patients unable to comply
 - Do not perceive movements reliably
- Only gross movements appreciated by mother
- Insufficient evidence to recommend fetal kick count routinely to prevent fetal death

Cardiotocography

Continuous recording of the fetal heart rate is called cardiotocography (CTG) or electronic fetal monitoring (EFM).

The use of CTG (Fig. 11.1) involves the placement of two transducers on the abdomen of the woman. One transducer records the fetal heart rate using ultrasound. The other transducer (tocodynamometer) monitors the contractions of the uterus. It does this by measuring the tension of the maternal abdominal wall during a contraction. This provides an indirect indication of intrauterine pressure (Box 11.6).

External cardiotocography

External CTG is used for antepartum fetal surveillance and also during labor (intrapartum) to monitor the fetal heart rate. An ultrasound transducer placed on the mother's abdomen detects the fetal heart rate. Jelly is applied between the



Figure 11.1 A cardiotocograph.

Box 11.6 Cardiotocograph (CTG) for continuous monitoring of fetal heart rate (FHR)

- 2 Transducers
 - Ultrasound for FHR
 - Tocodynamometer for contractions
- External CTG
 - Jelly applied
 - Transducer placed on maternal abdomen
 - FHR recorded on paper strip
- Internal CTG
 - Used in labor
 - Scalp electrode
 - After cervical dilatation
 - Membranes should be absent
 - Better recording obtained
- Tocodynamometer
 - Indirect recording of intrauterine pressure
 - Graphic recording on paper strip

transducer and the maternal skin to facilitate better apposition and conduction of the signal. The transducer is placed at the point where the fetal heart is best heard. This is done by moving the transducer over the abdomen till the best signal is obtained. The fetal heart rate is recorded on a strip of paper.

Internal cardiotocography

Internal CTG is used only during labor, after the membranes have ruptured. An electronic transducer is connected directly to the fetal scalp using an electrode called a spiral or scalp electrode. Internal monitoring provides a more accurate and consistent transmission of the fetal heart

rate than external monitoring because factors such as movement do not affect it. Internal monitoring may be used when external monitoring of the fetal heart rate is inadequate, or closer surveillance is needed. This will be further discussed in Chapter 17, *Intrapartum fetal surveillance*.

Definitions and terminology used in cardiotocography

Identification of normality versus abnormality of a CTG trace is based on the following features:

- Baseline heart rate
- Baseline variability
- Periodic changes
 - Accelerations
 - Decelerations

Baseline fetal heart rate

Normal baseline fetal heart rate after 30 weeks' gestation is 110–160 bpm. A heart rate above 160 bpm is referred to as **tachycardia**, and a heart rate below 110 bpm is referred to as **bradycardia**. Baseline heart rate should be determined over a minimum period of 10 minutes.

Baseline variability

Baseline variability is a function of the autonomic nervous system. The interval between consecutive heartbeats is termed **short-term variability**. This cannot be visualized on the usual CTG. **Long-term variability** refers to the oscillations above and below the baseline and can be seen on the trace. Normal long-term variability is 5–25 bpm. Variability of <5 bpm indicates fetal hypoxia, but it can also occur with certain drugs.

Acceleration

Acceleration is defined as a rise in the fetal heart rate above the baseline of 15 bpm that lasts for 15 seconds or more (after 32 weeks' gestation). This occurs in response to fetal movements, scalp stimulation, and uterine contractions. Accelerations are a sign of fetal well-being.

Deceleration

Deceleration is a visually apparent gradual or abrupt decrease in the fetal heart rate by >15 bpm, lasting for ≥15 seconds but <2 minutes in duration. Decelerations may be **early**, **late** or **variable** in relation to a contraction. They are

indicative of fetal hypoxia, cord compression, or vagal stimulation.

Baseline fetal heart rate, variability, and periodic changes are discussed in detail in Chapter 17, *Intrapartum fetal surveillance*.

onstress test

The NST is performed using an external CTG. The fetal heart rate is recorded in the absence of contractions. Accelerations of the fetal heart rate are looked for.

Rationale

The heart rate of the healthy fetus will temporarily accelerate with fetal movement. A fetus that is acidotic or neurologically depressed will not show accelerations on CTG. The presence of accelerations with movements is called **reactivity**. Heart rate reactivity is considered a good indicator of normal fetal autonomic function. Loss of reactivity is associated most commonly with a fetal sleep cycle but may result from any cause of central nervous system depression, including fetal acidosis (Box 11.7).

Performing an ST

With the patient in the lateral recumbent or reclining position, the fetal heart rate is monitored with the external transducer of a cardiotocograph. The fetal movements are perceived by the mother and recorded by the press of a button (Fig. 11.2). The fetal heart rate is recorded on a graph. The trace should be recorded for at least 20 minutes.

Box 11.7 Fetal heart rate accelerations in the nonstress test

- Rationale
 - Accelerations present with fetal movements (reactivity)
- Presence
 - Well-oxygenated fetus
 - 15 bpm above baseline
 - Lasting for at least 15 seconds
- Absence
 - Fetal sleep
 - Narcotic medications to the mother
 - Fetal hypoxemia
 - Fetal acidosis



Figure 11.2 Nonstress test. The mother is in a reclining position. She is recording perceived movements with a marker button. The graph is recording the fetal heart rate.

Interpretation

An NST is interpreted as follows:

- **Reactive** (Fig. 11.3): Two or more fetal heart rate accelerations reaching a peak of at least 15 bpm above the baseline rate and lasting for at least 15 seconds from onset to return in a 20-minute period (Box 11.8). The duration of

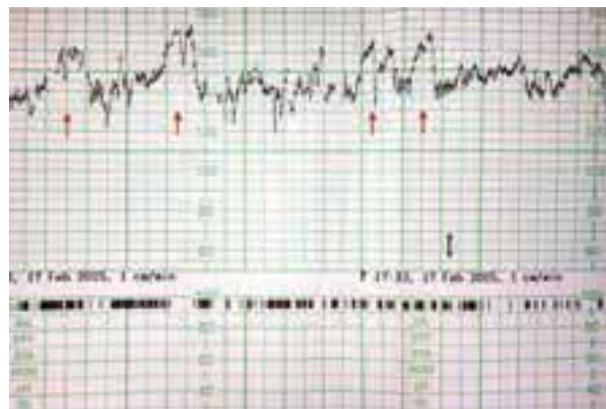


Figure 11.3 Reactive nonstress test showing accelerations. The waveform represents the fetal heart rate. The arrows point to the accelerations.

Box 11.8 Reactive nonstress test

- 2 or more acceleration
 - Recorded over 20 minutes
 - Up to 40 minutes if no accelerations
- Peak at least 15 bpm above baseline
- Lasting at least 15 seconds

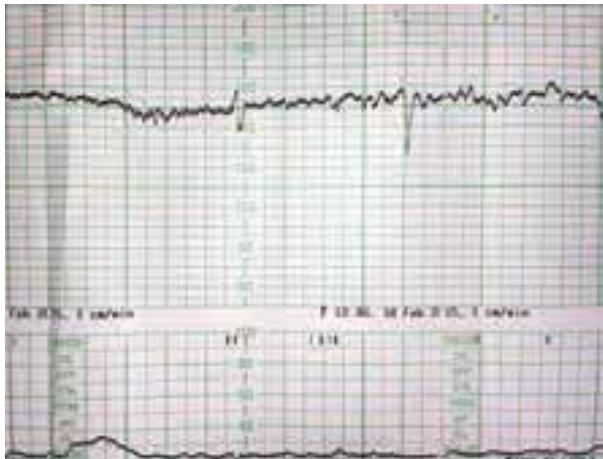


Figure 11.4 Nonreactive nonstress test showing no accelerations. The upper waveform represents the fetal heart rate.

the test should be extended to 40 minutes if there are no accelerations.

- **Nonreactive** (Fig. 11.4): A nonreactive NST is defined as one that does not show accelerations over a 40-minute period. A nonreactive test may indicate fetal hypoxemia or acidosis. Additional tests such as vibroacoustic stimulation or a BPP may be needed to confirm that the fetal condition is nonreassuring (Box 11.9).
- **Decelerations during an NST:** Fetal heart rate decelerations during an NST that persist for 1 minute or longer are significant and are associated with an increased risk of both cesarean delivery and fetal demise.

A nonreactive NST may be due to fetal sleep or prematurity but may be indicative of fetal hypoxia or sepsis (Box 11.10). Hence, a nonreactive NST needs further evaluation.

Vibroacoustic stimulation test

Auditory stimulus to the fetus can alert a sleeping or inactive fetus. An acoustic stimulator is applied on or just above the maternal abdomen. A short burst of sound is delivered to the fetus for

Box 11.9 onreactive nonstress test

- No accelerations in 40 minutes
- May be repeated after feeding the mother
- Vibroacoustic or BPP required to confirm
- Decelerations lasting ≥ 1 minute: significant

BPP biophysical profile.

Box 11.10 Causes for nonreactive nonstress test

- Associated with
 - fetal immaturity
 - quiet fetal sleep
 - fetal hypoxemia or acidosis
 - fetal neurological or cardiac anomalies
 - fetal sepsis
 - maternal ingestion of drugs with cardiac effects

1–2 seconds. Acceleration of the fetal heart rate is looked for (Box 11.11). This can also be used to reduce the duration of a nonreactive NST.

Other findings on an NST

bradycardia

Significant bradycardia is associated with increased perinatal mortality and morbidity and has a higher positive predictive value than a nonreactive NST. In the presence of bradycardia, further evaluation by a BPP may be indicated.

tachycardia

Preterm fetuses have a higher baseline fetal heart rate. In a term fetus, tachycardia may be due to maternal fever, fetal hypoxemia, or acidosis.

loss of variability

Loss of variability may occur with maternal sedation. When loss of variability occurs along with baseline tachycardia, it is indicative of fetal acidosis and requires further evaluation.

Predictive value of an ST

The following points should be noted regarding the predictive value of an NST:

- An NST predicts the fetal status for the next 72 hours; therefore, in high-risk pregnancies such as postmaturity, diabetes mellitus, or

Box 11.11 vibroacoustic stimulation test

- Auditory source placed on maternal abdomen
- Short burst of sound delivered (1–2 seconds)
- Rules out quiet fetal sleep
- Accelerations
 - Healthy fetus
- Absence of accelerations
 - Fetal hypoxemia or acidosis

severe hypertension, the test should be performed twice a week.

- A reactive NST has a higher predictive value. The false-negative rate is approximately 0.2%–0.8%.
- A nonreactive NST has a false-positive rate of 50%. This means that half the fetuses showing a nonreactive pattern may actually be well oxygenated. Hence, fetuses with a nonreactive NST should be evaluated further and management decisions should not be based on the NST alone.
- An NST cannot predict sudden events such as placental abruption or cord accidents.

Contraction stress test

Contraction stress test is performed using a cardiotocograph. The fetal heart rate is recorded in the presence of induced contractions. The response of the fetal heart rate is noted in relation to the contractions.

Rationale

During a uterine contraction, there is a transient decrease in fetal oxygenation. If a fetus is already hypoxic, the intermittent worsening in oxygenation during a uterine contraction will result in **late decelerations** of the fetal heart rate (see Chapter 17, *Intrapartum fetal surveillance*). Uterine contractions may also cause fetal umbilical cord compression in the presence of

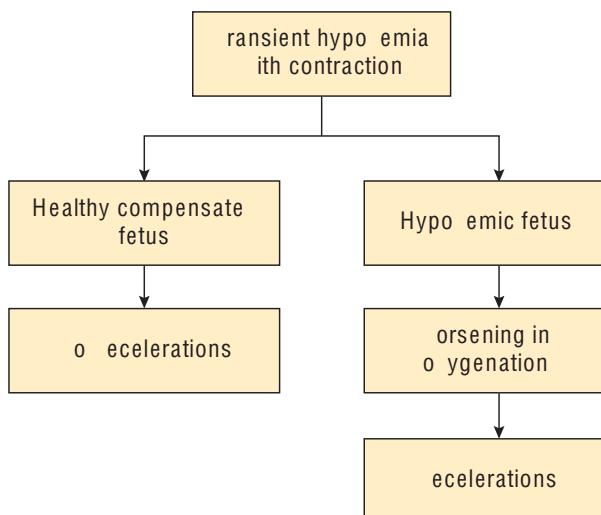


Figure 11.5 Rationale for contraction stress test.

decreased amniotic fluid (oligohydramnios) in a high-risk pregnancy. This can result in **variable decelerations** (Fig. 11.5).

Performing a CST

The patient lies in the lateral recumbent position, and the fetal heart rate and uterine contractions are simultaneously recorded with an external fetal monitor. Contractions are induced with either nipple stimulation or intravenous administration of dilute oxytocin till there are at least three contractions of 40 seconds' duration within 10 minutes (Box 11.12).

The criteria for interpretation of a CST are given in Box 11.13.

Contraindications to CST

CST-induced contractions can lead to complications such as stimulation of regular uterine contraction and rupture of membranes. Hence, it is not commonly performed and is contraindicated in the following situations:

Box 11.12 Contraction stress test

- Lateral recumbent position
- Contractions induced
 - Nipple stimulation
 - Intravenous oxytocin
- 3 contractions in 10 minutes
- Contractions recorded
- Decelerations recorded

Box 11.13 Interpretation of contraction stress test

- **Positive (nonreassuring)**
 - Late decelerations following 50% or more contractions
- **Negative (reassuring)**
 - No late or significant variable decelerations
- **Equivocal-suspicious**
 - Intermittent late decelerations or
 - Significant variable decelerations
- **Equivocal-hyperstimulatory**
 - Decelerations that occur in the presence of hyperstimulation
 - Contractions >6 in 10 minutes
 - Contractions lasting >90 seconds
- **Unsatisfactory**
 - Tracing is uninterpretable or
 - Contractions <3 in 10 minutes

- Preterm labor or high risk of preterm labor
- Preterm rupture of membranes
- History of extensive uterine surgery or classical cesarean delivery
- Known placenta previa

Biophysical profile

The BPP combines an NST with four biophysical variables measured by ultrasonography — fetal movements, breathing, tone and amniotic fluid volume (Box 11.14). The BPP is a noninvasive,

easily applied, accurate means for predicting the presence of significant fetal hypoxemia/acidosis. However, it may take 30–60 minutes to perform because the fetus might be in its normal sleep cycle and time has to be given for it to be in a wake cycle.

Rationale

Fetal biophysical activities such as body movements, breathing, fetal heart rate, and tone are regulated and controlled by discrete centers within the brain. The presence of these biophysical variables implies normal oxygenation of the fetal central nervous system. On the other hand, fetal hypoxemia/acidosis causes loss of accelerations of the fetal heart rate, decreased body and breathing movements, and hypotonia. These four variables reflect **acute hypoxia**. Decreased amniotic fluid volume reflects **chronic hypoxia** (Fig. 11.6).

Box 11.14 Components of a biophysical profile

- Nonstress test
- Fetal breathing movements
- Gross body movements
- Fetal tone
- Amniotic fluid volume

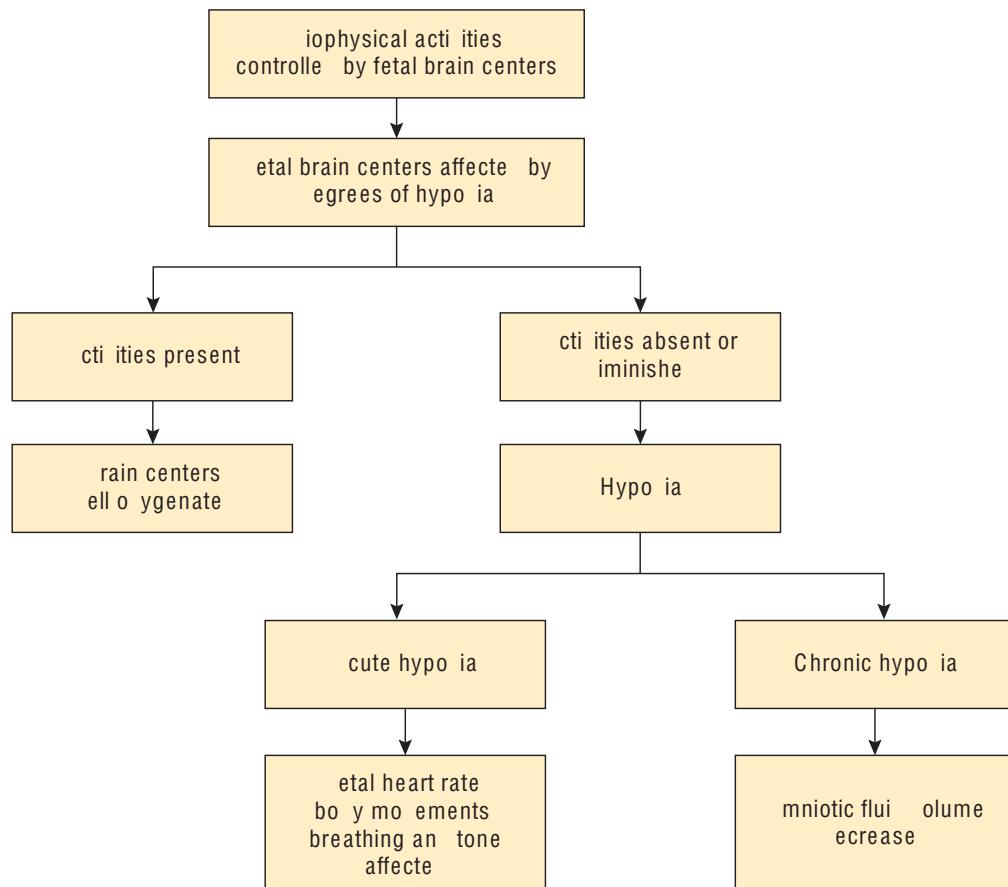


Figure 11.6 Rationale for fetal biophysical profile.

Table 11.1 Scoring of biophysical profile

	Normal (Score 2)	Abnormal (Score 0)
Nonstress test	Reactive	Nonreactive
Fetal breathing movements	<ul style="list-style-type: none"> • ≥1 episodes of rhythmic fetal breathing movements • Lasting ≥30 seconds • Within 30 minutes 	No fetal breathing movements in 30 minutes
Gross body movements	<ul style="list-style-type: none"> • ≥3 discrete body or limb movements • Within 30 minutes 	<3 movements in 30 minutes
Fetal tone	<ul style="list-style-type: none"> • ≥1 episodes of extension of fetal extremity with return to flexion or • Opening or closing of a hand 	No movements or slow movements
Amniotic fluid volume	<ul style="list-style-type: none"> • Single vertical pocket of amniotic fluid >2 cm 	Largest single vertical pocket <2 cm

Performing a BPP

An ultrasonographic examination is done, and gross body movements, fetal breathing movements, and fetal tone are noted. The amniotic fluid volume is also measured. An NST is performed using a fetal monitor. Each variable is given a score of 2 (normal) or 0 (abnormal, absent, or insufficient) using the criteria in Table 11.1.

Interpretation of BPP

A score of 8 or 10 is considered normal provided the amniotic fluid is normal. If the score is 8 and amniotic fluid volume is abnormal, chronic hypoxia is likely and a repeat evaluation or delivery is indicated. A score of 4 or less is definitely

abnormal and immediate delivery should be considered (Table 11.2).

Measuring the amniotic fluid volume

The amniotic fluid volume is measured during an ultrasound examination. The transducer must be kept perpendicular (at right angle) to the uterine contour. Two methods—single deepest pocket and amniotic fluid index—are described to measure the volume.

Single deepest pocket

The vertical dimension of the largest pocket of amniotic fluid not containing umbilical cord or fetal extremities is measured in centimeters (Fig. 11.7). This is referred to as the single deepest pocket measurement (Box 11.15). This measurement is usually utilized as part of the BPP.

Table 11.2 Interpretation and management of BPP score

BPP score	Management
10/10	Low risk of developing fetal asphyxia
8/10, normal AFV	Low risk of developing fetal asphyxia
8/10, low AFV	<ul style="list-style-type: none"> • Consider chronic hypoxia • Repeat test or deliver
6/10	<ul style="list-style-type: none"> • Significant possibility of developing fetal asphyxia • If AFV abnormal—deliver • If AFV normal—repeat test and consider delivery
4/10	High risk of fetal asphyxia within one week—deliver
0–2/10	Certain fetal asphyxia—deliver

AFV, amniotic fluid volume; BPP, biophysical profile.



Figure 11.7 Measurement of single deep pocket. (Photo courtesy: Mediscan Systems, Chennai.)

Box 11.15 Single deepest pocket measurement of amniotic fluid volume

- Largest pocket
- Vertical measurement
- No cord or extremities
- Part of biophysical profile

Box 11.16 Interpretation of single deepest pocket measurements

- Oligohydramnios: Depth <2 cm
- Normal: Depth ≥2 and <8 cm
- Polyhydramnios: Depth ≥8 cm

The interpretation of the single deepest pocket measurements is given in Box 11.16.

Amniotic fluid index

To measure the AFI, the uterus is divided into four imaginary quadrants. The linea nigra is used to divide the uterus into right and left halves. The umbilicus serves as the dividing point for the upper and lower halves (Fig. 11.8).

The maximum vertical amniotic fluid pocket diameter in each quadrant is measured in centimeters (Fig. 11.9). Care is taken to see that the pocket does not contain cord or fetal extremities. The four measurements from all the quadrants

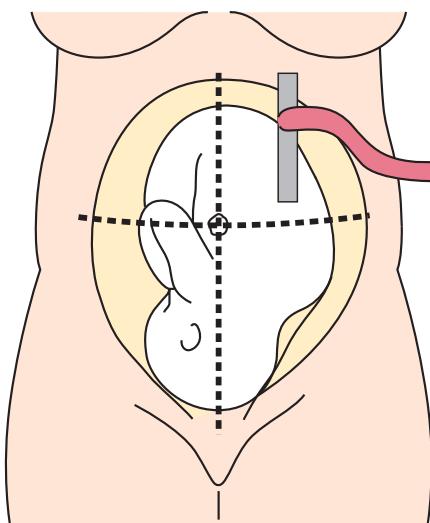


Figure 11.8 Measurement of amniotic fluid index. The uterus is divided into four imaginary quadrants. The linea nigra is used to divide the uterus into right and left halves. The umbilicus serves as the dividing point for the upper and lower halves.



Figure 11.9 Ultrasonographic measurement of the amniotic fluid index. The single deepest pocket in each quadrant is measured and added up. (Photo courtesy: Mediscan Systems, Chennai.)

are added, and this gives the AFI expressed in centimeters (Box 11.17).

This measurement is usually utilized as part of the modified BPP (mBPP; see below). The interpretation of the AFI measurements is given in Box 11.18.

Predictive value and usefulness of BPP

The following points should be noted regarding the predictive value and usefulness of a BPP:

- The false-negative rate of a BPP is low, and a normal BPP correlates well with good outcome.

Box 11.17 Amniotic fluid index

- Abdomen divided into four quadrants
 - Linea nigra to divide right and left quadrants
 - Umbilicus to divide upper and lower quadrants
- Maximum vertical diameter of amniotic fluid
 - All four quadrants measured
 - Cord and extremities avoided
 - Measured in centimeters
 - All four measurements added up

Box 11.18 Interpretation of amniotic fluid index

- Oligohydramnios: AFI ≤5 cm
- Normal: AFI >5 and <24 cm
- Polyhydramnios: AFI ≥24 cm

A = amniotic fluid index.

- The earliest manifestations of hypoxia are an abnormal NST and loss of breathing movements.
- A low BPP score has a high positive predictive value, and an abnormal BPP of <4 correlates with fetal asphyxia.

However,

- Evidence shows no difference in outcome when a BPP is compared with doing an NST alone.
- The BPP is a time-consuming test.

Therefore, the BPP is not a first-line fetal surveillance test.

Modified biophysical profile

A properly performed BPP may take 30–60 minutes to perform. To make it less time consuming, the modified biophysical profile (mBPP) was introduced. In the mBPP, just two variables are measured: AFI and NST.

Rationale

Amniotic fluid volume will decrease in the presence of placental dysfunction. With decreased placental perfusion, there is reduced perfusion of ‘nonessential’ organs such as the kidneys. This results in decreased urine production and is reflected as oligohydramnios. Amniotic fluid volume assessment can therefore be used to evaluate long-standing or **chronic hypoxia** (Box 11.19). Amniotic fluid volume is measured by the AFI.

The NST, on the other hand, is a short-term indicator of fetal hypoxemia/acidosis. It therefore assesses the presence of **acute hypoxia**.

The interpretation of the mBPP is given in Box 11.20.

Box 11.19 Rationale for modified biophysical profile

- Less time consuming than BPP
- Measures 2 components
 - AFI, which reflects
 - Chronic hypoxia
 - NST, which indicates
 - Acute hypoxia

A = amniotic fluid index; BPP = biophysical profile; S = nonstress test.

Box 11.20 Interpretation of the modified biophysical profile

- Normal
 - NST reactive
 - AFI, 5 or >5 cm
- Abnormal
 - NST nonreactive
 - AFI <5 cm

A = amniotic fluid index; S = nonstress test.

Predictive value and usefulness of mBPP

The following points should be noted regarding the predictive value and usefulness of the mBPP:

- The false-negative rate of the mBPP is low.
- The predictive value is as good as that of other biophysical tests.
- The mBPP has been found to be an excellent fetal surveillance tool.

Umbilical artery Doppler velocimetry

Doppler ultrasonography is a noninvasive technique used to measure blood flow in the placenta and fetal umbilical artery. In the presence of fetal growth restriction and/or preeclampsia, it helps differentiate the compensated healthy fetus from the hypoxicemic/acidotic fetus. In growth-restricted fetuses, antepartum assessment with this modality has been clearly shown to decrease perinatal mortality.

Rationale

A healthy, normally growing fetus will have a high-velocity diastolic flow in the umbilical artery. Under normal conditions, the placenta offers little resistance to fetal and maternal blood flow, even during maternal diastole. In certain conditions of abnormal placentation, blood flow to the placenta may be reduced and accompanied by increased resistance to perfusion. This will be reflected in the umbilical artery diastolic flow. Abnormal placentation may result in a growth-restricted fetus. In this situation, there is a decrease in the umbilical artery diastolic flow. **With severe growth restriction, as the placental**

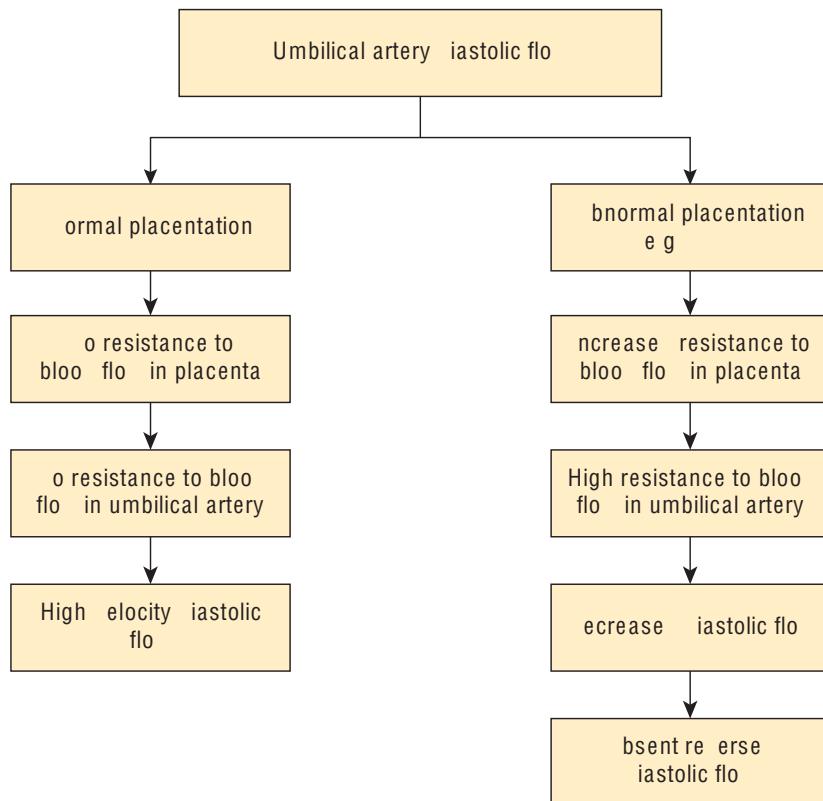


Figure 11.10 Changes in umbilical artery diastolic blood flow with normal and abnormal placentation.
, fetal growth restriction.

resistance increases, the diastolic flow can be absent or even reversed. This indicates severe hypoxia and acidosis (Fig. 11.10).

Umbilical artery flow indices

Peak systolic and end-diastolic blood flow in the fetal umbilical artery is measured and various indices are calculated (see Chapter 10, *Obstetric ultrasound and other imaging*). As the diastolic flow decreases, the indices rise. Therefore, high indices indicate increased resistance to blood flow.

The application of Doppler in obstetric decision making

Umbilical artery Doppler velocimetry helps in deciding the time of delivery in the presence of fetal growth restriction.

- **Normal indices:** Continue to observe with weekly Doppler studies, NST, and AFI.
- **Absent end-diastolic flow:** Ominous finding with increased risk of perinatal mortality (Fig. 11.11). Immediate delivery should be considered if beyond 34 weeks' gestation.

- **Reversed end-diastolic flow:** Preterminal event associated with poor perinatal outcome (Fig. 11.12). Immediate delivery is warranted.

Doppler velocimetry of other fetal vessels

In addition to the umbilical artery, Doppler velocimetry can be performed on other vessels and this contributes to the information on fetal status.

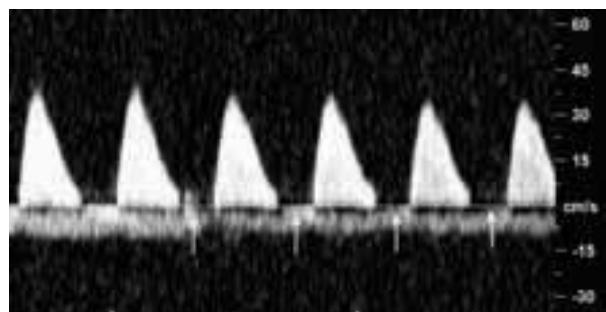


Figure 11.11 Absent end-diastolic flow in the fetal umbilical artery. The arrows point to the absence of diastolic flow following the systolic peak. (Photo courtesy: Mediscan Systems, Chennai.)

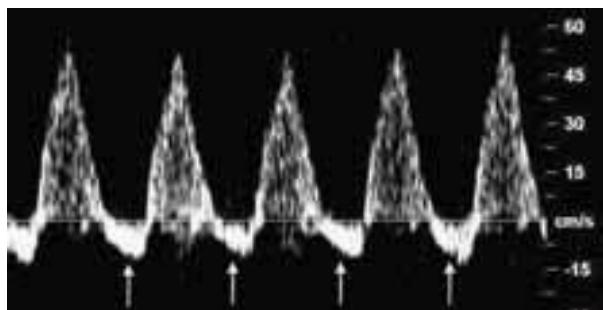


Figure 11.12 Reversed end-diastolic flow in the fetal umbilical artery. The arrows point to diastolic flow seen below the baseline (reversal). (Photo courtesy: Mediscan Systems, Chennai.)

i Middle cerebral artery

When there is fetal hypoxia, there is preferential blood flow to preserve 'essential' organs such as the brain. Increased diastolic flow in the fetal MCA indicates that the blood is being shunted preferentially to the brain. This is termed the **brain-sparing effect** (Box 11.21). This is an early sign of fetal hypoxia.

Box 11.21 Middle cerebral artery Doppler

- In the presence of fetal hypoxia
 - Increased flow to brain
 - Reflects as increased diastolic flow
 - 'Brain-sparing' effect
 - Early sign of hypoxia

Ductus venosus

Changes in the waveform pattern of the fetal ductus venosus occur late in hypoxia and indicate cardiac decompensation. This indicates a poor prognosis.

Box 11.22 Predictive value of Doppler velocimetry in antepartum fetal surveillance

- Umbilical artery Doppler
 - Useful for fetal surveillance
 - Reduces the perinatal mortality in growth restricted fetuses
 - No benefit in diabetes or postdated pregnancy
 - Used to decide on timing of delivery when
 - BPP is abnormal or,
 - AFV is low
- Middle cerebral artery Doppler
 - Useful as an adjunct to umbilical artery Doppler
- Ductus venosus Doppler
 - Good but late predictor of poor perinatal outcome

A = amniotic fluid volume; BPP = biophysical profile.

Predictive value and usefulness of Doppler velocimetry

The usefulness of different Doppler studies in fetal surveillance is summarized in Box 11.22.

Sequential changes in the presence of hypoxia

Changes in fetal heart rate (nonreactive NST) are often the earliest signs of fetal compromise (Fig. 11.13). Sequential changes in the fetal MCA and umbilical artery are detectable next. This is followed by abnormalities in biophysical parameters such as fetal breathing movements, fetal body movements, and fetal tone. These changes, however, do not always follow this sequence. Some fetuses who exhibit the full range of these findings may still not exhibit significant metabolic acidosis at birth.

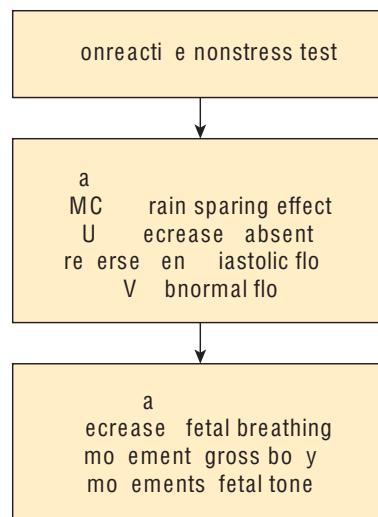


Figure 11.13 Sequential changes in fetal blood flow and biophysical parameters in the presence of worsening hypoxia. BPP, biophysical profile; DV, ductus venosus; MCA, middle cerebral artery; UA, umbilical artery

Management of pregnancies with nonreassuring antepartum testing

Management of the fetus with nonreassuring antepartum surveillance results depends on the clinical condition and the availability of clinical services. After 36–37 weeks' gestational

age, immediate delivery might be indicated to prevent further morbidity from worsening hypoxemia/acidosis.

Repetitive late decelerations or severe variable decelerations on an NST or CST generally mandate immediate delivery. Doppler velocimetry indices must be used in conjunction with other tests such as NST, AFI, and BPP. Absent

or reversed end-diastolic flow in the umbilical artery is an indication of perinatal morbidity and mortality. In pregnancies complicated by fetal growth restriction, absent or reversed end-diastolic flow mandate immediate delivery if >34 weeks' gestation. Management in the presence of prematurity has to be tailored to the individual pregnancy, to optimize fetal outcome.

Key points

- The aim of antepartum fetal surveillance is to prevent fetal demise.
- Antepartum fetal surveillance techniques are useful in assessing the risk of fetal death in pregnancies complicated by preexisting maternal conditions as well as those in which complications have developed.
- Indications may include conditions that occurred in the previous pregnancy or maternal or fetal conditions that have developed in the current pregnancy.
- Decreased fetal movements may precede intrauterine fetal death. Fetal movement counting is an easy method of fetal surveillance but has not been shown to decrease stillbirth rates.
- The nonstress test (NST) looks for the presence of accelerations of the fetal heart rate.
- A reactive NST shows two or more fetal heart rate accelerations reaching a peak of at least 15 bpm above the baseline rate and lasting for at least 15 seconds from onset to return in a 20-minute period.

- A nonreactive NST does not show accelerations over a 40-minute period.
- In a contraction stress test (CST), the fetal heart rate is recorded in the presence of induced contractions.
- In a CST, late or variable decelerations indicate fetal hypoxia.
- A biophysical profile (BPP) includes an NST and assessment of gross body movements, fetal breathing movement, fetal tone, and amniotic fluid volume.
- The modified BPP includes only NST and amniotic fluid index.
- Fetal umbilical artery Doppler velocimetry is very useful in assessing the growth-restricted fetus and determining the timing of delivery.
- Middle cerebral artery Doppler is useful in assessing the brain-sparing effect in the presence of fetal hypoxia.

Self-Assessment

Case-based questions

Case 1

A 34-year-old woman was pregnant for the first time after 8 years of marriage. She was found to have high blood pressure in the 28th week of pregnancy. At 32 weeks the fetus was found to be smaller than expected (fetal growth restriction).

1. When should fetal surveillance be started?
2. What is a reactive nonstress test?
3. What are the two methods of measuring the amniotic fluid volume?
4. Will Doppler studies be useful in a case of fetal growth restriction?

Case 2

A 26-year-old gravida 2, para 1 developed hypertension at 34 weeks. She was admitted at 37 weeks with the complaint of decreased fetal movements.

1. What is the first test that should be performed for fetal well-being?
2. What should be done in the presence of a nonreactive NST?
3. What is vibroacoustic testing?
4. What are the components of a biophysical profile?

Answers

Case 1

1. Fetal surveillance should be started immediately on the diagnosis of fetal growth restriction.
2. A reactive NST shows two or more fetal heart rate accelerations reaching a peak of at least 15 bpm above the baseline rate and lasting for at least 15 seconds from onset to return in a 20-minute period.
3. Single deepest pocket and measurement of the amniotic fluid index are the two methods of measuring amniotic fluid volume.

4. Fetal umbilical artery Doppler velocimetry is very useful in assessing the growth-restricted fetus, determining the timing of delivery, and improving perinatal outcome.

Case 2

1. In the presence of decreased fetal movements, an NST is the first test to be performed.
2. A nonreactive NST has a false-positive rate of 50%. Therefore, a fetus with a nonreactive NST should be evaluated further with a BPP or mBPP.
3. Vibroacoustic testing uses a short burst of sound for 1–2 seconds. It results in accelerations in a healthy fetus and rules out a nonreactive test due to quiet fetal sleep.

4. A biophysical profile includes an NST and assessment of gross body movements, fetal breathing movement, fetal tone, and amniotic fluid volume.

Sample questions

Long-answer question

What is antepartum fetal surveillance? What are the indications and tests performed?

Short-answer questions

1. Nonreactive nonstress test
2. Contraction stress test
3. Modified biophysical testing
4. Absent and reversed end-diastolic umbilical artery flow

12

Prenatal Screening, Prenatal Diagnosis, and Fetal Therapy

Case scenario

Mrs. AM, 36, married for 6 months, was 10 weeks pregnant. She was concerned that her baby might be abnormal because of her age. She had heard of Down syndrome affecting children of older mothers. She wanted screening for chromosomal abnormalities.

Introduction

In the past few decades, there has been better understanding of the genetic basis of a large number of fetal diseases. Screening and diagnostic techniques have been developed that make it possible to diagnose abnormalities early. Early diagnosis enables obstetricians and perinatologists to offer counseling regarding continuation of pregnancy or termination, and decide on timing and place of delivery. It also allows for a discussion of postnatal intervention, including surgery.

Fetal imaging may reveal abnormalities that could not have been treated even a decade or two ago. Advances in technology have provided the ability to offer fetal therapy. Instead of resorting to termination of pregnancy, active intervention is instituted to improve the long-term outcome of the fetus.

Prenatal screening

Prenatal testing may be broadly divided into screening tests and diagnostic tests.

Screening is the process of testing a population that is apparently healthy, using a specific marker or markers, to detect a particular condition.

Screening tests do not specify whether an individual is affected. They help divide the screened population into high- and low-risk groups for the condition in question, using a predefined cutoff. The high-risk group is then offered a diagnostic procedure.

Prenatal screening tests are used most commonly to screen for chromosomal abnormalities, especially aneuploidy. Aneuploidy refers to chromosomal mutations where the chromosomal number is abnormal. The number could be less

than or more than the normal chromosomal number. In humans, each cell normally contains 23 pairs of chromosomes, for a total of 46. **Twenty-two of these pairs are called autosomes. The 23rd pair comprises the sex chromosomes.**

Aneuploidy can present as a trisomy, triploidy, or monosomy (Box 12.1). Approximately 90% of these involve chromosome 21, 18, 13, X, or Y. One of the major objectives of prenatal screening programs is the antepartum detection of fetal aneuploidy.

Of the aneuploidies, **Down syndrome (trisomy 21)** is the most common chromosome abnormality and the most frequent cause of mental disability in humans. The syndrome is characterized by moderate-to-severe learning disability and low IQ, in combination with short stature, characteristic facial features, heart defects, intestinal malformations, and problems with vision and hearing. Prenatal screening programs were first introduced to detect Down syndrome.

Down syndrome is caused by the presence of an extra copy of chromosome 21, as a free chromosome, a Robertsonian translocation, or a reciprocal translocation involving chromosome 21. Approximately 95% of cases result from sporadic nondisjunction during parental meiosis.

Chromosomal abnormalities result in a high rate of fetal loss. Due to this, chromosomal abnormalities are more commonly detected in the first and second trimesters than in live-born infants.

Calculation of risk

A risk is the chance of an event occurring. For example, the risk of Down syndrome of 1 in 100

Box 12.1 Aneuploidies

- Aneuploidy
 - More chromosomes (trisomy, triploidy)
 - Trisomies 21, 18, and 13
 - XYY (Klinefelter syndrome)
 - Triploidy (69 chromosomes)
 - Less chromosomes (monosomy)
 - XO (Turner syndrome)
- Most common aneuploidy
 - Down syndrome (trisomy 21)
 - Extra copy of chromosome 21
 - Robertsonian translocation
 - Reciprocal translocation
 - Due to nondisjunction

means that if 100 women have this test result, the chances are that 1 of these women would have a baby with Down syndrome and that 99 would not. In other words, the baby has a 1% chance of having Down syndrome and a 99% chance of not having the syndrome.

The results of the screening tests are expressed as **high risk**, **intermediate risk**, and **low risk** depending on whether the risk result is above or below an arbitrary cutoff point of 1 in 250. This helps in deciding whether further invasive tests are required to confirm or rule out trisomy.

Screening is applied to a population, whereas diagnosis is applied at the individual patient level. For example, screening for Down syndrome can be offered to all pregnant women. When a woman's screening test places her in a high-risk group, a diagnostic test is done to confirm or rule out fetal Down syndrome. Terms commonly used in screening programs are listed in Table 12.1.

Who should be screened

All women should be offered screening for aneuploidy, regardless of age. In developing countries, screening tests may not be accessible to

Table 12.1 Common terms used in screening for aneuploidies

Term in aneuploidy screening	Explanation
Screen-positive	The group that has been identified as being at high risk for aneuploidy
Screen-negative	The group that has been identified as being at low risk for aneuploidy
Sensitivity/detection rate	The effectiveness of screening is measured by the sensitivity of the test used. The proportion of affected cases that are identified as screen-positive by the test determines its sensitivity
False-positive rate	The group that has been identified as being at high risk but does not actually have aneuploidy
Positive predictive value	The proportion of people with screen-positive results in whom fetal aneuploidy is confirmed

everyone. However, screening should be offered where facilities are available. Many centers in India are now offering screening for aneuploidy.

Counseling before screening

All couples who are being offered screening for aneuploidy should be counseled about why the test is being done, and should be helped to understand the interpretation of the results. They should also be aware about the follow-up of a positive result.

Maternal age as a screening test

The risk of chromosomal problems, such as trisomies, varies with the age of the mother. In an older mother, the oocyte has aged along with her and is prone to nondisjunction errors in the meiotic division, thereby increasing her chances of having a baby with aneuploidy. **Therefore, the risk of trisomies 21, 18, and 13 increases with maternal age.** However, the risk of triploidy and Turner syndrome (XO) does not vary with maternal age.

Because the risk of Down syndrome is higher in older women, initially maternal age over 35 years was used as a cutoff for offering testing. However, nearly 70% of Down syndrome babies are born to mothers who are younger than 35 years. Therefore, maternal age is not recommended in isolation as an indication for further invasive testing (Box 12.2).

The risk of having a baby with Down syndrome with increasing maternal age is given in

Box 12.2 Maternal age alone as screening test

- High risk with age >35 years
 - Increase in risk continuous with increase in age
- Aged oocytes
 - Increased risk of nondisjunction
- Reason for not using maternal age alone
 - 70% of Down babies born to women <age 35

Table 12.2. As seen in the Table, the risk of Down syndrome is continuous with increasing age, with no significant change at age 35.

However, maternal age is taken into consideration while calculating the background risk and likelihood ratios for the final risk of aneuploidy. These likelihood ratios are derived based on population-based statistics and may differ from one population to another.

Screening tests for fetal aneuploidy

Maternal age, maternal serum markers, and sonographic findings are all considered in screening for aneuploidy.

Screening tests for aneuploidy (specifically for Down syndrome, trisomy 18 and trisomy 13) are listed in Box 12.3.

Maternal serum screening

In the 1980s, serum screening for neural tube defects was introduced. At that time it was

Table 12.2 Risk of Down syndrome (DS) in the fetus in relation to maternal age (MA) at estimated date of delivery (EDD)

MA at EDD	Risk of DS	MA at EDD	Risk of DS	MA at EDD	Risk of DS
20	1:1450	30	1:940	40	1:85
21	1:1450	31	1:820	41	1:70
22	1:1450	32	1:700	42	1:55
23	1:1400	33	1:570	43	1:45
24	1:1400	34	1:460	44	1:40
25	1:1350	35	1:350	45	1:35
26	1:1350	36	1:270	46	1:30
27	1:1200	37	1:200	47	1:30
28	1:1150	38	1:150	48	1:30
29	1:1050	39	1:110	49	1:25

Box 12.3 Screening tests for fetal aneuploidy

- First trimester combined test
- Second trimester testing
 - Triple test
 - Quadruple test
- Integrated test
- Sequential testing
- Contingent testing
- Genetic sonogram
- Noninvasive prenatal screening (cell-free DNA) in maternal blood

noticed that serum levels of a few analytes were at different levels in mothers carrying fetuses with Down syndrome when compared with those in the rest of the population. These differences are now used to screen for Down syndrome, trisomy 18 and trisomy 13.

The analytes used for screening for Down syndrome, trisomy 18, and trisomy 13 include the following:

- First trimester
 - β human chorionic gonadotropin (β hCG)
 - Pregnancy-associated plasma protein A (PAPP-A)
- Second trimester
 - Unconjugated estriol (uE3)
 - Alpha fetoprotein (AFP)
 - β hCG
 - Inhibin A

The concentration of each serum marker is expressed as a multiple of the median (MoM) for unaffected pregnancies of the same gestational age. The serum marker is plotted on a graph, and whether it is higher or lower than the MoM of an unaffected pregnancy is calculated.

In the first trimester, the level of β hCG is elevated and that of PAPP-A is decreased in Down syndrome, but both are decreased in trisomy 18 and trisomy 13. In the second trimester, while AFP, uE3, and PAPP-A are lower, levels of β hCG and inhibin A are higher in women whose fetuses have Down syndrome (Table 12.3).

Maternal serum screening may be carried out in isolation but usually is combined with ultrasound estimation of nuchal translucency.

Ultrasound markers

Fetuses affected by Down syndrome and other trisomies have increased fluid behind the neck

Table 12.3 Changes in levels of serum markers in the common trisomies

	Trisomy 21	Trisomy 18	Trisomy 13
<i>First trimester</i>			
PAPP-A	Decreased	Decreased	Decreased
β hCG	Increased	Decreased	Decreased
<i>Second trimester</i>			
AFP	Decreased	Decreased	Decreased
hCG	Increased	Decreased	Decreased
uE3	Decreased	Decreased	Decreased
Inhibin A	Increased	Decreased	Increased

A β alpha fetoprotein; hC human chorionic gonadotropin; PAPP-A pregnancy-associated plasma protein A; u unconjugated estriol.

as seen on ultrasound in the first trimester (see Chapter 10, *Obstetric ultrasound and other imaging*). The term, **increased nuchal translucency** (NT) was introduced in 1992. This has become an integral and essential component of screening for Down syndrome in the first trimester (Fig. 12.1). NT is also expressed in MoMs and uses maternal age-related risk as the background risk for calculation.

Other ultrasound markers for Down syndrome in the first trimester include the following:

- Absent nasal bone
- Increased impedance to flow in the ductus venosus
- Tricuspid regurgitation



Figure 12.1 Ultrasound image of nuchal translucency. The arrow points to the anechoic area behind the fetal neck. (Photo courtesy: Mediscan Systems, Chennai.)

These require higher expertise to image and so NT continues to be the most important ultrasound marker for Down syndrome.

Using the serum and ultrasound markers, the detection rate of Down syndrome in the first trimester is 90%–95% (Box 12.4).

First trimester combined test

The first trimester combined test includes serum testing for free β hCG and PAPP-A and ultrasound measurement of the NT. It is done at 11–13⁺⁶ weeks. This test should be offered to all women to screen for Down syndrome. The risk for trisomy 18 and trisomy 13 can also be predicted with this test.

Serum markers

As mentioned earlier, several factors influence the serum levels and once these are factored in, the built-in software generates a screening risk based on the serum levels of the analytes and NT.

Advantages of first trimester combined screening

First trimester combined screening enables early risk prediction in pregnancy, so decisions can be taken earlier (Box 12.5). Invasive diagnostic tests can be offered early and the couple can make decisions about further management.

Increased NT is not only a marker for trisomies but also a marker for major cardiac defects, diaphragmatic hernia, renal anomalies, body stalk disruption, and abdominal wall defects. Therefore, when the NT is increased and the fetus is proved to have normal chromosomes by

Box 12.5 Advantages of first trimester screening

- Early risk prediction
- Opportunity for early decision-making
- Increased NT is a marker for
 - Trisomies
 - Major cardiac defects
 - Diaphragmatic hernia
 - Renal anomalies
 - Body stalk disruption
 - Abdominal wall defects
- Decreased PAPP-A/increased β hCG predicts
 - Uteroplacental insufficiency
 - Preeclampsia

β C, human chorionic gonadotropin; NT, nuchal translucency; PAPP-A, pregnancy-associated plasma protein A.

invasive testing, the pregnancy needs to be carefully monitored with serial ultrasound scans.

Decreased PAPP-A or increased β hCG is also a predictor of uteroplacental dysfunction and can be used for screening for preeclampsia.

In twin pregnancies, a first trimester combined screening test is the best screen for Down syndrome and trisomy 18.

Second trimester testing

Serum markers

Second trimester maternal serum screening is best offered between 15 and 20 weeks' gestation and involves the analysis of three analytes (**triple test**) or four analytes (**quadruple test**) (Box 12.6).

Box 12.6 Second trimester screening for aneuploidy (Down syndrome, trisomy 18, trisomy 13)

- Done between 15 and 20 weeks
- Serum biochemistry
 - Triple test
 - AFP
 - uE3
 - hCG
 - Quadruple test
 - Above 3 + inhibin A
 - AFP and uE3
 - Both decreased in Down syndrome
 - hCG and inhibin A
 - Both doubled in Down syndrome

A P alpha fetoprotein; hC human chorionic gonadotropin; u unconjugated estriol.

Box 12.4 First trimester screening for aneuploidy

- 11–13⁺⁶ weeks
- Serum markers
 - β human chorionic gonadotropin (β hCG)
 - Pregnancy-associated plasma protein A (PAPP-A)
- Ultrasound
 - Nuchal translucency (most important)
 - Nasal bone
 - Ductus venosus flow
 - Tricuspid regurgitation
- 90%–95% detection rate
- Can be used in twin pregnancy

The serum markers used for the second trimester **triple test** are as follows:

- Triple test
 - AFP
 - uE3
 - β hCG
- Quadruple test
 - The above 3 + inhibin A

The levels of the analytes are interpreted as MoMs from the unaffected population and a risk algorithm is created.

The levels *in vitro* of these serum markers are affected by various factors that need to be taken into consideration before allocating the pregnancy into a high-risk or a low-risk category. These factors are as follows:

- Maternal weight
- Maternal diabetes
- Number of fetuses
- *In vitro* fertilization
- Smoking

Ultrasound markers

There are both major and minor markers for aneuploidy in the second trimester scan.

Major markers for aneuploidies include the following:

- Increased nuchal fold thickening
- Exomphalos
- Duodenal atresia
- Atrioventricular septal defects

When major markers for aneuploidy are identified, they should prompt further workup and/or correlation with laboratory data and risk factors. They are an indication for a diagnostic test for karyotyping.

Minor markers for aneuploidies include the following:

- Choroid plexus cysts
- Echogenic foci in the fetal heart
- Mild hydronephrosis
- Echogenic bowel
- Short femur

Minor markers (or soft markers) do not carry the implications that a major marker does. In general, an isolated minor marker does not appear to carry a significant risk for chromosomal

abnormality, whereas if two or more minor markers are identified, the risk of trisomy increases.

Markers associated with certain chromosomal abnormalities are listed in Table 12.4.

Integrated test

Integrated screening test is a two-step screening process and requires measurement of serum markers in both the first and second trimesters. Ultrasound may or may not be included. Although the detection rate is high, the woman has to wait till the second trimester to know her risk estimate.

The full integrated test consists of ultrasound measurement of NT at 11–13 $\frac{6}{7}$ weeks, PAPP-A obtained at 10–13 weeks, and AFP, uE3, β hCG, and inhibin A obtained at 15–18 weeks. The integrated test has detection rates of 85% or 95% and the lowest false-positive rate among Down syndrome screening tests.

Sequential screening

The stepwise sequential screening process involves performing the first trimester portion

Table 12.4 Markers associated with aneuploidies

Chromosome abnormality (aneuploidy)	Markers
Trisomy 21 (Down syndrome)	Increased nuchal translucency, absent nasal bone, cardiac defects (especially atrioventricular canal defects), echogenic bowel, short femur/humerus, renal pelviectasis, and sandal gap deformity of the feet
Turner syndrome (45, XO)	Cystic hygromas and coarctation of the aorta; pleural effusion, ascites, and cardiac defects (in lethal type)
Trisomy 18 (Edwards syndrome)	Choroid plexus cyst, overlapping fingers, abnormal corpus callosum, strawberry-shaped head, micrognathia, omphalocele, diaphragmatic hernia, clenched hands, radial ray anomalies, clubfeet, and rocker bottom feet
Trisomy 13 (Patau syndrome)	Polydactyly, microcephaly, holoprosencephaly, cleft lip/palate, ocular anomalies, neural tube defects, and cardiac defects

of the integrated screen and then offering counseling and chorionic villus sampling (CVS) to women who are reported as being very high risk (e.g., ≥ 1 in 50) of having an affected fetus. Those women who are at low or moderate risk do not have their results disclosed to them and undergo a subsequent second trimester serum screening. An integrated risk of screen-positive or screen-negative is given.

Contingent sequential screening

In contingent sequential screening, three groups are identified based on risk: (a) women identified as being at **very high risk** (e.g., >1 in 50) of having a fetus with Down syndrome after first trimester testing are offered immediate invasive prenatal diagnosis, (b) women at **low risk** (e.g., <1 in 2000) after first trimester testing are provided with their risk estimate and will not undergo any additional testing, and (c) women at **intermediate risk** (between 1 in 50 and 1 in 2000) will have a second trimester blood screening to complete the integrated test.

Genetic sonogram

Ultrasound markers, both minor and major (Table 12.4), are assessed at 18–20 weeks' gestation to modify the age-related risk for Down syndrome.

Noninvasive prenatal testing in maternal blood

Noninvasive prenatal testing (NIPT) for aneuploidy using cell-free DNA(cfDNA) in the maternal blood has been available for clinical use since 2011. It is an expensive test and is not available freely in developing countries.

Fetal cell-free nucleic acids (cfDNA and cfRNA) not contained within cell membranes are abundant in the maternal circulation. Screening using cfDNA can identify common autosomal trisomies (chromosomes 21, 18, and 13), as well as select sex chromosome aneuploidies (45X, 47XXY, 47XXX, 47XXX).

Initially, detecting trisomies using fetal cfDNA required the use of multiple placental DNA or RNA markers, making the test time-consuming

and expensive. Recently, massively parallel genomic sequencing or chromosome selective sequencing allows accurate detection of trisomy 13, trisomy 18 and trisomy 21. The test can be done as early as the 10th week of pregnancy and the result may be available in 1 week. Detection rates for fetal trisomy 13, trisomy 18, and trisomy 21 are greater than 98% with false-positive rates $<0.5\%$. Cell-free fetal DNA appears to be the most effective screening test for aneuploidy in high risk women.

Noninvasive prenatal testing should be offered to only patients at high risk of aneuploidy. Factors that make the pregnancy high risk are listed in Box 12.7.

It is recommended that these assays only be used as screening tests. A positive result requires confirmation with invasive prenatal diagnosis.

Management of the screen-positive pregnancy

A screen-positive result provokes anxiety in the couple. Detailed counseling and explanation of the results are important (Fig. 12.2).

A screen-positive result does not mean that the fetus is affected. However, a screen-positive test requires follow-up with an invasive test for karyotyping to confirm or rule out aneuploidy. Based on the gestational age, CVS or amniocentesis should be offered (see below).

Even with a normal karyotype, fetuses with significantly increased NT are at risk for congenital anomalies. However, fetuses with increased NT and normal karyotype that have a normal scan at 18–20 weeks have $<5\%$ chance of an adverse outcome in the postnatal or late antenatal period.

Box 12.7 Risk factors for which noninvasive prenatal testing should be offered

- Maternal age ≥ 35 years at delivery
- Fetal sonography indicating an increased risk of aneuploidy
- A previous pregnancy with fetal trisomy
- Parental balanced Robertsonian translocation with increased risk of fetal trisomy 21 or trisomy 13

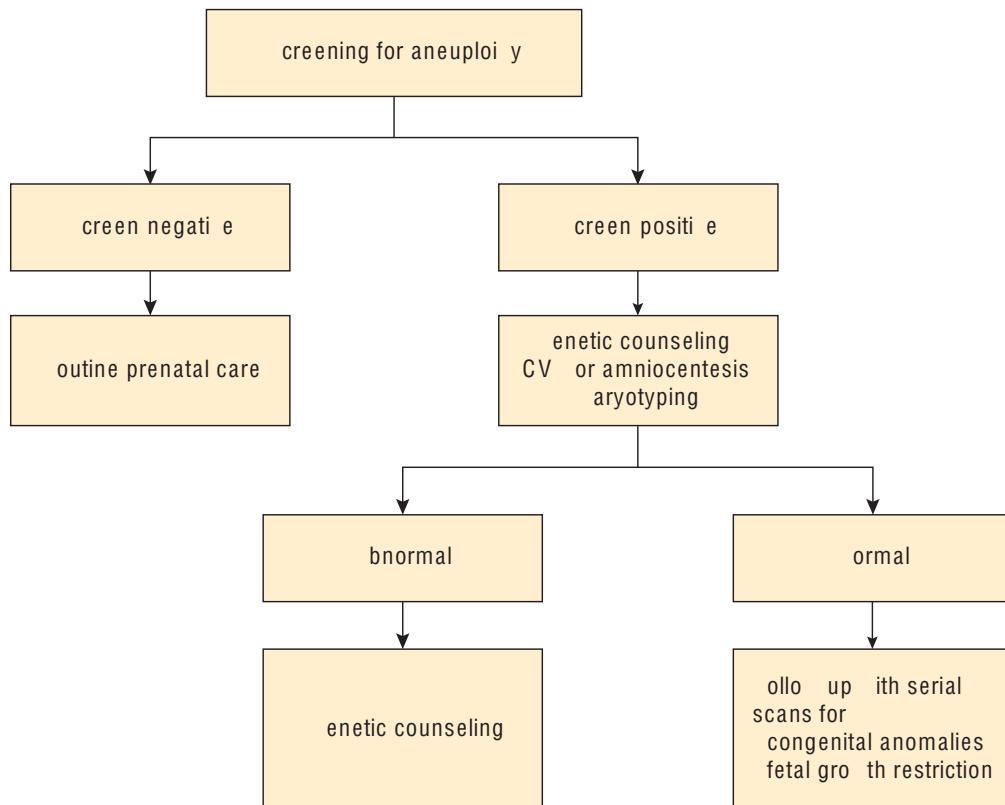


Figure 12.2 Counseling and management of the screen-positive pregnancy. CVS, chorionic villus sampling.

Pregnancies with a low PAPP-A value are at increased risk for small-for-gestational-age (SGA) fetuses and therefore should be monitored for fetal growth.

Prenatal diagnosis

Prenatal diagnosis focuses on detection of abnormalities in the fetus in pregnancies suspected to be at high risk for congenital or chromosomal abnormalities.

Indications

Indications for performing prenatal diagnostic tests are listed in Box 12.8.

Tests for prenatal diagnosis

Both noninvasive and invasive techniques are used for prenatal diagnosis.

Box 12.8 Indications for prenatal diagnostic tests

- Positive screening test for chromosomal anomaly
- Past/family history of previous child with
 - congenital malformation
 - chromosomal anomaly
 - inherited disorder
- Couple known carrier of chromosomal translocation
- Suspected or confirmed viral infections during pregnancy
- Maternal exposure to teratogenic drugs
- Maternal diabetes
- Polyhydramnios
- Early onset fetal growth restriction

Noninvasive tests

Ultrasonography is the most commonly used test for prenatal diagnosis. Noninvasive prenatal diagnostic tests are listed in Box 12.9.

These tests are described in Chapter 10, *Obstetric ultrasound and other imaging*.

Box 12.9 Noninvasive prenatal diagnostic tests

- Ultrasonography
 - Three-dimensional (3D) ultrasonography
 - Fetal echocardiography
- MRI
- Plain radiography

Invasive techniques

Invasive tests are used to obtain samples of amniotic fluid, fetal blood, or fetal tissue for further testing. The tests are listed in Box 12.10.

Box 12.10 Invasive prenatal diagnostic tests

- Amniocentesis
- Chorionic villus sampling (CVS)
- Fetal blood sampling (FBS) or percutaneous umbilical blood sampling (PUBS)
- Percutaneous biopsy of organs
- Preimplantation biopsy of blastocyst
- Fetoscopy

Prenatal diagnostic tests are used for the investigation of the following conditions:

- Congenital malformations
- Chromosomal anomalies
- Single gene defects
- Effects of intrauterine infections

Congenital malformations

Structural malformations affecting one or more organs of the fetus may occur in women with pregestational diabetes or who have been exposed to infections, teratogenic drugs, or radiation. First trimester ultrasonography may identify some anomalies, but second trimester sonography at 18–20 weeks is used for the identification of most malformations. The malformation may involve the central nervous, cardiovascular, renal, gastrointestinal, skeletal, or respiratory system. Fetal echocardiography is used when cardiovascular anomalies are suspected. MRI may be required in certain situations.

Chromosomal anomalies

Screening for aneuploidy has been discussed earlier in this chapter. When screening is positive, further diagnostic tests such as CVS or

amniocentesis are performed to obtain samples for karyotyping.

Single gene defects

Hemoglobinopathies, sickle cell disease, thalassemias, and cystic fibrosis are the common inherited genetic disorders. When these are suspected due to a positive family history or carrier status in the parents, genetic analysis is performed on the sample obtained by CVS or fetal blood sampling (FBS).

Effects of intrauterine infections

Intrauterine infections with viruses such as parvovirus, rubella, cytomegalovirus, and herpes simplex virus or a parasite such as *Toxoplasma gondii* can give rise to congenital anomalies. When the mother has an acute infection during pregnancy suggestive of one of the infections mentioned, fetal infection is confirmed or ruled out by amniocentesis or FBS. Decision regarding termination of pregnancy may be made based on the results.

Prenatal invasive diagnostic procedures

The commonly used invasive tests for prenatal diagnosis are amniocentesis, CVS, and FBS.

Fetal blood sampling (cordocentesis) carries a greater risk of pregnancy loss and therefore is reserved only for clinical situations in which amniocentesis, CVS, or maternal blood sampling does not provide adequate diagnostic information.

Karyotyping following invasive diagnostic procedure

Karyotyping is done to count the number of chromosomes (Fig. 12.3) and look for structural changes in chromosomes. It is done using one or more of the following methods:

- Metaphase analysis of cultured amniocytes or chorionic villus cells is highly accurate, and takes between 1 and 3 weeks to obtain results.
- Fluorescence in situ hybridization (FISH) analysis provides a result in 48–72 hours (Fig. 12.4). It is specific for chromosomes 21, 13, 18, X, and Y.

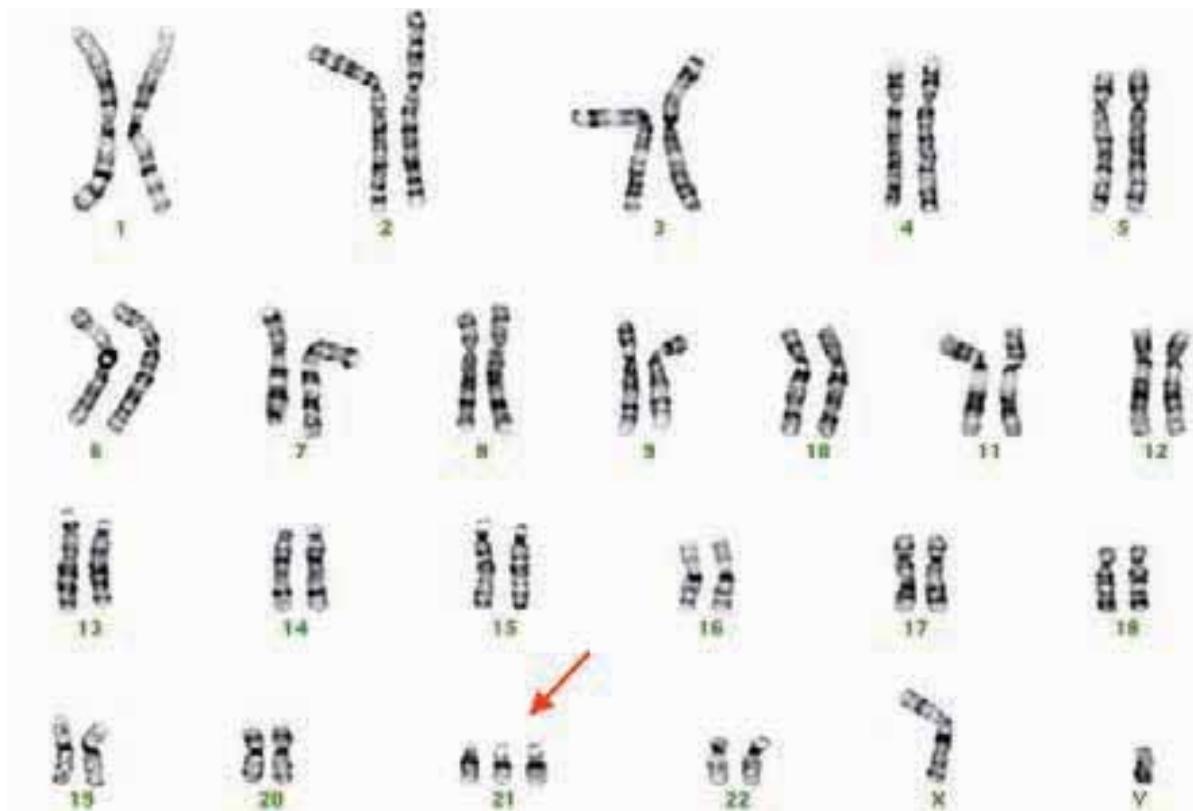


Figure 12.3 Karyotype showing three sets of chromosome 21 in Down syndrome. The red arrow points to chromosome 21. (Photo courtesy: Mediscan Systems, Chennai.)

- A newer technique has been introduced recently for the rapid detection of aneuploidies involving chromosomes 21, 18, and 13 and is called quantitative fluorescent polymerase chain reaction (QF-PCR).

Chorionic villus sampling

Chorionic villus sampling is a procedure in which placental villi are obtained through a transcervical or transabdominal route for prenatal genetic diagnosis. The fact that the results are available earlier in pregnancy as compared with amniocentesis is the primary advantage of CVS. The advantages of the procedure are given in Box 12.11.

Procedure

The transabdominal route has come to be the preferred route in most centers performing invasive prenatal diagnosis.

The transcervical route can also be used but is technically more challenging and may be associated with vaginal bleeding.

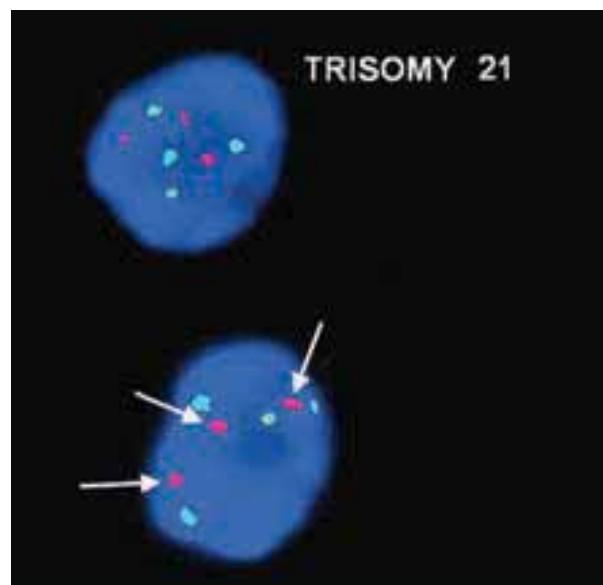


Figure 12.4 Picture of a fluorescence in situ hybridization (FISH) test showing three signals for chromosome 21 (arrows) in a sample from a fetus with trisomy 21. There are two blue signals for chromosome 13 and two green signals for chromosome 18. (Photo courtesy: Mediscan Systems, Chennai.)

Box 12.11 Advantages of chorionic villus sampling

- Performed in the first trimester, after 10 weeks
- Results available early
- Makes termination of pregnancy (if needed) easier and safer
- Miscarriage rate low: 0.5%–1%

The following steps are followed:

- The procedure is done under aseptic conditions and under ultrasound guidance.
- A long 20-gauge needle with stylet is inserted transabdominally under continuous visualization, into the thickest portion of the placenta (Fig. 12.5a). If the transcervical route is used, a flexible catheter is introduced (Fig. 12.5b). Figure 12.6 demonstrates the ultrasound image of transabdominal CVS.
- The stylet is removed and the culture medium-containing syringe is then attached to the hub of the needle.
- An adequate sample of placental villi is aspirated by negative pressure created in the syringe.

Amniocentesis

Amniocentesis is an invasive procedure done under ultrasound guidance to obtain a sample of amniotic fluid from the uterine cavity (Box 12.12). The amniotic fluid contains exfoliated fetal cells that are cultured and used for karyotyping. High-resolution banding of chromosomes is possible

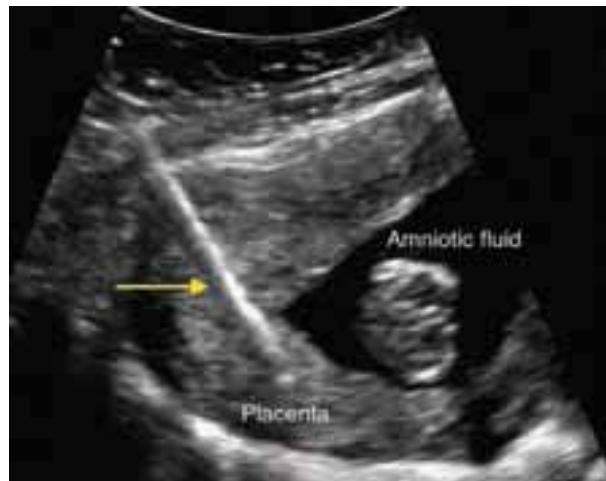


Figure 12.6 Ultrasound image of chorionic villus sampling. The needle (arrow) is seen in the placenta. (Photo courtesy: Mediscan Systems, Chennai.)

Box 12.12 Amniocentesis

- Aspiration of amniotic fluid
- Performed after 15 weeks' gestation
- Performed under ultrasound guidance
- Miscarriage rate: 0.5%–1%
- Advantages
- High-resolution banding of cells possible
- Useful for diagnosis of structural chromosomal rearrangements

with cells obtained from amniocentesis, so this is the preferred procedure when structural chromosomal rearrangements need to be identified.

Procedure

The procedure of performing amniocentesis consists of the following steps:

- Using ultrasonography, a pocket of amniotic fluid is identified.
- A fine needle is passed transabdominally into the amniotic cavity (Figs 12.7 and 12.8) and 20 mL of amniotic fluid is aspirated.

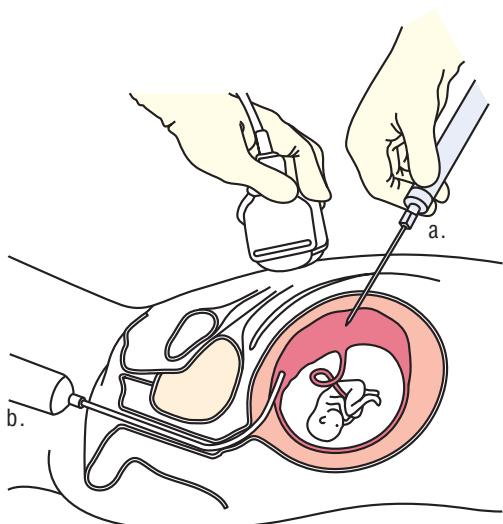


Figure 12.5 Chorionic villus sampling **a.** Transabdominal. **b.** Transvaginal.

Fetal blood sampling

The indications for FBS are as follows:

- Rapid karyotype
- Fetal hemolytic disease (*see Chapter 38, Redcell alloimmunization*)
- Severe early onset fetal growth deficiency
- Suspected congenital infection

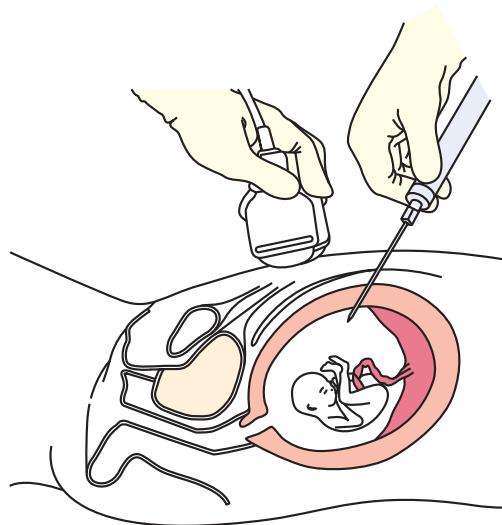


Figure 12.7 Amniocentesis under ultrasound guidance.

Fetal blood sampling is not routinely used for karyotyping, although karyotyping can be accomplished in 24–48 hours on fetal blood cells. It is performed only if neither CVS nor amniocentesis is possible. The procedure-related pregnancy loss rate is <2%.

Procedure

The procedure of performing FBS consists of the following steps:

- It is done under aseptic precautions, using ultrasound guidance.

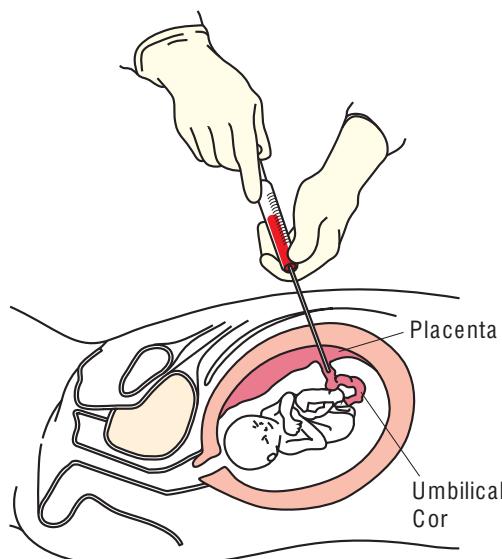


Figure 12.9 Fetal blood sampling from the umbilical cord.



Figure 12.8 Ultrasound image of amniocentesis. The echogenic tip of the needle (yellow arrow) is seen in the amniotic fluid. (Photo courtesy: Mediscan Systems, Chennai.)

- A 20- to 22-gauge spinal needle is passed transabdominally.
- The fetal umbilical vein is punctured and blood is obtained from the fetal umbilical cord (Figs 12.9 and 12.10).
- Usually 2–5 mL of blood is collected.



Figure 12.10 Ultrasound image of fetal blood sampling. The needle (yellow arrow) is seen entering the insertion of the umbilical cord (two white arrows) into the placenta. (Photo courtesy: Mediscan Systems, Chennai.)

Table 12.5 Prenatal invasive diagnostic procedures

	Chorionic villus sampling	Amniocentesis	Fetal blood sampling
Gestational age	First trimester (after 10 weeks)	After 15 weeks	After 18 weeks
Route	Transabdominal/transcervical	Transabdominal	Transabdominal
Site of sampling	Thickest part of placenta	Most accessible pocket of fluid	Umbilical cord/intrahepatic portal vein/fetal heart
Tissue obtained	Placental villi	Amniotic fluid (amniocytes)	Fetal blood (RBCs, serum)
Time taken to obtain karyotyping	<ul style="list-style-type: none"> • Metaphase culture: 1–3 weeks • FISH: 48–72 hours 	<ul style="list-style-type: none"> • Metaphase culture: 1–3 weeks • FISH: 48–72 hours 	48–72 hours
Risk of pregnancy loss	0.5–1%	0.5–1%	<2%

S = fluorescence in situ hybridization; RBCs = red blood cells.

- Fetal blood can also be obtained from the intrahepatic portal vein or rarely, the fetal heart.
- If the fetal blood sample is obtained from the cord at its insertion into the placenta, the blood must be tested to confirm that it is fetal blood and not maternal contamination.

Table 12.5 lists the different invasive diagnostic procedures available.

Preimplantation screening and diagnosis

Technology is now available to perform tests for genetic disorders on the DNA extracted from an oocyte or an embryo.

A couple that has no known chromosomal abnormality may undergo **preimplantation screening (PGS)** to rule out a genetic defect. Preimplantation screening may help avoid transfer of aneuploid embryos, reduce the risk of pregnancy failure, and improve the probability of conceiving a viable pregnancy with assisted reproductive technology (ART).

In certain couples, one or both partners may have an inheritable genetic disorder or a balanced translocation. In these couples, **preimplantation diagnosis (PGD)** for chromosomal abnormality or genetic defect may be offered.

Any couple that chooses to have PGS or PGD will necessarily have to use ART even if they have no problem conceiving. The testing is done on the embryo obtained by using ART or the polar body of the oocyte. Patients should be aware of this because ART is expensive and invasive.

Indications for PGS

The various indications for PGS are as follows:

- Women at high risk for aneuploid embryos
 - Women over age 35
 - Multiple IVF failures
 - Recurrent pregnancy loss

Indications for PGD

The various indications for PGD are as follows:

- Inherited familial disorder
- One or both partners with balanced translocation
- High risk of recurrent pregnancy loss
- Sex selection to avoid sex-linked disorders

D A for analysis

The DNA for preimplantation genetic testing is obtained from different cells (Box 12.13).

Box 12.13 Source of D A for preimplantation testing

- Polar body biopsy
 - First or second polar body of oocyte
 - Indicated for maternally inherited mutations
- Blastomere biopsy
 - Day 3 after fertilization
 - 6- to 9-cell stage
 - 1 or 2 blastomeres removed
- Blastocyst biopsy
 - Day 5 or 6 after fertilization
 - Hundreds of cells available
 - Provides maximum DNA for analysis

Fetal therapy

The exponential advances in fetal imaging and increased understanding of fetal physiology have changed the way many fetal problems, both structural and physiological, are managed. Instead of resorting to termination of pregnancy, active intervention is instituted to improve the long-term outcome of the fetus.

Fetal interventions

Most fetal therapy involves the use of ultrasound-guided interventions, fetoscopy, or open fetal surgery.

Ultrasound-guided interventions

Intrauterine fetal transfusion

The commonest indication for intrauterine transfusion is Rh alloimmunization in pregnancy. This is discussed in detail in Chapter 38, *Red cell alloimmunization*.

Vesicoamniotic shunt

Fetal lower urinary tract outflow obstruction prevents the fetus from passing urine. This can result in a reduction in the volume of amniotic fluid. Severe oligohydramnios may interfere with the development of the fetal lungs and kidneys.

A vesicoamniotic shunt is a tube that is inserted into the fetal bladder to drain the excess urine into the amniotic cavity. The amniotic fluid is maintained at normal levels till delivery is decided upon. Fetal chromosomal analysis is advised before the procedure to diagnose or exclude associated chromosomal abnormalities.

Thoracoamniotic shunt

Isolated fetal pleural effusions are uncommon but can result in pulmonary hypoplasia (nondevelopment of the lung). They may be bilateral but

are more commonly unilateral. They can arise in association with many problems including congenital malformations, chromosomal abnormalities, chylothorax, anemia, heart defects, cardiac arrhythmias, and viral infections.

Once the mother and fetus are investigated to identify any treatable underlying causes of the pleural effusion such as anemia or cardiac arrhythmias, an attempt is made to aspirate the fluid under ultrasound guidance. If the fluid reappears, thoracoamniotic shunt placement is used to drain the pleural effusion.

Fetoscopic interventions

Using a fetoscope through a small abdominal incision, the procedure is performed inside the uterus. Ultrasound guidance is required along with the view obtained through the fetoscope.

Indications for fetoscopy-guided interventions include the following:

- Ligation of umbilical cord in acardiac twin
- Selective laser photocoagulation of communicating vessels in twin-to-twin transfusion
- Ablation of posterior urethral valve

Open fetal surgery

Open fetal surgery is an extremely expensive option and is performed only at very few centers in the West. Complications such as chorioamnionitis, preterm labor, bleeding, and direct trauma to the fetus are risks in most of these procedures. Open fetal surgery has been attempted successfully in the following fetal problems:

- Neural tube defects such as myelomeningocele and spina bifida
- Congenital diaphragmatic hernia
- Congenital cystic adenomatoid malformation
- Congenital heart disease
- Pulmonary sequestration
- Sacrococcygeal teratoma

Key points

- Aneuploidy refers to chromosomal mutations where the chromosomal number is abnormal. It can present as a trisomy, triploidy, or monosomy.

- Of the aneuploidies, Down syndrome (trisomy 21) is the most common chromosome abnormality and the most frequent cause of mental disability in humans.

(Continued)

Key points *Continued*

- Screening is the process of testing a population that is apparently healthy, using a specific marker or markers, to detect a particular condition.
- The results of the screening tests for aneuploidy are expressed as 'high risk,' 'intermediate risk,' and 'low risk' depending on whether the risk result is above or below an arbitrary cutoff point of 1 in 250.
- Maternal age, maternal serum markers, and sonographic findings are all considered in screening for aneuploidy.
- Maternal age is not recommended in isolation as a screening parameter.
- The first trimester combined test is done at 11–13⁺⁶ weeks. It includes serum testing for free β hCG and pregnancy-associated plasma protein A (PAPP-A), and ultrasound measurement of the nuchal translucency.
- Second trimester maternal serum screening is best offered between 15 and 20 weeks' gestation.
- The serum markers used for the second trimester *triple test* are alphafetoprotein (AFP), unconjugated estriol (uE3), and human chorionic gonadotropin (hCG). The additional serum marker for the *quadrupe test* is inhibin A.
- Major ultrasound markers for aneuploidies include increased nuchal fold thickening, exomphalos, duodenal atresia, and atrioventricular septal defects.
- Minor ultrasound markers for aneuploidies include choroid plexus cysts, echogenic foci in the fetal heart, mild hydronephrosis, echogenic bowel, and short femur.
- Noninvasive prenatal testing (NIPT) for aneuploidy uses cell-free DNA in the maternal blood and can be offered to women at high risk for aneuploidy.
- A screen-positive result requires follow-up with an invasive test for karyotyping to confirm or rule out aneuploidy.
- Chorionic villus sampling (CVS) is a procedure in which placental villi are obtained through a transabdominal or transcervical route for prenatal genetic diagnosis. It is usually performed in the first trimester after 10 weeks' gestation.
- Amniocentesis is an invasive procedure done under ultrasound guidance to obtain a sample of amniotic fluid from the uterine cavity. It is usually performed after 15 weeks' gestation.
- Fetal blood sampling is not routinely used for karyotyping, although karyotyping can be accomplished in 24–48 hours on fetal blood cells.
- A couple that has no known chromosomal abnormality may undergo *preimplantation screening* (PGS) to rule out a genetic defect. This supposedly avoids transfer of aneuploid embryos, reduces the risk of pregnancy failure, and improves the probability of conceiving a viable pregnancy with assisted reproductive technology (ART).
- In certain couples, one or both partners may have an inheritable genetic disorder or a balanced translocation. In these couples, *preimplantation diagnosis* (*P* *D*) for chromosomal abnormality or genetic defect may be offered.
- Most fetal therapy involves the use of ultrasound-guided interventions, fetoscopy, or open fetal surgery.

Self-Assessment

Case-based questions

Case 1

Mrs. AM, 36, was married 6 months ago. She was 10 weeks pregnant. She was concerned that her baby might be abnormal because of her age. She had heard of Down syndrome affecting children of older mothers. She wanted screening for chromosomal abnormalities.

1. How does maternal age increase the risk for aneuploidy?
2. Which screening test for aneuploidy can be offered in the first trimester?
3. What is nuchal translucency?
4. Which serum markers are used in the second trimester?

Case 2

Mrs. JK, 31, gravida 2, para 1, live 1, underwent routine screening for aneuploidy at 12 weeks. The result showed that her risk of having a baby with Down syndrome was 1 in 100 (normal cutoff 1 in 250).

1. What invasive diagnostic procedure can be offered to her?
2. What are the methods for obtaining a karyotype?
3. What are the ultrasound markers for Down syndrome in the first trimester?
4. What is the risk of miscarriage following chorionic villus sampling and amniocentesis?

Answers

Case 1

1. In an older mother, the oocyte has aged along with her and is prone to nondisjunction errors in the meiotic division, thereby increasing her chances of having a baby with aneuploidy.
2. The first trimester combined test can be offered at 11–13⁺6 weeks. It includes serum testing for free β hCG and pregnancy-associated plasma protein A (PAPP-A), and ultrasound measurement of the nuchal translucency.
3. Fetuses affected by Down syndrome and other trisomies have increased fluid behind the neck as seen on ultrasound in the first trimester. This is called nuchal translucency (NT) on ultrasound examination.
4. The serum markers used for the second trimester triple test are alpha fetoprotein (AFP), unconjugated estriol (uE3), and human chorionic gonadotropin (hCG). The additional serum marker for the quadruple test is inhibin A.

Case 2

1. She can be offered chorionic villus sampling.
2. Metaphase analysis of cultured amniocytes or chorionic villus cells, fluorescence in situ hybridization (FISH) analysis, and quantitative fluorescent polymerase chain reaction (QF-PCR) can be used for karyotyping.

3. Increased NT, absent nasal bone, increased impedance to flow in the ductus venosus, and tricuspid regurgitation are the ultrasound markers for aneuploidy in the first trimester.
4. The risk of miscarriage following chorionic villus sampling or amniocentesis is 0.5%–1%.

Sample questions

Long-answer questions

1. Discuss prenatal screening for aneuploidy.
2. Discuss prenatal diagnostic tests and the common indications. Briefly describe the procedures.

Short-answer questions

1. First trimester screening for Down syndrome
2. Nuchal translucency
3. Integrated test for Down screening
4. Noninvasive screening (cell-free DNA) in maternal blood
5. Chorionic villus sampling
6. Amniocentesis
7. Fetal blood sampling (percutaneous umbilical blood sampling)

13

Medical Termination of Pregnancy

Case scenario

Mrs. AD, 34, mother of two children, came to the clinic with history of having missed her periods. Her last child was 2 years old and she had an intrauterine contraceptive inserted 2 months after delivery. Her menstrual periods had always been regular. The pregnancy test done at home was positive. She wanted termination of pregnancy since her financial situation was not good enough to take care of a third child. She was also upset that she had conceived in spite of using contraception.

Introduction

Termination of pregnancy is required in many situations; pregnancy in spite of using contraception, pregnancy where the fetus has a chromosomal anomaly, an unintended pregnancy, and pregnancy in a woman with a medical problem. Annual estimates of abortion in India vary from 4 to 6 million but the majority of abortions are not reported. The majority of terminations are performed in the first trimester but about 10% are performed in the second trimester. Unsafe abortion is one of the major causes of maternal mortality. To make abortion safe and accessible to Indian women, guidelines have been developed by the Government of India, the Federation of Obstetricians and

Gynecologists of India (FOGSI), and the Indian College of Obstetrics and Gynecology (ICOG), governing all aspects of termination of pregnancy. Thorough knowledge of the guidelines, the methods available for termination of pregnancy, and the evidence-based guidelines for the choice of method is essential for the practicing obstetrician.

Definition and terminology

Abortion is the termination of pregnancy before the period of viability. The cut off as defined by WHO is gestational age before 20 weeks and fetal weight <500 g.

The terms used for abortion or termination of pregnancy are as follows:

- *Miscarriage*: Spontaneous abortion
- *Induced abortion*: Termination of pregnancy by medical or surgical methods.
 - *Therapeutic abortion*: Induced abortion for medical indications
 - *Elective abortion*: Induced abortion at the request of woman, not for medical reasons
 - *Medical termination of pregnancy* (MTP): Induced abortion for indications described under the MTP Act

The Medical Termination of Pregnancy Act

The **Medical Termination of Pregnancy** (MTP) Act, formulated in 1971 by the Government of India, was aimed at improving maternal health by preventing unsafe abortions, legalizing abortion services, and promoting access to safe abortion services for women. An amended act with some changes was passed in 2002. The act clearly defines

- indications for MTP,
- persons who are qualified to perform the procedure, and
- place of implementation of MTP.

Indications

- Continuation of pregnancy constitutes risk to the life or grave injury to the physical or mental health of the woman.
- Substantial risk of physical or mental abnormalities in the fetus as to render it seriously handicapped.
- Pregnancy caused by rape (presumed grave injury to mental health).
- Contraceptive failure in married couple (presumed grave injury to mental health).

Gestational age

- Can be performed up to 20 weeks' gestation.
- If <12 weeks, opinion of one medical practitioner is required before proceeding.

- If 12–20 weeks, opinion of two medical practitioners is required before proceeding.

Consent

- Consent of the pregnant woman is essential.
- If the girl is a minor (<18 years) or mentally ill, consent of the guardian is essential.

Place where it can be performed

- Hospital established or maintained by the government.
- A place that has been approved for this purpose by the District Level Committee constituted by the government, with the Chief Medical Officer or the District Health Officer as chairperson.

Persons qualified to perform MTP

- Registered medical practitioner
- Person whose name is with recognized medical qualification
- Person whose name is entered in State Medical Register
- Person with experience in gynecology and obstetrics

Preprocedure preparations

Before embarking on an MTP, a through history, examination, evaluation, and counseling are essential (Box 13.1).

Ultrasonography

Ultrasonography is not mandatory before performing the procedure. If the woman has regular menstrual cycles, she is sure of dates and if the uterine size corresponds to the period of gestation, menstrual date is acceptable.

When in doubt about the presence of pregnancy or the gestational age, ultrasonography is useful for the confirmation and assessment of the pregnancy.

Box 13.1 Preprocedure preparations for medical termination of pregnancy

- History
 - LMP
 - Medical illnesses
- Clinical examination
- Assessment of gestational age
 - LMP
 - Clinical examination
 - Ultrasonography if required or in doubt
- Counseling
 - Procedures available
 - Complications
 - Subsequent contraception/sterilization
- Investigations
 - Hemoglobin and hematocrit
 - Blood group and Rh type
 - HIV/Hepatitis B surface antigen screening
 - Urine sugar/protein
- Informed consent

human immunodeficiency virus; P last menstrual period.

Antibiotic prophylaxis

Antibiotic prophylaxis is recommended for surgical abortions since randomized trials have shown that it significantly reduces the frequency of postabortal endometritis. The antibiotics are given on the day of the procedure.

Options include the following:

- Doxycycline 100 µg orally twice a day
or
- Ofloxacin oral 400 µg orally twice a day
or
- Ceftriaxone 1 g intravenously 30 minutes prior to the procedure

Rh immunoglobulin

Rh typing should be done for all women undergoing MTP. If the mother is Rh negative, Rh immunoglobulin should be administered at the following dosage:

- 50 µg, if gestational age <12 weeks
- 300 µg, if gestational age >12 weeks

Contraceptive advice

Women who are undergoing an MTP should be given contraceptive advice to avoid another

unintended pregnancy. Contraceptive choices should be discussed prior to the procedure with all women. The type of contraception offered depends on the woman's preference.

- Tubectomy can be performed along with surgical termination or following medical termination, for women who have completed their family.
- Immediate postabortal insertion of intrauterine devices is safe and practical and is recommended by the WHO and the American College of Obstetricians and Gynecologists (ACOG). Expulsion rate is slightly higher and women should be counseled regarding this.
- Prescription for oral contraceptives should be given at the time of discharge from hospital.

Methods of MTP

Methods of termination of pregnancy used in the first trimester are different from those used in the second trimester. In the first trimester, the fetal bony structures are not formed; therefore, removing the products of conception vaginally is not difficult.

Methods of MTP in the first trimester

Methods used for MTP in the first trimester include medical and surgical methods.

Medical methods

Termination of pregnancy by medical methods is very safe and effective and is the method of choice in the first trimester. It has a success rate of 95%–99%. Three drugs are used for this purpose (Box 13.2). Prophylactic antibiotics are not required for termination of pregnancy using medical methods.

The recommended dosage of mifepristone and misoprostol is given in Box 13.3. It may be administered by the clinician or self-administered at home by the patient.

Misoprostol is associated with diarrhea, nausea and vomiting, and occasionally fever (lasting less than 24 hours). The vaginal route is more effective and is usually preferred. The dose of 800 µg may be administered as a single dose or as two divided doses 4 to 6 hours apart.

Box 13.2 Drugs used for termination in the first trimester

- Mifepristone
 - Antiprogestin
 - Acts by
 - decidua degeneration
 - release of prostaglandins
 - Induces uterine contractions
 - Softens the cervix
- Misoprostol
 - Prostaglandin E₁
 - Induces uterine contractions
- Methotrexate
 - Folic acid antagonist
 - Causes trophoblastic degeneration

Box 13.3 Dosage regimen for mifepristone and misoprostol

- Mifepristone 200 µg oral
- Followed 36–48 hours later by
 - Misoprostol 800 µg vaginal or 400 µg oral

Procedure

The procedure of medical termination includes the following steps:

- Preprocedure assessment and counseling
- Administration of oral mifepristone
- Instructions regarding misoprostol administration at home/clinic
- Oral or parenteral nonsteroidal anti-inflammatory agents (NSAIDs) for pain/cramping
- Prophylactic antibiotics not indicated

- Repeat visit 2 weeks after first visit to ensure complete abortion by history, pelvic examination, and ultrasonography, if necessary.
- If the pregnancy is ongoing, surgical evacuation is indicated; if the abortion is incomplete, repeat misoprostol or proceed with surgical evacuation.

Other medications

Misoprostol with or without methotrexate can also be used.

Misoprostol alone

This is less effective than when used with mifepristone. It may be used alone where mifepristone is not available.

Methotrexate and misoprostol

Methotrexate (75 µg oral or 50 µg/m² IM) followed by 800 µg of misoprostol 5–7 days later is also used. This regimen is less efficacious and termination may take longer.

Complications

Medical methods of termination of pregnancy are associated with very few complications. Complications and their management are listed in Table 13.1. Rarely, if pregnancy continues, termination by surgical methods is recommended because of the risk of teratogenic effects of the drugs. Occasionally, an ectopic pregnancy is diagnosed after medical methods have been tried with the assumption of an intrauterine pregnancy. This should be managed surgically.

Table 13.1 Complications and management of MTP

Complications	Management
Side effects of drugs Nausea, vomiting, diarrhea, headache, dizziness	Symptomatic treatment
Abdominal pain, cramps	NSAIDs
Excessive bleeding	Exclude incomplete abortion
Incomplete abortion	Repeat misoprostol/MVA
Ongoing pregnancy	Surgical methods of termination
Fever and infection	Antibiotics
Ectopic pregnancy	Surgical intervention

P, medical termination of pregnancy; A, manual vacuum aspiration; SA Ds, nonsteroidal anti-inflammatory drugs.

Outcome

Success of medical methods in the first trimester is 95%–98%. About 5% of women expel with mifepristone alone, before misoprostol administration.

Surgical methods

Surgical methods used for first trimester pregnancy termination are listed in Box 13.4.

Manual vacuum aspiration

In very early pregnancy, manual vacuum aspiration (MVA) may be used. It is also used to evacuate the uterus in an incomplete abortion following medical termination.

- Manual vacuum aspiration is an outpatient procedure.
- It is performed up to 10 weeks' gestation.
- Prophylactic antibiotics are not recommended.
- The equipment consists of a handheld 50–60 mL plastic syringe in which a vacuum is created by withdrawing the plunger. The syringe is connected to a Karman cannula (6–8 mm size) (Fig. 13.1).

Box 13.4 Surgical methods of MTP used in the first trimester

- Manual vacuum aspiration
- Electric vacuum aspiration or suction evacuation
- Dilatation and evacuation

P medical termination of pregnancy.



a.

- The procedure is performed under paracervical block.
- The cannula is inserted into the uterine cavity and moved in and out and rotated through 360 degrees simultaneously till the products are completely aspirated.
- The aspirated products are placed in a bowl of saline and the blood clots washed away. If fetal membranes or fronds of villi are seen, histopathological examination is not required.
- If products of conception are not visualized, the procedure should be repeated. In the absence of intrauterine products of conception, an ectopic pregnancy should be excluded.

Electric vacuum aspiration

Electric vacuum aspiration (EVA) is usually referred to as *suction evacuation*. This can be performed anytime in the first trimester and is also used to evacuate vesicular mole, incomplete abortion, and missed abortion. If the pregnancy is beyond 7 weeks, dilatation of the cervix is required.

Cervical dilatation

Dilatation of the cervix is required in order to insert the suction cannula. This may be achieved by the following:

- Manual dilatation with metal dilators
- Osmotic dilators—laminaria tent
- Vaginal misoprostol

Manual dilatation is done just before the procedure, using Hegar's dilators (Fig. 13.2). The diameter of the dilator in millimeters should be



b.

Figure 13.1 Manual vacuum aspirator and Karman cannula. **a.** The syringe is used to create a vacuum to aspirate the products of conception and the cannula is introduced into the uterine cavity. **b.** The plunger of the aspiration syringe is withdrawn to create vacuum and cannula is connected to the syringe.



Figure 13.2 Hegar's dilators. Blunt-tipped Hegar's dilators of different sizes are used to dilate the cervix prior to curettage. *Photo courtesy:* Dr Rajnish Samal

equal to the gestational age in weeks (i.e., 8 mm dilator for 8 weeks' gestational age).

Osmotic dilators should be inserted 10–12 hours before the procedure. They absorb water and increase in diameter, dilating the cervix gradually.

Misoprostol at a dose of 400 µg can be used vaginally 12 and 6 hours before the procedure.

Procedure

- Manual vacuum aspiration is an inpatient procedure.
- A rigid plastic or metal cannula of size in millimeters equal to that of the gestational age in weeks is used. The cannula is connected to the electric suction device through polythene tubing (Fig. 13.3).



a.

- The procedure is performed under general or spinal anesthesia.
- After pelvic examination to assess the size of the uterus, a uterine sound is passed into the uterine cavity to measure the uterocervical length.
- The cannula is introduced just beyond the internal os and connected to suction.
- The cannula is rotated in both directions but not moved in and out. This minimizes the risk of perforation.
- Intravenous ergometrine is given to promote uterine contraction and reduce bleeding.
- After completion of aspiration, a gentle check curettage is performed with a metal curette (Fig. 13.4). When the uterus is empty, a gritty sensation is felt while curetting.



Figure 13.4 Uterine curette. Blunt and sharp curettes used for curetting the uterine cavity. *Photo courtesy:* Dr. Rajnish Samal



b.

Figure 13.3 Metal cannula for suction evacuation and electric suction. **a.** Metal cannula used for aspiration of products of conception for dilatation and evacuation. *Photo courtesy:* Dr Rajnish Samal **b.** Electric suction apparatus used for creating suction.

Dilatation and evacuation

In this procedure, dilatation of the cervix is followed by evacuation of the products using ovum forceps and finally curettage using a metal curette. Dilatation of the cervix may be achieved using one of the methods described earlier. Ovum forceps can be used to remove large chunks of products (Fig. 13.5). The cavity



Figure 13.5 Ovum forceps. The tip of the ovum forceps is shaped like a spoon to grasp and remove products of conception. *Photo courtesy:* Dr. Rajnish Samal

is then gently curetted with the largest metal curette that can be passed through the dilated cervix. This procedure has a higher risk of perforation and therefore has been replaced by suction evacuation.

Complications

Complications with surgical methods are uncommon. These are listed in Table 13.2.

Outcome

MVA and EVA are successful in 98%–100% of cases.

Advantages and disadvantages of medical versus surgical methods of abortion

These are listed in Table 13.3. In the first trimester, both methods have equal success rate and acceptability. Since medical abortion does not necessitate admission to hospital, anesthesia, and antibiotics, and the cost is low, it is recommended as the first choice.

Table 13.2 Complications of surgical methods

Complications	Prevention	Management
Hemorrhage	Ergometrine IM/IV	Ergometrine/PGF _{2α}
Cervical laceration	Dilatation with laminaria/misoprostol	Observation/suture
Uterine perforation	Meticulous surgical technique	Observation/laparoscopy
Incomplete abortion	Thorough curettage	Repeat evacuation
Endometritis, sepsis	Prophylactic antibiotics	Antibiotics
Ectopic pregnancy	Confirm intrauterine pregnancy before procedure	Surgical intervention

, intramuscular; , intravenous; P α, prostaglandin F_{2α}.

Table 13.3 Medical versus surgical methods of termination of pregnancy

Parameter	Medical methods	Surgical methods
Hospitalization	Not required	Required except for MVA
Anesthesia	Not required	Required
Number of visits	Two or more	Single
Duration	Days to weeks	At single visit
Success rate	95%–98%	98%–100%
Bleeding	Perceived as moderate	Perceived as light
Follow-up	Required to ensure completion	Not routinely required

A manual vacuum aspiration.

Methods of termination of pregnancy in the second trimester

Termination of pregnancy in the second trimester is technically more difficult and has a higher rate of complications. The usual indications are as follows:

- Diagnosis of pregnancy has been delayed
- Maternal illness (e.g., malignancy)
- Fetal anomalies—congenital, chromosomal
- Intrauterine death of the fetus

Medical methods using mifepristone and misoprostol or dilatation and evacuation (D&E) are the preferred methods. The patient must be hospitalized for both medical and surgical procedures.

The methods used are as follows:

- Medical methods
- Intra-amniotic/extramnionic instillation of substances
- Surgical methods

Medical methods

Termination of pregnancy using medications is the method of choice. The medications used are listed in Box 13.5. Prostaglandin F_{2α}, which was popular earlier, is associated with nausea, vomiting, and other systemic side effects. Hence, it is no longer recommended for MTP.

Mifepristone and misoprostol

The combination of mifepristone and misoprostol is the recommended medical method of termination. The dosage is given in Box 13.6.

Outcome

The success rate with mifepristone and misoprostol is 95%.

Box 13.5 Drugs used for second trimester MTP

- Mifepristone
- Misoprostol
- Oxytocin

P medical termination of pregnancy.

Box 13.6 Dosage regimen for mifepristone and misoprostol in second trimester MTP

- Mifepristone 200 µg oral
- Followed 36–48 hours later by misoprostol 800 µg vaginal
 - Followed 3 hours later by misoprostol 400 µg oral/vaginal
 - Repeated every 3 hours
 - Maximum of 5 doses

P medical termination of pregnancy.

Complications

These are listed in Table 13.4.

Oxytocin

Oxytocin infusion with progressively and gradually increasing concentrations (from 50 units to 300 units in 500 mL of normal saline) has been used. This is preceded by cervical dilatation using misoprostol or osmotic dilators for better efficacy. Oxytocin infusion is not a routine method of choice. This is used only when mifepristone or misoprostol are not available.

Extra-amniotic injection of ethacridine

Extra-amniotic injection of ethacridine stimulates uterine contractions directly and by releasing prostaglandins from the decidua.

Ethacridine lactate

Ethacridine lactate is an aromatic organic compound. Extra-amniotic instillation of ethacridine

Table 13.4 Complications of medical methods of termination in the second trimester

Complication	Management
Incomplete abortion Retained placenta	Dilatation and curettage
Uterine rupture	Surgical intervention
Cervical laceration	Surgical intervention
Infection	Antibiotics
Hemorrhage	<ul style="list-style-type: none"> • Oxytocics/ blood transfusion • Exclude incomplete abortion

Box 13.7 Ethacridine lactate in second trimester MTP

- Aromatic organic compound
- Instilled into extra-amniotic space for midtrimester abortion
- Dosage
 - 0.1% solution
 - 10 mL/week of gestation, maximum 150 mL
- Action
 - Local release of prostaglandin
 - Stimulates uterine contractions

P medical termination of pregnancy.

for midtrimester abortion has been well studied and its safety has been established (Box 13.7).

roce ure

- A Foley's catheter (14–16 F size) is introduced through the cervix into the extra-amniotic space (Fig. 13.6).
- The bulb is inflated with 10 mL of saline and pulled down to occlude the cervix.

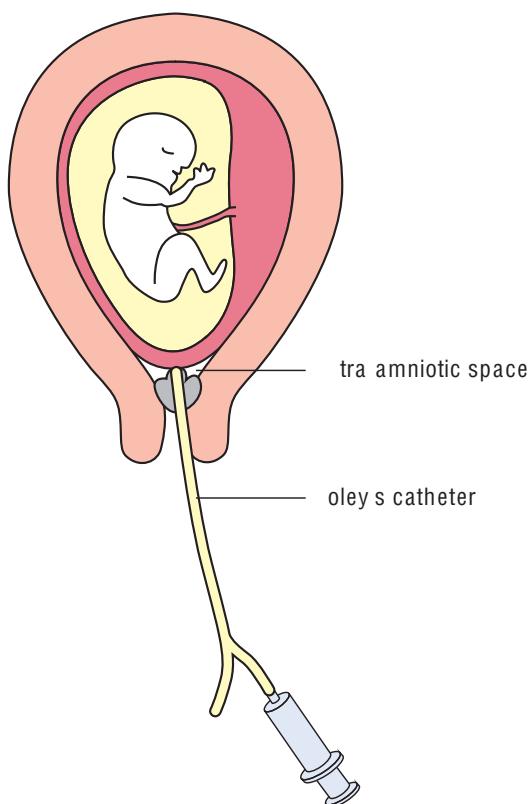


Figure 13.6 Extra-amniotic instillation. A Foley's catheter is introduced into the extra-amniotic space and the bulb is inflated. Ethacridine lactate is instilled through the catheter.

- Ethacridine lactate is injected through the catheter.
- The Foley's catheter is clamped, left in situ, and is removed after 8 hours.

The induction-abortion interval is usually 24–36 hours. This interval can be shortened by the additional use of vaginal misoprostol.

Intra-amniotic instillation of substances

Hypertonic saline and hyperosmolar urea are used for this purpose (Box 13.8). A needle is inserted into the uterine (amniotic) cavity transabdominally (Fig. 13.7). A small quantity of amniotic fluid is initially aspirated. Hypertonic saline or urea is then instilled slowly at the rate of 10 mL/min. The induction-abortion interval with saline is 28–36 hours. Using urea along with PGF_{2α}, reduces the interval to 15–20 hours.

Instillation methods are not frequently used at present, largely because alternative methods, including prostaglandins and surgical options, have fewer side effects, lower risk of complications, and shorter induction-abortion intervals.

Box 13.8 Intra-amniotic instillation of substances for second trimester MTP

- Hypertonic (200%) saline
 - Dosage
 - 10 mL/week of gestation
 - Slow instillation at the rate of 10 mL/min
 - Contraindications
 - Cardiac disease
 - Renal disease
 - Complications
 - Hypernatremia
 - Pulmonary edema
 - Infection
 - Disseminated intravascular coagulation
- Hyperosmolar (40%) urea
 - Dosage
 - 80 g in 200 mL of distilled water
 - Used along with low-dose PGF_{2α} (intra-amniotic)
 - Complications minimal
 - Superior to saline

P medical termination of pregnancy; P_{2α} prostaglandin F_{2α}.

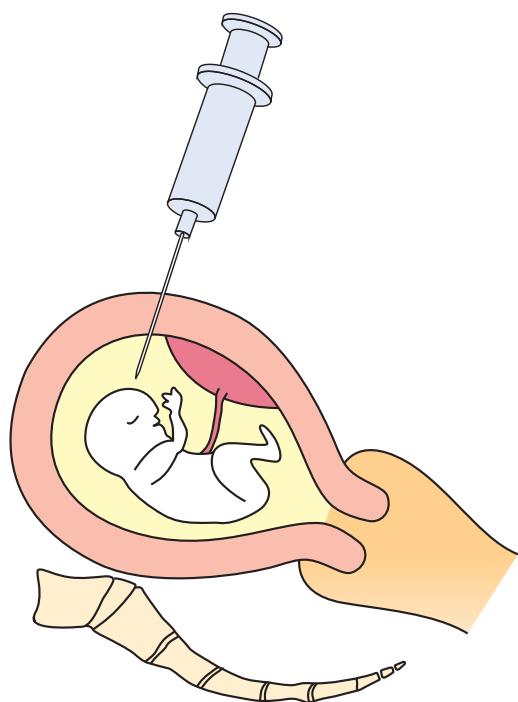


Figure 13.7 Transabdominal instillation. Needle is introduced into the amniotic cavity transabdominally and saline or urea is instilled.

Surgical methods

Surgical methods include the following:

- Dilatation and evacuation
- Dilatation and extraction
- Hysterotomy

Dilatation and evacuation (D & E)

- This procedure is usually performed up to 16 weeks' gestation though this was used up to 20 weeks earlier.
- It is not often used now since prostaglandins are very effective.
- Spinal or general anesthesia is required.
- Prophylactic antibiotic should be given.
- Cervix should be dilated prior to the procedure with osmotic dilators. Misoprostol may also be used but osmotic dilators are preferred.
- Further dilatation to 16–18 mm with metal dilators may be required.
- Fetus is removed by large bore suction cannula (size 16–18 mm).
- Fetal extraction forceps may be used to crush and disarticulate fetal parts.

- Fetus and placenta are removed.
- Intravenous ergometrine or oxytocin infusion may be used to promote uterine contraction, reduce bleeding, and reduce the risk of perforation during curettage.
- Cavity is curetted to complete the procedure.

Dilatation and extraction (D & E)

The fetus is removed intact through a dilated cervix using fetal extraction forceps. This procedure has been replaced by medical methods.

Hysterotomy

Delivering the preivable fetus through an incision on the uterus is known as hysterotomy. A transverse incision is made on the lower part of the uterus. If the woman has opted for a concomitant tubectomy, a vertical incision on the upper segment may be used. A hysterotomy may have to be resorted to in cases where medical methods fail.

Complications of surgical methods

The complications of surgical methods used in the second trimester are listed in Box 13.9.

Box 13.9 Complications of surgical methods of second trimester MTP

- Cervical laceration
- Uterine perforation
- Hemorrhage
- Infection
- Incomplete abortion
- Late sequelae
 - Due to cervical lacerations
 - Recurrent abortions
 - Preterm labor
 - Due to infection
 - Infertility due to tubal block
 - Ectopic pregnancy
 - Chronic pelvic pain
 - Psychological
 - Depression
 - Anxiety
 - Feeling of guilt

Key points

- Abortion is the termination of pregnancy before the period of viability (<20 weeks' gestation, <500 g fetal weight). Termination of pregnancy by medical or surgical means for specific and social indications is known as *medical termination of pregnancy*.
- The Medical Termination of Pregnancy (MTP) Act, 1971, defines the indications, places of implementation, and persons qualified to perform the procedure.
- An MTP may be performed in the first or second trimester. First trimester termination is technically simpler and associated with fewer complications.
- Preprocedure preparations consist of history, especially last menstrual period, assessment of gestational age clinically, ultrasonography when required, counseling, and a few investigations.
- Antibiotic prophylaxis is recommended for all surgical procedures.
- Methods used in the first trimester are medical and surgical. A combination of mifepristone and misoprostol is the medical method of choice.
- Manual vacuum aspiration, suction evacuation, and dilatation and curettage are the surgical methods used in the first trimester.
- Medical termination of pregnancy in the second trimester is technically more difficult and has more complications.
- Mifepristone and misoprostol have a high success rate in the second trimester as well.
- Extra-amniotic instillation of ethacridine lactate is a safe and effective procedure.
- Complications of MTP in the first and the second trimester include hemorrhage, incomplete abortion, and infection. Late sequelae are due to cervical injury and pelvic infection.

Self-Assessment

Case-based questions

Case 1

Mrs. AD, 34, mother of two children, came to the clinic with history of having missed her periods. Her last child was 2 years old and she had an intrauterine contraceptive inserted 2 months after delivery. Her menstrual periods had always been regular. A pregnancy test done at home was positive. She wanted termination of pregnancy.

1. What is the indication for MTP in this woman?
2. What is the MTP Act?
3. What counseling would you give this woman?
4. If the gestational age was 9 weeks, what method of termination would you recommend?

Case 2

Mrs. SN, 30, second gravida, was diagnosed as having an anencephalic fetus at 16 weeks' gestation.

1. How will you terminate this pregnancy?
2. What complications do you anticipate?
3. If she presented with retained placenta and bleeding, what is the management?

Answers

Case 1

1. The indication is failure of contraception.
2. The MTP Act was formulated by the Government of India to provide guidelines regarding the indications

for MTP, persons who can perform it, and places where it can be performed. It is meant for making abortions safer.

3. Counseling regarding (a) procedure, (b) complications, and (c) permanent method of contraception.
4. Mifepristone 200 µg orally followed 36–48 hours later by misoprostol 800 µg vaginally.

Case 2

1. Mifepristone 200 µg orally followed by misoprostol 800 µg vaginally, followed by 400 µg of misoprostol orally every 3 hours up to a maximum of 5 doses.
2. Excessive bleeding, retained placenta, incomplete abortion, infection, and cervical laceration.
3. Prophylactic antibiotics followed by suction evacuation or D&E.

Sample questions

Long-answer question

1. What is medical termination of pregnancy (abortion)? What are the indications and procedures used in the first and second trimesters?

Short-answer questions

1. Methods used for first trimester MTP
2. The MTP Act
3. Complications of MTP
4. Methods used in second trimester MTP

Section 3

Intrapartum Management

14

Normal Labor: Mechanics, Mechanism, and Stages

Case scenario

Mrs. PS, 27, primigravida, was admitted to the labor room at 40 weeks' and 3 days' gestation with blood-stained discharge and uterine contractions. Her husband was very anxious since this was the first delivery. He wanted to know why she had the vaginal discharge, how long she would be in labor, when the delivery was expected, and if all was well.

Introduction

Normal labor is considered to be a retrospective diagnosis since no one can predict the course and complications of labor in a particular individual. While the fetus passes through the birth canal and is born, it has to go through a complicated but well-orchestrated sequence of movements, the uterus has to contract and the cervix has to dilate. There are several factors that facilitate the process of labor.

Definition

Labor is the process by which the fetus, after the period of viability, is expelled from the genital tract. The World Health Organization (WHO) defines *normal labor* as 'spontaneous in onset, low-risk at the start of labor and remaining so

throughout labor and delivery. The infant is born spontaneously in the vertex position between 37 and 42 completed weeks of pregnancy. After birth, the mother and infant are in good condition' (Box 14.1). There is no absolute time cutoff, though an arbitrary duration of 24 hours is considered normal. *Preterm labor* is the onset of labor before 37 weeks' gestation.

Box 14.1 Definition of normal labor

The following criteria should be met to classify labor as being normal.

- Spontaneous in onset
- Term gestation: 37–42 weeks
- Vertex presentation
- Uncomplicated
- Natural expulsive forces
- Vaginal delivery

Mechanics of labor

Uterine contractions act during labor to achieve both cervical dilatation as well as the expulsion of the fetus through the birth canal. To achieve this, normal progress of labor depends on the complex interaction of three factors known as the 'three Ps': passage, passenger, and powers. Abnormality in any of these can lead to abnormal labor.

Passage

The fetal passage consists of the bony pelvis and soft tissues. These are listed in Box 14.2. The gynecoid pelvis and its dimensions are described in Chapter 2, *Anatomy of the bony pelvis and fetal skull*. Shape and diameters of the true pelvis are usually assessed by clinical pelvimetry. X-ray, computerized tomography (CT), and magnetic resonance imaging (MRI) are rarely used to perform pelvimetry.

The soft tissues (i.e., cervix and pelvic muscles) undergo changes over several weeks before the onset of labor. With uterine contractions, the lower uterine segment is formed, the cervix effaces and dilates, and the vagina distends and stretches, as described later. The fetus is gradually pushed down into the lower segment, through the dilated cervix into the vagina, and delivered. Pelvic muscles offer resistance that aid inflexion and rotation of the presenting part in the first and second stages of labor.

Passenger (fetus)

The fetus contributes several factors that play a crucial role in the mechanics of labor and lead to successful delivery (Table 14.1).

Box 14.2 Fetal passage

- Bony pelvis
 - Inlet
 - Midpelvis
 - Outlet
- Soft tissues
 - Lower uterine segment
 - Cervix
 - Vagina
 - Pelvic muscles

Table 14.1 Fetal factors influencing labor

	Favorable	Unfavorable
Lie	Longitudinal	<ul style="list-style-type: none"> • Transverse • Oblique
Presentation	Vertex	<ul style="list-style-type: none"> • Face • Brow • Breech
Position	LOA	ROP
Attitude	Flexion	<ul style="list-style-type: none"> • Deflection • Extension
Station	0 and below	Above 0
Fetal size	2–3.5 kg	>4 kg

A, left occipitoanterior; P, right occipitoposterior.

Fetal factors indicating the best prognosis for successful vaginal delivery include the following:

- Average weight
- Longitudinal lie
- Vertex presentation
- Well-flexed attitude
- Left occipitoanterior position

Fetal factors indicating poor prognosis for successful vaginal delivery are as follows:

- Fetal weight >4 kg
- Deflexed head
- Occipitoposterior positions
- Malpresentations such as breech, brow, and face

Powers

Powers (uterine contraction)

Uterine contraction is the most important force that contributes to the progress of labor. Hydrostatic pressure exerted by the amniotic fluid also helps in cervical dilatation. Uterine contractions are intermittent, with periods of relaxation in between, which permit uteroplacental perfusion. The *interval* between contractions (measured in minutes) gradually decreases and the *intensity* of contractions (measured in Montevideo units) gradually increases. Three to five contractions in 10 minutes is considered normal and adequate during active labor (Table 14.2). More than five contractions in 10 minutes is called *tachysystole*.

Table 14.2 Uterine contractions

Phase of labor	Contraction		Intensity
	Duration (seconds)	Interval (minutes)	
Latent phase	20–30	5–10	
Active phase	30–60	2–3	200–250 MVU
Second stage	60–90	1–2	

montevideo units.

Assessment of uterine contractions is discussed in Chapter 40, *Abnormal labor: abnormalities in passage and powers*. Uterine contractions are usually assessed by simple palpation of the abdomen. During the peak of contraction, fingers cannot ‘indent’ the uterus. External tocography is a non-invasive method of assessing uterine contractions and often used along with external fetal heart monitoring. Intra-amniotic pressure during contractions, as measured by intrauterine pressure catheter, is 20–60 mm Hg (mean—40 mm Hg). The strength of uterine contractions is expressed in Montevideo units (MVU). MVU is calculated by the average strength of contraction in mm Hg × number of contractions in 10 minutes. It is 200–250 MVU in active phase of labor.

Formation of the upper and lower uterine segments

As pregnancy advances, the isthmus of the uterus stretches and becomes the lower uterine segment. As labor progresses, an **active upper segment** and **passive lower segment** become evident. The myometrium of the upper segment contracts but the muscle fibers do not return to their original length after contraction; instead they remain slightly shorter. Similarly, the muscle fibers of the lower segment stretch during contraction and do not return to their original length after contraction. They remain slightly longer or stretched (receptive relaxation). Gradually, a thick upper segment and a thinner lower segment are formed (Box 14.3; Fig. 14.1). The lower segment is identified by the loose attachment of the peritoneum on its anterior surface. The contents of the uterus are thus slowly pushed down into the lower segment and the cervix also dilates. **The boundary between**

Box 14.3 Uterine changes in labor

- Formation of upper uterine segment
 - Shortening of muscle fibers
 - Thickening of uterine segment
- Formation of lower uterine segment
 - Stretching of muscle fibers
 - Thinning of uterine segment
- Physiological retraction ring
 - Junction between upper and lower uterine segments
- Elongation of uterine ovoid
 - Increases fetal axis pressure
 - Helps in cervical effacement

the upper and lower segments of the uterus is the physiological retraction ring. In obstructed labor, this becomes the *pathological retraction ring or Band's ring* (see Chapter 44, *Obstructed labor and uterine rupture*).

As labor progresses, the uterus becomes more elongated. This increases the downward fetal axis pressure and also pulls the cervical fibers upward, resulting in cervical effacement.

Hydrostatic pressure of the amniotic fluid

With uterine contractions, there is an increase in the hydrostatic pressure of the amniotic fluid (Fig. 14.2). This in turn dilates the cervical canal and forms the bag of membranes that lies below the presenting part.

Mechanism of normal labor

Due to the irregular shape of the pelvis and the relatively large dimensions of a term fetal head, not all the diameters of the head will fit through all the diameters of the pelvis. The mechanisms of labor allow for changes in fetal position to be made throughout labor which allow the fetal head to be accommodated within the pelvic canal and ultimately facilitate delivery.

Towards term, the fetus assumes an attitude of universal flexion with the head well flexed and the chin almost touching the chest. Therefore, the normal presentation is vertex. The *occiput* may be on the *left* or *right* side of the pelvis, pointing *anteriorly*, *posteriorly*, or *laterally*, giving rise to left occipitoanterior (LOA), left

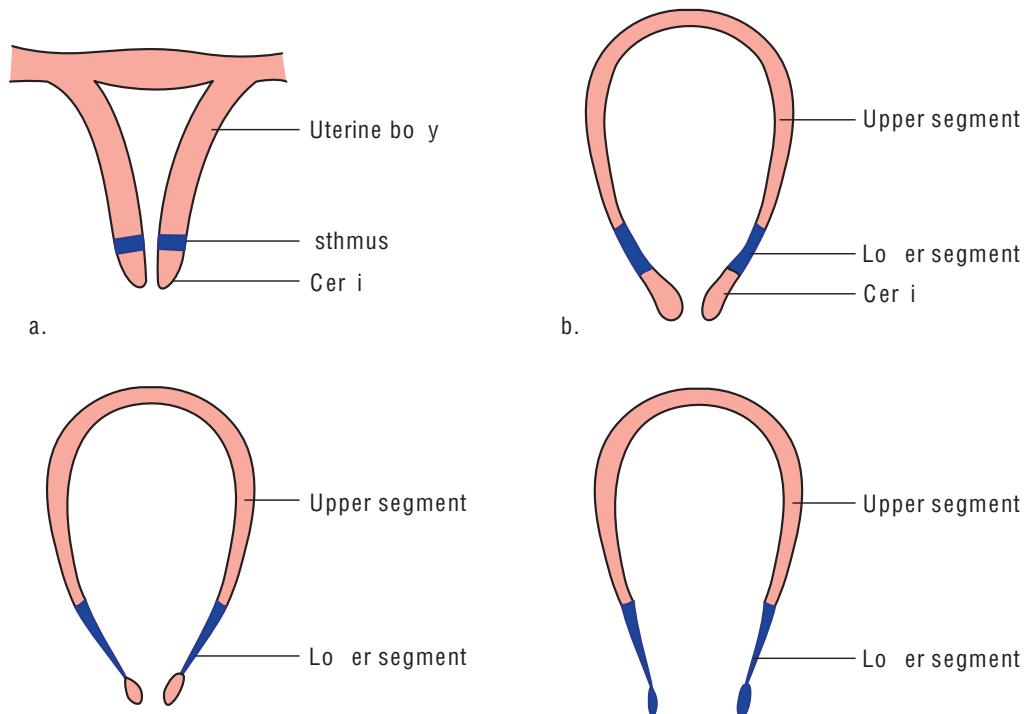


Figure 14.1 Formation of upper and lower segment. The isthmus of the uterus stretches as pregnancy advances and becomes the lower segment. **a.** Nonpregnant uterus. The isthmus is marked. **b.** Term pregnancy. **c** and **d.** Early and late labor. Lower segment is well differentiated as labor progresses.

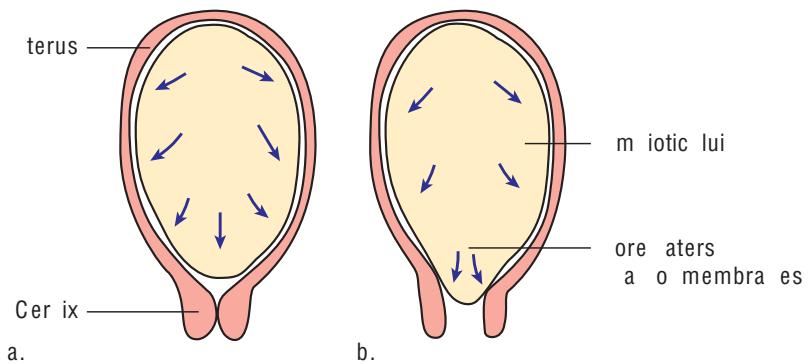


Figure 14.2 Increase in hydrostatic pressure and formation of bag of membranes. The hydrostatic pressure increases with uterine contractions. **a.** The pressure is directed downward. **b.** Bag of membranes is formed below the presenting part.

occipitoposterior (LOP), or left occipitotransverse (LOT) positions and right occipitoanterior (ROA), right occipitoposterior (ROP), or right occipitotransverse (ROT) positions (Fig. 14.3).

The transverse and oblique diameters are greater than the anteroposterior diameter at the pelvic inlet; the anteroposterior diameter is more than the transverse diameter at the pelvic outlet (see Chapter 2, *Anatomy of the bony pelvis and*

fetal skull). Therefore, the fetus has to enter the pelvis with the engaging diameter in the oblique or transverse diameter of the pelvis and rotate, so as to bring the largest diameter to lie in the anteroposterior diameter at the pelvic outlet. This is achieved by the *cardinal movements*, discussed below. The engaging diameter in the vertex presentation with a well-flexed head is the *suboccipitobregmatic diameter* (Fig. 14.4).

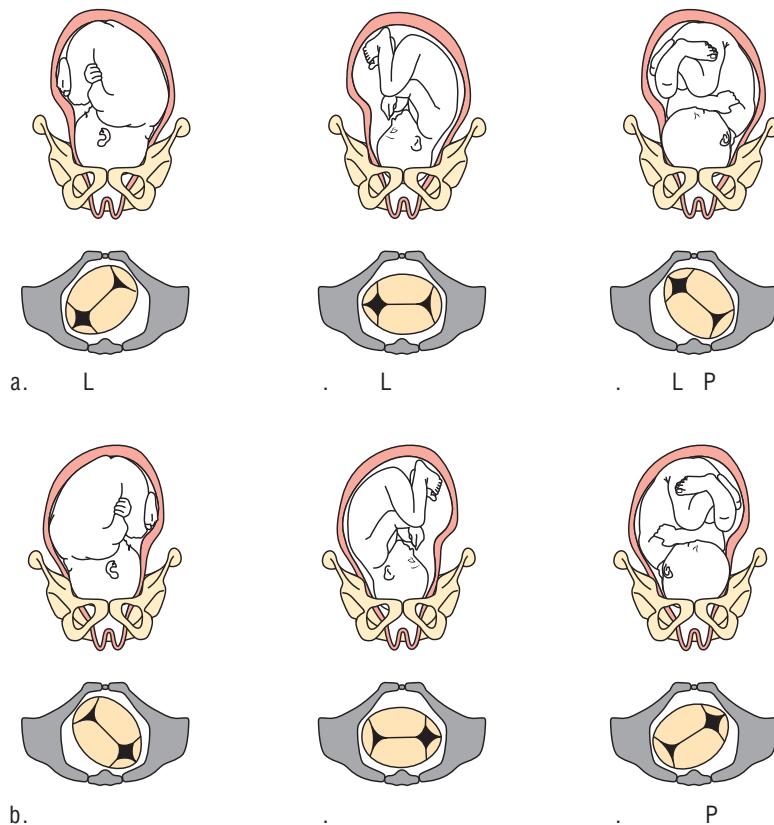


Figure 14.3 Positions of the fetal head in vertex presentation. The occiput may be on the left or right side of the pelvis, pointing anteriorly, laterally, or posteriorly, giving rise to **a.** left occipitoanterior (LOA), **b.** right occipitoanterior (ROA), **c.** left occipitotransverse (LOT), **d.** right occipitotransverse (ROT), **e.** left occipitoposterior (LOP), and **f.** right occipitoposterior (ROP) positions.

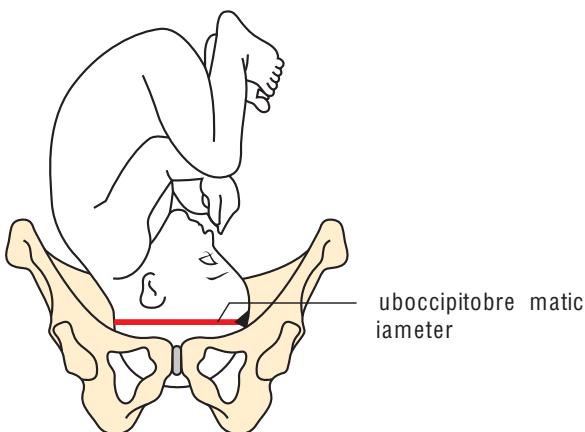


Figure 14.4 Suboccipitobregmatic diameter. This is the engaging diameter in vertex presentation with well-flexed head.

Vertex presentation with LOA or LOT position is the most common. When the fetus enters in the LOT position, rotation to LOA takes place soon after labor begins. LOA is the most common position, for the reasons given below (Box 14.4).

Box 14.4 Reasons for left occipitoanterior presentation

Longitudinal lie	Uterine ovoid longitudinal
Cephalic presentation	Bulky breech occupies broad upper pole of uterus
Vertex presentation	Attitude of universal flexion
Occipitoanterior position	Maternal abdominal wall accommodates fetal vertebral column
Left occipitoanterior position	Left oblique diameter of pelvis occupied by sigmoid colon

Cardinal movements of labor

The cardinal movements of labor help the fetus to successfully negotiate the birth canal.

The position of the fetal head rotates during its passage through the birth canal because of an asymmetry in both the shape of the fetal head and the maternal bony pelvis.

Seven distinct cardinal movements of the fetus occur over the course of labor and delivery (Box 14.5).

The following terms are important for understanding the cardinal movements:

- *Engaging diameter* is the anteroposterior diameter of the fetal skull that enters the pelvis.
- *Diameter of engagement* is the diameter of the pelvic inlet in which the engaging diameter lies.
- *Denominator* is the reference point on the fetal skull. It is the occiput in vertex presentation.

At the onset of labor, the following are the findings in an example of vertex presentation with LOA or LOT:

- Presentation: Vertex
- Attitude: Flexion
- Position: LOA/LOT
- Engaging diameter: Suboccipitobregmatic (9.4 cm)
- Denominator: Occiput
- Diameter of engagement: Right oblique/transverse diameter of pelvis

Box 14.5 Cardinal movements of labor

- Engagement
- Descent
- Flexion
- Internal rotation
- Extension
- Restitution
- External rotation
- Expulsion

On abdominal examination, the back of the fetus and the occiput are to the left and the sinciput is to the right of the midline. Vaginal examination reveals the sagittal suture in the right oblique or transverse diameter, posterior fontanel in the left anterior quadrant of the pelvis, and the anterior fontanel in the right posterior quadrant of the pelvis (see Fig. 14.3).

Engagement

When the greatest transverse diameter (biparietal diameter) of the fetal head passes through the pelvic inlet, the head is said to be engaged. The widest transverse diameter is the biparietal diameter (9.4 cm) in cephalic presentations (Fig. 14.5). The suboccipitobregmatic diameter is at the same level as the biparietal diameter; therefore, when the head is engaged, the occiput enters the pelvis and only the sinciput is felt per abdomen (head is one-fifth palpable). When the head is engaged, the leading bony point of the vertex is at or below the ischial spines. Engagement of the head implies that there is no disproportion at the level of the pelvic inlet (Box 14.6).

Box 14.6 Engagement

- Biparietal diameter enters pelvic inlet
- Implies no disproportion at inlet
- Occurs at
 - 38 weeks or later in primigravidae
 - Onset of labor in multigravidae
- Diagnosis
 - Abdominal examination
 - Head one-fifth palpable
 - Occiput not felt
 - Vaginal examination
 - Leading bony part of vertex at level of ischial spines

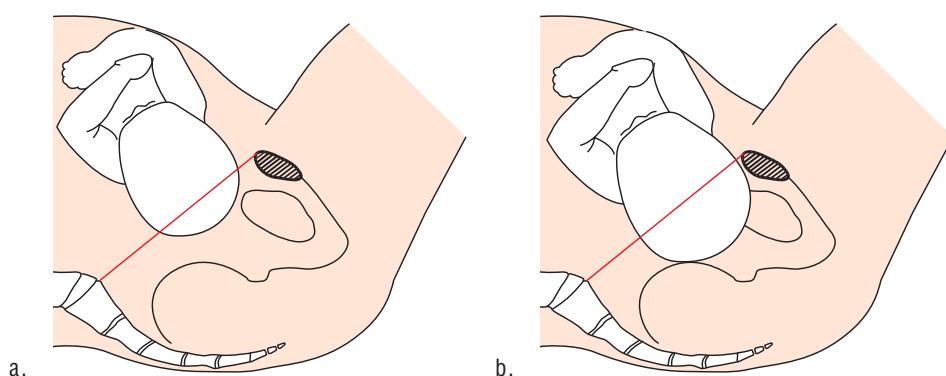


Figure 14.5 Engagement of the fetal head in vertex presentation. **a.** The biparietal diameter lies above the pelvic brim when the head is not engaged. **b.** The biparietal diameter is below the pelvic brim when the head is engaged.

In primigravidae, engagement may occur 2 weeks prior to the onset of labor (38 weeks) but often occurs at the onset of labor. In multigravidae, it usually occurs after the onset of labor.

Asynclitism

When the head enters the pelvis in the occipitotransverse position, the sagittal suture should lie in the transverse diameter of the pelvis, midway between the pubic symphysis and sacral promontory. But in order to negotiate the anteroposterior diameter of the inlet, the head tilts laterally and the *subparieto-supraparietal* diameter enters the pelvis. The sagittal suture is deflected anteriorly or posteriorly. When the suture is deflected toward the sacral promontory, the anterior parietal bone enters the pelvis: this is known as *anterior asynclitism*. When the suture is deflected toward the symphysis pubis, the posterior parietal bone enters the pelvis and is known as *posterior asynclitism* (Box 14.7; Fig. 14.6). In moderate degrees of asynclitism, labor progresses normally. When asynclitism is severe, dystocia can occur. Anterior parietal presentation (anterior asynclitism) has a better prognosis for successful vaginal delivery.

Descent

Descent of the fetus occurs with uterine contractions. In the second stage, bearing down efforts also contribute to fetal descent. Descent is assessed by abdominal examination and expressed in terms of 'fifths' of the fetal head palpable above the pubic symphysis (Crichton's maneuver). Five fingers of the examining hand are placed on the abdomen with the ulnar or radial border of the hand in line

Box 14.7 Asynclitism

- Head tilted to one side
- Sagittal suture deflected anteriorly or posteriorly
- Subparieto-supraparietal diameter enters anteroposterior diameter of pelvis
- Normal delivery occurs with moderate asynclitism
- Anterior asynclitism
 - Sagittal suture toward sacral promontory
 - Anterior parietal presentation
 - Better prognosis
- Posterior asynclitism
 - Sagittal suture toward pubic symphysis
 - Posterior parietal presentation

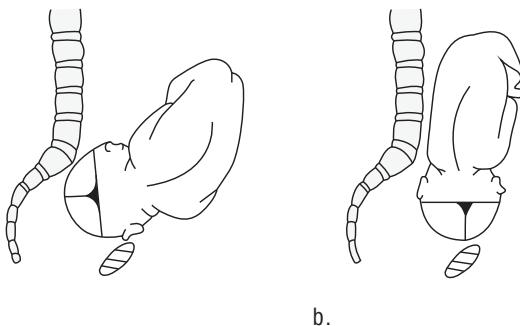


Figure 14.6 Asynclitism. **a.** Anterior asynclitism. When the sagittal suture of the fetal head deflects posteriorly, the anterior parietal bone enters the pelvis. **b.** Posterior asynclitism. When the sagittal suture deflects anteriorly, the posterior parietal bone enters the pelvis.

with the pubic symphysis (Fig. 14.7). The number of fingers required to cover the part of the head above the symphysis is equal to the number of fifths of head palpable. When the whole head is above the inlet, it is five-fifth palpable; as the head descends, it may be four-fifth, three-fifth, two-fifth, or one-fifth palpable. **When it is one-fifth palpable, only the sinciput is felt, the occiput has entered the pelvic brim, and the lowermost bony point of the head is at the level of the ischial spines; the head is engaged.**

Flexion

At the beginning of labor, when flexion is not complete, the engaging diameter (Fig. 14.8) is the occipitofrontal diameter (12 cm). **Flexion of the fetal head is essential to enable the smallest diameter, which is the suboccipitobregmatic (9.5 cm), to present.** With increasing flexion, the fetal chin touches the chest. Flexion is brought about by the resistance offered by (a) the cervix, (b) pelvic walls, and (c) the pelvic floor.

Internal rotation

Internal rotation brings the occiput toward the pubic symphysis and *aligns the suboccipitobregmatic diameter to the anteroposterior diameter of the pelvic cavity*. This is essential for normal delivery to occur. Rotation is through 45 degrees (one-eighth of a circle) in occipitoanterior positions. This movement is brought about by (a) the shape of the pelvis, (b) impetus given by the ischial spines, and (c) the shape and elastic recoil of the levatorani muscle. Internal rotation

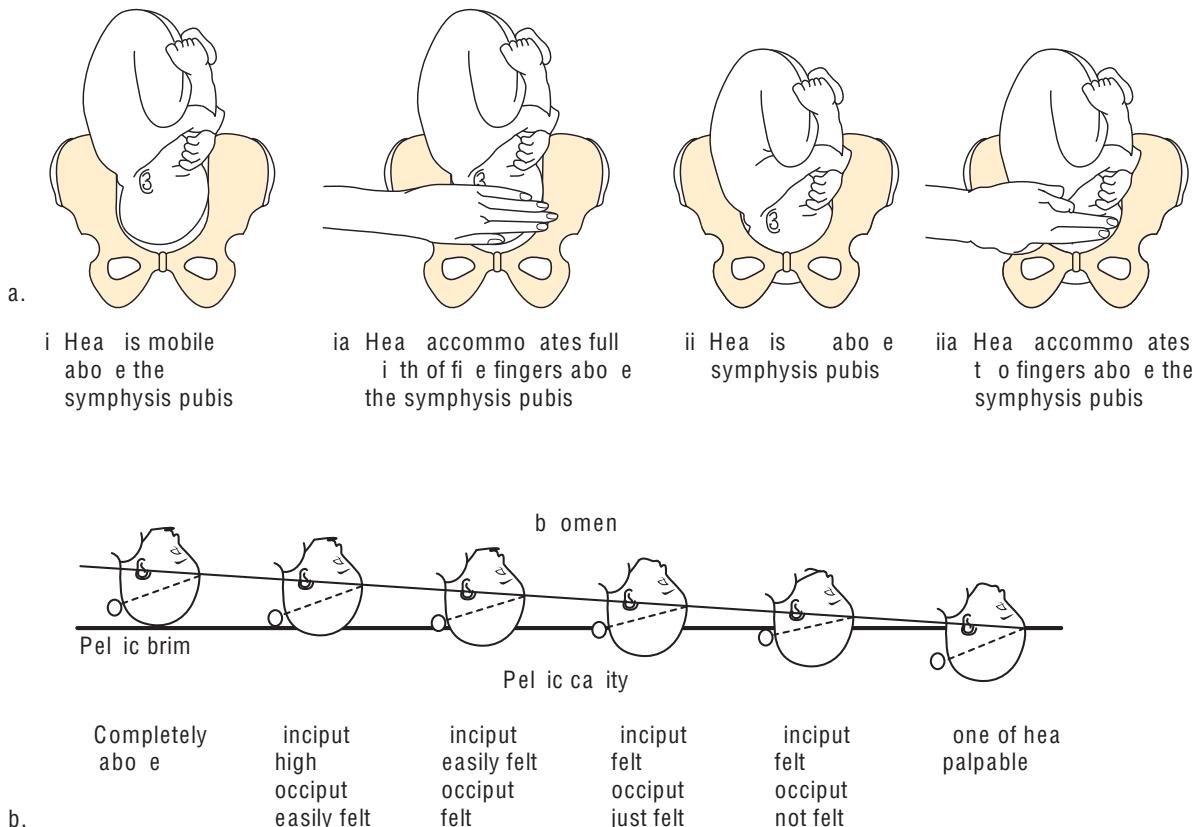


Figure 14.7 Descent of the presenting part. **a.** Five fingers of the examining hand are placed on the abdomen to cover the part of the fetal head that is above the pubic symphysis and the descent is expressed in fifths. When the whole head is above the brim, all five fingers are required to cover the head, it is five-fifth palpable. **b.** Diagrammatic representation of descent in fifths.

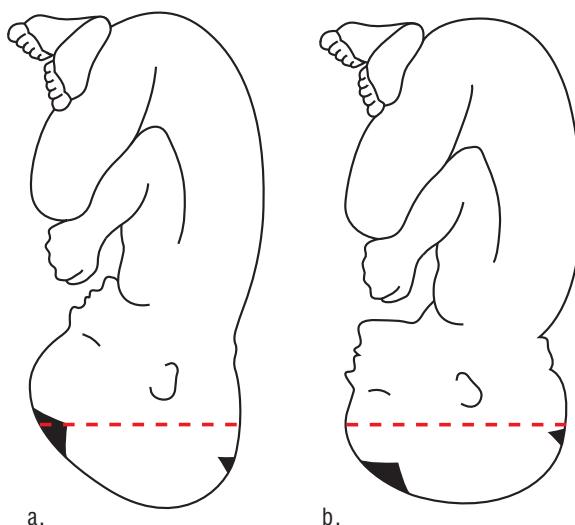


Figure 14.8 Flexion of the fetal head. **a.** When head is completely flexed, the engaging diameter changes to suboccipitobregmatic. **b.** When head is not fully flexed, the occipitofrontal diameter engages.

usually occurs at the level of the ischial spines but can occur at a lower level.

Extension

When the head reaches the outlet, the occiput hitches under the inferior margin of the symphysis pubis. The biparietal diameter stretches the vulval outlet. Since the pelvic canal curves anteriorly at this point, the head extends gradually and sequentially, the occiput, bregma, nose, mouth, and chin are born. Uterine contractions, maternal bearing down efforts, and force exerted by the levatorani are responsible for extension and delivery of the fetal head.

Restitution

The fetal head rotates back to the original position in a quick untwisting movement, in a

direction opposite to that of internal rotation. The occiput is directed toward the maternal thigh.

External rotation

The shoulders engage in the opposite (left) oblique diameter of the pelvis. The anterior shoulder rotates toward the pubic symphysis by 45 degrees. This causes external rotation of the head in the same direction in which restitution occurred.

Delivery of the shoulders

When the anterior shoulder rotates, the bisacromial diameter lies in the anteroposterior diameter of the pelvis. The anterior shoulder hitches under the pubic symphysis and the posterior shoulder distends the perineum and is born by lateroflexion of the spine. This is followed by delivery of the anterior shoulder.

Expulsion

With uterine contractions, delivery of the shoulders is followed by the delivery of the rest of the fetus.

Cardinal movements in mechanism of labor, how they occur, and what they achieve are summarized in Table 14.3 and Figure 14.9.

Stages of labor

Labor is a continuous process. However, it is divided into three stages to assist in clinical management. The stages of labor are described from the onset of regular contractions. However, preparatory changes take place for a few weeks prior to the onset of labor, described as 'prelabor' or 'preparatory stage of labor.'

Labor has three stages:

- First stage: Stage of dilatation
- Second stage: Stage of expulsion of the fetus
- Third stage: Stage of expulsion of placenta

The contraction and retraction of the uterus and the arrest of bleeding that follow delivery are also described as the *fourth stage* of labor. These extend for 1–2 hours after delivery. Postpartum hemorrhage due to uterine atony can occur during this phase; therefore, close monitoring is essential.

Preparatory stage or prelabor

This stage extends over a few days (see Chapter 6, *Physiology of labor*). This phase is mediated by estrogen, progesterone, prostaglandin, and other substances. During this period, changes occur in the genital tract in preparation for the onset of labor (Box 14.8).

Table 14.3 Cardinal movements of labor

Movement	What it achieves	How it is brought about
Engagement	Engaging diameter enters pelvic inlet	Uterine contractions
Descent	Downward movement of fetus	Uterine contractions
Flexion	Suboccipitobregmatic diameter presents	<ul style="list-style-type: none"> • Uterine contractions • Resistance by cervix, pelvic wall, pelvic floor
Internal rotation	Suboccipitobregmatic diameter comes to lie in AP diameter of pelvis	<ul style="list-style-type: none"> • Uterine contractions • Shape of pelvis, shape of levatorani muscle, elastic recoil
Extension	Delivery of fetal head	<ul style="list-style-type: none"> • Shape of birth canal, uterine contractions, force of levatorani • Maternal expulsive efforts
Restitution	Untwisting of fetal neck	Spontaneous
External rotation	Brings shoulders in AP diameter	Uterine contractions, shape of pelvis, shape of levator ani
Expulsion	Delivery of shoulders and whole fetus	Uterine contractions, maternal expulsive efforts

AP anteroposterior.

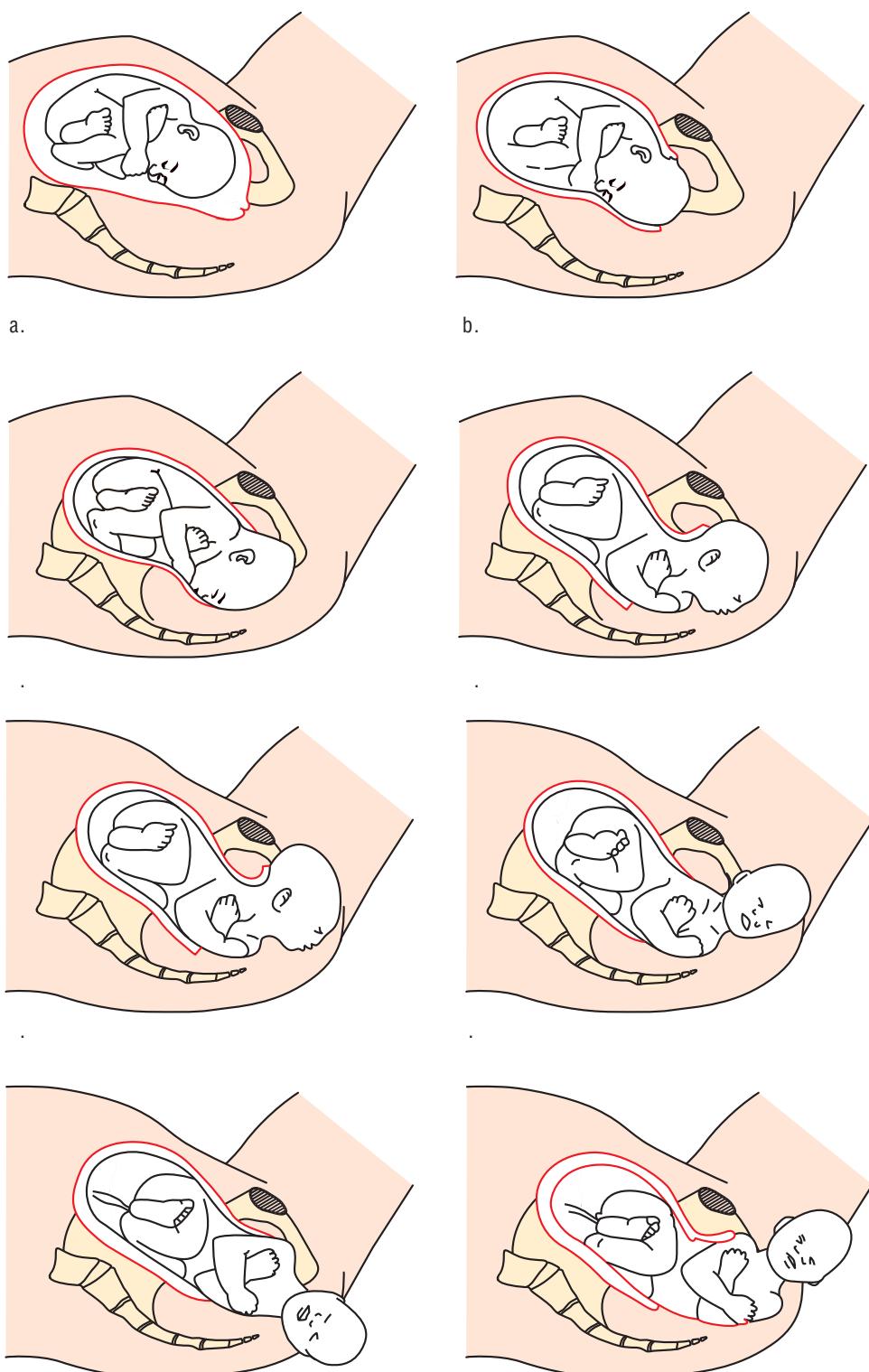


Figure 14.9 Cardinal movements of labor. The cardinal movements of **a.** engagement, **b.** flexion and descent, **c.** internal rotation, **d.** beginning of extension, **e.** complete extension and delivery of head, **f.** external rotation **g.** delivery of anterior shoulder, and **h.** delivery of posterior shoulder.

Box 14.8 Preparatory stage of labor

- Corresponds to activation phase of labor
- Changes
 - Falling forward of the uterus
 - Shelving
 - Lightening
 - Ripening (softening) of cervix
 - Increase in uterine contractility
- Mediated by
 - estrogen
 - progesterone
 - contraction-associated proteins
 - prostaglandins
 - MMP, GAGs
 - interleukin-8

A s, glycosaminoglycans; P, matrix metalloproteinases.

Falling forward of the uterus is due to the formation of the lower uterine segment and the head entering the pelvis. This is described as *shelving*. The uterine height comes down from the level of the xiphisternum by 2 cm or so and the flanks appear distended. The woman perceives a feeling of relief since the upward pressure on the diaphragm is reduced. This is described as *lightening*.

Ripening or softening of the cervix is due to alteration in collagen structure and relative concentration of matrix metalloproteinases (MMP) and glycosaminoglycans (GAGs). Increase in uterine contractility is mediated by oxytocin and prostaglandins.

First stage of labor

The first stage begins with the onset of regular uterine contractions and ends with full cervical dilatation. The exact time of onset of labor is difficult to establish. The time at which regular, painful uterine contractions begin, leading to cervical effacement and dilatation, is the time of true onset of labor. It is not possible to determine this accurately.

Events that take place in the first stage of labor are listed in Box 14.9.

Show

Mucosanguineous discharge that is normally seen in the first stage of labor is known as show. This is the expulsion of the mucous plug of the cervix mixed with a small quantity of blood. It occurs as a result of cervical effacement and dilatation.

Box 14.9 Events in the first stage of labor

- Uterine contractions
 - Regular
 - Painful
 - Progressive increase in
 - intensity
 - duration
 - frequency
- Show
- Cervical changes
 - Effacement
 - Dilatation
- Formation of lower uterine segment
- Descent of presenting part
- Formation of bag of membranes
 - Rupture of membranes

Cervical effacement

The cervix is soft and 'ripens' as term approaches, in preparation for effacement and dilatation (see Chapter 6, *Physiology of Labor*). Cervical effacement and dilatation are fundamental to the first stage of labor.

Effacement or 'taking up' refers to the shortening of the cervix in labor. The fibers of the cervix are thinned out, pulled upward into the lower segment of the uterus, and the cervix that is 4 cm long before the onset of labor, becomes progressively shorter (Box 14.10; Fig. 14.10). Effacement may begin before the onset of labor but is completed in labor. At the onset of labor, in a nullipara, the cervix is about 4 cm long and the internal os is closed. Effacement takes place first and dilatation begins after the cervix is fully effaced. In a multipara, the cervical canal and internal os are partially open, admitting one or two fingers at the onset of labor. Effacement and dilatation progress simultaneously in labor. Effacement is expressed either as a percentage of the length of cervix that is taken up (e.g., 25%, 50%) or in terms of the actual length of the cervix below the presenting part (e.g., 3 cm, 2 cm).

Box 14.10 Cervical effacement

- May begin prior to onset of labor
- Completed before active phase of labor
- Cervix thinned out and pulled upward
- Merges with lower uterine segment
- Expressed in percentage or centimeters of length

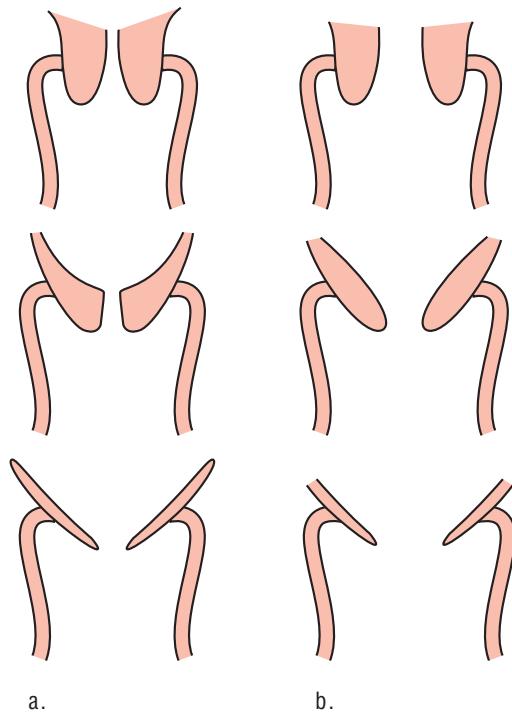


Figure 14.10 Cervical effacement. **a.** Cervical effacement in nullipara. The cervix first effaces, becomes shorter and thinner, and dilates later. **b.** Cervical effacement in multipara where the internal os is partially open. Effacement and dilatation proceed simultaneously.

Cervical dilatation

Cervical dilatation is an essential prerequisite to delivery. The internal os is closed prior to labor in primigravidae but may be patulous in multigravidae. With increasing uterine contractions and pressure exerted by the amniotic fluid and the presenting part, the cervix dilates to 10 cm (full dilatation) at the end of the first stage of labor (Box 14.11; Fig. 14.11).

Phases of first stage of labor

Cervical dilatation is divided into two phases:

- Latent phase
- Active phase
 - Acceleration phase
 - Phase of maximum slope
 - Deceleration phase

This is based on the graph of cervical dilatation and phases of labor (Friedman labor curve). It is a sigmoid curve that begins with the latent phase and goes on to the active

Box 14.11 Cervical dilatation

- Occurs due to
 - uterine contractions
 - hydrostatic pressure of the amniotic fluid
 - pressure of the presenting part
- Dilates to 10 cm by the end of the first stage
- Mediated by
 - prostaglandins
 - oxytocin

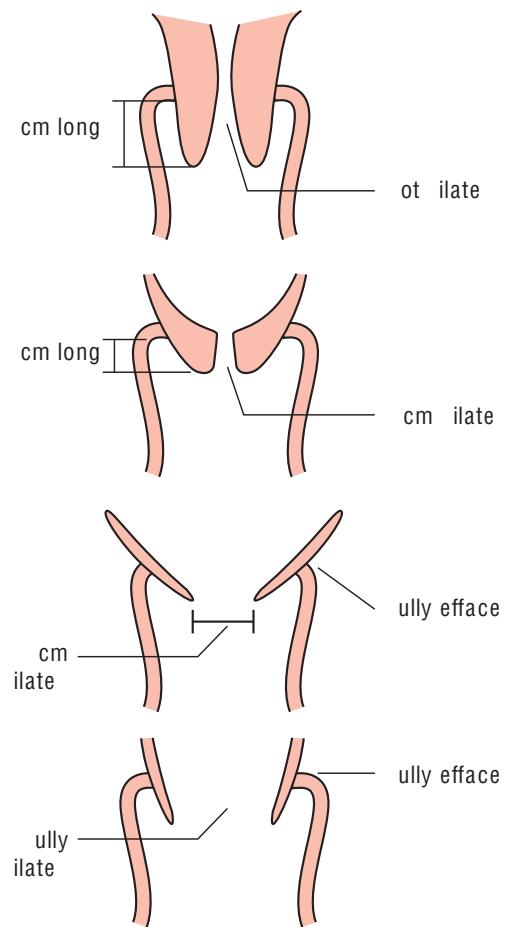


Figure 14.11 Cervical dilatation. The cervix dilates gradually to 10 cm by the end of first stage.

phase, which in turn is divided into acceleration phase, phase of maximum slope, and deceleration phase (Fig. 14.12). Both latent and active phases together constitute the first stage of labor.

latent phase

The latent phase is the period between onset of labor and beginning of the active phase. It is the early phase of labor during which cervical

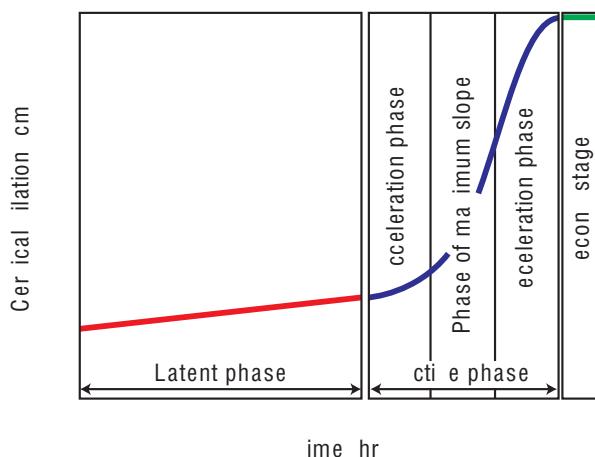


Figure 14.12 Friedman's curve showing the phases of labor. The active phase begins at 3 cm in this curve and is divided into acceleration phase, phase of maximum slope, and deceleration phase.

effacement occurs (thinning from 4 cm to 0.5 cm) and the cervix dilates to 4 cm. Time of onset of labor is difficult to determine, as already discussed. Initiation of regular uterine contractions as perceived by the woman is usually taken as the time of onset. Cervical dilatation of 4 cm marks the end of the latent phase and beginning of the active phase. (In the original Friedman curve, active phase began at 3 cm dilatation.) Duration of latent phase is variable but the average duration in a nullipara is 6–8 hours and in a multipara is 4–6 hours (Box 14.12).

Active phase

The active phase begins at 4 cm dilatation and ends with full dilatation of cervix. This phase is divided into the following phases:

- Acceleration phase
- Stage of maximum slope
- Deceleration phase

Box 14.12 Latent phase of labor

- Begins with onset of labor
- Ends with onset of active labor (4 cm dilatation)
- Duration variable
 - Nullipara: 6–8 hours
 - Multipara: 4–6 hours
- Increase in duration
 - Inadequate ripening of cervix
 - Early sedation

The rate of cervical dilatation begins to increase in the acceleration phase, proceeds faster during the phase of maximum slope, and slows down toward the end (after 8 cm), during the deceleration phase. The rate of dilatation in the active phase is 1.5 cm/hour in a multipara and 1.2 cm/hour in a nullipara (two standard deviations below the mean). A minimum dilatation of 1 cm/hour should occur, below which progress of labor is considered abnormal. The mean duration of the active phase is 3–4 hours in a multipara and 5–6 hours in a nullipara. The duration is affected by several factors (Box 14.13).

Friedman's curve was introduced in the 1950s. More recent studies have refuted some of his findings. The following facts are considered to better reflect actual labor patterns:

- The increase in rate of dilatation in active phase is gradual.
- Latent phase ends and active phase begins at 4 cm dilatation.
- More rapid dilatation occurs after 6 cm.
- There is no deceleration phase.
- Due to these differences, the shape of the curve is not sigmoid.
- Total duration of labor is longer.

Formation of lower uterine segment

This has been described earlier in this chapter. The active upper segment contracts and pushes the fetus down into the passive lower segment, which stretches to accommodate it.

Box 14.13 Active phase of labor

- Divided into
 - acceleration phase
 - stage of maximum slope
 - deceleration phase
- Duration
 - Multipara: 3–4 hours
 - Nullipara: 5–6 hours
- Rate of dilatation
 - Multipara: 1.5 cm/hour
 - Nullipara: 1.2 cm/hour
 - Minimum: 1cm/hour
- Duration increased by
 - fetal malposition
 - deflexion
 - inadequate uterine contractions
 - large baby

Descent of the presenting part

During the latent phase, engagement of the vertex may take place. Some descent occurs in the active phase, especially in the latter part.

Formation of bag of membranes

As the cervix effaces and dilates, a portion of the amniotic sac with amniotic fluid bulges into the cervical canal and *serves as a dilating fluid wedge*. This lies below the presenting part and is known as *bag of membranes or forewaters* (Fig. 14.13). This *fluid wedge* further dilates the cervix when the uterus contracts and increases the *hydrostatic pressure of the amniotic fluid*.

Rupture of membranes

The bag of membranes ruptures due to further increase in intra-amniotic pressure. This usually occurs toward the end of the first stage when the cervix is nearly fully dilated but may occur earlier.

Second stage of labor

The second stage of labor begins with full cervical dilatation and ends with the delivery of the fetus. This is the stage in which descent of the presenting part leads to expulsion of the fetus. Events in the second stage are as follows:

- Descent of the fetus
- Bearing down pains
- Crowning of the head
- Delivery of the fetus

Most of the descent of fetal head occurs during late first stage and early second stage, when uterine contractions are more frequent and last longer. In addition, the mother feels the urge to 'push' or 'bear down' when the head enters the vagina and presses on the rectum. The resistance offered by the soft tissues is overcome by

- voluntary bearing down by the mother and
- uterine contractions.

The occiput rotates and hitches under the symphysis pubis and does not recede between contractions. This is known as *crowning*. With further contractions and maternal efforts, expulsion of the fetus occurs (Box 14.14). Duration of the second stage is 30 minutes in a multipara and 1 hour in a nullipara but, in the absence of

Box 14.14 Second stage of labor

- Has two phases
 - Phase I: Pelvic phase or phase of descent
 - Phase II: Perineal phase or phase of expulsion
- Uterine contractions
 - Increase in frequency
 - Increase in duration
- Bearing down pains
 - Maternal expulsive efforts
- Crowning
 - Occiput hitches under symphysis pubis
 - Does not recede between contractions
- Expulsion of fetus
- Duration
 - Multipara: 30 minutes
 - Nullipara: 1 hour

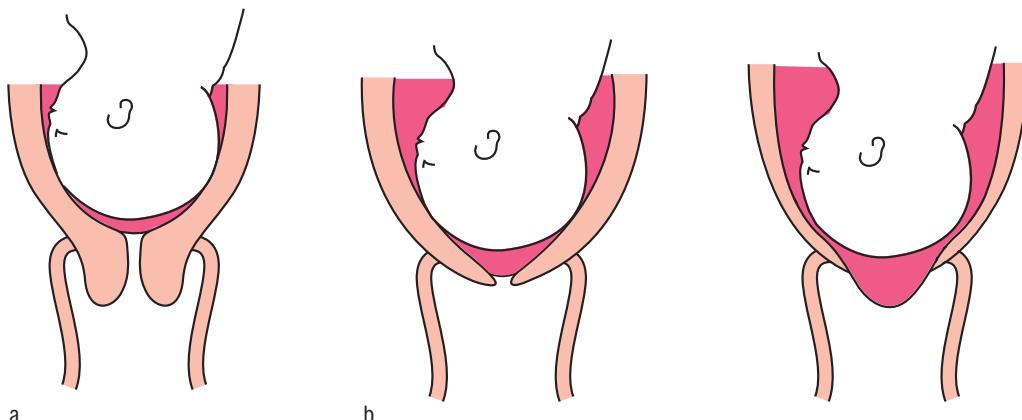


Figure 14.13 Formation of the bag of waters. With uterine contractions and increasing hydrostatic pressure, the portion of amniotic sac above the cervix, below the presenting part, bulges into the cervical canal. This is known as bag of membranes or forewaters. **a.** Early in labor **b.** Formation of bag of waters begins **c.** Bag of waters formed below the head.

fetal heart rate abnormalities, up to 1 hour in a multipara and 2 hours in a nullipara are considered normal.

Phases of second stage of labor

The second stage of labor has been divided into two phases:

- Pelvic phase
- Perineal phase

Phase I Pelvic phase or phase of descent

The pelvic phase extends from full dilatation of cervix to the time when the head reaches the pelvic floor. The beginning of this phase is difficult to define precisely since pelvic examination is usually performed 4 hourly. The rapid descent of the fetal head occurs during this phase. The end of this phase is marked by 'bearing down' pains that begin when the head reaches the pelvic floor.

Phase II Perineal phase or phase of expulsion

The perineal phase extends from the beginning of 'bearing down' pains to delivery of the fetus. The duration of this phase is important. When this phase of second stage is prolonged, fetal hypoxia and damage to pelvic floor muscles and fascia can occur.

Third stage of labor

This extends from the time of expulsion of the fetus to the expulsion of the placenta. The duration of the third stage is usually 5 minutes but up to 30 minutes is considered normal.

Placental separation

Contraction of the uterus causes thickening of the uterine wall and reduction in surface area of the placental site. The disparity in the surface areas of the placenta and placental site causes a shearing force, and the placenta separates from the uterine wall along the spongy layer. The fetal membranes peel off the uterine wall, aided by uterine contractions. Expulsion of the placenta follows.

The process of placental separation is divided into four phases:

- Latent phase: Placenta-free wall of the uterus contracts.

- Contraction phase: Uterine wall at the placental site contracts.
- Detachment phase: Placenta separates from the uterine wall.
- Expulsion phase: Placenta is expelled from the uterine cavity.

Two methods of placental separation, namely Schultz method and Duncan method, are shown in Figure 14.14.

Central separation (Schultz)

The central cotyledons separate first and the blood collects retroplacentally. The separation continues peripherally and the entire placenta separates. The placenta is expelled, with the fetal

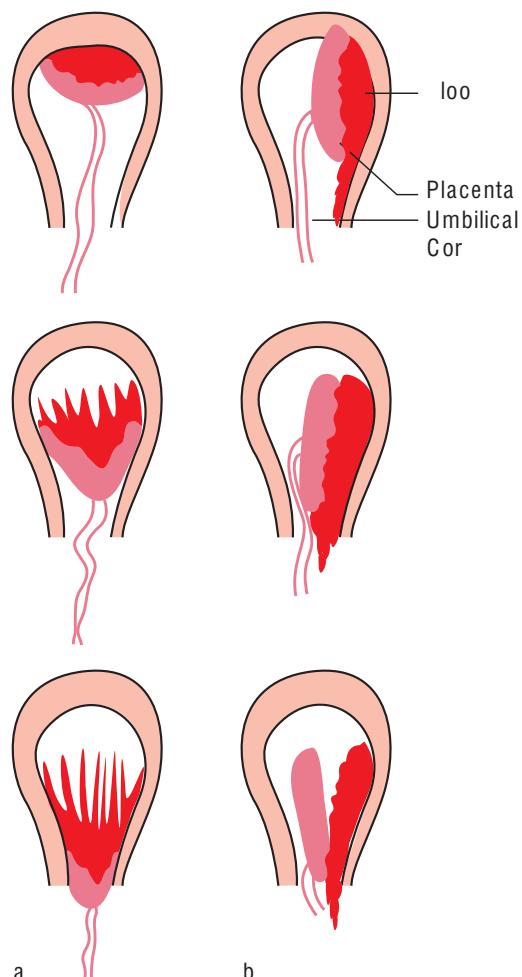


Figure 14.14 Methods of placental separation. **a.** Central separation or Schultz method in which the centre of the placenta separates first. **b.** Marginal separation or Duncan method in which the margin of the placenta separates first and extends to the center.

surface presenting at the introitus, with the cord attached, like an inverted umbrella. During the separation, external bleeding is minimal.

Marginal separation (Duncan)

This is the mechanism of separation of a fundal placenta. The separation begins in the periphery and extends to the center. Bleeding is evident. The placenta folds upon itself and is expelled. This method of separation is more common (Box 14.15).

Arrest of bleeding (fourth stage of labor)

After the separation and expulsion of placenta, there is bleeding from the torn ends of the placental vessels. The uterine myometrium contracts and retracts. The crisscross fibers of the

Box 14.15 Placental separation

- Central separation (Schultz)
 - Starts in the central cotyledons
 - Forms retroplacental hematoma
 - Expelled as inverted umbrella
 - External bleeding less
- Marginal separation (Duncan)
 - Starts in the periphery
 - Associated with bleeding
 - More common

middle layer of myometrium act as 'living ligatures' and compress the blood vessels (Fig. 14.15). Clots form in the vessels, completing the occlusion and controlling hemorrhage (Box 14.16). This phase, which extends over 1–2 hours after placental expulsion, is referred to as the fourth stage of labor.

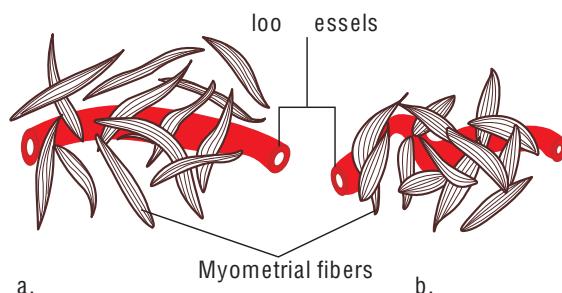


Figure 14.15 Living ligatures. The arrest of bleeding after the third stage occurs by compression of the blood vessels in the middle layer of myometrium. **a.** Before delivery of placenta, the muscle fibers are arranged around the blood vessels in a criss-cross manner. **b.** After delivery of placenta, the muscle fibers come together and compress the blood vessels to occlude them.

Box 14.16 Arrest of bleeding

- Uterine contraction and retraction
- Occlusion of arterioles by myometrium—'living ligatures'
- Formation of clots and thrombosis of vessels

Key points

- Labor is the process by which the fetus, after the period of viability, is expelled from the genital tract.
- Three factors (3 Ps) are involved in the mechanics of labor—passage, passenger, and powers.
- The fetal passage consists of the bony pelvis and soft tissues.
- Passenger or the fetal factors influencing labor are fetal lie, presentation, position, attitude, size, and station.
- Uterine contraction is the most important power. Frequency and duration of contractions increase as labor progresses.
- The uterus differentiates into an active upper segment and passive lower segment during labor.
- Mechanism of labor consists of seven distinct cardinal movements: engagement, descent, flexion, internal rotation, extension, restitution, and external rotation.

- Vertex presentation with left occipitoanterior or left occipitotransverse position is the most commonly seen presentation.
- The head is said to be engaged when the biparietal diameter crosses the pelvic inlet. Asynclitism is common during labor but, if severe, can lead to dystocia.
- Descent of the fetal head is assessed by abdominal examination and expressed in 'fifths' of head palpable above pubic symphysis.
- Flexion, internal rotation extension, and delivery are brought about by uterine contractions, resistance offered by bony pelvis, and levatorani muscle.
- External rotation of head indicates internal rotation of the shoulder.

(Continued)

Key points *Continued*

- Preparatory stage of labor extends over few days to few weeks prior to labor. Lightening, shelving, softening of the cervix, and increase in uterine contractility occur during this phase.
- Labor is divided into three stages. First stage is further divided into two phases.
- The first stage of labor extends from onset of labor to full dilatation of cervix.
- Important events in the first stage are cervical effacement and dilatation, formation of the lower uterine segment, and rupture of membranes when cervix is nearly fully dilated.
- Cervical effacement is expressed as percentage of cervix effaced or length of cervix in centimeters below the presenting part.
- Cervical dilatation is divided into two phases. Latent phase extends upto dilatation of 3–4 cm.
- Active phase extends from 3–4 cm to full dilatation. This is divided into acceleration phase, phase of maximum slope, and deceleration phase.
- Second stage of labor is the stage of expulsion of fetus and extends from full cervical dilatation to delivery of the fetus.
- Third stage is the stage of placental expulsion. Separation and expulsion of placenta and membranes takes place during this stage.
- After delivery of the placenta, bleeding is arrested by myometrial contraction and retraction and formation of thrombi in the vessels. This is described as the fourth stage of labor.

Self-Assessment

Case-based questions

Case 1

Mrs. PS, a primigravida at 40 weeks' and 3 days' gestation, was presented with mucosanguineous discharge and pains.

1. What is the mucosanguineous discharge known as and why does it occur?
2. What changes do you expect in the cervix if she is in labor?
3. If the cervix is 3 cm long and 2 cm dilated, which phase of labor is she in?
4. When will she be considered to be in active phase of labor?

Case 2

Mrs. TD, wsecond gravida, at 39 weeks' gestation, was admitted to the labor room with pains.

1. How will you assess descent of the fetal head by abdominal palpation?
2. How will you identify engagement of the head?
3. If she is 5 cm dilated at admission, what is the expected rate of dilatation from this point?

Answers

Case 1

1. The mucosanguineous discharge is known as show. It is the mucus plug of the cervix mixed with blood that is expelled in early labor.
2. Progressive effacement and dilatation.

3. Latent phase.

4. When the cervix is 4 cm dilated.

Case 2

1. By placing the hand on the lower abdomen with the ulnar border of the hand along the pubic symphysis. It is expressed as the number of 'fifths' of fetal head palpable above the symphysis.
2. When the head is one-fifth palpable, the occiput is not felt, only the sinciput is felt abdominally. A vaginal examination will show the leading bony point of the head at or below the level of the ischial spines.
3. 1.5 cm/hour since she is a multipara in the active phase of labor.

Sample questions

Long-answer questions

1. Define normal labor. Describe the mechanism of labor in occiput anterior position.
2. What are the stages of labor? Discuss the events in each stage.

Short-answer questions

1. Monitoring uterine activity during labor
2. Engagement
3. First stage of labor
4. Restitution
5. Cervical effacement
6. Friedman's curve
7. Placental separation
8. Formation of lower segment of uterus

15

Management of Normal Labor and Delivery

Case scenario

Mrs. BN, 22, a primigravida at 40 weeks' gestation, was admitted to the labor room with backache and pain in the lower abdomen. She had noticed blood-stained vaginal discharge, and the pain was intermittent, but progressively becoming more frequent and more severe.

Introduction

Most labors progress normally and have a good maternal and perinatal outcome. This, however, is dependent on prompt diagnosis of labor, adequate monitoring, and appropriate management. Complications in labor occur at the most unexpected moments, and the obstetrician has to be vigilant. Adherence to protocols, adequate staffing, and facilities to handle emergencies swiftly are essential for ensuring good outcome.

Procedures at admission

It is essential to first establish the diagnosis of labor. The stage of labor and fetal and maternal condition should also be assessed.

Diagnosis of labor

Accurate diagnosis of labor is difficult especially if the woman is in the latent phase of labor. False labor is common and admitting women in false labor must be avoided since it can lead to unnecessary intervention. Differences between true and false labor are listed in Table 15.1. If a diagnosis cannot be made with certainty, the parturient may be observed for a few hours.

Clinical evaluation

History

A review of antenatal records is mandatory. Risk factors in the present pregnancy and complications during the previous pregnancy and

Table 15.1 Differences between true and false labor

	True labor	False labor
Uterine contractions	<ul style="list-style-type: none"> • Regular • Increasing frequency • Increasing intensity 	<ul style="list-style-type: none"> • Irregular • Variable intervals • Variable intensity
Location of pain	Low back and abdomen	Lower abdomen
Cervical effacement and dilatation	Present	Absent or not progressive and dilatation
Show	Present	Absent
Sedation	No effect	Relieved

delivery should be noted (see Chapter 8, *History taking and examination of the obstetric patient*). Details regarding time of onset of contractions, their frequency, duration, presence of show, leakage of fluid, bleeding, and fetal movements should be obtained (Box 15.1).

Physical examination

This consists of recording vital signs, including maternal pulse, blood pressure, and temperature. Uterine contractions, fetal lie, presentation, and position should be assessed by abdominal examination. Second pelvic grip and Crichton's

Box 15.1 Clinical evaluation

- Review antenatal records
 - Antenatal risk factors
 - Complications in previous pregnancy/labor
- History
 - Labor pains
 - Time of onset
 - Frequency
 - Duration
 - Presence of show
 - Leakage of fluid
 - Fetal movements
- General examination
 - Vital signs
 - Pulse
 - Blood pressure
 - Temperature
- Abdominal examination
 - Uterine contractions
 - Duration
 - Frequency
 - Intensity
 - Fetal presentation
 - Position
 - Descent
 - Fetal heart sounds

maneuver (see Chapter 14, *Normal labor: Mechanics, mechanism, and stages*) should be performed to assess flexion or deflexion, engagement and descent of fetal head. Fetal heart sounds should be checked by auscultation.

Routine enema and shaving of pubic hair are no longer recommended. Pubic hair may be clipped if necessary.

Vaginal examination

This is performed with the parturient in the dorsal position, with the hips and knees flexed, and the hips slightly abducted. Aseptic precautions must be taken and the index and middle fingers of the gloved right hand are used. (Vaginal examination should not be performed if there is significant active bleeding.) On vaginal examination, cervical effacement, dilatation, consistency, position, status of membranes, fetal presentation, and position and station of the presenting part should be noted. If the membranes are ruptured, presence of meconium should be looked for (Box 15.2). Lastly, the type of pelvis should be determined, and contracted pelvis excluded.

Consistency of the cervix may be firm, medium, or soft, depending on the prelabor ripening. *Position* of the cervix is in relation to the fetal head and can be anterior, midposition, or posterior.

Fetal position is the relationship of the occiput to the quadrant of the pelvis, for example, left occipitoanterior (LOA) or right occipitoanterior (ROA) (Fig. 15.1). *Flexion* is determined by the portion of the sagittal suture and the fontanel that is felt on vaginal examination. When the head is well flexed, the posterior fontanel is easily felt and the anterior fontanel is not felt or felt with difficulty (Fig. 15.2). If the anterior and posterior fontanelles are felt with equal ease

Box 15.2 Vaginal examination

- Cervix
 - Consistency: Soft/medium/firm
 - Effacement (in centimeters of length of cervix)
 - Dilatation (in centimeters)
 - Position: Anterior/midposition/posterior
- Status of membranes
 - Intact
 - Ruptured
- Meconium, if membranes ruptured
- Fetus
 - Presentation
 - Position
 - Flexion: Flexed/deflexed/extended
 - Station
- Assessment of bony pelvis
 - Shape
 - Any abnormality

at either end of the sagittal suture or if the anterior fontanel is felt more easily, then the head is deflexed. The head is extended if the presentation is brow or face (see Chapter 41, *Abnormal labor: Malposition and malpresentations*).

Station or level of the vertex (or other presenting part) is determined by the relationship of the leading part to the ischial spines. The level

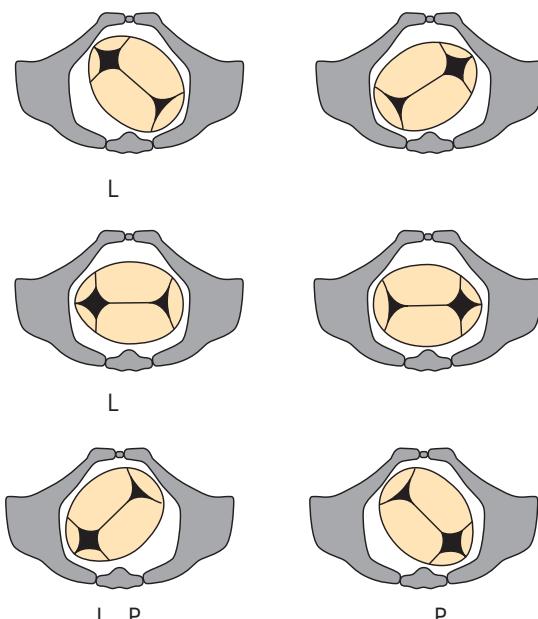


Figure 15.1 Fetal position. On vaginal examination, position is determined by the relationship of the occiput to the quadrants of the pelvis. In occiput transverse positions, the occiput is pointing directly to the left or right side of the pelvis.

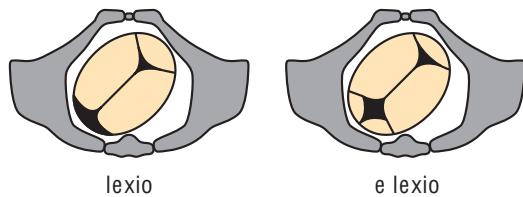


Figure 15.2 Flexion of the fetal head as determined by vaginal examination. When head is well flexed (vertex presentation), the posterior fontanel is well felt and anterior fontanel is felt with difficulty. When head is deflexed, anterior and posterior fontanels are felt with equal ease.

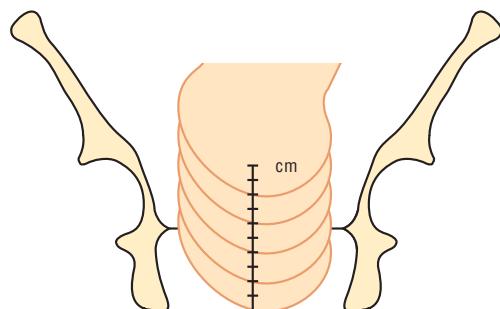


Figure 15.3 Station of the presenting part as determined by vaginal examination. The level of the ischial spines is considered as '0'. There are 5 levels above and below, as minus (-) 1–5 and plus (+) 1–5.

of the ischial spines is considered '0' station. The portion of the pelvis from the inlet to the ischial spines is divided into five levels, each 1 cm above the other, designated as stations -1, -2, -3, -4, and -5. Similarly, the part of the pelvis below is divided into five levels, designated as +1, +2, +3, +4, and +5. Minus 5 is at the level of the inlet or pelvic brim and +5 at the introitus (Fig. 15.3).

Caput succedaneum

A caput succedaneum develops on the fetal scalp when labor is prolonged. The area of the scalp that is pressed against the cervix becomes edematous (Box 15.3; Fig. 15.4a and b). An extensive and thick caput forms in the most dependent part of the vertex when there is obstructed labor or prolonged labor. The caput appears as a diffuse swelling, and the location depends on the position of fetal head. It may be difficult to feel the sutures of the vertex and ascertain position and flexion when there is a large caput. The station of the fetal head may also appear to be lower if the vertex is not carefully palpated through the caput. The caput is present at birth but disappears in 24–48 hours.

Box 15.3 Caput succedaneum

- Localized edema of fetal scalp
- Appears as diffuse swelling
- Subsides 1–2 days after delivery
- If cervix is thick
 - forms where fetal scalp presses against the cervix
 - is few millimeters thick
- In prolonged/obstructed labor
 - covers larger area
 - thicker and more edematous
 - forms in the most dependent area of scalp
 - sutures and fontanel become difficult to palpate

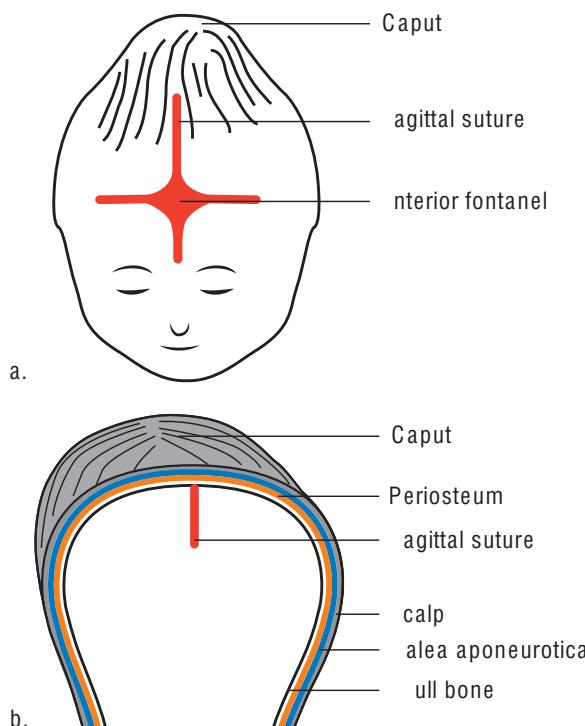


Figure 15.4 Caput succedaneum. **a.** Caput succedaneum. The area of the scalp that is pressed against the cervix becomes edematous. **b.** The fluid is superficial to the periosteum and goes across the suture lines.

Molding

The sutures joining the skull bones of the fetus are quite flexible. The fetal skull bones come together or even overlap when resistance is encountered in the maternal bony pelvis, thus reducing the diameters of the skull and enabling normal delivery. The extent of overlapping of skull bones is called molding (Box 15.4). During molding, the occipital bone slips under the parietal bones and one parietal bone slips under the

Box 15.4 Molding

- Coming together/overlapping of skull bones
- Occurs in occipitoparietal and parietoparietal sutures
- Reduces diameters of the fetal skull
- Expressed as
 - 1+: Bones touch each other
 - 2+: Bones overlap but separate on finger pressure
 - 3+: Bones overlap and do not separate on finger pressure
- Physiological when mild (1+)
- Indicates obstructed labor when severe (2+/3+)

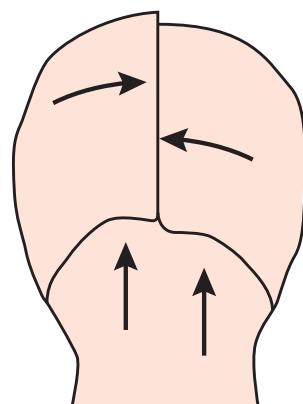


Figure 15.5 Molding. When resistance is encountered in the bony pelvis, the fetal skull bones come together or even overlap.

other; therefore, there is molding at the occipitoparietal suture and the sagittal (parietoparietal) suture. The degree of molding is expressed as follows (Fig. 15.5):

- 1+: The bones touch each other.
- 2+: The bones overlap but separate on pressure by finger (reducible).
- 3+: The bones overlap and do not separate with pressure by finger (irreducible).

In mild degrees of cephalopelvic disproportion, molding may reduce the suboccipitobregmatic diameter and facilitate vaginal delivery. Some degree of molding is physiological and occurs in most women in labor when the head negotiates the midpelvis.

Assessment of the bony pelvis

Assessment of the bony pelvis is described in detail in Chapter 8, *History taking and examination of the obstetric patient*. The type of pelvis should be determined by noting its

characteristic features. The diagonal conjugate should be measured if the sacrum is tipped. A decrease in any diameter at any level should be documented.

Admission test

A short nonstress test for 20 minutes, using cardiotocography, is performed at admission in some centers. Women with a normal trace are then monitored by intermittent auscultation. Several studies have concluded that admission cardiotocography is not useful in low-risk women.

Management of first stage of labor

During the first stage of labor, uterine contractions become progressively stronger, the cervix dilates and the presenting part descends. Close monitoring of these is essential to ensure that the events are progressing normally.

Supportive measures in labor

The first stage of labor usually extends for a few hours. It is important that the parturient be made comfortable during this time and the necessary pain relief and support provided.

Ambulation maternal position

During the early stage of labor, women may be allowed to walk about or sit in a comfortable chair. In the active phase of labor, most women prefer to lie down. When they lie down, they must be encouraged to lie in the lateral position to avoid supine hypotension.

Oral intake

Gastric emptying is delayed in labor. Vomiting and aspiration are common. Solid food is, therefore, not recommended during labor. Clear fluids should be given orally, and the woman should remain well hydrated. If labor is prolonged, intravenous (IV) dextrose saline may be administered to prevent dehydration and acidosis.

Bladder function

Women in labor should be encouraged to void frequently. As the head descends, women may find it difficult to void. If the bladder is distended and the woman cannot void, catheterization may be required.

Analgesia

Analgesia is administered to relieve pain. Epidural analgesia, where available, is a good means of providing analgesia without interfering with uterine contractions.

Method of pain relief in labor should be discussed during the antenatal period. Labor analgesia is discussed in *Chapter 18, Obstetric analgesia and anaesthesia*. Administration of analgesia should not be delayed too long but administration in early latent phase can result in prolongation of the latent phase of labor.

General management of normal labor is outlined in Box 15.5.

Box 15.5 General management of normal labor

- Ambulation/maternal position
 - Early labor
 - Ambulation
 - Active phase
 - Lying in lateral position
 - Oral intake
 - Frequent clear fluids
 - No solids
 - Intravenous fluids
 - Dextrose saline in prolonged labor
 - Bladder function
 - Frequent voiding
 - Catheterization if unable to void
 - Analgesia
 - Parenteral or epidural

Monitoring

Maternal monitoring

Pulse, blood pressure, and temperature should be recorded hourly and more frequently, if there are indications. If labor is prolonged, look for signs of dehydration.

Uterine contractions

Uterine contractions are monitored with the palm of the hand on the abdomen. The duration,

interval between contractions (frequency), and intensity should be noted. As described in Chapter 14, *Normal labor: Mechanics, mechanism, and stages*, the examining fingers cannot indent the uterus when the contraction is of adequate intensity. If cardiotocography is used, contractions can be recorded on the trace.

Fetal monitoring

In low-risk pregnancies, during the first stage of labor, fetal heart rate should be checked after a contraction, by intermittent auscultation, every 30 minutes. During the second stage, monitoring should be every 15 minutes. When the laboring woman is pushing, the fetal heart rate should be monitored more frequently. If electronic fetal monitoring is used, the trace should be reviewed every 30 minutes in the first stage and every 15 minutes in the second stage. Monitoring should be more frequent in high-risk women.

Monitoring in labor is outlined in Box 15.6.

Box 15.6 Monitoring in labor

- Maternal
 - Pulse, blood pressure, temperature (4 hourly)
- Uterine contractions
 - With palm of hand on abdomen
 - Frequency
 - Duration
 - Intensity
- Fetal heart
 - Intermittent auscultation/electronic fetal monitor
 - Every 30 minutes during first stage
 - Every 15 minutes during second stage
 - More frequently while pushing

Assessment of progress in labor

Progress in labor is assessed by abdominal and vaginal examination (Box 15.7). Descent of the head in fifths should be recorded by abdominal palpation. On vaginal examination, effacement and dilatation of cervix, station of presenting part, degree of flexion, caput formation, molding, and status of membranes should be noted. Frequency of vaginal examination must be individualized but 4-hourly examination is the norm in the first stage of labor. In addition, a vaginal examination may be required when

Box 15.7 Assessment of progress in labor

- Abdominal examination
 - Descent of fetal head in 'fifths'
- Vaginal examination
 - Cervical effacement, dilatation
 - Presenting part: Station, flexion
 - Status of membranes
 - Performed every 4 hours in first stage
 - Performed when membranes rupture and head not engaged
 - Frequency variable

membranes rupture, especially if the head is not engaged.

Amniotomy

Membranes usually rupture at or near full dilatation of the cervix but can rupture earlier. Membranes are sometimes ruptured electively when the cervix is >4-cm dilated, with the intention of accelerating labor. Randomized trials have shown that artificial amniotomy is not associated with significant reduction in duration of labor, need for oxytocin, or cesarean section rate. Routine amniotomy is, therefore, not recommended.

The advantages and disadvantages of amniotomy are enumerated in Box 15.8.

Box 15.8 Amniotomy

- Elective amniotomy
 - Performed in spontaneous labor
 - After 4–5 cm dilatation
- Advantages
 - Can diagnose meconium staining
 - Facilitates fixing of fetal scalp electrode
- Complications
 - Chorioamnionitis
 - Cord prolapse
- No difference in
 - duration of labor
 - need for oxytocin
 - cesarean section rate

Partograph (or partogram)

A partograph (or partogram) is a simple, inexpensive tool that provides a graphic documentation of progress in labor and that allows early recognition of dysfunctional labor.

Friedman, in 1955, found that the least rate of cervical dilatation in the active phase of labor in multigravidae is 1.5 cm/hour and in primigravidae it is 1.2 cm/hour. The minimum acceptable rate of dilatation is 1cm/hour for both multipara and primigravida; below this, progress is considered abnormal.

Philpott and Castle, in 1972, introduced alert and action lines based on Friedman's data. The **alert line** is drawn from 3-cm dilatation (when active phase begins, as per Friedman's definition). The alert line represents a progress rate of 1 cm/hour, until full dilatation. Any labor where the graph is to the left of this line is normal. When the graph crosses the alert line, progress is considered to be slow and the obstetrician is alerted to the possibility of dysfunctional labor. If the parturient is in a primary or secondary care center, she may be transferred to a tertiary center. An **action line** is drawn 4 hours to the right of the alert line. When the graph crosses the action line, definitive action to prevent prolonged/obstructed labor is indicated (Fig. 15.6).

The WHO composite partograph

Subsequently, as per the recommendations of the Safe Motherhood Conference, WHO introduced a partograph in 1990. In addition to cervical dilatation, descent of the presenting part, uterine

contractions, maternal vital signs, oxytocin augmentation, and fetal parameters such as fetal heart rate, presence of meconium, and molding of the head are recorded in the graph, which is known as *the composite partograph* (Fig. 15.7). The first composite WHO partograph included a latent phase of 8 hours and the alert line began at 3-cm dilatation (beginning of active phase). A modified WHO partograph was introduced in 2000. This does not include the latent phase and the alert line (and active phase) begins at 4-cm dilatation.

The features of modified WHO partograph are listed in Box 15.9.

Advantages of partograph

The partograph has proved valuable in both resource-rich and resource-poor areas for early recognition of prolonged labor.

The advantages of partograph are listed in Box 15.10.

Management of second stage of labor

After full cervical dilatation, descent and delivery of the fetus occur in the second stage. Management of this stage consists of the identification of onset of the second stage, preparation for delivery, and conduct of delivery.

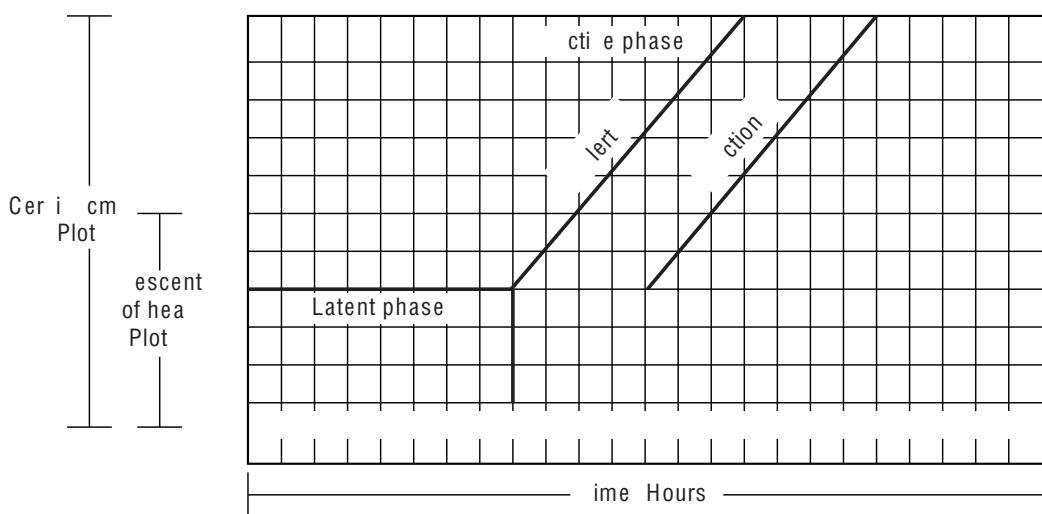


Figure 15.6 The partograph. Duration of labor in hours is marked on the X axis and cervical dilatation and descent of the fetal head are marked on the Y axis. Alert line begins at 3-cm dilatation and action line begins 4 hours to the right.

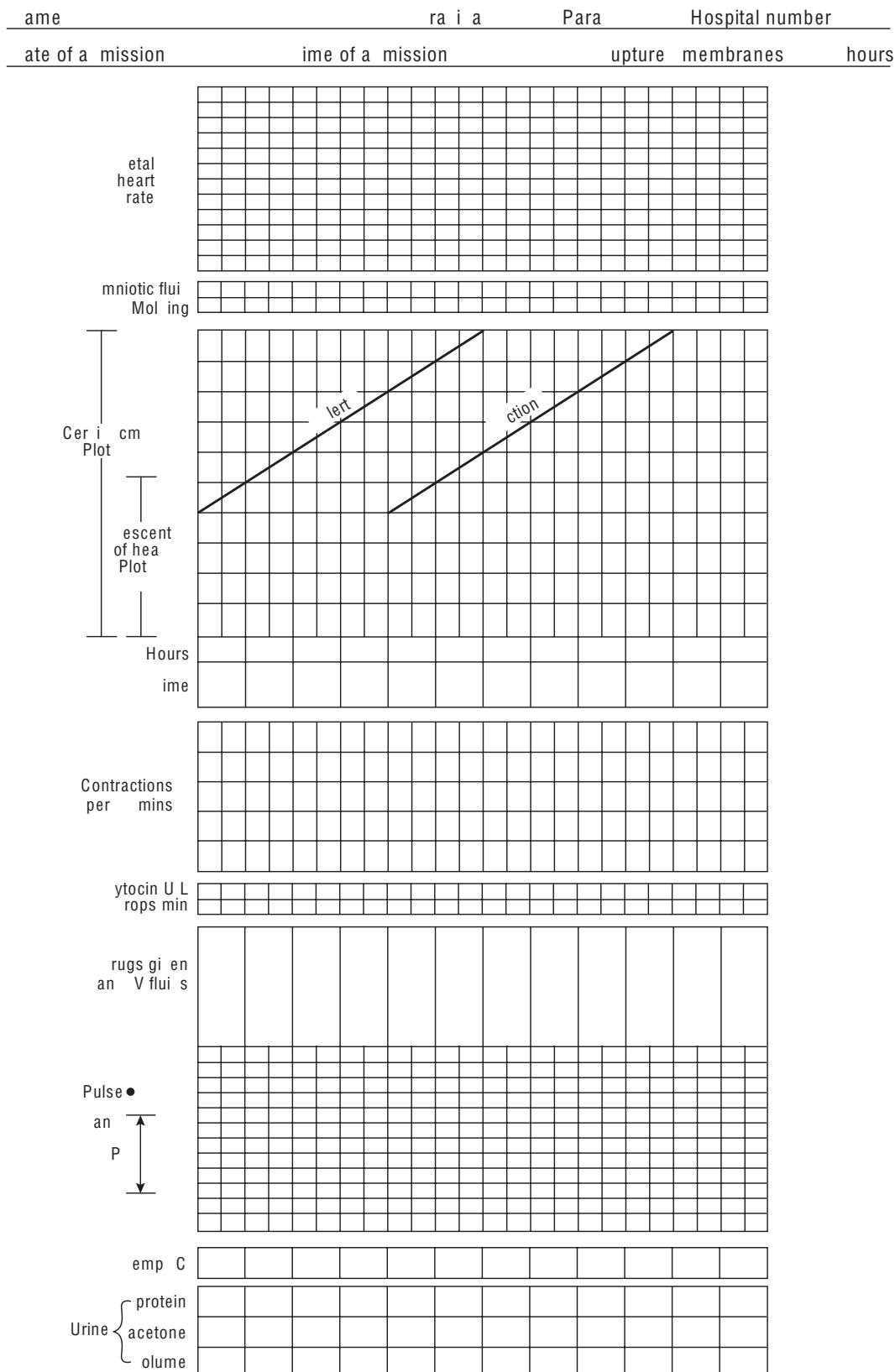


Figure 15.7 Composite partograph. In this, in addition to cervical dilatation and fetal decent, uterine contractions, maternal vital signs, urine output oxytocin augmentation, fetal heart rate, presence of meconium, and molding of the head are recorded.

Box 15.9 Features of modified WHO partograph*Components*

- Cervical dilatation and descent
- Latent phase not included
- Cervical dilatation plotted against time
- Minimum rate of dilatation: 1 cm/hour
- Alert line: Begins at 4-cm dilatation
- Action line: 4 hours to the right of alert line
- Fetal parameters
 - Fetal heart rate
 - Liquor
 - Molding
- Maternal parameters
 - Vital signs
 - Urine output/protein
 - IV fluids
 - Drugs
 - Uterine contractions
 - Oxytocin dose

Box 15.10 Advantages of partograph

- Effective tool to
 - document events in labor
 - assess progress of labor
 - diagnose dysfunctional labor early
 - prevent obstructed labor
- Assists in
 - early augmentation of labor
 - early termination of labor
 - early transfer of the parturient to tertiary center

Watching for bearing down pains

When the cervix is fully dilated and the fetal head descends low into the vagina, the woman has an uncontrollable urge to bear down. She usually will flex her knees and bear down. Uterine contractions increase in duration, last for 1–1.5 minutes and the interval between contractions decreases to 1 minute. When the fetal head presses on the rectum, the woman has an urge to defecate. At this time, preparations for delivery should be made.

Preparations for delivery

Maternal position

The dorsal position with flexion at hips and knees and abduction of the thighs is most

Box 15.11 Preparations for delivery*Maternal position*

- Dorsal/semirecumbent/dorsal lithotomy
 - Clean the vulva
 - Sterile drapes
 - Keep local anesthetic ready, if required
 - Delivery tray to be opened and ready
 - Keep 10 units of oxytocin ready for use in third stage

commonly used. When the woman is brought down to the edge of the cot, soiling of obstetrician's clothes and feet by amniotic fluid and blood is more. Mid-cot delivery (delivering in the middle of the cot) is recommended for normal delivery to avoid this. A semirecumbent position with head and shoulders elevated to 45 degrees may also be used. A lithotomy position with the legs in stirrups and the buttocks at the edge of the delivery table is preferred if instrumental delivery is anticipated. The lateral position does not interfere with venous return and is preferred in women with cardiac valvular disease. Preparations for delivery are listed in Box 15.11.

Delivery of the head

The head descends and is seen at the vulva, initially during contractions and later in between contractions as well. When the head is seen at the vulval outlet and does not recede between contractions, *crowning* is said to have occurred (Fig. 15.8). The anus is stretched and the anal opening appears prominent. If an

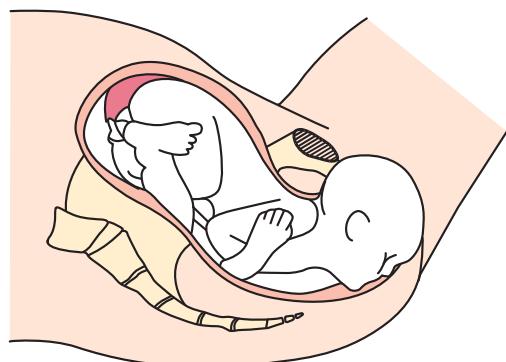


Figure 15.8 Crowning of the fetal head. When the fetal head is visible at the vulval outlet and does not recede between contractions, crowning is said to have occurred.

episiotomy is indicated, it should be performed at this time; however, routine episiotomy is not recommended.

A sterile towel or pad is held in the right hand and placed over the perineum. The left hand is placed on the occiput to apply gentle downward pressure to promote flexion and controlled delivery of the head. This ensures that the smallest diameter of the fetal head presents at the outlet. Simultaneously, the perineum is supported with the right hand through the towel to reduce the incidence of perineal lacerations, especially third and fourth degree perineal tears. Once the occiput is born, gentle pressure is exerted on the chin of the fetus with the right hand, to promote extension of the head; the forehead, nose, mouth, and chin are born. This procedure is called the *modified Ritgen maneuver* (Fig. 15.9). The *hands poised technique* involves waiting and watching without touching the fetal head or perineum. Randomized trials have not shown any difference in incidence of perineal lacerations between the two methods of delivery.

Once delivered, the head undergoes restitution and external rotation. The infant's face is turned toward the maternal thigh. The infant's neck should be palpated and if the umbilical cord is wound around the neck of the fetus (nuchal cord), it can be slipped over the head. If the cord is tight around the neck, two clamps are placed on it and the cord is cut between the clamps to facilitate delivery.

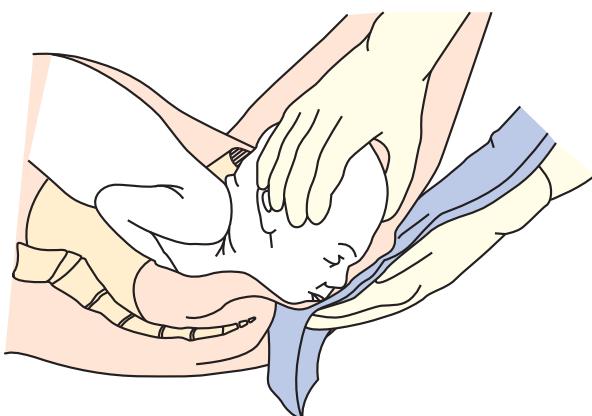


Figure 15.9 Modified Ritgen maneuver. One hand is placed on the occiput to prevent rapid delivery, the other hand supports the perineum to prevent perineal lacerations and promote extension of the fetal head.

Suctioning the baby's nose and mouth when the head is at the perineum is not recommended irrespective of meconium staining of amniotic fluid.

Delivery of the shoulders

With external rotation of the fetal head, the shoulders rotate to lie in the anteroposterior diameter of the pelvis. The anterior shoulder is delivered first by downward traction and then the posterior shoulder by an upward sweeping movement (Fig. 15.10). The rest of the body usually slips out immediately. Management of the second stage is outlined in Box 15.12.

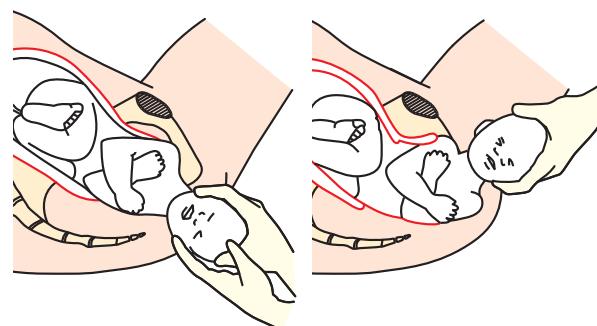


Figure 15.10 Delivery of shoulders. The anterior shoulder is delivered by downward traction and posterior shoulder by an upward lifting of the fetus.

Box 15.12 Management of second stage

- Delivery of the head
 - Wait for crowning
 - Modified Ritgen maneuver
 - Support perineum with towel/pad in right hand
 - Prevents perineal laceration
 - Downward pressure with left hand on occiput
 - Promotes flexion
 - Controlled delivery
 - Upward pressure on chin through perineum
 - Promotes extension and delivery of face
 - Delivery of shoulders
 - Wait for external rotation of head
 - Downward traction to deliver anterior shoulder
 - Upward movement for delivery of posterior shoulder

Prophylactic uterotonic

The oxytocics used for prophylaxis against postpartum hemorrhage are methyl ergometrine (methergine) and oxytocin.

oxytocin

Oxytocin is the drug of choice and can be administered intramuscularly or intravenously. **The current recommendation is to administer 10 units of oxytocin intramuscularly (IM) with the anterior shoulder or within 1 minute of delivery of the baby.** It may also be given as an IV infusion in doses of 10–20 units in 500 mL of saline over a period of 2 hours if an IV line is already in place. Intravenous bolus injection of 10 units can cause hypotension. Side effects are uncommon with IM use. Unlike methergine, the need for manual removal of placenta is not increased with IM oxytocin, even when administered before placental delivery.

Ergometrine

Methyl ergometrine should be administered intravenously, in a dose of 0.25 mg, at the delivery of the anterior shoulder. If administered after delivery of the fetus but before placental delivery, hourglass contraction of the uterus, retention of the placenta, and the need for manual removal can occur. It can also cause a sudden increase in blood pressure, nausea, and vomiting. It is, therefore, contraindicated in hypertensive disorders of pregnancy and cardiac valvular disease.

A combination of ergometrine 0.5 mg and oxytocin 5 units, known as *syntometrine*, is also available and equally effective but can cause hypertension.

Prostaglandins

PGF_{2α} is not used for prophylaxis though it is useful for the treatment of atonic postpartum

hemorrhage. Misoprostol can be used orally or rectally in a dose of 600–800 mg when oxytocin and ergometrine are not available. Its advantage is that refrigeration is not required because it is stable at room temperature, but it is less effective than ergometrine and oxytocin. It is recommended for use in resource-poor settings, where refrigeration facilities for drug storage and skilled birth attendants who can administer injections are not available.

Prophylactic uterotronics are listed in Table 15.2.

Clamping of umbilical cord

Timing of clamping

Early cord clamping, as soon as the baby is delivered, reduces the amount of blood returning to the fetus from the placenta. About 80 mL of blood flows into the fetus if cord clamping is delayed by 3 minutes. This increases the baby's iron stores and reduces the risk of neonatal anemia. However, delaying cord clamping can cause hyperbilirubinemia, necessitating phototherapy. Therefore, **it is recommended that the cord should be clamped 1–3 minutes after the delivery of the baby.** In preterm babies delayed clamping can cause cardiac overload and therefore, the cord should be clamped immediately in preterm births (Box 15.13).

Site of clamping

The cord is usually clamped 5–6 cm from the fetal abdomen. Two clamps are placed 3–4 cm apart and the cord cut between the two. The cord should be milked after placing the first clamp,

Table 15.2 Prophylactic uterotronics

Drug characteristic	Ergometrine	oxytocin	Misoprostol
Efficacy	Effective	Effective	Less effective
Route of administration	IV/IM	IM/IV/infusion	Oral/rectal
Timing of administration	At anterior shoulder or after placental delivery	At anterior shoulder or after delivery of baby	After delivery of placenta
Dose	0.25 mg	10 units	600–800 mg
Side effects	<ul style="list-style-type: none"> • Sudden hypertension • Nausea, vomiting • Hourglass contraction • Retained placenta 	Rarely hypotension	<ul style="list-style-type: none"> • Nausea, vomiting • Pyrexia
Refrigeration	Not required	Required	Not required

Box 15.13 Clamping of umbilical cord

- Early clamping
 - Reduces blood to fetus from placenta
 - No gain in hematocrit
 - No hyperbilirubinemia
 - Preferred in preterm births
- Late clamping
 - Increases blood flow from placenta to fetus
 - 80 mL in 3 minutes
 - Improves fetal iron stores and reduces fetal anemia
 - Increased risk of hyperbilirubinemia
- Recommendation
 - 1–3 minutes after delivery of the baby
- Site of clamping
 - 5–6 cm from umbilicus

and the second clamp should be placed just beyond the milked segment, so that a bloodless field is obtained for dividing the cord. After the baby is handed over to the nurse/pediatrician, and immediate baby care has been provided, a disposable cord clamp is placed 2–3 cm distal to the umbilicus.

If blood is being drawn for umbilical cord blood banking (for stem cells), it has to be done before cord clamping.

Management of third stage

Placental separation and expulsion occur in the third stage of labor.

Signs of placental separation

When the placenta separates, there is a gush of blood, especially if the separation is marginal (Chapter 14, *Normal labor: Mechanics, mechanism, and stages*). The uterus contracts and retracts. The placenta comes to lie in the lower uterine segment and the vagina, forming a bulge in the suprapubic area and pushing the uterus upward. The part of the cord protruding outside the vulva lengthens, and on pushing the uterus upward, the cord does not recede into the vagina since the placenta is no longer attached to the uterus.

Signs of placental separation are listed in Box 15.14.

Box 15.14 Signs of placental separation

- Uterus becomes firm and globular
- Gush of blood from vagina
- Increase in the extravulval portion of the cord
- Appearance of suprapubic bulge
- Uterus pushed upward by placenta in lower segment
- When uterine fundus is pushed up, cord does not recede

The placenta separates within 5 minutes of delivery of the baby. Once signs of placenta separation appear, the uterus is pushed upward (cephalad) with the left hand on the abdomen and the cord is held taut with the right hand. This is called *controlled cord traction* or *modified Brandt–Andrews maneuver* (Box 15.15; Fig. 15.11). This method of placental delivery prevents uterine inversion since there is no downward pressure on the uterine fundus. Once the placenta appears at the vulva, it is grasped with both hands and gently removed, taking care to remove the membranes as well.

Box 15.15 Modified Brandt–Andrews technique

- Controlled cord traction
- Left hand grasps uterine fundus through abdomen
- Right hand holds cord taut
- Left hand pushes uterus upward (cephalad)

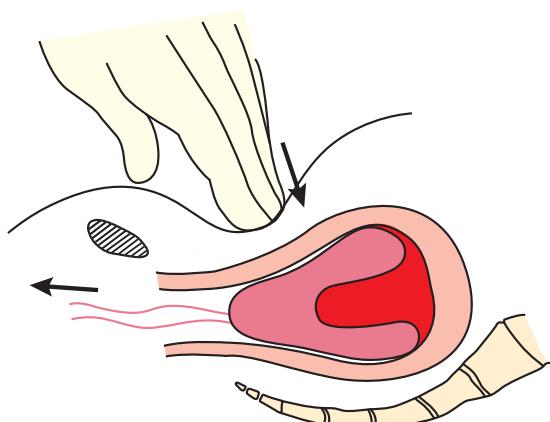


Figure 15.11 Modified Brandt–Andrews maneuver. The placenta is delivered by controlled cord traction wherein the uterus is pushed upward with the left hand and gentle, steady traction is applied with the right hand in the direction indicated by the arrow.

Active management of third stage of labor (AMTSL)

Active management of the third stage is aimed at preventing the two main complications of third stage: postpartum hemorrhage and retained placenta. The active management of the third stage consists of the following:

- *Administration of uterotonic agent*

Oxytocin 10 units IM is administered with the anterior shoulder or within 1 minute of delivery of the baby.

- *Delivery of placenta by controlled cord traction*

Controlled cord traction following oxytocin administration prevents postpartum hemorrhage.

- *Assessment of uterine tone and size*

The uterus is assessed intermittently to see if it is well contracted by placing the left hand on the fundus, abdominally.

Uterine massage to promote uterine contraction and prevent excessive bleeding was a common practice earlier. However, uterine massage causes discomfort and does not reduce blood loss. It is therefore not recommended currently.

Early clamping of the cord does not contribute much to prevention of postpartum hemorrhage; therefore, this is not included in active management of the third stage.

Examination of the placenta

The placenta, fetal membranes, and umbilical cord must be examined after delivery (Box 15.16). The normal placenta weighs about one-sixth the weight of the baby and the normal umbilical

Box 15.16 Examination of the placenta

- Weight: One-sixth the baby's weight (500–600 g)
- Cord length: 50–60 cm
- Vessels in the cord: Two arteries, one vein
- Look for
 - missing cotyledons
 - completeness of membranes
 - other abnormalities

cord is 50–60 cm long. The normal cord should have two arteries and one vein. The maternal and fetal surfaces of the placenta should be examined for abnormalities (see Chapter 46, *Abnormalities of the placenta: Cord and fetal membranes*). Missing cotyledons must be looked for and membranes examined to ensure that the placenta is complete.

Management of fourth stage

The delivered woman should be monitored closely during the fourth stage of labor, which extends over 1–2 hours after delivery. Postpartum hemorrhage, vulval hematoma, and postpartum collapse can occur during this time. The pulse should be checked every 30 minutes and blood pressure monitored every hour. A distended bladder should be watched for as it may indicate a vulval hematoma. The urine output should be monitored (Box 15.17).

Box 15.17 Fourth stage of labor

- Watch for complications
 - Postpartum hemorrhage
 - Vulval hematoma
 - Postpartum collapse
- Monitor
 - Pulse half-hourly
 - Blood pressure hourly
 - Voiding and urine output

Episiotomy

Episiotomy is the surgical incision on the perineum to enlarge the vaginal introitus and facilitate delivery. There are two types of episiotomy (Fig. 15.12):

- **Median:** In the midline, extending from the posterior fourchette toward the anus
- **Mediolateral:** Extending laterally from the posterior fourchette in the midline, at an angle of 45 degrees

The incision involves the vaginal wall, perineal muscles, and skin and is about 3–4 cm in length. Episiotomy was routine practice for all nullipara and most multipara. With increasing

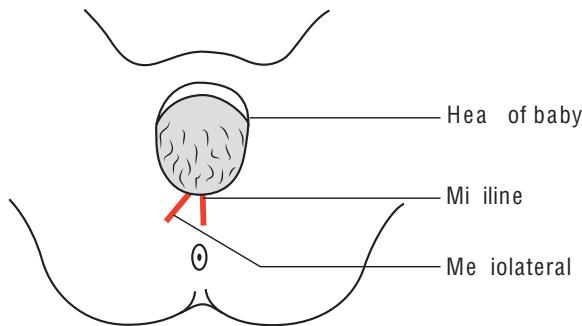


Figure 15.12 Types of episiotomy. Episiotomy can be median or mediolateral; both begin at the midline and extend either vertically toward the anus or laterally at 45 degrees.

Box 15.18 Proposed benefits of episiotomy

- Maternal
 - Slightly shorter second stage
 - Surgical incision rather than tear
 - Prevention of pelvic floor relaxation
 - Less urinary incontinence
 - Less fecal incontinence
 - Less anal sphincter injury
 - Less sexual dysfunction
- Neonatal
 - Less intracranial hemorrhage in preterms

awareness regarding the complications of episiotomy, the benefits of routine episiotomy have been questioned. The proposed benefits of episiotomy are listed in Box 15.18.

A review of randomized trials has found no difference in healing or postoperative pain with lacerations, an increase in anal sphincter injury with median episiotomies, and no increase in sexual dysfunction or urinary and fecal incontinence without episiotomies. **The American College of Obstetricians and Gynecologists and the Royal College of Obstetricians and Gynaecologists currently recommend selective (restrictive) episiotomy only if failure to perform episiotomy will result in perineal tear.**

Indications

Indications for episiotomy are listed in Box 15.19.

Types of episiotomy

A mediolateral episiotomy is the preferred type. Left or right mediolateral may be used according

Box 15.19 Indications for episiotomy

- When failure to perform episiotomy will result in tear
- Large baby
- Delivery as occipitoposterior
- Operative vaginal deliveries
 - Forceps
 - Vacuum extraction
- Shoulder dystocia
- Vaginal breech delivery

to the convenience of the obstetrician. Median episiotomy is not recommended because of risk of the extension to the anus and the rectum. However, a midline episiotomy is associated with less blood loss, better healing, easier repair, and less postoperative dyspareunia.

Timing of episiotomy

The timing for episiotomy is given in Box 15.20.

Box 15.20 Recommended type and timing of episiotomy

- Type
 - Mediolateral
- Timing
 - When head is 'crowning'
 - When breech is climbing the perineum
 - Before or after blades of forceps are placed but before traction

Procedure

The procedure for an episotomy is as follows:

- Local anesthetic is infiltrated at the site of the episiotomy, if the woman is not on epidural analgesia.
- Index and middle fingers are inserted between fetal scalp and perineum to protect the scalp.
- Knife or scissors may be used.
- Should start at midline of posterior fourchette.
- Should be cut
 - at 45 degrees for mediolateral (Fig. 15.13) and
 - directly downward for median.

Repair of episiotomy

This is performed after the placenta is delivered (Box 15.21).

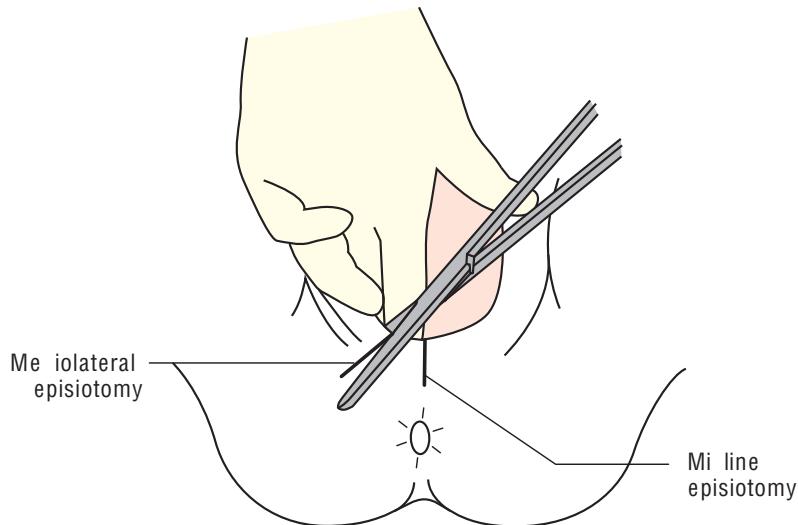


Figure 15.13 Episiotomy procedure. Index and middle fingers are inserted between the fetal scalp and perineum to protect the scalp and the cut is made with scissors or a knife.

Box 15.21 Repair of episiotomy

- After delivery of placenta
- 2–0 chromic catgut or rapidly absorbable polyglactin
- Continuous suturing preferred
- Adequate exposure of apex
- Suture in three layers
 - Vaginal mucosa
 - Perineal muscle
 - Skin
- Start with vaginal mucosa at apex
- Continue through muscle layer
- Continue through skin

If the three layers are sutured independently, continuous sutures are used for vaginal mucosa, interrupted sutures for muscle layer, and either continuous or interrupted for skin (Fig. 15.14).

Postoperative care

This includes a nonsteroidal anti-inflammatory agent orally or as a suppository. Local hygiene is maintained with regular cleaning with soap and water. Infrared or dry heat may be used for pain relief. Sitz baths are soothing. Antibiotics are *not* recommended.

Perineal lacerations

Perineal lacerations are classified as follows:

- *First degree*: Involves skin and vaginal mucosa
- *Second degree*: Involves skin, vaginal mucosa, and muscle (like an episiotomy)
- *Third degree*: Involves the anal sphincter
- *Fourth degree*: Involves the rectal mucosa (Fig. 15.15)

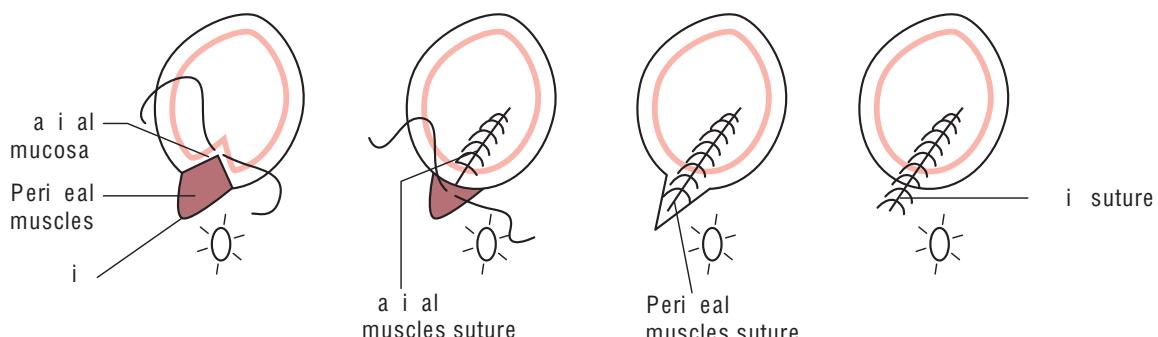


Figure 15.14 Suturing the episiotomy. Suturing is performed in three layers but with a continuous stitch, beginning with the apex of vaginal mucosa and continued through the muscle layer and skin.

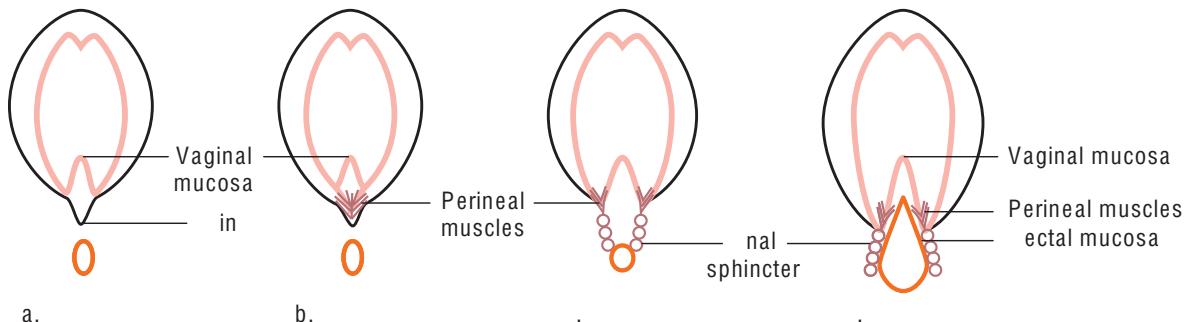


Figure 15.15 Perineal lacerations. **a.** First degree laceration involves skin and vaginal mucosa. **b.** Second degree laceration involves muscle layers as well. **c.** Third degree lacerations involve the anal sphincter. **d.** Fourth degree lacerations involve rectal mucosa.

Risk factors

Risk factors for perineal laceration are listed in Box 15.22. When laceration is anticipated, episiotomy should be performed to avoid it.

Box 15.22 Risk factors for perineal laceration

- Nulliparity
- Delivery as occipitoposterior
- Large baby
- Midline episiotomy
- Instrumental delivery
- Vaginal breech delivery

Box 15.23 Management of perineal lacerations

- First degree: No repair required unless bleeding
- Second degree: Similar to episiotomy
- Third and fourth degree
 - Repair in operating room
 - Regional or general anesthesia
 - Lithotomy position
 - Adequate lighting
 - Adequate exposure
 - Interrupted sutures: 2-0 rapidly absorbable polyglactin
 - Anal mucosa: Interrupted sutures
 - Anal sphincters: Overlap or end-to-end approximation
 - Vaginal mucosa, muscle layer, and skin: As in episiotomy
 - Postoperative
 - Laxatives: 3–4 days
 - Antibiotics: 5 days

Management of perineal lacerations

First degree lacerations do not require repair unless there is bleeding. Second degree lacerations are repaired in the same way as an episiotomy. Local anesthetic should be injected before suturing. Third and fourth degree lacerations should be repaired preferably in the operating room, under adequate anesthesia, good exposure, proper positioning, and adequate lighting (Box 15.23).

The repair is started initially with the anal mucosa. The mucosa is approximated with 2–0 rapidly absorbable polyglactin or chromic catgut. The internal and external anal sphincters are approximated next, using overlap or end-to-end approximation technique. The vaginal mucosa,

muscle layer, and skin are then sutured as done in an episiotomy (Fig. 15.16).

Postoperative care

After the repair of third and fourth degree lacerations, stool softeners are given for 3–4 days postoperatively to reduce the incidence of wound dehiscence. Antibiotics (third-generation cephalosporin + metronidazole) should be administered for 5 days. Infrared, dry heat, and oral analgesics should be administered for pain relief.

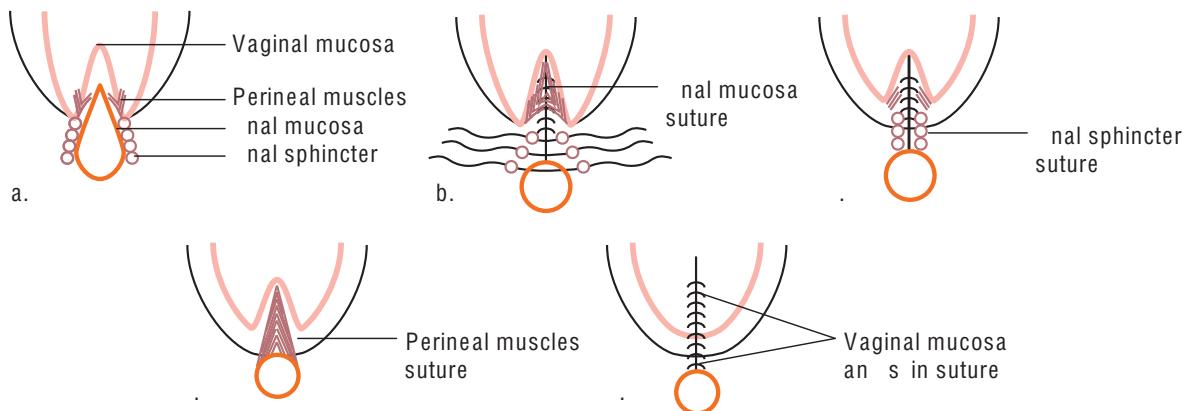


Figure 15.16 Suturing of the fourth degree laceration. **a.** Fourth degree laceration. **b.** Suturing begins with rectal mucosa. **c.** The anal sphincter fibers are approximated next. **d.** Perineal muscles sutured next. **e.** Finally, vaginal mucosa and skin are sutured.

Key points

- Management of labor begins with the diagnosis of labor. True labor must be differentiated from false labor. The woman should be admitted to the labor room only if the diagnosis of labor is reasonably certain.
- The woman's antenatal records must be reviewed and risk factors noted.
- Physical examination includes checking vital signs, abdominal palpation to ascertain frequency, duration and interval between contractions, presentation, position, and descent of fetal head, and fetal heart sounds.
- Vaginal examination to assess the cervix, status of membranes, and level and position of fetal head is the next step. The pelvis should be assessed for any abnormality.
- The presence of caput and molding should be looked for. The degree of molding should be noted.
- During the first stage of labor, the woman may be ambulated. Frequent clear fluids should be given orally and voiding encouraged. Uterine contractions and fetal heart rate should be monitored.
- Progress in labor is assessed by Crichton's maneuver and vaginal examination.
- Partograph is the graphic documentation of progress in labor. Cervical dilatation is plotted against time. Other maternal and fetal parameters are also recorded in the WHO composite partogram.
- Taking the minimum rate of dilatation as 1 cm/hour, the alert line is drawn beginning at 4-cm dilatation. The action line is drawn 4 hours to the right.
- Once the woman reaches the second stage of labor, preparations for delivery are made.
- The head is delivered by the modified Ritgen maneuver in which flexion is promoted by the downward

- pressure of the left hand on the occiput and extension aided by the right hand on the perineum.
- Shoulders are delivered by downward traction to deliver the anterior shoulder and upward movement to deliver the posterior shoulder.
- Prophylactic oxytocin (10 units IM) should be administered at the delivery of the anterior shoulder or after delivery of the baby, to prevent postpartum hemorrhage.
- The cord should be clamped 30 seconds to 1 minute after the delivery of the baby, about 5–6 cm from the baby's umbilicus. The cord should be cut between clamps.
- Monitoring of the mother should continue for 2 hours after delivery.
- Placental separation is identified by observing the signs. Placenta is delivered by controlled cord traction (modified Brandt–Andrews technique).
- Placenta and membranes should be examined for completeness. The woman should be monitored for 1–2 hours after delivery.
- Routine episiotomy is not recommended for all women. Use of episiotomy should be selective and only when indicated.
- Suturing of episiotomy should be in layers—vaginal mucosa, perineal muscles, and skin.
- Perineal lacerations are classified as first, second, third, and fourth degree lacerations. Third and fourth degree lacerations involve the rectal sphincter and mucosa and should be sutured under regional or general anesthesia in an operating theater under good light.

Self-Assessment

Case-based questions

Case 1

Mrs. CA, 22, primigravida, is admitted to the labor room with backache and pain in the lower abdomen. She has blood-stained discharge, and the pain is intermittent, progressively increasing in severity.

1. Is she in labor? How will you differentiate true from false labor?
2. What physical examination will you perform at admission?
3. How will you assess and document progress in labor?
4. What are the alert and action lines on the partograph?

Case 2

Mrs. DA, 27, second gravida, is admitted in labor. Her contractions are every 7 minutes, lasting for 30–40 seconds. It is a vertex presentation, head two-fifths palpable, cervix 5-cm dilated, vertex at -1 station, left occipitoanterior position. Membranes present. Fetal heart rate is 130/min.

1. How will you manage the first stage of labor?
2. How will you prepare for and conduct delivery?
3. How will you manage the third stage?
4. What would be the indications for episiotomy in this woman?

Answers

Case 1

1. Yes, she is in labor, because she has backache and lower abdominal pain, the uterine contractions are increasing in frequency and intensity, and there is associated show. Further signs to look for would be dilatation and effacement of the cervix.
2. General examination for vital signs such as pulse and blood pressure, abdominal examination for uterine contractions, duration, frequency, presentation, and position of presenting part, descent of head, and fetal heart rate. Vaginal examination for effacement and dilatation of cervix, presentation, position, station of presenting part, status of membranes, and type of pelvis.
3. Dilatation of cervix and descent of head should be evaluated by abdominal and vaginal examination every 4 hours. This should be plotted on a partograph. In addition, uterine contractions, fetal heart

rate, meconium, and maternal parameters should be noted in the composite partograph.

4. The alert line is drawn from 4 cm dilatation, taking minimum rate of dilatation as 1 cm/hour. The action line is drawn 4 hours to the right. If the graph crosses the alert line, progress is slow and labor is abnormal. If it crosses the action line, definitive steps should be taken to rectify the problem and expedite delivery.

Case 2

1. Ambulate the parturient, maintain hydration by frequent clear fluids orally, and encourage voiding. Administer analgesia. Monitor progress in labor and maternal and fetal well-being.
2. When in the second stage, the parturient should be put in dorsal position, vulva and perineum cleaned with antiseptic, and draped. The head is delivered by modified Ritten maneuver by downward pressure on the occiput with the left hand and gentle upward pressure on the chin through the perineum with the right hand. Perineal support should be given to prevent lacerations. Shoulders are delivered by downward traction to deliver the anterior shoulder and upward movement to deliver the posterior shoulder.
3. Administer prophylactic oxytocin 10 units IM, look for signs of placental separation, and deliver placenta by controlled cord traction. Monitor the tone and size of uterus with the left hand on the abdomen.
4. If the baby is large, perineal tear imminent, or shoulder dystocia.

Sample questions

Long-answer questions

1. Define normal labor. Discuss the stages of labor and their management.
2. What is partograph? How will you monitor a woman in labor and document the progress of labor?

Short-answer questions

1. False labor
2. Partograph
3. First stage of labor
4. Delivery of placenta
5. Episiotomy
6. Perineal laceration
7. Caput succedaneum
8. Molding of fetal head

16

Induction of Labor

Case scenario

Mrs. MN, 25, was admitted to the hospital in the 37th week of pregnancy. She had developed pregnancy induced hypertension at 36 weeks. Within a week, her blood pressure went up to 160/100 mm Hg and a urine test revealed 2+ albumin. Delivery of the baby would be the best treatment for her condition. She needed induction of labor.

Introduction

Induction of labor is a therapeutic option when the benefits of delivery outweigh the risks of continuing the pregnancy. Induction is indicated when complications of pregnancy may have a negative impact on the health of the mother, the fetus, or both. The decision to induce labor must take into consideration the potential maternal and fetal risks associated with this procedure.

Definition

Induction of labor refers to methods used for the stimulation of uterine contractions to bring about delivery before the onset of spontaneous labor or after the period of viability.

Indications

Labor may be induced because of maternal or fetal indications (Box 16.1). In some cases, the indications may overlap.

Contraindications

Induction of labor is contraindicated generally in the same situations where spontaneous labor and vaginal delivery are contraindicated (Box 16.2).

Prerequisites for induction

Before a decision is made to induce labor, certain prerequisites should be met:

- The indication for the induction must be assessed and discussed.

Box 16.1 Indications for induction of labor

- aternal*
 - Postdated or postterm pregnancy
 - Preterm, prelabor rupture of membranes
 - Prelabor rupture of membranes at term
 - Placental abruption
 - Hypertensive disorders
 - Gestational hypertension
 - Preeclampsia
 - Eclampsia
 - Chronic hypertension
 - Diabetes mellitus
 - Antiphospholipid syndrome
 - Intrauterine fetal demise
- etal*
 - Fetal growth restriction
 - Oligohydramnios
 - Rh alloimmunization
 - Nonreassuring fetal testing

Box 16.2 Contraindications for induction of labor

- Abnormal fetal presentation
 - Breech
 - Brow
 - Face
 - Transverse lie
- Suspected cephalopelvic disproportion/contracted pelvis
- Placenta previa
- Umbilical cord presentation
- Severe fetal growth restriction with signs of fetal compromise
- Previous uterine rupture
- Surgical scar on the uterus
 - Previous classical cesarean section
 - Previous inverted T incision
 - Previous myomectomy scar entering the endometrial cavity
- Active maternal genital herpes infection
- Invasive cervical cancer

- Any contraindication must be ruled out.
- The cervix must be assessed to see if it is favorable for induction (Bishop score).
- The pelvis must be assessed to rule out the possibility of fetopelvic disproportion or dystocia.
- Fetal size and presentation must be assessed.
- Fetal well-being must be assessed prior to induction.

The checklist for induction of labor is enumerated in Box 16.3.

Box 16.3 Checklist for induction of labor

- Review indication
- Assess and discuss
 - Indication
 - Probability of failed induction
- Confirm gestational age
 - LMP
 - Ultrasound scan before 20 weeks
- Evaluate fetal well-being
 - Cardiotocography
 - Biophysical profile/Doppler, if required
- Abdominal examination
 - Fetal size
 - Presentation
 - Descent of presenting part
- Pelvic examination
 - Favorability of cervix
 - Effacement
 - Dilatation
 - Consistency
 - Station of presenting part
 - Adequacy of pelvis

P, last menstrual period.

Prediction of success of induction of labor

It is difficult to predict the success of labor induction. When a vaginal delivery follows labor induction, the induction is considered successful. *Failed induction* results in cesarean section.

Some patient characteristics have been found to be associated with a higher rate of vaginal delivery (Box 16.4). They are not specific predictors, since they are indicative of likelihood of vaginal delivery in spontaneous labor as well. The only method that is currently in use to predict the success of labor induction is the modified Bishop score.

Box 16.4 Predictors of success of induction of labor

- Patient characteristics
 - Gestational age close to term
 - Favorable pelvic configuration
 - Multiparity
 - Fetal weight <3.5 kg
 - Tall stature
 - Normal body mass index
 - High Bishop score

Bishop score for assessment of the cervix

The most important predictor of the success of induction of labor is the status of the cervix. To assess if the cervix is **favorable (ripe)** or **unfavorable (unripe)**, the Bishop score, first described in 1964, is used.

The modified Bishop score (Table 16.1) is based on a pelvic examination to assess the status of the cervix and the station of the vertex. The five parameters assessed are as follows:

- Dilatation of the cervix (cm)
- Effacement of the cervix (%)
- Station of the vertex (from -3 to +2)
- Consistency (firm, medium, or soft)
- The position of the external os (posterior, mid, or anterior)

Effacement may also be assessed by the length of the cervix since the cervix becomes shorter as it effaces. This is a more objective assessment of effacement.

Each parameter is given a score and the total is called the *Bishop score*. The cervix is considered unfavorable if the score is 6 or less.

A **high Bishop score prior to induction (8 or more)** predicts that the likelihood of vaginal delivery is similar to spontaneous onset of labor. A **low Bishop score (6 or less)** predicts an increased rate of failed induction, resulting in cesarean section. When the Bishop score is low, cervical ripening is performed to improve the score, prior to induction.

Preinduction cervical ripening

Induction may be indicated even when the cervix is unfavorable or unripe (Bishop score <6). In these cases, techniques for cervical ripening are utilized. The methods used include the following:

- Sweeping of membranes
- Pharmacological
- Mechanical

The methods of cervical ripening are summarized in Box 16.5.

Box 16.5 Methods for cervical ripening

- Sweeping of membranes
- Pharmacological
 - Prostaglandin E₂ (intracervical, intravaginal)
 - Prostaglandin E₁ (vaginal, oral)
- Mechanical
 - Transcervical balloon catheter
 - Foley catheter
 - Double balloon catheter
 - Transcervical catheters with extra-amniotic saline instillation (EASI)
 - Laminaria

Sweeping of fetal membranes

Sweeping of fetal membranes is also called *stripping of membranes*. It is an outpatient procedure. It can only be performed if the cervix is dilated enough to allow insertion of a finger. This method should only be offered if the indication

Table 16.1 Bishop score

Parameter	Bishop score			
	0	1	2	3
Dilatation (cm)	0	1–2	3–4	5–6
Length of cervix/effacement	>4 cm/0%–30%	2–4 cm/40%–50 %	1–2 cm/60%–70%	<1cm/80%
Station	-3	-2	-1 or 0	+1 or +2
Consistency	Firm	Medium	Soft	–
Position	Posterior	Mid	Anterior	–

*Each parameter gets 0–3 points and the cumulative points give the Bishop score.

Box 16.6 Sweeping of membranes

- Outpatient procedure
- For nonurgent induction
- More effective in multigravidae than in primigravidae
- Works by releasing prostaglandin F_{2α}
- May result in rupture of membranes

for induction is nonurgent because the response to membrane sweeping is unpredictable and slow (Box 16.6).

The sweeping is done by gently inserting a finger through the open external os into the space between the membranes and the lower uterine segment. The finger is then swept in a circular motion through 360 degrees. Care is taken to keep the finger close to the uterine wall. The process strips the amniotic membrane off the lower uterine segment.

Sweeping the membrane from the uterine wall causes increased local production and release of prostaglandin F_{2α} (PGF_{2α}) from the decidua and adjacent membrane, thereby leading to onset of labor. Following sweeping of membranes, women must be counseled that there may be bleeding, discomfort, and contractions that may not lead to labor in the next 24 hours.

Sweeping of membranes may result in pre-labor rupture of membranes. Bleeding can be a serious complication if sweeping is done in an undiagnosed placenta previa or vasa previa.

Pharmacological methods of cervical ripening

Pharmacological agents available for cervical ripening and labor induction currently include

prostaglandins and misoprostol. Other pharmacological agents, including oxytocin, are less commonly used.

Prostaglandins

Prostaglandins are most commonly used for cervical ripening in an unscarred uterus. Quite often, prostaglandins not only improve the cervical score and cause ripening, they also initiate labor. The need for oxytocin to induce or augment labor is thus reduced. The commonly used prostaglandins are prostaglandin E₂ (PGE₂) and prostaglandin E₁ (PGE₁). See Table 16.2 for prostaglandin regimens for cervical ripening.

rostaglan in (inoprostone)

There are two PGE₂ preparations available (Box 16.7). One is in the form of a preloaded intracervical gel which contains 0.5 mg of dinoprostone in 2.5 mL of gel. The other is an intra-vaginal insert which contains 10 mg of dinoprostone in a timed-released formulation.

Intracervical gel (Box 16.8): The preloaded syringe comes with a plastic insertor, which is placed into the cervical canal under direct vision. 0.5 mg of the intracervical gel

Box 16.7 Prostaglandin E₂

- Route
 - Intracervical
 - Intravaginal
- Induces cervical ripening
- Reduces failed induction rate
- Reduces the need for oxytocin
- Shortens induction-delivery interval

Table 16.2 Prostaglandin regimens for cervical ripening (in unscarred uterus)

Drug	Route dose	Caution
Dinoprostone gel (PGE ₂) 0.5 mg	Cervical insertion every 6 hours for a maximum of 3 doses in a 24-hour period	Interval of 6 hours from last dose before oxytocin is started
Dinoprostone (PGE ₂) insert 10 mg	Placed high in posterior fornix	Easy to remove in case of tachy-systole
Misoprostol (PGE ₁)	Vaginal: 25 µg tablet every 3–6 hours Oral: 50 µg every 3–6 hours	<ul style="list-style-type: none"> • Tachysystole common with vaginal dose of >25 µg • Interval of 4 hours after the last dose before oxytocin is started

Box 16.8 Prostaglandin E₂ intracervical gel

- 0.5 mg
- Inside cervical canal
- Every 6 hours
- Maximum of 3 doses in 24 hours

is administered into the cervical canal every 6 hours up to a maximum of three doses in a 24-hour period.

Intravaginal insert (Box 16.9): This contains 10 mg of dinoprostone in a small white polymer mesh sac and has an attached tape that helps during removal. It is left in the vagina until active labor starts or for 12 hours.

rostaglan in (misoprostol)

Misoprostol is available as a 25 µg or 100 µg tablet. The 100 g tablet can be broken into four equal pieces for cervical ripening. The tablets can be administered both vaginally and orally (Box 16.10). The dosages for the vaginal and oral routes are summarized in Boxes 16.11 and 16.12, respectively.

Side effects of prostaglandin ins

Though prostaglandins have minimal systemic side effects, they are associated with tachysystole and uterine hyperstimulation.

Box 16.9 Prostaglandin E₂ intravaginal insert

- 10 mg
- In posterior fornix
- Left for 12 hours or until labor starts
- Expensive

Box 16.10 Prostaglandin E₁

- Route
 - Vaginal
 - Oral
- Induces cervical ripening
- More effective than PGE₂
- Associated with
 - tachysystole
 - fetal heart rate abnormalities
 - meconium staining
- Can cause uterine rupture
- Contraindicated in scarred uterus (previous cesarean or myomectomy)
- No increase in cesarean section rate
- Effects are dose related

Box 16.11 Vaginal misoprostol (prostaglandin E₁) for cervical ripening

- 25 µg
- Placed high in vagina
- Can be repeated every 3–6 hours
- Maximum 6 doses

Oral misoprostol (prostaglandin E₁) for cervical ripening

- 50 µg
- Can be repeated every 4–6 hours
- Not used routinely for cervical ripening

Vaginally administered PGE₂ is associated with tachysystole (six or more contractions in 10 minutes) in 1%–5% of women. Misoprostol has been associated with uterine hyperstimulation (tachysystole leading to nonreassuring fetal heart rate pattern). A summary of side effects of prostaglandins used for cervical ripening is presented in Box 16.13.

Prostaglandins (especially misoprostol) are contraindicated in a woman with a previous cesarean section, due to the increased risk of uterine rupture.

Other pharmacological agents

Oxytocin has been extensively used in the past for cervical ripening. Since PGE₂ and PGE₁ have been found to be better than oxytocin in randomized trials, it is now used only for labor induction. Relaxin, hyaluronidase, and other agents such as glyceryl trinitrate and isosorbide mononitrate have been tried. Success rates vary and their safety profiles are not known (Box 16.14).

Nipple stimulation (to induce oxytocin release from the pituitary gland) and sexual intercourse

Box 16.13 Side effects of prostaglandins used for cervical ripening

- Vaginal prostaglandin E₂
 - Tachysystole (6 or more contractions in 10 minutes)
 - Affects 1%–5% of women
- Misoprostol
 - Hyperstimulation (tachysystole leading to nonreassuring fetal heart rate pattern)
 - Contraindicated in previous cesarean section

Box 16.14 Pharmacological agents not recommended for cervical ripening

- Oxytocin
- Relaxin
- Mifepristone
- Hyaluronidase
- Nitric oxide donors
 - Glyceryl trinitrate
 - Isosorbide mononitrate

have also been described but are not methods of choice (Box 16.15).

Mechanical methods of cervical ripening

The common methods used for mechanically stimulating cervical ripening are as follows:

- Transcervical catheter
 - Foley
 - Double balloon catheter
- Transcervical catheter with extra-amniotic saline infusion (EASI)
- Laminaria

Transcervical Foley catheter

A #16 Foley catheter with a 30 mL bulb and with the tip cut off is used. It is passed through the cervical canal, past the internal os, and into the extra-amniotic space. The bulb is then filled with 30 mL of saline and the Foley catheter is pulled back gently so that the bulb rests against the internal os (Fig. 16.1). The catheter is taped to the woman's thigh.

The catheter is left in place till it is extruded or for 12 hours. Cervical ripening is usually achieved with this method and may also result in the onset of labor.

Box 16.15 Methods not recommended for cervical ripening

- Nipple stimulation
- Sexual intercourse
- Castor oil
- Acupuncture
- Hot baths
- Enema

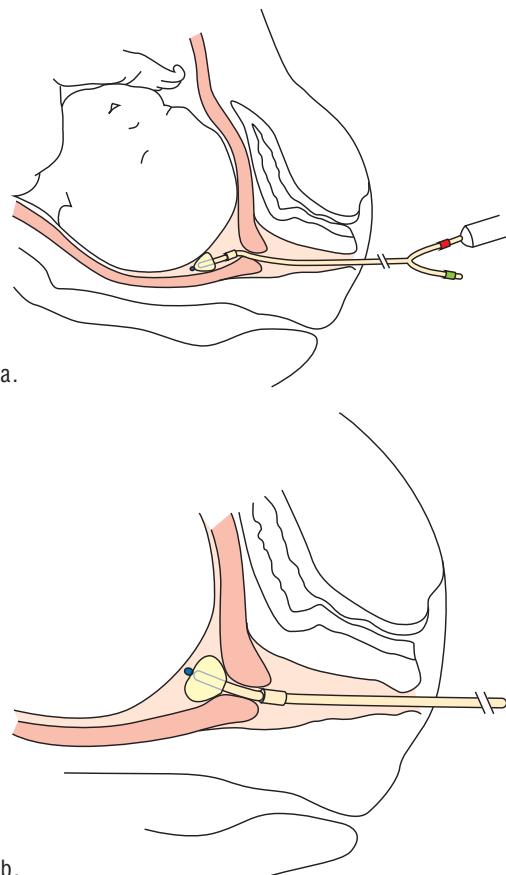


Figure 16.1 Transcervical Foley catheter for cervical ripening. **a.** Foley catheter being introduced into the extra-amniotic space. **b.** Foley bulb inflated and placed snugly against the internal os.

Transcervical double balloon catheter

Double balloon catheters with one balloon placed below and the other above the internal os are available (Fig. 16.2). The first (distal) balloon is inserted beyond the internal os and inflated with 40 mL of saline, and gentle traction is applied to the catheter. The second (proximal) balloon appears below the external os and is inflated. When inflated, the two balloons are above and below the cervical canal. As the cervix effaces, the two balloons come together. The cervix dilates simultaneously. Success rates have been higher with the double balloon catheters but they are not in common use.

Extra-amniotic saline infusion (EASI) is a modification of this method (Fig. 16.3). Room temperature saline is infused through the catheter port. This method has not been shown to

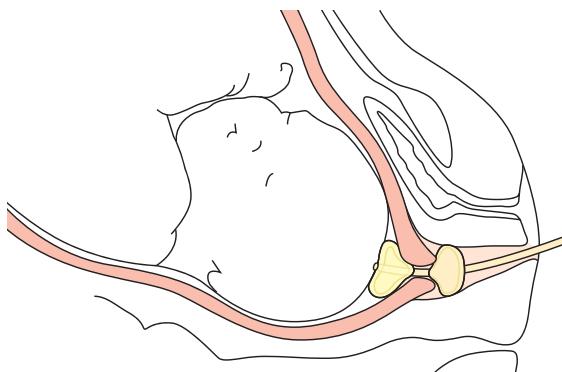


Figure 16.2 Transcervical double balloon catheter being placed in the extra-amniotic space.

Box 16.16 Complications of catheter insertion for cervical ripening

- Rupture of membranes
- Febrile morbidity
- Displacement of the presenting part
- Significant vaginal bleeding in women with a low-lying placenta

have a major advantage over other methods of cervical ripening.

The complications of catheter insertion for cervical ripening are summarized in Box 16.16.

Laminaria

Laminaria tents are usually used for pregnancy termination rather than for preinduction cervical ripening. They are hygroscopic, that is, they absorb moisture. Once they are placed in the cervix, they slowly expand due to the absorption of moisture. By disrupting the chorioamniotic decidual surface, they cause the release of endogenous prostaglandins and result in cervical ripening. Laminaria are removed 12–24 hours after placement.

Labor induction

Once the cervix becomes favorable, labor is induced, usually with oxytocin. Amniotomy (artificial rupture of membranes or AROM) may or may not be performed along with oxytocin infusion. Prostaglandins used for ripening the cervix may also stimulate uterine contraction, and labor may follow. Mechanical methods of

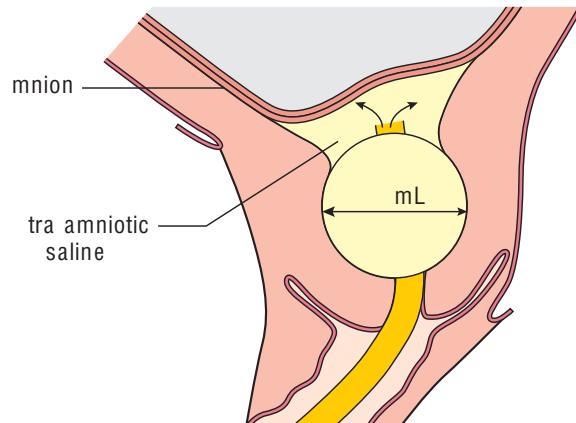


Figure 16.3 Extra-amniotic saline infusion.

cervical ripening are usually followed by oxytocin to induce labor. The terminology used to describe uterine contractions during labor induction is listed in Box 16.17.

Methods of induction

The available methods of labor induction are as follows:

- Intravenous oxytocin
- Amniotomy

Box 16.17 Terminology used to describe uterine contractions during labor induction

- Uterine contractions
 - Frequency
 - Duration
 - Intensity
 - Relaxation time between contractions
- Desired frequency
 - 3–5 contractions in 10 minutes
- Effective duration
 - 30–60 seconds
- Desired intensity
 - Uterus cannot be indented by palpating fingers at the peak of the contraction
- Optimal relaxation time between contractions
 - ≥3 minutes
- Tachysystole
 - >6 contractions in 10 minutes
- Uterine hypertonus
 - Single contraction lasting >2 minutes
- Hyperstimulation
 - Tachysystole or hypertonus associated with nonreassuring fetal heart rate pattern

- Prostaglandins
- Sweeping (or stripping) of membranes

Oxytocin

Oxytocin is an octapeptide which is available in its synthetic form. Oxytocin was the first polypeptide hormone to be sequenced and synthesized and won Vincent du Vigneaud a Nobel Prize in 1953.

Oxytocin is the most common drug used for the induction of labor. It is administered intravenously. It is not used orally since it is degraded to inactive form when administered orally. In the presence of a ripe cervix, induction of labor with oxytocin has a high rate of success. If the cervix is not favorable (Bishop score of 6 or less), cervical ripening will improve the success of induction, as described previously.

When oxytocin is administered, uterine activity and fetal heart rate must be continuously monitored.

Intravenous oxytocin administration

- 5 units of oxytocin are diluted in 500 mL of normal saline.
- Ideally, it should be administered with an infusion pump.
- If an infusion pump is not available, the rate of infusion must be monitored manually.
- 5 units of oxytocin in 500 mL gives a concentration of 10 mU/mL (or 0.5 mU in 1 drop of the infusion, calculated at 20 drops/mL).

Dosage of oxytocin

Two regimens are described for the administration of intravenous oxytocin: *low dose* and *high dose* (Table 16.3).

Low-dose regimens

- Low dose of oxytocin
- Less frequent increases in dose (every 40 minutes)

- Less occurrence of uterine tachysystole and associated fetal heart rate changes

High-dose regimens

- High dose of oxytocin
- More frequent dose increases (every 20 minutes)
- Associated with shorter labor
- Lower rates of cesarean delivery for dystocia
- Increased rates of uterine tachysystole with associated fetal heart rate changes

Box 16.18 lists the optimal end points looked for in induction with oxytocin.

Side effects of oxytocin

The maximum dose recommended for oxytocin varies from 32 mU/min to 40 mU/min. If the uterus does not respond to 32 mU/min, it probably is prudent not to increase the dose beyond that. Oxytocin dosage in mU, drops/min, and mL/hour (using 5 units in 500 mL of normal saline) is given in Table 16.4.

Side effects of oxytocin

The side effects of oxytocin are enumerated in Box 16.19.

Hyponatremia (water intoxication)

Hyponatremia occurs when high doses of oxytocin (e.g., 40 mU/min) are administered in large quantities of hypotonic solutions such as dextrose in water. This results in excessive water retention and ends in severe, symptomatic hyponatremia. It can be avoided by using more concentrated solutions of oxytocin (5 units in

Box 16.18 Optimal end points with oxytocin induction

- Strong contractions
- At intervals of 2-3 minutes
- Lasting 45–60 seconds
- Progressive cervical dilatation

Table 16.3 Low- and high-dose regimens for oxytocin administration

Regimen	Starting dose (mU)	Incremental increase (mU/min)	Dosage interval in minutes
Low dose	0.5–2	1–2	15–40
High dose	6	3–6	15–40

Table 16.4 Dosage of oxytocin for induction of labor

m of oxytocin	Drops min (manual)	mL hour (infusion pump)
0.5	1	3.75
2	4	15
4	8	30
6	12	45
8	16	60
10	20	75
14	24	90
16	28	105
18	32	120
20	36	135
24	40	150
28	44	165
30	48	180
32	52	195

Box 16.19 Side effects of oxytocin

- Hyponatremia (water intoxication)
 - Anorexia
 - Nausea and vomiting
 - Abdominal pain
 - Lethargy, drowsiness, unconsciousness
 - Grand mal seizures
- Hypotension (rare)
- Neonatal hyperbilirubinemia

500 mL of normal saline) and avoiding oxytocin dose of more than 32 mU/min.

Treatment of water intoxication includes immediate stopping of oxytocin and any hypotonic solutions. Correction of hyponatremia must be performed carefully and consists of restricting water intake and careful administration of hypertonic saline if the woman is symptomatic.

Hypotension

This is a very rare complication and may occur with rapid infusion of oxytocin.

Neonatal hyperbilirubinemia

Though the induction of labor with oxytocin is associated with an increased rate of hyperbilirubinemia in the neonate, it is probably not a direct side effect of oxytocin.

Augmentation of labor with oxytocin

Oxytocin is used to augment labor in women who have a protracted latent phase or protracted active phase of labor. The dosage regimens used are similar to the dosage used for induction of labor. However, since the woman is already in labor, the uterus might respond at lower doses.

Amniotomy or artificial rupture of membranes (ARM)

The combination of amniotomy plus intravenous oxytocin administration is more effective than amniotomy alone. During oxytocin induction, early amniotomy at a cervical dilatation of 4 cm or more is an effective way of hastening labor. The other advantage of early amniotomy is that it helps in the assessment of the liquor, particularly for the presence of meconium. The fetal heart rate should be auscultated/monitored soon after amniotomy to look for fetal heart rate decelerations, which may signal occult cord prolapse (Box 16.20).

- Amniotomy may be performed
- to induce labor;
 - to augment labor when progress of labor is slow;
 - as an elective procedure after 4-cm dilatation.

Procedure

Under aseptic conditions, two fingers are inserted into the cervix and the membranes are palpated (Fig. 16.4). Using a sharp instrument such as an artery forceps, Kocher's forceps, or a sterile plastic hook called an *amnihook*, the membranes are ruptured. It helps to wait for a contraction, so that the membranes bulge a little, making it easier to rupture them. Any meconium staining of the amniotic fluid should be noted. Cord prolapse must be looked for before the hand is withdrawn.

Box 16.20 Amniotomy

- Reduces the duration of labor
- Helps in assessing liquor for meconium
- Needs monitoring for occult cord prolapse
- Should be done only when
 - cervix is partially effaced and dilated
 - vertex has descended into the pelvis
 - decision has been made to deliver within 12–24 hours of amniotomy

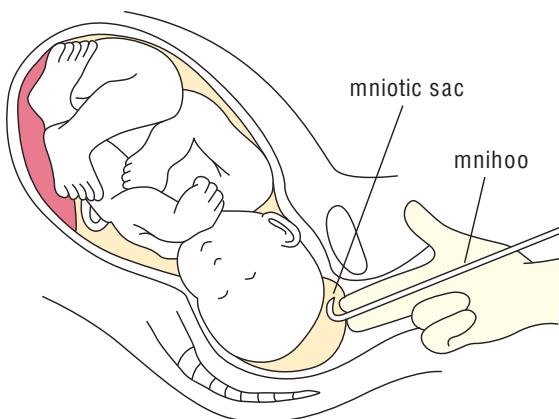


Figure 16.4 Amniotomy (artificial rupture of membranes).

Complications of amniotomy

Complications include the following:

- Cord prolapse
- Chorioamnionitis, if labor is prolonged
- Fetal heart decelerations due to cord compression

Prostaglandins

Prostaglandins E₂ and E₁ are typically used for cervical ripening, as mentioned previously. The role of prostaglandins in the presence of a favorable cervix in a term pregnancy is not clear, and oxytocin is preferred in that situation.

Role of prostaglandins in intrauterine fetal demise (IUD)

If pregnancy needs to be terminated in the second or third trimester in the presence of an

Box 16.21 Prostaglandins for pregnancy termination in intrauterine fetal demise

Second trimester

- Mifepristone (200 mg) administered orally
- Misoprostol
 - 48 hours after mifepristone
 - 600–800 µg intravaginally
 - Followed by
 - 400 µg orally or intravaginally
 - Every 3 hours up to 4 doses.

Third trimester

- Prostaglandin E₂ or misoprostol
 - For cervical ripening
 - Followed by oxytocin for induction of labor

intrauterine fetal death, prostaglandins are the drugs of choice for inducing labor (Box 16.21).

Sweeping (or stripping) of membranes

Routine stripping of membranes at 38 weeks to induce labor is of limited benefit, when compared to prostaglandins.

Complications of labor induction

Induction of labor can be associated with certain complications (Box 16.22).

Management of tachysystole, hypertonus, and uterine hyperstimulation

If excessive uterine activity (>6 contractions in 10 minutes or contractions lasting longer than 2 minutes) occurs, with or without a nonreassuring fetal heart rate pattern,

- Discontinue intravenous oxytocin infusion.
- Reposition the woman in the lateral position.
- Administer oxygen by face mask (at 10 L/min).
- Increase intravenous hydration if not contraindicated by the maternal condition (a bolus of 500 mL of Ringer's solution).
- Assess blood pressure.
- Perform pelvic examination to assess cervical dilation and rule out cord prolapse.
- Administer a tocolytic, such as terbutaline 250 µg, subcutaneously or intravenously, if hypertonus does not respond to the above measures.

Box 16.22 Complications of induction

- Tachysystole, hypertonus, and uterine hyperstimulation
- Uterine rupture (in women with previous cesarean section)
- Amniotic fluid embolism
- Chorioamnionitis
- Risk of cesarean section
- Atonic postpartum hemorrhage

Starting oxytocin after tachysystole

Oxytocin should be restarted carefully after an episode of tachysystole. If there are no persistent abnormal changes in fetal heart rate, the oxytocin is restarted at a lower dosage. The incremental increase should be reduced to 3 mU/min if hyperstimulation is present and reduced to 1 mU/min if there is recurrent hyperstimulation.

Uterine rupture

Though the risk of uterine rupture is very low with induction, care must be taken in the case of a grand multipara. Most cases of uterine rupture occur in women with a scarred uterus and therefore special care must be taken in women with a previous cesarean section.

Amniotic fluid embolism

This is a very rare complication of labor induction. Its incidence has been reported as 10.3 per 100,000 births with medical induction versus 5.2 per 100,000 births without medical induction.

Chorioamnionitis

If the interval between the onset of induction and delivery is prolonged, the risk of chorioamnionitis increases. Once membranes are ruptured, the risk of chorioamnionitis will increase with increase in the duration between amniotomy and delivery.

Risk of cesarean section

Any increase in the risk of cesarean delivery related to induction appears to be associated primarily with an unfavorable cervix at admission.

The rate of cesarean delivery is increased approximately twofold in nulliparous women undergoing elective induction as compared to those women in spontaneous labor. With optimal cervical ripening, this difference in rate comes down considerably.

Postpartum hemorrhage

The risk of postpartum hemorrhage increases with induction of labor. Prophylactic measures must be taken to avoid postpartum hemorrhage in women undergoing induction of labor.

Failed induction

When, following induction, labor does not enter the active phase (failure to generate regular contractions and cervical change) or, in the presence of regular contractions, vaginal delivery is not achieved, it is termed a *failed induction*. This term must only be used in the following cases:

- Adequate measures have been taken to achieve cervical ripening.
- Adequate dosage of oxytocin has failed to generate regular contractions.
- Regular contractions have failed to establish active phase of labor.

Causes of failed induction are given in Box 16.23.

Box 16.23 Causes of failure to progress with induction

- Inadequate cervical ripening
- Inadequate dosage of oxytocin
- Large baby
- Malposition
- Deflexion of vertex
- Small pelvis
- Cervical dystocia

Key points

- The decision to induce labor is taken when the benefits of delivery outweigh the potential risks of induction to the mother and fetus, and there are no contraindications to induction.
- Assessing the cervix with the Bishop score is the best predictor of the success of induction.
- In the presence of an unfavorable cervix, cervical ripening with prostaglandins or mechanical methods improves the success rate of induction.
- Prostaglandins should be avoided in a uterus with a scar (previous cesarean section).
- Oxytocin is the drug of choice for induction of labor in the presence of a favorable cervix.
- Oxytocin may be administered with a low-dose regimen or a high-dose regimen as long as a specific protocol is followed.
- High doses of oxytocin should not be administered in hypotonic solutions, as this can lead to excessive water retention and dilutional hyponatremia.
- Early amniotomy (at a cervical dilatation of 4 cm or more) is an effective way of hastening labor. Amniotomy also allows assessment of the amniotic fluid for the presence of meconium.
- The side effects of labor induction include tachysystole, hypertonus, uterine hyperstimulation, uterine rupture (in women with previous cesarean section), amniotic fluid embolism, chorioamnionitis, risk of cesarean section, and atonic postpartum hemorrhage.

Self-Assessment

Case-based questions

Case 1

Mrs. MN, 25, primigravida, was admitted to the hospital in the 37th week of pregnancy. She had developed pregnancy induced hypertension at 36 weeks. Within a week, her blood pressure went up to 160/100 mm Hg and the urine test revealed 2+ albumin. Her Bishop score was 4.

1. What is a favorable Bishop score?
2. Mention three methods of cervical ripening.
3. Which cervical ripening agent does not result in hyperstimulation?
4. What is the contraindication to the use of misoprostol?

Case 2

Mrs. JK, 26, gravida 2, para 1, was admitted in labor. Due to nonprogress of labor, augmentation was started with oxytocin.

1. What is oxytocin?
2. What are the starting doses of oxytocin for the low-dose and high-dose regimens?
3. Mention two interventions for hyperstimulation with oxytocin.
4. What is water intoxication?

Answers

Case 1

1. A Bishop score of ≥ 8 is considered favorable.
2. Foley catheter, PGE₂ gel, and PGE₁.

3. Foley catheter does not result in hyperstimulation.
4. Misoprostol should not be used in a scarred uterus.

Case 2

1. Oxytocin is an octapeptide which is available in its synthetic form.
2. Low-dose regimen: 0.5–2 mU
High-dose regimen: 6 mU
3. a. Stop the oxytocin infusion.
b. Turn the patient to the lateral position.
4. When high doses of oxytocin (e.g., 40 mU/min) are administered in large quantities of hypotonic solutions such as dextrose in water, it results in excessive water retention and ends in severe, symptomatic hyponatremia (water intoxication).

Sample questions

Long-answer question

1. Mention indications, contraindications, and complications of induction of labor.

Short-answer questions

1. Cervical ripening
2. Bishop score

17

Intrapartum Fetal Surveillance

Case scenario

Mrs. MG, 25, came in labor at 38 weeks' gestation. She was having contractions every 3–4 minutes and the contractions were lasting 40–50 seconds. She was a known hypertensive. At 4-cm cervical dilatation, membranes ruptured spontaneously and the amniotic fluid was meconium stained. She needed intrapartum evaluation to make sure that the fetus was tolerating labor well and there was no fetal hypoxia.

Introduction

It is the goal of every obstetrician to ensure that the mother and fetus tolerate labor well. However, assessing the fetal response to labor is a challenge. Intrapartum fetal surveillance aims to prevent adverse perinatal outcomes arising from fetal metabolic acidosis related to labor. Monitoring of the fetal heart is an integral part of the care of the fetus in labor.

rationale for intrapartum fetal surveillance

Two major factors affect fetal oxygenation in labor:

- Placental blood flow
- Blood flow through the umbilical cord

In the normal course of labor, uterine contractions cause a decrease in uteroplacental blood flow and therefore a decrease in oxygen delivery to the fetus. A well-oxygenated term fetus usually tolerates this and shows no adverse effect. Even a well-compensated, term fetus may respond poorly to a prolonged period of decreased oxygenation as may occur in abruptio, bleeding due to placenta previa, supine hypotension, and hypotension associated with epidural analgesia.

In conditions with chronic placental insufficiency such as hypertension, diabetes, and antiphospholipid antibody syndrome where there is fetal growth restriction, the fetus may not tolerate the decrease in oxygenation and may show signs of hypoxia. The preterm fetus too tolerates hypoxia poorly (Fig. 17.1).

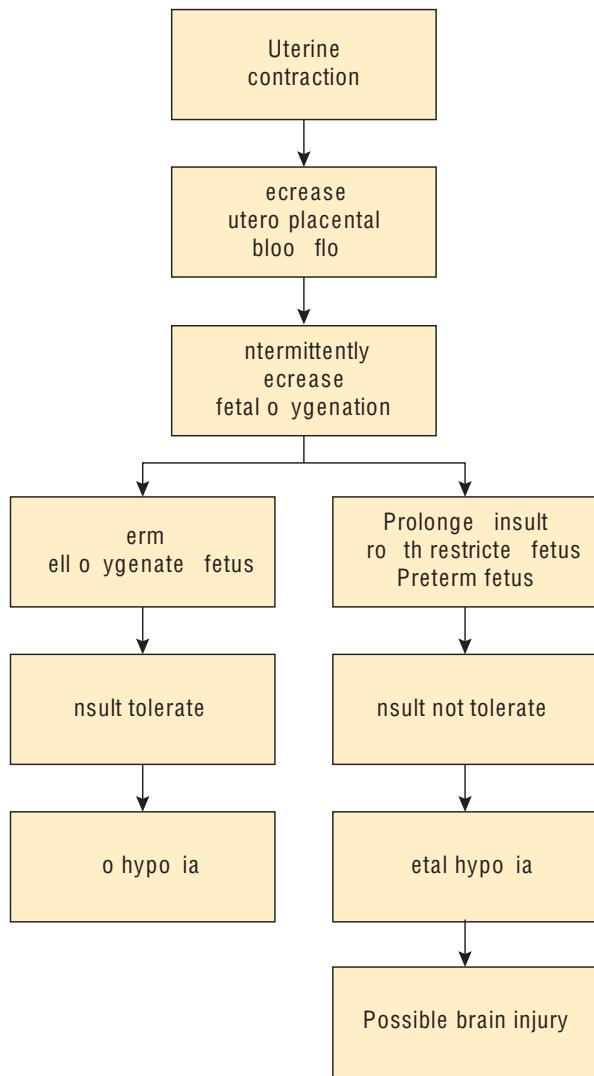


Figure 17.1 Response of the fetus to intermittent decrease in oxygenation during a uterine contraction.

Aim of intrapartum fetal surveillance

Intrapartum fetal surveillance aims to detect potential fetal harm due to decreased oxygenation during labor. Timely detection allows for prompt and effective intervention, leading to a decrease in perinatal/neonatal morbidity and mortality.

Box 17.1 Aim of fetal surveillance in labor

- Identification of decreased fetal oxygenation
- Timely and effective intervention
- Prevention of brain injury

Decreased oxygenation may result in brain injury. At present no technology is available to directly assess brain injury during labor. Certain fetal heart rate changes occur prior to brain injury. Recognition of fetal heart rate changes is the basis for fetal monitoring in labor. Therefore, the aim of intrapartum fetal surveillance is to identify abnormal fetal heart patterns and implement timely and effective interventions to prevent brain injury (Box 17.1).

Hypoxia and hypoxic injuries to the fetus

When there is decreased oxygenation to the fetus, there is a chain of events that leads to long-term neurological sequelae (Fig. 17.2).

Hypoxic injury affects the fetus in several ways. Multiorgan dysfunction may result, but the fetal nervous system is the most vulnerable to long-term injury. The types of hypoxic injuries are listed in Box 17.2.

Causes of intrapartum hypoxia

Any interference with the uterine blood flow due to maternal factors, placental dysfunction, or fetal factors can lead to compromise of fetal oxygenation in labor (Box 17.3).

Methods of intrapartum fetal surveillance

The methods available for evaluating and assessing the fetal response to labor include the following:

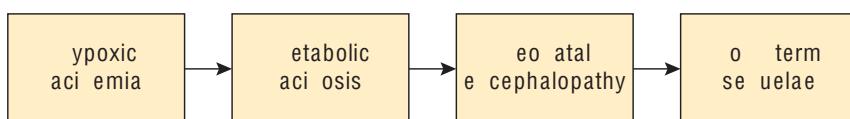


Figure 17.2 Chain of events leading to hypoxic brain injury.

Box 17.2 Hypoxic fetal injuries

- Hypoxic-ischemic encephalopathy (HIE)
 - Due to intrapartum hypoxia
 - Can be mild, moderate, or severe
 - Severe HIE can be associated with
 - neonatal death
 - disabilities in survivors
- Neonatal encephalopathy
 - Majority due to conditions that occur before labor
 - Prenatal stroke
 - Infection
 - Cerebral malformation
 - Genetic disorders
 - Small percentage occur due to
 - intrapartum asphyxia
 - hypoxicemic insult to the brain
- Cerebral palsy (CP)
 - Majority not due to asphyxia during labor
 - Majority due to
 - insult occurring in the antenatal period
 - genetic or environmental factors
 - Small percentage
 - Due to acute intrapartum hypoxia
 - Results in spastic quadriplegic CP

- Intermittent auscultation (IA)
 - Pinard fetoscope
 - Stethoscope
 - Handheld Doppler device
- Cardiotocography (CTG) or electronic fetal monitoring (EFM)
 - Intermittent (when required)
 - Continuous
- Fetal scalp blood sampling
 - Scalp pH
 - Fetal lactate concentration
- Fetal electrocardiography
- Pulse oximetry

Intermittent auscultation

Using a device such as a Pinard fetoscope, a stethoscope, or a handheld Doppler device, the obstetrician or nurse listens to the fetal heartbeat through the maternal abdomen. The heartbeats are usually counted for 30 or 60 seconds and the baseline fetal heart rate calculated.

In the absence of maternal and fetal risk factors, intermittent auscultation is the recommended fetal surveillance method during labor (Fig. 17.3). The fetal heart rate is better assessed with the handheld Doppler device as compared

Box 17.3 Causes for decreased fetal oxygenation in labor*maternal factors*

- Chronic maternal conditions
 - Chronic hypertension
 - Type I diabetes
 - Antiphospholipid syndrome
- Decreased uterine blood flow
 - Hypotension (e.g., acute blood loss)
 - Regional anesthesia (epidural, spinal)
 - Maternal positioning (supine hypotension)
- Significant anemia

uteroplacental factors

- Excessive uterine activity or tone
 - Hyperstimulation
 - Placental abruption
- Uteroplacental dysfunction
 - Fetal growth retardation
 - Postterm pregnancy
 - Oligohydramnios

fetal factors

- Cord compression
 - Oligohydramnios
 - Cord prolapse or entanglement
- Decreased fetal oxygen-carrying capacity
 - Significant anemia
 - Rh alloimmunization
 - Maternal-fetal bleed
 - Ruptured vasa previa

with the other two methods because it amplifies sound. This is an advantage, especially in obese women, in the presence of polyhydramnios, or an actively moving fetus.

Frequency of auscultation for fetal heart rate in labor

There are established protocols for the frequency of assessment of the fetal heart rate by auscultation to determine fetal status during labor.

First stage of labor (till complete cervical dilation)

The recommendation for frequency of auscultation of the fetal heart rate in the first stage of labor (till complete cervical dilation) are as follows:

- Auscultate every 15 minutes during the active phase of the first stage of labor.



Figure 17.3 Listening to fetal heartbeat with
a. Pinard fetoscope. b. Stethoscope. c. Handheld Doppler device.

- Auscultate from before the start of the contraction to after the contraction is over. This is important because it will help pick up any change in the heart rate *after* the contraction since oxygenation to the fetus is decreased

during a contraction. If there is any abnormal change, it will alert the obstetrician to the presence of fetal distress.

Second stage of labor (from complete cervical dilation to delivery of the fetus)

The recommendations for frequency of auscultation of the FHR in the second stage of labor (from complete cervical dilation to delivery) are as follows:

- Every 5 minutes during the second stage of labor
- After every contraction during the pushing phase of labor

Interpretation of fetal heart rate by auscultation

Baseline fetal heart rate

The fetal heartbeats are counted between contractions for 60 seconds, at least for the first time, to establish the baseline fetal heart rate. The fetal heart rate is expressed as *beats per minute (bpm)*. The normal baseline fetal heart rate is 110–160 bpm.

Following the initial counting, the fetal heart rate can be intermittently counted for 15–30 seconds (and multiplied by 4 or 2, respectively), to continue monitoring the heart rate. The frequency of counting should follow a set protocol (Box 17.4).

Fetal heart rate changes

Once a baseline fetal heart rate has been established, it is easy to identify changes from the baseline by auscultation. There can be **accelerations** (the fetal heart rate abruptly rising above baseline for 15–60 seconds) or **decelerations** (the fetal heart rate abruptly dropping below baseline for 15–60 seconds). Accelerations are a reassuring sign of fetal well-being. There can be **tachycardia**, defined as a fetal heart rate above 160 bpm for >10 minutes, or **bradycardia**, which

Box 17.4 Establishing baseline fetal heart rate by intermittent auscultation

- Initial counting for 60 seconds
- Between contractions
- Follow-up assessment for 30–60 seconds
- Normal baseline fetal heart rate 110–160 bpm

Box 17.5 Intermittent auscultation

- Baseline fetal heart rate
 - Normal: 110–160 bpm
- Accelerations
 - Abrupt rise
 - >15 bpm above baseline
 - Lasting 15–60 seconds
 - Reassuring sign
- Decelerations
 - Abrupt drop below baseline
 - Lasting 15–60 seconds
 - Cannot diagnose etiology
- Tachycardia
 - Fetal heart rate above 160 bpm for >10 minutes
- Bradycardia
 - Fetal heart rate below 110 bpm for >10 minutes

is a fetal heart rate below 110 bpm for >10 minutes (Box 17.5). It is important to compare the fetal heart rate with the maternal pulse to ensure that there is no confusion between the two.

These changes are best looked for after a contraction, when the fetus has been subjected to a temporary decrease in oxygenation. When there is no drop in the baseline fetal heart rate following a contraction, it establishes the ability of the fetus to withstand labor contractions. In a decompensated fetus, the fetal heart rate will drop following a contraction.

Drawbacks

The drawbacks of auscultation of the fetal heart rate are as follows:

- It is often difficult to auscultate the fetal heart rate in an obese woman or in a woman with polyhydramnios.
- It is also not possible to distinguish between decelerations caused by cord compression or by placental insufficiency.
- Baseline variability, which can be seen on electronic fetal monitoring and is a good marker for the presence or absence of fetal hypoxia, cannot be made out with intermittent auscultation.

Electronic fetal monitoring

From the beginning of the 20th century, intermittent auscultation has been the method of assessing the fetal heart rate during labor. In the 1960s,

continuous electronic recording of the fetal heart rate on a graph paper, known as electronic fetal monitoring, was introduced for obtaining more accurate information, early diagnosis of fetal hypoxia, and immediate intervention.

However, randomized controlled trials comparing electronic fetal monitoring, with intermittent auscultation have shown that the reduction in perinatal mortality is not statistically significant. There is no reduction in cerebral palsy when electronic fetal monitoring is used. A decrease in neonatal seizures has been reported. On the other hand, electronic fetal monitoring is associated with an increase in interventions, including cesarean section, vaginal operative delivery, and the use of anesthesia. No difference in the long-term outcome has been demonstrated.

Electronic fetal monitoring is useful in assessing fetal heart rate patterns when intermittent auscultation picks up abnormalities or there is meconium present in the amniotic fluid. In these situations, a reassuring fetal heart rate tracing allows the obstetrician to continue monitoring labor without any major intervention.

It is reasonable clinical practice to use intermittent auscultation followed by electronic fetal monitoring if fetal heart rate abnormalities are recognized on intermittent auscultation. Continuous electronic fetal monitoring has not been shown to improve perinatal outcomes in low-risk women.

Indications for electronic fetal monitoring

Electronic fetal monitoring (if available) is indicated in pregnancies at high risk for adverse perinatal outcome. Some of the indications for electronic fetal monitoring are mentioned in Box 17.6.

Equipment for electronic fetal monitoring

Electronic fetal monitoring may be performed by the following methods:

- External electronic monitoring
- Internal electronic monitoring

The external electronic monitoring equipment consists of the following (Fig. 17.4):

Box 17.6 Indications for electronic fetal monitoring

- Maternal
 - Hypertension
 - Pregestational diabetes
 - Previous cesarean section
 - Induced or augmented labor
 - Chorioamnionitis
 - Antiphospholipid antibody syndrome
 - Oligohydramnios
- Fetal
 - Meconium-stained amniotic fluid
 - Fetal growth restriction
 - Multiple pregnancy
 - Prematurity
 - Postterm
 - Previous intrapartum asphyxia/death

- **The external monitor:** An ultrasound transducer that detects the fetal heart rate.
- **The external tocotransducer:** A pressure-sensitive device that demonstrates the beginning and the end of the contraction and shows the relationship between contractions and fetal heart accelerations/decelerations. This however does not reflect the actual intrauterine pressure.

Both monitors are placed on the maternal abdomen with the help of two elastic belts.

- **Graphic tracing:** This provides a permanent record of the fetal heart rate and uterine contractions.



Figure 17.4 External fetal monitoring. The ultrasound transducer and the external tocotransducer are placed on the maternal abdomen. A graphic tracing is being obtained.

External fetal heart rate monitoring is used for nonstress testing in the antenatal period and for monitoring women in labor. In active labor, fetal and maternal movements may make it difficult to use.

The internal electronic monitoring equipment consists of the following:

- **Internal fetal heart rate monitor**—a spiral electrode that is fixed to the fetal scalp. The membranes must be ruptured for the insertion of the electrode. The signal processor counts every R-R interval of the fetal ECG and displays it on a fetal monitor recording paper.
- Uterine contractions are monitored by **external tocodynamometer** as in external monitoring.
- **Intrauterine pressure catheters** provide a more accurate measurement of uterine activity but are not often used.

Advantages of internal fetal heart rate monitoring are as follows:

- It can be used in active labor when maternal movements may make it difficult to use an external monitor.
- It can be used in obese women.
- The fetal heart rate monitoring is more accurate.

Interpretation of fetal heart rate pattern on electronic fetal monitoring

Terminology

Fetal heart rate patterns are described using the following terms:

- Baseline fetal heart rate
- Baseline variability
- Periodic changes
 - Accelerations
 - Decelerations

Baseline fetal heart rate

The normal baseline fetal heart rate is 110–160 bpm. It can be interpreted only in a segment of a minimum of 2-minute duration with no periodic changes. Figure 17.5 shows the baseline fetal heart rate and baseline variability.

When the fetal heart rate exceeds 160 bpm for 10 minutes or more, it is called tachycardia. When the fetal heart rate is below 110 bpm for 10 minutes or more, it is called bradycardia. The causes for fetal tachycardia and bradycardia are listed in Box 17.7.

Box 17.7 The causes for fetal tachycardia and bradycardia

- Tachycardia (heart rate of >160 bpm)
 - Causes of tachycardia
 - Maternal fever
 - Chorioamnionitis
 - β -Sympathomimetics
 - Fetal compromise
- Bradycardia (heart rate of <110 bpm)
 - Causes of bradycardia
 - Head compression
 - Fetal compromise

Baseline variability

Baseline variability refers to the fluctuations in the baseline fetal heart rate that are irregular in amplitude and frequency. The normal baseline variability has an amplitude range of 6–25 bpm. It is measured from peak to trough. The fetal heart rate variability is a reflection of modulation of the heart rate by the central and the autonomic nervous systems. It is said to be **minimal** when it is <5 bpm, **moderate or normal** when it is 5–25 bpm, and **marked** when it is >25 bpm.

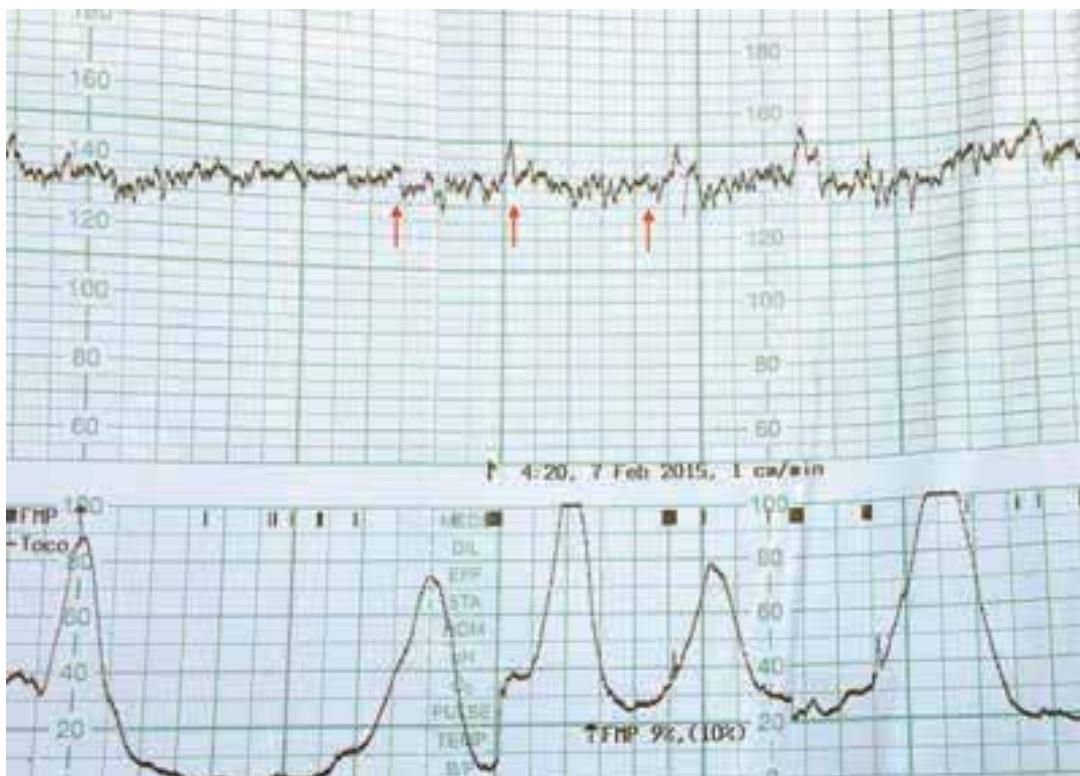


Figure 17.5 Electronic fetal monitoring: Fetal heart rate tracing showing a baseline fetal heart rate of 130 bpm. Baseline variability is good (arrows).

Box 17.8 Causes of decreased or absent baseline variability

- Maternal administration of
 - analgesics
 - sedatives
 - magnesium sulfate
- Fetal hypoxia

Decreased variability is an important sign of fetal hypoxia (Box 17.8).

Periodic changes

Accelerations

Accelerations are transient increases in the basal heart rate by >15 bpm, lasting for at least 15 seconds (Fig. 17.6). **They are a reassuring sign, and the presence of accelerations rules out fetal hypoxia.**

Decelerations

Electronic fetal monitoring can differentiate decelerations into three types based on their relationship to uterine contractions. **A deceleration is considered significant if it decreases >15 bpm below baseline, lasts for >15 seconds, and is repetitive.**

- *Early decelerations:* They are symmetric gradual drops in the fetal heart rate that mirror the uterine contraction. The nadir (the lowest point) of the deceleration coincides with the peak of the contraction. These are caused by head compression and do not denote fetal hypoxia (Fig. 17.7a).
- *Late decelerations:* They commence after the start of the contraction and return to the baseline after the contraction is over. The nadir of the deceleration occurs after the peak of the contraction. They are caused by placental insufficiency (Fig. 17.7b).
- *Variable decelerations:* They are characteristically variable in duration, intensity, and timing. They are caused by cord compression. They resemble the letters 'U,' 'V' or 'W' and may be variable even in relation to the uterine contraction (Fig. 17.7c). Intermittent variable decelerations are often seen even in a normal labor tracing, but the fetus tolerates transient cord compression. However, persistent, deep, and recurrent variable decelerations are indicative of fetal acidosis. They vary in onset, depth, and duration.

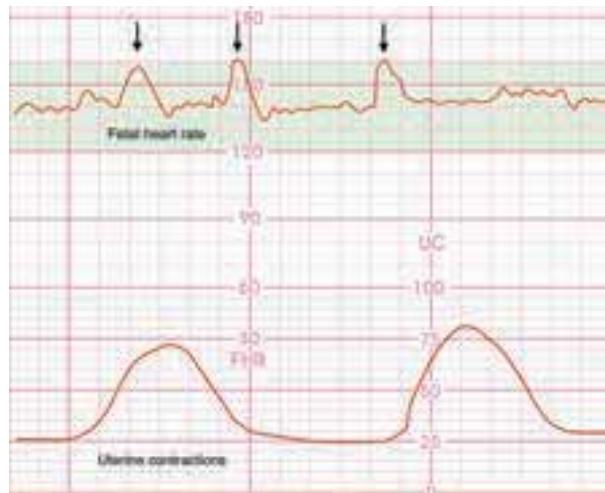


Figure 17.6 Fetal heart rate monitoring graph.
Accelerations are seen (arrows).

The following types of decelerations may also occur:

- *Prolonged deceleration:* Prolonged deceleration is one where the deceleration lasts >2 minutes but <10 minutes. If it continues for >10 minutes, it is considered a shift of the baseline fetal heart rate (bradycardia). It is indicative of prolonged cord compression, hypotension, or severe, acute placental insufficiency.
- *Sinusoidal pattern:* This is a smooth, sine wave-like undulating pattern in the baseline fetal heart rate with a cycle frequency of 3–5 per minute that persists for 20 minutes or more (Fig. 17.7d). The characteristic features are as follows:
 - Baseline fetal heart rate is 120–160 bpm.
 - Variability is markedly decreased or absent.
 - The oscillations are 5–15 bpm,
 - Cycle frequency is 3–5 times/min.
 - There are no accelerations.

Sinusoidal pattern indicates

- fetal anemia,
- severe hypoxia/acidosis.

Interpretation of the electronic fetal monitoring graph is summarized in Box 17.9.

et al heart rate patterns in the second stage o f labor

Variable decelerations may be associated with almost every contraction in the second stage because the fetal head and cord are compressed. This makes it difficult to interpret the electronic

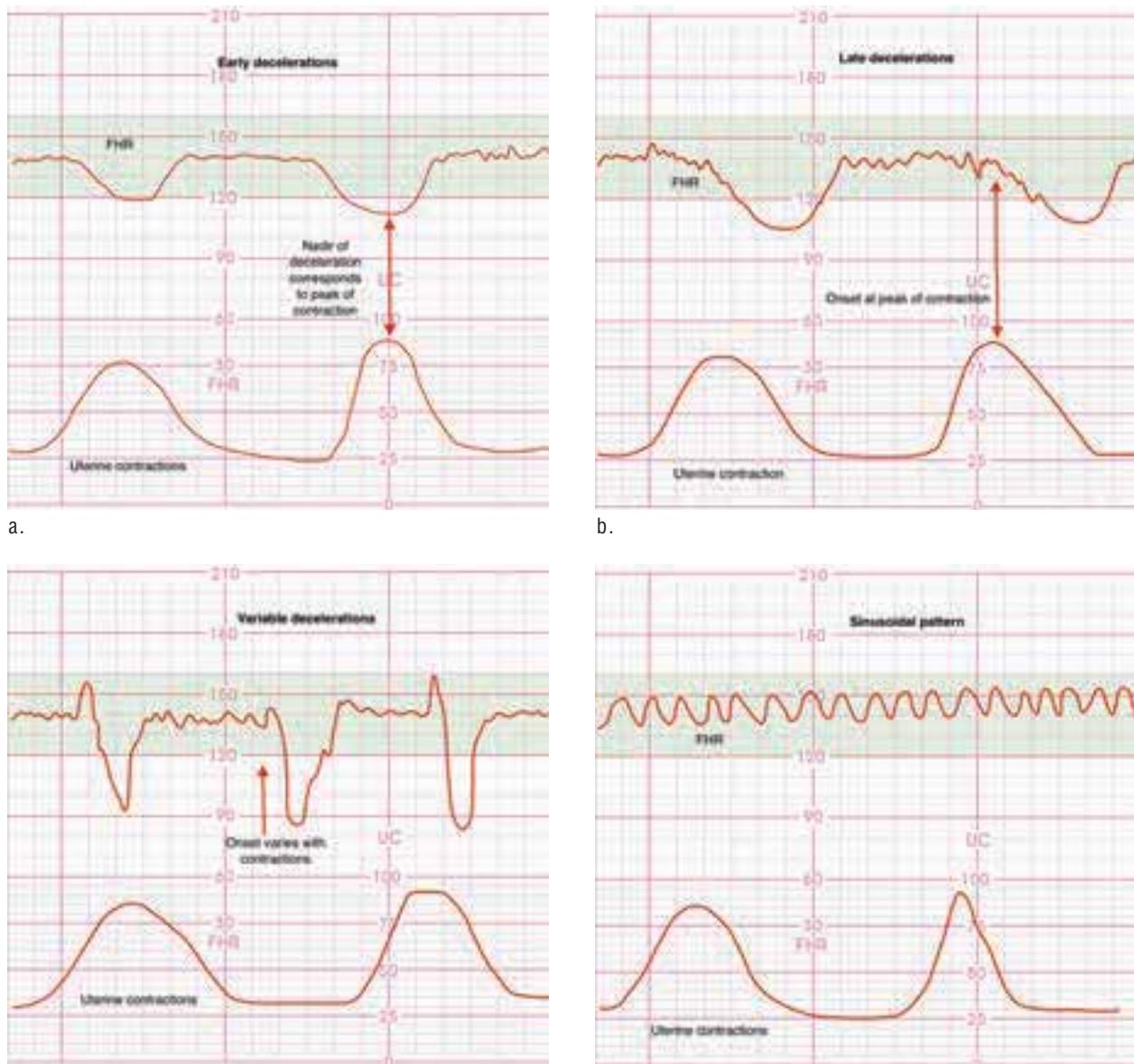


Figure 17.7 Electronic fetal monitoring showing **a.** Early decelerations. The decelerations are symmetric and mirror the contraction. **b.** Late decelerations. Onset occurs at the peak of contraction and returns to normal after contraction ends. **c.** Variable decelerations. Abrupt decrease from baseline and onset is variable. **d.** Sinusoidal pattern.

fetal monitoring trace. Patterns suggestive of fetal hypoxia are as follows:

- Decelerations to <70 bpm
- Loss of variability
- Persistent baseline bradycardia/tachycardia

Three tiered fetal heart rate interpretation system

Electronic fetal monitoring tracings are classified as follows:

- **Reassuring (Category I by ACOG or Normal by RCOG)**
- **Indeterminate (Category II by ACOG or Suspicious by RCOG)**
- **Nonreassuring (Category III by ACOG or Pathological by RCOG)**

Category I or **reassuring** tracings are considered ‘normal’ since they are associated with a normal fetus that is tolerating labor well. There is no fetal acidemia. A Category I tracing (Fig. 17.8) will have all of the following:

Box 17.9 Interpretation of an electronic fetal monitoring graph

Interpretation of an electronic fetal monitoring graph requires mention of the following:

- Baseline fetal heart rate (in bpm)
- Baseline variability (normal, decreased, absent)
- Presence of accelerations (duration and elevation above baseline)
- Presence of decelerations (duration, decrease below baseline, and relation to contraction)
 - Early
 - Late
 - Variable
- A baseline fetal heart rate of 110–160 bpm
- Absence of late or variable fetal heart rate decelerations
- Moderate fetal heart rate variability (6–25 bpm)
- Fetal heart rate accelerations—present or absent
- Early decelerations—present or absent

Category II tracings or indeterminate fetal heart rate patterns (Fig. 17.9) neither suggest acidosis nor give a clear indication of fetal well-being. They include the following:

- Tachycardia
- Bradycardia without absent variability
- Minimal or marked variability
- Absent variability without recurrent decelerations
- Absence of accelerations without absent variability
- Recurrent, variable, or late decelerations with moderate variability
- Prolonged decelerations ≥ 2 minutes but <10 minutes

Category III or nonreassuring tracings (Fig. 17.10) are considered ‘abnormal’ because they are associated with an increased risk of fetal hypoxic acidemia, which can lead to cerebral palsy and neonatal hypoxic ischemic encephalopathy. Findings on the tracings include the following:

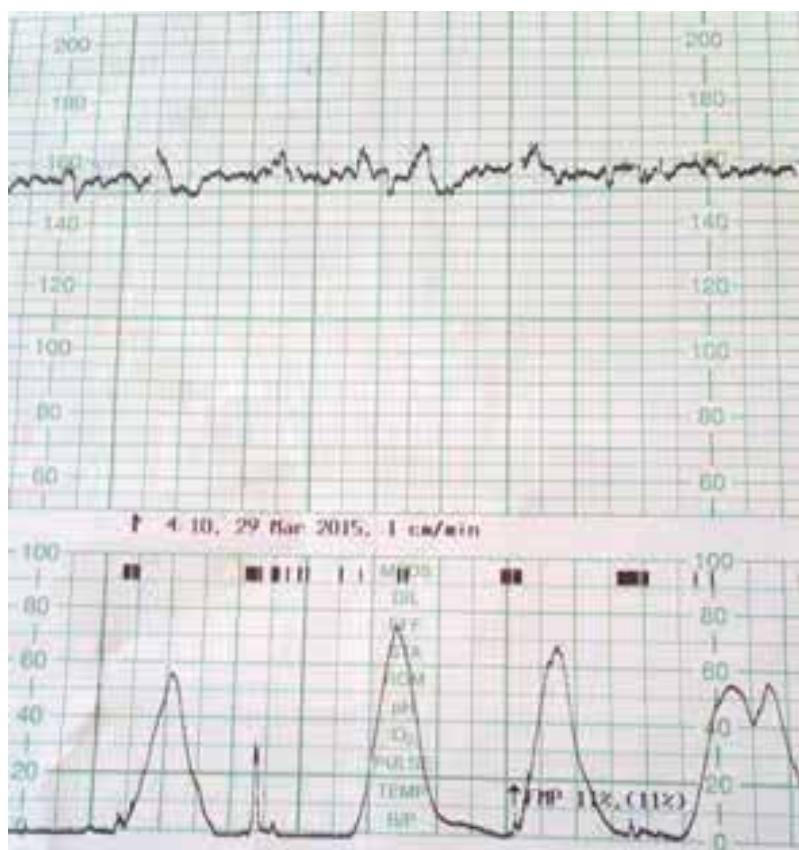


Figure 17.8 Category I tracing. Baseline fetal heart rate of 155 bpm and moderate baseline variability is seen, with no decelerations.



Figure 17.9 Category II tracing. Recurrent variable decelerations (arrows) are seen with moderate variability.

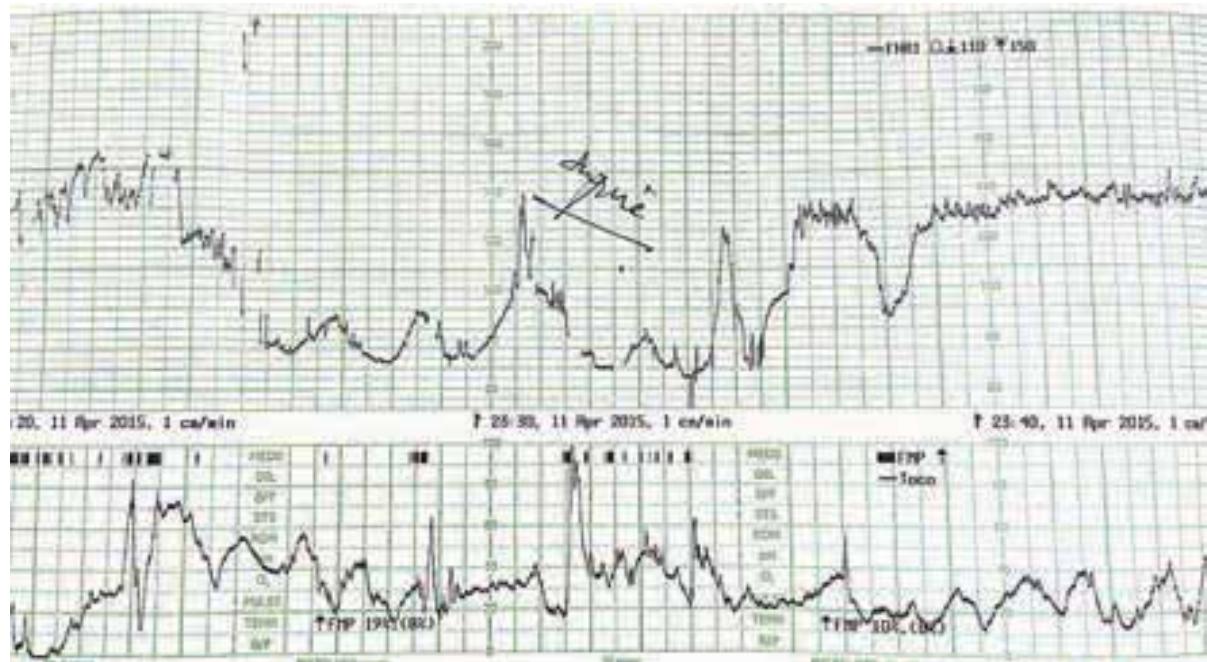


Figure 17.10 Category III tracing. Poor baseline variability with severe recurrent variable decelerations seen.

- Absent baseline fetal heart rate variability with any of the following:
 - Recurrent late deceleration
 - Recurrent variable decelerations
 - Bradycardia
- Sinusoidal pattern

Further evaluation of Category II and Category III tracings

In the presence of a Category II or Category III tracing, it is important to try and assess the degree of fetal acidemia. The tests mentioned below may be done.

Fetal scalp stimulation test

The fetal scalp stimulation test is a reassuring technique for determining fetal reserves and to rule out hypoxia and acidemia. It is easily performed and immediately reassuring. During a vaginal examination, the examiner strokes the fetal scalp with firm digital pressure. This should elicit a fetal heart rate acceleration of ≥ 15 bpm above the baseline and lasting for ≥ 15 seconds. A positive test rules out fetal acidemia in 90% of cases, and a negative test may indicate fetal acidemia in 50% of fetuses.

Fetal scalp blood sampling

The methodology and interpretation of this test are described later in this chapter. If the pH is 7.2 or less, it is indicative of acidemia and requires immediate delivery (see below).

Management of Category I, Category II and Category III tracings

Category I

Since Category I tracings denote a normal fetus that is tolerating labor well, no intervention is required. The electronic fetal monitoring tracing may be reviewed every 30 minutes in the first stage and every 15 minutes in the second stage of labor.

Category II and Category III

Category II tracings are suspicious and need to be managed before acidemia sets in. Since Category III tracings indicate fetal acidemia, preparations for delivery should be made while simultaneously initiating steps to improve uteroplacental perfusion and oxygen delivery.

If membranes are not ruptured yet, artificial rupture of membranes (ARM) would help assess the amniotic fluid. Thick meconium adds to the seriousness of the situation. **Transcervical amnioinfusion** may be attempted to decrease cord compression by increasing the amniotic fluid. It also helps to dilute the meconium.

Amnioinfusion

After rupture of the fetal membranes, a pediatric nasogastric feeding tube is inserted using standard technique and attached to intravenous extension tubing. Normal saline (without dextrose), at body temperature, is infused through the catheter. Usually a bolus of 50–1000 mL is given, followed by a constant infusion.

The following steps should be taken for managing Category II and III tracings:

- **Step 1:** Immediate evaluation for the likely cause of the abnormality such as rapid descent of fetal head, tachysystole, cord compression, cord prolapse, placental abruption, or maternal medication.
- **Step 2:** Correction of the problem by attempting to improve fetal oxygenation
 - Change maternal position
 - Provide oxygen by mask or nasal prongs
 - Amnioinfusion, if indicated
 - Stop oxytocics.
- **Step 3:** Fetal scalp stimulation test to determine fetal reserve and signs of acidosis.
- **Step 4:** Make a decision whether operative intervention (cesarean or instrumental vaginal delivery) is required.

The management of Category II and Category III tracings is summarized in Box 17.10.

Amission test

On admission to the labor room, all pregnancies are monitored by electronic fetal monitoring for 20 minutes. This is called the admission test. Based on this trace, a decision is made regarding the need for continuous electronic fetal monitoring in labor. The fetus is considered to be healthy and capable of withstanding labor if

- the baseline variability is good,
- there are at least two accelerations in 20 minutes, and
- there are no decelerations.

Box 17.10 Interventions in Category II and Category III tracings

- Decrease uterine activity
 - Stop oxytocin infusion (if there is one)
 - Tocolysis with terbutaline in the presence of hyperstimulation
- Improve uterine blood flow
 - Turn the mother to the lateral recumbent position
- Improve umbilical artery blood flow
 - Reposition the mother to relieve cord compression
 - Amnioinfusion, if indicated
- Improve maternal/fetal oxygenation
 - Institute oxygen by mask/nasal prongs
- Perform vaginal examination
 - Assess progress of labor
 - Stimulate the scalp to induce accelerations
- Prepare for delivery

However, there is no difference in neonatal outcome when this test is used in low-risk pregnancies. Its value in high-risk pregnancies is not proven. Admission test, therefore, is not routinely recommended.

Other methods of intrapartum fetal surveillance

Fetal scalp blood sampling

Fetal scalp blood sampling is carried out if there is an abnormality in the fetal heart rate. It is done to confirm the presence of fetal hypoxia and/or acidemia. The cervix must be at least 4–5 cm dilated and the vertex at least at –1 station. Using a lancet, a blood sample is obtained from the fetal scalp. The blood sample is then checked for pH. The pH values are interpreted as follows:

- >7.25: Normal, continue monitoring with electronic fetal monitoring
- 7.25–7.2: Borderline, repeat test in 20–30 minutes
- <7.2: Acidemia, immediate delivery indicated

Fetal lactate concentration

Using the fetal scalp blood, blood lactate can also be determined. Lactate levels are used for

prediction of acidemia. However, randomized trials have not found this to be superior to fetal scalp pH measurements.

Disadvantages

The disadvantages of fetal scalp blood sampling are as follows:

- The test is cumbersome, requires special equipment, and is expensive.
- It has poor sensitivity and positive predictive value for identification of HIE.
- The test is not used commonly in many institutions.

Fetal electrocardiography

Fetal electrocardiography can be recorded by internal fetal monitoring with special equipment that processes fetal ECG, known as the STAN system. Fetal hypoxia causes ST segment and T wave changes in the fetal ECG. Randomized trials have shown that when STAN was used as an adjunct to electronic fetal monitoring, there is a significant reduction in neonatal acidosis. This technique of fetal monitoring is being evaluated further.

Fetal pulse oximetry

Fetal oxygen saturation (SpO_2) of <30% for >2 minutes has been shown to be associated with fetal acidosis. Fetal SpO_2 can be measured using a sensor introduced transcervically and positioned against the fetal face. Initial trials showed a reduction in cesarean section rate for fetal distress with the use of this technique, but larger randomized trials later have failed to show any benefit. Fetal pulse oximetry is not used currently.

The fetus faces stress during labor. Fetal surveillance during labor helps in recognizing the fetus that is not tolerating labor well and is hypoxic/acidemic. Recognition of fetal compromise guides decisions about appropriate intervention so that short- and long-term neurological damage may be avoided.

Key points

- In the normal course of labor, uterine contractions cause a decrease in uteroplacental blood flow and therefore a decrease in oxygen delivery to the fetus.
- Intrapartum fetal surveillance aims to detect potential fetal harm due to decreased oxygenation.
- Certain fetal heart rate changes occur prior to brain injury. Recognition of these heart rate changes is the basis for fetal monitoring in labor.
- The aim of intrapartum fetal surveillance is to identify abnormal fetal heart patterns and provide timely and effective response to prevent brain injury.
- In the absence of maternal and fetal risk factors, intermittent auscultation is the recommended fetal surveillance method during labor.
- Fetal heart rate changes are best looked for after a contraction, when the fetus has been subjected to a temporary decrease in oxygenation.
- When there is no drop in the baseline fetal heart rate following a contraction, it establishes the ability of the fetus to withstand labor contractions. In a decompensated fetus, the fetal heart rate will drop following a contraction.
- Electronic fetal monitoring, if available, is indicated in pregnancies at high risk for adverse perinatal outcome.
- Interpretation of the electronic fetal monitoring requires a mention of the baseline fetal heart rate, baseline variability, presence of accelerations, and presence of decelerations (early, late, and variable).
- Electronic fetal monitoring tracings can be classified as Category I (reassuring), Category II (suspicious), or Category III (nonreassuring).
- Fetal scalp stimulation is a simple clinical test for ruling out fetal acidemia.
- Fetal scalp blood sampling is carried out (if available) in the presence of an abnormality in the fetal heart rate. A pH of 7.2 or less is an indication for immediate delivery.
- The admission electronic fetal monitoring has a doubtful value in high-risk pregnancies and is not recommended routinely in low-risk pregnancies.
- In the presence of a persistent or repetitive fetal heart rate abnormality, oxytocin is stopped, the mother is placed in the lateral recumbent position, oxygen is given by mask, a vaginal examination is done, and preparations are made for delivery.

Self-Assessment

Case-based questions

Case 1

Mrs. MG, 25, came in labor at 38 weeks' gestation. She was having contractions every 3–4 minutes and the contractions were lasting 40–50 seconds. She was a known hypertensive. At 4-cm dilatation, membranes ruptured spontaneously and the amniotic fluid was meconium stained.

1. How often will you auscultate the fetal heart rate in the first stage and the second stage? Which is the best time to pick up an abnormal fetal heart rate?
2. What is the normal baseline fetal heart rate?
3. Describe late decelerations. What causes late decelerations?
4. What are variable decelerations and what causes them?

Case 2

Mrs. ST, 30, gravida 2, para 1, was in active labor. She was 6-cm dilated and the vertex was at 0 station. She was on oxytocin augmentation. She was having contractions every 2–3 minutes, lasting 45 seconds. On auscultation,

there were decelerations, with the fetal heart rate dropping to 80 bpm after contractions.

1. What is the first step in the management of the abnormal fetal heart rate?
2. How can maternal and fetal oxygenation be improved?
3. Is there a simple test to check for fetal well-being?

Answers

Case 1

1. The fetal heart is auscultated every 15–30 minutes in the first stage and every 5 minutes in the second stage. It is best to listen immediately after the contraction.
2. The normal baseline fetal heart rate is 110–160 bpm.
3. Late decelerations commence after the start of the contraction and return to the baseline after the contraction is over. They are caused by placental insufficiency.
4. Variable decelerations are characteristically variable in duration, intensity, and timing. They are caused by cord compression.

Case 2

1. Decrease uterine activity by stopping oxytocin infusion.
2. Maternal and fetal oxygenation can be improved by turning the mother to a lateral recumbent position and by giving oxygen by mask.
3. The scalp stimulation test will elicit fetal heart rate acceleration in a healthy fetus. It is a reassuring sign.

Sample questions

Long-answer questions

1. What are the methods of assessing fetal well-being in labor?
2. What are reassuring and nonreassuring signs of fetal status? How are Category III tracings managed?

Short-answer questions

1. Early, late, and variable decelerations
2. Fetal scalp blood sampling
3. Sinusoidal pattern
4. Fetal pulse oximetry
5. Admission test

18

Obstetric Analgesia and Anesthesia

Case scenario

Mrs. JR, 23, went to the hospital in active labor. It was her first pregnancy and she was in severe pain. She requested pain relief.

Introduction

Labor pain is the most severe pain a woman will ever experience in her life. In no other situation involving so much pain is one expected to manage without pain relief.

It is difficult for the obstetrician and the woman herself to predict her reaction to labor pain. Women tend to underestimate the level of pain they will experience in labor and therefore may lose control when the pains continue to intensify. It is the responsibility of the obstetric team to alleviate pain by providing all laboring women with options for pain relief.

Effect of pain on labor and the laboring woman

Pain has the following effects on labor (Fig. 18.1):

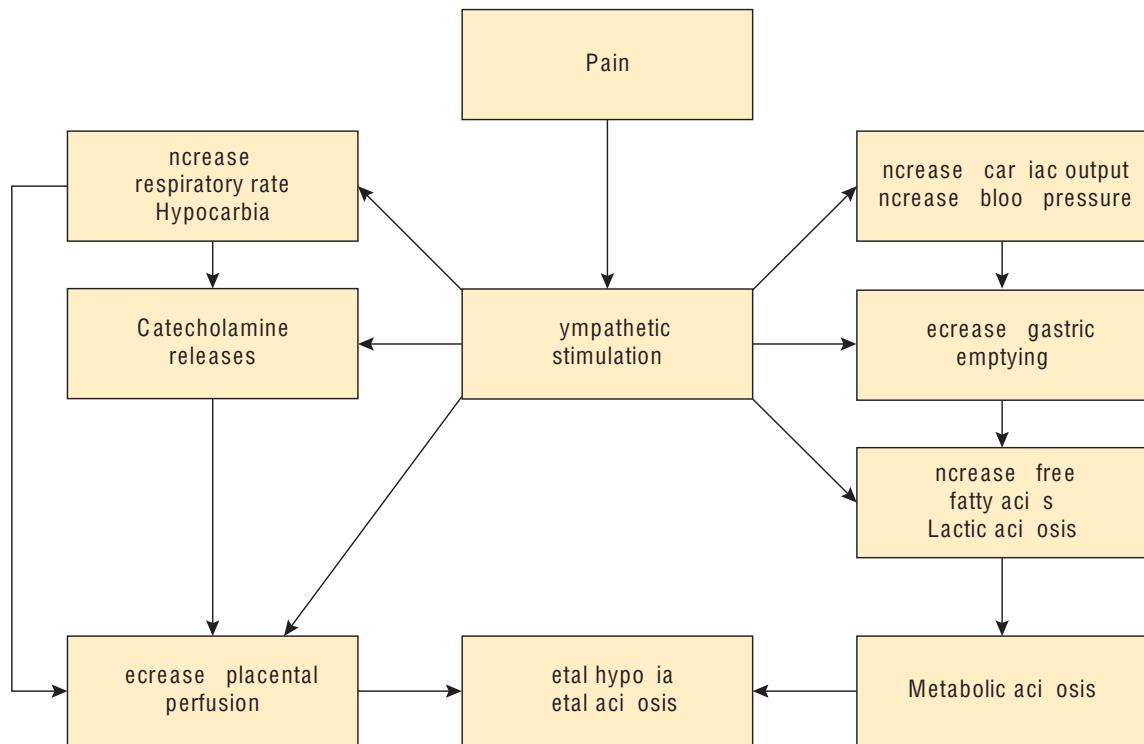
- Neurohormonal response to stress and release of catecholamines
 - The intensity of labor pains causes stress and the release of catecholamines. This in turn

triggers various systemic responses: tachycardia, hypertension, increased cardiac output, and increased oxygen consumption.

- Hyperventilation and resultant hypocarbia
 - The pain pushes the woman into hyperventilation–hypoventilation–apnea cycles during contractions. This results in maternal respiratory alkalosis and fetal acidemia, both of which are tolerated by healthy mothers and fetuses. However, in the presence of fetal or maternal compromise, this may lead to maternal or fetal decompensation.
- Psychological effects
 - Unrelieved pain during labor can contribute to the development of postpartum depression and posttraumatic stress disorder.

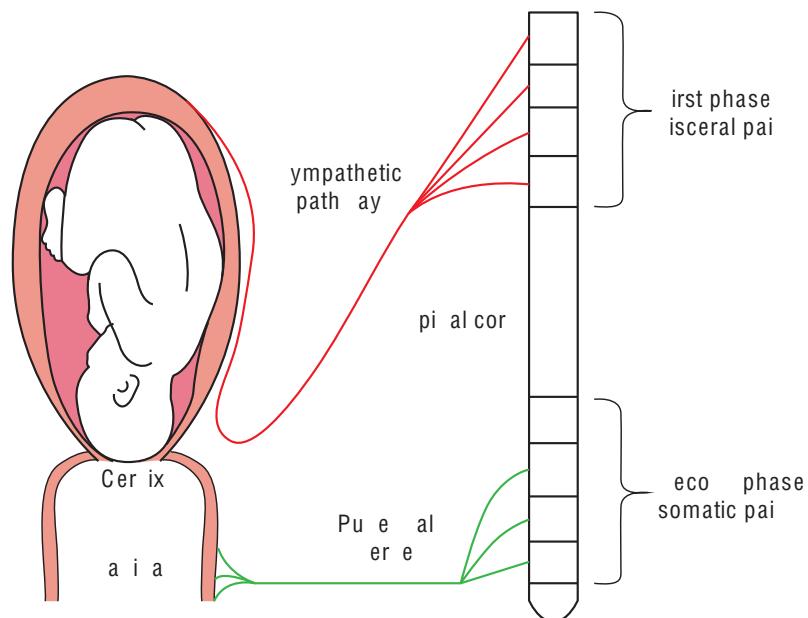
Pain pathways

Somatic and autonomic innervation of the female reproductive tract is discussed in Chapter 1, *Anatomy of the female reproductive tract*. Pain from the uterus and cervix is transmitted through

**Figure 18.1** Effect of pain on labor.

sympathetic and parasympathetic nerve fibers. The sympathetic nerve fibers carry the pain from the uterus to spinal levels T10–L1. Therefore, pain of uterine contractions is felt in the lumbosacral area. The sensory pain fibers from the cervix and

upper vagina pass through the pelvic splanchnic nerves to the second, third, and fourth sacral nerves. Pain from the perineum is transmitted through somatic fibers of the pudendal nerve to the same sacral segments (Fig. 18.2).

**Figure 18.2** Pain pathways in labor.

Causes of labor pain

The causes of labor differ in the different stages of labor.

First stage of labor

In the first stage of labor, the pain results from uterine contractions. It is described as severe cramping in the uterus and may radiate to the abdominal wall, low back, gluteal areas, and thighs. As mentioned earlier, it involves spinal roots T10–L1 (Fig. 18.2). It is caused by both distension of the uterus and ischemia of cervical and uterine tissues (Box 18.1).

Second stage of labor

In addition to the pain originating from the uterus and cervix, the laboring woman now starts to experience somatic pain from distension of the vagina, perineum, and pelvic floor as the fetal head passes through the pelvis (Box 18.2).

The ideal labor analgesic would decrease both visceral and somatic pain.

Options for obstetric analgesia and anesthesia

Labor analgesia refers to relief of pain in labor with pharmacological and nonpharmacological

Box 18.1 Pain in the first stage of labor

- Visceral pain (uterus and cervix)
- Occurs with
 - uterine contractions
 - cervical dilatation
- Caused by
 - distension of uterus
 - ischemia of uterine and cervical tissues
- Mediated through T10–L1 spinal root

Box 18.2 Pain in the second stage of labor

- Somatic pain in addition to visceral pain
- Worse than first-stage pain
- Caused by distension of
 - vagina
 - perineum
 - pelvic floor
- Transmitted by pudendal nerve (S2, S3, S4)
- Rectal pressure and ‘bearing down’ sensation

methods. **Anesthesia** refers to complete block of pain sensation with or without loss of consciousness. This is used during cesarean delivery and for some obstetric procedures (Box 18.3).

Nonpharmacological methods for labor analgesia

Nonpharmacological approaches to labor pain management do not aim to make pain disappear. They give the laboring mother means for coping with the pain and therefore maintain a sense of personal control over the birth process.

Prenatal or antenatal education

When a woman is well informed about the labor process and what to expect during labor, she will be able to cope better with labor pains. Antenatal classes can be used to educate the couple and teach methods for managing pain.

Box 18.3 Options for obstetric analgesia and anesthesia

abor analgesia

- Nonpharmacological
 - Prenatal/antenatal education
 - Rhythmic breathing techniques
 - Continuous labor support
 - Touch and massage
 - Warm water baths
 - Transcutaneous electrical nerve stimulation (TENS)
 - Music
 - Acupuncture
 - Hypnosis
- Pharmacological
 - Opioids
 - Inhalational analgesia (Entonox)
 - Neuralgic analgesia
 - Epidural
 - Local analgesia
 - Pudendal block
 - Paracervical block
 - Perineal infiltration

Anesthesia

- Without loss of consciousness
 - Spinal
 - Epidural
 - Combined spinal–epidural
- With loss of consciousness
 - General

hythmic breathing techniques

Rhythmic, controlled breathing allows the woman to divert her mind from the pain. This contributes to her ability to cope with labor pain. Women express high satisfaction with breathing techniques, and it should be taught to them in antenatal classes or even during labor.

Continuous labor support

The term continuous labor support refers to the use of a companion to provide nonmedical care of the laboring woman throughout labor and birth. Husbands, in the labor room, can provide emotional support during labor and help the woman cope.

Touch and massage

When a woman is feeling helpless in labor, a caring and reassuring touch by another person can be very comforting. Massage of the low back and thighs also helps relieve some of the pain.

Warm water baths

In countries with the necessary facilities, immersion in a warm water bath has been shown to be soothing.

Transcutaneous electrical nerve stimulation

Low-voltage electrical impulses (mild shocks) from a handheld battery-powered unit are transmitted to the skin via surface electrodes. One pair of electrodes is usually placed paravertebrally at the level of T10–L1 and another at the level of S2–S4. The woman controls the intensity of the current by turning a dial. The mild shocks supposedly reduce the awareness of contraction pain. There is no strong evidence that transcutaneous electrical nerve stimulation (TENS) provides significant pain relief in labor.

Acupuncture and acupressure

In acupuncture, needles are placed at specific points on the body depending on the location of pain. There is a high level of satisfaction and reduction in dosage of analgesics used with this method. Acupressure involves applying pressure

(instead of needles) at specific points. Studies have shown a modest benefit.

Music

Music has been shown to have a great influence on mood and emotional well-being. Playing music in the labor room helps divert the woman's mind from the pain and helps her cope better.

Application of heat and cold, hypnosis, and aromatherapy are other nonpharmacological methods that have been tried.

Pharmacological agents for labor analgesia

pioids

Opioids have been safely used for many decades for labor analgesia. However, only 50% of women will report adequate pain relief. The decrease in pain perception is mostly mediated by inducing sedation. Although opioids are usually administered as intramuscular (IM) or intravenous (IV) injections, they may also be administered with a pump [patient-controlled analgesia (PCA)].

Commonly use opioid s

The commonly used opioids are listed in Table 18.1.

Meperidine (pethidine)

Meperidine (pethidine) is the most commonly used, cost-effective opioid for labor analgesia (Box 18.4). The dose is 50 mg IM (or 1–2 mg/kg body weight), which can be repeated after 4–6 hours if the woman has not delivered yet. It can also be used IV at the dose of 25 mg every 2 hours. The onset of action is within 45 minutes after IM administration and almost immediate

Box 18.4 Pethidine (meperidine) for labor analgesia

- 50 mg IM repeated 4–6 hourly
- Onset of action 45 minutes
- Antiemetic may be given for nausea
- Infant preferably to be delivered
 - Within 1 hour of maternal dosing or
 - After 4 hours of maternal dosing
- Does not facilitate cervical dilatation
- Decreased beat-to-beat variability on fetal heart tracing

Table 18.1 Opioids used in labor

Drug	Dose	Onset (Minutes)	Duration (Hours)	Comments
Pethidine	<ul style="list-style-type: none"> • 50–100 mg IM • Can be repeated at intervals of 4–6 hours 	40	2–3	<ul style="list-style-type: none"> • Respiratory depressant • Neonatal effects seen if delivery occurs between 1 and 4 hours after administration
Fentanyl	<ul style="list-style-type: none"> • 25–50 µg IV (given slowly over 1–2 minutes) 	2–3	0.45–1	<ul style="list-style-type: none"> • Analgesic efficacy not as effective as pethidine • Less side effects than opioid • Short acting • Potent respiratory depressant
Butorphanol	<ul style="list-style-type: none"> • 1–2 mg IM 	10–15	3–4	<ul style="list-style-type: none"> • Not commonly used in labor • Excessive sedation

after IV administration. The IM route is most commonly used. Since nausea is one of the most common side effects of pethidine, an antiemetic is often administered along with it.

It is recommended that the infant be delivered within 1 hour of, or >4 hours after, a dose of pethidine, as pethidine reaches a maximal concentration in the fetus from 2 to 3 hours after maternal dosing. Delivering the infant 2–3 hours after the administration of pethidine may result in neonatal respiratory depression.

Pethidine does not facilitate cervical dilatation in cervical dystocia and has been shown to worsen neonatal outcomes when given for that indication. Decrease in beat-to-beat variability of the fetal heart tracing can also occur with pethidine, and the obstetrician should be aware of this while interpreting the trace.

Tramadol

Tramadol is a synthetic opioid analgesic. It is administered at a dose of 100 mg IM (or 1–2 mg/kg body weight). Its potency is 10% of pethidine. It causes no clinically significant respiratory depression. The onset of action is within 10 minutes of IM administration, and the effect lasts for 2–3 hours. It is not as effective as pethidine.

Fentanyl

Fentanyl has a rapid onset of action (within 2–3 minutes after IV administration) with a short duration of action, making it useful for labor analgesia. It is a highly lipid-soluble synthetic opioid, with analgesic potency 100 times that of morphine and 800 times that of pethidine. It can be administered in IV boluses of 25–50 µg (given slowly over 1–2

minutes) every hour. Compared with pethidine, it performs better in terms of pain scores in women in labor. Remifentanil is also gaining popularity, especially for PCA.

Butorphanol

Butorphanol is an opioid that is 5 times as potent as morphine and 40 times as potent as pethidine. It offers analgesia with sedation. The dose of butorphanol is 1–2 mg IM. It is not used frequently for labor analgesia as it produces excessive sedation.

Side effects of opioids

Opioids are associated with side effects, especially nausea, vomiting, and neonatal respiratory depression. Box 18.5 lists the common side effects of opioids.

Patient-controlled analgesia

Intravenous analgesia, where the woman herself controls the frequency of administration, provides good pain relief in labor. It is used in women who desire continuous analgesia but where epidural analgesia is contraindicated. Maternal respiration should be closely monitored when PCA

Box 18.5 Common side effects of opioids

- Nausea and vomiting
- Drowsiness
- Respiratory depression
- Delayed gastric emptying
- Decreased variability on fetal heart tracing
- Neonatal respiratory depression

is administered. Fentanyl and remifentanil are the drugs used in the dosage given as follows:

Fentanyl

Loading dose:	50–100 µg
Patient-controlled dose:	20–60 µg every 5–10 minutes

Remifentanil

Patient-controlled dose:	25–50 µg every 5–10 minutes
--------------------------	-----------------------------

opioid analgesics

Barbiturates and benzodiazepines such as midazolam and diazepam are used as anxiolytics in early labor. They do not provide adequate analgesia and can cause neonatal respiratory depression.

Inhalational analgesia

nitrous oxide

Nitrous oxide inhalation analgesia is administered as a blend of 50% nitrous oxide and 50% oxygen (Entonox). The laboring woman uses a handheld face mask to self-administer the anesthetic gas. Since Entonox takes 50 seconds to take effect, the woman is instructed on correctly timing each inhalation. She should start with the onset of contraction so that the analgesia is effective at the peak of the contraction.

It is safe because when the woman becomes too drowsy, she will automatically drop the mask. Entonox provides women with a significant degree of pain relief, and may be useful in situations where epidural analgesia is not available. It does not cause neonatal respiratory depression or affect uterine contractility (Box 18.6).

Box 18.6 Entonox for labor analgesia

- Inhalation analgesia
- 50% nitrous oxide and 50% oxygen
- Self-administered
- Through handheld mask
- Taken with start of contraction
- Significant pain relief
- No neonatal respiratory depression
- No effect on uterine contractility

euraxial analgesia

Neuraxial analgesia provides the best pain relief in labor and is widely used. It is also beneficial to the mother in certain clinical situations. A local anesthetic with or without an opioid is injected into the epidural or intrathecal space close to the spinal nerves that transmit pain from the uterus to the spinal column (T10–L1). The dose is adjusted to provide analgesia without affecting motor function and appreciation of pressure during uterine contractions. Neuraxial analgesia may be epidural, spinal, or combined epidural and spinal analgesia.

Epidural analgesia

Epidural analgesia is a central nerve block technique accomplished by injecting a local anesthetic (Box 18.7). It is widely used as a form of pain relief in labor. The primary goal of neuraxial analgesia during labor or vaginal delivery is to provide adequate maternal analgesia with minimal motor block. Epidural analgesia achieves this when a local anesthetic (e.g., bupivacaine) is used at low concentrations with or without opioids (e.g., fentanyl).

The contraindications to epidural analgesia are listed in Box 18.8.

Epidural for cesarean section

With a larger dose of anesthetic and opioid, an epidural can also be used for a cesarean section.

Box 18.7 Epidural analgesia

- Commonest neuraxial block in labor
- Most effective method for pain relief
- Preload with IV fluids to avoid hypotension
- Bupivacaine and fentanyl commonly used
- Repeated bolus doses or continuous infusion
- Can be used for cesarean section

Box 18.8 Contraindications to epidural analgesia

- Coagulopathy
- Thrombocytopenia
- Raised intracranial pressure
- Skin or soft tissue infection at the site of the epidural placement
- Anticoagulant therapy
 - Within 6–12 hours after the last dose

If a woman has been receiving epidural analgesia during labor, it can be continued in case she undergoes a cesarean section.

Procedure

Epidural analgesia is administered as follows:

- A preload of 500 mL of IV fluids should be given prior to administering epidural analgesia since the procedure is often associated with hypotension.
- Aseptic precautions must be used (gown, gloves, masks, and povidone-iodine skin prep).
- Epidural block can be performed in the lateral or sitting position (Fig. 18.3).
- The lumbar spinous process is palpated and the widest interspace below L3 is chosen.
- A local anesthetic is used to numb the skin.
- A spinal needle is slowly advanced while feeling for resistance. A sudden loss of resistance is felt as the epidural needle enters the epidural space. Care is taken not to puncture the dura. An epidural catheter is threaded through the needle and the needle is removed.
- The catheter is fixed in place.
- A combination of low-concentration bupivacaine and fentanyl is given as bolus every 2 hours or as needed to maintain maternal comfort. Continuous infusion may also be used.



Figure 18.3 Administration of epidural analgesia. The laboring woman is sitting up and arching her back. The epidural needle is being inserted into the L2–L3 space.

cautions

The following precautions need to be taken in the case of epidural analgesia:

- Blood pressure should be recorded prior to administration of an epidural. Thereafter it should be checked at 5- to 15-minute intervals.
- Continuous fetal heart rate monitoring should be done since the epidural may cause maternal hypotension, leading to fetal heart rate abnormalities.

Drugs used for epidural analgesia

The following drugs are used for epidural analgesia:

- *Local anesthetic:* Bupivacaine is the most commonly used anesthetic for epidural analgesia.
- *Opioid:* Fentanyl is the most commonly used opioid for epidural analgesia.

Commonly, bupivacaine is combined with fentanyl. Epidural analgesia usually starts taking effect 5–10 minutes after injection. The maximal effect may not be achieved for 15–20 minutes.

Complications of epidural analgesia

Complications associated with epidural analgesia are listed in Box 18.9.

Effect of epidural analgesia on labor

Epidural analgesia has the following effects on labor:

- Timing of epidural analgesia has no effect on labor progression; therefore, it is not necessary

Box 18.9 Complications associated with epidural analgesia

- Hypotension
- Nausea and vomiting
- Inadequate or failed analgesia
- Fetal heart rate abnormalities (due to maternal hypotension)
- Prolonged labor leading to increase in instrumental delivery
- Fever
- Postdural puncture headache (PDPH) due to inadvertent dural tear

to wait until the active phase of labor for administration of epidural analgesia.

- Epidural analgesia prolongs active phase of labor by 1 hour.
- Due to the motor blockade induced by the analgesic, the duration of the second stage is prolonged.
- The need for operative vaginal delivery for prolonged stage is higher. Discontinuation of epidural analgesia in the second stage of labor does not reduce the likelihood of instrumental delivery but increases pain.
- There is no increase in the cesarean section rate.
- Epidural analgesia is not associated with any increase in adverse neonatal outcome.

Patient-controlled epidural analgesia

Patient-controlled epidural analgesia (PCEA) gives women a feeling of being in control of their own pain relief, and results in a lower total dose of the local anesthetic used and less motor blockade. This must be combined with a continuous epidural infusion for best results. The same drugs are used.

Pudendal block

A pudendal block provides relief of pain resulting from the stretching of the vagina and perineum by the descending fetal presenting part in the second stage of labor. The pain of the second stage of labor is mediated through the pudendal nerve. The sacral nerve roots 2, 3, and 4 (via the pudendal nerve) provide sensory and motor innervation to the lower vagina, perineum, and vulva, respectively. Analgesia over these areas is obtained by infiltrating a local anesthetic around the trunk of the pudendal nerve.

A pudendal block also provides analgesia during the surgical repair of vaginal and perineal tears and/or episiotomy. It is important to remember that the pudendal block does not abolish sensation to the anterior part of the perineum because branches of the ilioinguinal and genitofemoral nerves supply this region. Therefore, lacerations in this area will require local infiltration with additional medication. A pudendal block has no adverse effects on the neonate.

Indications for a pudendal block are as follows:

- Outlet forceps delivery
- Assisted breech delivery
- Repair of episiotomy and perineal lacerations

Procedure for pudendal block

A pudendal block is administered as follows:

- The procedure should be performed with all aseptic precautions.
- The woman is placed in a dorsolithotomy position.
- The perineum should be prepped with povidone-iodine solution.
- Sterile gloves must be used.
- 1% solution of lidocaine (Xylocaine) is used.
- The anesthetic solution is drawn up into a 10-mL syringe.
- A 20-gauge, 15-cm spinal needle is used.
- Usually a transvaginal approach is used (Fig. 18.4), although a transperineal approach has been described.
- The pudendal nerve lies behind the sacrospinous ligament that stretches between the ischial spine and the sacrum.
- The ischial spine is palpated with the index and middle fingers and the needle advanced for a distance of 1 cm through the vaginal mucosa into the sacrospinous ligament. A needle guide may be used, if available.
- The syringe is aspirated to ensure that the needle has not entered a blood vessel.

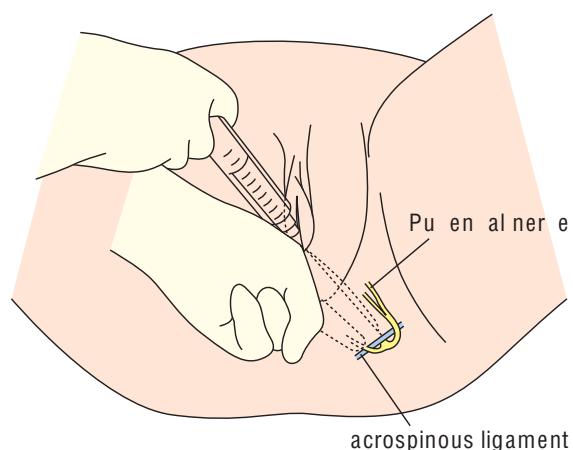


Figure 18.4 Transvaginal pudendal block. The needle is advanced through the sacrospinous ligament into the loose areolar tissue around the pudendal nerve.

- If there is no backflow of blood, 3 mL of the anesthetic solution is injected into the sacrospinous ligament.
- The needle is then advanced through the sacrospinous ligament into the loose areolar tissue around the pudendal nerve.
- After aspirating to ensure no vascular puncture, another 7 mL of the anesthetic solution is injected into this area.
- The procedure is repeated on the other side.

Complications of pudendal block

Complications of a pudendal block are rare but include the following:

- Hematoma formation from perforation of a blood vessel during needle insertion
- Infection at the site of injection
- Ischial region paresthesias and sacral neuropathy
- Seizures, hypotension, and cardiac arrhythmias after intravascular administration

Paracervical block

A paracervical block relieves the pain caused by cervical dilatation during the first stage of labor. The anesthetic blocks the visceral sensory fibers of the lower uterus, cervix, and upper vagina (T10–L1) as they pass through the uterovaginal plexus (Frankenhäuser's plexus) on each side of the cervix. It does not significantly affect the progression of labor. A paracervical block does not block the sensory nerves from the perineum, so it is ineffective during the second stage of labor.

Paracervical blocks can be given only after a cervical dilatation of 4 cm and may need to be repeated every 1–2 hours depending on the anesthetic agent used. The pain relief has been reported to be effective. Paracervical blocks are no longer used commonly for pain relief during labor.

Procedure

A paracervical block is administered as follows:

- The procedure is done under aseptic conditions.
- The woman is placed in a dorsolithotomy position.
- The perineum and vagina are prepped with povidone-iodine solution.

- Two fingers are used to direct the tip of the guide into the lateral vaginal fornix. Care must be taken to interpose the fingers between the cervix or fetal head and the needle. A needle guide may be used, if available.
- The needle is usually inserted close to the cervix at the 3 and 9 o'clock positions in the lateral fornix (imagining the cervix as a clock face). Some authors suggest 4 and 8 o'clock positions to avoid blood vessels (Fig. 18.5).
- The needle is inserted into the vaginal mucosa for a depth of 3–5 mm (Fig. 18.6).
- The syringe is aspirated to rule out needle position inside a blood vessel.
- If there is no backflow of blood, 5 mL of the anesthetic solution is injected into the vaginal submucosa. Injection is avoided during contractions.
- The process is repeated on the other side.

Complications of paracervical block

The following are the complications of a paracervical block:

- Postblock fetal bradycardia is one of the reasons that paracervical blocks are not popular.

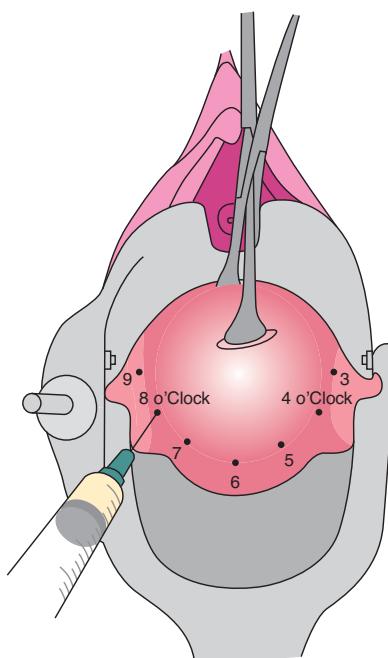


Figure 18.5 Sites for paracervical block. The needle is usually inserted close to the cervix at the 3 and 9 o'clock positions in the lateral fornix (imagining the cervix as a clock face). Some authors suggest 4 and 8 o'clock positions to avoid blood vessels (as shown in the figure).

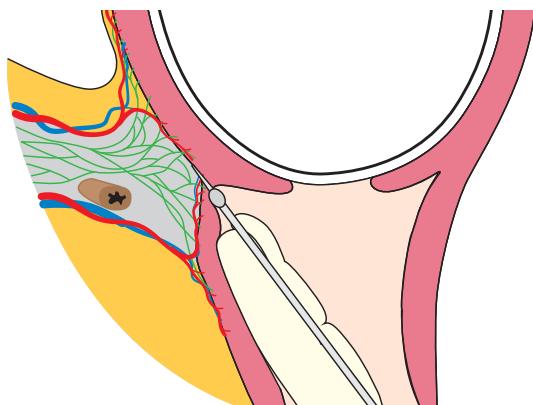


Figure 18.6 Paracervical block. The needle is inserted into the vaginal mucosa for a depth of 3–5 mm.

It may occur within 10 minutes of the injection. It is usually transient, but can last as long as 40 minutes. The mechanism of postblock fetal bradycardia is unclear.

- Systemic toxicity after intravascular administration may result in excessive sedation, generalized convulsions, and cardiovascular collapse.
- Lower extremity paresthesias have been reported.
- Vaginal/broad ligament hematoma or infection is a rare complication.

Anesthesia for labor and delivery

Spinal anesthesia

In a woman undergoing a vaginal delivery, spinal anesthesia is not used for labor analgesia

because the effect lasts only for a short time (90–120 minutes). It may be used for short obstetric procedures such as forceps, vacuum delivery, or manual removal of placenta in the case of a retained placenta. However, spinal anesthesia is the anesthesia of choice for a cesarean section.

Spinal anesthesia is achieved by a subarachnoid injection of a local anesthetic (bupivacaine) and an opioid (fentanyl). It is usually given in the L3/L4 interspace or the one above or below it. It blocks the sensation of pain below the level of the umbilicus. The motor pathways are also affected, so the woman will not be able to move her lower limbs till the anesthetic wears off.

Its advantages over epidural analgesia include the following:

- Short procedure time
- Rapid onset of the block (within 5 minutes)
- High success rate

Spinal anesthesia in a pregnant woman differs from spinal anesthesia in the nonpregnant woman. The differences are summarized in Table 18.2.

Procedure

Spinal anesthesia is administered as follows:

- A preload of 500–1000 mL of IV fluids is given to prevent hypotension resulting from sympathetic block that may result from spinal anesthesia.
- The procedure is done under complete aseptic precautions.
- The woman can be sitting or lying on her side.

Table 18.2 Differences between spinal anesthesia in pregnant and nonpregnant women

	In pregnant women	In nonpregnant women
Dose of anesthetic	Smaller	Larger
Risk of high block	More common	Less common
Hypotension	More common	Less common
Spinal headache	More common	Less common
Technical difficulty in finding subarachnoid space	More	Less
Fetal adverse effects	Secondary to maternal hypotension	—

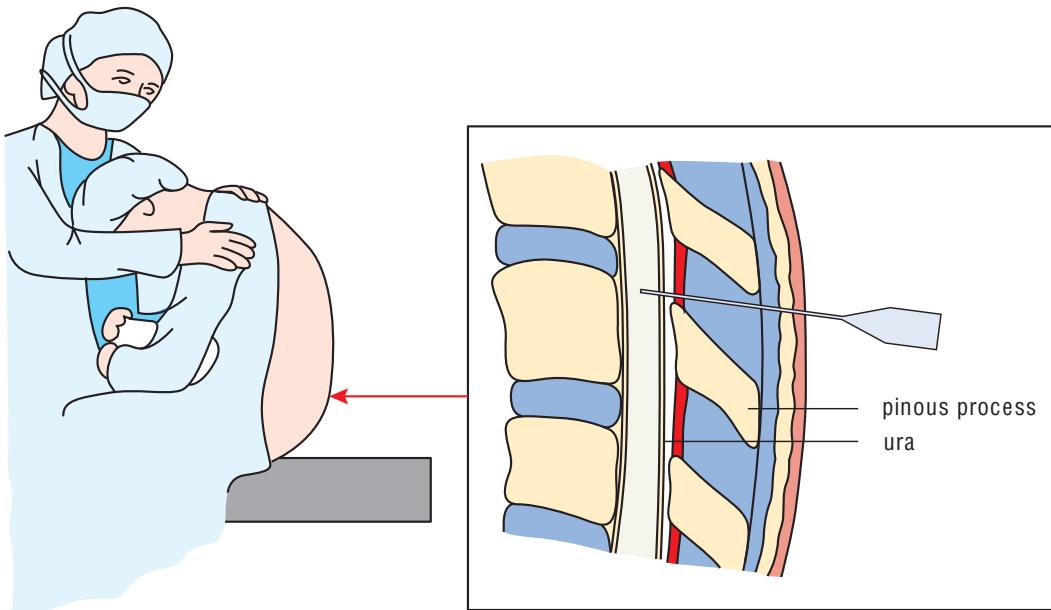


Figure 18.7 Positioning for spinal anesthesia and placement of spinal needle.

- The woman is instructed to arch her back since flexion of the spine opens the intervertebral spaces.
- The L3/4, L4/5, or L5/S1 interspace is identified.
- The chosen interspace is infiltrated with a local anesthetic.
- The spinal needle is inserted in the midline, aiming slightly cranially (Fig. 18.7).
- Resistance increases as the ligamentum flavum is entered and when the dura is encountered, with a sudden 'give' as the dura is pierced.
- Correct placement of the needle is confirmed by a drop of clear cerebrospinal fluid (CSF) appearing at the hub of the needle when the stilette is removed.

Complications

Complications associated with spinal anesthesia are listed in Box 18.10.

Box 18.10 Complications associated with spinal anesthesia

- Hypotension
- Nausea and vomiting
- High spinal (cephalad progression of the level of anesthesia)
- Pruritus
- Postdural puncture headache (PDPH)

ost ural puncture hea ache

A postdural puncture headache (PDPH) is an extremely distressing complication of spinal anesthesia. It is caused by leakage of the CSF through the dural rent made by the spinal needle. The resultant traction on cranial structures and accompanying cerebral vasodilation cause a severe headache that is worsened by sitting or standing and relieved by lying down.

CSF leakage can be avoided or reduced by using a 26- or 27-gauge spinal needle with a short bevel or a pencil point.

The headache is treated with oral or parenteral analgesics and caffeine. If the headache is very severe and does not respond to conventional treatment, it can be treated with an epidural blood patch. The epidural blood patch is performed by injecting 10–20 mL of the woman's blood into the epidural space, thereby sealing the dural defect.

Combined spinal epidural anesthesia

Combining spinal with epidural anesthesia provides the rapid onset of action of a spinal and the longer duration of action of an epidural. It is not a routinely practiced technique.

The technique involves placing a needle into the epidural space. Another smaller-gauge needle

is then threaded through this into the subarachnoid space. After injecting the required drugs into the spinal space, a catheter is inserted into the epidural space for additional drug injection.

General anesthesia

Indications for general anesthesia in the peripartum period

The indications for general anesthesia in the peripartum period are as follows:

- Cesarean section
- Suturing of extensive vaginal or perineal tears after vaginal delivery
- Removal of retained placenta
- Management of acute uterine inversion

General anesthesia is indicated for a cesarean section in the following situations:

- Emergency cesarean section where anesthesia has to be induced without delay due to fetal condition
- Failed/inadequate spinal or epidural anesthesia
- Contraindications to spinal or epidural anesthesia
 - Coagulopathy
 - Anticoagulant therapy

- Profound maternal hypovolemia
- Certain maternal medical conditions
- Skin infection in the lower back
- Mother unwilling to have spinal/epidural anesthesia

Procedure

Preoxygenation with 100% oxygen for 3–5 minutes is recommended. Anesthesia is induced with IV sodium pentothal or propofol. Succinylcholine is the most commonly used muscle relaxant. The woman is intubated with an endotracheal tube to maintain the airway. Inhalation agents such as sevoflurane or isoflurane, with or without nitrous oxide, are used to maintain anesthesia.

Neonatal effect

General anesthesia can cause respiratory depression in the neonate. To avoid exposing the fetus to anesthetic agents for a longer time, it is recommended that the woman have the skin prepped and the abdomen draped before anesthesia is induced. The skin incision is made as soon as anesthesia is induced.

Key points

- Labor pain is the most severe pain a woman will ever experience in her life. It is the responsibility of the obstetric team to alleviate pain by providing all laboring women with options for pain relief.
- Labor pain, by causing maternal respiratory alkalosis and fetal acidemia, can have deleterious effects on the mother and fetus.
- Pain in the first stage of labor is visceral in nature and is mediated by T10–L1 nerve roots.
- Pain in the second stage is somatic and is mediated by the splanchnic nerves and the pudendal nerve (S2–S4).
- Labor analgesia refers to relief of pain in labor with pharmacological and nonpharmacological methods.
- Anesthesia refers to complete block of pain sensation with or without loss of consciousness.
- Pain relief in labor can be provided by nonpharmacological or pharmacological techniques.
- The commonest pharmacological techniques used in labor are opioids, Entonox, and epidural analgesia.

- Epidural analgesia is the most effective technique for labor analgesia.
- Epidural analgesia is a central nerve block technique accomplished by injecting a local anesthetic close to the nerves that transmit labor pain in the first and second stages of labor.
- Hypotension, which is the commonest complication of epidural, can be avoided by preloading the mother with 500–1000 mL of IV crystalloid solution.
- A pudendal block provides relief of pain resulting from the stretching of the vagina and perineum by the descending fetal presenting part in the second stage of labor.
- Complications of a pudendal block are rare but include hematoma formation, infection at the site of injection, ischial region paresthesias, and sacral neuropathy.
- A paracervical block relieves the pain caused by cervical dilatation during the first stage of labor. Paracervical blocks are not commonly used for pain relief during labor.

(Continued)

Key points *Continued*

- In a woman undergoing a vaginal delivery, spinal anesthesia is not used for labor analgesia because the effect lasts only for a short time (90–120 minutes).
- Spinal anesthesia may be used for short obstetric procedures such as forceps, vacuum delivery, or manual removal of placenta in the case of a retained placenta.
- Spinal anesthesia is the anesthesia of choice for a cesarean section.
- Complications of spinal anesthesia include hypotension, nausea and vomiting, high spinal (cephalad progression of the level of anesthesia), pruritus, and postdural puncture headache (PDPH).
- General anesthesia is used for a cesarean section in situations where delivery is urgent due to fetal condition, in failed neuraxial anesthesia, in cases where there is a contraindication to neuraxial anesthesia, or if the woman is unwilling for neuraxial anesthesia.

Self-Assessment

Case-based questions

Case 1

Mrs. JR, 23, came to the hospital in active labor. This was her first pregnancy and she was in severe pain. She requested pain relief.

1. What is the cause of pain in the first stage of labor?
2. What is the cause of pain in the second stage of labor?
3. Which is the ideal labor analgesia for both the first and second stages of labor?
4. Which block would be useful in the second stage of labor if the woman does not want epidural analgesia?

Case 2

Mrs. RJ, 28, requested epidural analgesia in labor. Soon after the epidural was given, there was fetal bradycardia.

1. What causes fetal heart rate abnormalities following epidural analgesia?
2. What are the measures for avoiding hypotension following an epidural?
3. What is a postdural puncture headache?
4. How is a postdural puncture headache managed?

Answers

Case 1

1. The pain in the first stage of labor is caused by distension of the uterus and ischemia of the uterine and cervical tissues. It is mediated through T10–L1 spinal roots.
2. The pain in the second stage of labor is caused by distension of the vagina, perineum, and pelvic floor and is transmitted by the pudendal nerve (S2, S3, S4).

3. Epidural analgesia is ideal to relieve the pain of both the first and second stages of labor.
4. A pudendal block may be given in the second stage to relieve the pain from cervical dilatation and for analgesia during suturing of lacerations/episiotomy.

Case 2

1. Maternal hypotension is a major complication following epidural analgesia. This leads to decreased placental perfusion and heart rate abnormalities.
2. Preloading with 500–1000 mL of IV fluids before administering the epidural can decrease the risk of hypotension.
3. A postdural puncture headache can result from an accidental dural rent while administering the epidural. Leakage of the cerebrospinal fluid leads to traction on cranial structures and, along with cerebral vasodilation, results in a severe headache.
4. The postdural puncture headache is treated with analgesics and oral hydration. If unrelieved and severe, an epidural blood patch is used. This is achieved by injecting 10–20 mL of the woman's blood into the epidural space.

Sample questions

Long-answer questions

1. What are the nonpharmacological and pharmacological methods of labor analgesia?
2. List and explain the different methods of neuraxial analgesia used in labor.

Short-answer questions

1. Pudendal block
2. Complications of epidural analgesia in labor
3. Spinal anesthesia for labor and delivery

19

Operative Vaginal Delivery and Destructive Operations

Case scenario

Mrs. BN, a primigravida at term, was admitted to the labor room with pains. Labor progressed normally and a vaginal examination revealed that the cervix was fully dilated. An hour later, she had pushing pains. The fetal heart rate was found to be 100 bpm and continued at that rate for 3 minutes. She was delivered by forceps and a live, term, girl baby was born. The newborn's cry was initially feeble, but the baby recovered rapidly after oxygen administration by mask.

Introduction

Once the first stage of labor proceeds normally and the cervix is fully dilated, delivery of the fetus takes place spontaneously in most situations. However, when the mother's expulsive efforts are inadequate or when there is a possible compromise to the fetus while waiting for normal delivery, operative vaginal delivery is required. Operative vaginal delivery is an art. When the instruments are used appropriately, the procedure is simple and there is no injury to mother or fetus. Training in the technique operative vaginal delivery is essential for every obstetrician to avoid high cesarean section rates.

operative vaginal delivery

Operative vaginal delivery refers to a procedure where the mother is assisted in the delivery of the fetal head by the use of a forceps or vacuum device.

Incidence

The incidence of operative vaginal delivery varies widely. It is about 5%–10% globally. Vacuum is used more frequently than forceps.

The obstetric forceps

The obstetric forceps are an instrument used to assist in the delivery of the fetal head. The forceps may be used for traction, rotation, or simple 'lift out'.

History

Paired instruments similar to obstetric forceps were used in 1500 BCE in Egypt, Greece, and Persia. The modern forceps, however, were invented by Peter Chamberlen of England in the 17th century. The instrument was kept secret for nearly 150 years and surfaced in 1813. Chamberlen's forceps did not have a pelvic curve and were associated with high perinatal mortality. In 1723, Jean Palfyn presented forceps invented by him in the Academy of Sciences in Paris. These forceps had parallel blades. The pelvic curve was introduced by Andre Levret in France in 1747 and William Smellie in England in 1751. With this, the application of forceps became easier. Tarnier later introduced a traction system (axis traction). The forceps with cephalic and pelvic curves were developed by Sir James Simpson in 1845. Milne Murray (1891) and Neville (1886) introduced the detachable angled traction rods and traction handles. This facilitated traction in the axis of the birth canal. More than 700 types of forceps have been developed subsequently.

Description and design

Forceps consist of two crossing halves or *branches* with a locking mechanism in the center. Each branch of the forceps consists of a *blade*, *shank*, *handle*, *finger guards*, and *lock* (Fig. 19.1; Box 19.1).

The *blade* is the part that hugs the fetal skull. It is usually fenestrated but may be solid or pseudofenestrated. The blade joins the *shank*. The *lock* is located at the point where the shank joins the handle. The handles are used to grasp the forceps to apply traction. The blades are referred to as right and left blades corresponding to the side of the maternal pelvis into which they are inserted.

The *cephalic curve* is the curvature on the inner surface of the blades and can be measured by the radius of the blades when they are in opposition



Figure 19.1 Parts of a forceps. The forceps consist of two branches. Each branch has a blade (black arrow), shank (orange arrow), handle (white arrow), finger guard, and lock (red arrow).

Box 19.1 Parts of the obstetric forceps

- Two halves with a lock
 - Each half consists of
 - fenestrated blade
 - shank
 - lock
 - handle
 - finger guard
- Cephalic curve
- Pelvic curve
- Perineal curve
- Locking system
 - English lock
 - French lock
 - Sliding lock

(Fig. 19.2a). The curvature helps to grasp the fetal head and distribute the force evenly.

The *pelvic curve* is the curvature along the long axis of the blade that conforms to the axis of the birth canal and facilitates the application of the forceps along this axis (Fig. 19.2b).

The *perineal curve* is unique to some types of forceps and is the curvature on the lower border of the shank as in Piper's forceps or in the traction rods of axis traction forceps (Fig. 19.2c).

The *lock* is the fulcrum. The *sliding lock* allows one branch of the forceps to slide up and down along the other (Keilland's forceps) and is useful for correcting asynclitism. Axis traction forceps have a *nut and screw system* that locks one

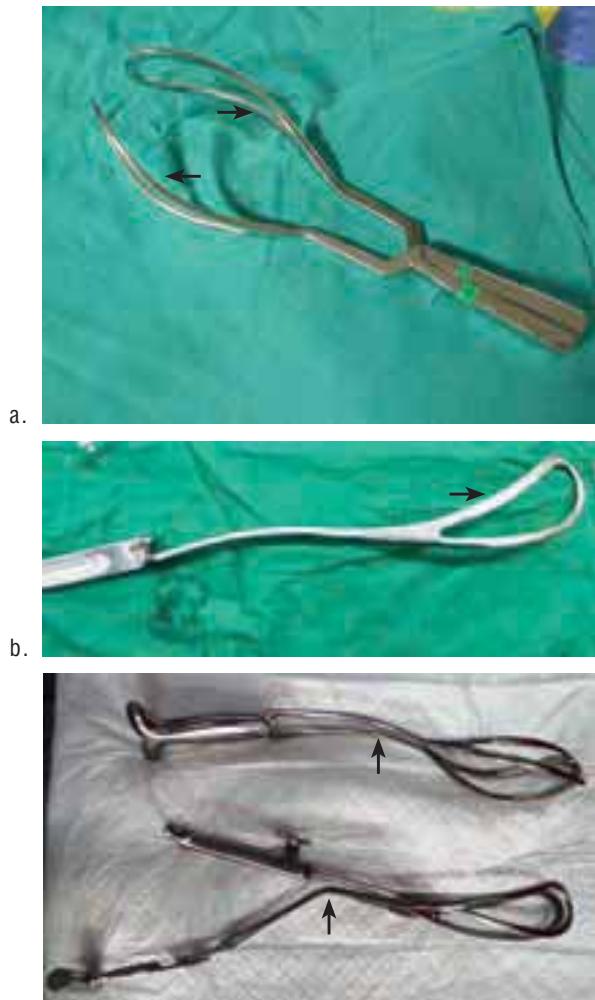


Figure 19.2 Cephalic, pelvic, and perineal curves. **a.** The cephalic curve is the curvature on the inner surface of the blades (arrow). **b.** The pelvic curve is the curvature along the upper border of the blades (arrow). **c.** The perineal curve is unique to some forceps and is the curvature on the lower border of the shank (arrow). (Photo courtesy: Dr Rajnish Samal.)

branch firmly on to the other. The *English lock* is most common and consists of a socket at the base of one shank that fits into the socket at the base of the opposite shank (Fig. 19.3).

Functions of forceps

The functions of forceps are as follows:

- Traction
- Rotation



Figure 19.3 Locks on the forceps. **a.** Sliding lock allows one branch of the forceps to slide along the other. **b.** Nut and screw system locks one branch to the other. **c.** English lock has a socket that fits into the socket of the opposite shank.

Types of forceps

The types of forceps are listed in Table 19.1 and shown in Figure 19.4.

Classification of operative vaginal delivery

The American College of Obstetricians and Gynecologists (ACOG) has classified forceps and vacuum delivery according to station and position, as given in Box 19.2.

High forceps delivery is not included in the above classification because of the following reasons:

- Head is $>two\text{-fifth}$ palpable per abdomen
- Presenting part above ischial spines
- Not practiced in modern obstetrics

Indications for forceps delivery

Forceps delivery is used when delivery needs to be expedited due to fetal compromise, maternal exhaustion, or to shorten the second

Table 19.1 Types of forceps

Name of forceps	Level of use	Features
Traction forceps		
Wrigley's forceps	• Outlet forceps	Short, light forceps
	• Simple lift out	Cephalic and pelvic curves
	• Cesarean section	English lock
Simpson's forceps	} Low forceps	<ul style="list-style-type: none"> • Longer forceps • Cephalic and pelvic curves • English lock
Elliot's forceps		
Milne Murray's forceps	} Low/mid forceps	<ul style="list-style-type: none"> • Axis traction forceps • Has traction rods and handle • Has cephalic, pelvic, and perineal curves • English lock, nut, and screw • Traction along axis of birth canal
Tarnier's forceps		
Rotational forceps		
Kielland's forceps	Midforceps	<ul style="list-style-type: none"> • Cephalic and minimal pelvic curves • Sliding lock • Used in occipitotransverse position • Corrects asynclitism
Barton's forceps	Midforceps	<ul style="list-style-type: none"> • One blade hinged • Sliding lock • Cephalic curve
Special forceps		
Piper's forceps	<ul style="list-style-type: none"> • Aftercoming head • In breech delivery 	<ul style="list-style-type: none"> • Long shaft • Cephalic, pelvic, and perineal curves • English lock

Box 19.2 ACOG classification of operative vaginal delivery**Outlet**

- Scalp visible at introitus without separating labia
- Fetal skull has reached the pelvic floor
- Sagittal suture is in the AP diameter, or occiput in LOA, LOP, ROA, or ROP position.
- Fetal head is at or on the perineum
- Rotation does not exceed 45 degrees

Low forceps

- Leading point of fetal skull is at $\geq +2$ cm station and not on the pelvic floor
 - Rotation ≤ 45 degrees (to LOA/ROA to OA, or LOP/ROP to OP), or
 - Rotation ≥ 45 degrees including OP position

Midforceps

- Station above $+2$ cm, but head engaged
 - Rotation ≤ 45 degrees (to LOA/ROA to OA, or LOP/ROP to OP), or
 - Rotation ≥ 45 degrees including OP position

AC American College of Obstetricians and Gynecologists;
 AP anteroposterior; A left occipitoanterior; P left
 occipitoposterior; A occipitoanterior; P occipitoposterior;
 A right occipitoanterior; P right occipitoposterior.

stage in case of maternal medical conditions. Terms such as *prophylactic* and *elective* forceps are not used in modern obstetrics. The indications for forceps delivery are given in Box 19.3.

Contraindications

There are very few contraindications to forceps delivery, usually pertaining to potential harm to the fetus. An unengaged head, unknown fetal position, malpresentation (e.g., brow, mentoposterior) are contraindications. Fetal prematurity is a relative contraindication. Suspected fetal bleeding disorders such as thrombocytopenia and maternal human immunodeficiency virus (HIV) infection (to avoid scalp abrasion) are relative contraindications. Forceps delivery should not be attempted in suspected cephalopelvic disproportion and mentoposterior position.



Figure 19.4 Types of forceps. **a.** Wrigley's forceps. **b.** Simpson's forceps. **c.** Milne Murray's axis traction forceps. **d.** Kielland's forceps. **e.** Piper's forceps. (Photo courtesy: Dr Rajnish Samal.)

Box 19.3 Indications for forceps delivery

- Maternal
 - Prolonged second stage
 - Without epidural analgesia
 - Nullipara >2 hours
 - Multipara >1 hour
 - With epidural analgesia
 - Nullipara >3 hours
 - Multipara >2 hours
 - Maternal exhaustion
- Fetal
 - Nonreassuring fetal heart pattern
 - Malpositions
 - Occipitoposterior
 - Occipitotransverse
 - Malpresentations
 - Breech: Aftercoming head
 - Face: Mentoanterior
- To shorten second stage
 - Cardiac disease class III/IV
 - Severe preeclampsia/hypertension
 - Myasthenia gravis

Morbidity

Maternal and perinatal morbidities increase with (a) higher station of the fetal head and (b) rotational forceps. When outlet or low forceps are properly applied, perinatal mortality is low. The benefits clearly outweigh the risks. Causes of morbidity are given in Box 19.4.

Box 19.4 Morbidity from forceps delivery

- Maternal
 - Injuries
 - Perineal lacerations
 - Need for episiotomy
 - Vaginal and cervical tears
 - Traumatic postpartum hemorrhage
 - Long-term
 - Urinary incontinence
 - Anal sphincter dysfunction
 - Puerperal endometritis
- Perinatal
 - Soft tissue injury to face
 - Facial nerve palsy
 - Intracranial hemorrhage
 - Cephalhematoma

Maternal and fetal evaluation

Forceps delivery should be undertaken only after careful assessment of the mother and fetus (Box 19.5). History of maternal medical condition, progress in labor, duration of second stage, and indication for forceps delivery must be reviewed. Routine ultrasonography for assessment of fetal position is not recommended.

Prerequisites for forceps delivery

Forceps should only be applied if the head is engaged, cervix fully dilated, membranes ruptured, bladder empty, and vertex or mentoanterior presentation, and when the position of the presenting part is precisely known (Fig. 19.5). Forceps should not be applied if there is cephalopelvic disproportion. These prerequisites are listed in Box 19.6.

Procedure

The procedure of forceps delivery consists of application, traction, and delivery of the fetal head.

Box 19.5 Assessment before forceps delivery

- Abdominal examination
 - Uterine contractions
 - Descent of the head
 - Fetal heart rate
 - Weight of the baby
- Vaginal examination
 - Cervical dilatation
 - Rupture of membranes
 - Color of amniotic fluid
 - Presenting part
 - Station
 - Flexion
 - Asynclitism
 - Position
 - Degree of molding
 - Caput succedaneum

Box 19.6 Prerequisites for forceps delivery

- Head must be engaged
- Cervix must be fully dilated
- Membranes must be ruptured
- Presentation must be vertex or mentoanterior
- Position must be precisely known
- There should be no cephalopelvic disproportion
- Bladder must be empty
- Informed consent must be obtained from the mother

Application of forceps

- Aseptic technique must be used. Prophylactic antibiotics are not recommended.
- The mother should be in the lithotomy position (dorsal position may be sufficient for outlet forceps).
- A pudendal block is recommended for low and midforceps delivery. In addition, the perineum should be infiltrated with local anesthetic for episiotomy.
- The bladder should be empty. Catheterize if bladder is full.
- Reevaluate station, position, and rotation of vertex.
- Forceps should be selected according to station of vertex:
 - +3 cm: Wrigley's
 - +2 cm: Simpson's
 - Above +2 cm: Simpson's or Milne Murray's
- The left blade is inserted first. This should be held in the left hand, using the thumb and two fingers, with the shank and handle held vertical, with the tip of the blade pointing to the floor (Fig. 19.5).
- The index and middle fingers of the right hand are introduced into the posterior aspect of the vagina toward the left, between the fetal head and the vaginal wall.
- The left blade is guided along the palmar surface of the fingers of the right hand, initially into the posterior part of the vagina, gradually rotating it to the left, and finally placing it horizontally on the left side of the pelvis.
- The handle is depressed and held in place by the assistant.
- The right blade is held in the right hand. Two fingers of the left hand are introduced into the right posterior aspect of the vagina.



Figure 19.5 Application of the left blade. The left blade is held in the left hand with the thumb and fingers, the shank and handle is held vertical with the tip pointing to the floor. This is guided along the palmar surface of the right hand into the posterior aspect of the vagina.



Figure 19.6 Application of the right blade. The right blade is held in the right hand and introduced along the palmar aspect of the left hand into the right posterior aspect of the vagina.



Figure 19.7 Locking the forceps. The handles of the blades are approximated and the forceps are locked.

- The right blade is introduced along the fingers of the left hand and the procedure is repeated (Fig. 19.6).
- The handles are approximated, and the blades are locked (Fig. 19.7).

Checking for accurate application

- The sagittal suture should be perpendicular to the plane of the shanks and equidistant from the two blades.
- The posterior fontanel should be midway between the blades and one finger breadth anterior to the line joining the shanks.
- A small part of the fenestration of the blade may be felt on either side.

When correctly applied, and the above criteria are satisfied, the forceps grasp the head in the *occipitomental diameter*. In the occipitoanterior position, the major part of the blade is on the fetal face (Fig. 19.8).

If rotation is not complete

- If the sagittal suture is <45 degrees short of full rotation, the blades should be applied in the same order but the application should be cephalic, with the blades over the parietal bones. The vertex rotates when traction is applied.

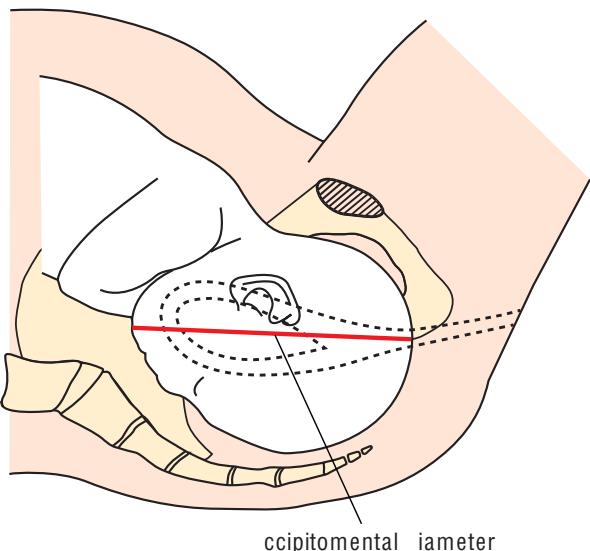


Figure 19.8 Correct application of forceps. When the forceps are applied and blades are locked, the head is grasped in the occipitomental diameter with the major part of the blade on the fetal face.

- If the sagittal suture is >45 degrees from the midline (low or midforceps), manual rotation may be tried first. If not successful, forceps can be applied and rotation takes place during traction.

Traction

Traction should be applied during contraction. Direction of traction depends on station and position. It should be in the axis of the birth canal, along the curve of Carus. From the level of ischial spines, the maternal pelvis is 'J' shaped. Hence, the direction of traction is as given below:

- Outlet forceps: Upward to complete extension of head (Fig. 19.9).
- Low forceps: Horizontal until head crowns and perineum bulges, followed by upward traction
- Midforceps: Downward and backward initially, followed by upward and forward and finally upward.
- Delivery as occipitoposterior: Horizontal until the root of the nose hitches under the pubic symphysis, upward and forward until occiput is born, and downward and backward for the nose, face, and chin to be born.

Episiotomy

Although routine episiotomy is not recommended, it is required in most forceps deliveries.



Figure 19.9 Traction. When forceps are applied at the outlet, upward traction completes the extension of and delivery of the head.

Episiotomy should be performed when the perineum bulges and the head crowns.

Occipitotransverse positions

When the vertex is in occipitotransverse position, delivery is by one of the following methods:

- Manual rotation and forceps delivery
- Forceps rotation and delivery
- Vacuum extraction
- Cesarean section

Manual rotation is discussed in Chapter 41, *Abnormal labor: Malposition and malpresentations*.

Rotational forceps

This requires specialized skill and training. Kielland's or Barton's forceps must be used. The Kielland's forceps have minimal pelvic curve to facilitate rotation. The blades are referred to as *anterior* and *posterior blades*. The forceps should be assembled and held in front of the patient with the knob on the lock pointing in the direction of the occiput; in this position, the anterior and posterior blades are determined. There are three methods of application of the anterior blade (Fig. 19.10).

Classical method

The anterior blade is introduced between the head and the uterine wall under the pubic symphysis, with the cephalic curve facing upward.



Figure 19.10 Methods of application of Keilland's forceps. **a.** Identification of anterior and posterior blades by assembling the forceps in front of the patient. **b.** Classical method. The anterior blade is inserted with the cephalic curve facing upward. **c.** Wandering method. The anterior blade is inserted along the posterior aspect of the head and swept over the face to anterior position. **d.** Direct method. The anterior blade is applied directly anteriorly with the cephalic curve facing the fetal head. **e.** The posterior blade is applied directly and the blades are locked.

The blade is turned 180 degrees after it is in the uterine cavity, to grip the fetal head.

Wandering method

The anterior blade is inserted posterior to the head and swept over the face to the anterior position.

Direct method

The anterior blade is inserted directly behind the pubic symphysis with the cephalic curve facing downward and is slipped over the fetal head.

In all the three methods, the posterior blade is inserted directly behind the head and the head is grasped. Traction is applied during contraction,

and rotation is performed between contractions. Gradually, the head is rotated and delivery is completed.

Rotational forceps are associated with higher rate of maternal and fetal complications. Spiral tears of the vagina, and uterine rupture, especially with the classical method of application, are well-known complications. **Therefore, rotational forceps have been replaced by vacuum delivery and cesarean section in modern obstetrics.**

Forceps for the aftercoming head in breech is discussed in Chapter 42, *Abnormal labor: Breech presentation and shoulder dystocia*.

Trial of forceps

When difficulty is anticipated in vaginal delivery with forceps, an attempt is made in the operating room, fully equipped with facilities for immediate cesarean section. This is known as *trial of forceps*. This should be attempted only when the likelihood of success is high. If difficulty is encountered in application, locking, or traction, immediate cesarean section should be proceeded with. Neonatal outcome in the trial of forceps, when attempted in selected cases, is similar to elective cesarean section.

Failed forceps

When difficulty is not anticipated in forceps delivery but the attempt fails, it is known as *failed forceps*. Neonatal morbidity is much higher with failed forceps delivery. Maternal morbidity also increases when cesarean section is performed in the second stage with the fetal head jammed in the pelvis. Forceps delivery should be abandoned in the following situations:

- There is difficulty in application of the blades.
- There is no progressive descent with moderate traction.
- Delivery is not imminent after three pulls.

The vacuum extractor (ventouse)

The vacuum extractor was first devised by Tage Malmström in 1953. The instrument consists of a metal cup attached to a pump by suction tubing.

Negative pressure is created between the cup and the fetal scalp by the pump, and traction is applied to the scalp to pull the fetus.

Description and design

Vacuum extractors are classified into two types according to the material used to make the cup:

- Rigid cups
 - Rigid metal cups
 - Rigid plastic, polyurethane, or polyethylene cups
- Soft cups
 - Soft silastic/plastic cups

Rigid cups

The traditional metal cup is the *Malmström cup*.

- The cup is made of stainless steel. It is mushroom shaped with a smaller diameter at the rim than above the rim (Fig. 19.11). This shape helps in drawing the scalp into the cup to create an artificial caput succedaneum (*chignon*) (Fig. 19.12) and allows a firm grip. The diameter of the cup may be 40, 50, or 60 mm.
- A metallic disk is attached to a traction chain that goes through the tubing.



Figure 19.11 Vacuum extractor—the metal cup. The cup is mushroom shaped, with a smaller diameter at the brim rather than above the brim.



Figure 19.12 Chignon. This is formed on the fetal scalp when it is drawn into the metal cup by negative pressure.



Figure 19.13 The vacuum extractor—Silastic cup. The cup is funnel shaped and fits over the scalp without the need for the formation of a chignon.

- The rubber tubing connects the center of the cup to the suction pump.
- The suction pump may be a handheld pump or wall suction.

Bird's cup is a modification in which the tube is attached eccentrically near the rim of the cup. This is particularly useful for occipitoposterior and transverse positions.

Soft cups

The Silastic cup was first introduced by Kobayashi in 1973.

- The cup has a diameter of 65 mm and is funnel shaped (Fig. 19.13). Smaller sizes of 50 mm and 60 mm are also available
- The cup fits over the occiput without the need for the formation of a chignon.
- There is less scalp trauma but more failure due to the slipping of the cup.

There are several modifications of this cup. The most commonly used one is the *Kiwi cup*, which consists of a Silastic cup attached directly to a hand pump. The traction handle may be flexible to allow easy placement and lateral traction as in Bird's cup.

Rigid versus soft cups

The rigid cups generate more traction force by creating a good chignon. The traction force is, therefore, more with metal cups. The differences between soft and rigid cups are given in Table 19.2.

Table 19.2 Differences between soft and rigid cups

Soft cups	Rigid cups
More likely to fail	Less likely to fail
Less scalp injuries	More scalp injuries
More suitable for OA positions	More suitable for OP positions, asynclitism and larger fetus

A occipitoanterior; P occipitoposterior.

Functions

Functions of the vacuum extractor are as follows:

- Traction
- Rotation

Indications for vacuum delivery

The indications for vacuum delivery are the same as for forceps delivery. However, it must be remembered that vacuum cannot be used in malpresentations.

Contraindications

Since the formation of chignon and traction on the scalp can result in trauma to the scalp, there are a few contraindications (Box 19.7).

Box 19.7 Contraindications for vacuum extraction

- Gestational age <34 weeks
 - Risk of fetal intraventricular hemorrhage
 - Malpresentations
 - Cephalopelvic disproportion
 - Fetal bleeding disorders
 - Maternal HIV infection
- human immunodeficiency virus.

Morbidity from vacuum delivery

The morbidity from vacuum delivery is similar to that seen with forceps delivery. The risk of subaponeurotic hemorrhage and scalp lacerations is higher.

Forceps versus vacuum delivery

Vacuum delivery has advantages and disadvantages over forceps delivery (Box 19.8). The vacuum extractor is preferred to forceps in many centers, but the decision rests on the operator's experience and personal preferences.

Box 19.8 Advantages and disadvantages of vacuum over forceps

- Advantages
 - The cup does not occupy space in the pelvis
 - Precise positioning on the head not mandatory
 - Less maternal injury
 - Third and fourth degree perineal tears
 - Vaginal lacerations
 - No compression of fetal head
 - Less risk of
 - Birth injuries
 - Seizures
 - Assisted ventilation
- Disadvantages
 - More failure rate
 - Cannot be used in
 - Preterm fetuses
 - Malpresentations
 - Higher risk of
 - Subgaleal hemorrhage
 - Retinal hemorrhage
 - Cephalhematoma
 - Shoulder dystocia

Prerequisites for vacuum delivery

The prerequisites for vacuum extraction are similar to those for forceps delivery and are listed below:

- Presentation must be cephalic.
- Head must be engaged; station should be +2 cm or below.
- Cervix should be fully dilated.
- There should be no cephalopelvic disproportion.
- Bladder should be empty.

Procedure

Before vacuum delivery, progress in labor, fetal heart tracing, engagement of the head, and uterine contractions must be evaluated. Indication for vacuum delivery should be clearly documented.

- The mother should preferably be in the lithotomy position. Dorsal position can also be used.
- Prophylactic antibiotics are not recommended.
- Pudendal block anesthesia is recommended.
- Vaginal examination is performed to assess the position and station of the head and ensure that the cervix is fully dilated.
- The largest cup that can be applied should be selected.
- The cup should be placed at the *flexion point* (point on the fetal skull where the suction cup is placed, so that appropriate flexion can be achieved). In occipitoanterior positions, the flexion point is located on the sagittal suture, 6 cm from the anterior fontanel and 3 cm from the posterior fontanel. The center of the cup should be over this point; the posterior edge of the cup should be just at the edge of the posterior fontanel (Fig. 19.14).
- If using a soft Silastic cup, the cup can be folded for easy insertion into the vagina.
- Once the cup is placed on the scalp, two fingers should be inserted into the vagina to check all around the cup to ensure that vaginal or cervical tissue is not trapped in the cup.
- Negative pressure is created using the pump and the pressure is raised to 0.2 kg/cm^2 . The perimeter of the cup is checked again to ensure that vaginal or cervical tissue is not trapped in the cup.



Figure 19.14 Flexion point. This is the point on the fetal skull where the suction cup is placed so that appropriate flexion is achieved. In occipitoanterior position, it is on the sagittal suture, 6 cm from the anterior fontanel and 3 cm from posterior fontanel.

- Negative pressure is raised rapidly to 0.8 kg/cm^2 . Slow, gradual increase was practiced earlier, but randomized trials have shown that rapid increase reduces the duration of application without compromising effectiveness and safety.
- Traction is applied during contractions, with the right hand, with the direction of traction perpendicular to the surface of the cup. Two fingers of the left hand should be placed on the scalp and the thumb on the cup to exert counter traction and prevent the cup from slipping. The woman should be encouraged to push when traction is being applied.
- Traction should be in the direction of the birth canal, that is, downward and backward initially followed by upward and forward as the head crowns.
- If the vertex is in the occipitoposterior or transverse position, rotation takes place automatically as traction is applied and progressive descent occurs.
- A maximum of three pulls during descent and three pulls during crowning and delivery are acceptable. Usually the baby is delivered with three pulls. The total duration of the procedure should not exceed 20 minutes.

Detachment of the cup

Detachment or slipping of the cup can occur due to the following reasons:

- Large caput succedaneum
- Faulty application

- Faulty direction of traction
- Cephalopelvic disproportion

The cup may be reapplied two to three times. However, there should be descent with each pull. If no descent occurs after three pulls, vacuum extraction should be abandoned. Detachment of the cup can cause lacerations on the scalp.

Sequential use of vacuum and forceps

Often, when the vacuum extractor detaches, the vertex may have rotated and some descent also may have occurred. Delivery at this stage can be completed by outlet forceps if the head is on the pelvic floor. However, if the cup had detached because of excessive force being applied during traction, and there is no descent of the head, sequential use of instruments is associated with an increase in neonatal morbidity, trauma, intracranial hemorrhage, and asphyxia. Cesarean section is a safer alternative and should be resorted in this situation.

Destructive operations

Destructive operations are performed to reduce the fetal size or skull diameter to relieve obstruction and achieve vaginal delivery of a *dead fetus* or *one with lethal malformation*. These are seldom performed in modern obstetrics for the following reasons:

- The majority of lethal fetal malformations are diagnosed early by ultrasonography and the pregnancy terminated.
- Obstructed labor with fetal death is rarely encountered in developed countries.
- Lack of expertise and experience in these procedures.
- Risk of maternal complications.

Types of destructive operations

Several destructive operations have been described and have been performed in the past. These are listed in Table 19.3. Perforation of the

Table 19.3 Destructive operations

Terminology	Procedure	Indication
Craniotomy	Removal of intracranial contents by making an opening in the skull	Hydrocephalus Obstructed labor with CPD
Cleidotomy	Dividing the clavicle(s)	Shoulder dystocia with or without anencephaly
Decapitation	Separating the head from the trunk	Transverse lie
Spondylotomy	Dividing the fetal trunk	Transverse lie
Evisceration	Removal of abdominal contents	Macrosomia

CPD cephalopelvic disproportion.

fetal skull in a hydrocephalic fetus is the only procedure performed with any frequency currently. Cleidotomy may occasionally be undertaken in shoulder dystocia in a fetus with anencephaly.

Craniotomy

This procedure is most commonly indicated in following conditions:

- Fetus with gross hydrocephalus, even if alive
- Obstructed labor
 - Cephalopelvic disproportion
 - Dead fetus
 - No threatened or suspected rupture

Procedure

- General or regional anaesthesia is recommended.
- The woman should be in a lithotomy position.
- The bladder should be catheterized.
- The cervix should be fully dilated for perforation in a normally formed dead fetus. If the fetus is hydrocephalic, this can be done through an incompletely dilated cervix.
- In a fetus with hydrocephalus, the skull bones may be thin, and any skull bone that is within reach or a fontanel may be perforated. The fluid is drained and the head delivered with further uterine contractions.
- In obstructed labor, the site of perforation depends on the fetal presentation
 - Vertex presentation—parietal bones
 - Brow presentation—frontal bone
 - Face presentation—roof of the mouth or orbit
 - Aftercoming head of breech—occipital bone
- The index and middle fingers of the left hand should be introduced into the vagina

anteriorly, with palm facing down, to protect the bladder.

- The Simpson's or Oldham's perforator (Fig. 19.15) is introduced along the palmar aspect of the left hand into the vagina and cervix (Fig. 19.16).
- The perforator should be pushed into the fetal skull after steadyng the head by suprapubic



Figure 19.15 Simpson's perforator. This is used for perforating the head of a dead fetus or a fetus with lethal malformation.



Figure 19.16 Perforation of the fetal head. The index and middle finger of the left hand are placed anteriorly to protect the bladder. The perforator is introduced along the palmar aspect of the left hand.

pressure. The scalp may have to be incised with a knife before this. The perforator is opened in one direction and then at right angles to make a cruciate incision. Brain matter should be

drained by thrusting the perforator into the skull and breaking it up.

- Delivery is completed with traction by volsellum as the skull diameter reduces.

Key points

- Operative vaginal delivery can be by forceps or vacuum extraction.
- The obstetric forceps consist of two branches with a locking mechanism.
- Each branch of the forceps has a cephalic and a pelvic curve. Some forceps have a perineal curve as well.
- Functions of the forceps are traction, rotation, and minimal compression of fetal skull to facilitate delivery.
- There are different types of forceps, broadly classified as traction forceps, rotational forceps, and special forceps.
- Indications for operative vaginal delivery are prolonged second stage, nonreassuring fetal status, and necessity to shorten the second stage due to maternal medical conditions.
- Instrumental delivery is associated with maternal and neonatal morbidity. However, the benefits outweigh the risks.
- There are prerequisites for application of forceps. The mother and fetus should be clinically evaluated before forceps delivery is attempted.

- Guidelines and appropriate procedures should be followed for application, traction, and rotation.
- Vacuum extractors are classified as rigid and soft cups according to the material used to make the cup.
- Indications and risks for vacuum extraction are the same as for forceps delivery. However, vacuum extraction should not be used in preterm delivery and malpresentations.
- Risk of subgaleal hemorrhage is higher with vacuum extraction.
- Evaluation of the mother and fetus and adherence to guidelines and appropriate procedure are mandatory for vacuum delivery as well.
- Sequential use of vacuum and forceps is associated with a high neonatal morbidity and should be avoided.
- Destructive operations are not commonly performed in modern obstetrics. Perforation of the fetal head in cases of hydrocephalus or obstructed labor with a dead fetus is the only one that is undertaken in some centers.

Self-Assessment

Case-based questions

Case 1

Mrs. BN, a primigravida at term, was admitted to the labor room with pains. Labor progressed normally and vaginal examination revealed that the cervix was fully dilated. An hour later, she had pushing pains, and the fetal heart rate was found to be 100 bpm. It continued at that rate for 3 minutes.

1. What is the diagnosis?
2. How will you make a decision regarding the mode of delivery?
3. How will you make a decision regarding the type of forceps to be used?
4. If the position is direct occipitoposterior, what is the direction of traction?

Case 2

Mrs. VM, 25, third gravida at term, was admitted to the labor room with pains. Pelvic examination revealed that the vertex was in right occipitoposterior position. Pelvic configuration was normal. Labor progressed normally and cervix was fully dilated at 8 PM. Two hours later, on vaginal examination, vertex was in occipitotransverse position.

1. What is the diagnosis?
2. How will you make a decision regarding the mode of delivery?
3. If the vacuum cup detaches during traction, what will you do?
4. What is the most common neonatal morbidity?

Answers

Case 1

1. Nonreassuring fetal status.
2. If the vertex is fully rotated or <45 degrees short of rotation and station is $\geq +2$ cm, forceps or vacuum delivery may be attempted. If the station is higher, cesarean section is the best option.
3. If the station is $\geq +3$, outlet forceps and, if between +2 and +3, midforceps should be used.
4. Horizontal traction until root of the nose is born, followed by upward and forward until occiput is born, and finally downward and backward.

Case 2

1. Deep transverse arrest.
2. If the vertex is $\geq +2$ cm below the spines and there is caput or molding, delivery may be instrumental, preferably vacuum extraction. Keilland's rotational forceps are an option but are not commonly used now. If the vertex is above +2 station and/or there is significant molding, cesarean section should be performed.

3. Reevaluate the station of the presenting part, the rotation, and the location of the cup. One more attempt can be made, making sure that the direction of traction is perpendicular to the surface of the cup.
4. Subgaleal hemorrhage and scalp lacerations, especially when the cup detaches.

Sample questions

Long-answer question

1. Describe the procedure for forceps delivery and vacuum extraction. What are the advantages and disadvantages of both?

Short-answer questions

1. Outlet forceps
2. Chignon
3. Prerequisites for forceps delivery
4. Advantages of vacuum over forceps
5. Rotational forceps

20

Cesarean Section and Management of Pregnancy with Previous Cesarean

Case scenario

Mrs. SS, 25, was a short primigravida (149 cm). She presented at 38 weeks' gestation in spontaneous labor. Labor did not progress due to cephalopelvic disproportion. She delivered a 3.6-kg baby by a cesarean section.

Introduction

Globally, at least one in five women delivers by a cesarean section. When done for the right indications, cesarean sections are life-saving procedures that benefit mothers and babies. Advances in anesthetic services and improved surgical techniques have considerably reduced the morbidity and mortality of this procedure.

Cesarean section

Definition

A cesarean delivery is defined as the birth of a fetus through an incision in the abdominal wall (laparotomy) followed by another incision in the uterus (hysterotomy).

Incidence

Over the past 20 years, there has been a disturbing increase in the rate of cesarean sections around the world, including India. Some studies in urban India have shown the rate to be as high as one out of two women. At the other end of the spectrum, cesarean sections are very low in underresourced areas in India due to lack of facilities, leading to increased maternal and perinatal mortality. Women are more likely to have a cesarean section if they have had a previous cesarean section or have a baby with a breech presentation.

Do increasing rates of cesarean decrease perinatal mortality

The increased rate of cesarean sections does not decrease perinatal deaths in low risk pregnancies.

On the other hand, in a low-risk, uncomplicated pregnancy, a cesarean section has an eight-fold higher maternal mortality than a vaginal delivery and an 8–12 times higher morbidity. There is also a higher incidence of complications in subsequent pregnancies.

Types of cesarean section

A woman may undergo a cesarean section for the first time or have a repeat cesarean section.

- *Primary cesarean section:* When a cesarean section is performed for the first time on a pregnant woman, it is called a primary cesarean section.
- *Repeat cesarean section:* When a woman has had one or more previous cesarean sections, it is known as a repeat cesarean section.
- *Lower segment cesarean section (LSCS):* In modern obstetrics, the uterine incision is made in the lower uterine segment. The lower uterine segment is the thinner, less active part of the uterus. The advantages of the lower uterine segment transverse incision are as follows:
 - Ease of suturing
 - Decreased bleeding
 - Decreased risk of uterine rupture in subsequent pregnancies
 - Decreased risk of bowel/bladder adhering to the uterine scar
- *Classical cesarean section:* In rare cases, a vertical incision is made in the upper uterine segment. This is called a classical cesarean section. It is not routinely used in modern obstetrics because of the increased risk of uterine rupture in a subsequent pregnancy.
- *Extrapерitoneal cesarean section or Porro's technique:* This technique is not routinely used. It was described in an era where there was an increased risk of peritoneal infection.
- *Cesarean hysterectomy:* This procedure is done in rare situations. The most common indications are intractable hemorrhage due to uterine atony, placenta percreta or increta, and uterine rupture.

Classification of cesarean sections (based on indication)

Cesarean sections may be classified under three categories, depending on the indication, as follows:

- *Elective or planned cesarean section:* An elective cesarean section is a planned cesarean for maternal or fetal indications that arise in the antepartum period. It is done in a woman who has not gone into labor.
- *Emergency cesarean section:* A cesarean section done for indications arising during labor is known as an emergency cesarean section.
- *Cesarean on demand:* A cesarean done at the woman's request is known as cesarean on demand.

Indications for cesarean section

Elective cesarean section

There are both maternal and fetal indications for elective cesarean section.

Maternal indications

- **Previous cesarean section** is a leading indication for elective cesarean sections. A previous **classical** cesarean section is an absolute indication for an elective cesarean section. However, in a woman with a previous LSCS, an elective cesarean section is done only after assessing that the chances for a successful vaginal delivery are low.
- **Placenta previa** partially or completely covering the internal os is an indication for a cesarean section.
- **Maternal HIV** is an indication for a cesarean section, to minimize transmission to the baby.
- **Primary genital herpes** with visible lesions at the time of labor or ruptured membranes requires a cesarean section to prevent congenital herpes in the infant.
- An **elderly primigravida** who has conceived after extensive infertility treatment may be offered an elective cesarean delivery. She may also have associated complications such as gestational and pregestational diabetes, hypertension, and fetal macrosomia.
- **Dystocia** may be an indication for planned cesarean section. Dystocia may be due to
 - pelvic deformity or abnormal pelvic configuration;
 - *soft tissue dystocia* resulting from uterine fibroids or ovarian tumors obstructing labor.

- **Anomalies of the lower genital tract** such as vaginal septum and scarring of the vagina or cervix are also indications for planned cesarean section.
- **Previous vaginal surgery for pelvic organ prolapse or extensive vaginal lacerations** after a previous vaginal delivery may be an indication for an elective cesarean section.
- **Cervical cancer** necessitates a cesarean section because a vaginal delivery can pose a risk for hemorrhage and dissemination of disease.

Fetal indications

- **Fetal growth restriction** with oligohydramnios/abnormal Doppler findings requires a cesarean delivery to prevent fetal compromise.
- **Multiple gestations** with the first baby in a noncephalic presentation is an indication.
- **Malpresentations**
 - *Term singleton breech*, if external cephalic version is contraindicated or has failed, is considered an indication for an elective cesarean section in some obstetric units. However, each obstetric unit needs to work out its policy for allowing a vaginal delivery in selected cases of breech presentation (see Chapter 42, *Abnormal labor: Breech presentation and shoulder dystocia*).
 - A fetus in a *transverse lie* will need a cesarean delivery.
- **Suspected macrosomia** (estimated fetal weight >4000 g), especially in diabetic mothers, is an indication to avoid shoulder dystocia and maternal trauma.
- **Fetal anomalies** such as severe hydrocephalus may necessitate a cesarean section.
- **A previous adverse perinatal event**, for example, stillbirth or a difficult vaginal delivery resulting in a severely asphyxiated infant, may be considered an indication for an elective cesarean section.

The indications for an elective cesarean section are summarized in Box 20.1.

Emergency cesarean section (during labor)

The majority of primary cesarean sections are performed as an emergency due to problems that arise in labor.

Box 20.1 Indications for elective cesarean section

Maternal

- Previous cesarean
 - Classical
 - Lower segment
 - Placenta previa
 - Infections
 - Maternal HIV
 - Primary herpes with visible vesicles
 - Elderly primigravida with treatment for infertility
 - Previous vaginal surgery
 - Pelvic organ prolapse
 - Third- or fourth-degree perineal lacerations
 - Dystocia
 - Abnormal pelvic configuration
 - Pelvic deformity
 - Soft tissue dystocia
 - Pelvic tumors
 - Vaginal septum
 - Cervical cancer
- Fetal*
- Fetal growth restriction with fetal compromise
 - Twin pregnancy
 - First twin noncephalic
 - Malpresentation (breech or transverse presentation)
 - Macrosomia
 - Fetal anomalies, e.g., severe hydrocephalus
 - Previous adverse perinatal event, e.g., stillbirth

Maternal indications

- **Dystocia** is one of the commonest indications for an emergency cesarean section done for a laboring woman (see Chapter 40, *Abnormal labor: Abnormalities in passage and powers*).
- **Cephalopelvic disproportion (CPD)** is one of the reasons for failure to progress in labor. This may be due to a malformed or inadequate maternal pelvis resulting in CPD. Although it can be suspected prior to labor, it is usually diagnosed during labor.
- **Dysfunctional labor**, resulting from abnormal uterine action, protraction, and arrest disorders, may require a cesarean section if other treatment modalities fail (see Chapter 40, *Abnormal labor: Abnormalities in passage and powers*).
- When labor has been induced but does not progress to a vaginal delivery, it is termed **failed induction**. A cesarean section is indicated in this situation.

Fetal indications

- **Nonreassuring fetal status** is a common indication for cesarean sections. In the presence of abnormal fetal heart rate on auscultation (persistent tachycardia or bradycardia) or abnormal fetal heart tracing on an electronic fetal monitor (absent baseline variability, recurrent variable decelerations, recurrent late decelerations, or bradycardia), a timely cesarean section will reduce perinatal morbidity and mortality. Compression of a prolapsed umbilical cord can also be a cause of fetal distress.
- **Placental abruption** occurring during labor can be an acute indication for a cesarean section (see Chapter 39, *Antepartum hemorrhage*).
- **Fetal macrosomia** leading to CPD and prolonged labor is an indication for a cesarean section.
- **Difficulty in delivery of the second twin** may also necessitate a cesarean section.

The indications for emergency cesarean section are summarized in Box 20.2.

Cesarean section on demand

Patient demand has complicated the already complex issue of rising cesarean section rates. This is also known as cesarean section on maternal request. Fear of the pain of labor and

avoiding injury to the perineum, which may lead to sexual or bladder dysfunction, are some of the reasons quoted. Advantages of cesarean section on maternal request are convenience, prevention of postmaturity, reduced risk of pelvic floor injury, and prevention of late stillbirths. However, these should be weighed against the disadvantages, which are maternal morbidity, prematurity, increase in neonatal respiratory problems, and risk of scar rupture in future pregnancies. These have to be discussed in detail with the woman and her partner before decisions are made. Cesareans on demand cannot be supported, on either ethical or medical grounds.

Timing of cesarean delivery

Planned cesarean sections should be performed after 39 weeks' gestation. Delivery earlier than this gestation increases the risk of transient tachypnea (TTN) of the newborn and other complications.

Technique of cesarean delivery

Being the most common surgical procedure in obstetrics, the steps of a cesarean section have been standardized over the years.

Preoperative care

Oral intake

It is preferable to stop oral intake for at least 8 hours prior to an elective cesarean section. Women who have been in labor should ideally have been on clear liquids. In women who need to undergo an emergency cesarean section soon after a meal, steps should be taken to prevent acid aspiration syndrome, which results from pulmonary aspiration of gastric contents if general anesthesia is used (Box 20.3).

Shaving

Only hair that will interfere with the operative area is shaved on the day of surgery. Extensive

Box 20.2 Indications for emergency cesarean section

uterine

- Dystocia
 - Cephalopelvic disproportion
- Dysfunctional labor
 - Abnormal uterine action
 - Protraction disorders
 - Arrest disorders
- Failed induction
- Soft tissue dystocia

fetal

- Fetal distress
 - Placental insufficiency
 - Cord compression
 - Cord prolapse
- Placental abruption
- Macrosomia
- Difficulty in delivery of second twin

Box 20.3 Prevention of acid aspiration syndrome

- Regional anesthesia (spinal or epidural) preferred
- General anesthesia avoided
- Gastric pH increased
 - Nonparticulate antacids (sodium citrate 30 mL)
 - Intravenous ranitidine

shaving is not necessary. Shaving on the night before surgery increases the risk of wound infection and should be avoided.

Chlorhexidine bath

In elective cesarean sections, bathing with chlorhexidine on the day of surgery has been shown to decrease surgical site infection. 100-mL bottles of chlorhexidine are available commercially and may be used for this purpose.

Bladder drainage

An indwelling Foley catheter is inserted just before starting the surgery and is usually removed 24 hours after surgery.

Prophylactic antibiotics

Prophylactic antibiotics have conclusively been shown to decrease wound infection and endometritis following a cesarean section (Box 20.4). A single dose of a first-generation cephalosporin (cefazolin) is commonly recommended. Women with a documented history of penicillin allergy may receive IV clindamycin or IV erythromycin.

Prophylactic anticoagulation

Anticoagulation to prevent venous thromboembolism (VTE) is not recommended for cesarean

Box 20.4 Prophylactic antibiotics for cesarean section

- Administered within 60 minutes before making incision
- Cefazolin 2 g IV as single dose
- Clindamycin 600 mg IV or erythromycin 500 mg IV (single dose) in women with a documented history of penicillin anaphylaxis

sections in low-risk pregnancies. It may be used in women at high risk for VTE. This includes women with previous VTE, high-risk thrombophilia (inherited or acquired), or body mass index (BMI) $>40 \text{ kg/m}^2$.

Anticoagulation is begun 6–12 hours postoperatively, after risk of hemorrhage has decreased and is continued till ambulation. *Unfractionated heparin*, 5000 units every 12 hours, or *low-molecular-weight heparin (enoxaparin)* 40 mg daily can be used.

Anesthesia

Regional anesthesia

Spinal anesthesia is the most common type of anesthesia used for a cesarean delivery. It has the advantage of quick placement and rapid onset of anesthesia. **Epidural anesthesia** is used when an epidural catheter is already in place for labor analgesia, or when the cesarean section is not an emergency. **Combined spinal-epidural anesthesia** is preferred by some anesthetists.

General anesthesia

The indications for general anesthesia are as follows:

- Urgency for delivery of baby
- Inadequate or failed regional anesthesia
- Coagulation disorders
- Spinal abnormalities (preventing spinal anesthesia)

General anesthesia is induced with propofol and succinylcholine. After endotracheal intubation, anesthesia is maintained by an inhalational agent such as sevoflurane.

Operative techniques

Positioning of the woman

The gravid uterus may cause aortocaval compression and cardiovascular compromise. Therefore, the woman should be positioned supine with a 15% left lateral tilt. Alternatively, a wedge may be placed under the right hip.



Figure 20.1 Skin cleansing. The abdominal skin is cleansed with povidone-iodine solution.

Skin cleansing

The skin is cleansed with 10% povidone-iodine solution (Fig. 20.1).

Skin incision

The commonly used skin incisions for a cesarean delivery include the following:

- Vertical (midline) incision
- Transverse incisions (Pfannenstiel, Joel-Cohen, Maylard)

The type of incision usually is dictated by the clinical situation and the preferences of the operator (Fig. 20.2).

Transverse skin incision

A low transverse skin incision is most commonly used for a cesarean delivery. The Pfannenstiel incision is usually 2–3 cm above the pubic symphysis and placed in a natural fold of skin (the ‘smile’ or ‘bikini’ incision). The Joel-Cohen type incision is straight, 3 cm below the line that joins the anterior superior iliac spines, and slightly more cephalad than Pfannenstiel (Fig. 20.3a and b).

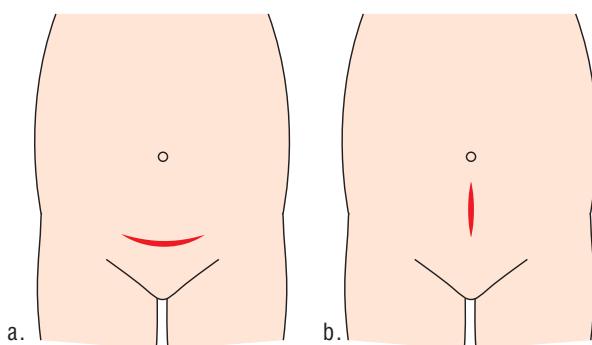
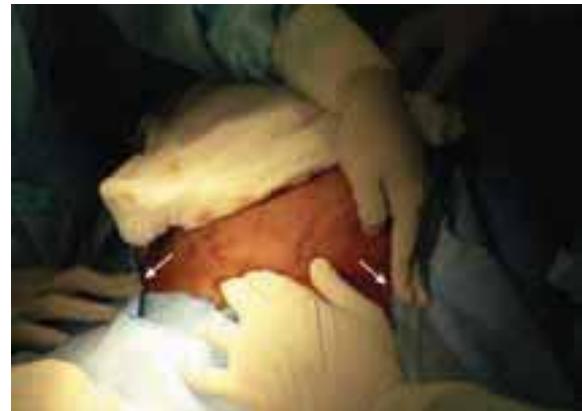


Figure 20.2 Incision for cesarean section. **a.** Low transverse incision (Pfannenstiel). **b.** Low midline incision.



a.



b.

Figure 20.3 Joel-Cohen type of transverse incision.

- a.** The anterior superior iliac spines are being identified on either side (arrows). **b.** A straight transverse incision is made, 3 cm below the line joining the two anterior superior iliac spines.

The advantages and disadvantage of a transverse skin incision are listed in Box 20.5.

The types of transverse abdominal incisions commonly used are listed in Box 20.6.

Vertical skin incision

The vertical skin incision is less commonly used for cesarean sections. The advantages and disadvantages of a vertical skin incision are listed in

Box 20.5 Advantages and disadvantage of transverse skin incision

- Advantages
 - Less postoperative pain
 - Greater wound strength
 - Better cosmetic results
- Disadvantage
 - Does not allow access to the upper abdomen

Box 20.6 Types of transverse abdominal incisions for cesarean section

- Pfannenstiel incision
 - Curved
 - 2–3 cm above the symphysis pubis
 - Midportion of the incision within the shaved area of the pubic hair
- Joel-Cohen incision
 - Straight
 - 3 cm below the line that joins the anterior superior iliac spines
 - Higher than Pfannenstiel incision
 - Associated with
 - less pain and analgesic requirements
 - less blood loss
 - shorter duration of surgery

Box 20.7. Paramedian incisions are not recommended in modern surgery.

fascia and muscle

The important differences in the incisions are as follows:

- In the Pfannenstiel incision, the fascia is cut with a transverse incision and raised as flaps (Fig. 20.4). The rectus muscles are separated in the midline with blunt finger dissection.
- In the Joel-Cohen incision, the fascia is nicked in the midline and opened transversely with blunt finger dissection (Fig. 20.5a and b) or by pushing laterally with slightly opened scissor tips. The rectus muscles are then separated by finger traction.
- In the Maylard technique, the rectus muscles are cut 2 cm above the insertion into the pubic bone, using a knife or electrocautery (Fig. 20.6). This has the advantage of providing more operative space.

Box 20.7 Vertical skin incision

- Advantages
 - Faster abdominal entry
 - Less bleeding and nerve injury
 - Can be easily extended upward if more space is required for access to the upper abdomen
- Disadvantages
 - Greater risk of postoperative wound dehiscence and incisional hernia
 - Greater postoperative pain
 - Scar cosmetically less pleasing



Figure 20.4 Pfannenstiel incision. The fascia has been cut transversely and raised as flaps.



Figure 20.5 Joel-Cohen incision. **a.** A nick is made in the fascia in the midline. **b.** The fascia is opened transversely with blunt finger dissection.

Entering the peritoneal cavity

After lifting the peritoneum with toothed forceps, a small incision is made in the peritoneum and the incision is extended transversely with blunt or sharp dissection (Fig. 20.7a–c). Using the fingers to bluntly open the peritoneum may minimize the risk of inadvertent injury to the bowel or other organs that may be adherent to the underlying surface.



Figure 20.6 Maylard incision. The rectus muscle is lifted up and divided 2 cm above its insertion, using electrocautery.

On entering the peritoneal cavity, the lower part of the uterus is exposed. The uterus is often tilted to the right (dextrorotated), due to presence of the rectosigmoid colon on the left side. The left round ligament will be found lying more anterior and nearer the midline than the right round ligament. This dextrorotation can be quickly corrected by inserting a hand between the uterus and the right pelvic sidewall and lifting the uterus gently upward and to the left.

Raising the bladder flap

The uterovesical fold of peritoneum is grasped with toothed forceps, just above the upper margin of the bladder, and a small nick is made in the midline with fine scissors (Fig. 20.8). The peritoneum is then cut sharply to both sides, taking care to cut so that the incision forms a curve, with the lateral ends curving upward. The lower edge of the peritoneal flap is then grasped with a toothed forceps or artery clamp, and the bladder is separated gently by blunt dissection.

Uterine incision

The uterine incision is made in the lower uterine segment. It must be large enough to allow atraumatic delivery of the fetal head and trunk without either tearing into or having to cut the uterine vessels at the lateral margins of the uterus. It is important to be aware of the placental position at the time of making the uterine

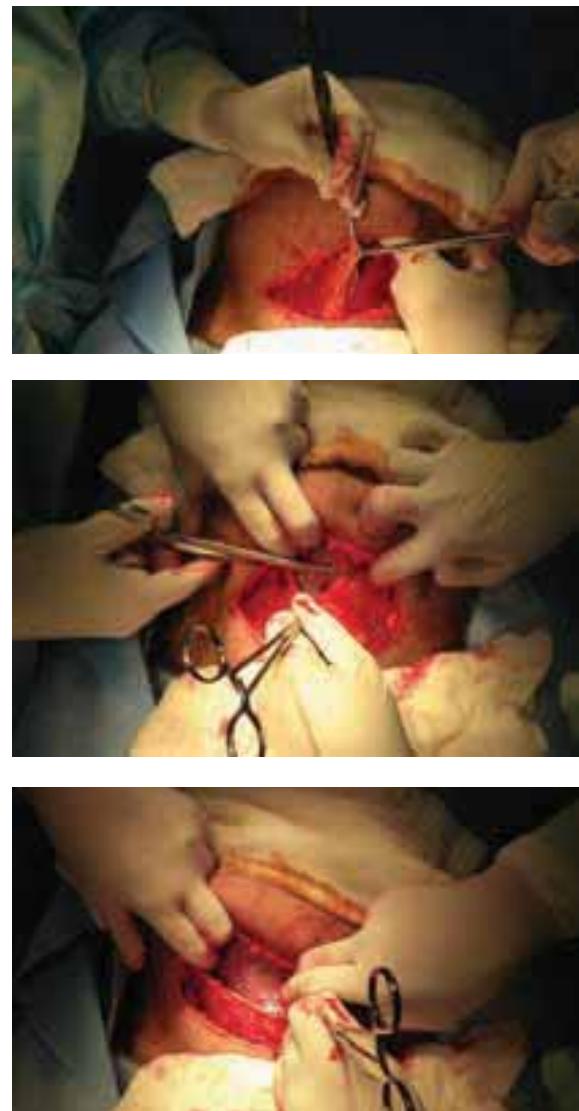


Figure 20.7 Opening the peritoneal cavity. **a.** After lifting the peritoneum with toothed forceps, a small incision is made in the peritoneum. **b.** The incision is extended transversely with sharp or **c.** Blunt dissection.

incision, especially if an ultrasound scan has indicated a low-lying placenta or placenta previa.

Transverse incision

A transverse uterine incision (Munro Kerr incision) is used most commonly. The advantages of a low transverse uterine incision are mentioned in Box 20.8.

A small incision is made in the midline with the scalpel. Care must be taken not to nick the baby's skin. When entry into the uterine cavity



Figure 20.8 Raising the bladder flap. The uterovesical fold of peritoneum is grasped with toothed forceps, just above the upper margin of the bladder, and a small nick is made in the midline with fine scissors.

Box 20.8 Advantages of transverse uterine incision

- Less blood loss
- Less need for bladder dissection
- Easier reapproximation
- Lower risk of rupture in subsequent pregnancies

is achieved, the incision can be extended using blunt expansion with the surgeon's fingers or by sharp dissection with scissors (Fig. 20.9). Blunt expansion is fast, has less chance of lateral extension, and has less risk of inadvertent trauma to the fetus as compared with sharp dissection.

In certain situations, when more space is required to deliver the baby, a 'J' (vertical extension in one lateral angle) or inverted midline 'T' extension is used (Fig. 20.10). If these incisions have been made during the cesarean section, it is important to document them because of increased risk of uterine rupture in a subsequent pregnancy.

Vertical incision

The low vertical incision (Kronig, De Lee, or Cornell) is performed in the lower, noncontractile uterine segment (Fig. 20.11). The low vertical incision has not found much favor in practice because of the possibility of extension upward into the uterine fundus or downwards into the bladder.

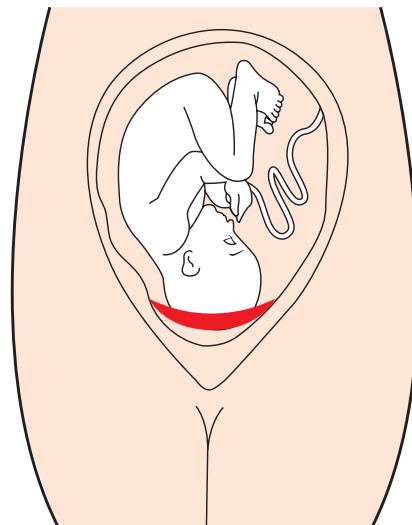


Figure 20.9 Transverse incision in the lower uterine segment (Munro Kerr incision). **a.** Diagrammatic representation. **b.** A small incision is made with a scalpel in the lower part of the lower uterine segment. **c.** The incision is expanded by blunt dissection.

Classical cesarean incision

A vertical incision that extends into the upper uterine segment/fundus is termed a 'classical' incision (Fig. 20.12).

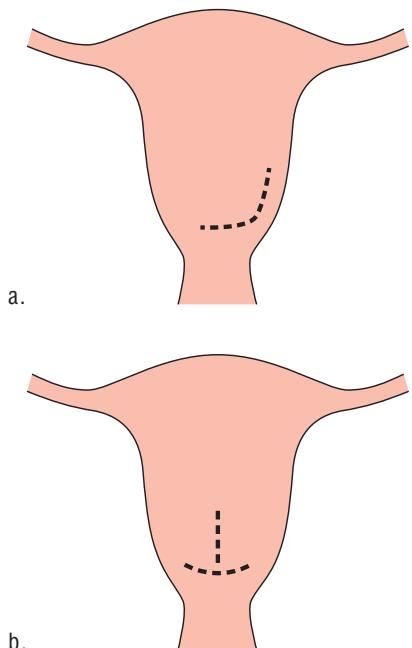


Figure 20.10 Extending the transverse uterine incision. **a.** 'J' incision extending up one of the lateral edges of uterus. **b.** Inverted T-shaped incision extending into the upper muscular segment of uterus.

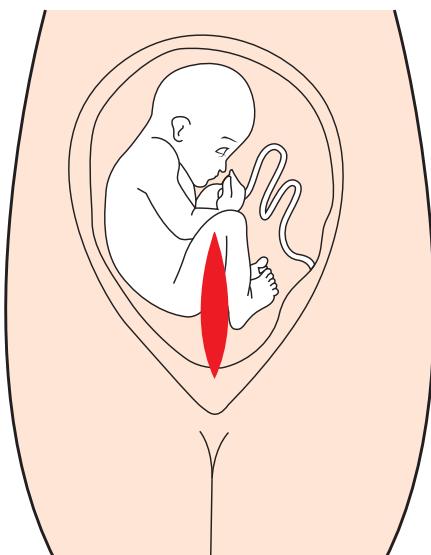


Figure 20.11 Low vertical uterine incision.

This incision is not performed in modern obstetrics because of the high frequency of catastrophic uterine rupture in a subsequent pregnancy. The only indications for a classical cesarean incision may be invasive cervical cancer or the need for a quick delivery where the woman will also be undergoing tubal ligation.

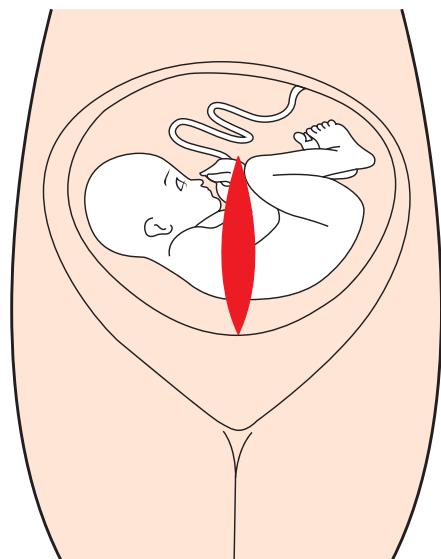


Figure 20.12 Classical cesarean section: The vertical incision is in the upper uterine segment.

Delivery of fetus

After the uterine cavity is entered, the membranes (if still intact) are ruptured. The presentation of the fetus is assessed.

In a cephalic presentation, the operator's hand is used to scoop the head up and bring it to the level of the uterine incision. The head is then extracted through the uterine incision (Fig. 20.13). To facilitate the delivery of the head through the uterine incision, the surgical assistant applies appropriate transabdominal fundal pressure. The shoulders are then delivered by gentle traction, and the rest of the body will readily follow. Once the infant's cord is clamped and cut, it is handed over to trained personnel who will take over the care of the infant.



Figure 20.13 Delivery of the fetal head through the lower uterine segment incision.

Although forceps and ventouse have been used to deliver the fetal head at a cesarean section, the current recommendations favor a manual delivery.

Delivery of the breech at a cesarean section is described in Chapter 42, *Abnormal labor: Breech presentation and shoulder dystocia*.

Delivering the placenta

Spontaneous delivery of the placenta is encouraged with gentle traction on the cord and use of oxytocin to enhance uterine expulsive forces. Although many obstetricians remove the placenta manually, waiting for the spontaneous expulsion of the placenta is recommended. The placenta is inspected, and it is ensured that the entire placenta has been removed with the membranes. After delivering the placenta, the uterine cavity is explored or wiped with a sponge.

Prophylaxis against postpartum hemorrhage

The uterus is massaged immediately after the delivery of the placenta to facilitate uterine contraction. Oxytocin is the commonest uterotonic drug used to promote uterine contraction. 10–20 units of oxytocin are added to 500 mL of normal saline and infused over 30 minutes immediately after the cord is clamped. This is followed by two more bottles of 500 mL of dextrose saline or lactated Ringer's with 10–20 units of oxytocin in each bottle, given as an infusion at the rate of 125 mL/hour.

Closing the uterine incision

Temporary lifting up of the uterus from the pelvic cavity (**exteriorization of the uterus**) to facilitate repair of the uterine incision may be a good technique and is practiced by many obstetricians (Fig. 20.14). If the cesarean section has been done under regional anesthesia, the mother may experience discomfort and vomiting when the uterus is exteriorized.

Apart from providing good exposure for suturing the angles of the uterine incision, exteriorization allows visualization of the ovaries and also facilitates tubal ligation.



Figure 20.14 Exteriorization of uterus. The uterus has been exteriorized by lifting it out of the pelvic cavity.

Technique for closure of the uterine incision

The uterine incision is closed with a two-layer repair (Fig. 20.15). The first layer is closed with a locking suture that ensures hemostasis. This is followed by an imbricating layer.

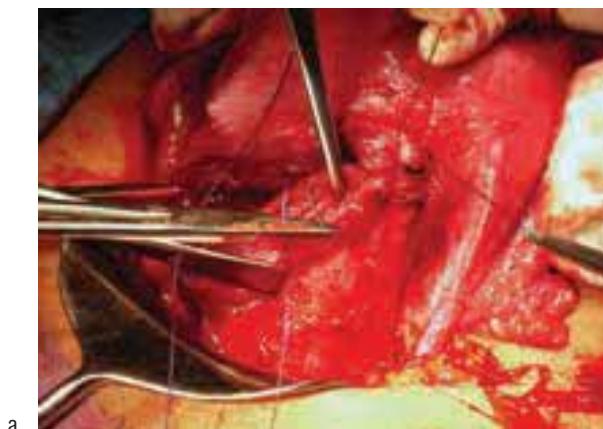


Figure 20.15 Closure of the uterine incision. **a.** The first layer is closed with a locking suture that ensures hemostasis. **b.** The second layer is an imbricating layer.

A single-layer closure has been described and saves time. However, due to the increased risk of uterine rupture in a subsequent pregnancy, a single-layer technique is reserved for women who undergo tubal sterilization at the same time. Polyglactin 910 (Vicryl[®]) or chromic catgut may be used for suturing.

Abdominal irrigation

Intra-abdominal irrigation is not recommended. The excessive amniotic fluid and blood that may have collected in the peritoneal cavity may be suctioned out.

Inspection of adnexae

Examining the adnexae during a caesarean section is a good clinical practice. This ensures that an ovarian cyst or mass is not missed.

Closure of peritoneum

There is currently no evidence to justify the time taken and cost of peritoneal closure. Nonclosure of visceral and parietal peritoneum results in significantly fewer adhesions at subsequent surgery.

Rectus muscles

Reapproximation of the rectus muscles is not recommended. When the edges of the rectus fascia are approximated, the muscles will come together naturally.

Closure of rectus fascia

This is probably the most important step in closure of the abdomen. **A properly done fascial closure is essential in preventing the occurrence of incisional hernia.** The recommendation for fascial closure is a continuous nonlocking technique, with the sutures placed 1 cm from the edge of the fascia and placed 1 cm apart (Fig. 20.16).

The fascial closure can be done using a delayed absorbable suture such as polydioxanone or polyglactin. A permanent suture such as 1-0 nylon has also been recommended and may be cost-effective for developing countries.



Figure 20.16 Closure of rectus fascia. The fascial edges (arrows) have been grasped with Allis clamps and suturing has started from the left angle.

Closure of the subcutaneous tissue

Routine subcutaneous tissue closure in women with a depth <2 cm cannot be recommended. However, when the subcutaneous tissue is >2 cm, closure with an interrupted delayed absorbable suture prevents formation of seroma and subsequent wound breakdown. Placing a drain in the subcutaneous tissue is unnecessary and may lead to infection.

Closure of skin

The skin can be closed with vertical mattress sutures using fine nylon. Better cosmetic results and patient satisfaction can be achieved with subcuticular sutures using a delayed absorbable suture. Adhesive paper strips are the least painful and have excellent cosmetic results (Fig. 20.17).



Figure 20.17 Closure of skin. Adhesive paper strips have been used to approximate the skin edges.

Wound dressing

A light protective gauze dressing is recommended. One or two narrow strips of tape can hold the dressing in place. An occlusive dressing is not necessary. The dressing can be removed after 24–48 hours.

Incidental surgery during cesarean section

The two common incidental findings at cesarean section are adnexal masses and fibroids.

- Inspecting the adnexae after closing the uterine incision is good clinical practice. If an ovarian mass is found during a cesarean section, and the mass is suspected of being a neoplasm, excision may be required.
- Myomectomy in the pregnant uterus has the potential for severe blood loss. Myomectomy is generally contraindicated for this reason. Pedunculated myomas, however, can usually be removed safely during a cesarean section.

Difficulties encountered at cesarean section

Difficulties may be encountered at any stage during surgery. The common problems encountered are skin scar, intra-abdominal adhesions, delivery of the head, extension of the uterine incision, and atonic uterus.

Difficulties and the measures to manage these are listed in Table 20.1. If a prominent scar or keloid is present, the incision may be made above or below it and the scar excised after the cesarean section is completed. Intra-abdominal adhesions should be released only if the lower segment cannot be accessed. The bladder may be pulled up and edematous in prolonged and obstructed labor. If the peritoneum is opened at the usual level, there is a risk of entering the bladder. Hence, care must be taken to open the peritoneum at a higher level. Large veins on the lower segment may be ligated or cauterized. Difficulties in delivering the head can arise due to a deeply engaged head or mobile head. A deeply engaged head may be delivered by

- An assistant pushing the head up from the vagina
- Delivery as a breech by bringing the feet down into the incision
- Delivering the shoulders first, followed by the breech and then the head (Patwardhan's method)

Extension of the incision to the vagina, upper segment or laterally involving the uterine vessels, must be managed by careful suturing and ligation of uterine vessels.

Postoperative care

Postoperatively, pulse, BP, and urine output should be monitored. A watch must be kept for uterine atony and vaginal bleeding (Box 20.9).

Table 20.1 Difficulties encountered during cesarean section and their management

Stage of surgery	Difficulty	Management
At incision	Previous scar/keloid	<ul style="list-style-type: none"> • Incision above or below scar • Excise scar before or after surgery
Opening abdomen	Adhesions	Release if lower segment not accessible
Incision of UV peritoneum	Bladder edematous and pulled up	Incise higher up to avoid the bladder
Incision on uterus	Engorged veins on lower segment	Ligate/cauterize if required
	Placenta previa	<ul style="list-style-type: none"> • Cut through the placenta • Separate the placenta and enter from above
Difficulty in delivering head	Deeply engaged	<ul style="list-style-type: none"> • Push up by hand in vagina • Deliver as breech • Deliver shoulders first
	Mobile head	Use forceps/vacuum
Closure of uterine incision	Extension of uterine incision	Suture with care
	Extension to uterine vessels	Avoid bladder, ureter
Atonic uterus	Postpartum hemorrhage	<ul style="list-style-type: none"> • Ligate uterine vessels • B-Lynch or hysterectomy

Box 20.9 Postoperative care

- Monitor
 - Pulse: half-hourly
 - BP hourly
 - Urine output 4 hourly
 - Uterine atony
 - Vaginal bleeding
- Intravenous fluids
 - Dextrose saline/lactated Ringer's
 - 500 mL 4 hourly for 12 hours
- Oral intake
 - Fluids and soft solids within 6–8 hours
- Analgesia
 - Pethidine/buprenorphine 6 hourly for 24 hours
- Oral NSAIDs after 24 hours
 - Catheter removed after 12–24 hours

Intravenous fluids

Intravenous fluids are continued for 12–14 hours after a cesarean section till the mother is able to tolerate and retain oral feeding. Lactated Ringer's solution or normal saline solution containing 5% dextrose is used. The usual amount administered is 500 mL every 4 hours.

Feeding after cesarean section

Early oral fluids or food intake is encouraged. Early intake of oral fluids or food is associated with the following:

- Reduced time to first food intake
- Reduced time to return of bowel sounds
- Reduced postoperative hospital stay

Resumption of feeding (clear liquids or solids according to the mother's preference) within 8 hours of surgery is recommended.

Pain relief

Pain relief is provided by narcotic analgesics such as meperidine (pethidine) 75–100 mg every 6 hours, according to requirement. Buprenorphine is also a good choice for post-operative pain and can be given in the dosage of 0.3–0.6 mg intramuscularly every 6–8 hours. Oral nonsteroidal anti-inflammatory agents should suffice after 24 hours.

Urinary catheter

The urinary catheter may be removed after 12–24 hours. Routine urine culture after catheterization is not recommended.

Intraoperative complications at cesarean section

Intraoperative surgical complications occur more often in an emergency cesarean section than in an elective cesarean section. These include damage to adjacent organs, including bladder, urinary tract, or bowel, bleeding >1000 mL, and lacerations of the uterus or cervix. Injuries to the fetus may also occur during uterine incision or fetal extraction (Box 20.10).

Postoperative complications after cesarean section

Postoperative complications following a cesarean section include wound infection, endometritis, and hemorrhage (Box 20.10).

Long-term complications of a cesarean section include abnormal placentation in the subsequent pregnancy, scar dehiscence or rupture in the next pregnancy, and subfertility. Complications related to the uterine and abdominal scar include pregnancy in the hysterotomy

Box 20.10 Intraoperative and postoperative complications of cesarean section*Intraoperative*

- Damage to adjacent organs
 - Bladder
 - Urinary tract
 - Bowel
- Bleeding >1L
- Lacerations of uterus and cervix
- Injuries to fetus
 - At uterine incision
 - During fetal extraction

Postoperative

- Wound infection
- Endometritis
- Subsequent pregnancy
 - Abnormal placentation
 - Scar dehiscence or rupture
- Subfertility
- Uterine scar
 - Hysterotomy scar pregnancy
- Abdominal scar
 - Numbness and pain
 - Scar endometriosis
- Neonatal
 - Transient tachypnea
 - Respiratory distress syndrome

scar pregnancy, pain and numbness over the abdominal scar, and scar endometriosis.

Neonatal complications include transient tachypnoea of the newborn or respiratory distress syndrome (due to unexpected prematurity).

Intraoperative and postoperative complications of a cesarean section are listed in Box 20.10.

Management of pregnancy with previous cesarean section

All women who have had a prior cesarean delivery should be counseled about the maternal and perinatal risks and benefits of either a planned vaginal birth or an elective repeat cesarean section. The risk of uterine rupture while attempting a vaginal delivery following a prior cesarean section is 7 per 1000 as compared with 0.2 per 1000 in an unscarred uterus. This has a major influence on the decisions made by women and their obstetricians.

The decision to be made involves the following:

- Should she have an elective repeat cesarean section?
- Should she have a trial of labor after cesarean (TOLAC)?
- Would she be able to have a successful vaginal birth after cesarean (VBAC)?

In a woman who has had one previous low transverse uterine incision, the chances of a successful vaginal delivery in a subsequent pregnancy are approximately 50%–60%. However, a careful selection of the ideal candidate for TOLAC will ensure success.

Uterine dehiscence and uterine rupture

Uterine dehiscence and uterine rupture are major complications of TOLAC. Uterine rupture may occur in 0.9%–1.5% of women attempting vaginal delivery following LSCS. The occurrence is 4%–5% with J-shaped or lower segment vertical incisions and much higher with classical sections.

Uterine dehiscence is an incomplete uterine scar separation where the visceral peritoneum

remains intact. It may go unrecognized if the uterine scar is not explored after the vaginal delivery. The risk of hemorrhage or adverse maternal or perinatal outcomes is low.

Uterine rupture is defined as the complete disruption of the uterine scar, including the visceral peritoneum. It is a catastrophic event, jeopardizing the life of the mother and fetus. It may be associated with severe hemorrhage and bladder laceration, and may often necessitate hysterectomy. Perinatal morbidity and mortality may result from intrauterine hypoxia.

Maternal and perinatal morbidity

Risk of hemorrhage, infection, hysterectomy, and perinatal asphyxia are higher in women undergoing TOLAC if the attempt is unsuccessful and scar dehiscence or rupture results. On the other hand, uterine rupture and other complications are fewer in women who undergo an elective repeat cesarean section. However, the absolute risk of these complications is low. Silent scar dehiscence may be seen even during elective cesarean sections, and morbidities associated with a cesarean section should also be considered. The morbidity with a failed VBAC varies with the facilities available for an immediate cesarean section.

Candidates for trial of labor

Factors that can predict a successful TOLAC in a woman are

- History of a vaginal delivery (before or after the cesarean section)
- Onset of active spontaneous labor at ≤ 40 weeks' gestation
- Fetal weight not suggestive of macrosomia
- Nonrecurrent indication for a previous cesarean section, for example, fetal malpresentation or fetal distress

Factors that decrease chances for a successful VBAC are

- Induced labor
- No previous vaginal birth
- Previous cesarean section for dystocia
- Postdates
- Estimated fetal weight >4000 g

- Occipitoposterior position and deflexion
- Interdelivery interval <18 months
- Interpregnancy interval <6 months
- Advanced maternal age
- Cervical dilatation <4 cm on admission in labor
- BMI >30 kg/m²

Contraindications to BAC

Certain factors increase the risk of uterine rupture when attempting VBAC. These are therefore considered contraindications to TOLAC, and the woman should be directly offered an elective repeat cesarean section. These factors are

- High risk uterine scars
 - Two or more previous cesarean scars
 - Inverted T incision or J incision
 - Classical cesarean
 - Myomectomy scar extending deep into the myometrium
- Previous uterine rupture
- Obstetric complications, for example, placenta previa and breech presentation
- Limited facilities
 - Surgical, anesthetic, nursing, and pediatric staff
 - Blood and blood products

Prediction of scar rupture

Although attempts have been made to predict the risk of scar dehiscence using ultrasonographic measurement of the thickness of the lower uterine segment, it has not proved useful. Measurement is taken from the amniotic fluid to the bladder, and the normal scar thickness is 2–3.5 mm. Although the risk of rupture increases with thin scars, there is no established cutoff value and the predictive value of the test is low.

Management of labor and delivery in a woman with a previous cesarean scar

The risks and benefits of TOLAC should be discussed with the mother and her partner. The possibility of a successful vaginal delivery should be estimated and contraindications excluded.

Ultrasonography should be performed to estimate the weight of the baby and the placental location.

Uterine contractions should be noted. Pelvic examination should be performed to assess the pelvic configuration, cervical effacement, and dilatation.

Recognition and management of uterine rupture is the most important aspect of the care of a woman undergoing TOLAC. The following are guidelines to be followed for a successful VBAC:

- Facilities and personnel for an immediate cesarean section should be available.
- Labor should be monitored carefully. Electronic fetal monitoring of the fetal heart rate is recommended.
- Induction of labor should be avoided. **Misoprostol for cervical ripening is contraindicated with a previous cesarean scar.** Many units will not use any prostaglandins with a previous cesarean scar. Use of prostaglandins followed by oxytocin is not recommended.
- Augmentation of labor can be carried out with judicious use of oxytocin. There should be a lower threshold to intervene with a cesarean section if labor does not progress normally.
- Epidural analgesia may mask the signs and symptoms of uterine rupture. However, it may be used with close fetal monitoring and is not contraindicated.
- The parturient should be monitored during labor
 - Half-hourly pulse
 - Hourly BP
 - Electronic fetal monitoring if available
- Abnormal fetal heart tracing, including baseline bradycardia, tachycardia, variable and late decelerations, and maternal tachycardia, is suggestive of scar dehiscence and warrants an immediate cesarean section.
- Maternal hypotension is a late sign and indicates rupture with internal hemorrhage.
- Following a successful VBAC, exploration of the uterine cavity is practiced by many, but the benefits of this procedure are not clear. Moreover, surgical intervention is not required for asymptomatic dehiscence. Hence, there is no recommendation regarding routine scar exploration.

Cesarean hysterectomy

Surgical removal of the uterus at the time of a cesarean delivery is called cesarean hysterectomy (see Chapter 43, *Complications of third*

stage of labor). It is not only a surgically challenging procedure but also an emotionally challenging one because it ends the fertility potential of the woman.

Indications

Abnormal placentation (placenta accreta, placenta percreta, and placenta increta) is the commonest indication for cesarean hysterectomy (Box 20.11; see Chapter 46, *Abnormalities of the placenta, umbilical cord, and fetal membranes*). The increased incidence of cesarean sections is one of the reasons for the increasing incidence of abnormal placentation.

Box 20.11 Indications for cesarean hysterectomy

- Abnormal placentation
 - Placenta accreta, increta, and percreta
- Postpartum hemorrhage
- Cervical cancer

Key points

- A cesarean delivery is defined as the birth of a fetus through an incision in the abdominal wall (laparotomy) followed by an incision in the uterus (hysterotomy).
- The commonest type of cesarean section done is a lower segment cesarean section (LSCS) through a transverse uterine incision.
- Classical cesarean and extraperitoneal cesarean are rarely done.
- Cesarean sections are classified as elective, emergency, or on demand.
- Previous cesarean section, failure to progress in labor or dystocia, and fetal distress are the three commonest indications for cesarean section.
- Spinal anesthesia is the preferred mode of anesthesia for a cesarean section. If a woman has had epidural analgesia during labor, it can be continued for providing anesthesia.
- A single dose of a first-generation cephalosporin (cefazolin) is most commonly used as a prophylactic antibiotic. A single dose of metronidazole may be given in addition.
- A transverse skin incision (Pfannenstiel or Joel-Cohen) is usually used. A vertical skin incision is

Postpartum hemorrhage during a cesarean section can result in a cesarean hysterectomy, if all other interventions fail (see Chapter 43, *Complications of third stage of labor*).

Cervical cancer is a rare indication for a cesarean hysterectomy.

A cesarean hysterectomy is technically challenging due to the following factors:

- It is usually done as an emergency, when the woman may not be hemodynamically stable and her life may be in danger.
- Increased vascularity from the pregnancy may result in excessive bleeding.
- The cervix may be effaced due to labor, and there may be difficulty in differentiating it from the lower part of the uterus.
- A subtotal hysterectomy (removing the uterus and leaving the cervix behind) may be an option to cut short the operating time.

reserved for situations where fast abdominal entry is required. Paramedian incisions are not used.

- The commonest uterine incision is the transverse incision in the lower uterine segment.
- The uterine incision is closed in two layers. A single-layer closure is used when a tubal ligation is being done concomitantly since a single-layer closure is associated with an increased risk of rupture in a subsequent pregnancy.
- Postoperatively, IV fluids are continued for 12 hours, a Foley is left in situ for 12–24 hours, and early feeding (by 6–8 hours) is encouraged.
- In a woman who has had a previous cesarean section, the decision for the route of delivery depends on the risk factors for uterine rupture.
- Trial of labor after a cesarean section should follow recommended guidelines. Close monitoring is mandatory and facilities for an immediate cesarean section should be available.
- A cesarean hysterectomy is usually an emergency and can be technically challenging.

Self-Assessment

Case-based questions

Case 1

Mrs. SS, 25, is a short primigravida (149 cm). She presents at 38 weeks' gestation in spontaneous labor. Labor does not progress due to cephalopelvic disproportion. She delivers a 3.6-kg baby by cesarean section.

1. What are the risk factors for possible cesarean section in this woman?
2. Which is the most commonly used uterine incision?
3. If the uterine incision has to be extended to deliver the large baby, what are the options?
4. Why has the classical cesarean section been given up?

Case 2

Mrs. JK, 31, gravida 2, para 1, live 1, has had a lower segment cesarean section for a breech presentation 3 years ago. She is now 36 weeks' pregnant with a vertex presentation. The estimated fetal weight is 2.9 kg. She has been counseled for a vaginal delivery.

1. What is the risk of uterine rupture in a woman with a previous lower segment cesarean scar?
2. What are the chances for a successful VBAC in a woman attempting a trial of labor after a cesarean section?
3. What are the contraindications to attempting a trial of labor in a woman with a previous cesarean section?
4. What are the indicators for a successful VBAC?

Answers

Case 1

1. Short primigravida and large baby.
2. Transverse incision in the lower segment.

3. The uterine incision can be extended along the lateral edge of the uterus as a 'J' incision or in the midline as an inverted 'T.'
4. The classical cesarean section is associated with a high incidence of uterine rupture in a subsequent pregnancy.

Case 2

1. The risk of uterine rupture is 0.9%–1.5%.
2. The chances for a successful VBAC are 50%–60%.
3. Two or more uterine scars, previous uterine rupture, fetal macrosomia, abnormal pelvic configuration, previous classical, J-shaped, or T-shaped incision, and obstetric complications such as malpresentations.
4. A history of vaginal delivery, nonrecurrent indication, spontaneous labor, gestational age <40 weeks, and average fetal weight.

Sample questions

Long-answer question

1. Enumerate the indication for LSCS. Discuss the management of a case of previous LSCS.

Short-answer questions

1. Advantages of LSCS over classical section
2. Indications for emergency cesarean section
3. Advantages of elective cesarean section
4. Scar dehiscence
5. Trial of vaginal delivery after cesarean section
6. Complications of VBAC

Section 4

Postpartum Management

21

The Normal Puerperium

Case scenario

Mrs. KM, 30, delivered normally. On the second postnatal day, she found that her abdomen was flabby, her breasts were full, and she had vaginal bleeding. She felt inadequate to take care of the baby. She also received conflicting suggestions about food, clothing, breastfeeding, and medications from her parents, in-laws, and friends. She was confused and wanted help.

Introduction

There are several cultural practices, traditional rituals, and religious beliefs about how the postnatal mother and the newborn should be managed. The mother goes through physiological and emotional changes during this period. Obstetricians, nurses, and other health care providers must be aware of the local practices and mother's medical and psychological needs and provide support and appropriate advice.

during pregnancy revert to the normal prepregnancy state. It may take up to 8–12 weeks for some organ systems to return to baseline.

Immediate postnatal period

The first few hours after delivery are referred to as immediate postnatal period. During this time the woman recovers from the strain of labor and the infant may be put to the breast.

Definition

The puerperium is the period from the delivery of placenta till 6 weeks postpartum. This is the time during which the physiological changes

Postpartum chills

This occurs in 25%–50% of women. The shivering or chills start soon after delivery and may last up to 1 hour. The etiology is not known. It

is self-limiting and only supportive treatment (warm blankets) is required.

Anatomical and physiological changes

During the days following delivery, several changes occur in the various organ systems.

uterus

The uterus is well contracted and has the consistency of 'cricket ball' soon after expulsion of the placenta. The fundus is at the level of the umbilicus. *Involution* of the uterus occurs in the puerperium, and the fundal height decreases by 1 cm (one fingerbreadth) every day (Fig. 21.1). The fundus lies midway between umbilicus and pubic symphysis 1 week after delivery and is not palpable after 2 weeks (Box 21.1). By 6 weeks, the uterus returns to its prepregnant size. The weight decreases from 1000 g postdelivery to 500 g after a week, 300 g after 2 weeks, and 100 g after 6 weeks. The process of involution is by reduction in size of individual muscle cells and not by reduction in number of cells. *Lower segment* of the uterus also contracts and becomes the isthmus. The placental site vessels undergo thrombosis and hyalinization.

Cervix

The cervix, which was dilated to 10 cm, contracts gradually and thickens. The external os, which

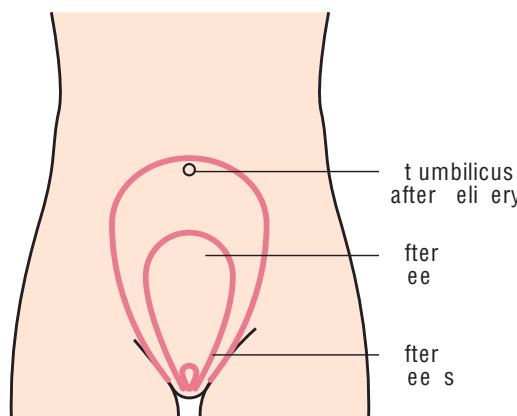


Figure 21.1 Involution of the uterus. The uterus shrinks by 1 cm/day and lies midway between umbilicus and pubic symphysis 1 week after delivery and becomes a pelvic organ (not palpable) by 2 weeks.

Box 21.1 Changes in the uterus during puerperium

- Uterus
 - Involution
 - After third stage
 - At the level of umbilicus, weighs 1000 g
 - After 1 week
 - Midway between umbilicus and pubic symphysis, weighs 500 g
 - After 2 weeks
 - Within the pelvis, weighs 300 g
 - After 6 weeks
 - Prepregnant size, weighs 100 g
 - Lower segment
 - Contracts and becomes isthmus
 - Cervix
 - Contracts and thickens
 - Becomes a transverse slit
 - Endometrium
 - Superficial decidua sloughs
 - New endometrium from basal layer of decidua
 - Leukocytic infiltration

is round in the nulliparous woman, becomes a transverse slit in multipara. This differentiates the parous cervix from the nulliparous one. Hyperplasia and hypertrophy of the glands, edema, and hemorrhage begin to regress a few days after delivery and the regression is complete by 6 weeks.

Endometrial changes

The decidua differentiates into two layers. The superficial layer becomes necrotic, sloughs, and is expelled with the lochia. The deeper layer of decidua (basal layer) remains and is the source of new endometrium. The placental site and the rest of the regenerating endometrium are infiltrated with granulocytes and lymphocytes. After Day 10, the leukocytic infiltration decreases. Plasma cells appear and may be seen in the endometrium for a few months.

Changes in the uterus during puerperium are summarized in Box 21.1.

Lochia

The discharge from the uterus in the postpartum period is known as *lochia*. It begins as bleeding following delivery of placenta and decreases during the next 4–5 days. This bloody discharge,

Box 21.2 Lochia

- Discharge from the uterus in the puerperium
- Consists of
 - decidua
 - blood
 - leukocytes
 - exudates
- First 4–5 days: Lochia rubra
- Next 2–3 weeks: Lochia serosa
- Till 6–8 weeks: Lochia alba

which consists of blood and sloughed decidua, is known as *lochia rubra* (Box 21.2). During the following 2–3 weeks, the discharge is pale, thinner, and blood stained and is known as *lochia serosa*. *Lochia rubra* and *serosa* have a unique offensive mildly fishy odor. Following this, yellowish-white discharge consisting of leukocytes and exudates persists for a few days, referred to as *lochia alba*. Total duration of lochial discharge is 6–8 weeks.

Afterpains

The uterus contracts intermittently, giving rise to pain similar to but milder than labor pains. During suckling, oxytocin is released by the pituitary and the afterpains are more pronounced. They usually subside within 3–4 days.

Vagina and vulva

The vagina becomes vascular from first trimester and enlarges during delivery, especially second stage. It contracts and vaginal rugae gradually appear in the puerperium. The vascularity decreases. The stretching ligaments, fascia, levator ani, and other pelvic muscles may result in pelvic floor relaxation.

Ovarian function

In lactating women, prolactin levels remain elevated and estrogen levels decreased till about 6 weeks. In nonlactating women, the levels normalize after 2–3 weeks. Follicle-stimulating hormone (FSH) levels are normal but the ovary is unresponsive to FSH. These hormonal changes form the basis of ovulation suppression and amenorrhea. Nonlactating women begin ovulating about 75 days after delivery and

Box 21.3 Changes in vagina, vulva, and ovarian function during puerperium

- Vagina
 - Decrease in vascularity
 - Reappearance of rugae
 - Vulva
 - Partial/complete regression of
 - relaxation/enlargement of introitus
 - relaxation of pelvic muscles/ligaments/fascia
 - Ovarian function
 - Suppression of ovulation due to
 - high prolactin
 - suppression of pulsatile GnRH release
 - Return of ovulation
 - Nonlactating: Mean 75 days
 - Lactating: Mean 6 months
 - Return of menstruation
 - Nonlactating: 8–12 weeks
 - Lactating: Depends on duration of breastfeeding
- n gonadotropin-releasing hormone.

menstruation may resume by 8–12 weeks. In women who breastfeed, ovulation may resume by 6 months but amenorrhea can continue for 1–2 years depending on the duration of lactation.

Changes in the vulva, vagina, and ovarian function are summarized in Box 21.3.

Abdominal wall

The abdominal wall is flabby and the muscles are lax in the immediate postnatal period. The muscles regain their tone over a period of time and can be aided by exercises. *Divarication of recti* may persist. The rupture of elastic fibers of the skin results in *striae gravidarum*, which is permanent.

Changes in the urinary tract

The dilatation of the renal pelvis and ureter, changes in renal plasma flow, and glomerular filtration rate return to normal by 6–8 weeks postpartum. Following vaginal delivery, there is edema and submucosal hemorrhage in the bladder with associated increase in bladder capacity and mild reduction in bladder sensation. Due to these changes, stasis of urine, incomplete voiding, and bladder distension can occur (Box 21.4). Epidural analgesia and reflex spasm of urethra due to pain at the episiotomy/perineal tear can

Box 21.4 Changes in the urinary tract during puerperium

- Renal plasma flow
 - Glomerular filtration rate
 - Dilatation of renal pelvis and ureter
 - Postnatal urinary retention and stasis due to
 - increased bladder capacity
 - reduced bladder sensation
 - Edema of bladder base
 - Submucosal hemorrhage
 - reflex urinary spasm due to pain
 - epidural analgesia
- } Return to normal by 6–8 weeks

worsen these. Urinary incontinence can occur following prolonged labor or instrumental delivery, due to stretching and damage to the pelvic muscles and fascia.

Weight loss

Delivery of the fetus, placenta, and amniotic fluid results in a weight loss of 5–6 kg (11–13 lbs) in the immediate postpartum period (Box 21.5). There is some water retention in the intra- and extravascular compartments in the immediate postpartum period, and the water is mobilized and excreted gradually. This leads to further weight reduction of about 2–5 kg. Women who had excessive weight gain in pregnancy have a net weight gain which has to be shed by diet and exercise.

ther systems

Changes in the other systems are summarized in Box 21.6.

thyroïdysunction

Postpartum thyroiditis occurs in about 10% of women. Etiology is autoimmune and it is largely

Box 21.6 Changes in other systems during puerperium

- Hematological changes
 - Leukocytes
 - Increase immediately after delivery
 - Decrease soon after
 - Hemoglobin
 - Fluctuates
 - Rises after 1 week
 - Increase in blood coagulability
 - Thrombocytosis
 - Increased platelet adhesiveness
 - Increase in fibrinogen
 - Persistence of increase in other coagulation factors
 - Cardiovascular system
 - Fall in cardiac output
 - Decrease in blood volume
 - Fall in heart rate
 - Peripheral resistance increases
 - Blood pressure returns to normal
 - Third heart sound and functional systolic murmurs disappear
- } Occur within a week

asymptomatic. A small percentage of affected women can present with symptoms of transient hypo- or hyperthyroidism. Symptomatic women should be evaluated and treated with appropriate medications.

Management of puerperium

This consists of monitoring the mother and baby for complications and providing care, support, and advise.

Maternal monitoring

After delivery, mother should be closely monitored in the labor room for 2 hours (Table 21.1). She should be shifted to the postnatal ward only after ensuring that all parameters are normal.

Subsequent care

Subsequent care should include care of the mother, neonate, breastfeeding, and advice at discharge (Box 21.7).

Box 21.5 Weight loss during puerperium

- Immediate postpartum: 5–6 kg
 - Fetus
 - Placenta
 - Amniotic fluid
 - Blood
- Subsequent loss: 2–5 kg
 - Extra- and intravascular fluid

Table 21.1 Maternal monitoring after delivery

Clinical parameters	To detect
Pulse	
Blood pressure	Atonic/traumatic PPH
Temperature	Sepsis
Vaginal bleeding	PPH
Fundal height/consistency	Uterine atony
Voiding of urine	
Distension of bladder	Urinary retention
Dyspnea	Pulmonary embolism
Perineal pain	Vulval hematoma

PP , postpartum hemorrhage.

Box 21.7 Subsequent care after the delivery

- Mother
 - Ambulation
 - Perineal care
 - Care of the bladder and bowel
 - Diet
 - Breastfeeding and care of the breast
- Neonate
 - Feeding
 - Immunization
- Advice at discharge
 - Contraception
 - Exercises

Ambulation

Early ambulation, few hours after delivery, is important to facilitate bowel movement and reduce the risk of venous thrombosis and embolism. The mother and child can be discharged 48 hours after delivery.

Care of the bladder and bowel

Reduction in bladder sensation, increase in bladder capacity, epidural analgesia, and perineal pain due to tears or episiotomy can cause *urinary retention*. Large doses of oxytocin have antidiuretic effect and the mother may not be hydrated adequately. These factors reduce the urine output. Hence, women should be encouraged to void. If bladder is distended and woman does not void in 6–8 hours, an indwelling catheter should be introduced and left in place for 24 hours.

Constipation is common. Plenty of fluids, high residue diet, and, if required, mild laxatives are recommended. Thrombosed external hemorrhoids may appear during the postnatal period. They should be treated with laxatives and local ointments. If persistent, surgical intervention is required.

Care of the perineum

Perineal hygiene is important. Cleaning the vulva should be from anterior to posterior toward the anus, in order to avoid bacteria from the perianal region contaminating the vulva. Moist heat, iced sitz bath, and rectal or oral analgesics may be required for painful episiotomy or lacerations. Lochia must be checked for abnormal foul odor.

Diet and supplements

Normal diet (30 cal/kg ideal body weight) with extra 500 kcal for lactation is recommended. Iron supplementation should be continued for 3 months and calcium supplements as long as breastfeeding continues.

Breastfeeding and care of the breast

Breastfeeding is discussed in Chapter 25, *Lactation and breastfeeding*. Breastfeeding should begin within an hour of delivery. Rooming in and skin-to-skin contact are essential. Nulliparous women must be given instructions regarding proper positioning of the mother and infant and the technique of breastfeeding.

Nipples should be cleaned before and after each feed. Breast supports must be encouraged. Retracted nipples are common and must be attended to in the antenatal period. Drawing out the nipples using fingers or the reverse end of a syringe may be necessary. In case of cracked nipples, local application of breast milk or lanolin and using a nipple shield are recommended.

Care of the neonate

The neonate is usually weighed, swaddled, and kept warm. The cut end of the umbilical cord should be kept clean. The cord usually shrivels and falls off in a week. Demand feeding is recommended.

Immunization

Mother must be counseled regarding the importance of immunization and the schedule should be given. BCG vaccine may be administered before mother and baby are discharged.

Advice at discharge

Mother should be advised regarding exercises and contraception. Pelvic floor exercises and abdominal exercises can be started after a week in case of normal delivery. Contraception is discussed in Chapters 26, *Contraception: Temporary methods* and Chapter 27, *Emergency contraception and sterilization*.

Follow-up

First postnatal follow-up is at 6 weeks (Box 21.8).

Resumption of sexual activity

Mother may resume sexual activity about 2–3 weeks after delivery or whenever she is comfortable. Decrease in libido is often noticed. This is due to hormonal changes, postpartum blues, and depression. Dyspareunia due to episiotomy or perineal laceration and vaginal dryness due to estrogen deficiency are also common.

Weight reduction

Women who have gained weight excessively must be advised regarding diet, regular exercises, and return to normal weight before embarking on next pregnancy.

Box 21.8 Postnatal checkup

- History
 - Vaginal bleeding/discharge
 - Breastfeeding
- General examination
 - Blood pressure
 - Pallor
- Breast examination
 - Engorgement
 - Cracked nipple
- Abdominal examination
 - Involution of uterus
- Local and pelvic examination
 - Episiotomy/laceration
 - Lochia
 - Uterine size
- Investigations
 - Oral GTT if gestational diabetic
- Advice
 - Contraception
 - Resumption of sexual activity
 - Postnatal exercises
 - Weight reduction

, glucose tolerance test.

Postnatal exercises

Pelvic floor exercises and exercises for toning up the back and abdominal muscles can be started 4–6 weeks after normal delivery and 8 weeks after cesarean section. These exercises can prevent urinary incontinence, chronic backache, and lax abdominal wall.

Key points

- Puerperium is the period from delivery of the placenta to 6 weeks postpartum. The physiological changes during pregnancy revert to normal during this period.
- In the immediate postpartum period, mother should be monitored closely. Pulse, blood pressure, temperature, fundal height and consistency, bladder distension, perineal pain, and vaginal bleeding should be monitored.
- The uterus undergoes involution during this period. The fundus is at the level of umbilicus immediately after delivery, midway between umbilicus and pubic symphysis 1 week later, and not palpable 2 weeks later.
- The superficial layer of decidua sloughs off and is expelled with lochia. The deeper layer is the source of new endometrium. There is leukocytic infiltration of decidua during puerperium.
- Lochia is the discharge from uterus. This consists of decidua, blood, leukocytes, and exudates. The discharge persists for 6–8 weeks.
- Changes in the vagina, vulva, and abdominal wall regress. The striae gravidarum persist.

(Continued)

Key points *Continued*

- Changes in the urinary system regress gradually. Cardiac output, blood volume, and heart rate fall within 1 week.
- Mother should be ambulated early and discharged after 48 hours of vaginal delivery.
- Normal diet and extra 500 kcal for lactation should be advised and perineal care should be given.
- Advice regarding care of the neonate and breastfeeding should be given.
- During follow-up at 6 weeks, clinical examination should be performed to exclude cracked nipples, breast engorgement, anemia, and episiotomy breakdown. Advice regarding contraception, exercises, immunization, and return to sexual activity are mandatory.

Self-Assessment

Case-based questions

Case 1

Mrs. KM, 30, delivered normally. On the second postnatal day, she found that her abdomen was flabby, her breasts were full, and she had vaginal bleeding. She was not sure about how to take care of the baby. She also received conflicting suggestions about food, clothing, breastfeeding, and medications from her parents, in-laws, and friends.

1. What are the clinical findings you would look for on routine postnatal evaluation?
2. What is uterine involution? Where would you expect the uterine fundus to be on the second postnatal day?
3. What dietary advice would you give her?
4. What medications are recommended in the puerperium?

Case 2

Mrs. NC, 29, mother of one child, postnatal 6 weeks, came for routine checkup.

1. What clinical evaluation will you do?
2. What advice will you give her regarding postnatal exercises?
3. Her body mass index (BMI) is 30. What advice will you give her?

Answers

Case 1

1. Temperature and pulse, for puerperal fever; blood pressure, for hypertension; fundal height, for involution; lochia, for color and odor; perineum, for episiotomy and laceration; and breasts, for engorgement, cracked nipples, and abscess.
2. The gradual reduction in size of the uterus and regression of changes of pregnancy and return to

normal prepregnant conditions is uterine involution. The size reduces by one fingerbreadth every day. On Day 2, it should be one fingerbreadth below the umbilicus.

3. Normal diet with extra 500 kcal for lactation.
4. Iron supplementation for 3 months and calcium supplementation as long as breastfeeding continues. Analgesics for afterpains and perineal pain.

Case 2

1. General examination for pallor and blood pressure, breast examination, abdominal examination for uterine involution, pelvic examination for uterine size and examination of lochia for color and odor.
2. Postnatal pelvic floor exercises and exercises to tone up back and abdominal muscles can be started 2–4 weeks after vaginal delivery and 8 weeks after cesarean section.
3. Advice on lifestyle modification, 1500 cal weight-reducing diet, and regular exercises. The goal is to reduce 1–1.5 kg/month and get back to normal BMI before embarking on next pregnancy.

Sample questions

Long answer question

Define puerperium. Discuss the physiological changes in puerperium.

Short-answer questions

1. Care of the mother in the puerperium
2. Lochia
3. Involution of the uterus
4. Postnatal checkup

22

The Abnormal Puerperium

Case scenario

Mrs. RM, 28, presented with fever after having delivered 5 days ago at a local hospital. She was feeling ill, had lower abdominal pain, and a slight increase in vaginal bleeding. Her husband was worried since she had just delivered and had to take care of the baby as well.

Introduction

Most women have an uncomplicated recovery after delivery but postpartum complications do occur. Puerperal infection is a common cause of febrile morbidity. Though it is a time of happiness for the entire family, the woman can feel overwhelmed and inadequate and develop mental health problems, which may enhance the severity of physical symptoms. The obstetrician should recognize these complications early and treat them appropriately.

Postpartum complications

Several complications can develop in the puerperium. These are listed in Box 22.1.

Box 22.1 Postpartum complications

- Secondary postpartum hemorrhage
- Puerperal pyrexia
- Thromboembolism
- Postpartum neuropathy
- Musculoskeletal pain
- Mental health issues

Secondary postpartum hemorrhage

Excessive vaginal bleeding that occurs between 24 hours and 12 weeks after delivery is known as **secondary postpartum hemorrhage (PPH)**. It most often occurs within the first 3–4 weeks after delivery.

Box 22.2 Causes of secondary postpartum hemorrhage

- Retained placental tissue
 - Cotyledons
 - Membranes
- Infection
 - Endometritis
- Arteriovenous malformations
- Choriocarcinoma/placental site trophoblastic tumor

Box 22.3 Clinical features and diagnosis of secondary postpartum hemorrhage

- Clinical features
 - Bleeding excessive but not profuse
 - Fever, constitutional symptoms
 - Foul-smelling lochia
 - Uterine subinvolution
 - Uterine tenderness
- Diagnosis
 - Clinical examination
 - Ultrasonography
 - Placental tissue
 - GTN/Choriocarcinoma
 - Color Doppler
 - Arteriovenous malformations
 - If >4 weeks after delivery
 - Serum β hCG to rule out GTN gestational trophoblastic neoplasm.

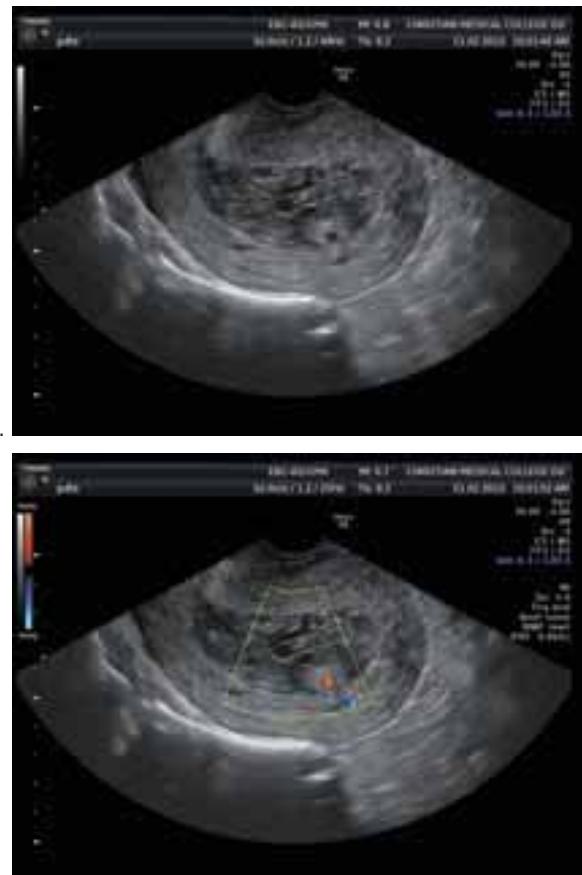


Figure 22.1 Ultrasonographic images of retained placental tissue. **a.** Placental tissue visible in the uterine cavity. **b.** Color Doppler shows vascularity in the periphery of the tissue.

Causes

Causes of secondary PPH are listed in Box 22.2.

Clinical features and diagnosis

The clinical features and diagnosis of secondary PPH are listed in Box 22.3.

Management

Since secondary PPH usually occurs in the presence of infection (endometritis), antibiotics must be administered to all women with secondary PPH. The offending organisms are a combination of aerobic gram-negative and anaerobic bacteria. Hence, a combination of antibiotics that cover these organisms should be used. Oral amoxicillin/clavulanic acid and metronidazole are commonly used.

Curettage is indicated if ultrasonography reveals retained placental tissue (Fig. 22.1). Curettage should be performed with caution to avoid uterine perforation.

Puerperal pyrexia

Pyrexia or fever in the puerperium can occur due to several causes. Clinical evaluation of symptoms and signs and appropriate investigations are necessary to arrive at a diagnosis.

Definition

Puerperal pyrexia (puerperal febrile morbidity) is defined as oral temperature of 38°C (100.4°F) or higher, on any 2 of the first 10 days postpartum, exclusive of the first 24 hours. Low-grade fever in the first 24 hours after delivery is common and therefore not included.

Box 22.4 Etiology of puerperal fever

- Genital tract infection
 - Uterine infection
 - Pelvic cellulitis
 - Peritonitis
 - Septicemia
 - Septic pelvic thrombophlebitis
- Wound infections
- Urinary tract infection
- Mastitis/breast abscess
- Respiratory tract infections

Etiology

Causes of puerperal fever are listed in Box 22.4.

uterine infection

Puerperal uterine infection usually involves the endometrium, myometrium, and parametrium and is therefore better described as **endometritis or paramyometritis** or **metritis with pelvic cellulitis**.

is actors

The most important risk factor for puerperal infection is cesarean section. Without antibiotic prophylaxis, the risk is 8–10 times higher with cesarean delivery, and mortality due to sepsis is 25 times higher as compared with vaginal delivery. Other risk factors are listed in Box 22.5.

Box 22.5 Risk factors for uterine infection

- Cesarean section
- Prolonged labor
- Prolonged rupture of membranes
- Multiple vaginal examinations
- Internal fetal monitoring
- Meconium-stained amniotic fluid
- Vaginal colonization with
 - Group B *Streptococcus*
 - *ycoplasma hominis*
 - *reaplasma urealyticum*
 - *ardnerella vaginalis*
 - *Chlamydia trachomatis*
- Low socioeconomic status
- Operative vaginal delivery
- Intrapartum chorioamnionitis
- Maternal anemia, diabetes
- Manual removal of placenta
- Younger age, nulliparity
- HIV infection

human immunodeficiency virus.

Box 22.6 Common pathogens causing uterine infections

- Aerobes
 - Gram positive
 - *Streptococcus*—group A, B, and D
 - *Staphylococcus aureus*
 - *nterococcus*
 - Gram negative
 - *schierichia coli*
 - *lebsiella pneumonia*
 - *Proteus species*
 - *eisseria gonorrhoeae*
 - Others
 - *ardnerella vaginalis*
 - *ycoplasma hominis*
 - *Chlamydia trachomatis*
- Anaerobes
 - Peptostreptococci and peptococci
 - *Bacteroides species*
 - *Clostridium sordellii* and *C perfringens*
 - *usobacterium* and *obiluncus*

icrobiology

The infection is usually *polymicrobial* and a combination of gram-negative, gram-positive, and anaerobic bacteria are involved. Most infections are caused by organisms that colonize the genital tract. In women infected with HIV, other less likely pathogens, such as herpes simplex virus and cytomegalovirus, may also play a role. The common pathogens are listed in Box 22.6.

athogenesis

The organisms from the lower genital tract enter the amniotic fluid when the membrane ruptures. Given the right conditions, they invade the site of placental attachment or the uterine incision. The infection subsequently spreads to the parametrial connective tissue (*pelvic cellulitis*) and can later involve the adnexae (Fig. 22.2). Pelvic and general peritonitis and pelvic abscess can result. Septicemia can occur at any time during the process of spread of infection.

The spread of infection is by

- contiguous spread from uterus,
- bloodstream (hematogenous), and
- lymphatics.

Clinical features

Fever is the most predominant symptom. Other symptoms and signs are listed in Box 22.7.

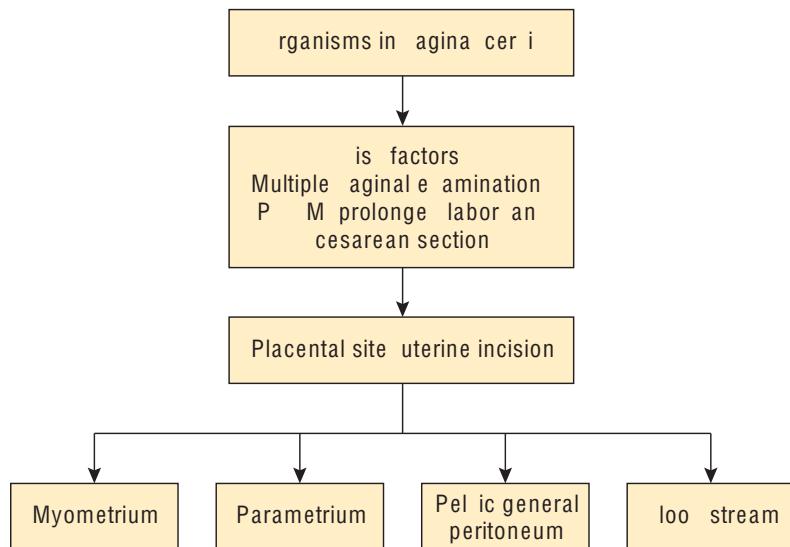


Figure 22.2 Pathogenesis of puerperal infection. *P*, prelabor rupture of membranes.

Box 22.7 Clinical features of puerperal infection

- Symptoms
 - Fever, chills
 - Lower abdominal pain
 - Headache, malaise
 - Malodorous lochia
 - Excessive vaginal bleeding
- Signs
 - Tachycardia
 - Uterine tenderness
 - Subinvolution of uterus
 - Purulent lochia
 - Parametrial tenderness

- Antibiotic prophylaxis at cesarean section: A single dose of ampicillin 2 g IV or first-generation cephalosporin (cefazoline) 1–2 g IV given not more than 30 minutes before skin incision has been found to reduce the incidence of infection.
- Spontaneous delivery of the placenta at cesarean section reduces the incidence of infection.

Antibiotic prophylaxis is not recommended for vaginal delivery. Cleansing the vagina with chlorhexidine or providone-iodine prior to labor or cesarean section has not been found to be useful in reducing infection rates.

Diagnosis

In women who present with puerperal fever, a detailed history of risk factors for uterine infection should be asked for. Clinical evaluation is important to look for the symptoms and signs of uterine infection and to exclude other causes of puerperal fever. **Routine cultures from the vagina or endometrium are not recommended.** Blood culture is recommended when the woman appears acutely ill with sepsis syndrome, the fever does not respond to treatment, or the woman is immunocompromised.

Prevention

Postpartum uterine infection and its complications can be prevented by the following strategies:

treatment

Treatment should include antibiotics to cover aerobic gram-positive, gram-negative, and anaerobic organisms.

Mild endometritis following vaginal delivery can be treated with oral amoxicillin-clavulanic acid and oral metronidazole.

Infection following cesarean sections and more severe infections with fever, chills, abdominal pain, and purulent discharge that occur after vaginal delivery should be treated with parenteral antibiotics. **A combination of clindamycin and gentamycin has a 95% cure rate and is the recommended first-line treatment** (Table 22.1).

Other antibiotics that have an equivalent efficacy are third-generation cephalosporins (cefotetan, cefoxitin, and ceftizoxime), piperacillin, and ampicillin-sulbactam. Women who are

Table 22.1 Antimicrobial treatment of puerperal uterine infection

Severity of infection	Antibiotic	Dose	Frequency	route
Mild infection, vaginal delivery	Amoxicillin/clavulanic acid + metronidazole	625 mg 400 mg	12 hourly 8 hourly	Oral Oral
Moderate-to-severe, infection, vaginal delivery; infection following cesarean section	Clindamycin + Gentamycin	900 mg 5 mg/kg	8 hourly Once daily	IV IV

known to be colonized with group B streptococcus on antepartum screening should be treated with ampicillin-sulbactam alone or in combination with clindamycin and gentamycin.

Duration of therapy

Clinical response is usually evident within 48 hours of initiation of treatment. IV antibiotics must be continued for 24 hours after the patient becomes afebrile. In women with positive blood culture, parenteral antibiotics should be continued for a total period of 2 weeks.

If there is no response to treatment in 48–72 hours, consider the following:

- Other causes of fever: Evaluate
- Drug resistance: Change antibiotics
- Pelvic cellulitis, abscess, and uterine wound dehiscence: Perform imaging and surgery as required
- Unusual organisms: Treat according to blood culture
- Retained products: Perform ultrasonography and curettage

Pelvic cellulitis

Spread of infection to the retroperitoneal connective tissue between the layers of the broad ligament is also known as pelvic cellulitis or parametrial phlegmon (Fig. 22.3). The uterine incision may also undergo necrosis.

Clinically, prolonged fever persists in spite of antibiotic therapy. Pelvic examination reveals induration in the parametrium. CT scan clinches the diagnosis.

If uterine wound dehiscence is diagnosed, laparotomy, resuturing of the wound, or hysterectomy is indicated. Clinical features and management of pelvic cellulitis are summarized in Box 22.8.

Adnexal infection

The infection can spread from the uterus to the adnexa and an ovarian abscess may develop. Rupture of an ovarian abscess results in peritonitis and septicemia (Box 22.9). A high index of suspicion is necessary for the diagnosis. Imaging by ultrasonography and/or CT is

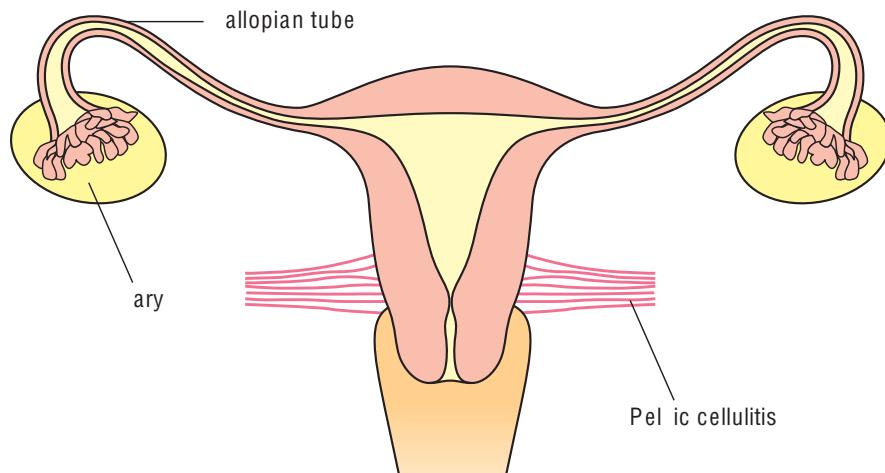


Figure 22.3 Pelvic cellulitis. The infection spreads between the layers of the broad ligament.

Box 22.8 Pelvic cellulitis

- Infection of tissue between layers of broad ligament
- Can be associated with uterine wound dehiscence
- Spread of infection from uterus
- Symptoms
 - Persistent fever
 - Parametrial tenderness
- U/S, CT for confirmation
- Treatment
 - Antibiotics
 - Surgery, if uterine wound dehiscence present

C computerized tomography; S, ultrasound scan.

Box 22.9 Adnexal infections

- Spread from uterus
- Can result in ovarian abscess
- Rupture of ovarian abscess results in
 - Peritonitis
 - Septicemia
- Diagnosis by U/S, CT
- Treatment
 - Antibiotics
 - Surgical excision of ovary

C computerized tomography; S ultrasound scan.

usually required. Treatment is by resection of the ovarian abscess.

Peritonitis

This may occur following endomyometritis, uterine wound dehiscence, or pelvic cellulitis. Clinical features and management of peritonitis are given in Box 22.10.

Box 22.10 Clinical features and management of peritonitis

- Occurs following
 - uterine infection
 - uterine wound dehiscence
 - pelvic cellulitis
- Clinical features
 - Persistent fever
 - Abdominal pain
 - Abdominal tenderness and rigidity
 - Paralytic ileus
- Treatment
 - Intravenous antibiotics
 - Conservative management of paralytic ileus
 - Surgical intervention in case of
 - uterine wound dehiscence
 - bowel perforation

Pelvic abscess

Following peritonitis, pus may collect in the broad ligament, between bowel loops or in the pouch of Douglas (Fig. 22.4). If the abscess is in the pouch of Douglas and can be accessed through the posterior fornix, it should be drained by colpotomy. Others can be managed by ultrasound-guided or CT-guided aspiration. Antibiotics must be administered.

Septicemia

Once the bacteria enters the bloodstream, septicemia results. Gram-negative septicemia can lead to septic shock with associated hypotension, respiratory distress syndrome, and renal failure, and is associated with high mortality. Septic shock is discussed in Chapter 45, *Nonhemorrhagic shock in pregnancy*.

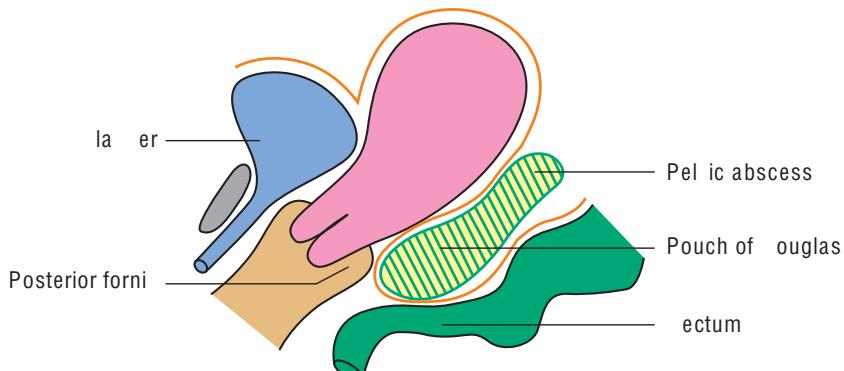


Figure 22.4 Pelvic abscess. The pus collects in the pouch of Douglas and can be drained through the posterior fornix.

Septic pelvic thrombophlebitis

This is a rare complication of puerperal uterine infection. Incidence has declined remarkably with the use of prophylactic antibiotics during cesarean section. The infection spreads along the veins and causes thrombosis. The thrombosis may extend upwards from the uterine veins to the internal and common iliac veins, ovarian veins and occasionally, to the inferior vena cava and renal vein (Fig. 22.5).

Clinical presentation includes fever, pelvic pain, tachycardia, abdominal tenderness, and guarding. Diagnosis is by ultrasonography, CT, or MRI. Treatment is by broad-spectrum antibiotics. Use of anticoagulants is controversial.

Toxic shock syndrome

Rarely, endotoxins released by *Staphylococcus aureus* or beta-hemolytic streptococci give rise to a clinical condition called toxic shock syndrome. Clinical features include fever, headache, vomiting, diarrhea, renal failure, disseminated

intravascular coagulation, and hepatic failure. Mortality is high in this condition. Management consists of early diagnosis, inotropic support, appropriate antibiotics, and management of renal failure.

Wound infections

Abdominal wound infection may be associated with uterine infection or may occur alone. Wound infection with collection of pus is managed as given in Box 22.11.

Necrotizing fasciitis with extensive tissue necrosis is a rare wound infection, associated with

Box 22.11 Management of abdominal wound infection

- Antibiotics as for endometritis
- Surgical drainage of wound
- Daily dressing
- Single layer closure after healthy granulation tissue seen

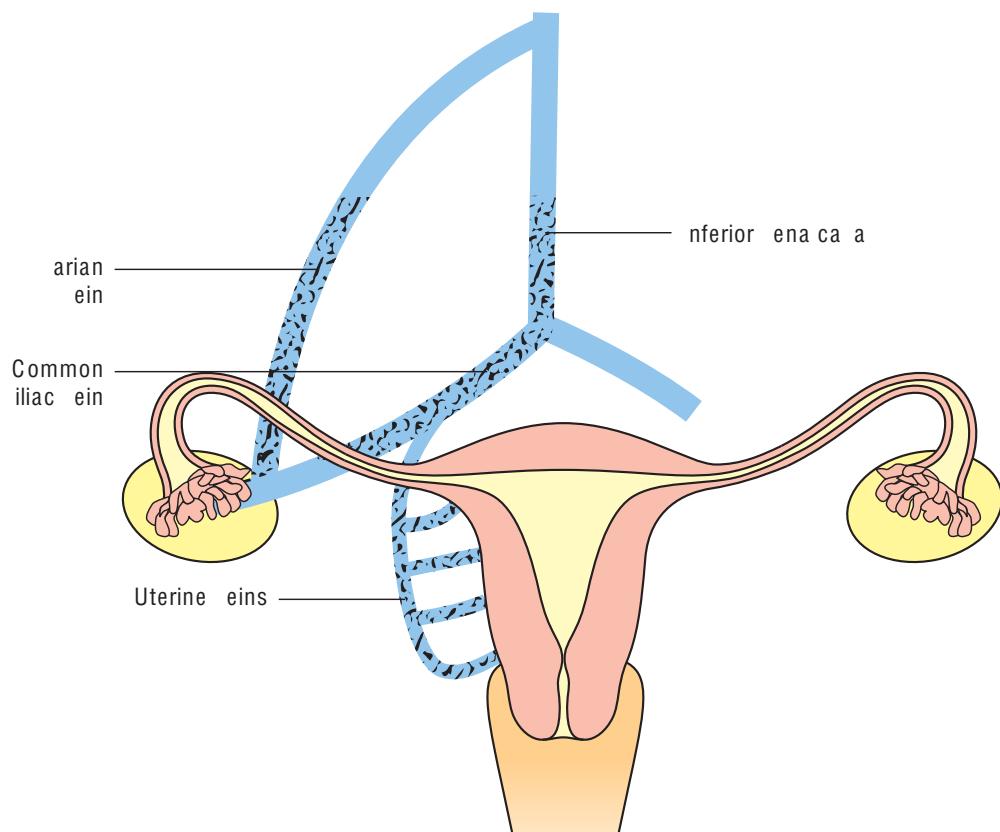


Figure 22.5 Septic pelvic thrombophlebitis. The thrombosis extends from the uterine veins to internal and common iliac veins, ovarian veins, inferior vena cava, and renal vein.

high mortality. It is usually seen in women with diabetes, hypertension, and obesity. Antibiotics and excision of the necrotic tissue is the treatment.

Infection of episiotomy and perineal tears

Infection may involve the skin and subcutaneous tissue alone or the muscle layer as well, resulting in episiotomy breakdown. The entire wound should be opened and allowed to granulate. Antibiotics are not recommended. Analgesics and warm Sitz bath relieve pain, and wound debridement assists in healing. Large deep wound breakdown should be resutured after 6–7 days. Closure is performed in layers as for primary repair of episiotomy.

Urinary tract infections

Urinary tract infection is a common cause of puerperal pyrexia. Cystitis occurs mainly due to incomplete emptying of the bladder (urinary stasis). The infection ascends easily since the physiological dilatation of the ureters takes a few days to regress.

Aetiology

The predisposing factors for urinary tract infections in the puerperium are listed in Box 22.12.

Aetiogens

The most common organism is *E. coli*. *Proteus*, *Klebsiella*, *Enterobacter*, and *Staphylococci* are the other organisms responsible for UTI.

Clinical features

The most common presentation is fever, chills, and dysuria. Presence of renal angle tenderness and high fever indicates pyelonephritis.

Box 22.12 Predisposing factors for urinary tract infections

- Decreased bladder sensation
 - Pressure on the bladder by fetal head
 - Epidural analgesia
- Voiding difficulty (urinary stasis)
 - Pain of episiotomy/perineal tear
 - Vaginal/vulval hematoma
- Catheterization during labor/postpartum

Management

Since most infections are caused by *E. coli*, treatment can be started based on clinical symptoms and signs. The urine sample should be sent for culture prior to the initiation of therapy. Diagnosis and management of urinary tract infections is discussed in Chapter 55, *Renal and urinary tract disorders*.

Breast engorgement, mastitis, and breast abscess

These are common causes of puerperal pyrexia and are discussed in Chapter 25, *Lactation and breastfeeding*.

Pneumonia infections

Respiratory infections are usually seen after cesarean section, especially if general anesthesia has been used. Stasis and aspiration are the leading causes of pneumonitis.

Differential diagnosis of puerperal pyrexia

Arriving at the right diagnosis requires a careful history, physical examination, and appropriate investigations (Table 22.2). Fever, chills, malaise, and headache are common to all conditions causing puerperal pyrexia. Leukocytosis is usually present.

Thromboembolic disease

Puerperal thromboembolism commonly occurs in women with prior history of thrombosis or inherited thrombophilias. Occasionally, it can occur in women with other high risk factors but without inherited thrombophilias. The increase in clotting factors, pressure on the vena cava by the enlarging uterus, and the resultant stasis are contributing factors. It may present as the following:

- Thrombophlebitis
- Deep vein thrombosis
- Pulmonary embolism

Table 22.2 Differential diagnosis of puerperal pyrexia

History	Physical examination	Investigations	Diagnosis
Risk factors, lower abdominal pain, malodorous lochia, excessive vaginal bleeding	Uterine tenderness, subinvolution, malodorous lochia		Uterine infection
Persistent fever	Parametrial tenderness, induration	U/S	Pelvic cellulitis
	Adnexal mass, tenderness	U/S	Adnexal infection
	Abdominal tenderness rigidity, paralytic ileus		Peritonitis
	Mass in POD	U/S, CT	Pelvic abscess
	Pelvic pain	CT/MRI	Septic pelvic thrombophlebitis
Pain at operative site or perineum	Erythema, induration, tenderness, discharge		Wound infection
Dysuria, frequency, loin pain	Suprapubic/renal angle tenderness	Urine culture	Urinary tract infection
Pain in the breast	Breast engorgement, cracked nipple, tenderness, erythema		Mastitis, breast abscess
Cough, purulent sputum	Respiratory signs	Chest X-ray	Respiratory infection

C, computerized tomography; U/S, magnetic resonance imaging; P D, pouch of Douglas; S, ultrasound scan.

Thrombophlebitis

It is thrombosis with associated inflammation or infection. It can affect the superficial veins of the leg but more often is deep seated. Septic pelvic thrombophlebitis extends retrograde to involve the iliofemoral veins. The leg is swollen and edematous. If the collateral veins are open and there is no venous congestion, the leg is pale and swollen, described as *phlegmasia alba dolens*. If collateral veins are involved, the leg is congested and edematous, described as *phlegmasia cerulia dolens*. Treatment is the same as for septic pelvic thrombophlebitis.

Deep vein thrombosis

It affects the left leg more often (Fig. 22.6). The leg may be swollen and painful, and calf muscle tenderness is present. Homan's sign is usually positive (pain in the calf muscle on dorsiflexion of the foot). Diagnosis is by ultrasonography and Doppler imaging. Bed rest, elastic stockings, analgesics, and therapeutic doses of anticoagulants are indicated.

- Unfractionated heparin (UFH)
 - Weight-adjusted full dose
 - 10,000 units 12 hourly
 - Dose adjusted according to *activated partial thromboplastin time (aPTT)*
- Low molecular weight heparin (LMWH)
 - Weight-adjusted full dose
 - Dalteparin 100 U/kg 12 hourly
- UFH followed by oral anticoagulants:
 - Warfarin 7 mg started along with UFH
 - UFH stopped after 3 days
 - Warfarin dose adjusted to 2–3 mg daily according to INR (international normalized ratio)



Figure 22.6 Deep vein thrombosis. The affected leg is swollen, discoloured, and tender.

Pulmonary embolism

Pulmonary embolism is associated with high maternal mortality. It may follow deep vein thrombosis of the leg or can occur without any prior symptoms. Dyspnea, cough, and chest pain are the usual symptoms.

Diagnosis requires a high index of suspicion. Chest X-ray, arterial blood gas analysis, ventilation/perfusion scan, and MRI are helpful. Treatment is by immediate anticoagulation. Intracaval filters may be inserted into the inferior vena cava to prevent recurrent emboli reaching the lungs from the legs or pelvis.

Postpartum neuropathy

Neuropathies occur in the postpartum period due to traction, compression, or vascular injury. The incidence is less in modern obstetric practice. The weakness and paralysis are usually transient; most women recover within 72 hours. *Foot drop* may persist for longer and requires physiotherapy. The etiology and management are listed in Box 22.13.

Box 22.13 Postpartum neuropathy

- Risk factors
 - Fetal macrosomia
 - Malpresentations
 - Prolonged labor
 - Mid/high forceps delivery
 - Prolonged lithotomy position
 - Improper use of stirrups
 - Hyperflexion of thighs
 - Epidural analgesia
- Involves
 - Lumbosacral trunk
 - Femoral nerve
 - Lateral cutaneous nerve of thigh
 - Pudendal nerve
 - Peroneal nerve
- Clinical features
 - Pain
 - Weakness of leg
 - Foot drop
- Management
 - Physiotherapy
 - Splinting
 - Electrical nerve stimulation

Musculoskeletal pain

The most common musculoskeletal problems in the puerperium are *sacroiliac joint pain* and *separation (diastasis) of the pubic symphysis*. Sacroiliac joint pain can occur during pregnancy or puerperium and is due to hormonal changes resulting in lax joint ligaments, lumbar lordosis, and position in labor. It is managed by rest, analgesics, and physiotherapy. Separation of pubic symphysis is summarized in Box 22.14.

Mental health issues

Mood disturbances, depression, and psychosis are experienced by many women during the postpartum period. Preexisting anxiety disorders, obsessive disorders, and depressive illness can exacerbate or recur in the postnatal period. The common disorders that occur in puerperium are postpartum ‘blues,’ depression, and psychosis. Posttraumatic stress disorder can also occur in the postpartum period.

Etiology

Hormonal changes in pregnancy and puerperium have been implicated in the causation. Interaction between various steroid hormones, genetic predisposition, and environmental

Box 22.14 Separation (diastasis) of pubic symphysis

- Can occur in late pregnancy or during delivery
- Etiology
 - Hormonal changes in pregnancy
 - Delivery of large baby
 - Position in labor
- Clinical features
 - Difficulty in walking
 - Severe pain
 - Tenderness over pubic symphysis
 - Palpable joint defect
- Management
 - Bed rest
 - Analgesics
 - Binders
 - Injection of local anesthetics

Box 22.15 Predisposing factors for mental health problems

- History of depression
 - Family history
 - Past history
- Stressful environment
 - At home
 - At work
- Marital conflicts
- Malformed infant

factors may explain the onset of these mental health problems, but definite proof is lacking.

Predisposing factors are listed in Box 22.15.

Postpartum blues

Postpartum ‘blues’ occur in almost 50% of women. The condition is self-limiting. It is characterized by mood swings, insomnia, anxiety, and crying spells that occur by 2–3 days after delivery, peak by the fifth day, and resolve within 2 weeks. The condition is treated by supportive therapy and minor tranquilizers.

Postpartum depression

If the postpartum ‘blues’ last for longer than 2 weeks, postpartum depression must be suspected. Depression occurs within the first 1 month but later than postpartum ‘blues’. This is one of the differentiating features. Criteria for diagnosis are the same as in nonpregnant women. Insomnia, low energy level, loss of appetite and weight, anger, feeling of being overwhelmed or inadequate, and obsessional thoughts are the usual symptoms. Treatment is by supportive therapy and antidepressants. Selective serotonin reuptake inhibitors are the drugs of choice.

Postpartum psychosis

Some women develop delusions, hallucinations, and psychotic behavior in the postnatal period. Usually, there is a past history of schizophrenia or bipolar disorder. The condition is uncommon but can recur in a subsequent pregnancy. Hospitalization, antipsychotic therapy, and occasionally electroconvulsive therapy are required.

Mental health issues in the puerperium are summarized in Table 22.3.

Table 22.3 Mental health problems in puerperium

Condition	Timing	Clinical features	Management
Postpartum blues	Begin 2–3 days after delivery, peak by fifth day subside by 2 weeks	Mood swings, anxiety, crying spells	Supportive, mild tranquilizers
Depression	2 weeks after delivery	Insomnia, low energy levels, loss of appetite/weight, anger, feeling of inadequacy	Supportive, antidepressants
Psychosis	Within first month	Mania, hallucinations, delusions, psychotic behavior	Hospitalization, antipsychotics, electroconvulsive therapy

Key points

- The most common postpartum complications are puerperal pyrexia and secondary postpartum hemorrhage (PPH).
- Secondary PPH occurs due to endometritis or retained placental tissue. Antibiotics must be administered to all women with secondary PPH. If ultrasonography shows retained placental tissue, curettage is required.
- Puerperal pyrexia is a temperature of 100.4°F or higher on any two occasions in the first 10 days postpartum, excluding the first 24 hours.
- Puerperal pyrexia is caused by uterine infection or its complications, wound infection, urinary tract infection, or mastitis.
- Uterine infection occurs in women with risk factors. The infection is polymicrobial, caused by aerobic and anaerobic organisms.
- Infection spreads from the uterus to the parametrium, adnexa, and peritoneal cavity or enters the blood stream.

(Continued)

Key points *Continued*

- Treatment is by antibiotics to cover polymicrobial infection. Cultures are not necessary. Severe infection warrants hospitalization and IV antibiotics. Clindamycin and gentamycin are the antibiotics of choice.
- Cesarean wound infection and episiotomy breakdown should be managed by wound debridement, antibiotics, and resuturing if required.
- The most common organism involved in urinary tract infection is *coli*.
- Thromboembolic disease may be thrombophlebitis, deep vein thrombosis, or pulmonary embolism. Deep vein thrombosis and pulmonary embolism should be treated by prompt anticoagulation.
- Postpartum neuropathy is caused by traction, compression, or occlusion of blood supply to the nerves. Most neuropathies are self-limiting. Foot drop may take time to resolve.
- Musculoskeletal pain involves the pubic symphysis or sacroiliac joint. Diastasis of the pubic symphysis is treated by rest, strapping, and analgesics.
- The mental health issues encountered in the puerperium are postpartum 'blues', depression, and psychosis. All require supportive therapy. Depression and psychosis should be treated with medications.

Self-Assessment

Case-based questions

Case 1

Mrs. RM, 28, presented with fever after having delivered 5 days ago at a local hospital. She was feeling ill, had lower abdominal pain, and a slight increase in vaginal bleeding.

1. What is the diagnosis?
2. How will you ascertain the cause of fever?
3. What is the most likely cause? Why?
4. What is the management?

Case 2

Mrs. MS, 20, was delivered by forceps for prolonged second stage. She developed acute pain in the pubic area and difficulty in walking after delivery.

1. What is the most likely diagnosis?
2. What are the risk factors?
3. How will you manage this condition?

Answers

Case 1

1. Puerperal pyrexia
2. a. History: Degree of fever, risk factors for infection, difficulty in breastfeeding, associated chills, abdominal pain, dysuria, excessive vaginal bleeding.
b. Look for any of the following: Uterine tenderness, subinvolution, foul-smelling lochia, adnexal mass or tenderness, cracked nipple, breast engorgement or abscess, wound breakdown.
3. Endometritis, because the patient presented with lower abdominal pain and vaginal bleeding along with the fever.

4. Since the patient presents with vaginal bleeding, she should be hospitalized.
 - a. If the temperature is mild to moderately high, bleeding is not profuse, and the patient is otherwise well, oral amoxicillin with clavulanic acid 625 mg 12 hourly with metronidazole 400 mg 8 hourly is indicated.
 - b. If bleeding is moderate, the temperature is high and the condition is suggestive of moderate to severe infection, IV clindamycin 900 mg 8 hourly and gentamycin 5 mg/kg daily are indicated.

Case 2

1. Diastasis of pubic symphysis.
2. Delivery of large baby, instrumental delivery, and positioning in labor. Hormonal changes of pregnancy may also contribute.
3. Bed rest, analgesics, and strapping. Gradual ambulation after a few days.

Sample questions

Long-answer questions

1. Discuss the importance of postnatal care. Describe the clinical features, diagnosis, and management of puerperal sepsis.
2. What is puerperium? Describe the complications of puerperium and their management.

Short-answer questions

1. Secondary postpartum hemorrhage
2. Prevention of puerperal sepsis
3. Predisposing causes for puerperal sepsis
4. Septic pelvic thrombophlebitis
5. Deep vein thrombosis.

23

The Newborn

Case scenario

Mrs. NK, 32, a multigravida, was delivered by forceps at term. The baby did not cry at birth and was limp and pale.

Introduction

The first few breaths in an infant's life are representative of a profound and challenging mechanism that marks the remarkable transition from intrauterine to extrauterine life. After depending entirely on the mother during fetal life for thermoregulation, metabolic homeostasis, and respiratory gas exchange, the fetus has to transition effectively and rapidly to postnatal respiratory and circulatory pathways.

Transition from intrauterine to extrauterine life

The transition from intrauterine to extrauterine life is a complex process, the failure of which can jeopardize the infant's life. In simple terms, the baby's first cry reassures the mother and the obstetrician that the baby has had a smooth, uncomplicated

transition and has adapted to extrauterine life. When the baby struggles to take its first breath or does not attempt to take a breath, it indicates failure of a process. The baby needs assistance from the obstetrician and neonatologist.

The transition involves:

- Pulmonary adaptation and
- Circulatory adaptation.

Pulmonary adaptation and changes

Pulmonary adaptation involves clearance of fluid from the alveoli and expansion of the lungs, with air completely replacing fluid. Surfactant plays a major role in the transition.

Alveolar fluid clearance

During fetal life, the lungs are filled with a fluid that is essential for normal growth and development of the lungs. Transition from intrauterine

to extrauterine life involves a smooth process of converting the fluid-filled lungs into an organ capable of gas exchange. This transition happens during labor, delivery, and in the first few instants of extrauterine life.

During labor

During labor, the following two mechanisms go into action:

- Production of lung fluid stops.
- Reabsorption of lung fluid begins.

During vaginal delivery

During vaginal delivery, one more mechanism comes into play:

- Fluid is mechanically squeezed out of the lungs.

Delivery of the head causes the expulsion of tracheal fluid. The amount of fluid squeezed out from the lungs during vaginal delivery is much more than that during a cesarean delivery.

The first breath

The baby's first breath establishes an air–liquid interface that rapidly involves the major part of the lungs and the lungs fill with air. The first breath of air after birth is typically a quick inspiration, followed by constriction of the larynx that holds air within the lungs with a positive intrathoracic pressure. This is followed by a short active expiration through a narrowed larynx with an immediate inspiration. This results in the first burst of crying by the baby.

Postnatally

The lymphatics and pulmonary capillaries absorb the remaining minimal amount of lung liquid.

Lung expansion

As the newborn initiates the first breath, intrathoracic pressure falls and air starts moving into the lungs. Increasing inspiratory pressure expands the alveolar air spaces and establishes functional residual capacity (FRC). Expansion of the alveoli also stimulates surfactant release, which has an important role in reducing alveolar surface tension, increasing lung compliance, and stabilizing the functional residual capacity. Pulmonary adaptation and changes are summarized in Box 23.1.

Box 23.1 Pulmonary adaptation and changes

- Fetal life
 - Lungs filled with fluid
- During labor
 - Production of lung fluid stops
 - Reabsorption of lung fluid begins
- Vaginal delivery
 - Fluid squeezed out mechanically
- First breath
 - Quick inspiration
 - Short expiration
 - Fluid-filled space becomes air filled
- Lung expansion
 - Due to fall in intrathoracic pressure
 - Leads to stimulation of surfactant production

Role of surfactant

When the infant takes its first breath, air rushes into the pulmonary alveoli. The alveoli are the primary site of gas exchange with the blood and consist of an epithelial layer and extracellular matrix surrounded by capillaries. During expiration the alveoli have a tendency to collapse. If this happens, then a much greater inspiratory effort is required to open them with the next breath. Surfactant is essential to prevent the alveoli from collapsing after they have expanded with the first few breaths (Box 23.2).

- Surfactant forms a very thin film that covers the surface of the alveolar cells and acts by reducing the surface tension at the air–liquid interface of the alveolus, thus preventing its collapse during end-exhalation. Surfactant is a

Box 23.2 Pulmonary surfactant

- Phospholipids and 4 surfactant proteins
- Produced by type II alveolar epithelial cells (pneumocytes)
 - Production initiated by 20 weeks' gestation
 - Increased production by 30–32 weeks
 - Production stimulated by glucocorticoids
 - Low production in preterm infants
- Forms thin film covering surface of alveolar cells
 - Reduces surface tension at air–liquid interface
 - Prevents alveolar collapse during end-exhalation
- Natural or synthetic surfactant used in treatment/prevention of RDS

DS respiratory distress syndrome.

- complex substance containing phospholipids and four different types of surfactant proteins.
- Surfactant is produced in the fetal lungs by type II alveolar epithelial cells, also called pneumocytes. At approximately 20 weeks' gestation, the components start to appear. The natural production of surfactant increases at approximately 30–32 weeks, and adequate amounts are produced by 34 weeks' gestation.
 - Surfactant production is stimulated by several hormones and growth factors: glucocorticoids, thyroid hormone, thyrotropin-releasing hormone, and others. Glucocorticoids are the most important stimulating factors and are used in clinical practice to accelerate fetal lung maturity.
 - **Preterm infants may have low amounts of surfactant, and this may result in respiratory distress syndrome (RDS).** Aspiration of meconium into the fetal lungs is known to inactivate surfactant and may lead to **meconium aspiration syndrome**.
 - Both natural and synthetic surfactants are effective in the treatment and prevention of RDS. The management of RDS is described later in this chapter.

Circulatory adaptation

The following two important circulatory changes occur during the transition from intrauterine to extrauterine life:

- There is a rise in neonatal systemic blood pressure. This happens when the placenta is abruptly removed from the neonatal circulation with the clamping of the umbilical cord.
- Both pulmonary vascular resistance and the pulmonary artery pressure drop significantly with the expansion of the lungs.

These two changes in turn result in the following:

- Increased left-to-right shunt at the ductus arteriosus
 - Increased ventricular stroke volume
 - Increased cerebral oxygen saturation
- Increased blood flow through the pulmonary arteries and lungs

Closure of ductus arteriosus

As lung perfusion and expansion increase, neonatal oxygenation saturation is increased, which

stimulates closure of the ductus arteriosus. The ductus arteriosus is functionally closed within 4 days of birth.

Failure of closure of the ductus arteriosus results in a condition called *patent ductus arteriosus* (PDA) and will require medical and/or surgical intervention.

Closure of the foramen ovale

The increased pulmonary arterial blood flow raises pulmonary venous return to the left atrium. As the left atrial pressure increases and the right atrial pressure falls, right-to-left shunting across the foramen ovale decreases. Closure of the foramen ovale occurs when the left atrial pressure exceeds the right atrial pressure.

The transition of intrauterine to extrauterine life is summarized in Figure 23.1.

Immediate assessment of the newborn in the delivery room

Delivery room assessment of the clinical status of the newborn includes the following:

- Clinical estimation of the infant's age (term or preterm)
- Apgar score

Apgar score

Dr. Virginia Apgar, an anesthetist, introduced the Apgar score in 1952. **The Apgar score is a quick screening test used worldwide to assess the health of the newborn infant at 1 and 5 minutes after birth.** The Apgar score is a convenient way of determining whether the infant needs prompt intervention to establish breathing.

- The 1-minute Apgar score measures how well the newborn tolerated labor and delivery.
- The 5-minute Apgar score assesses how well the newborn is adapting to the extrauterine environment.

Assignment of the Apgar score is detailed in Table 23.1.

Scores of 7 and above are generally considered normal, 4–6 low, and 3 and below are

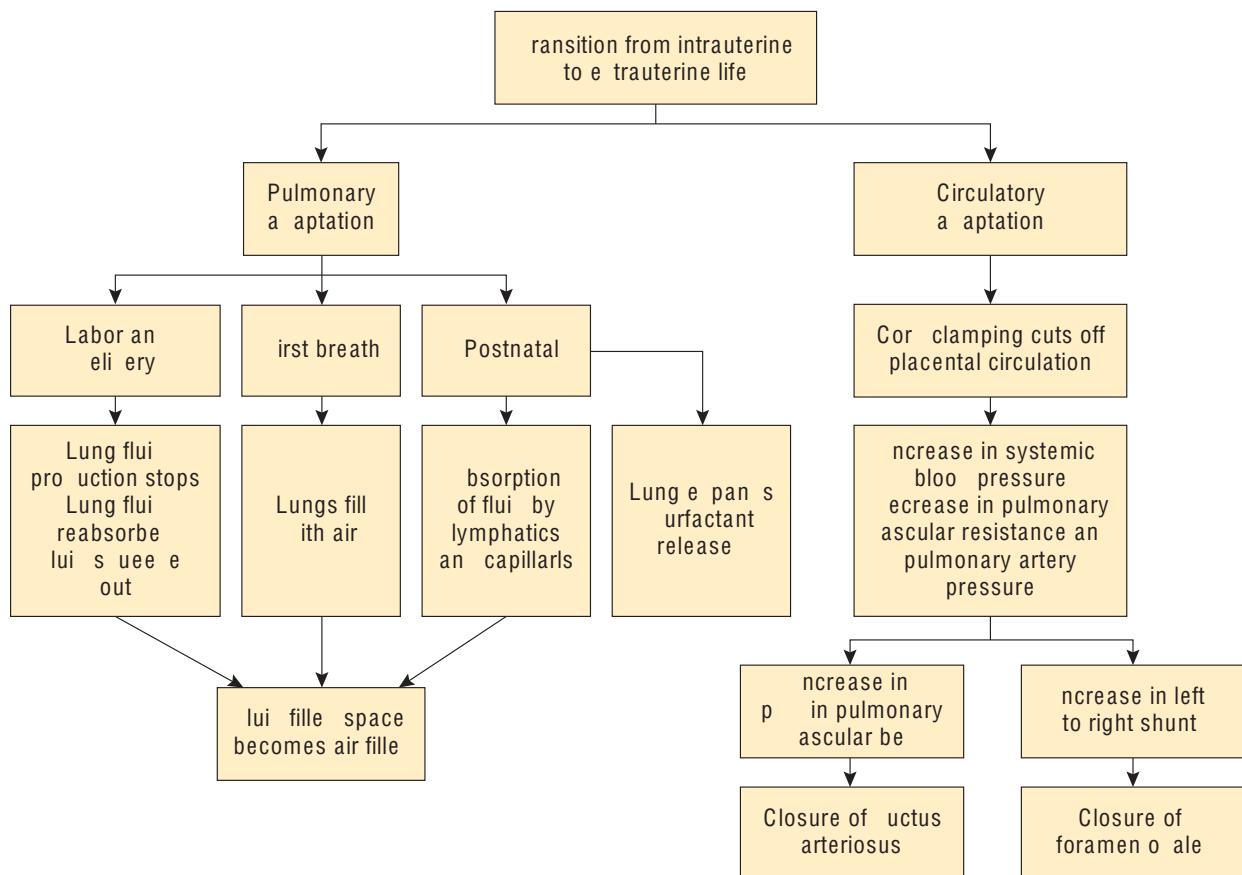


Figure 23.1 The transition of intrauterine to extrauterine life.

Table 23.1 Assignment of Apgar score

	Score		
	0	1	2
A: Appearance	Pale or blue	Pink with blue extremities	Pink all over
P: Pulse rate	Absent	<100 bpm	>100 bpm
G: Grimace (response to stimulation)	Nil	Grimace	Cry or cough
A: Activity (muscle tone)	Limp	Some flexion	Well flexed, active movement
R: Respiratory effort	Absent	Gasping or irregular	Regular or strong cry

generally regarded as critically low. However, the Apgar score should not be used as the only measure to evaluate the possibility that neurological damage occurred during the birthing process.

The clinical significance of the Apgar score and association with morbidity are listed in Box 23.3.

Examination of the normal newborn

A term infant with good respiratory effort, muscle tone, and good Apgar score does not require further treatment and, after the initial care, can remain with the mother to encourage

Box 23.3 The clinical significance of the Apgar score

- Low score at 1 minute
 - Medical attention required by the neonate
 - Does not necessarily indicate a long-term problem
 - If the score improves at the 5-minute test
- Low score at 5 minutes (0–3)
 - May have poor outcome/cerebral palsy
 - Associated with neonatal seizures
- Score below 3 at 10, 15, or 30 minutes
 - Indicates long-term neurological damage
 - Must be correlated with fetal hypoxemia and hypercarbia

- infant–maternal bonding by skin-to-skin contact and
- early initiation of breastfeeding.

Every newborn should be examined in the neonatal period. This allows confirmation of normalcy and also the detection of any minor or major abnormality. The physician's hands must be washed thoroughly before examining the baby to reduce the risk of cross-infection.

History

History should include the following:

- History of neonatal problems in previous siblings
- Family history of inherited disorders
- Antenatal history—high-risk factors, medications, and intrapartum complications
- Mode of delivery

Documentation of physical parameters

The following must be documented for the infant:

- Gender of the infant
- Weight
- Temperature
- Length (from top of the head to the heels)
- Head circumference

Systematic head-to-toe examination

The infant should have a complete examination, and both normal and abnormal findings should

be documented. A checklist should contain the following:

- Head
 - Shape of head
 - Fontanel: normal, sunken, or bulging
 - Sutures: molding, fused sutures
 - Facial appearance and eye position
 - Asymmetry or abnormality of facial form
- Face
 - Asymmetry
 - Facial palsy
- Eyes
 - Normal shape and appearance
 - Movement
 - Ophthalmoscope exam for presence of red reflex
 - Present: Normal
 - Abnormal: Rule out
 - Retinoblastoma
 - Cataracts
 - Retinal dysplasia
- Ears
 - Shape, size, malformed
 - Set at the normal level or ‘low-set’
 - Patency of external auditory meatus
- Mouth
 - Color of the mucous membrane
 - Tongue
 - Freely mobile
 - Tethered (tongue-tie)
 - Palate
 - High palate
 - Cleft palate
 - Lips
 - Cleft lip
 - Suckling reflex present
- Neck
 - Masses (e.g., cystic hygroma)
 - Torticollis (head tipped to one side and chin rotated toward the other)
- Arms and legs
 - Normal length and shape, and moving normally
 - Hands and feet
 - Polydactyly (extra digits)
 - Syndactyly (fused digits)
 - Palmar creases—multiple or single
 - Single palmar crease may be normal or sign of Down syndrome
- Peripheral pulses
 - Brachial, radial, and femoral pulses for rate, rhythm, and volume

- Hyperdynamic suggestive of patent ductus arteriosus
- Radial-femoral delay suggestive of aortic coarctation
- Heart
 - Palpation
 - Cardiac position
 - Thrill or heave
 - Auscultation
 - Added sounds
 - Murmurs
- Lungs
 - Respiratory rate, pattern, and depth
 - Intercostal retraction
 - Stridor or grunting
 - Auscultation of lung fields for added sounds
- Abdomen
 - Abdominal distension
 - Scaphoid abdomen—suggestive of diaphragmatic hernia
 - Umbilical stump for infection or hernia
 - Gentle palpation for organs, masses, or herniae
 - Liver and spleen palpable in newborn
- External genitalia
 - Female infant
 - Size and location of
 - Labia, clitoris, urethral meatus, vaginal opening
 - Male infant
 - Presence of testes
 - Location of urethral meatus
 - Appearance of scrotum
 - Ambiguous genitalia
- Anus
 - Location
 - Patency (establish whether meconium passed)
- Back
 - Spinal curvature/symmetry
 - Neural tube defect
 - Deep sacral dimple (spina bifida occulta)
- Hips
 - Test for congenital dislocation of the hip
- Central nervous system
 - Level of alertness
 - Spontaneous motor activity
 - Tone
 - Muscle strength
 - Primitive reflex responses

Further examination should be conducted as necessary according to any abnormalities that are detected, or suspicions of undetected illness in the baby. Depending on the abnormality found, the appropriate specialist can be called in.

outline care of the newborn

Following birth, the routine care of the newborn usually includes the following:

- Prophylactic eye care
- Administration of vitamin K
- Breastfeeding
- Care of the skin
- Meconium passage and voiding
- Umbilical cord care
- Hepatitis B vaccination

Prophylactic eye care

Prophylactic eye care is given shortly after birth as a preventive measure against developing gonococcal conjunctivitis. The commonly used medications are one of the following:

- Silver nitrate solution
- Erythromycin ointment 0.5%
- Tetracycline ointment 1%
- Povidone-iodine solution 2.5%

Vitamin K

Prophylactic vitamin K is given intramuscularly to newborns shortly after birth to prevent vitamin K-deficient bleeding, previously known as hemorrhagic disease of the newborn. Vitamin K should be given to all newborns as a single intramuscular dose of 0.5–1 mg.

Umbilical cord care

If the umbilical cord has been cut under aseptic conditions, no further treatment is required. However, in underresourced areas, cord care helps in reducing neonatal morbidity and mortality due to cord stump sepsis. Use of antiseptic agents (alcohol, silver sulfadiazine, or chlorhexidine) for cord care is recommended in this situation.

Care of the skin

Vernix and blood should be gently wiped off. Bathing should be delayed till the baby's temperature stabilizes.

Meconium passage and voiding of urine

Using a rubber catheter, the patency of the anal canal and rectum should be checked in all neonates. The baby usually passes meconium at birth or soon after. If meconium passage does not occur by 48 hours, further evaluation is recommended. The color of the stools gradually changes to yellow over the next few days.

The baby usually voids urine immediately after delivery. If urine is not passed by 48 hours, evaluation is indicated.

Breastfeeding

Breastfeeding should be initiated in the labor room as soon as the mother is made comfortable. The mother should be advised regarding the techniques for holding the baby, and should be helped in having the baby latch on and begin proper sucking. Breastfeeding is discussed further in Chapter 25, *Lactation and breastfeeding*.

hepatitis B vaccination

Universal vaccination of newborns, regardless of maternal hepatitis B virus surface antigen (HBsAg) status, is recommended. In addition to hepatitis B vaccine (HBV), infants of HBsAg-positive mothers should receive hepatitis B immunoglobulin (HBIG) shortly after birth, preferably within 12 hours of birth.

hepatitis B vaccine schedule

The schedule for Hepatitis B vaccine is as follows:

- *First dose* 0.5 mL at birth
- *Second dose* 0.5 mL at 1–2 months
- *Third dose* 0.5 mL at 6 months

hepatitis B immunoglobulin

One dose of HBIG should be given within 12 hours of birth (for infants of HBsAg-positive mothers).

Common findings seen in the newborn

The following are the common findings seen in the newborn:

- *Hemangiomas* ('strawberry hemangioma') are seen around the eyes and nape of the neck. They usually disappear within a year.
- *Mongolian spots* are blue-black pigmented areas seen at the base of the back and on the buttocks. These are common in dark-skinned babies and normally disappear over the first year.
- *Urticaria* of the newborn is most evident on Day 2 as a fluctuating, widespread erythematous rash with a raised white/cream dot at the center of a red flare, mostly apparent on the trunk. This disappears spontaneously without treatment.
- *Miliaria* may appear as either red, macular patches or superficial, clear vesicles that are most marked on the forehead and around the neck. It is associated with warm humid environments and will clear in cooler, drier conditions.
- *Breast enlargement* can be seen in both girls and boys; occasionally there might be secretion of a small amount of milk. This occurs as a result of circulating maternal hormones. It will subside spontaneously.
- *Milia* or *white pimples* are seen on the nose and cheeks and are found in approximately 40% of newborns, due to blocked sebaceous glands. These clear spontaneously.
- *Natal teeth* can be present at birth. No action is required unless they are loose or abnormal, in which case they may have to be extracted..
- *Accessory skin tags* are often seen on the face as accessory auricles anterior to the ears.
- *Vestigial extra digits* can usually be excised easily.

Common reflexes of the newborn

The presence of the following reflexes is reassuring and usually denotes an intact neurological system.

Moro reflex

When newborns are startled, their arms and legs swing out and forward with fingers outstretched.

Rooting reflex

When either side of the mouth is touched, newborns turn their head toward that side. This reflex enables newborns to find the nipple.

Sucking reflex

When an object is placed in their mouth, newborns begin sucking immediately.

Newborn metabolic screening

Newborn metabolic screening is done to screen infants shortly after birth for metabolic conditions that are treatable, but not clinically evident in the newborn period. Newborn screening tests are most commonly done from whole blood samples obtained from a heel prick and collected on specially designed filter paper. The infant should have been fed at least once. Usually the sample is collected 2–4 days after birth.

The common disorders that are screened for are:

- Phenylketonuria
- Congenital adrenal hyperplasia
- Congenital hypothyroidism
- Galactosemia

Other conditions screened for in high-risk populations are:

- Cystic fibrosis
- Sickle cell anemia

Resuscitation of the newborn

When an infant is unable to make a smooth transition to extrauterine life, it needs resuscitation. Approximately 10% of infants will require some form of intervention, and only 1% will require major resuscitative efforts.

Certain high-risk pregnancies should alert the obstetrician to anticipate the need for resuscitation in the newborn. These factors are listed in Box 23.4.

Immediately after delivery, infants are assessed and placed into three categories. These are:

1. The infant can be left alone.

Box 23.4 Conditions where the infant is likely to require resuscitation

- Maternal complications
 - Advanced or very young maternal age
 - Maternal diabetes mellitus or hypertension
 - Previous history of stillbirth, fetal loss, or early neonatal death
- Fetal factors
 - Prematurity
 - Postmaturity
 - Congenital anomalies
 - Multiple gestation
- Antepartum complications
 - Placenta previa or placental abruption
 - Oligohydramnios or polyhydramnios
- Delivery complications
 - Abnormal fetal heart rate pattern
 - Instrumental delivery
 - Cesarean delivery
 - Malpresentation
 - Chorioamnionitis
 - Maternal administration of opioid <4 hours of birth

2. The infant requires some assistance in breathing.
3. The infant requires prompt resuscitation.

Category 1

Category 1 comprises infants with the following characteristics:

- Healthy term baby
- Cries within seconds
- Good tone and activity
- Heart rate of >100 bpm
- Rapidly turns pink

This baby only needs to be dry, wrapped in a towel, and handed over to the mother. Routine neonatal examination can be performed according to hospital protocol.

Category 2

Category 2 comprises infants with the following characteristics:

- Not breathing regularly
- Heart rate of >100 bpm
- Centrally cyanosed

This baby needs to be rubbed dry, which might provide enough stimulation to induce

breathing. The baby should be placed under a heat source. Active resuscitation is needed if there is no response to these simple measures.

Category 3

Category 3 comprises infants with the following characteristics:

- Not breathing
- Heart rate of <100 bpm
- Pale
- Poor tone/floppy

This baby needs prompt resuscitation and will deteriorate without it.

Resuscitative steps

The ABCDs of resuscitation can be applied to the neonate, with some modification.

The 2010 American Heart Association (AHA)/American Academy of Pediatrics (AAP)/International Liaison Committee on Resuscitation (ILCOR) guidelines recommend the following approach:

- Initial steps (provide warmth, clear Airway if necessary, dry, and stimulate)
- Breathing (ventilation)
- Chest compressions
- Administration of Drugs, such as epinephrine and/or volume expansion

Initial steps

The following are the initial steps:

- Provide warmth (avoiding hypothermia)
 - Dry and wrap in cloth or towel
 - Ensure skin-to-skin contact with mother and cover with blanket
 - Polyurethane bags or wraps for infants <1500 g
 - Raise room temperature (turn off air conditioning)
 - Use warming lamps/pads
- Airway
 - Place flat on back
 - Neck in neutral or slightly extended position
 - Suction secretions if required
 - Bulb syringe
 - Mechanical suction device

- Stimulation
 - Rub infant's back
 - Gently slap or flick infant's soles of feet

Subsequent resuscitative steps

The subsequent resuscitative steps consist of the following:

- Supplemental oxygen
 - Blended oxygen or room air recommended
 - 100% oxygen not recommended
- Positive pressure ventilation
 - Required when
 - infant is gasping or apneic
 - heart rate is <100 bpm
 - Equipment
 - Bag-mask ventilation (BMV)
 - 40–60 times/min for 30 seconds
 - Check heart rate
 - Continuous positive pressure ventilation (CPAP)
- Endotracheal intubation indicated if
 - BMV is ineffective or prolonged
 - chest compressions are being performed
 - tracheal suctioning for meconium is required
- Chest compression initiated if
 - infant's heart rate remains <60 bpm despite adequate ventilation for 30 seconds
- Drugs
 - Used only if required
 - Epinephrine if heart rate <60 bpm
 - Naloxone not recommended
 - Sodiumbicarbonate nolonger recommended

The guidelines for neonatal resuscitation are given in Figure 23.2.

Discontinuing resuscitation

Resuscitative procedures may be discontinued after 10 minutes of resuscitation if the neonate has demonstrated no signs of life:

- No heartbeat
- No respiratory effort for >10 minutes

The outcome in these infants is associated with high early mortality and unacceptably severe motor and sensory disabilities.

Noninitiation of resuscitation

In some situations, resuscitation may not be initiated because of the poor prognosis for the

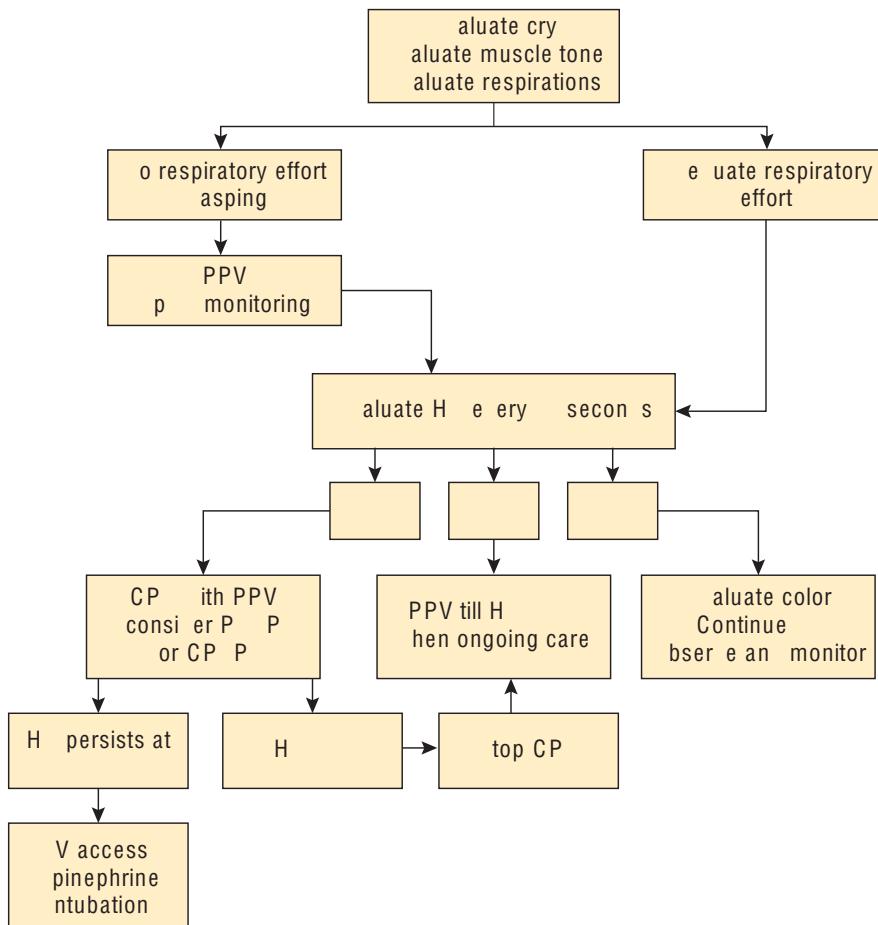


Figure 23.2 Algorithm for resuscitating the neonate. CPAP, continuous positive airway pressure; CP, cardiopulmonary resuscitation; H, heart rate; I, intravenous; PEP, positive end expiratory pressure; PPV, positive pressure ventilation; Sp_{O₂}, oxygen saturation.

infant. This decision must be taken in consultation with the parents. These conditions include the following:

- Gestational age <24 weeks
- Birth weight <500 g
- Anencephaly or other lethal anomaly
- Chromosomal abnormalities incompatible with life
 - Trisomy 13 or 18

the goal of reducing infant mortality rates by promoting breastfeeding practices in hospitals, both in government and private sectors.

The initiative is a global effort for educating mothers about the benefits of breastfeeding and improving the role of maternity services to enable mothers to breastfeed babies for the best start in life. Maternity services are encouraged to protect, promote, and support breastfeeding.

Recommendations of the BFHI

Recommendations of the BFHI are as follows:

- Babies should be breastfed exclusively for the first 6 months of life.
- Breastfeeding should be initiated within 1 hour of birth. Early skin-to-skin contact between mother and baby encourages this practice.
- No prelacteal feeds (e.g., glucose water, honey, plain water) should be given.

Baby Friendly Hospital Initiative

The Baby Friendly Hospital Initiative (BFHI) is a worldwide program launched in 1991 by the World Health Organization (WHO) and UNICEF. It was launched in India in 1993. It is considered one of the key interventions toward achieving

- No supplemental feeds should be given, especially formula.
- Pacifiers or teats should not be used.

Achieving the goals of the BFHI

Achieving the goals of the BFHI requires the following:

- Doctors and nurses should receive training in breastfeeding practices.
- Breastfeeding practices should be taught in the antenatal period.
- Adequate support should be received from lactational specialists/nurses to help women with breastfeeding problems (*see Chapter 25, Lactation and breastfeeding*).
- Rooming-in and demand feeding should be encouraged.

Advantages of breastfeeding for the infant

Studies have shown that breastfed babies are less likely to suffer from the following:

- Gastroenteritis
- Asthma

- Eczema
- Respiratory and ear infections

Benefits of breastfeeding for the mother

Women who breastfeed have decreased risk of developing the following:

- Metabolic syndrome (heart disease, hypertension, diabetes, high cholesterol)
- Breast cancer
- Ovarian cancer
- Hip fractures in later life

The aim of BFHI is to increase the numbers of babies who are exclusively breastfed worldwide, a goal which the WHO estimates could contribute to avoiding >1 million child deaths each year, and potentially many premature maternal deaths as well.

Key points

- The first few breaths in an infant's life are representative of a profound and challenging mechanism that marks the remarkable transition from intrauterine to extrauterine life.
- The transition from intrauterine to extrauterine life is a complex process, the failure of which can jeopardize the infant's life. The transition involves both pulmonary and circulatory adaptation.
- Surfactant is essential for normal breathing. It is produced in the fetal lungs by type II alveolar epithelial cells, also called pneumocytes. It prevents the alveoli from collapsing after they have expanded with the first few breaths.
- The Apgar score is a quick screening test used worldwide to assess the health of the newborn infant at 1 and 5 minutes after birth. 5-minute scores of 7 and above are generally considered normal, 4–6 low, and 3 and below are generally regarded as critically low.
- Following birth, the routine care of the newborn usually includes prophylactic eye care, administra-
- tion of vitamin K, umbilical cord care, and hepatitis B vaccination.
- Every newborn should be examined in the neonatal period, and the gender of the infant, weight, length, and head circumference must be documented for the infant.
- The infant should have a complete examination, and both normal and abnormal findings should be documented.
- The presence of the following reflexes is reassuring and usually denotes an intact neurological system: Moro reflex, rooting reflex, and sucking reflex.
- Newborn screening for hearing loss is important since hearing loss is one of the most common congenital anomalies and occurs in approximately 2–4 infants per 1000.
- Newborn metabolic screening is done to screen infants shortly after birth for metabolic conditions that are treatable, but not clinically evident in the newborn period.

(Continued)

Key points *Continued*

- Immediately after delivery, infants are assessed and placed into three categories. This helps determine which infant can be left alone, which infant requires some assistance in breathing, and which infant requires prompt resuscitation.
- Neonatal resuscitation involves ABCDs: initial steps (provide warmth, clear airway if necessary, dry, and stimulate), **b**reathing (ventilation), **c**hest compressions, and administration of drugs, such as epinephrine and/or volume expansion.
- The subsequent steps in resuscitation include supplemental oxygen, positive pressure ventilation, endotracheal intubation when required, chest compression, and drugs such as epinephrine.
- The Baby Friendly Hospital Initiative (BFHI) is considered one of the key interventions toward achieving the goal of reducing infant mortality rates by promoting breastfeeding practices in hospitals, both in government and private sectors.

Self-Assessment

Case-based questions

Case 1

Mrs. NK, 32, a multigravida, was delivered by forceps at term. The baby did not cry at birth and was limp and pale.

- How will you assess the condition of the baby?
- How will you categorize a newborn in relation to resuscitation?
- What are the basic steps of resuscitation?
- How will you resuscitate this baby?

Case 2

Mrs. MT had a vaginal delivery of a term baby that breathed and cried immediately after birth.

- What routine examination will you do?
- What is routine newborn care?
- The baby had some milky discharge from the breast on the third postnatal day. How will you counsel?
- The mother complained that the baby did not pass meconium or urine for 6 hours after delivery. What will you do?

Answers

Case 1

- By noting the color, respiration, muscle tone, heart rate, and cry at 1 and 5 minutes and calculating Apgar score.
- Newborns can be placed into category 1, 2, or 3. Category 1 needs no resuscitative measures, category 2 requires warmth and stimulation, and category 3 requires prompt active resuscitation.
- These are airway, breathing, chest compression, and drugs (ABCD).
- This baby probably belongs to category 3. The baby should be wiped dry and wrapped in a towel and

should be placed under a warming lamp; gentle stimuli should be given first. Secretions should be suctioned and oxygen administered. Heart rate should be counted, and if <100 bpm, positive pressure ventilation is required with bag and mask. If recovery is delayed, the baby should be intubated and ventilated.

Case 2

- Routine examination consists of history and documentation of gender, weight, temperature, length, and head circumference. This should be followed by systematic head-to-toe examination of all organs and systems.
- Routine newborn care consists of prophylactic eye care, administration of vitamin K1, umbilical cord care, care of the skin, breastfeeding, checking for passage of meconium and voiding of urine, and hepatitis B vaccination.
- This is common in newborns and is due to maternal hormones. The condition will subside in a few days.
- Although the baby usually passes meconium and voids urine within a few hours after birth, the process may take up to 48 hours. If rectal patency has been checked, further evaluation can wait till 48 hours.

Sample questions

Long-answer question

- What is Apgar score? How will you resuscitate a newborn baby?

Short-answer questions

- Surfactant
- Care of a healthy newborn
- BabyFriendly Hospital Initiative

24

Common Problems of the Newborn

Case scenario

Mrs. KL, 27, delivered her baby at 35 weeks + 4 days. The baby developed high levels of bilirubin on the second day of life. The parents were very concerned and were anxious about the prognosis.

Introduction

The first 4 weeks are the most challenging period in an infant's life. During this time, the neonate faces the highest mortality rate in all of childhood. The greatest risk occurs during the first few days after birth. Management of neonatal problems is challenging and requires a trained neonatologist and a well-equipped neonatal care facility.

Common metabolic disorders in the newborn

eonatal aundice and hyperbilirubinemia

It is common for neonates to develop jaundice, which is the yellowish discoloration of the skin and/or conjunctiva caused by bilirubin deposition. Hyperbilirubinemia is a more

serious condition that may result in neurological sequelae in the neonate.

eonatal or physiological aundice

Newborn infants commonly develop a total serum or plasma bilirubin level >1 mg/dL, which is the upper limit of normal for adults. This results in neonatal jaundice. There is yellowish discoloration of the skin and/or sclera due to the deposition of unconjugated bilirubin. Neonatal jaundice first becomes visible on the face and forehead. Identification is aided by gentle pressure on the skin (especially tip of the nose), since blanching reveals the underlying color.

The risk of developing significant neonatal jaundice is higher in male infants and preterm infants.

Neonatal physiological jaundice results due to the following:

- Since newborns have more red blood cells (hematocrit between 50% and 60%) and fetal

red blood cells have a shorter life span (approximately 85 days) than those in adults, the rapid turnover of red blood cells produces more bilirubin.

- The immature neonatal liver is unable to process bilirubin because of
 - insufficient concentrations of the binding protein ligand in the hepatocytes and
 - low activity of glucuronyl transferase, the enzyme responsible for binding bilirubin to glucuronic acid, making bilirubin water soluble or conjugated.

is actors or neonatal jaun ice

The risk factors for neonatal jaundice are listed in Box 24.1.

yperbilirubinemia

Hyperbilirubinemia or high levels of serum bilirubin, >25–30 mg/dL (in a term infant), are associated with an increased risk for **bilirubin-induced neurologic dysfunction (BIND)**. In preterm infants, these sequelae can arise at levels of 20 mg/dL. This occurs when bilirubin crosses the blood–brain barrier and binds to brain tissue. The chronic and permanent sequelae of BIND are called **kernicterus**, a devastating chronic condition in which bilirubin-mediated irreversible brain damage results in cerebral palsy and loss of hearing. This is why neonates must be monitored for hyperbilirubinemia.

Severe hyperbilirubinemia must be suspected in the following cases:

- Jaundice occurs in the first 24 hours.
- Total bilirubin is >15 mg/dL and continues to rise.
- Rate of rise of total bilirubin is >0.2 mg/dL/hour.
- Jaundice in a term newborn after 2 weeks of age.

Signs of worsening jaundice that suggest BIND and require immediate intervention are enumerated in Box 24.2.

Box 24.1 Neonates at risk for developing jaundice

- Infants of diabetic mothers
- Preterm infants/low-birth-weight infants
- Babies born at high altitudes
- Breastfed infants
- Underfed infants

Box 24.2 Signs suggestive of bilirubin-induced neurologic dysfunction

- Intense yellow discoloration (lemon yellow or orange yellow)
- Infant refuses feeds
- Infant not rousable
- Infant irritable, with a continuous, high-pitched cry
- Infant arches neck or body backward

Causes of severe hyperbilirubinemia

The important causes of pathologically high levels of bilirubin are listed in Box 24.3.

Treatment of severe hyperbilirubinemia

Therapeutic interventions for infants with hyperbilirubinemia include the following:

- Improving the frequency and efficacy of breastfeeding
- Phototherapy
- Exchange transfusion

hototherapy

The following points should be noted regarding phototherapy:

- Phototherapy acts principally by converting bilirubin to **lumirubin**, which is more soluble than bilirubin and is easily excreted into bile and urine.
- Effectiveness of phototherapy depends on the type of the light used, distance between the light and infant, and the exposed surface area of the infant.
- Lamps with output predominantly in the blue region of the spectrum (460–490 nm) are most

Box 24.3 Causes of pathologically high levels of bilirubin

- ABO incompatibility (mother O blood group, baby A or B blood group)
- Rh incompatibility (see Chapter 38, *red cell alloimmunization*)
- Glucose-6-phosphate dehydrogenase (G6PD) deficiency
- Hereditary spherocytosis/elliptocytosis
- Sepsis

effective. Fluorescent blue light or halogen white light is commonly used.

- The baby is exposed to phototherapy wearing only a diaper and an opaque blindfold to shield the eyes.
- Continuous phototherapy is recommended for bilirubin levels of ≥ 20 mg/dL. Below this level, phototherapy can be interrupted for breastfeeding.

Exposure to early morning and late evening sunlight is useful for neonatal jaundice in under-resourced areas but is not effective for severe hyperbilirubinemia.

change trans usion

Exchange transfusion is used to remove bilirubin from the circulation in severe hyperbilirubinemia. The indications are as follows:

- Intensive phototherapy fails to bring down the bilirubin level
 - Below 25 mg/dL in term infants
 - Below 20 mg/dL in preterm or very-low-birth-weight infants
- Infants with signs of BIND

Rh incompatibility and ABO incompatibility are two of the more common reasons for performing exchange transfusion. With the advent of anti-D prophylaxis, the incidence of exchange transfusion has declined due to the decline in hemolytic disease of the newborn.

Procedure

A double-volume exchange transfusion (160–180 mL/kg) is performed with appropriately cross-matched blood reconstituted from packed red blood cells and fresh frozen plasma. This will replace approximately 85% of the infant's circulating red blood cells.

eonatal hypoglycemia

Transient low blood glucose levels are common after birth as the continuous transplacental glucose infusion from the mother is replaced by an intermittent supply from feeds. Persistent or recurrent hypoglycemia can result in neurologic sequelae.

Neonatal hypoglycemia is the most common metabolic problem in newborns. It is defined as a plasma glucose level of

- <30 mg/dL in the first 24 hours of life
- <45 mg/dL thereafter

Box 24.4 eonates at risk for developing hypoglycemia

- Infants of diabetic mothers
- Preterm or low-birth-weight infants
- Growth-restricted infants
- Infants with sepsis

isk factors for hypoglycemia

Certain neonates are at risk for hypoglycemia (Box 24.4), and it is important to monitor their blood glucose levels.

Signs of hypoglycemia

Many infants remain asymptomatic and that is why blood glucose levels should be monitored, especially in high-risk infants. The immediate consequences of prolonged or severe hypoglycemia are listed in Box 24.5.

Long-term consequences of severe hypoglycemia

Major long-term sequelae include neurologic damage resulting in mental disability, recurrent seizure activity, developmental delay, and personality disorders.

Management

Management of hypoglycemia involves the following measures:

- Frequent feeds in asymptomatic infants
- Parenteral glucose infusions in symptomatic infants

eonatal hypocalcemia

Hypocalcemia is defined as serum total calcium concentration <8 mg/dL in term infants or

Box 24.5 Short-term consequences of prolonged or severe hypoglycemia

- Jitteriness/tremors
- Hypotonia
- Changes in level of consciousness
- Apnea/bradycardia
- Cyanosis
- Tachypnea
- Poor feeding
- Hypothermia
- Seizures

<7 mg/dL in preterm infants. Risk factors for hypocalcemia include the following:

- Preterm infant
- Infant of diabetic mother
- Growth-restricted or low-birth-weight infant
- Perinatal asphyxia

Signs of hypocalcemia are similar to those for hypoglycemia. In an infant with neonatal seizures, serum calcium level should be included in the workup.

Treatment is by a slow IV infusion of 10% calcium gluconate. This is followed up with oral calcium.

Common respiratory disorders of the newborn

Transient tachypnea of the newborn

Transient tachypnea of the newborn (TTN) is a benign disorder that causes respiratory distress in the neonate. It occurs due to pulmonary edema resulting from delayed resorption and clearance of fetal alveolar fluid. The risk factors for TTN are listed in Box 24.6.

Transient tachypnea of the newborn presents as tachypnea within 2 hours after delivery. The infant has nasal flaring, intercostal and subcostal retractions, and expiratory grunting. Symptoms usually disappear after 12–24 hours, but may persist for as long as 72 hours.

Management

Transient tachypnea of the newborn is a benign, self-limited condition and management is supportive. Supplemental oxygen may be required.

Respiratory distress syndrome

Respiratory distress syndrome (RDS) is a common problem in preterm infants of <34 weeks'

Box 24.6 Risk factors for transient tachypnea of the newborn

- Prematurity
- Cesarean delivery
- Maternal diabetes
- Maternal asthma

gestation. The lesser the gestational age, the greater is the risk of RDS. The risk is the highest in extremely preterm infants.

Though less common, RDS may also occur in late preterm infants (34–36⁺ weeks).

Deficiency of pulmonary surfactant in an immature lung is the main reason for preterm infants developing this condition. RDS can be a major cause of morbidity and mortality in preterm infants.

Pathophysiology

Surfactant deficiency leads to the following:

- Higher surface tension in the alveoli
- Collapse of large portions of the lung (atelectasis)
- Lung inflammation and respiratory epithelial injury causing
 - Pulmonary edema
 - Increased airway resistance

In addition to the problems resulting from surfactant deficiency, there is hypoxemia due to intrapulmonary and extrapulmonary right-to-left shunts. Extrapulmonary shunting occurs typically across the foramen ovale and patent ductus arteriosus (PDA).

Signs of respiratory distress syndrome

The signs of RDS in preterm infants are listed in Box 24.7.

Diagnosis

The results of diagnostic tests include the following:

- Chest X-ray
 - Reticulogranular ground-glass appearance
 - Air bronchograms

Box 24.7 Signs of respiratory distress syndrome

- Tachypnea
- Nasal flaring
- Use of accessory respiratory muscles
- Expiratory grunting
- Intercostal, subxiphoid, and subcostal retractions
- Cyanosis due to right-to-left intrapulmonary and extrapulmonary shunting

- Arterial blood gas measurement
 - Hypoxemia
 - High levels of CO₂ as disease worsens

Treatment

Exogenous surfactant replacement therapy is effective in reducing RDS mortality and morbidity in preterm infants. Both natural and synthetic surfactants are effective, but natural surfactants have been shown to be superior to synthetic preparations.

Continuous positive airway pressure (CPAP) is the preferred initial therapy for neonates with respiratory distress. If CPAP fails, endotracheal intubation is performed and surfactant therapy is administered. Surfactant therapy should be administered within 30–60 minutes after delivery.

Meconium aspiration syndrome

In utero meconium passage usually results from fetal hypoxic stress. The most severe complication of this is aspiration of meconium-stained amniotic fluid before, during, and after birth. The diagnosis of meconium aspiration syndrome (MAS) is made when there is neonatal respiratory distress in the presence of meconium-stained amniotic fluid. It is confirmed by characteristic radiographic abnormalities. Meconium aspiration syndrome can result in significant neonatal morbidity and mortality.

Routine infusion of warm, sterile saline to dilute the meconium in amniotic fluid (amnio-infusion) has not been shown to prevent MAS. Suctioning of the infant above the vocal cords, as soon as the head is delivered, is also currently not recommended in the presence of meconium-stained amniotic fluid. This procedure has not shown to decrease MAS.

Pathophysiology

Meconium aspiration causes neonatal hypoxia through the following pulmonary effects:

Airway obstruction

Meconium may completely obstruct the airways, resulting in atelectasis. When there is partial

obstruction, air trapping and hyperdistention of the alveoli occur. The gas that is trapped may rupture into the pleura (*pneumothorax*), mediastinum (*pneumomediastinum*), or pericardium (*pneumopericardium*).

Surfactant dysfunction

Meconium deactivates surfactant and may also inhibit surfactant synthesis. The end result is diffuse atelectasis.

Chemical pneumonitis

Enzymes, bile salts, and free fatty acids in meconium irritate the airways and parenchyma, initiating a diffuse pneumonitis that may begin within a few hours of aspiration.

Pulmonary hypertension

Many infants with MAS have primary or secondary persistent pulmonary hypertension of the newborn (PPHN) resulting from chronic in utero stress. PPHN further contributes to the hypoxemia caused by MAS.

The pathophysiology of MAS is summarized in Box 24.8.

Box 24.8 The pathophysiology of meconium aspiration syndrome

- Airway obstruction
 - Complete obstruction
 - Atelectasis
 - Partial obstruction
 - Air trapping and hyperdistention of alveoli
 - Pneumothorax
 - Pneumomediastinum
 - Pneumopericardium
 - Surfactant dysfunction
 - Meconium
 - Deactivates surfactant
 - Inhibits surfactant synthesis
 - Diffuse atelectasis
 - Chemical pneumonitis
 - Caused by meconium which contains
 - enzymes
 - bile salts
 - free fatty acids
 - Pulmonary hypertension
 - PPHN
 - Worsens hypoxemia

Signs of MAS

Infants who develop MAS exhibit the following signs of respiratory distress immediately after birth:

- Barrel-shaped chest
- Rales and rhonchi on auscultation

Diagnosis

Diagnosis is made from the immediate onset of respiratory distress with a history of meconium-stained amniotic fluid at birth. The diagnosis is confirmed by the chest X-ray that demonstrates the following:

- Streaky, linear densities
- Hyperinflated lungs with flattening of the diaphragms
- Diffuse patchy densities alternating with areas of expansion

Management

The approach to the management of MAS is listed in Box 24.9.

Common birth injuries

Minor or major birth injuries may occur during delivery. These may be due to the following reasons:

- Fetal macrosomia
- Shoulder dystocia
- Fetal breech presentation
- Instrumental delivery
- Cesarean delivery
- Maternal morbid obesity

Box 24.9 Management of meconium aspiration syndrome

- Maintenance of adequate oxygenation and ventilation
- Maintenance of adequate blood pressure and perfusion
- Correction of hypoglycemia and acidosis
- Empirical antibiotic therapy
- Minimal handling of the infant to
 - avoid agitation
 - exacerbation of PPHN

PPH persistent pulmonary hypertension of the newborn.

Bruising, petechiae, lacerations

Difficult deliveries and instrumental deliveries may be associated with soft tissue injuries. Lacerations are the most common birth injury occurring during a cesarean section.

Cular in uries

Minor injuries, in and around the eye, such as retinal and subconjunctival hemorrhages, and lid edema, are commonly encountered and resolve spontaneously without affecting the infant.

Extracranial in uries

The passage through the vaginal canal and the process of birth may result in swelling over the head. Application of a vacuum cup for delivery may also result in an asymmetrical swelling over the head.

The three common causes of swelling over the newborn's head are as follows:

- Caput succedaneum
- Chignon
- Cephalhematoma

Caput succedaneum

A caput succedaneum is a subcutaneous, extra-periosteal fluid collection with poorly defined margins on the scalp over the neonatal head. It may occasionally be hemorrhagic. It is caused by the pressure of the presenting part of the scalp against the dilating cervix during labor. The edema in caput succedaneum crosses the suture lines (Fig. 24.1a). It may involve a large area of the head or it may just be the size of a large egg.

Causes

Causes include the following:

- Mechanical trauma of the initial portion of the scalp pushing against the undilated cervix
- Prolonged or difficult delivery

anagement

A caput succedaneum needs no treatment. The edema is gradually absorbed and disappears within a few days.

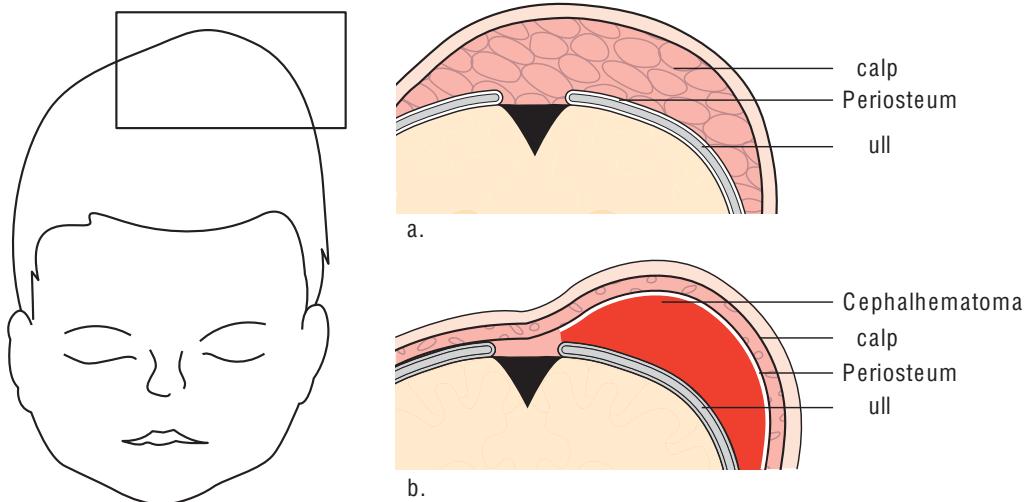


Figure 24.1 Difference between caput succedaneum and cephalhematoma. **a.** Caput succedaneum showing the edematous fluid raising the scalp and crossing the suture line. **b.** Cephalhematoma is raising the periosteum and does not cross the suture line.

Chignon

A chignon is an iatrogenic caput succedaneum that develops after the application of a vacuum cup for delivery. It is an edematous swelling that develops due to the suction applied by the vacuum cup to the scalp. It may take as little as 2 hours or as long as 2 weeks to resolve. A chignon is associated with a higher incidence of neonatal jaundice.

Cephalhematoma

Cephalhematoma is a collection of blood under the periosteum of the skull. It is estimated to occur in 1%–2% of all deliveries and is much more common when forceps or vacuum delivery is performed.

The swelling does not cross suture lines (Fig. 24.1b). It may or may not be accompanied by discoloration and usually does not expand after

delivery. It is not commonly associated with significant blood loss.

Causes

Causes are as follows:

- Rupture of a periosteal capillary due to the pressure of birth
- Instrumental delivery

Management

The majority of cephalohematomas will resolve spontaneously in a few weeks without any intervention. Occasionally, calcification of the hematoma can occur with a subsequent bony swelling that may persist for months.

Resorption of the blood from a large cephalhematoma may cause hyperbilirubinemia.

The differences between a caput succedaneum and a cephalhematoma are illustrated in Figure 24.1 and enumerated in Table 24.1.

Table 24.1 Differences between caput succedaneum and cephalhematoma

Presentation	Caput succedaneum	Cephalhematoma
Location	Above the periosteum	Subperiosteal
Extent of involvement	One or both hemispheres	Usually occipital or parietal bone
Relation to suture line	Crosses the suture lines	Does not cross the suture lines
Period of absorption	3–4 days	Few weeks
Treatment	None	Supportive

neurologic injuries

Brachial plexus injury and facial nerve injury are neurologic injuries that can occur in the newborn.

Brachial plexus injury

Brachial plexus injury is rare, although among neonatal neurologic birth injuries, it is one of the most common. The only established risk factor for neonatal brachial plexus palsy (NBPP) is shoulder dystocia. It occurs when there is excessive lateral traction on the fetal head. There are no proven measures that can predict or prevent NBPP. The clinical classification of NBPP is given in Box 24.10.

Facial nerve injury

Facial nerve injury is usually due to traumatic compression of the nerve by

- forceps or
- prominent maternal sacral promontory (rare).

Commonly, only the mandibular branch of the facial nerve is affected. The clinical features of facial palsy are listed in Box 24.11.

Traumatic facial nerve palsy has an excellent outcome. Spontaneous resolution usually occurs within the first 2 weeks of life.

Box 24.10 Clinical classification of neonatal brachial plexus palsy

- Upper brachial plexus palsy (Erb's palsy)
 - Involves injury to C5, C6, and occasionally C7
 - C5 and C6 injury
 - Adduction and internal rotation of the arm
 - Forearm extension
 - C7 additionally involved
 - Flexion of wrists and fingers in addition to the above features
- Total brachial plexus palsy (not common)
 - Involves all the roots from C5 to T1
 - Arm paralysis

Box 24.11 Clinical features of facial palsy

- Diminished movement on affected side of the face
- Loss of nasolabial fold
- Partial closing of eye
- Inability to contract lower facial muscles on affected side
- Mouth being drawn over to unaffected side when crying

Fractures

Fractures are uncommon in modern obstetrics. However, they may occur in difficult vaginal deliveries. Four of the more common fractures are described here.

Clavicular fractures

Clavicular fractures are the most commonly reported fractures in neonates. They can occur in the following conditions:

- Shoulder dystocia
- Instrumental delivery
- Macrosomia

Clavicular fractures in infants heal spontaneously with no long-term sequelae.

Symptoms of neonatal clavicular fracture are enumerated in Box 24.12.

Humeral fractures

Humeral fractures are rare. They may occur with the following:

- Shoulder dystocia
- Macrosomia
- Cesarean delivery
- Breech delivery

After radiographic confirmation, treatment of humeral fractures consists of immobilization of the affected arm with the elbow in 90 degrees flexion to prevent rotational deformities.

Femoral fractures

Fractures of the femur as a result of birth trauma are very rare. They may occur during delivery of twins or in breech presentation.

Skull fractures

Skull fractures as a result of birth trauma are usually depressed skull fractures. These are often associated with forceps-assisted deliveries.

Box 24.12 Symptoms of neonatal clavicular fracture

- Crepitus and edema over affected clavicle
- Lack of movement of affected extremity
- Asymmetrical bone contour
- Crying with passive motion

Complications of prematurity in the neonate

Complications resulting from prematurity contribute to the higher rate of infant mortality and morbidity in preterm infants, compared with that in infants born at term. The greater the immaturity, the greater is the risk of complications.

Complications of the premature infant are listed in Box 24.13.

Hypothermia

The low-birth-weight premature infant is susceptible to hypothermia. Hypothermia is managed by drying and wrapping the baby in cloth or towel, skin-to-skin contact with the mother and covering with blanket, polyurethane bags, or wraps in infants <1500 g (very effective in developing countries), raising room temperature (turn off air-conditioning), and the use of warming lamps/pads.

Respiratory distress syndrome

It is the result of low levels of surfactant in the premature lung. It is discussed in greater detail in the section *Common respiratory disorders of the newborn*.

Patent ductus arteriosus

Ductal closure is delayed in preterm infants (see Transition from intrauterine to extrauterine life in Chapter 23, *The newborn*). The higher

Box 24.13 Short-term and long-term complications of the premature infant

- Short-term complications in the neonatal period
 - Hypothermia
 - Respiratory distress syndrome
 - Patent ductus arteriosus
 - Intraventricular hemorrhage
 - Hypoglycemia
 - Necrotizing enterocolitis
 - Infection
 - Retinopathy of prematurity
- Long-term sequelae in neonates who survive and are discharged from the neonatal intensive care unit
 - Neurodevelopmental disabilities such as cerebral palsy

incidence of PDA in preterm infants may be explained by the effect of prematurity and may also be precipitated by RDS.

In infants with a PDA, the left-to-right shunting of blood results in an excessive blood flow through the pulmonary circulation and hypoperfusion of the systemic circulation. The physiological consequences of the shunting depend on the size of the shunt and the response of the heart, lungs, and other organs to the shunt. Moderate-to-large shunts may result in the following:

- Pulmonary edema and hemorrhage
- Bronchopulmonary dysplasia
- Decreased perfusion and oxygen delivery to end-organs

The treatment modalities for PDA are summarized in Box 24.14.

Intraventricular hemorrhage

Intraventricular hemorrhage is an important cause of brain injury in premature infants. It occurs most frequently in infants born before 32 weeks' gestation or <1500 g birth weight. Improved survival of extremely premature infants has resulted in a greater number of survivors with this condition, and, therefore, a greater number of infants with neurodevelopmental disabilities.

In preterm infants, hemorrhage is primarily within the capillary network, which freely communicates with the venous system, although bleeding can also occur from the arterial circulation.

Severity and grading of I

Severity of hemorrhage is based on the extent of spread into the adjacent ventricular system or white matter (intraparenchymal). The following

Box 24.14 Treatment modalities for PDA

- Medical intervention
 - Indomethacin
 - Ibuprofen
 - PDA closes within 24 hours of administration
- Surgical ligation
 - When medical therapy fails
 - Large PDA

PDA, patent ductus arteriosus.

grading system is used to define the extent of bleeding:

- *Grade I:* Bleeding is confined to the germinal matrix.
- *Grade II:* IVH occupies 50% or less of the lateral ventricle volume.
- *Grade III:* IVH occupies >50% of the lateral ventricle volume.
- *Grade IV:* Hemorrhagic infarction in periventricular white matter ipsilateral to large IVH.

Diagnosis

Cranial ultrasonography is the most sensitive diagnostic modality for IVH. Coronal and parasagittal views are performed to identify blood in the germinal matrix, ventricles, or cerebral parenchyma, and any other echogenic abnormalities. Ultrasonography can accurately grade the severity of IVH. Since 25%–50% of the IVH cases are clinically silent, routine ultrasound screening should be performed in preterm infants.

Clinical presentation

The various clinical presentations of IVH are given in Box 24.15.

Prevention of I

Antenatal corticosteroids

Antenatal corticosteroids given before preterm birth reduce the risk of IVH.

Delaye clamping o the umbilical cor

A delay of 30–60 seconds in umbilical cord clamping is associated with up to 50% reduction in IVH in preterm infants.

In utero trans er to tertiary center

Premature infants whose mothers are transported to a tertiary center prior to delivery are less likely to have IVH than similar infants who are transported after delivery, because of prompt management.

Management

Management to decrease the consequences of IVH includes the following:

- Maintenance of arterial perfusion
 - Avoidance of hypotension or hypertension

Box 24.15 Clinical presentations of I

- Silent
 - 25%–50% of cases of IVH
 - Diagnosed only on routine ultrasonography
- Saltatory or stuttering course
 - Most common presentation
 - Evolves over hours to several days.
 - Associated with
 - altered level of consciousness
 - hypotonia
 - decreased spontaneous and elicited movements
 - subtle changes in eye position and movement
- Catastrophic
 - Uncommon presentation
 - Can deteriorate over minutes to hours
 - Infant may have
 - stupor or coma
 - generalized seizures, especially tonic seizures
 - irregular respirations, hypoventilation, or apnea
 - cranial nerve abnormalities
 - decerebrate posturing
 - flaccid weakness
 - bulging anterior fontanel
 - circulatory failure
 - metabolic acidosis

, intraventricular hemorrhage.

- Preservation of cerebral blood flow
- Adequate oxygenation and ventilation
 - Avoidance of hypocarbia, hypercarbia, and acidosis
- Appropriate fluid, metabolic, and nutritional support
- Treatment of seizures

Sequelae

Posthemorrhagic hydrocephalus (PHH), periventricular hemorrhagic infarction, and periventricular leukomalacia are major sequelae of IVH.

osthemorrhagic hy rocephalus

PHH is the major complication of IVH. Serial studies with weekly cranial ultrasound can help detect early asymptomatic PHH. Other assessments include daily head measurement and monitoring for signs and symptoms of increased intracranial pressure (relatively uncommon).

ecroti ing enterocolitis

Necrotizing enterocolitis (NEC) is one of the most common gastrointestinal emergencies in the preterm neonate. The incidence is highest

(approximately 6%–7%) in very-low-birth-weight infants (<1500 g).

Pathogenesis

Necrotizing enterocolitis occurs in low-birth-weight premature infants after starting milk feeds. The terminal ileum and colon are involved in the majority of cases.

The majority (90%) of cases occur following initiation of milk feeds. Immaturity of the gastrointestinal tract in premature infants predisposes to NEC because of the following:

- Impaired mucosal defense
- Impaired intestinal motility and function
 - Microbial overgrowth inflammation
 - Ischemia and gangrenous necrosis of intestinal mucosa

Clinical presentation

NEC may present with both nonspecific systemic signs and abdominal signs. The signs of NEC are enumerated in Box 24.16.

Diagnosis

Diagnosis is based on the clinical signs of abdominal distension and rectal bleeding.

Abdominal X-ray will show the following:

- Dilated loops of bowel consistent with ileus, in the early stages of NEC
- *Pneumatosis intestinalis*, which is the hallmark of NEC, appears as bubbles of gas in the small bowel wall, and is seen in the later stages of NEC

Box 24.16 The clinical signs of necrotizing enterocolitis

- Nonspecific systemic signs
 - Apnea
 - Respiratory failure
 - Poor feeding
 - Lethargy, or temperature instability
- Abdominal signs
 - Abdominal distension
 - Gastric retention
 - Tenderness
 - Vomiting
 - Rectal bleeding
 - Diarrhea

Management

Medical management

Medical management consists of discontinuation of enteral feeds, parenteral nutrition, and correction of metabolic and hematologic abnormalities. Antibiotic therapy is initiated with a course of parenteral antibiotics that cover a broad range of aerobic and anaerobic intestinal bacteria.

Surgical management

Surgical management is indicated only when there is an intestinal perforation or extensive necrosis.

Retinopathy of prematurity

Retinopathy of prematurity (ROP) is a potentially blinding eye disorder that primarily affects premature infants weighing <1500 g or of <32 weeks' gestation. The incidence and severity of ROP increase with decreasing gestational age and birth weight. This disorder is usually bilateral and is one of the most common causes of visual loss in childhood and can lead to lifelong vision impairment and blindness.

Pathogenesis

Retinopathy of prematurity is a developmental proliferative vascular disorder that occurs in the retina of preterm infants with incomplete retinal vascularization.

Neovascularization then involves the entire retina. Hypotension, hypoxia, or hyperoxia, with free radical formation, affects these newly forming vessels. These abnormal blood vessels are fragile and can leak, scarring the retina, and can lead to retinal detachment. Retinal detachment is the leading cause of visual impairment and blindness in ROP.

High levels of oxygen given to preterm infants have been implicated in the pathogenesis of ROP. It is therefore important not to use 100% oxygen for resuscitation.

Management

All premature infants must be screened for ROP, 4–6 weeks after birth.

Ninety percent of infants with ROP have only the mild degree of disease and will recover spontaneously. The infants with severe degree of disease

will require ablation of the peripheral avascular retina, usually by laser photocoagulation.

Neonatal seizures

The occurrence of neonatal seizures may be the first clinical sign of a central nervous system (CNS) disorder in the neonate. Seizures may be the indication of a potentially treatable etiology. Immediate evaluation for the cause will help in instituting specific therapy.

There is a high incidence of early death associated with neonatal seizures. Survivors have a greatly increased risk of the following:

- Neurologic impairments
- Developmental delay
- Postneonatal epilepsy

Although neonatal seizures may have multiple etiologies (Box 24.17), the causes can be broadly classified as follows:

- Hypoxic-ischemic encephalopathy (HIE)
- Metabolic disturbances
- CNS or systemic infections
- Neonatal epileptic syndromes

Hypoxic-ischemic encephalopathy

Hypoxic-ischemic encephalopathy (*see Chapter 17, Intrapartum fetal surveillance*) is the most common cause of neonatal seizures. The seizures usually occur within the first 1–2 days of birth.

Neonatal seizures with HIE can be anticipated with the following:

- Apgar score <5 at 5 minutes
- Umbilical cord pH <7.0
- Intubation required in the delivery room

Box 24.17 Common etiologies of neonatal seizures

- Hypoxic-ischemic encephalopathy
- Metabolic disturbances
 - Hypocalcemia
 - Hypoglycemia
 - Hypomagnesemia
- Inborn errors of metabolism
- Central nervous system infection
 - Bacterial meningitis
- Neonatal epileptic syndromes

Management

The supportive management of moderate and severe neonatal encephalopathy should take place in an NICU.

Management of HIE is summarized in Box 24.18.

Metabolic causes of seizures

Metabolic etiologies include the following:

- Hypocalcemia
- Hypoglycemia

These disorders are discussed earlier in this chapter.

Inborn errors of metabolism

Inborn errors of metabolism, for example, aminoacidurias, urea cycle defects, or organic acidurias, may result in neonatal seizures. These disorders should be suspected when seizures do not respond to conventional treatment and are associated with progressive clinical and electroencephalographic worsening.

Infections

Bacterial meningitis is an important cause of neonatal seizures. Fever associated with irritability, seizures, and poor feeding should raise a suspicion of bacterial meningitis.

Infections occurring in the first 3–6 days after birth, and especially those in the first 2 days after birth, are usually vertically transmitted from the maternal genital tract flora. Late-onset infections occurring after the first week of life suggest nosocomial (hospital-acquired) or community-acquired infections.

Box 24.18 Management of hypoxic-ischemic encephalopathy

- Therapeutic hypothermia
 - In the first 6 hours after birth
 - Treatment of choice
- Maintenance of adequate ventilation
- Avoidance of systemic hypotension or hypertension
- Maintenance of normal metabolic status
- Control of seizures
- Control of brain edema

Neonatal risk factors for developing meningitis include the following:

- Low birth weight
- Prematurity
- Prelabor rupture of membranes
- Prolonged rupture of membranes (>18 hours)
- Maternal chorioamnionitis
- Low socioeconomic status

Pathogens causing meningitis in developing countries differ from the ones in developed countries. The pathogens more commonly identified within developing countries, including India, are as follows:

- Gram-negative bacilli (excluding *E. coli*)
- *Streptococcus pneumoniae*
- *S. aureus*
- *Hemophilus influenza*
- *Klebsiella pneumoniae*

Management

In developing countries, the World Health Organization (WHO) recommends initial antibiotic therapy with either of the following:

- Ampicillin and an aminoglycoside (e.g., gentamicin)

- Third-generation cephalosporin (e.g., ceftriaxone or cefotaxime)

However, resistance to commonly used antibiotics is now a global problem. Most gram-negative bacilli are now resistant to ampicillin and increasingly to gentamicin.

Further antibiotic management depends on the culture and sensitivity reports from the cerebrospinal fluid obtained from a spinal tap.

Neonatal epileptic syndromes

Neonatal epileptic syndromes are rare. Four distinct neonatal epileptic syndromes have been described:

- Benign neonatal convulsions
- Benign neonatal familial convulsions
- Early myoclonic encephalopathy
- Early infantile epileptic encephalopathy

Antiepileptic drugs, particularly phenobarbital, phenytoin, and benzodiazepines, are used in the management of these cases.

Key points

- The first 4 weeks are the most challenging period in an infant's life.
- Neonatal physiological jaundice results from rapid turnover of fetal red blood cells and the inability of the immature liver to metabolize the bilirubin.
- Severe hyperbilirubinemia with serum bilirubin levels >25–30 mg/dL is associated with an increased risk for bilirubin-induced neurologic dysfunction (BIND). The chronic and permanent sequelae of BIND result in kernicterus.
- The important causes of pathologically high levels of bilirubin are ABO incompatibility, Rh incompatibility, glucose-6-phosphate dehydrogenase deficiency, hereditary spherocytosis/elliptocytosis, and sepsis.
- Phototherapy acts principally by converting bilirubin to lumirubin, which is more soluble than bilirubin and is easily excreted into the bile and urine.
- Exchange transfusion is used to remove bilirubin from the circulation in severe hyperbilirubinemia.

- Neonatal hypoglycemia is the most common metabolic problem in newborns. It is defined as a plasma glucose level of <30 mg/dL in the first 24 hours of life and <45 mg/dL thereafter.
- Hypocalcemia is defined as serum total calcium concentration <8 mg/dL in term infants or <7 mg/dL in preterm infants. Risk factors for hypocalcemia include preterm infant, infant of diabetic mother, growth-restricted or low-birth-weight infant, and perinatal asphyxia.
- Common respiratory disorders of the newborn include transient tachypnea of the newborn, respiratory distress syndrome, and meconium aspiration syndrome.
- Common birth injuries include bruising, petechiae, lacerations, ocular injuries, extracranial injuries, neurologic injuries, and fractures.
- Complications resulting from prematurity contribute to the higher rate of infant mortality and morbidity in preterm infants.

(Continued)

Key points *Continued*

- Complications of the premature infant are divided into short-term complications (hypothermia, RDS, patent ductus arteriosus, intraventricular hemorrhage, hypoglycemia, necrotizing enterocolitis, infection, and retinopathy of prematurity) and long-term sequelae (cerebral palsy).
- The occurrence of neonatal seizures may be the first clinical sign of a central nervous system (CNS) disor-

der in the neonate. Seizures may be the indication of a potentially treatable etiology. Immediate evaluation for the cause will help in instituting specific therapy.

- Although neonatal seizures may have multiple etiologies, the causes can be broadly classified as hypoxic-ischemic encephalopathy, metabolic disturbances, CNS or systemic infections, and neonatal epileptic syndromes.

Self-Assessment

Case-based questions

Case 1

Mrs. KL, 27, delivered her baby at 35^{+4} weeks. The baby weighed 1.6 kg. It developed high levels of bilirubin on the second day of life. The parents were very concerned and were anxious about the prognosis.

1. What is the reason in this case for neonatal jaundice?
2. What would be the initial treatment for the hyperbilirubinemia?
3. What are the consequences of high levels of bilirubin?
4. What are the indications for exchange transfusion?

Case 2

Mrs. BV, 32, a known diabetic on insulin, delivered at 37 weeks. On the second day of life, the baby developed seizures.

1. How would you investigate the baby?
2. Define hypoglycemia and hypocalcemia in the neonate.
3. What is the management for hypoglycemia and hypocalcemia?
4. What are the other causes of neonatal seizures?

Answers

Case 1

1. The baby is preterm and low birth weight. The immature liver is unable to metabolize the bilirubin produced by the rapid turnover of RBCs.
2. Phototherapy would be the initial treatment. It acts principally by converting bilirubin to lumirubin, which is more soluble than bilirubin and is easily excreted into bile and urine.
3. Hyperbilirubinemia is associated with an increased risk for bilirubin-induced neurologic dysfunction (BIND). The chronic and permanent sequelae of BIND are called kernicterus, a devastating chronic

condition in which bilirubin-mediated irreversible brain damage results in cerebral palsy and loss of hearing.

4. Exchange transfusion is indicated when intensive phototherapy fails or the infant exhibits signs of BIND.

Case 2

1. A history of birth asphyxia and family history of epilepsy should be asked for. Blood glucose and calcium levels should be obtained because she is a diabetic and the infant could have low levels of glucose or calcium.
2. Hypoglycemia: plasma glucose level of <30 mg/dL in the first 24 hours of life and <45 mg/dL thereafter. Hypocalcemia: serum total Ca concentration <8 mg/dL in term infants or <7 mg/dL in preterm infants.
3. Parenteral glucose infusions should be started immediately in the case of hypoglycemia and followed with frequent feeds. Treatment of hypocalcemia is by a slow IV infusion of 10% calcium gluconate. This is followed up with oral calcium.
4. Other causes of neonatal seizures: hypoxic-ischemic encephalopathy, CNS or systemic infections, and neonatal epileptic syndromes.

Sample questions

Long-answer questions

1. What is physiological jaundice? Enumerate the causes and management of hyperbilirubinemia.
2. What is respiratory distress syndrome? Discuss prevention and treatment of RDS.
3. What are the complications associated with prematurity?

Short-answer questions

1. Cephalhematoma
2. Caput succedaneum
3. Physiological jaundice
4. Neonatal convulsions
5. Meconium aspiration syndrome
6. Prematurity

25

Lactation and Breastfeeding

Case scenario

Mrs. AS, 23, had a cesarean section 3 days ago. She had been trying to breastfeed but felt that the baby was not getting enough milk. She and her family were anxious that the baby may not be receiving the nutrition it needed.

Introduction

It is clearly established that breast milk is the best form of nutrition for neonates and infants. Breast milk has unique properties and is composed of a combination of nutrients essential to a child's health. In the first 6 months, the baby should be nourished exclusively by breast milk. It is recommended that mothers breastfeed for at least the first year of a child's life.

Human milk provides a diverse array of bioactive substances during critical periods of development of the brain, immune system, and gut in the growing infant. Obstetricians and other caretakers play a crucial role in facilitating the mother's success in lactation. Not only is lactation important for infant nutrition, it also influences bonding between mother and newborn.

Anatomy and development of the breast

The breast is made up of many lobules, and each lobule consists of alveoli drained by ductules. The ductules unite to form lactiferous ducts. The ducts converge to open at the nipple. Proximal to the opening, they dilate to form lactiferous sinuses where milk is stored (Fig. 25.1). The space between the glandular tissue is filled with fat. Estrogen stimulates development of the ductal system of the breast, whereas progesterone is responsible for the alveolar development. Together, the two hormones facilitate the formation of the adult breast. Full alveolar development and maturation occurs only with hormonal changes in pregnancy.

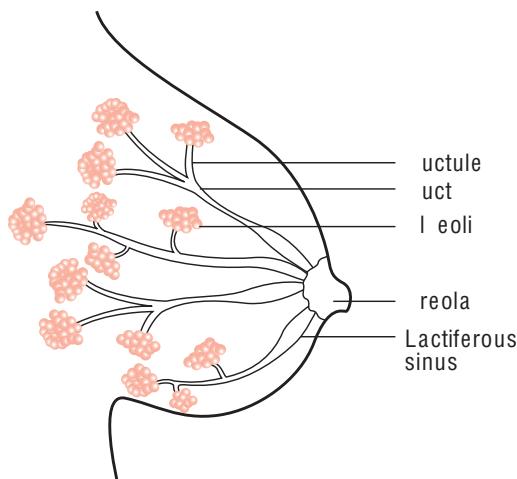


Figure 25.1 Anatomy of the breast.

The physiology of lactation

During pregnancy, changes occur in the breast (**mammogenesis**) that prepare it for the secretion of milk (**lactogenesis**) followed by the establishment and maintenance of milk secretion (**galactopoiesis or lactation**). After breastfeeding has been stopped, **involution** occurs.

Mammogenesis

Mammogenesis includes the following changes in the breast:

- Mammary (breast) growth occurs. The size and weight of the breast increase.
- The increased volume of breast tissue during pregnancy results from the development and proliferation of secretory tissue.
- Hormonal changes of pregnancy promote alveolar development and maturation of the epithelium.
- Progesterone plays an important role in stimulating alveolar development during this phase.

Mammogenesis is summarized in Box 25.1.

Lactogenesis

In lactogenesis, the breasts develop the capacity to secrete milk. Processes occur in the

Box 25.1 Mammogenesis

- Breast growth
- Size and weight increase
- Increased volume due to
 - Development and proliferation of secretory tissue
- Estrogen
 - Ductal development
- Progesterone
 - Alveolar development

pregnant breast that transform it into an organ capable of lactation. There are three stages of lactogenesis.

Stage 1 or secretory initiation (occurs by midpregnancy)

- The mammary glands become sufficiently differentiated and become capable of secreting milk. Women may notice drops of colostrum on their nipples in the second or third trimester.
- Lactose, total protein, and immunoglobulin concentrations increase within the secreted glandular fluid.
- Sodium and chloride concentrations decrease.
- High circulating levels of progesterone and estrogen inhibit the secretion of milk.

Stage 2 or secretory activation (after delivery)

- It is defined as the onset of copious milk secretion.
- In the majority of women, this occurs 2–3 days postpartum.
- There is swelling of the breasts and secretion of colostrum until this stage begins.
- Blood flow in the breasts increases.
- This stage is triggered by the rapid decline in progesterone that follows delivery of the placenta.
- Elevated levels of prolactin, cortisol, and insulin play an important role.

Stage 3 or galactopoiesis lactation

The stage of galactopoiesis begins 4–6 days postpartum. Milk production continues at the established rate during this period till weaning is started.

The stages of lactogenesis are summarized in Box 25.2.

Box 25.2 Stages of lactogenesis

- Stage 1 or secretory initiation
 - Mammary glands differentiate
 - Colostrum produced
 - Increase in
 - lactose
 - total protein
 - immunoglobulins
 - Decrease in
 - sodium and chloride
 - High levels of estrogen and progesterone
 - inhibit milk secretion
- Stage 2 or secretory initiation
 - Onset of milk secretion
 - Occurs 2–3 days postpartum
 - Blood flow in breast increases
 - Triggered by
 - drop in progesterone level
 - elevated levels of prolactin, cortisol, insulin
- Stage 3 or galactopoiesis/ lactation
 - Begins 4–6 days postpartum
 - Milk production continues till weaning

Hormonal influence on lactation

For the continuing synthesis and secretion of human milk, the mammary gland responds to hormonal signals. Stimulation of the nipple and areola during suckling sets off these signals. The signals are then relayed to the central nervous system. This cyclical process of milk synthesis and secretion is termed lactation.

The following two hormones are essential for the initiation and maintenance of lactation:

- Prolactin
- Oxytocin

Prolactin and oxytocin act independently on different cellular receptors, but their combined actions are critical for successful lactation (Fig. 25.2).

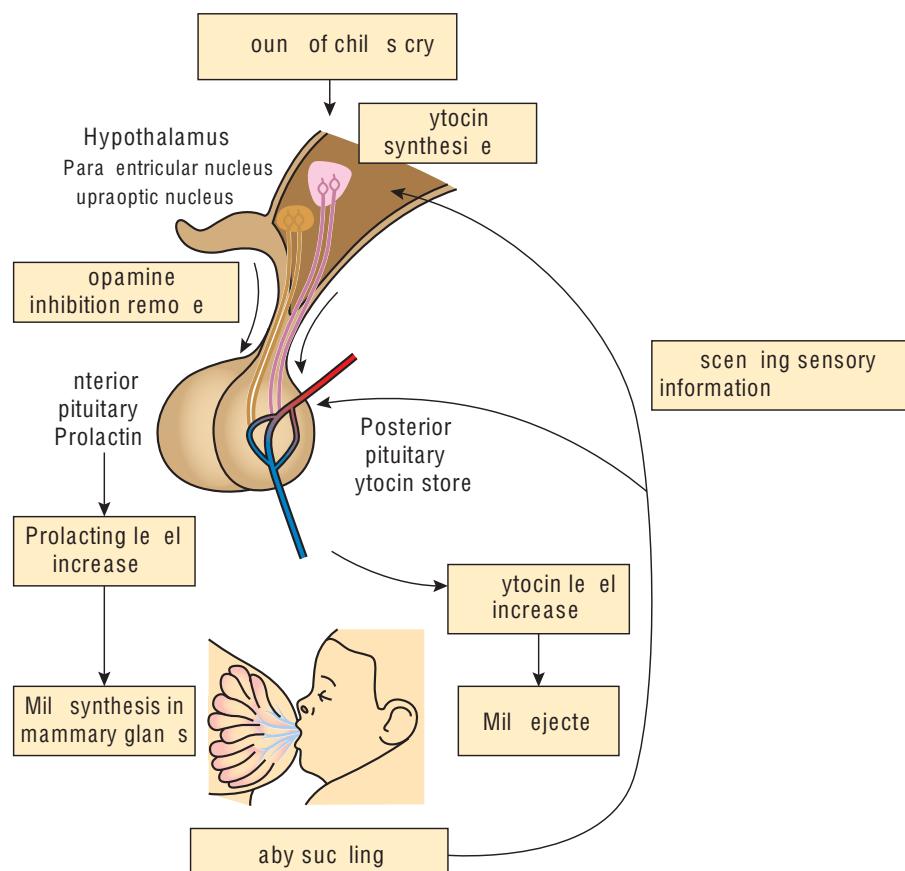


Figure 25.2 Hormonal influence on lactation. The sound of the baby's cry removes the prolactin inhibitory factors (dopamine). Prolactin levels increase and lead to milk synthesis. Suckling sends afferent impulses to the hypothalamus and oxytocin is synthesized. Impulses to the posterior pituitary release the stored oxytocin that stimulates ejection of milk.

Box 25.3 Characteristics of prolactin

- Polypeptide hormone from anterior pituitary
- Synthesized by lactotrophic cells
- Structurally similar to
 - growth hormone
 - human placental lactogen
- Acts on prolactin receptors in epithelial cells
- Stimulates secretion of milk
- Under inhibitory control of hypothalamus through dopamine
- Inhibition removed by the sound of baby's cry

Prolactin

Prolactin is the most important hormone for continued lactation. The characteristics of prolactin are summarized in Box 25.3.

Oxytocin

Oxytocin is responsible for milk ejection or the 'letdown' reflex. Characteristics of oxytocin are listed in Box 25.4.

The infant's suckling stimulates nerve endings in the areola. The afferent impulses reach the pituitary gland through the spinal cord. This releases oxytocin in a pulsatile fashion to adjacent capillaries, traveling to the mammary myoepithelial cell receptors.

Oxytocin causes contraction of the myoepithelial cells that line the ducts of the breast. These smooth muscle-like cells, when stimulated, expel milk from the alveoli into ducts and subareolar sinuses that empty through a nipple pore (Fig. 25.2).

Involution

Involution begins approximately 40 days after last breastfeeding. Milk secretion decreases due to the buildup of inhibiting peptides and lack of production of stimulatory hormones.

Box 25.4 Characteristics of oxytocin

- Synthesized by hypothalamus
- Stored in posterior pituitary gland
- Stimulated by suckling
- Acts on
 - myoepithelial cells of lactiferous ducts

Regulation of milk synthesis

The regulation of milk synthesis is an efficient mechanism. The actual volume of milk secreted may be adjusted to the requirement of the infant by **feedback inhibitor of lactation**, a local factor secreted into the milk. The rate of milk synthesis is related to the degree of breast emptiness or fullness.

- Increased suckling of the hungry infant, leading to increased emptying of the breast, is associated with increased milk volume.
- If the breast remains full due to decreased interfeeding intervals, breast milk production is decreased.

Milk production is also affected by maternal stress and fatigue. The mechanism for this effect is the down-regulation of milk synthesis with increased levels of dopamine, norepinephrine, or both, which inhibit prolactin synthesis. The more anxious a mother is about her ability to feed the baby, the less the production of milk. Relaxation is essential for successful lactation.

Composition and properties of human milk

Human milk is a unique, complex fluid with nutritional qualities, immunologic properties, and growth-promoting characteristics essential for the healthy growth of the infant. Milk actually changes its composition to meet the changing needs of the baby during growth and maturation. Colostrum has lower concentrations of fat than mature milk but higher concentrations of protein and minerals. The composition of milk reverses as the infant matures.

Characteristics of colostrum

Colostrum is secreted by the breasts in the first 24–48 hours after delivery, till stage 2 of lactogenesis begins. It is a thin fluid and contains fat globules, acinar cells, and **colostrum corpuscles**. The colostrum corpuscles are large, round polymorphonuclear leukocytes.

Box 25.5 Characteristics of colostrum

- Secreted in the first 24–48 hours after delivery
- Thin fluid
- Contains
 - Fat globules
 - Acinar cells
 - Colostrum corpuscles
 - Protein
 - Immunoglobulins

The colostrum has higher protein content than breast milk. It also contains immunoglobulin A (IgA), immunoglobulin G (IgG), and immunoglobulin M (IgM). The IgA protects the neonate gastrointestinal infections.

The characteristics of colostrum are listed in Box 25.5.

Unique characteristics of human milk

Foremilk and hind milk

The quality of milk varies within a given breastfeeding session.

- **Foremilk** is the milk first ingested by the infant.
 - Lower fat content
- **Hindmilk** is produced as the infant continues to breastfeed over the next several minutes.
 - Fat content increases
 - Facilitates satiety in the infant
- Diurnal variations in breast milk depend on the maternal diet and daily hormonal fluctuations.

Enzymes to aid neonatal digestion

Human milk contains various enzymes.

- They are specific for the digestion of proteins, fats, and carbohydrates that facilitate the infant's ability to break down food and to absorb human milk.
- They serve as transport moieties for other substances, such as zinc, selenium, and magnesium.

Essential nutrients

Human milk provides appropriate amounts of essential nutrients as shown in Box 25.6.

Arachidonic acid (AA) and docosahexaenoic acid (DHA) are deposited in the developing brain and retina during prenatal and early postnatal

Box 25.6 Essential nutrients in human breast milk

- Proteins (primarily α -lactalbumin and whey)
- Carbohydrates (lactose)
- Minerals, vitamins
- Fats
 - Cholesterol
 - Triglycerides
 - Short-chain fatty acids
 - Long-chain polyunsaturated fatty acids
 - Arachidonic acid
 - Docosahexaenoic acid

growth. These two fatty acids may be considered essential fatty acids. Many infant formulas have supplemental AA, DHA, or both, although the benefits of this are doubtful.

Passive immunity from mother to breast milk in infant

Breastfeeding is important for the passive immunity that is passed on to the infant from the mother.

- Mother's milk contains immunoglobulins that passively immunize the infant.
- There is decreased risk for gastrointestinal infections by *E. coli* and rotavirus, dermatitis, allergies, and respiratory infections in breastfed infants, particularly during the first year of life.

Breastfeeding

Suckling and breastfeeding are areas that new mothers frequently struggle with. It is often taken for granted that the newborn infant will instinctively take to breastfeeding or that the mother will be able to successfully feed her baby. However, it is important to instruct all mothers on the proper techniques for breastfeeding to ensure a successful and uncomplicated breastfeeding experience.

Baby-friendly hospital initiative

The *Ten Steps to Successful Breastfeeding* developed by the World Health Organization (WHO) and the United Nations Children's Fund

(UNICEF) as criteria for a Baby-Friendly Hospital include the following:

1. Have a written policy on breastfeeding that is communicated routinely to all staff.
2. Train all health care staff in the skills needed to implement the policy.
3. Inform all pregnant women of the benefits and management of breastfeeding.
4. Help mothers start breastfeeding within 1 hour after birth.
5. Show mothers how to breastfeed and maintain lactation, even if they are separated from their infants.
6. Give newborns only breast milk, unless other feedings are medically indicated. Hospitals must pay a fair market price for formula and feeding supplies.
7. Allow mothers and infants to remain together at all times (continuous rooming-in).
8. Encourage breastfeeding on demand.
9. Provide no pacifiers or artificial teats to nursing infants.
10. Foster the establishment of breastfeeding support groups and refer mothers to them.

Early initiation of breastfeeding

It is crucial for sustained breastfeeding to initiate the process immediately after delivery, be it a vaginal or cesarean delivery.

- Unless there are neonatal complications, the baby should be given to the mother immediately after birth, in the delivery room. This has two advantages:
 - The infant is still alert soon after delivery. Approximately 6–12 hours after birth, the baby enters a deep sleep period and will not be interested in feeding.
 - The mother's oxytocin levels are still high, and this has been shown to help in
 - milk letdown
 - bonding with the infant
- Physical contact between the mother and the infant, and placing the baby on the breast are associated with increased duration of breastfeeding.
- Weighing, measuring, and routine care for the infant should be delayed until the first feeding is completed.

- **Rooming-in** and **demand feeding** are two crucial methods to help in establishing breastfeeding.

Mechanics of breastfeeding

To ensure successful breastfeeding, the two important factors are as follows:

- Positioning of the infant
- Latching-on

Positioning

The correct positioning of the infant facilitates successful breastfeeding.

- The mother must be in a comfortable position while breastfeeding her infant.
- The infant should be positioned to face the mother's body.
- The mouth of the infant should be opposite the mother's nipple.
- The infant's neck should be slightly extended.
- The head, shoulders, and hips of the infant should be in alignment.

Latching-on

Latching-on refers to the formation of a tight seal of the infant's lips around the nipple and a sufficient portion of the surrounding areola. This facilitates efficient extraction of milk during suckling.

It is normal instinct for the baby to open its mouth wide when the nipple touches its upper or lower lip. The tongue extends under the nipple, and the nipple is drawn into the mouth, initiating the suckling reflex. The mother's nipple and areola should be maneuvered to the infant's open mouth instead of pushing the infant's head toward the breast. This simple maneuver may seem difficult to an anxious first-time mother.

When the latching-on is correct, the nipple and areola extend as far as the junction between the infant's hard and soft palates. The infant's jaw then moves the tongue toward the areola, compressing it. This process causes the milk to travel from the lactiferous sinuses into the infant's mouth.

Assessing adequacy of infant intake

Adequacy of intake is assessed based on the following:

- Frequency and duration of feeding
 - There should be an average of 8–12 feeds in 24 hours, for 10–15 minutes per feed.
- Urine and stool output
 - Voiding of urine occurs 4–6 times during the third and fourth days, and increases to 6–8 times on day 5 and after, with adequate feeds.
 - Meconium changes to transitional stools within approximately 3 days of birth. The baby has 3–4 stools per day after day 4, with adequate feeds.
- Weight of the infant
 - Weight loss is normal after delivery, and infants lose 5%–7% of birth weight soon after birth.
 - Usually infants stop losing weight by 5 days after birth and will regain their birth weight by 1–2 weeks of age.
 - If the breastfeeding is adequate, infants gain 15–40 g/day.

Maternal nutrition during breastfeeding

The mother needs an additional 500–700 kcal/day during breastfeeding. Protein intake should be 25 g/day. Iron and calcium supplementation must be continued throughout the duration of breastfeeding. Vitamins and minerals should also be supplemented.

Advantages of breastfeeding

Breastfeeding has several advantages as listed in Table 25.1.

Common problems during breastfeeding

The following are some of the common problems encountered during breastfeeding:

- *Retracted nipple:* This should be identified during the antenatal period and treated. Drawing out the nipple daily during bath, with

Table 25.1 Advantages of breastfeeding

Nutritional	Has all essential nutrients in the right proportion
Economical	Economical when compared with formula feed
Immunologic	<ul style="list-style-type: none"> • Immunoglobulins protect against infections • Reduced allergies, respiratory, and gastrointestinal infections
Psychological	Better mother to child bonding
Developmental	<ul style="list-style-type: none"> • Better physical and psychological development • IQ and mental development better
Socioeconomic	<ul style="list-style-type: none"> • Cost-effective for family and society • Best for low-resource countries
Protection against cancer	Lowers risk of breast cancer in mother

lubricant applied to the fingers, is sufficient. If retracted nipple persists, the nipple should be pulled out by the inverted syringe technique. The nozzle of a 10-mL syringe is cut off and the piston introduced through the cut end. The smooth end is placed on the breast, around the nipple, and the piston withdrawn slowly. This procedure should be performed daily before each feed for a few days.

- *Engorgement:* This can occur due to interstitial edema or excessive milk. The breasts become swollen and painful. The treatment is prevention with frequent breastfeeding. Pumping of milk may be required to soften the areola and allow better latch-on. Analgesics and firm support with well-fitting underclothes are recommended.
- *Sore nipple and cracked nipple:* This problem is commonly associated with improper latch-on. Proper technique should be taught. Placing a drop of milk on each nipple and allowing this to air dry after breastfeeding may help.
- *Mastitis:* Mastitis is a localized inflammation of the breast that is associated with fever, myalgia, breast pain, and redness. It is usually caused by organisms from the infant's mouth. It is treated with antibiotics. Analgesics may be required. Breastfeeding should be continued.
- *Breast abscess:* Mastalgia may progress to a breast abscess. Clinically, there is redness, tenderness, and induration. High spiking fever

is characteristic. Treatment is with antibiotics. Oral cloxacillin (500 mg 6 hourly) is recommended since the infection is most often staphylococcal or streptococcal. Drainage of the abscess may be required by

- ultrasound-guided aspiration of the pus
- surgical incision and drainage

The mother should continue to breastfeed on the unaffected side and pump the affected side to relieve pressure and facilitate recovery.

The common problems encountered during breastfeeding are listed in Box 25.7.

Box 25.7 Common problems encountered during breastfeeding

- Retracted nipple
 - Should be identified in antenatal period
 - Corrected
 - Manually
 - Inverted syringe technique
- Engorgement
 - Caused by
 - interstitial edema
 - excessive milk
 - Breasts swollen and painful
 - Treated with
 - frequent breastfeeding
 - mechanical pumping
 - analgesics
 - firm support
- Sore/cracked nipple
 - Due to improper latching-on
 - Proper technique advised
 - Drops of milk applied to nipple
- Mastitis
 - Localized inflammation
 - Associated with
 - fever
 - myalgia
 - breast pain
 - redness
 - Treated with antibiotics
- Breast abscess
 - Redness, tenderness, induration
 - High spiking fever
 - Oral cloxacillin 500 mg 6 hourly
 - Drainage
 - Ultrasound guided
 - Surgical incision and drainage

Galactogogues

Some women have a problem with establishment of adequate lactation. If there is no improvement with proper techniques of breastfeeding, galactagogues may be used. Galactagogues are drugs that facilitate milk production. The agents most commonly used are dopamine receptor antagonists: metoclopramide and domperidone. These are particularly useful for mothers of preterm infants.

Suppression of lactation

Suppression of lactation may be required in certain situations. The indications are enumerated in Box 25.8.

Drugs for suppression of lactation

Cabergoline is the drug of choice as it is well tolerated. It can be given as

- a single dose of 1 mg or two doses of 0.5 mg 12 hourly.

Bromocriptine was used earlier but is not recommended now due to the high risk of vomiting, seizures, hypertension, and thromboembolism. There is currently no evidence that nonpharmacologic methods (e.g., jasmine flowers or cabbage leaves) are better than placebo in lactation suppression.

Box 25.8 Indications for suppression of lactation

- Stillbirth
- Mother decides against breastfeeding
- Contraindications to breastfeeding
 - HIV positive mother
 - Active pulmonary tuberculosis
 - Puerperal psychosis
 - Mother on drugs secreted in breast milk

Key points

- Breast milk is the best form of nutrition for neonates and infants.
- In the first 6 months, the baby should be nourished exclusively by breast milk. It is recommended that mothers breastfeed for at least the first year of a child's life.
- During pregnancy, changes occur in the breast (**mammogenesis**) that prepare it for the secretion of milk (**lactogenesis**) followed by the establishment and maintenance of milk secretion (**galactopoiesis or lactation**). After breastfeeding has been stopped, **involution** occurs.
- The two hormones essential for the initiation and maintenance of lactation are prolactin and oxytocin.
- Prolactin and oxytocin act independently on different cellular receptors, but their combined actions are critical for successful lactation.
- Prolactin is responsible for synthesis of milk protein in the mammary glands.
- Oxytocin is responsible for milk ejection or the 'letdown' reflex.
- The regulation of milk synthesis is an efficient mechanism. The actual volume of milk secreted may be adjusted to the requirement of the infant by *feedback inhibitor of lactation*, a local factor secreted into the milk.
- Human milk is a unique, complex fluid with nutritional qualities, immunologic properties, and growth-promoting characteristics essential for the healthy growth of the infant.
- Colostrum has lower concentrations of fat than mature milk but higher concentrations of protein and minerals. The composition of milk reverses as the infant matures.
- Suckling and breastfeeding are areas that new mothers frequently struggle with.
- It is crucial for sustained breastfeeding to initiate the process immediately after delivery, be it a vaginal or cesarean delivery.
- Common problems during breastfeeding include retracted nipple, engorgement, sore and cracked nipple, mastitis, and breast abscess.
- If there is no improvement with proper techniques of breastfeeding, galactagogues may be used. Galactagogues are drugs that facilitate milk production.

Self-Assessment

Case-based questions

Mrs. AS, 23, had a cesarean section 3 days ago. She had been trying to breastfeed but felt that the baby was not getting enough milk. She and her family were anxious that the baby may not be receiving the nutrition it needed.

1. How would you reassure the couple and assess the adequacy of the infant's intake?
2. How does colostrum differ from mature milk?
3. What is the role of prolactin and oxytocin in lactation?
4. Name common problems during breastfeeding.

Answers

1. The couple should be reassured that it takes 3–4 days for lactation to set in. Adequacy of feeds is assessed by frequency and duration of breastfeeding, the infant's urine and stool output, and assessment of fetal weight.
2. Colostrum has lower concentrations of fat than mature milk but higher concentrations of protein and

minerals. The composition of milk reverses as the infant matures.

3. Prolactin is responsible for synthesis of milk protein in the mammary glands. Oxytocin is responsible for milk ejection or the 'letdown' reflex.
4. Common problems during breastfeeding include retracted nipple, engorgement, sore and cracked nipple, mastitis, and breast abscess.

Sample questions

Long-answer question

1. Describe the physiology of lactation.

Short-answer questions

1. Breastfeeding
2. Colostrum
3. Common problems with breastfeeding
4. Galactagogues

26

Contraception: Temporary Methods

Case scenario

Ms. YT, 24, was about to get married in 2 months and wanted to avoid pregnancy for the next 2 years till she finished her higher studies. She and her fiancé had come for contraceptive advice.

Introduction

The freedom of couples to plan the number, spacing, and timing of births is a fundamental human reproductive right. India was the first country in the world to initiate a nationwide family planning program in 1952. However, the number of unintended pregnancies is unacceptably high in developing countries, particularly in India. Since India has a very liberal Medical Termination of Pregnancy Act, unintended pregnancies lead to therapeutic abortions, many of which are unsafe. Repeated therapeutic terminations also have a short- and a long-term effect on the mother's health.

Therefore, contraceptive advice and counseling should be an important part of an obstetrician's responsibility.

Definition

Contraception is the planned use of temporary or permanent artificial measures to prevent pregnancy as an outcome of sexual intercourse. A person's choice of contraceptive method depends on his or her concern regarding its efficacy, side effects, and cost. The physician's role is to advise the right fit of contraceptive to the perceived need of the individual.

Ideal contraceptive method

An ideal contraceptive is one that is easy to use, cheap, easily available, safe, effective, and requires minimum motivation, supervision, and maintenance. Although there are many contraceptive

options available at present, none of them have all the characteristics of an ideal contraceptive.

Classification of available contraceptive methods

The array of available contraceptive choices is impressive (Box 26.1). However, both the individual and the physician need to make a decision on the best choice for that particular individual, based on his or her requirement.

Making the right choice

When considering the ideal method of contraception for an individual, several factors should be taken into consideration. The physician needs

Box 26.1 Classification of contraceptives

Temporary

- Natural methods
 - Coitus interruptus
 - Lactational amenorrhea
 - Periodic abstinence
- Mechanical barriers
 - Male condom
 - Female condom
 - Diaphragm
 - Cervical cap
 - Spermicidal agent
- Hormonal contraceptives
 - Combination oral contraceptives
 - Progestin-only oral contraceptives
 - Implants
 - Injectable depot medroxyprogesterone
 - Combination patch contraceptive
 - Contraceptive vaginal ring
- Intrauterine devices (IUDs)
 - Copper T
 - Levonorgestrel intrauterine system (IUS)

Permanent

- Female sterilization
- Male sterilization (vasectomy)

Emergency postcoital contraception

- Emergency contraceptive pills (ECP)
- Copper T
- Minipill emergency contraception method (MECM)
- Progesterone agonist/antagonist

to have a clear understanding of the advantages and disadvantages of the method so that appropriate counseling can be done.

Efficacy of the contraceptive method

The number of pregnancies that occur in spite of using the method correctly is called failure rate. The efficacy can be judged by **perfect-use rate** (used consistently with strict adherence to all instructions) and **typical-use rate** (not used every time and not according to instructions, which is what the average couple will do). The lower the failure rate, the more acceptable is the method. The efficacy also depends on frequency of intercourse, age, and regularity of menstrual cycles.

Failure rates can result from the following:

- Improper instructions being given on how to use the method
- Improper usage by the woman/man
- Noncompliance with method

Failure rate of any contraceptive method should be weighed against nonuse of contraception. **Unprotected intercourse has an unintended pregnancy rate of 85%.**

Pearl Index

The Pearl Index is the most common technique used for reporting the effectiveness of a contraceptive method. It is defined as the number of unintended pregnancies per 100 women-years (HWY).

The Pearl Index is calculated as

$$\text{Pearl Index} = \frac{\text{number of accidental pregnancies} \times 1200}{\text{number of patients observed} \times \text{total months of use}}$$

The higher the Pearl Index, the greater is the chance of an unintended pregnancy. For example, the Pearl Index for combined contraceptive pills is 2.18 per 100 women-years of use (effective) as compared with 20 per 100 women-years of use (least effective) for natural methods.

In clinical practice, contraceptive methods may be classified according to effectiveness (Table 26.1). This makes it easier to counsel the patient.

Convenience of use

If the contraceptive is inconvenient or difficult to use, compliance will be poor.

Table 26.1 Contraceptive methods and their failure rates

Contraceptive method	Failure rate (%)
most effective	
LARC	
• Intrauterine contraceptive devices	0.5–2
• Implants	0.05–0.1
• LNG-IUS	0.2
Sterilization (male or female)	0.1–0.5
effective	
Injectable contraceptives	0.3
Oral contraceptives	0.3
Transdermal contraceptive patches	0.3
Vaginal ring	0.3
In these methods, unintended pregnancy may occur due to incorrect or inconsistent use.	
least effective	
Barrier methods	15
Periodic abstinence	25

A C, long-acting reversible contraceptive; g- S, levonorgestrel-releasing intrauterine system.

Reversibility and time to return to fertility

A reversible contraceptive that has a quick return to fertility is highly desirable. Of the women trying to conceive, 70%–95% will become pregnant within 12 months following the use of

- oral contraceptives (OCs)
- intrauterine devices (IUDs)
- progestin-only pills

However, the time to conception is delayed up to 2 years after

- progestin-only injections.

Effect on uterine bleeding

Compliance will be affected and patients may discontinue contraception if it is associated with changes in the bleeding pattern (Box 26.2).

Cost

High cost of a contraceptive method is a deterrent in developing countries.

Protection against sexually transmitted diseases

Condoms provide protection against sexually transmitted diseases (STDs) and for this reason

may be used in conjunction with other, more effective contraceptive methods.

Temporary methods of contraception

Pregnancy spacing is an essential part of family planning. Temporary methods of contraception allow couples to space their pregnancies and give them the freedom to choose when they want to have a child, without jeopardizing their fertility. Temporary methods are also used until the couple decides on a permanent form of family planning. This chapter deals with temporary methods of contraception.

Box 26.2 Changes in bleeding pattern with contraceptives

- Heavy bleeding (IUDs)
- Scanty bleeding (OCPs)
- Breakthrough bleeding
 - Low-dose OCPs
 - Progestin-only pills
 - Progestin-only injectable
 - Progesterone-only ring

Ds, intrauterine contraceptive devices; CPs, oral contraceptive pills.

Natural methods

Natural methods are methods where no medications or contraceptive devices are used. Since conception requires the sperm to reach the ovum, methods of naturally avoiding the sperm from reaching the ovum work as contraception.

Coitus interruptus

Coitus interruptus involves withdrawing the entire penis from the vagina prior to ejaculation. This prevents contact between the sperm and the ovum. This method of contraception continues to be an important means of fertility control in the developing world.

Efficacy

Coitus interruptus fails mainly because of the man's inability to judge the timing of ejaculation and failure to withdraw prior to ejaculation. The failure rate is estimated to be approximately 20% during the first year of use.

Lactational amenorrhea

After delivery, when a woman is actively breastfeeding, ovulation is suppressed due to factors listed in Box 26.3.

Anovulation from lactational amenorrhea varies in duration. There can be breakthrough ovulation. Once the first menses has resumed following childbirth, this method is no longer safe and another contraceptive method must be adopted.

Efficacy

The failure rate within the first 6 months in a woman who is exclusively breastfeeding and is amenorrheic is 2%.

Advantages

The following are the advantages of lactational amenorrhea as contraception:

- The woman has complete control.
- There is no requirement for exogenous contraceptive methods.

Disadvantages

The following are the disadvantages of lactational amenorrhea as contraception:

- Return to fertility is uncertain.
- Pregnancy may occur during the period of amenorrhea.

Box 26.3 Causes for anovulation in lactational amenorrhea

- Elevated prolactin levels
- Reduction of gonadotropin-releasing hormone from the hypothalamus
- Decreased levels of LH
- Lack of follicular maturation

, luteinizing hormone.

- This method cannot be used if the mother has human immunodeficiency virus (HIV) infection.

Natural methods based on fertile days

Natural methods of pregnancy prevention based on fertile days are some of the most commonly used methods of fertility regulation. They involve identifying the woman's fertile days during the menstrual cycle and then avoiding unprotected sexual intercourse on those days.

Techniques to determine the fertile period include the following:

- The calendar method
- Cervical mucus method
- The sympto-thermal method

the rhythm method or calendar method

The rhythm method or calendar method is based on the following assumptions:

- The ovum can be fertilized only 12–24 hours after release.
- The sperm is viable for only 3–5 days in the cervical mucus and the upper genital tract.
- Ovulation occurs 12–16 days prior to the next menses.

Intercourse is avoided on the days calculated to be the ovulation time.

The standard days method

Women with regular cycles of 26–32 days are asked to avoid unprotected intercourse from days 8 through 19. The user abstains completely or uses a barrier method on those 12 days.

Two Day method

Women using the Two Day method are counseled to avoid unprotected intercourse on days when

they note cervical secretions and on the first day after a day with cervical secretions. The advantage of the Two Day method is that it can be used by women with short, long, or irregular cycles. With this method most women will abstain or use a barrier method for approximately 13 days in a cycle.

Cervical mucus or illings metho

Under the influence of estrogen, the mucus increases in quantity and becomes progressively more copious, clear, and stretchy until it peaks for 3–4 days immediately before, during, and immediately after ovulation. The woman is taught to test her cervical mucus several times each day and avoid intercourse on the days when the secretions suggest ovulation.

he sympto thermal metho

The sympto-thermal method combines the temperature method, the cervical mucus method, and the calendar method.

The first day of the fertile period is calculated by either the calendar method or the first day the mucus is detected.

The end of the fertile period is predicted by a slight rise ($0.2^{\circ}\text{C} - 0.5^{\circ}\text{C}$), in the basal body temperature (BBT). A special thermometer is required to measure the BBT. Intercourse can resume 3 days after the rise in temperature.

The characteristics of the basal body temperature of a woman are enumerated in Box 26.4.

Efficacy

The failure rate for the natural methods is high and is approximately 25%. The 1-year Pearl Index is 20 per 100 women-years of use.

Disadvantages

The disadvantages of natural methods of contraception are listed in Box 26.5.

Box 26.4 Basal body temperature and fertile period

- BBT
 - Relatively low during the follicular phase
 - Rises in the luteal phase of the menstrual cycle due to progesterone
 - Begins to elevate 1–2 days after ovulation
 - Changes vary from 0.2°C to 0.5°C
- Fertile period ends 3 days after rise in temperature

BB , basal body temperature.

Box 26.5 Disadvantages of the natural methods

- Most suitable for women with regular and predictable cycles
- Require complete abstinence during the fertile period unless backup contraception is used
- Require discipline
- Relatively high failure rate
- Do not protect against STDs

Barrier methods

Barrier methods prevent the sperm from coming in contact with the cervix. Barrier methods include **male condom**, **female condom**, **diaphragm**, **cervical cap**, and **spermicidal agents**. Unlike other methods of birth control, barrier methods are used only during sexual intercourse.

Male condom

The male condom is one of the most popular mechanical barriers used globally. The condom consists of a thin sheath placed over the glans and the shaft of the penis. It is most effective when applied before any vaginal insertion. It prevents pregnancy by acting as a barrier to the passage of semen into the vagina.

The leading noncontraceptive benefit of condom use is the protection offered against STDs, including HIV.

Types of condoms

Condoms are made of latex rubber or polyurethane and other synthetic material.

Natural rubber latex

The majority of male condoms are manufactured from natural rubber latex. Latex condoms, however, can cause latex sensitivity or allergy. They also have a tendency to tear with oil-based lubricants.

Polyurethane and other synthetic materials

Polyurethane condoms are generally non-allergenic, are compatible with both oil-based and water-based lubricants, and have a longer shelf life than latex condoms. Since they are more expensive, they are usually prescribed only for men with latex allergy.

Spermicide-coated condoms

Spermicide-coated condoms are not recommended as they are not more effective than regular condoms and are associated with adverse effects for the user.

Efficacy

The failure rate for male condoms is estimated to be approximately 18%. The reason for contraceptive failure with condoms is given in Box 26.6.

Advantages

The advantages of male condoms are enumerated in Box 26.7.

Disadvantages

There are some disadvantages associated with the use of male condoms (Box 26.8).

Female condom

The female condom is a polyurethane sheath intended for one-time use. It is approximately 17 cm in length. It covers the cervix, lines the vagina, and shields the introitus, thus providing a physical barrier to sperm and secretions during

Box 26.6 Causes for contraceptive failure with condoms

- Not using condoms with every act of intercourse and throughout intercourse
- Using oil-based lubricants with latex condoms
- Incorrect placement of the condom on the penis
- Poor withdrawal technique

Box 26.7 Advantages of male condoms

- Easy availability
- Inexpensive
- Easy to use
- No side effects
- Noncontraceptive benefits
 - Effective against STDs including HIV

Box 26.8 Disadvantages of male condoms

- Leave contraceptive choice to male partner
- Possibly decrease enjoyment of sex
- Possibility of latex allergy
- Effectiveness decreased due to condom breakage and slippage
- Possible damage to condom from oil-based lubricants

sexual intercourse. All female condoms have two anchors (a ring or frame). The inner smaller ring fits high up in the vagina and the outer ring lies outside the vagina to prevent the condom from being pushed inside the vagina during use (Fig. 26.1). The female condoms available in India are Femidom and Femshield.

Like the male condom, the female condom is designed to protect against both pregnancy and STDs. However, because it is not easy to use and women find it cumbersome, the female condom accounts for <1% of condoms produced globally.

Efficacy

Efficacy trials are limited. Initial trials have demonstrated a pregnancy rate of 20% with typical use.

Advantages

There are several advantages of the female condoms (Box 26.9).

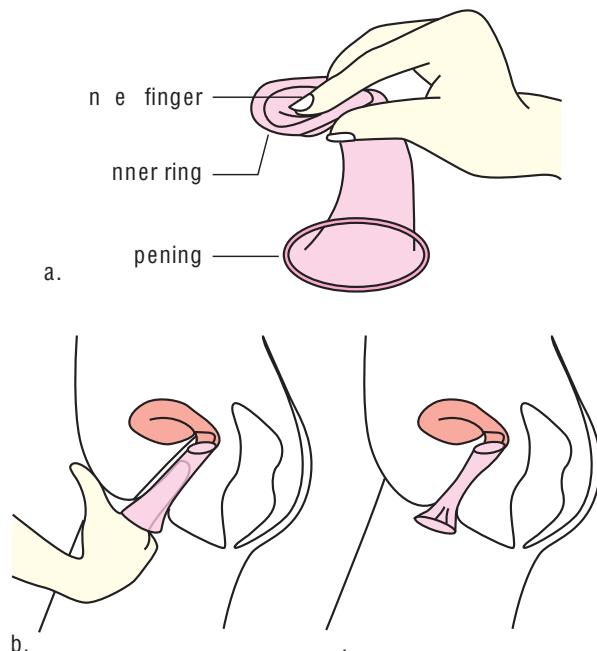


Figure 26.1 Inserting a female condom. **a.** Correct way of holding the condom prior to insertion. **b.** Using the index finger to insert the condom. **c.** The condom in position.

Box 26.9 Advantages of the female condoms

- Safe, effective, and reversible method of contraception
- Effective against both pregnancy and STDs
- Can be placed before intercourse

Box 26.10 Disadvantages of female condoms

- Difficult to insert and remove
- More expensive than male condoms
- Higher failure rate than nonbarrier methods and the male condom
- Cannot be used in women with pelvic organ prolapse
- Associated with urinary tract infections and, rarely, toxic shock syndrome

Disadvantages

Female condoms are not popular because of the disadvantages associated with them (Box 26.10).

Diaphragm

The diaphragm is a shallow latex cup with a spring mechanism in its rim to hold it in place in the vagina (Fig. 26.2). Diaphragms come in different sizes so the gynecologist examines and fits the woman for the size appropriate for her. The diagonal length of the vaginal canal is measured during a pelvic examination and the correct diaphragm size is determined. The diaphragm is not available in India.

Spermicidal cream or jelly (commonly nonoxynol-9) is applied to the inside of the dome, which is then inserted into the vagina before intercourse. Care must be taken to fit the posterior rim into the posterior fornix and the anterior rim behind the pubic bone. This way the entire dome covers the cervix (Fig. 26.3).

The diaphragm prevents pregnancy by acting as a barrier to the passage of sperm into the cervix. The spermicide used along with it enhances its

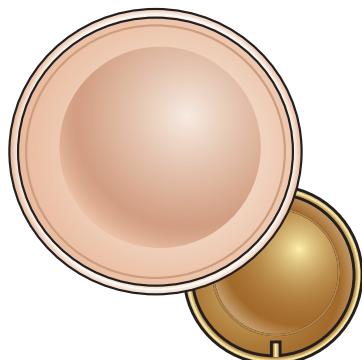


Figure 26.2 The female diaphragm and the cervical cap. The diaphragm is wider compared with the cervical cap. The cervical cap fits snugly over the cervix.

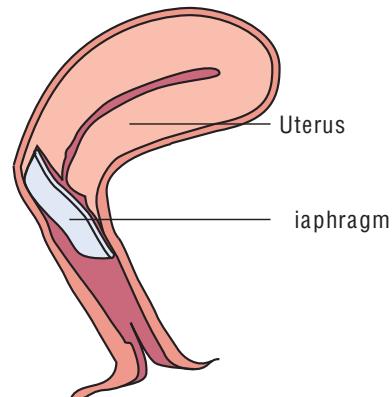


Figure 26.3 The female diaphragm. The diaphragm is fitting properly in the vagina and covering the cervix.

effectiveness. The diaphragm should be inserted at least 3 hours prior to sexual intercourse. Once placed in the right position, the diaphragm is effective for 6 hours. After intercourse, the diaphragm should not be removed immediately and must be left in place for at least 6 hours.

Efficacy

The typical-use failure rate within the first year is estimated to be 15%–20%. Failure rate is higher than hormonal methods and the IUD.

Advantages

The advantages of the diaphragm are listed in Box 26.11.

Disadvantages

The disadvantages of the diaphragm are listed in Box 26.12.

Box 26.11 Advantages of diaphragm

- Safe, effective, and reversible method of contraception
- Leaves contraceptive control to the woman
- Reusable
- Can be placed before intercourse

Box 26.12 Disadvantages of diaphragm

- Requires sizing and fitting by gynecologist
- Must be inserted before each episode of intercourse
- Does not protect against STDs, including HIV
- Must be used with a spermicide
- Difficult to use in the presence of significant pelvic relaxation and pelvic organ prolapse
- Frequent urinary tract infections and, rarely, toxic shock syndrome

Cervical cap

The cervical cap is similar to a diaphragm, only smaller in size, cup shaped, and made out of latex rubber instead of silicone. A groove along the inner circumference of the rim improves the seal between the inner rim of the cap and the base of the cervix (Figs 26.2 and 26.4). The cap is filled one-third full with spermicide prior to insertion. It may be inserted as long as 8 hours before intercourse and can be left in place for as long as 48 hours. The cervical cap is not available in India.

A cervical cap provides a mechanical barrier to sperm entering the cervical canal. The spermicidal used along with it increases its effectiveness.

Efficacy

The effectiveness of the cervical cap depends on parity, which changes the shape of the cervical os. With typical use within the first year, the failure rate is 20% in nulliparous women and 40% in parous women.

Advantages

The following are the advantages of the cervical cap:

- Provides continuous contraceptive protection for its duration of use
- Can be left in place for 48 hours

Disadvantages

The following are the disadvantages of the cervical cap:

- Like the diaphragm, requires fitting by gynecologist
- Relatively high failure rate, especially in parous women

Spermicidal agents

Spermicides are among the least effective methods of contraception. They consist of a base combined with either nonoxynol-9 or octoxynol. They are commercially available as vaginal foams, suppositories, jellies, films, foaming tablets, and creams.

Vaginal spermicides consist of a surfactant that destroys the sperm cell membrane and attacks the sperm's flagella and body. The sperm mobility is adversely affected. The sperm's fructolytic activity is also disrupted, thereby inhibiting their nourishment.

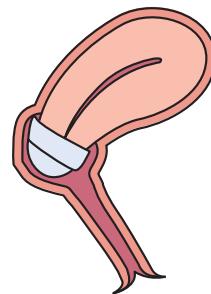


Figure 26.4 The cervical cap. The cervical cap is shown fitting snugly on the cervix.

Spermicides must be inserted into the vagina prior to each intercourse. They are also used along with diaphragms and cervical caps.

Efficacy

The typical-use failure rate is 25%.

Advantages and disadvantages

Box 26.13 lists the advantages and disadvantages of spermicides.

Box 26.13 Advantages and disadvantages of spermicides

Advantages

- Ease of application
- May provide lubrication
- Relatively inexpensive
- Augment contraceptive efficacy of the cervical cap and diaphragm

Disadvantages

- Possibility of vaginal irritation
- High failure rate
- Provide minimal protection from STDs

Hormonal contraceptives

Hormonal methods of birth control contain estrogen and progestin, or progestin only. They have been established as a safe and reliable way to prevent pregnancy in the majority of women.

The following kinds of hormonal contraceptives are available:

- Combination oral contraceptive pills (COCPs)
- Progestin-only oral contraceptive pills (POPs)
- Implants
- Injectable depot medroxyprogesterone
- Combination patch contraceptive
- Contraceptive vaginal ring

Combination oral contraceptives

The oral contraceptive pill (OCP) has been in use for more than five decades. It is a reliable form of contraception and also has noncontraceptive benefits. The past decade has seen a reduction in the estrogen content and the introduction of progestins with fewer side effects. This has resulted in improving the safety profile of OCPs and made them a dependable option for many women.

Composition of COCPs

The combination oral contraceptive contains

- Ethinyl estradiol (EE)
- Progestin

ethinyl estradiol

The addition of an ethinyl group to estradiol resulted in both an orally active estrogen compound and a dramatic increase in estrogenic potency. Ethinyl estradiol is the estrogen in oral contraceptives currently used.

Dosage of EE in OCPs

The dosage of EE in OCPs is as follows:

- Standard dose
 - 30–35 µg
- Low dose
 - 20–25 µg
 - Less risk of
 - minor side effects
 - thromboembolism

The lower dose of EE is associated with a decrease in the incidence of estrogen-related adverse effects such as bloating, breast tenderness, and nausea. Although venous thromboembolism (VTE) is an uncommon risk, the risk is least with the lower dose.

progestins

Most available progestins are derived from testosterone and bind to both the progesterone and androgen receptors. Norethindrone, lynestrol, and ethynodiol diacetate are first-generation progestins. Norgestrel and levonorgestrel are second-generation progestins. Being 19-nortestosterone derivatives, they have undesirable androgenic properties. Norgestrel and

levonorgestrel have the highest androgenic properties. This can result in adverse metabolic effects such as lowering serum high-density lipoprotein (HDL) cholesterol concentrations.

Third-generation progestins have been developed that have structural modifications that lower their androgenic activity, in spite of being 19-nortestosterone derivatives. These include norgestimate, desogestrel, and gestodene.

The commonly used progestins and their level of androgenic activity are tabulated in Table 26.2.

Mechanism of action

There are several mechanisms by which combination OCPs provide contraception. The estrogen and progestin components have different actions. The main mechanism of action is suppression of ovulation.

The mechanism of action is summarized in Box 26.14.

Side effects of oral contraceptive pills

The side effects can be minor or major.

minor side effects

Minor side effects are dependent on the preparation of estrogen and progestin in the pill and their dosage. The side effects are usually experienced during the initial 2–3 months of use. Changing to a lower dose of estrogen or changing to a preparation with less androgenic progestin relieves the symptoms. The minor side effects of OCPs are listed in Table 26.3.

Box 26.14 The mechanism of action of combination oral contraceptive pills

Effects of estrogen component

- Inhibition of the midcycle luteinising hormone (LH) surge
 - Prevention of ovulation
- Suppression of pituitary follicle-stimulating hormone (FSH) secretion
 - Suppression of ovarian folliculogenesis
- Suppression of gonadotropin secretion
 - Suppression of ovarian steroid production

Effects of progestin component

- Effects on the endometrium
 - Decidualization and eventual atrophy
 - Less suitable for implantation
- Alterations in cervical mucus
 - Less permeable to penetration by sperm
- Impairment of normal tubal motility and peristalsis

Table 26.2 Classification of progestins in combination with oral contraceptive pills and their level of androgenic activity

Progestin	Androgenic activity
1st generation	
<ul style="list-style-type: none"> • Norethindrone acetate • Ethynodiol diacetate • Lynestrenol • Norethynodrel 	Middle
2nd generation	
<ul style="list-style-type: none"> • Norgestrel • Levonorgestrel 	Highest
3rd generation	
<ul style="list-style-type: none"> • Desogestrel • Gestodene • Norgestimate 	Lowest
Unclassified	
<ul style="list-style-type: none"> • Drospirenone • Cyproterone acetate 	Has mineral ocorticoid activity Antiandrogenic properties

Major side effects

Major cardiovascular and cerebrovascular side effects were reported when higher doses (30–50 µg) of estrogen were used. The risk is very low with low-dose preparations and newer progestins. However, these adverse effects more commonly occur in women who are older than 35 years of age, smokers, obese, or have uncontrolled diabetes, hypertension, or dyslipidemia. Prolonged immobilization, past or family history of thromboembolism, and cardiovascular disease also increase the risk. Major side effects of OCPs are listed in Table 26.4.

Risks of cancers

The association between combined OCPs and cancers has been studied extensively. There is a small increase in breast cancer in current users with prolonged duration of use. Although association with cervical cancer has not been proven, regular cytologic screening is recommended in pill users.

Available preparations

Combination pills are available as follows:

- Standard dose or low dose
- 21- or 28-day packets
- Monophasic, biphasic, or triphasic
- Extended-cycle preparations

Table 26.3 Minor side effects of combination oral contraceptive pills

Side effects	Caused by
Nausea, vomiting	Estrogen
Headache and migraine	Estrogen
Chloasma	Estrogen
Water retention, edema	Progestin
Weight gain	Progestin
Acne	Progestin
Decreased libido	Progestin
Mental depression	Progestin
Breast tenderness	Estrogen and progestin
Breakthrough bleeding	Estrogen and progestin

Standard dose or low dose

Both standard-dose pills (containing 30 µg of EE) and low-dose pills (contain 20 µg of EE) are equally effective contraceptives. The aim of low-dose pills is to decrease side effects.

It is common practice to start with low-dose pills when prescribing COCPs.

Standard dose should be avoided with

- obesity ($\text{BMI} > 30 \text{ kg/m}^2$)
- age > 45 years

Standard dose is more often prescribed for noncontraceptive indications (discussed in detail later in this chapter).

Table 26.4 Major side effects of combination oral contraceptive pills

<i>Cardiovascular effects</i>	
Venous thrombosis	<ul style="list-style-type: none"> Increased risk (3/10,000) More in thrombophilias More in COCPs with newer progestins
Ischemic heart disease	Risk in heavy smokers
Stroke	<ul style="list-style-type: none"> Increased if smoker, diabetic, hypertensive Increased in migraine with aura
Blood pressure	Minimal effect—monitoring recommended
<i>Metabolic effects</i>	
Protein metabolism	<ul style="list-style-type: none"> Increase in SHBG Increase in angiotensinogen Increase in clotting factors
Liver	<ul style="list-style-type: none"> Cholestasis—uncommon Hepatocellular adenoma

C OCPs, combination oral contraceptive pills; S B₁₀₀, sex hormone-binding globulin.

Oral contraceptive

OCPs are available in a 21- or 28-day packet. Estrogen/progestin is present only in the first 21 tablets. In the 28-day packet, the last seven pills contain a placebo. Some brands add iron and/or folic acid to the last seven pills.

The 28-day packet is supposed to make it easier for the woman to take the pills without a pill-free interval. However, in studies it has been shown that women are quite comfortable taking a 21-day packet and having a pill-free break.

Monophasic, biphasic, and triphasic OCs

Monophasic, biphasic, and triphasic pills have 21 hormonally active pills. While multiphasic regimens slightly decrease total steroid content over the month, they have no proven clinical advantage over monophasic preparations.

The characteristics of monophasic, biphasic, and triphasic OCPs are summarized in Box 26.15.

Extended-cycle preparations or continuous pills

Extended-cycle preparations include 7-day interval of placebo pills approximately every 3 months. For example, there are 84 estrogen/progestin tablets followed by 7 days of placebo pills. The woman takes a tablet every day continuously. She will have approximately four periods in a year. Extended-cycle preparations are not available in India, but using four 21-day pill packets continuously will achieve the same effect.

The noncontraceptive indications for extended-cycle preparations are given in Box 26.16.

Screening of patient prior to starting OCPs

Minimal medical screening is required before starting a woman on OCPs. The important screening tests are listed in Box 26.17.

Box 26.15 Monophasic, biphasic, and triphasic oral contraception pills

- Monophasic pills
 - Same dose of EE and progestin in each
- Biphasic pills contain
 - fixed dose of 35 µg of EE
 - increasing dose of progestin
 - 0.5 mg for 10 days
 - 1.0 mg for remaining 11 days
- Triphasic pills
 - Varying doses of EE plus progestin
 - Gradually increasing dose of EE
 - 20 µg on cycle days 1–5
 - 30 µg on days 6–12
 - 35 µg on days 13–21
 - Gradually increasing dose of progestin

, ethinyl estradiol.

Box 26.16 Noncontraceptive indications for extended-cycle preparations

- Endometriosis
- Hyperandrogenism
- Lifestyle reasons (patient does not want frequent periods)

Box 26.17 Patient screening prior to starting COCPs

- History
 - Age
 - Breastfeeding
 - Past/family history of venous thromboembolism
 - Diabetes and hypertension
 - Family h/o of hypertriglyceridemia, diabetes, or coronary artery disease
- Physical examination
 - BMI
 - Blood pressure
 - Breast examination
 - Pelvic examination
 - Pap smear

B , body mass index; C CPs, combination oral contraceptive pills.

Initiation of combination OCPs

Women desiring contraception can start OCPs at their convenience. Following a miscarriage or delivery, the following considerations apply:

- Following first or second trimester miscarriage, the pill can be started immediately.
- COCPs reduce breast milk; therefore, progestin-only pills or IUDs are recommended in breastfeeding women till 6 months after delivery.
- Nonbreastfeeding women can start the pill 21 days after delivery.

Methods of initiation

There are three methods commonly used to start OCPs (Table 26.5). It is important to choose one method that is suitable and explain it properly to the woman. Starting pills can be confusing, and if the woman does not understand the instructions, she might get pregnant unintentionally.

Table 26.5 Methods for initiating oral contraceptive pills

Sunday start	First pill started on the first Sunday after her period (even if it is the next day)
First day start	First pill on the first day of menses
Quick start	First pill started on the day she is given the prescription

Backup contraception is needed for the first 7 days of use if the pill is started 5 days after onset of menses, which may be the case in Sunday start and quick start methods. Condoms may be used.

One pill a day is continued for 21 days. There is a 7-day pill-free interval. The woman will get her period either during or at the end of the 7 days, depending on when she started the pills. The pills are then started again on the first Sunday or the first day of the period. There are newer preparations available with less pill-free days.

With the 28-day packet, there is no pill-free interval. The period will start usually during or at the end of the placebo pills.

Time of day

The pill should preferably be taken at a fixed part of each day, for example, at bedtime or with morning coffee, so that it can become part of the daily routine. This means that the chances of forgetting decrease. It is also important to take the pill around the same time each day. This is particularly important for the low-dose pills.

Missed pills

Missed pills are a common cause of unintended pregnancy while on the pill.

The management of missed pills is summarized in Box 26.18. **This does not apply to the placebo pills in the 28-day packet.**

Drug interactions

Some drugs reduce the efficacy of COCPs. This must be kept in mind when prescribing these

Box 26.18 Management of missed pills

- Single pill missed anywhere in the packet
 - Forgotten pill to be taken when noticed
 - Next pill taken when it is due (may mean taking two pills on the same day)
 - No backup contraception required
- Two or more consecutive pills missed
 - One of the missed pills taken as soon as possible
 - One pill each day continued as prescribed
 - Backup contraception generally needed
- Two or more consecutive hormonal pills missed
 - In first week of the cycle and unprotected intercourse occurs during this week
 - Emergency contraception could decrease risk of pregnancy

drugs to women on OCPs. The dose of estrogen has to be increased in these situations.

- Impaired absorption of COCPs
 - Antibiotics such as ampicillin and cephalosporins
- Rapid degradation of COCPs
 - Enzyme-inducing drugs
 - Phenobarbitone, sodium valproate, rifampicin, clonazepam, griseofulvin and ketoconazole, warfarin, antiretrovirals

Noncontraceptive benefits and uses of oral contraceptives

Not only do COCPs have high contraceptive efficacy, they also have noncontraceptive benefits (Box 26.19).

Box 26.19 Noncontraceptive benefits and uses of oral contraceptives

- Menstrual cycle disorders
 - Menorrhagia (reduction in menstrual flow by 50%)
 - Dysmenorrhea (by inducing anovulation)
 - Premenstrual syndrome (not first line of treatment)
 - Prevention of menstrual migraine (with the use of extended-cycle preparation or continuous pills)
- Hyperandrogenism
 - Acne
 - Hirsutism
- Gynecologic disorders
 - Endometriosis and adenomyosis
 - Polycystic ovarian syndrome
 - Perimenopausal hot flushes
- Cancer risk reduction
 - Decreased risk of developing
 - Endometrial cancer (50% reduction of risk)
 - Ovarian cancer (40% reduction of risk)
 - Colon cancer
 - Protection
 - Lasts for at least 15 years following discontinuation of use
 - Increases with duration of use
- Other benefits of using COCPs
 - Reduction of occurrence of anemia (due to decreased menstrual flow)
 - Protection against
 - Pelvic inflammatory disease (thickened cervical mucus provides barrier against bacteria)
 - Ectopic pregnancy
 - Benign breast disease
 - Osteoporosis
 - Functional ovarian cysts
 - Improvement in rheumatoid arthritis

Return of menses and fertility

In a large number of women, menses returns within 30 days after stopping the pill. In the majority of women, menses and fertility should return to normal by 90 days. If amenorrhea persists for 6 months after discontinuation of the pills, the woman needs to be investigated.

Contraindications to the use of COCPs

Contraindications to use include the following:

- Age >35 years and smoking >35 cigarettes/day
- Undiagnosed abnormal vaginal bleeding
- Known or suspected pregnancy
- Untreated hypertension
- Diabetes with vascular complications
- Estrogen-dependent neoplasia
- History of deep vein thrombosis, pulmonary embolism, or congestive heart failure
- Cerebrovascular disease
- Significant structural heart disease, pulmonary hypertension, or coronary artery disease
- Atherogenic lipid disorders
- Breast cancer
- Active liver disease
- Protein C, protein S, and antithrombin deficiencies
- Prolonged immobilization and major surgery

Age beyond 40 years is no longer considered a contraindication to taking low-dose OCPs.

Efficacy

Combination OCPs are very effective, but failure rates are dependent on individual compliance. Rates range from 0.1% with perfect use to 5% with typical use.

Advantages

The advantages of combination OCPs are listed in Box 26.20.

Box 26.20 Advantages of combination OCPs

- Ease of use
- Low failure rate
- Reversible with quick return of fertility
- Noncontraceptive benefits

Disadvantages

The disadvantages of combination OCPs are listed in Box 26.21.

Box 26.21 Disadvantages of combination OCPs

- Daily ingestion necessary
- Side effects
 - Nausea
 - Breast tenderness
 - Breakthrough bleeding
 - Headaches
 - Postpill amenorrhea due to anovulation
- May decrease lactation

Progestin-only oral contraceptives

Progestin-only oral contraceptive pills (POPs) are also known as *minipills*. They are indicated in women who are breastfeeding and women who have a contraindication to the use of estrogen.

The progestins used for the minipill are as follows:

- Norethindrone (Micronor) 0.35 mg
- Norgestrel (Ovrette) 0.75 mg
- Levonorgestrel (Microval) 0.30 mg
- Desogestrel (Cerazette) 0.75 mg

Mechanism of action

Progestin-only oral contraceptive work by

- inhibition of ovulation,
- thickening of cervical mucus,
- thinning of endometrium,

Administration

Progestin-only oral contraceptives are started the same way as COCPs. In the postpartum period, if the woman is breastfeeding, the pill can be started within 3–4 weeks of giving birth. It has no deleterious effect on lactation.

POPs come in a 28-day packet. One pill is taken daily. There is no pill-free interval. The pill must be taken **at the same time each day** for maximum efficacy. This is because of the short duration of action and the short half-life of POPs.

The patient must be instructed that she will have amenorrhea while on the POP. There can be spotting and unscheduled bleeding, which may bother some women.

Delayed or missed pill

Abstention or backup contraception must be used for 2 days if

- norethindrone-containing pill is taken **3 hours late or missed for a day**,
- desogestrel-containing pill is taken **12 hours late or missed for a day**.

The pill must be resumed as soon as possible and continued daily.

Efficacy

Failure rates with typical use are estimated to be 7% in the first year of use.

Advantages

The advantages of POPs are enumerated in Box 26.22.

Disadvantages

The disadvantages of POPs are enumerated in Box 26.23.

Contraceptive implants

In recent years, contraceptive research has focused on the development of a range of contraceptive methods designed to provide

- maximum efficacy,
- nondependence on user compliance, and
- prompt return of fertility after removal.

Box 26.22 Advantages of progestin-only pills

- Safe in breastfeeding mothers
 - POPs do not reduce breast milk
- Absence of estrogen-dependent complications such as VTE
- Can be used in obese, hypertensive, and diabetic women
- Noncontraceptive benefits
 - Decreased dysmenorrhea
 - Decreased menstrual blood loss
 - Decreased premenstrual syndrome symptoms
 - Fertility immediately reestablished after cessation of pills

VTE, venous thromboembolism.

Box 26.23 Disadvantages of progestin-only pills

- Need for complete compliance with usage
- Amenorrhea and unscheduled bleeding/spotting, which may bother some women
- Breast tenderness
- Headache

Implants are long-acting reversible contraceptives (LARCs) that meet these requirements. Synthetic polymers have made it possible to develop delivery systems with a long duration of action, which continuously release low amounts of hormones. Initially, the Norplant implant was introduced. It consisted of six levonorgestrel-containing capsules for subdermal insertion (Fig. 26.5). It became unpopular because of the difficulty in removal of the implant.

Currently, the available implants are Norplant 1, Norplant 2, and Implanon. All are placed subdermally in the arm under local

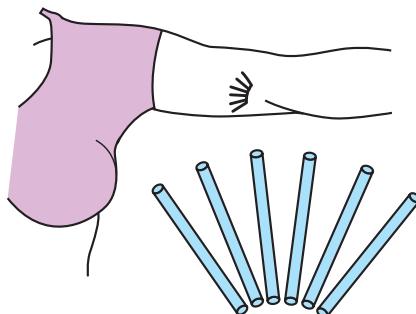


Figure 26.5 Norplant subdermal implant. Six rods are implanted in the upper inner arm.

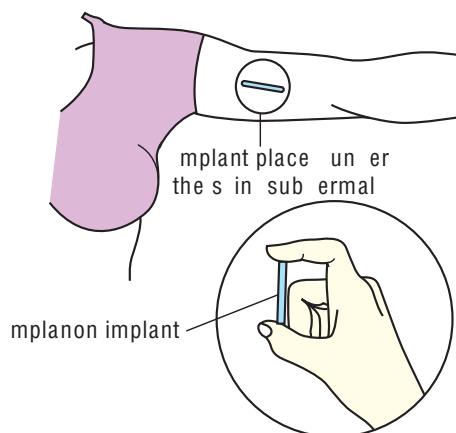


Figure 26.6 Implanon implant. One rod is placed subdermally in the upper inner arm.

anesthesia. Implanon is most commonly used at present (Fig. 26.6).

Contraceptive implants are ideal for women who are

- postpartum or breastfeeding and
- poor compliers.

Contraceptive implants are also useful in women who have contraindications to

- pregnancy (due to a medical condition) and
- the use of estrogen.

The features of subdermal implants are given in Table 26.6.

Mechanism of action

The mechanism of action of contraceptive implants is summarized in Box 26.24.

Efficacy

The implant is as efficient as female sterilization in preventing pregnancy. The rate of pregnancy with typical-use is <1%. The Pearl Index is 0.38 pregnancies per 100 women-years of use.

Advantages and disadvantages

Contraceptive implants have not become a popular form of contraception. The advantages and disadvantages of contraceptive implants are listed in Box 26.25.

Box 26.24 Mechanism of action of contraceptive implants

Progestogen in the implant acts by the following:

- Suppression of the LH surge
 - Suppression of ovulation
- Making cervical mucus thick and scant
 - Deters sperm penetration
- Decreasing tubal motility
 - Prevents fertilization
- Thinning endometrium

Table 26.6 Contraceptive subdermal implants: Features, dosage, and duration of action

Norplant 1	Norplant 2	Implanon
6 Silastic rods	2 Silastic rods	Single polymer rod
34 mm long, 2.4 mm wide	43 mm long, 2.5 mm wide	40 mm long, 2 mm wide
Levonorgestrel 36 mg each	Levonorgestrel 70 mg each	Etonogestrel 68 mg each
Releases 85 µg/day for 6 months, 50 µg/day for 15 months, 30 µg/day thereafter	Releases 50 µg/day	Releases 30 µg/day
Effective for 5 years	Effective for 3–5 years	Effective for 3 years

Box 26.25 Advantages and disadvantages of contraceptive implants
Advantages

- Long acting
- Quick return to fertility
 - Ovulation within 3 weeks
- No exogenous estrogen
- No adverse effect on lactation

Disadvantages

- A minor surgical procedure is necessary for insertion and removal
- Amenorrhea and unscheduled bleeding may occur
- Associated with
 - headaches, mood changes, weight gain, breast tenderness, acne

Injectable depot medroxyprogesterone acetate

Depot medroxyprogesterone acetate (DMPA) is an injectable, progestin-only contraceptive that provides highly effective, reversible contraception for 3 months at a time. Pharmacologically active blood levels are achieved within 24 hours after injection, and are maintained for 3 months. A dose of 150 mg of DMPA suppresses ovulation in most women for as long as 14 weeks. The contraceptive regimen consists of one dose every 3 months.

DMPA is ideal for women who do not want

- to take a contraceptive pill daily,
- an estrogen-containing contraceptive, and
- monthly periods.

However, the discontinuation rate for DMPA within 6–12 months is high globally. It might be due to the concern women have about the associated amenorrhea.

Mechanism of action

DMPA creates a relative hypoestrogenic state. It acts by

- suppressing FSH and LH levels,
- eliminating the LH surge, and
- suppressing folliculogenesis and ovulation.

Administration

The first DMPA injection can be given within 7 days of the start of menses. Backup contraception

or abstinence is indicated for 7 days if it is not started in the first 7 days of the cycle.

Repeat injections are given every 3 months.

Return to fertility

The return to fertility (ovulation) may be delayed for up to 1 year after DMPA is stopped. Women with higher BMIs take longer to ovulate.

Efficacy

DMPA is an extremely effective contraceptive option. The Pearl Index is 0–0.7 per 100 women-years.

Advantages and disadvantages

The advantages and disadvantages of DMPA are summarized in Box 26.26.

Injectable estrogen–progesterone combinations

Depot medroxyprogesterone is associated with irregular bleeding. Combining it with estrogen reduces this inconvenience. The two available preparations are used as a monthly injection.

- Cyclo-Provera is a combination of DMPA and estradiol propionate.
- Norigynon is a combination of 50 mg of norethindrone enanthate and 5 mg of estradiol valerate.

Box 26.26 Advantages and disadvantages of DMPA
Advantages

- Can be used by lactating mothers
- Not affected by high BMI
- Does not have adverse effects of estrogen
- Dysmenorrhea decreased
- Can be used for treatment of endometriosis

Disadvantages

- Disruption of the menstrual cycle leading to amenorrhea
- Persistent irregular bleeding
- Delay in return to fertility
- Weight gain
- Reduction of bone mineral density when used for >2 years
 - Due to suppression of gonadotropins
 - Does not necessitate stopping DMPA
 - Reversible after DMPA stopped

The injectable combinations are highly effective (failure rate 0.2–0.4 per HWY) and easy to use.

Combination patch contraceptive

The transdermal contraceptive patch has similar benefits, risks, and contraindications as combined hormonal OCPs. The difference is that the contraceptive transdermal patch releases estrogen and progesterone directly into the skin and is used only once a week. The transdermal patch is not available in India.

The patch is a small 20 cm² square that has an outer waterproof layer and an active layer that is medicated and adhesive. The patch contraceptive is most commonly applied on the upper arm, hip, thigh, buttock, or lower abdomen (Fig. 26.7). It should not be applied anywhere near the breast.

Each patch contains a 1-week supply of norelgestromin (150 µg) and EE (20 µg). A sustained low dose of hormones is released daily, equivalent to the lowest-dose OC.

Mechanism of action

The mechanism of action is the same as that of combined OCPs.

Administration

The patch is initiated the same way as COCPs—first day, first Sunday, or quick start. The patch is changed once a week for 3 weeks (21 total days), followed by 1 week that is patch free (Fig. 26.8). It should always be changed/applied on the same day of the week.

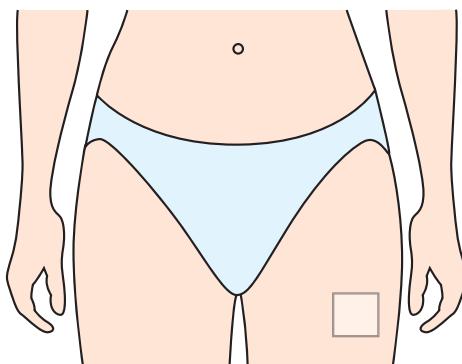


Figure 26.7 Transdermal combination patch contraceptive. It is most commonly applied on the upper arm, hip, thigh, buttock, or lower abdomen.

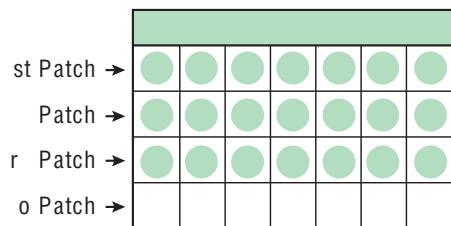


Figure 26.8 Calendar depicting usage schedule for contraceptive patch. The patch is changed once a week for three weeks (21 total days), followed by one week that is patch free.

Efficacy

The failure rate for the patch is 5% with typical-use, similar to that of other combination hormone methods.

Advantages

- Greater compliance
- Less nausea

Disadvantages and contraindications

- Similar to those of COCPs
- Irritation over the patch site

Combination contraceptive vaginal ring

The contraceptive vaginal ring offers the same benefits as OCPs, but has the advantage that the woman does not have to remember to use the contraceptive daily. The ring is left in place for 3 weeks and then removed for a single ring-free week.

The contraceptive vaginal ring is a latex-free, flexible device measuring 54 mm in diameter and 4 mm in cross-section (Fig. 26.9). The outer ring is composed of EE and an ethylene vinyl acetate

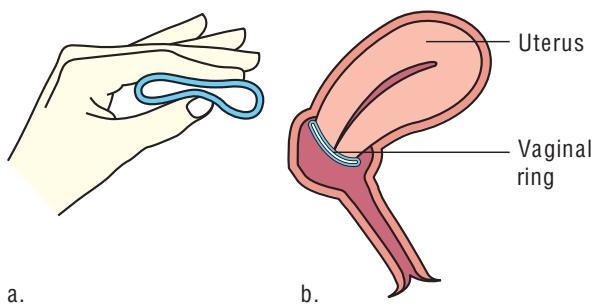


Figure 26.9 a. Combination contraceptive vaginal ring.
b. The flexible contraceptive vaginal ring is left in the vagina for 3 weeks and removed for 1 week.

copolymer that is embedded with crystals of etonogestrel. The dose of hormones released each day is 15 µg of EE and 120 µg of etonogestrel.

Mechanism of action

The mechanism of action is the same as COCPs.

Administration

The use of the vaginal ring is initiated in the same way as COCPs.

The sides of the ring are pressed together and then the ring is inserted into the vagina as high as possible for comfort and to decrease the chance of expulsion. The ring can be placed in the vagina even if the woman has not finished bleeding.

The ring is left in place for 3 weeks and then removed for 1 ring-free week to allow withdrawal bleeding. The new cycle is inserted on the same day of the week that the old ring was removed the previous week.

Efficacy

If used properly, it is as effective as COCPs with a failure rate of 5% with typical use.

Advantages and disadvantages

The advantages and disadvantages of combination contraceptive vaginal ring are summarized in Box 26.27.

Ormeloxifene

Ormeloxifene is a nonhormonal contraceptive. It is a selective estrogen receptor modulator (SERM) sold commercially in India as **Centchroman** or

Box 26.27 Advantages and disadvantages of combination contraceptive vaginal ring

Advantages

- Daily compliance not required
- Ease of use
- Rapid return of fertility
- Lowest dose of EE compared with other combined hormonal contraceptives

Disadvantages

- Increased vaginitis, vaginal wetness, and leukorrhea
- Expulsion

Saheli. It is a once-a-week contraceptive that acts by causing asynchrony between ovulation and endometrial changes, thereby preventing implantation. Initial dose is 30 mg twice a week for 3 months followed by once a week thereafter. It is contraindicated during breastfeeding and in hepatic dysfunction. Ormeloxifene is marketed only in India as a contraceptive. The failure rate with typical use is 9%.

Intrauterine devices

Intrauterine contraceptive devices are the most accepted reversible method of contraception available globally. They are among the safest and most effective methods existing today and rank alongside implants and sterilization in efficacy. The copper-based devices are also extremely cost-effective. Acceptance rates are high among women and continuance rates are as high as 80% after 1 year of use, placing them in the top tier of contraceptives.

Modern devices for intrauterine contraception are made of plastic and release either copper or a progestin to enhance the contraceptive action of the device.

Types of IUDs

Modern IUDs fall under two categories depending on the chemical component involved:

- Copper IUDs
- Levonorgestrel-releasing IUDs (LNG-IUS)

Inert or nonmedicated IUDs are available in certain countries but are not available in India.

All IUDs have monofilament plastic/nylon strings attached to one end. These strings are used both by the patient and obstetrician to check that the IUD is in position. They are also used to remove the IUD from the uterine cavity.

Copper IUDs

The copper T device is a T-shaped polyethylene frame with fine copper wire wound around the vertical stem (Fig. 26.10).

In India, the commonly available devices are CuT 250, CuT 375, and CuT 380A, which, in addition to the copper wire, also has copper collars on each of the horizontal arms.

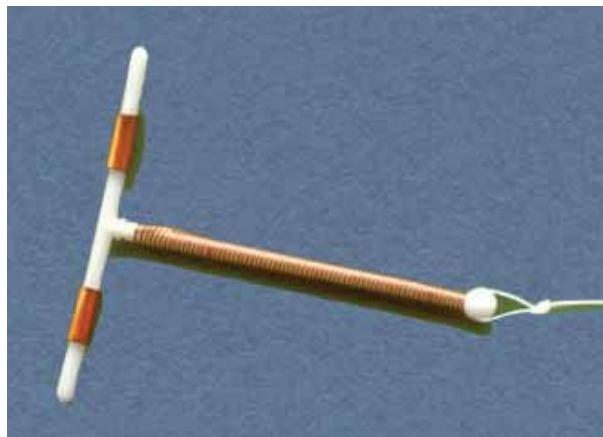


Figure 26.10 Copper T device. Copper wire is wound around the vertical stem. Copper collars are seen on each of the horizontal arms. There are plastic/nylon strings attached to one end.

Since the copper ions released by the copper wires play a major role in providing contraception, the amount of copper available in the IUD determines the duration of use. The numbers 250, 375, and 380 refer to the mm^2 of exposed surface of copper wire (Table 26.7).

mechanism o action

The exact mechanism of action of copper IUDs is not known. They primarily prevent fertilization. The factors involved are summarized in Box 26.28.

Box 26.28 Copper IUD: Mechanism of action

- Changes in cervical mucus
 - Due to increased Cu concentration
 - Inhibit sperm transport
- Changes in endometrium and fallopian tubes
 - Chronic aseptic inflammatory changes
 - Toxic to sperm and ova
 - Inhibit fertilization and implantation

Levonorgestrel-releasing IUD

Levonorgestrel-releasing IUD is marketed as an intrauterine system (LNG-IUS). It consists of a small T-shaped frame with a reservoir that contains 52 mg of levonorgestrel. The levonorgestrel has a release rate of 20 $\mu\text{g}/\text{day}$. The progestin acts locally on the endometrium. There is little or no systemic circulation of the progestin.

The very high cost of the LNG-IUS prevents it from being used commonly as an IUD in developing countries.

Duration o use

The LNG-IUS is approved for up to 5 years of use.

echanism o action

Like any progestin, levonorgestrel acts on the cervical mucus and locally on the endometrium. The mechanism of action is given in Box 26.29.

The features of the LNG-IUS are summarized in Box 26.30.

Box 26.29 LNG-IUS: Mechanism of action

- Changes in cervical mucus
 - Thickening of mucus
 - Inhibit sperm transport
- Changes in endometrium
 - Decidualization and glandular atrophy
 - Hostile to implantation

g- S, levonorgestrel-releasing intrauterine system.

Box 26.30 Features of the LNG-IUS

- Contains 52 mg of levonorgestrel
- Releases 20 μg daily
- Effective for 5 years
- Causes amenorrhea
- Reduces ectopic pregnancy, PID
- Failure rate 0.1%
- Side effects
 - Irregular bleeding
 - Uterine cramping

g- S, levonorgestrel-releasing intrauterine system; P D, pelvic inflammatory disease.

Table 26.7 Copper intrauterine devices with available copper and duration of action

Device	Surface area of copper (mm^2)	Copper released/day (μg)	Duration of action (years)
Copper T 200	200	50	3
Copper T 200B	215	50	4
Multiload Cu 250	250	60–100	3
Multiload 375	375	30	5
CuT 380A	380	30	10

Timing of insertion of IUDs

The following points should be noted regarding timing of insertion:

- The IUD is best inserted immediately after the period. This excludes pregnancy and also makes insertion easier.
- Insertion can also be done at any time during the menstrual cycle if pregnancy can be excluded before insertion.
- Following miscarriage or induced abortion, the IUD can be inserted immediately or anytime thereafter.
- Following delivery, it can be inserted 6 weeks postpartum.
- Postpartum or placental insertion is being popularized by the Government of India. The copper-bearing device can be inserted immediately after placental delivery using a sponge holding forceps. However, the expulsion rate is higher.
- CuT IUDs are also used for emergency contraception, following unprotected sexual intercourse (see Chapter 27, *Emergency contraception and sterilization*).

Technique of insertion

Insertion of Cu

The insertion should be done under aseptic conditions. Sterile gloves must be used. The IUDs come with special inserters (Fig. 26.11).

- No anesthesia is required and the procedure is an outpatient procedure.
- ‘No touch’ technique should be used while loading the device into the inserter, cleaning, and introducing the speculum and the inserter with device.
- The woman should be in the lithotomy position. Pelvic examination should be performed to assess uterine size and anteversion.
- The cervix should be visualized using a Sims speculum. The anterior lip is held with a tenaculum, and the uterus should be sounded to measure the uterocervical length.
- The device should be loaded into the inserter by bending the horizontal arms (Fig. 26.12).

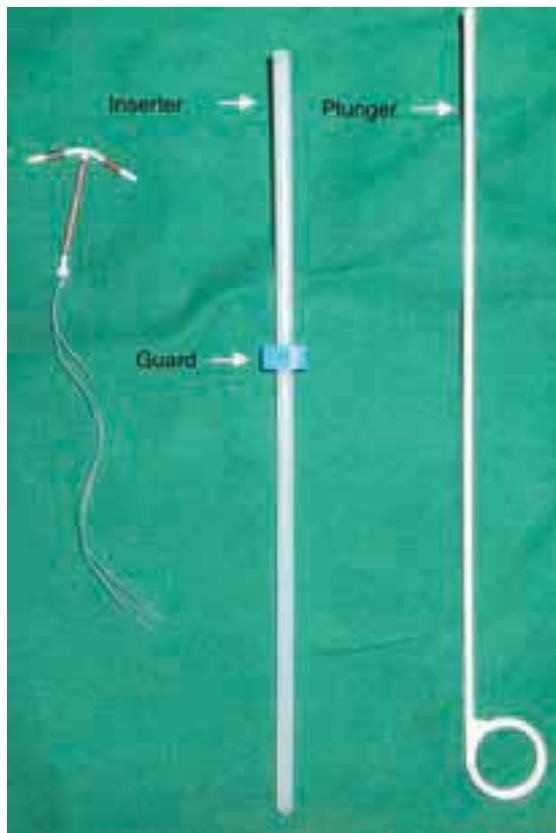


Figure 26.11 Copper T with inserter and plunger.



Figure 26.12 Preparation for insertion of Copper T. The device should be loaded into the inserter by bending the horizontal arms.

- The guard on the inserter should be adjusted according to the uterocervical length. The plunger is carefully placed inside the inserter.
- The inserter with the plunger should be introduced into the uterine cavity till it reaches just below the fundus and the guard is just below the cervix.
- The plunger is kept steady and the inserter is withdrawn, releasing the device into the uterine cavity (Fig. 26.13).
- After proper placement is confirmed, the strings are trimmed to approximately 2–3 cm.

Insertion of IUDs

The LNG-IUS comes with an inserter, plunger, guard, and a slider to push the device out of the inserter (Fig. 26.14). The device can be pulled



Figure 26.13 Demonstration of IUD insertion in plastic model. The inserter with the plunger is introduced into the uterine cavity till it reaches just below the fundus and the guard is just below the cervix. The plunger is kept steady and the inserter is withdrawn, releasing the device into the uterine cavity.



Figure 26.14 LNG-IUS shown with inserter.

into the inserter by traction on the threads. The guard is held 1.5 cm below the cervical os; the device is released, and the inserter is pushed up to the fundus. The rest of the steps of insertion are similar to CuT.

Removal of IUDs

An IUD can be removed any time during the menstrual cycle. The patient should be informed that fertility may return quickly. A new IUD can be placed immediately after removal of the old device, if the patient wants to continue the same form of contraception.

Discontinuation rates

Women are very satisfied with IUDs, and the percentage of women who continue to use them is approximately 80% after 1 year of use.

Efficacy of IUDs

IUDs have a very low failure rate. The typical-use failure rate is 0.6% with the CuT 380, and 0.1% with LNG-IUS. The failure rate is slightly higher with CuT 250 and CuT 375.

Advantages and disadvantages of IUDs

The advantages and disadvantages of IUDs are enumerated in Box 26.31.

Box 26.31 Advantages and disadvantages of IUDs

Advantages

- No adverse systemic effects
- Long acting
- Reversible
 - Immediate return of fertility
- Reduced chance of
 - intrauterine and ectopic pregnancies
- Significant decrease in bleeding (even amenorrhea) with LNG-IUS

Disadvantages

- Uterine cramps
 - Can occur immediately after insertion
 - Usually respond to NSAIDs
- Menorrhagia and dysmenorrhea
 - Usually in the first 3–4 months after insertion
 - Reduces gradually
 - Respond to oral mefenamic acid or tranexamic acid
- Increased vaginal discharge

g- S, levonorgestrel intrauterine system; SA Ds, nonsteroidal anti-inflammatory drugs.

Box 26.32 Complications associated with IUDs

- Expulsion of IUD
 - Greatest in the first year of use
 - 3%–10% with CuT
 - 3%–6% with LNG-IUS
- Perforation of uterus
 - 1 in 1000 chance of perforation during insertion
- Malposition
 - Contraception not effective if not positioned in fundus
- Infection and PID
- Migration into the peritoneal cavity
 - Diagnosed by X-ray or ultrasonography
 - IUD must be removed
 - Removal can be by laparoscopy or laparotomy
- Nonvisualization of thread
 - Device expelled, embedded in uterine wall, or migrated
 - Diagnosed by ultrasonography
 - Removed by hysteroscopy

Cu, copper T; *D*, intrauterine device; *g-*, levonorgestrel intrauterine system; *P D*, pelvic inflammatory disease.

Complications of IUDs

The complications associated with IUDs are enumerated in Box 26.32.

Postpartum IUD programs

Governmental programs have been initiated in many developing countries to insert an IUD immediately postpartum (**PPIUD**). This gives women an option for a long-acting, highly effective, and ‘forgettable’ method of contraception to meet their reproductive health needs. However, the conventional IUDs come with inserters which are too short for this purpose. The uterus immediately postpartum is still enlarged significantly and a longer inserter is required to reach the fundus of the uterine cavity. Newer IUDs have been manufactured for this purpose with longer inserters and strings.

Key points

- Contraception is the planned use of artificial methods or other techniques to prevent pregnancy as an outcome of sexual intercourse.
- Temporary forms of contraception are periodic abstinence, mechanical barriers, hormonal contraceptives, and intrauterine devices.
- Unprotected intercourse has an unintended pregnancy rate of 85%.
- The number of pregnancies that occur in spite of using the method correctly is called failure rate.
- The Pearl Index is the most common technique used for reporting the effectiveness of a contraceptive method. It is defined as the number of unintended pregnancies per 100 women per year.
- Natural methods include periodic abstinence, coitus interruptus, lactational amenorrhea, and methods based on fertile days.
- The male condom is one of the most popular mechanical barriers used globally. The failure rate is estimated to be approximately 18%.

- The female condom is a polyurethane sheath intended for one-time use. It covers the cervix, lines the vagina, and shields the introitus. The failure rate is 20%.
- The diaphragm is a shallow latex cup with a spring mechanism in its rim to hold it in place in the vagina. A woman has to be fitted for a diaphragm since it is manufactured in different diameters.
- The cervical cap is similar to a diaphragm, only smaller in size, and fits snugly around the cervix.
- Hormonal contraceptives include combination oral contraceptives, progestin-only oral contraceptives, implants, injectable depot medroxyprogesterone, combination patch contraceptive, and contraceptive vaginal ring.
- Intrauterine devices are long-acting reversible contraceptives. The two kinds available are copper T devices and the levonorgestrel-releasing device.

Self-Assessment

Case-based questions

Case 1

Ms. YT, 24, is getting married in 2 months. She wants to avoid a pregnancy for the next 2 years till she finishes her higher studies. She has regular periods. Her last period was 3 weeks ago. She is not sexually active. She and her fiancé have come for contraceptive advice.

1. Which contraceptive would you advise her and why?
2. How will you initiate combination oral contraceptive pills?
3. What should she do if she misses a pill?
4. When will fertility return when she stops COCPs?

Case 2

Mrs. VC, 34, has delivered her second baby 2 months ago. She is breastfeeding. She has come for contraceptive advice. She usually has regular periods with heavy bleeding. She has not resumed her periods yet.

1. What contraceptive options can be offered to her?
2. What are the complications encountered with progestin-only pills?
3. What are the disadvantages of IUD in her case?
4. What are the advantages and disadvantages of injectable DMPA?

Answers

Case 1

1. COCPs would be ideal for her. She needs reversible contraception, and an IUD cannot be inserted because she is not sexually active.
2. Since she had her period 3 weeks ago, she can wait for her next period and start from the first day of the period. Backup contraception for the first 7 days of use is not needed.
3. If a single pill is missed anywhere in the packet, the forgotten pill is to be taken when noticed and the next pill taken when it is due (may mean taking two pills on the same day). No backup contraception required. If two or more consecutive pills are missed, then one of the missed pills is to be taken as soon as possible and one pill each day continued as prescribed. Backup contraception needed.
4. In the majority of women, menses and fertility return to normal by 90 days. If amenorrhea persists for 6 months after discontinuation of the pills, the woman needs to be investigated.

Case 2

1. Since she is breastfeeding, COCPs cannot be prescribed. She can be placed on POPs or injectable DMPA. The contraception can be started immediately.
2. POPs can result in amenorrhea and unscheduled bleeding, and she should be instructed about it.
3. She has heavy periods, and although an IUD would be ideal for her, she runs the risk of having menorrhagia. If she can afford it, an LNG-IUS would be ideal since it leads to oligomenorrhea and even amenorrhea.
4. DMPA can be used by lactating mothers, is not affected by high BMI, and does not have adverse effects of estrogen. It can, however, cause disruption of the menstrual cycle, leading to amenorrhea and persistent irregular bleeding. There may be a delay in return to fertility. It can cause weight gain and result in reduction of bone mineral density.

Sample questions

Long-answer questions

1. What is the mechanism of action, method of administration, efficacy, advantages, and complications of combination oral contraceptive pills?
2. What are the types of intrauterine devices? How do they work? What are the complications of IUDs?

Short-answer questions

1. Pearl Index
2. Natural methods of contraception
3. Barrier contraception
4. Noncontraceptive benefits of oral contraceptive pills
5. Major and minor side effects of combined oral contraceptive pills
6. The minipill
7. Contraception during lactation
8. Contraceptive implants
9. Contraceptive vaginal ring
10. Injectable hormonal contraception
11. Levonorgestrel intrauterine system
12. Centchroman

27

Emergency Contraception and Sterilization

Case scenarios

Mrs. JK, 24, and her husband were very worried. They were married for 3 months and were using condom for contraception but the condom slipped. They were not willing for a pregnancy. They had come for advice on how to proceed.

Mrs. RE, 26, was pregnant for the second time and at 36 weeks' gestation. Her first child was 3 years old and healthy. She and her husband were very sure that they did not want any further pregnancies and wanted advice on a permanent method of contraception.

Introduction

Emergency contraception or postcoital contraception refers to the use of drugs or a device as an emergency approach to preventing pregnancy. Emergency contraception can prevent most pregnancies when taken after intercourse.

Currently, there is increased awareness about the advantages of a small family. Most couples consider stopping with one or two children. Using temporary methods is cumbersome and the chances of failure are a cause for anxiety. Hence, many couples prefer permanent methods of contraception. These include male and female sterilization.

Emergency contraception

Women who have had recent unprotected or inadequately protected intercourse require emergency contraception (EC). Emergency contraception is also useful for couples who have had a failure of some other form of contraception.

Indications

Common indications for emergency contraception are enumerated in Box 27.1.

Emergency contraception prevents pregnancy. There are no conditions in which the risks

Box 27.1 Indications for emergency contraception

- No contraceptive used during sexual intercourse
 - Within the previous 120 hours (5 days)
- Contraceptive failure or incorrect use of a contraceptive
 - Within the previous 120 hours (5 days), including
 - condom breakage, slippage, or incorrect use
 - 3 or more consecutively missed combination oral contraceptive pills
 - dislodgment, delay in placing, or early removal of contraceptive patch or vaginal ring
 - norethindrone-containing progestin-only pill (minipill) taken more than 3 hours late
 - desogestrel-containing progestin-only pill (minipill) taken more than 12 hours late
 - >2 weeks late for injection of depot medroxyprogesterone acetate
 - expulsion of intrauterine contraception
- Victim of sexual assault

of emergency contraception use outweigh the benefits. Emergency contraception should be offered to any woman in need of it. Medical eligibility for emergency contraception includes the following:

- Women with previous ectopic pregnancy
- Women with cardiovascular disease
- Women with migraines
- Women with liver disease
- Breastfeeding women

Contraindications to emergency contraception

The only reason not to give emergency contraception is in a woman with a confirmed pregnancy. However, if a woman inadvertently takes emergency contraceptive pills after she becomes pregnant, the available evidence suggests that the pills will not harm either the mother or her fetus.

It is important to emphasize to women that emergency contraceptive pills are for emergency use only and are not intended for regular use as an ongoing contraceptive method. There is a higher possibility of failure compared with non-emergency contraceptives. Frequent use of emergency contraception can also result in menstrual irregularities, although their repeated use is not associated with any known health risks.

Screening prior to prescribing emergency contraception

There is no necessity for a clinical examination or a pregnancy test before prescribing emergency contraception. Emergency contraception should not be withheld or delayed for the following reasons:

- To test for pregnancy
- Because the unprotected event did not occur during the fertile time of the cycle

Methods available for emergency contraception

The different methods available for emergency contraception are as follows:

- Levonorgestrel alone
- Levonorgestrel with ethinyl estradiol (EE)
- Copper intrauterine device (IUD)
- Antiprogestins
 - Mifepristone
 - Ulipristal

Levonorgestrel

Levonorgestrel can be administered as follows:

- 1.5-mg tablet taken as a single dose (more convenient and as effective as the split dose)
- 0.75-mg tablet taken in two doses 12 hours apart

Mechanism of action

Levonorgestrel emergency contraceptive pills act by

- preventing or delaying ovulation
- preventing fertilization of the ovum
 - by affecting the cervical mucus
 - by affecting the ability of the sperm to bind to the egg

Efficacy

When used within 72 hours of intercourse, levonorgestrel is 50% effective in preventing pregnancy. The regimen is more effective the sooner after intercourse it is taken.

Safety

Levonorgestrel-alone emergency contraception is very safe and does not cause miscarriage or affect future fertility. There are no medical contraindications to the use of levonorgestrel emergency contraception pills.

Side effects

Side effects are not common and generally mild:

- Nausea and rarely vomiting
- Irregular bleeding
 - Period may occur within 1 week before or after the expected time
- Breast tenderness, abdominal pain, dizziness, headache, and fatigue

Combined ethinyl estradiol levonorgestrel (Yuzpe regimen)

Unlike the levonorgestrel pills, the estrogen-progestin combination is not available in pill packets specifically intended for emergency contraception. The patient is instructed to take multiple oral contraceptive pills (OCPs) from packets of combined OCPs. The number of pills to be taken should have the equivalent of

- 100 µg of EE plus 0.50 µg of levonorgestrel.
- This is repeated 12 hours later.

Mechanism of action

Combined contraceptive pills, such as levonorgestrel alone, prevent pregnancy by preventing or delaying ovulation.

Side effects

Because of the high dose of EE, approximately 50% of women taking the combined contraceptive pills will experience nausea and vomiting. An antiemetic taken an hour before the first dose will help in reducing the nausea.

Antiprogestins Mifepristone and ulipristal

Mifepristone

Mifepristone (RU-486) is a progesterone and glucocorticoid antagonist. A single dose of mifepristone 600 mg was initially found to be effective for emergency contraception. A lower dose of 25–50

mg has been studied and has been found to be equally effective with fewer side effects. It is better tolerated and more effective than the Yuzpe regimen. However, there may be a delay in the timing of the next menstrual period with mifepristone especially with the higher dose, which is not usually seen with the lower dose. Low-dose mifepristone is currently recommended as the drug of choice for emergency contraception by the World Health Organization (WHO).

Mechanism of action

The main action of mifepristone is through its anti-progestinic effect. Withdrawal of progesterone

- disrupts or prevents implantation of a fertilized ovum and
- prevents further development of an implanted embryo.

Due to this dual action, mifepristone is an effective emergency contraceptive when given before or after implantation has occurred.

Efficacy

Mifepristone is 99%–100% effective in preventing pregnancy after a single episode of unprotected intercourse, when administered within 72 hours. It may be effective up to 12–17 days.

Side effects

Mifepristone can cause nausea and vomiting, but to a lesser degree than the Yuzpe regimen.

Ulipristal

Ulipristal has primarily an antiprogestin activity. It can delay ovulation by as much as 5 days. Like mifepristone, it appears to be effective in the advanced follicular phase, including after luteinizing hormone (LH) levels have begun to rise but not peaked (when levonorgestrel may not be effective).

Efficacy

When used within 72 hours of intercourse, ulipristal is 60–70% effective in preventing pregnancy. It can be used for emergency contraception up to 120 hours after intercourse.

Copper intrauterine device

It is recommended that for emergency contraception, a copper IUD be inserted within 5 days

of unprotected intercourse. This has the added advantage of providing an ongoing, highly effective contraceptive method.

The copper IUD primarily prevents fertilization by causing a chemical change that damages both the sperm and the ovum.

Efficacy

A copper IUD is >99% effective in preventing pregnancy when inserted within 5 days of unprotected intercourse. This is the most effective form of emergency contraception available. Once inserted, a woman can continue to use the IUD as an ongoing method of contraception. More than 80% of women choose to continue with the copper IUD as long-term contraception.

Safety

A copper IUD is very safe for providing emergency contraception. The risks of infection, expulsion, or perforation are low.

Box 27.2 Timing and efficacy of emergency contraception after unprotected or inadequately protected intercourse

- Levonorgestrel or levonorgestrel + EE
 - Most effective
 - Immediately after intercourse
 - Up to 72 hours after intercourse
 - Moderately effective
 - If first dose is taken after 72 hours and up to 5 days after intercourse
 - Unknown efficacy
 - If taken >5 days after intercourse
- Mifepristone
 - Effective if taken within 72 hours
 - May be effective up to 12–17 days
- Ulipristal
 - Effective if taken within 72 hours
 - Also effective between 72 and 120 hours
- Copper IUD
 - Inserted within 5 days after intercourse
 - >99% effective

ethinyl estradiol; D intrauterine device.

Timing of emergency contraception

Treatment is most efficacious when initiated as soon as possible after the unprotected or inadequately protected intercourse.

Timing of emergency contraception is summarized in Box 27.2.

Reasons for failure of emergency contraception

Emergency contraception may be less effective in the following situations:

- Obese women [body mass index (BMI) ≥30 kg/m²]
- Intercourse on the day before ovulation
 - Probability of conception high
- Further acts of unprotected intercourse after using emergency contraception

Follow-up

Menstrual bleeding after emergency contraception (progestin-only and estrogen-progestin

regimens) usually occurs within 1 week of the expected time. Menstrual periods may be delayed more than 1 week with antiprogestins.

With any form of emergency contraception, a pregnancy test should be performed to exclude the possibility of an intrauterine or ectopic pregnancy if

- bleeding has not occurred within 3–4 weeks;
- there is abdominal pain or irregular bleeding.

Couples who come for emergency contraception should also be advised a more reliable and long-term plan for contraception.

Pregnancy following use of emergency contraception

If a woman finds that she is pregnant after taking emergency contraception, she can choose to continue or terminate the pregnancy, depending on her wish for a child.

Levonorgestrel or levonorgestrel + EE used for emergency contraception have no teratogenic effects. The rate of major malformations after first trimester exposure to mifepristone or

ulipristal is only slightly higher than the expected 2%–3% rate in the general population.

Sterilization

Sterilization is a permanent form of contraception, used in both women and men. Surgical advances have resulted in safe, less invasive sterilization procedures, for both females and males. This safe and highly effective method has been accepted as the commonest form of contraception globally. Female sterilization is one of the most popular methods of permanent sterilization. The majority of sterilization procedures are done in the postpartum period. Couples also opt for interval procedures.

- The **ampulla** is wide, thin-walled, somewhat tortuous and is the largest portion of the tube, in both length and caliber.
- The **isthmus** is a narrow, straight, thin-walled portion of the tube immediately adjacent to the uterus. The isthmic portion of the fallopian tube is the site for intra-abdominal tubal occlusion. **Tubal sterilization by the Pomeroy technique should be performed at the isthmus. If a reversal of the tubal ligation is required, the size of the lumen on either side of the cut ends is similar, making reanastomosis feasible.**
- In the **interstitial** portion of the tube, the lumen narrows to approximately 1 mm or less as it passes through the uterine wall, terminating in the tubal ostium, which opens out in the superolateral aspect of the uterine cavity. Hysteroscopic occlusion utilizes this portion of the tube.

Female sterilization

Women who are sure that they do not want any more children or want to remain childless opt for female sterilization. It involves surgical occlusion of the fallopian tubes bilaterally. It can be performed at any time prior to conceiving (interval sterilization) or soon after a pregnancy (postpartum).

Mechanism of action

Tubal ligation techniques result in the permanent occlusion of the fallopian tubes, preventing the ovum and spermatozoa from coming together. The choice of occlusion method depends on the surgeon's training, personal experience, and the technical facilities available.

Relevant anatomy

The two fallopian tubes lie on either side of the uterus in the upper margin (mesosalpinx) of the broad ligament. Each tube is divided into four parts (Fig. 27.1).

Starting from the lateral end, the parts are as follows:

- The **fimbrial end** (infundibulum). Fimbriectomy was used as a procedure for sterilization earlier, but it has been given up due to the high risk of subsequent ectopic pregnancy.

Consent and counseling

Sterilization requires informed consent since it is a surgical procedure. It is a permanent procedure and this should be explained to the couple.

Only the woman who will be undergoing the operation needs to give consent. Consent of the spouse is not mandatory. The woman's right to privacy must be respected. However, it is probably prudent to involve both partners.

If there is any question of a person not having the mental capacity to consent to a procedure that will permanently remove their fertility, the case should be referred to a committee in the hospital (set up for this issue) or the court.

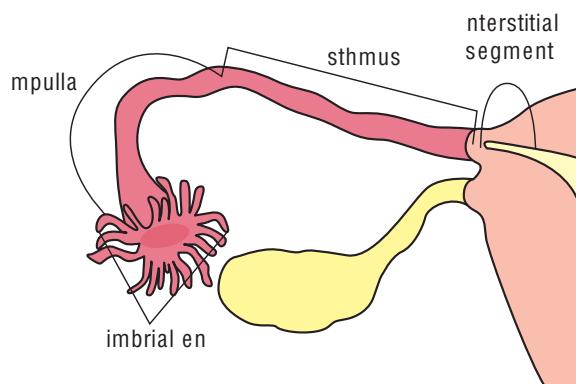


Figure 27.1 Anatomy of the fallopian tube. The isthmic portion of the fallopian tube is the site used for intra-abdominal tubal occlusion. The interstitial portion is the site for hysteroscopic occlusion.

Timing of sterilization

The surgical approach and the method chosen for the tubal ligation depend on the timing of the procedure. Sterilization can be of the following types:

- **Postpartum sterilization (PS)** is done usually within 48 hours of vaginal delivery or along with a cesarean delivery. It is referred to as postpartum sterilization when performed within 7 days of delivery.
 - Immediately postpartum the uterus is still enlarged and the subumbilical region is thinned out. This facilitates access to the tubes. A laparoscopic approach is not possible in the immediate postpartum period.
 - Hospital stay is only a little more than what is required for a normal delivery (72 hours).
- **Interval sterilization** is preferably done immediately after a menstrual period to ensure that there is no existing pregnancy. It can be done at any time of the menstrual cycle if the woman is using reliable contraception.
- **Postabortal sterilization** can be performed immediately or within 48 hours following miscarriage or induced abortion.

The types of sterilization based on timing are listed in Box 27.3.

Route of sterilization

Sterilization can be done by

- minilaparotomy
- laparoscopy
- colpotomy
- hysteroscopy

Box 27.3 Types of sterilization

- Postpartum sterilization (PS)
 - Vaginal delivery
 - Within 48 hours up to 7 days
 - Cesarean section
 - Along with cesarean section
- Interval sterilization
 - Immediately after period
 - Any time if on contraception
- Postabortal sterilization
 - Immediately
 - Within 48 hours

Minilaparotomy sterilization

A minilaparotomy, often referred to as 'minilap,' is an abdominal surgical approach to the fallopian tubes through an incision 2–3 cm in length. It is employed for PS and may also be used for interval sterilization if facilities for laparoscopy are not available.

The minilap may be through two types of approaches:

- Subumbilical approach (postpartum sterilization)
- Suprapubic approach (interval sterilization)

Postpartum sterilization (subumbilical approach)

As already discussed, this is performed within 48 hours and up to 7 days after delivery.

reoperative preparation

Preoperative counseling and informed consent are mandatory. History and physical examination must be performed and minimal investigations are required. Hemoglobin should be >8 g/dL.

Anesthesia

The procedure can be performed under short general, spinal, or local anesthesia. Intravenous sedation with pethidine and promethazine along with local infiltration with lidocaine is also recommended in under-resourced areas.

Procedure

The procedure includes the following steps:

- The patient must be asked to void before the procedure.
- The uterine fundus is palpated and a 2-cm incision is made 2 cm below the fundus.
- The index finger is introduced into the peritoneal cavity, run along the uterine fundus, posterior uterine surface and broad ligament, and the tube is hooked out.
- The tubes should be traced laterally and fimbriae visualized to differentiate it from the round ligament.
- A loop of 2–3 cm of tube is picked up with Babcock clamp at the isthmus (2–3 cm from the cornua). An avascular area on the mesosalpinx should be selected for application of the Babcock clamp.

- Sterilization is performed by the modified Pomeroy technique (described later), and approximately 1 cm of tube is excised. The procedure is repeated on the opposite side.
- The ovaries are inspected. The tube is returned into the abdomen and the abdomen closed.
- Prophylactic antibiotics are not recommended.

Interval sterilization (suprapubic incision)

Interval sterilization (suprapubic incision) is performed when the woman is not pregnant, or immediately after a miscarriage or induced abortion.

reoperative preparation and anesthesia

The preoperative preparation and anesthesia are the same as for PS.

Incision

A 2- to 3-cm transverse incision is made 2–3 cm above the upper border of the pubic symphysis.

Procedure

The procedure includes the following steps:

- The bladder may be catheterized or the patient asked to void just before surgery.
- The procedure can be performed in the dorsal position. However, if the uterus is elevated with a uterine manipulator to the level of the incision, it is easier to access the fallopian tube. The patient has to be placed in a semilithotomy position for vaginal manipulation.
- The rest of the procedure is the same as for PS.

Methods of tubal ligation

The commonest methods of tubal ligation are listed in Box 27.4.

Pomeroy method

The Pomeroy method is the commonest method used for tubal occlusion worldwide.

The isthmic portion of the Fallopian tube is identified and grasped with a Babcock clamp (Fig. 27.2a). The knuckle of the tube is then ligated with 0 or 2-0 plain or chromic catgut suture (Fig. 27.2b). **The suture material should**

Box 27.4 Methods of tubal ligation

- Pomeroy method
- Modified Pomeroy method
- Parkland method
- Other less commonly used methods are
 - Irving method
 - Uchida method
- Abandoned methods include
 - Madlener technique
 - Kroener technique

be absorbable so that the cut ends of the tubes separate, reducing chances of recanalization. The ligated segment of the fallopian tube is then excised (Fig. 27.2c). The ligated ends should be inspected for hemostasis and the presence of the tubal lumen confirmed. The same procedure is completed on the contralateral side.

The catgut suture resorbs in a few days, and the two ends of the cut tube separate (Fig. 27.2d). Permanent suture material increases the chance of fistula formation and sterilization failure and so it should not be used.

Modified Pomeroy method

The modified Pomeroy method differs from the Pomeroy method in that after the knuckle of the tube is ligated, the proximal and distal segments are ligated separately before excising the knuckle of tube. The cut ends separate after a few days.

Uchida method

An opening is made in an avascular portion of the mesosalpinx. 0 or 2-0 chromic catgut sutures are passed through the opening. The proximal and distal portions of the tube are ligated. The intervening segment of the tube is excised (Fig. 27.3). The cut ends separate immediately. The same procedure is completed on the contralateral side.

Failure rate: The failure rate for the Pomeroy and modified Pomeroy methods is 5–6 per 1000 procedures (0.5%).

Irving method

The Irving technique can be performed at the time of cesarean section. It is time-consuming and is associated with more blood loss. A similar procedure can be accomplished at laparoscopy.

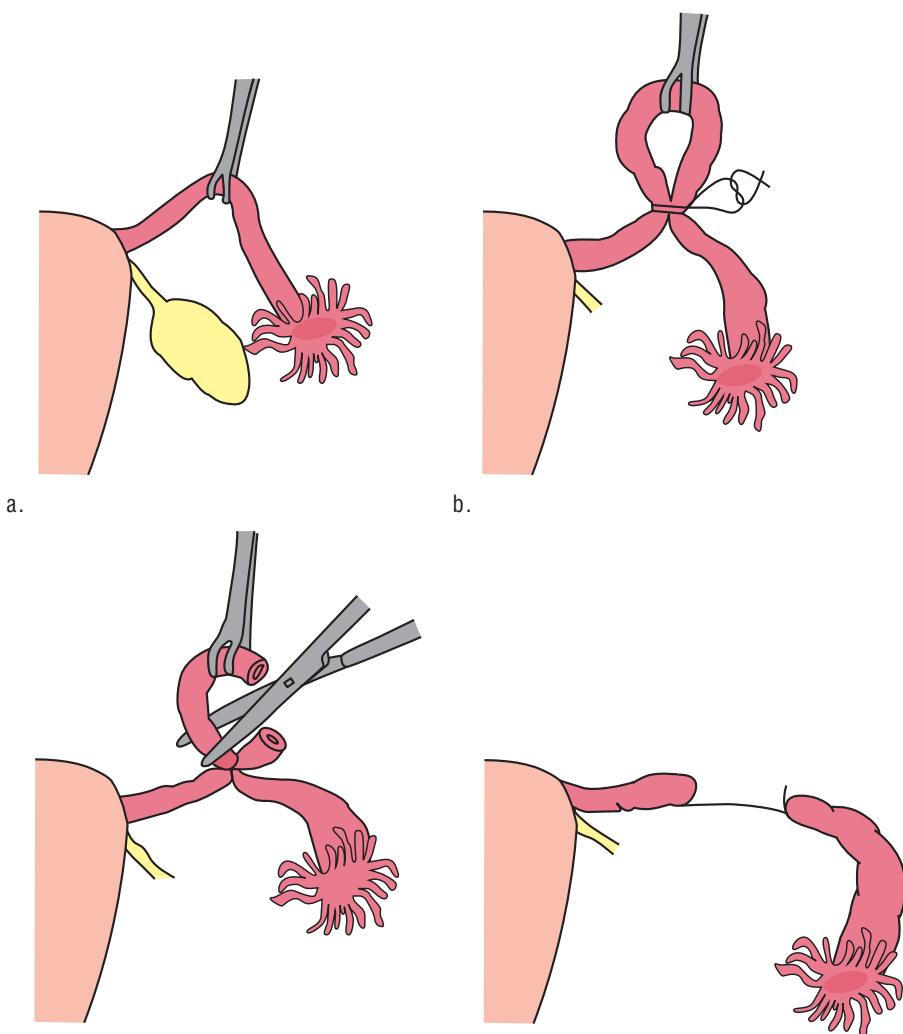


Figure 27.2 Pomeroy method of tubal sterilization. **a.** The tube is grasped at the isthmic portion. **b.** The knuckle of the tube is then ligated with 0 or 2-0 plain or chromic catgut. **c.** The ligated segment of the fallopian tube is excised. **d.** The two ends of the cut tube separate after a few days.

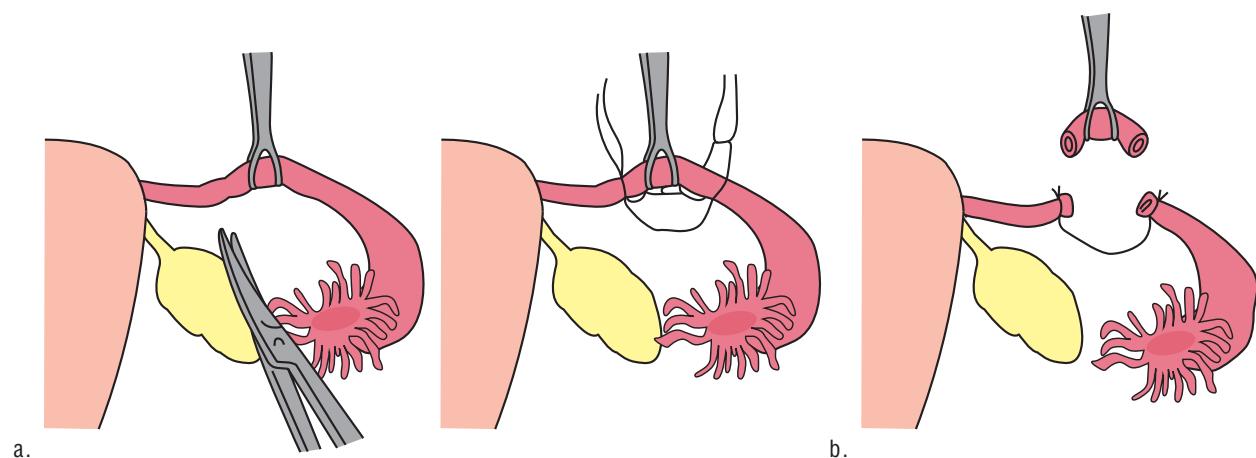


Figure 27.3 Parkland method of tubal sterilization. **a.** An avascular portion of the mesosalpinx is entered and the tube is separated from the mesosalpinx. **b.** A 2-cm segment of the midportion of the tube is ligated proximally and distally with 0 chromic catgut. The intervening segment is then excised.

After ligating the tube and excising a portion, the proximal end of the tube is buried into the posterior myometrium (Fig. 27.4).

Failure rate: The Irving sterilization technique has a failure rate of <1 per 1000 cases (0.1%).

Uchida method

The Uchida method is the most complicated sterilization procedure and very time-consuming. The tube is separated from the overlying serosa. After ligation and excision of a portion of the tube, the proximal end is buried inside the mesosalpinx and the distal stump is exteriorized (Fig. 27.5).

Failure rate: The failure rate for the Uchida method is reported to be nil.

Other methods

Methods of sterilization that have been abandoned include the Madlener method and the Kroener technique.

Madlener method

A loop of the ampullary portion of the tube is crushed with a hemostat. The tube is then ligated with nonabsorbable suture material without excision of a tubal segment. The Madlener method has been abandoned due to the very high failure rate resulting from fistula formation beneath the permanent suture material.

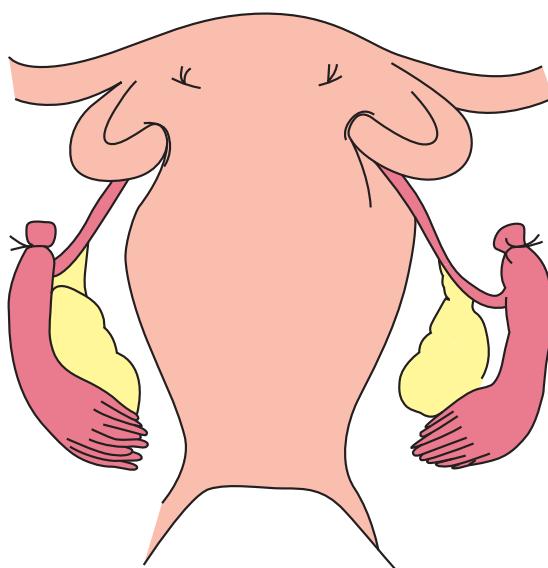


Figure 27.4 Irving technique for sterilization. The proximal ends of the cut tubes are buried into the posterior myometrium.

Kroener technique

A fimbriectomy is done by clamping the mesosalpinx and outer third of the tube, and doubly ligating it with synthetic absorbable suture. The tube is then excised to make certain that the entire fimbriated end of the tube (and a portion of ampulla) is removed. The most common complication is incomplete excision of the fimbriae, resulting in sterilization failure. This method is now abandoned.

The failure rates of the various methods of tubal sterilization are enumerated in Box 27.5.

Challenges of sterilization techniques done through minilaparotomy

Sterilization done through minilaparotomy may be associated with certain operative challenges and complications (Box 27.6).

Laparoscopic sterilization

Laparoscopic sterilization is the most commonly employed method for interval sterilization.

Box 27.5 Failure rates for tubal sterilization

- Pomeroy and modified Pomeroy methods
 - 5–6 per 1000 procedures (0.5%)
- Irving method
 - <1 per 1000 cases (0.1%).
- Uchida method
 - Nil

Box 27.6 Operative challenges and complications of sterilization done through minilaparotomy

- Difficulty in accessing tubes due to adhesions from
 - previous surgery
 - previous cesarean section
- Slippage of suture from tied tubes
 - Prevented by
 - ligating suture firmly and snugly
 - not applying unnecessary traction on the suture
- Ligation of round or utero-ovarian ligament instead of tube
 - Prevented by
 - identification of fimbrial ends of both tubes
- Broad ligament hematoma
- Bowel/bladder injuries
- Infection
 - Wound infection
 - Peritonitis
 - Pelvic infection

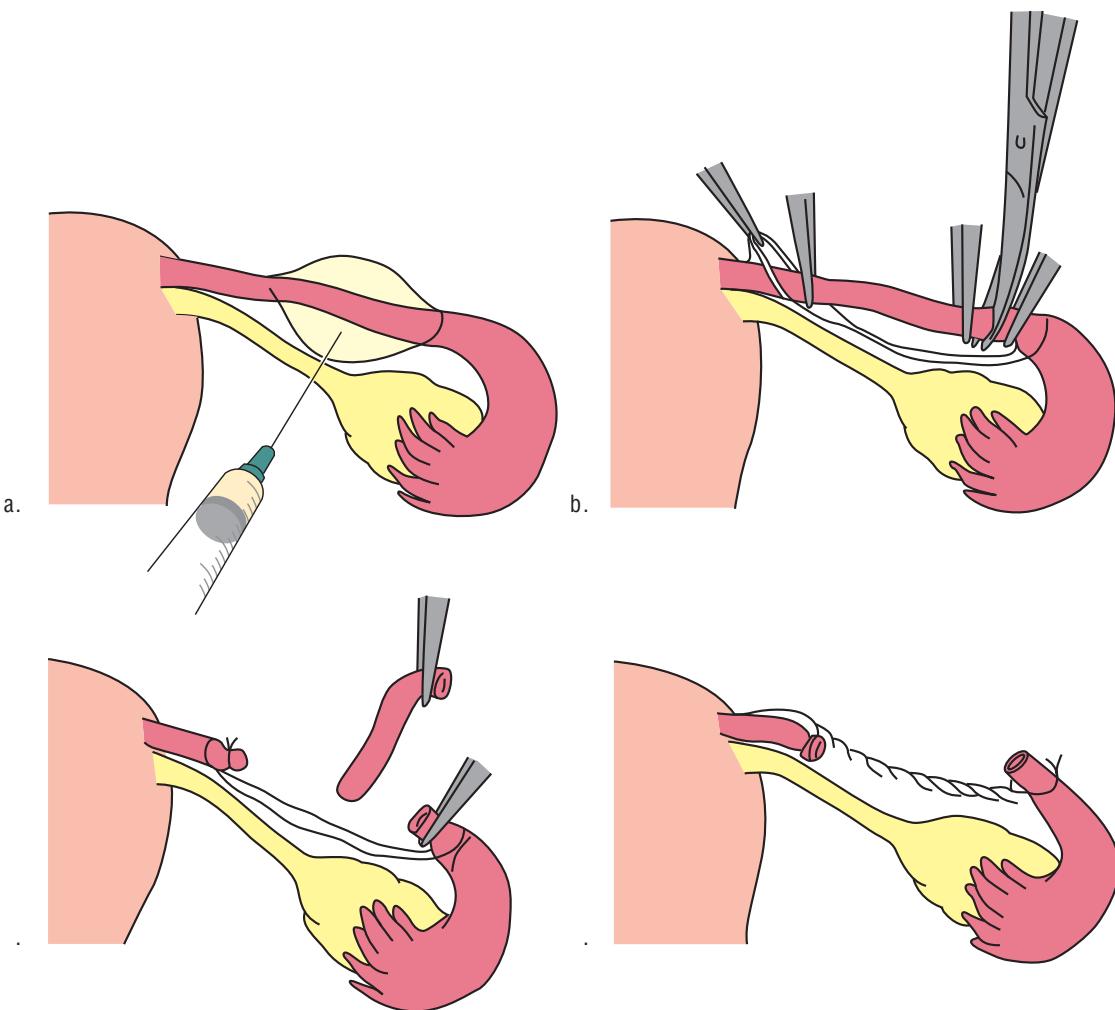


Figure 27.5 Uchida method of sterilization. **a.** Saline injected into the serosa. **b.** Segment of the tube isolated. **c.** Segment of the tube ligated and excised. **d.** The serosa is reapproximated so that the proximal stump is buried within the mesosalpinx and the distal stump is exteriorized.

This is also the method chosen most often for post-abortal sterilization. The small incision and rapid recovery make it a very acceptable procedure for women.

Advantages of laparoscopic sterilization

Laparoscopic sterilization has several advantages (Box 27.7). However, unexpected findings of dense adhesions or other complications may necessitate conversion to laparotomy.

Anesthesia

General or spinal anesthesia can be used.

Box 27.7 Advantages of laparoscopic sterilization

- Requires small incisions
- Provides opportunity to inspect abdominal and pelvic organs
- Immediately effective
- Rapid return to full activity
- Well accepted by women

Procedure for laparoscopy

Laparoscopic sterilization includes the following steps:

- The patient is placed in the dorsolithotomy position.
- The bladder should be catheterized.

- A speculum assists in direct visualization of the cervix.
- The cervix is cleaned with a povidone-iodine solution and a uterine manipulator is placed in position. This helps in antevertting a retroverted uterus and in bringing the tubes and ovaries into the operative field.
- An incision is made subumbilically for the main port.
- Another incision is made for a side port through which the second laparoscopic instrument is introduced.
- After insertion of the laparoscope, the pelvis is examined for any pelvic pathology.
- Adhesions are released if present.

Methods for laparoscopic sterilization

The available methods for laparoscopic sterilization are listed in Box 27.8.

bipolar electrocoagulation

Bipolar electrocoagulation is safer and has a lower failure rate than unipolar electrocoagulation. It is therefore preferred over unipolar electrocoagulation.

Procedure

The procedure consists of the following steps:

- The fallopian tube is grasped and maneuvered until the fimbrial end is identified. This step is essential to confirm that the tube is the structure that will be coagulated, and not the round or utero-ovarian ligament.
- The tube is grasped with bipolar forceps approximately 2–3 cm from the uterine cornu. A few millimeters of the mesosalpinx should also be held by the forceps to ensure that the blades of the forceps have completely encircled the tube.
- The tube is lifted up and away to ensure that the forceps are not in contact with any other structures (Fig. 27.6).

Box 27.8 Methods of laparoscopic sterilization

- Bipolar electrocoagulation
- Banding
 - Falope ring
- Clip application
 - Hulka-Clemens clip
 - Filshie clip



a.



b.

Figure 27.6 Bipolar electrocoagulation of the fallopian tube. **a.** The left tube is grasped at the isthmic portion with the bipolar forceps and elevated. **b.** Bipolar cauterity is used to coagulate the tube, including the mesosalpinx.

- Current is applied until visual inspection shows the tissue grasped has been completely coagulated and can no longer transmit an electrical current.
- The tube is then regrasped and desiccated at the immediately adjacent sites to coagulate 3 cm of contiguous tube.
- The same procedure is repeated on the opposite side.

banding procedures

Banding procedures are nonthermal methods that use a ring or clip to occlude the tube. Correct placement is important because full necrosis of

the tube only occurs after a few days and early slippage of the ring may lead to failure.

Falope (Yoon) ring

The Falope (Yoon) ring is made of a nonreactive silicone rubber. It is radiopaque, that is, it can be identified on an X-ray.

The applicator consists of inner grasping prongs and an outer double-barreled sheath. The Falope ring is stretched around the base of the applicator sheath. Some devices allow for double loading of the rings so that the applicator need not be inserted into the abdominal cavity twice.

Procedure

The procedure consists of the following steps:

- The preloaded ring applicator is placed through the operating channel of an operating laparoscope or through a side port.
- The grasping forceps is extended, and the fallopian tube is grasped approximately 2–3 cm distal to the uterotubal junction (Fig. 27.7a).
- The applicator is designed to draw a 2.5-cm tubal segment into the inner cylinder (Fig. 27.7b). If the tube is thickened, a complete knuckle of the tube may be difficult to pull through.
- Once the tube has been pulled in, the surgeon squeezes the handle to push the ring over the drawn-up tubal segment.
- With correct application, a 1.0-cm high knuckle of the tube will be seen above the ring and both the distal and proximal tubal segments can be observed entering the tubal ring (Fig. 27.7c).
- The ring cuts off the blood supply to the tubal knuckle and it will necrose. Following this, the tubal segments separate.

Clips

The two common clips used for sterilization are as follows:

- Hulka-Clemens clip
- Filshie clip

Hulka-Clemens clip

The Hulka-Clemens clip consists of two toothed jaws made of Lexan plastic, joined by a metal hinge pin. The lower jaw possesses a distal hook. A gold-plated spring maintains the clip in an open position. When completely advanced, the spring closes and locks the jaws.



Figure 27.7 Application of the Falope ring. **a.** The fallopian tube is grasped. **b.** A 2.5-cm tubal segment is drawn into the inner cylinder. **c.** The Falope ring has been applied on both tubes (arrows) and a 1.0-cm high knuckle of the tube is seen above the ring.

The Hulka applicator is specifically designed to open, close, and lock the clip. It is used through a laparoscope.

Procedure

The procedure consists of the following steps:

- The fallopian tubes are identified laparoscopically.
- The Hulka clip applicator is introduced with the clip in the closed position.
- The clip is opened after the applicator is intra-abdominal in position.
- The hook of the lower jaw is placed against the posterior mesosalpinx, the tube is pulled slightly upwards, and the clip is applied at right angles to the tube.
- The clip may be opened and repositioned until the correct position is achieved.
- The center piston is now advanced to permanently lock the clip and release it from the applicator (Fig. 27.8).
- If the clip has not been applied satisfactorily, a second clip is placed close to the first.
- The procedure is repeated on the opposite side.

Filshie clip

The Filshie clip is a 2.7-mm long clip made of titanium with a silicone rubber lining. The clip is applied laparoscopically with an applicator, similar to the Hulka spring clip. It is also applied at right angles to the isthmus, approximately 2–3 cm from the uterotubal junction. The procedure is repeated on the contralateral side.

Initially, the clip occludes the tubal lumen by pressure. As tubal necrosis occurs, the rubber expands and keeps the lumen blocked. The tube eventually divides, and the stumps close as they heal.

Failure rate of laparoscopic methods of sterilization

The failure rate of the different laparoscopic methods of sterilization is approximately 2–3 per 1000 (0.2–0.3%).

Transvaginal tubectomy

Transvaginal tubectomy (TVT) for interval and postabortal sterilization, through a colpotomy, was very popular till the advent of the

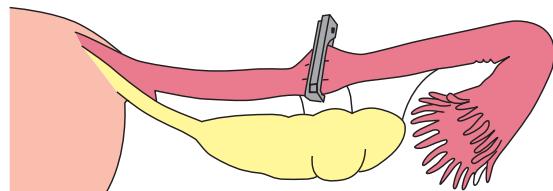


Figure 27.8 Hulka clip applied at a right angle to the isthmic portion of the fallopian tube, 2–3 cm from the uterotubal junction.

laparoscopic route. The laparoscopic route came to be preferred because of the risk of pelvic infection with the transvaginal route. However, routine use of prophylactic antibiotics decreases this risk.

The vaginal approach is useful in following cases:

- Very obese patients
- Women with an umbilical hernia
- Women with a previous umbilical hernia repair

Contraindications to the colpotomy route

The contraindications to transvaginal tubectomy are listed in Box 27.9.

Procedure

The procedure includes the following steps:

- The woman is placed in the dorsal lithotomy position.
- A retractor is used to expose the cervix. The posterior lip of the cervix is grasped with a tenaculum.
- The posterior cul-de-sac (pouch of Douglas) is exposed. The vaginal wall is held with tissue forceps and a transverse incision is made in the vaginal mucosa (colpotomy), along the line of junction of the vaginal wall and the cervix.
- The edge of the vaginal wall is held with tissue forceps that puts the peritoneum on stretch,

Box 27.9 Contraindications to transvaginal tubectomy

- Multiple pelvic surgical procedures
- Known endometriosis
- Known pelvic adhesive disease
- Uterine immobility on examination

and the peritoneum is cut with scissors. The opening is enlarged to 2–2.5 cm.

- The retractor is then introduced posterior to the cervix, just inside the incision. A narrow moistened pack is introduced into the peritoneal cavity to keep the bowel out of the operative field.
- The fallopian tube is visualized and grasped with a Babcock clamp and brought into the operative field.
- The sterilization is most commonly done using the Pomeroy technique.
- After doing the procedure on the contralateral tube, the colpotomy incision is closed using interrupted figure-of-eight sutures or a single running suture of an absorbable material.

Complications

Pelvic infection is the most serious postoperative complication. A single dose of a prophylactic antibiotic should be administered within 15 minutes before the incision, to prevent this complication.

Hysteroscopic sterilization

The principle behind hysteroscopic sterilization is the blocking of the interstitial portion of the fallopian tubes. The approach is through the ostia, which are visualized using the hysteroscope.

Methods currently available

Transcervical tubal occlusion

Transcervical tubal occlusion consists of the following steps:

- A metal microinsert (Essure[®]) is placed under hysteroscopic guidance into the interstitial portion of each fallopian tube. The insert consists of an inner coil of stainless steel and polyethylene terephthalate (PET) fibers and an outer coil of nickel-titanium (nitinol). Following placement, the PET fibers incite a benign tissue response and within several weeks, the fibrotic reaction around the device results in complete tubal occlusion (Fig. 27.9).
- The Adiana[®] sterilization method combines controlled thermal damage to the lining of the fallopian tube with insertion of a nonabsorbable silicone elastomer matrix within the tubal lumen.

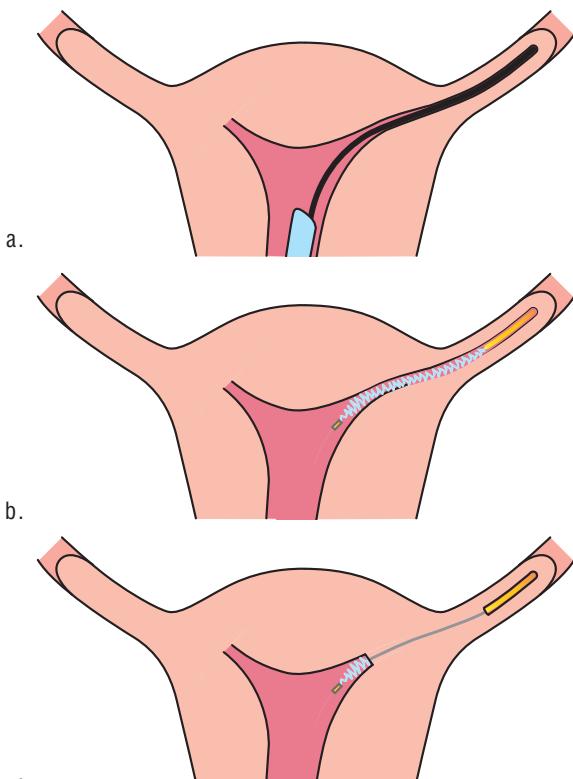


Figure 27.9 Hysteroscopic insertion of Essure[®] tubal occlusion system. **a.** The device delivery system is threaded into the tube through the ostium. **b.** A micro-insert is placed in the tube. It expands and fills the tube. **c.** Scar tissue forms around the micro-insert and blocks the tube.

- Quinacrine pellets:* Quinacrine scleroses the interstitial portion of the tube. Pellets of quinacrine are placed into the uterus using a tube similar to a copper T IUD inserter, for two to three doses 1 month apart.

Quinacrine is inexpensive and a good option for developing countries. However, the failure rates are high compared with other methods of sterilization. There have also been questions raised about quinacrine being a carcinogen.

Advantages of hysteroscopic sterilization

The advantages and disadvantages of hysteroscopic sterilization are enumerated in Box 27.10.

Complications of tubal ligation

Tubal ligation is the commonest permanent method of sterilization globally. Though they are rare (<1%), complications have been reported (Box 27.11).

Box 27.10 Advantages and disadvantages of hysteroscopic sterilization
Advantages

- No incision
- Less postoperative pain
- Can be performed in women
 - With extensive pelvic adhesions
 - With contraindications to laparoscopy and laparotomy

Disadvantages

- Need for contraception for 3 months postprocedure
 - Until tubal occlusion is confirmed
- Need for imaging study to confirm tubal occlusion
- Higher risk of unilateral tubal occlusion

Box 27.11 Complications of tubal ligation

- Intraoperative and postoperative complications
 - Wound infection
 - Hematoma
 - Perforation of the uterus, bladder, or intestine
 - Complications related to the mode of sterilization
 - Laparoscopy
 - Hysteroscopy
 - Colpotomy
- Factors that increase the risk of complications
 - Diabetes mellitus
 - General anesthesia
 - Previous abdominal or pelvic surgery
 - Obesity
- Mortality rate of tubal sterilization
 - 4.7 per 100,000 procedures
 - Mostly due to anesthetic complications
 - Lower than pregnancy-associated maternal mortality

Outcomes of sterilization

The following are the outcomes of sterilization:

- Pregnancy is uncommon after tubal sterilization. It is highest after clip sterilization, and lowest after Pomeroy or modified Pomeroy method.
- When pregnancy does occur, there is a greater risk that it will be an ectopic pregnancy.

Request for restoration of fertility

A couple may request reversal of sterilization. This usually follows the loss of a child. The two choices are as follows:

- Tubal reanastomosis
- In vitro fertilization (IVF)

Both have approximately 60% chance of a live pregnancy, although surgical reversal is less expensive.

Tubal reanastomosis

Procedure of reanastomosis

Tubal reanastomosis includes the following steps:

- The technique involves microsuturing using 6-0 to 10-0 sutures.
- The damaged and scarred portions of the tubes are excised.
- The healthy tubal segments are reapproximated with as little adhesion formation as possible.

Indicators for success of reanastomosis are listed in Table 27.1.

Male sterilization

Vasectomy is among the most reliable and cost-effective methods of contraception. The procedure involves interruption or occlusion of the vas deferens, and can be performed in an outpatient setting, under local anesthesia. It has a 98% success rate. Failure rates of vasectomy and tubal sterilization are comparable, as are their rates of successful reversal.

Although vasectomy is safer, less costly, and has a significantly shorter postprocedure

Table 27.1 Indicators for success of reanastomosis

Factor	Most successful	Least successful
Age (years)	<35	>35
Type of sterilization	Clips, band	Electrocautery
Length of residual tube (cm)	>6	<6
Years since tubal ligation	<10	>10

recovery time than tubal ligation, tubal ligation is performed five times more often than vasectomy, worldwide. This resistance to vasectomy is mostly from the husband, due to misperceptions regarding its effects on male libido and virility.

Consent and counseling

Vasectomy requires informed consent since it is a surgical procedure. It is a permanent procedure and this should be explained to the couple. Counseling for a vasectomy should stress that it has no deleterious effect on male libido or virility.

Methods of vasectomy

The following are the methods of vasectomy:

- Conventional vasectomy
- No-scalpel vasectomy

Conventional vasectomy

Traditionally, a vasectomy involves bilateral small scrotal incisions through which the vas deferens is visualized and mobilized. A portion of the vas is removed and the resulting end or ends are occluded.

Preoperative preparation

Preoperative preparation involves the following:

- The patient should be instructed to shower and cleanse the genital area thoroughly on the day of surgery.

- He should not eat for 2 hours before the procedure.
- Aspirin should not be taken for 1–2 weeks before the procedure.
- Nonsteroidal anti-inflammatory agents, platelet inhibitors, and anticoagulants should be withheld for 3–4 days before the procedure.

Anesthesia

Vasectomy is done under local anesthesia.

- Before administration of local anesthesia, a rapid examination of the genital area should be performed to confirm anatomic landmarks.
- For providing anesthesia, a 1- to 2-cm wheal should be made at the desired incision site, usually at the junction of the middle and upper one-third of the scrotum bilaterally.
- The needle is advanced through the wheal, without injecting the anesthetic, parallel and adjacent to the vas and toward the external inguinal ring.
- After gentle aspiration, 2–5 mL of 1% lidocaine (without epinephrine) is injected into the external spermatic fascia.

Procedure

The procedure of vasectomy involves three steps (Fig. 27.10):

- Isolation of the vas
- Interruption of the vas
- Management of the vasal ends

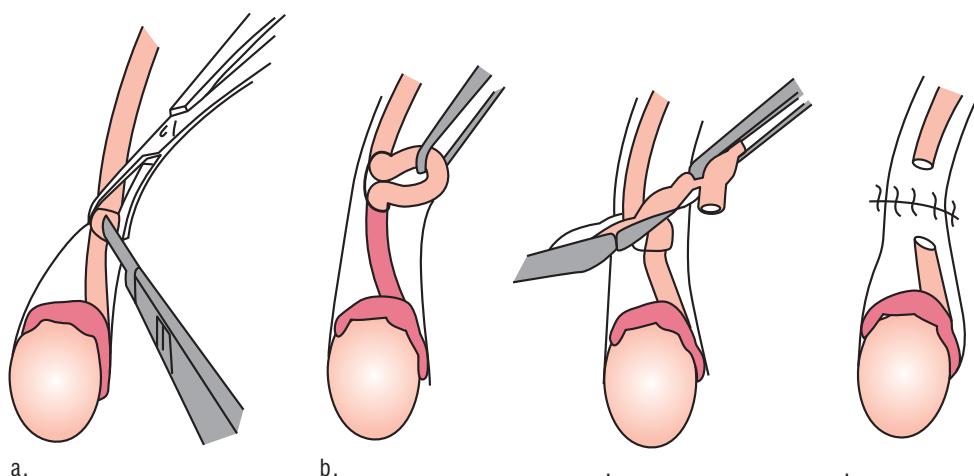


Figure 27.10 Surgical procedure for vasectomy. **a.** Incision exposes sheath, which is then opened. **b.** Vas is exposed and occluded. **c.** Segment of approximately 1.5 cm is excised. **d.** Vas is replaced in sheath after intraluminal fulguration and sealing of both ends, and skin is sutured.

Isolation of the vas

The vas needs to be isolated and maneuvered subcutaneously to the desired operative site, which is usually at the junction of the middle and upper one-third of the scrotum bilaterally.

- Isolation of the vas utilizes a 'three-finger technique' in which the nondominant hand is used to manipulate the vas into a subcutaneous position.
- A modification of this technique is to place the thumb of the nondominant hand posterior to the cord and scrotum, and trapping the vas between the posterior thumb and the middle finger in a pincer grasp.
- The index finger is then used to retract the skin, yielding improved exposure of the vas.
- Ligatures and clips should be avoided because of increased risk of vasectomy failure.

Interruption of the vas

The vas is interrupted in the following manner:

- After the vas is maneuvered to the desired location, a 1- to 2-cm horizontal or vertical skin incision is made.
- The vas is grasped with an Allis clamp.
- After further blunt dissection, the vas is fully isolated and is ready for division.
- Removal of at least 15 mm length of vas is recommended.

Management of the vasal ends

Occlusion of the vasal ends is an important step in vasectomy.

- Intraluminal fulguration of 1.5 cm of the prostatic end of the vas with fascial interposition between the prostatic and testicular vasal end appears to be the most effective method for managing the two cut ends of the vas.

No-scalpel vasectomy

This is the commonest method used for vasectomy. Instead of an incision, the no-scalpel technique uses a puncture made through the scrotal skin overlying the vas deferens. The puncture is widened just enough to exteriorize the vas

deferens for transection. The remainder of the procedure is performed in a similar fashion to the open incision method. The no-scalpel approach is associated with less bleeding, infection, and pain.

Vasal occlusion

Vasal occlusion with a plug (made of medical grade silicone rubber) requires microsurgery for implantation and later removal. Either a conventional open or a no-scalpel technique may be used to isolate the vas deferens for the implantation of these devices. Vasal occlusion procedures are still in the experimental stage.

Postoperative instructions

It is essential to perform a semen analysis 3 months after the procedure to check for azoospermia. Backup contraception should be used till sterility is confirmed.

Complications of vasectomy

The complications following vasectomy are listed in Box 27.12.

Failure rate: The failure rate of vasectomy is very low: 1 in 2000 or 0.2%.

Reasons for failure

The following are the various reasons for failure:

- Pregnancy occurs after a vasectomy in most cases because the couple has sexual intercourse before azoospermia is confirmed.
- True early failure, defined as the presence of motile spermatozoa in the ejaculate 4 months after surgery, is usually due to
 - technical error
 - early recanalization of the vas

Box 27.12 Complications following vasectomy

- Hematoma
- Infection
- Sperm granuloma
- Persistent postvasectomy pain

Key points

Emergency contraception

- Emergency or postcoital contraception refers to the use of drugs or a device as an emergency approach to preventing pregnancy.
- Common indications for emergency contraception include contraceptive failure and failure to use any form of contraception.
- The only reason not to give *emergency contraception* is in a woman with a confirmed pregnancy. However, if a woman inadvertently takes *emergency contraceptive* pills after she becomes pregnant, the available evidence suggests that the pills will not harm either the mother or her fetus.
- The different methods available for *emergency contraception* are levonorgestrel alone, levonorgestrel with ethinyl estradiol, copper intrauterine device, and antiprogestins.
- Emergency contraception pills are most effective when taken within 72 hours of unprotected intercourse.
- For emergency contraception, a copper intrauterine device should be inserted within 5 days of unprotected intercourse. This has the added advantage of providing an ongoing, highly effective contraceptive method.
- With any form of emergency contraception, a pregnancy test should be performed to exclude the possibility of an intrauterine or ectopic pregnancy if bleeding has not occurred within 3–4 weeks or if there is abdominal pain or irregular bleeding.
- Levonorgestrel or levonorgestrel + ethinyl estradiol used for emergency contraception has no teratogenic effects. The rate of major malformations after first trimester exposure to mifepristone or ulipristal is only slightly higher than the expected 2%–3% rate in the general population.

Sterilization (for women and men)

- Sterilization is a permanent form of contraception. It is a safe and highly effective method that has been accepted as the commonest form of contraception globally.
- Female sterilization involves surgical occlusion of the fallopian tubes bilaterally. It can be performed at any time prior to conceiving or soon after a pregnancy.

- Sterilization requires informed consent since it is a surgical procedure.
- Sterilization can be postpartum, postabortion, or an interval procedure (unrelated to pregnancy).
- A minilaparotomy sterilization is employed for post-partum sterilization and may also be used for interval sterilization if facilities for laparoscopy are not available.
- The commonest methods of tubal ligation are Pomeroy method, modified Pomeroy method, and the Parkland method.
- Other less commonly used methods are the Irving method and the Uchida method. The Madlener method and the Kroener technique have been abandoned.
- Probability of pregnancy for the Pomeroy and modified Pomeroy methods is 5–6 per 1000 procedures (0.5%).
- Laparoscopic sterilization is the most commonly employed method for interval sterilization and postabortal sterilization. The small incision and rapid recovery make it a very acceptable procedure for women.
- Methods for laparoscopic sterilization include bipolar electrocoagulation, banding (Falope ring), and clip application (Hulka-Clemens clip, Filshie clip).
- The failure rate of the different laparoscopic methods of sterilization is approximately 2–3 per 1000.
- Transvaginal tubectomy (TVT) for interval and post-abortal sterilization was very popular till the advent of the laparoscopic route.
- The principle behind hysteroscopic sterilization is the blocking of the interstitial portion of the fallopian tubes. The approach is through the ostia, which are visualized using the hysteroscope.
- Pregnancy is uncommon after tubal sterilization. It is highest after clip sterilization, and lowest after post-partum sterilization using the Pomeroy and modified Pomeroy methods.
- When pregnancy does occur, there is a greater risk that it will be an ectopic pregnancy.
- Vasectomy is among the most reliable and cost-effective methods of contraception. The procedure involves interruption or occlusion of the vas deferens, and can be performed in an outpatient setting, under local anesthesia. It has a 98% success rate.

Self-Assessment

Case-based questions

Case 1

Mrs. JK, 24, and her husband are very worried. They have been married for 3 months. They were using a condom for contraception but the condom slipped.

1. What would you advise the couple?
2. How does levonorgestrel work and what is the dose for emergency contraception?
3. Which would be the best choice of emergency contraception if the unprotected intercourse had occurred 4 days ago?
4. What would you advise the couple if she finds herself pregnant after taking the pills?

Case 2

Mrs. RE, 26, is pregnant for the second time and is at 36 weeks' gestation. Her first child is 3 years old and healthy. She and her husband are very sure that they do not want any further pregnancies and want a permanent method.

1. Which method of sterilization would be the best option for her?
2. What is the failure rate for the Pomeroy and modified Pomeroy procedures?
3. What are the methods available for laparoscopic sterilization?
4. If this couple wanted to have another child 5 years from now, what would be the options?

Answers

Case 1

1. Advise them a choice of levonorgestrel pills or a copper intrauterine device immediately.
2. Levonorgestrel emergency contraceptive pills prevent pregnancy primarily by preventing or delaying ovulation. They may also prevent fertilization of the ovum by affecting the cervical mucus and the ability of the sperm to bind to the egg. The dose is a 1.5-mg tablet taken as a single dose or a 0.75-mg tablet taken in two doses 12 hours apart.

3. A copper intrauterine device is >99% effective in preventing pregnancy when inserted within 5 days of unprotected intercourse.
4. If she finds that she is pregnant after taking emergency contraception, she can choose to continue or terminate the pregnancy, depending on her wish for a child. Levonorgestrel or levonorgestrel + EE used for emergency contraception has no teratogenic effects.

Case 2

1. Postpartum sterilization through a minilaparotomy would be the best option for her. A Pomeroy or modified Pomeroy method of sterilization should be used.
2. Probability of pregnancy for the Pomeroy and modified Pomeroy methods is 5–6 per 1000 procedures (0.5%).
3. Laparoscopic sterilization can be done using bipolar electrocoagulation, Falope ring, or clip application (Hulka-Clemens clip or Filshie clip).
4. She can undergo a tubal reanastomosis or an in vitro fertilization procedure.

Sample questions

Long-answer questions

1. What is emergency contraception? Describe the options available.
2. Discuss the methods of tubal sterilization. What are the advantages, disadvantages, and complications of the various methods?
3. What is laparoscopic sterilization? Enumerate the methods used.

Short-answer questions

1. Timing of emergency contraception
2. Minilaparotomy
3. Transvaginal (colpotomy) sterilization
4. Vasectomy

Section 5

Obstetric Complications: Antepartum

28

Hyperemesis Gravidarum

Case scenario

Mrs. GN, 20, had missed her periods and the pregnancy test was positive. She had experienced mild nausea a week after the expected date of menstruation but this progressed to vomiting three to four times a day. She was currently unable to retain even fluids, was weak and tired, and felt faint on standing. Her concerned husband brought her to the clinic. She was found to be dehydrated and had a weight loss of 4 kg. She was immediately hospitalized and necessary treatment was started.

Introduction

Nausea and vomiting is common in the first trimester of pregnancy and is considered physiological. It usually responds to home remedies, dietary modifications, and reassurance. Though often referred to as 'morning sickness', symptoms can occur at any time. Moderate symptoms can be controlled with oral medication. However, nausea and vomiting maybe severe in some women and can progress to dehydration and weight loss, necessitating hospitalization and parenteral medications. This severe form of nausea and vomiting is referred to as hyperemesis gravidarum.

Definition

Hyperemesis gravidarum is defined as persistent, severe vomiting in pregnancy, associated with weight loss of >5% of prepregnancy weight, dehydration, and ketonuria. Hypokalemia and hypochloremic alkalosis due to loss of potassium and hydrochloric acid in the vomitus are also usually present. Distinction between physiological nausea and vomiting and hyperemesis is important. Hyperemesis interferes with the quality of life.

Incidence

The incidence of hyperemesis varies with ethnic groups and ranges from 0.2% to 2%. Recurrence of hyperemesis in subsequent pregnancies is as high as 15%–20%. Nausea and vomiting begins at 5–6 weeks, peaks at 9–10 weeks, and subsides by 12–14 weeks in 70% of women and by 16–20 weeks in 90%.

Box 28.3 Hormonal changes implicated in hyperemesis

Elevated levels of

- Estrogen
- Progesterone
- Human chorionic gonadotropin
- Thyroxine
- Placental growth hormone
- Adrenocortical hormones
- Prolactin

Risk factors

Risk factors for hyperemesis are listed in Box 28.1.

Pathophysiology

There are several theories regarding the causation of hyperemesis but the exact mechanism is not known. There is a complex interaction between sociocultural, psychological, and biological factors. The factors involved are given in Box 28.2.

Box 28.1 Risk factors for hyperemesis gravidarum

- Primigravida
- Younger age
- Multifetal pregnancy
- Hydatidiform mole
- Genetic factors
- Past history
 - Motion sickness
 - Migraine
 - Hyperemesis in previous pregnancy
 - Female fetus

Box 28.2 Factors involved in causation of hyperemesis

- Hormonal changes
- Gastrointestinal dysfunction
- Hepatic dysfunction
- Infection
- Vestibular and olfactory stimuli
- Psychological factors
- Genetic factors

Hormonal changes

Several hormones have been implicated in the pathogenesis of hyperemesis (Box 28.3).

Estrogen and *progesterone* levels are elevated in pregnancy and may be implicated in the causation of nausea and vomiting. *Human chorionic gonadotropin* (hCG) increases rapidly in the first trimester. Moreover, hyperemesis is more common in hydatidiform mole and multifetal pregnancy, both conditions associated with high hCG levels. hCG can stimulate the thyroid-stimulating hormone (TSH) receptors and stimulate production of *thyroxine*. Transient elevation of T4 and suppression of TSH occurs in many women in the first trimester. These women are clinically euthyroid (*euthyroid hyperthyroxinemia*), have no thyroid enlargement or thyroid antibodies, but may present with hyperemesis. Hyperemesis is also more common in women who have nausea and vomiting when they are on oral contraceptives. So far, studies have not proved a causal association between hormonal changes and hyperemesis gravidarum.

Gastrointestinal dysfunction

Gastric dysmotility induced by progesterone, abnormal vagal and sympathetic tone, and thyroxine has also been considered to play a causative role. Relaxation of the lower esophageal sphincter and the resultant reflux can also give rise to nausea and vomiting.

epatic dysfunction

Mild elevation in serum transaminase levels occurs in hyperemesis. Impairment of mitochondrial fatty acid oxidation has been found in some women.

Infection

Infection with *Helicobacter pylori* may also play a role. Epidemiological studies have found an association and treatment of this infection improves symptoms.

vestibular and olfactory stimuli

Abnormal response to vestibular and olfactory stimuli has also been thought to cause vomiting. Women who have motion sickness have a hypersensitive labyrinth and a tendency to develop hyperemesis. Many olfactory stimuli such as oily food and strong perfumes can also trigger vomiting in pregnancy.

Genetic factors

Mothers and sisters of women with hyperemesis have a history of the same disorder in their pregnancies. This may indicate a genetic predisposition.

Psychological factors

Psychological factors are thought to play a major role. Hyperemesis may be a response to stress or a somatization disorder. The woman's attitude toward the pregnancy, environment, and lack of emotional support may also be underlying factors.

Complications

Hyperemesis usually responds to treatment and runs a benign course. But, in refractory and severe cases, complications can occur (Box 28.4). Loss of potassium, hydrogen, and chloride due to vomiting can lead to hypokalemia and hypochloremic alkalosis. Starvation leads to ketosis. Chronic vomiting and poor intake can cause vitamin K and vitamin B1 (thiamine) deficiency. Persistent dehydration can lead to hypovolemia,

Box 28.4 Complications of hyperemesis

- Ketosis
- Hypochloremic alkalosis
- Hypokalemia
- Vitamin K deficiency: Hypoprothrombinemia
- Thiamine deficiency: Wernicke's encephalopathy
- Mallory–Weiss tears, esophageal rupture
- Dehydration, hypovolemia, prerenal, and later renal failure

poor renal perfusion, and prerenal failure, which if not corrected in a timely fashion can lead to acute renal failure. Severe retching and vomiting can cause Mallory–Weiss tears in the esophagus, hematemesis and, rarely, esophageal rupture.

Clinical features

Symptoms

The severe nausea of hyperemesis usually begins by 5–6 weeks and resolves by 12–14 weeks. Symptoms continue till term or puerperium in 5% of women. Clinical features are listed in Box 28.5.

Clinical evaluation

Clinical evaluation of hyperemesis should begin with a detailed history (Box 28.6).

Physical examination

Physical examination in women with hyperemesis may reveal signs of dehydration. Physical examination should be as given in Box 28.7.

Box 28.5 Clinical features of hyperemesis gravidarum

- Nausea and vomiting >3 times a day
- Begin at 5–6 weeks
- Peak at 8–9 weeks
- Resolve by 12–14 weeks
- Fatigue
- Ptyalism (excessive salivation)
- Weight loss >5% or >3 kg
- Orthostatic hypotension

Box 28.6 History in hyperemesis gravidarum

- Gestational age at onset
- Severity
- Triggering factors
- History of hematemesis
- Past history
 - Hyperemesis in previous pregnancy
 - Motion sickness/migraine
 - Gastrointestinal disorders
 - Vomiting with oral contraceptives
- Family history
- Social history

Box 28.7 Physical examination in hyperemesis gravidarum

- Vital signs
 - Pulse
 - Blood pressure—lying and standing
- Signs of dehydration
 - Dry tongue
 - Skin turgor
- Weight
- Urine output
- Abdominal examination
 - Size of uterus
 - To exclude other causes
- Vaginal examination
 - Size of uterus

Investigations

Investigations should be aimed at assessing the severity of the problem and excluding other causes (Box 28.8). Rise in hematocrit indicates dehydration and hemoconcentration. In case of

Box 28.8 Investigations in hyperemesis gravidarum

- Serum electrolytes
- Urine for ketone bodies
- Hematocrit
- Ultrasonography to rule out
 - multifetal pregnancy
 - hydatidiform mole
- If vomiting severe
 - Liver function tests
 - Serum creatinine
 - Thyroid function tests

severe vomiting, liver enzymes can be elevated. Hyperthyroxinemia is usually transient and is not associated with signs of hyperthyroidism. Antithyroid medications should not be administered and there is no need for routine thyroid function tests.

Differential diagnosis

The diagnosis is fairly straightforward in uncomplicated cases. Disorders other than hyperemesis should be considered if the symptoms develop after 10 weeks, persist after 20 weeks, and are associated with hematemesis, abdominal pain, fever, elevated blood pressure, and jaundice.

The differential diagnosis is listed in Box 28.9.

Management

Management consists of dietary modification, supportive therapy and psychotherapy, and medical management.

Initial management

Initial management, when the woman is not dehydrated, is by simple measures such as modification of diet, avoidance of triggers, and supportive therapy. Pyridoxine with doxylamine is usually prescribed as an initial measure (Box 28.10).

Diet

Small meals at 2–3 hourly intervals should be recommended. Both an empty stomach and large meals leading to a full stomach can induce nausea and vomiting. Oily, spicy, and acidic

Box 28.9 Differential diagnosis

- Hepatitis
- Gastroenteritis
- Cholecystitis
- Pancreatitis
- Peptic ulcer
- Preeclampsia
- HELLP syndrome

P hemolysis, elevated liver enzymes and low platelets.

Box 28.10 Initial management in hyperemesis gravidarum

- Diet
 - Small meals at 2–3 hourly intervals
 - Fluids with lime/mint and electrolytes
 - Avoid oily, spicy, acidic, and sweet foods
- Avoidance of triggers
- Supportive therapy
- Acupressure
- Medications: Pyridoxine 10 mg + doxylamine 10 mg

foods and sweets should be avoided. Low-fat, bland, and dry snacks and meals are preferable. Oral fluids containing lemon, mint, and electrolytes should be advised in small quantities but at frequent intervals.

Avoidance of triggers

The common triggers for vomiting are coffee, tea, smell of oil, some spices, and smell of cooking, especially frying foods. These should be avoided. In addition, other activities, such as lying down after food, that are associated with vomiting should be avoided.

Supportive therapy

Counseling and reassurance that the problem is self-limiting, resolves by 12–14 weeks, and does not harm the fetus are helpful. Change of environment is also recommended.

Acupressure

Acupressure on the P6 point on the wrist has been found to be helpful. Randomized trials have revealed contradicting results. Some women benefit from it, though it is not certain if it is a placebo effect.

Medications

A combination of 10 mg of pyridoxine with 10 mg of doxylamine is the first-line treatment of choice for nausea and vomiting in pregnancy. It relieves symptoms in 70% of women. Pyridoxine is a coenzyme involved in the metabolism of

carbohydrates, proteins, and fats. It reduces nausea and may be used alone in doses of 25 mg four to six times a day. Doxylamine succinate is an antihistamine which, when used along with pyridoxine, is very effective in the treatment of nausea and vomiting and has no teratogenic effect on the fetus.

Subsequent management

Women with hyperemesis not responding to general measures and those who present with moderate-to-severe dehydration, ketosis, and electrolyte disturbances must be hospitalized.

- Other causes of vomiting should be excluded by clinical examination and investigations.
- Intravenous thiamine 100 mg should be considered before initiating IV dextrose, if vitamin B deficiency is suspected.
- Fluids and electrolytes should be replaced. Dextrose saline replaces the sodium and chloride loss due to vomiting. Dextrose provides carbohydrates and prevents utilization of fat and resultant ketosis.
- If serum potassium is low, additional potassium is added to the IV fluids (20 mmol of potassium [1.5 g KCl]) to each bottle of IV fluid.
- Ringer lactate can also be used initially and switched to dextrose saline after 6 hours.
- Dextrose saline should be continued till urine is free of ketone bodies.
- Hypomagnesemia and hypocalcemia also should be looked for and corrected.
- Oral fluids should be introduced gradually.

Pharmacotherapy

Medications are required in most women to control vomiting. In addition, adjunctive therapy is used to reduce acid reflux.

Antiemetic therapy

If pyridoxine with doxylamine is not effective, other drugs may be tried (Table 28.1). Each drug should be continued for a few days before switching to the next.

Table 28.1 Pharmacotherapy

Drug	Dosage	Route
Antihistamines		
• Doxylamine succinate	10 mg one to two times daily	Oral
• Diphenhydramine	25 mg 6 hourly	Oral
• Meclizine	25 mg 6 hourly	Oral
Dopamine antagonists		
• Metoclopramide	10 mg 8 hourly	Oral/IV
• Promethazine	12.5–25 mg 4 hourly	Oral/rectal/IM
Serotonin antagonists		
• Ondansetron	4–8 mg 8 hourly	Oral/IV

Adjuvantive therapy

To reduce gastric acidity, H₂ blockers such as ranitidine or proton pump inhibitors such as pantoprazole or omeprazole can be combined with antiemetics. This combination is effective in women with heartburn and acid reflux.

Management of refractory cases

Refractory hyperemesis is rare. Other underlying causes for vomiting should be excluded.

Treatment of refractory cases consists of the following:

- Total parenteral nutrition till vomiting stops
- Intravenous or intramuscular chlorpromazine 25–50 mg 4–6 hourly
- Intravenous methyl prednisolone 16 mg 8 hourly for 48–72 hours. This is rarely required

Termination of pregnancy is rarely indicated in refractory cases not responding to above measures.

Key points

- Nausea and vomiting is common in pregnancy; it begins by 5–6 weeks, peaks by 9–10 weeks, and subsides by 12–14 weeks.
- Hyperemesis gravidarum is persistent vomiting associated with weight loss of >5%, dehydration, ketonuria, and electrolyte disturbances.
- Risk factors for hyperemesis are younger age, first pregnancy, hydatidiform mole, multifetal pregnancy, genetic factors, female fetus, and past history of hyperemesis, motion sickness, or migraine.
- There are several theories regarding the causation of hyperemesis. Hormonal changes such as increase in human chorionic gonadotropin (hCG), thyroxine, estrogen, and progesterone, *elicobacter* infection, gastrointestinal and hepatic dysfunction, and genetic factors have been implicated.
- Complications of hyperemesis include ketosis, hypochloremic alkalosis, renal failure, thiamine deficiency, and Mallory–Weiss tears.
- Clinical evaluation consists of history, trigger factors, past history of migraine or motion sickness, and family and social history.
- Vital signs, skin turgor, weight, urine output, and uterine size should be checked.
- Blood tests for serum electrolytes and hematocrit, urine examination for ketone bodies, and ultrasonography to rule out hydatidiform mole and multiple pregnancy are essential investigations in hyperemesis.

(Continued)

Key points *Continued*

- Differential diagnosis includes cholecystitis, gastroenteritis, pancreatitis, hepatitis, peptic ulcer, preeclampsia, and HELLP syndrome.
- Initial management is by dietary modification, avoidance of triggers, supportive therapy, and doxylamine and pyridoxine.
- If there is no response and the woman is dehydrated, hospitalization, investigations to exclude other causes, intravenous dextrose saline with potassium supplementation, and additional pharmacotherapy are indicated.
- Refractory cases are rare and may require chlorpromazine or methylprednisolone with total parenteral nutrition.

Self-Assessment

Case-based question

Mrs. GN, 20, had missed her periods and pregnancy test was positive. She had experienced mild nausea a week after the expected date of menstruation but this progressed to vomiting three to four times a day. She was now not able to retain even fluids, was weak and tired, and felt faint on standing. Her concerned husband brought her to the clinic. She was found to be dehydrated and had a weight loss of 4 kg.

1. What is the diagnosis likely to be? How will you differentiate it from simple nausea and vomiting of pregnancy?
2. What is the initial management if she is not dehydrated?
3. If she does not respond to treatment and presents with dehydration, how will you manage?
4. What investigations will you order?

Answers

1. Hyperemesis gravidarum. If clinical examination reveals signs of dehydration, orthostatic hypotension, urine is positive for ketone bodies, and electrolyte abnormalities are present, it is not simple nausea and vomiting of pregnancy.

2. Dietary adjustment with frequent, small quantities of food, avoidance of oily and spicy foods and avoidance of triggers, and doxylamine 10 mg with pyridoxine 10 mg twice daily should be advised.
3. Hospitalization, intravenous dextrose saline infusion, potassium supplementation, intravenous thymine 100 mg, intravenous ondansetron 4–8 mg 8 hourly.
4. Serum electrolytes, urine for ketone bodies, and ultrasonography to exclude hydatidiform mole or multifetal pregnancy. If vomiting is severe and persistent, liver function tests, serum creatinine, and thyroid function tests are required.

Sample questions

Long-answer question

1. Discuss the pathology, etiology, clinical features, and management of hyperemesis gravidarum.

Short-answer questions

1. Etiology of hyperemesis gravidarum
2. Complications of hyperemesis gravidarum

29

Miscarriage and Recurrent Pregnancy Loss

Case scenario

Mrs. HR, 31, gravida 3, para 0, Ab 3, live 0, had three early miscarriages. She reported no medical problems or previous surgeries. She had recurrent pregnancy loss and needed investigation for the cause so that appropriate treatment, if any, could be offered.

Introduction

Miscarriages are quite common, as human reproduction is surprisingly inefficient and wasteful. Miscarriages occur in approximately 15% of confirmed pregnancies.

Recurrent pregnancy loss is a common clinical problem, occurring in approximately 1% of reproductive-aged women. Unfortunately, a definite cause can be established only in 50% of couples. Many supposed causes of recurrent pregnancy loss are controversial. Out of desperation, both the affected couples and their physicians sometimes turn to untested and controversial treatment options.

Miscarriage

Definition

The loss of a pregnancy before 20 weeks is called miscarriage, early pregnancy loss,

or spontaneous abortion. The World Health Organization (WHO) defines miscarriage as expulsion or extraction of an embryo (at or before 10 weeks) or fetus (after 10 weeks), weighing 500 g or less.

Incidence

Miscarriages occur in approximately 15% of confirmed pregnancies. If the loss of unrecognized or subclinical pregnancy losses is taken into consideration, the rate of loss is estimated to be as high as 30% of all pregnancies. The risk of pregnancy loss decreases with increasing gestational age. Although the miscarriage rate up to 20 weeks varies between 8% and 20%, having had a child in a previous pregnancy reduces a woman's risk of miscarriage to 5%. The risk of miscarriage increases with increasing maternal age. It is 10% in women aged 20–24 years, 50% in women aged 40–44 years, and 80% in women aged 45 years or older (Table 29.1).

Table 29.1 Incidence of miscarriage in relation to gestational age and maternal age

Miscarriage	Incidence rate (%)
In confirmed pregnancies	15
Up to 20 weeks	8–20
In unrecognized or subclinical pregnancies	30
Woman with previous child	5
Women aged 20–24 years	10
Women aged 40–44 years	50
Women aged ≥45 years	80

Terminology used for miscarriages

Miscarriage is the commonest complication of early pregnancy. It denotes failure of abnormal embryos or fetuses to progress to viability.

Biochemical loss

Biochemical loss is a pregnancy loss that occurs after a positive pregnancy test [urinary or serum β -human chorionic gonadotropin (β hCG)] but before ultrasound or histological verification. This usually occurs before 6 weeks' gestation.

Clinical miscarriage

The term 'clinical miscarriage' is used when the presence of an intrauterine pregnancy has been confirmed by ultrasound examination or histological evidence. Depending on the gestational age that the miscarriage occurs at, it may be subdivided into the following:

- Early clinical pregnancy loss (before gestational week 10) and
- Late clinical pregnancy loss (gestational weeks 10–20)

Missed miscarriage (missed abortion)

A missed miscarriage in the first trimester is characterized by the arrest of embryonic or fetal development. The cervix is closed and there is no or only slight bleeding.

Recurrent miscarriage

Known earlier as habitual abortion, recurrent miscarriage is defined as three or more consecutive pregnancy losses before 20 weeks' gestation.

Risk factors for miscarriage

The best predictors for miscarriage are maternal age and previous history of miscarriage.

Advanced maternal age

Advancing maternal age has an effect on miscarriage rate. Age primarily affects the oocyte. Older oocytes tend to result in chromosomal abnormalities, and therefore the pregnancies resulting from them tend to miscarry. This is proved by the fact that when oocytes from young women are used to create embryos for transfer to older recipients, implantation and pregnancy rates match those seen in younger women.

Previous spontaneous miscarriage

Having had one miscarriage increases the risk of miscarriage in subsequent pregnancies. The risk of miscarriage in future pregnancy increases exponentially with increasing number of miscarriages (Table 29.2). This is because of the increased probability of an underlying cause for the miscarriage.

Other risk factors

The effect of caffeine on spontaneous miscarriage is controversial, but one to two cups of coffee or the equivalent of 200–300 mg of caffeine/day as coffee, tea, or hot chocolate is considered safe. The risk increases with very high levels of intake (1000 mg/day or more).

Table 29.2 Risk of miscarriage in a future pregnancy

Number of miscarriages	Risk of miscarriage in future pregnancy (%)
0	5
1	20
2 consecutive miscarriages	28
3 or more consecutive miscarriages	43

Nonsteroidal anti-inflammatory drugs (NSAIDs), if used around the time of conception, are associated with an increased risk of miscarriage. These are, therefore, best avoided in women trying for a pregnancy.

Low levels of folate are associated with a higher rate of miscarriage, in the presence of chromosomal abnormality. If the fetus has no aneuploidy, folate levels have no effect on miscarriage rate.

Very low and very high body mass index (BMI) are also risk factors. Other risk factors include smoking (Box 29.1).

Etiology of spontaneous miscarriage (first and second trimesters)

Although most etiological factors can cause first and second trimester losses, some factors are more commonly associated with first trimester losses and some with second trimester miscarriages (Box 29.2).

- Chromosomal and congenital anomalies, maternal infections, medical disorders, and antiphospholipid antibody (APA) syndrome can cause miscarriage in the first or second trimester.
- Uterine anomalies, cervical incompetence, and thrombophilias are associated more often with second trimester losses.

Chromosomal defects

Approximately 50% of miscarriages are caused by chromosomal defects. Aneuploidy (of which trisomy is the commonest) is the chromosomal

Box 29.1 Risk factors for spontaneous miscarriage

- Maternal age
- Previous spontaneous miscarriage
- Low folate levels
- High consumption of caffeine
- NSAIDs at time of conception
- Very high or very low BMI
- Smoking

B = body mass index; SA Ds, nonsteroidal anti-inflammatory drugs.

Box 29.2 Etiology of miscarriage (first and second trimesters)

- Chromosomal defects
 - Aneuploidy (trisomy- commonest)
 - Structural aberrations
 - Mosaicism
- Congenital anomalies
- Uterine abnormalities
 - Uterine septum
 - Submucous fibroid
- Cervical insufficiency (incompetence)
 - Only in second trimester
- Infections
 - isteria monocytogenes*
 - o oplasma gondii*
 - Parvovirus B19
 - Rubella
 - Herpes simplex
 - Cytomegalovirus
- Maternal medical conditions
 - Thyroid dysfunction
 - Polycystic ovarian syndrome
 - Uncontrolled diabetes
 - Cushing syndrome
- Immunological factors
 - SLE
 - Antiphospholipid antibody syndrome
- Prenatal procedures
 - Chorionic villus sampling
 - Amniocentesis

S = systemic lupus erythematosus.

anomaly most often associated with miscarriage. Structural chromosomal aberrations and mosaicism account for a small number of miscarriages. The earlier the pregnancy loss occurs, the higher the chance of chromosomal defect as the cause (Table 29.3).

Congenital anomalies

Major anatomic defects in the fetus, whether resulting from chromosomal or genetic causes,

Table 29.3 Correlation of chromosomal defects with weeks of miscarriage

Week of miscarriage	Prevalence of chromosomal defect (%)
<6 (empty sac)	90
Between 8 and 11	50
Between 16 and 19	30

are usually lethal and can result in spontaneous miscarriages. Almost 20% of morphologically abnormal fetuses have a normal karyotype, and there is no known explanation for why these anatomic defects arise.

uterine abnormalities

A uterine septum may lead to defective implantation and has been associated with miscarriage. Other Müllerian anomalies such as bicornuate and unicornuate uterus are also associated with second trimester miscarriages. Similarly, a submucosal fibroid can interfere with implantation and growth and may result in miscarriage.

Cervical insufficiency (incompetence)

Congenital or acquired structural weakness of the cervix is called cervical insufficiency (earlier known as cervical incompetence). Cervical insufficiency can lead to recurrent second trimester losses/preterm births. It is not associated with early pregnancy loss (see the Section, *Recurrent pregnancy loss*).

Infectious causes

Many acute maternal infections have been implicated in miscarriage. Some of the organisms known to cause miscarriage are *Listeria monocytogenes*, *Toxoplasma gondii*, parvovirus B19, rubella, herpes simplex, or cytomegalovirus. It is important to remember that these do not cause recurrent pregnancy loss (RPL).

Maternal medical conditions

Endocrine disorders such as thyroid dysfunction, polycystic ovarian syndrome, uncontrolled diabetes, and Cushing syndrome have been implicated in miscarriage. **Progesterone deficiency has been studied as an etiological factor, but there is no evidence that there is a difference in progesterone levels in normal pregnancies or failed pregnancies.**

Immunological factors

Autoimmune diseases such as systemic lupus erythematosus (SLE) are associated with

spontaneous miscarriages. Women with and without SLE, who have **antiphospholipid antibodies**, are at a high risk of miscarriage in the first or second trimester. Antiphospholipid antibody syndrome is discussed further in Chapter 54, *Thromboembolic disorders*.

Prenatal procedures

Invasive procedures such as chorionic villus sampling or amniocentesis can result in a miscarriage in 0.5%–1% of cases.

natural progression of miscarriage

A spontaneous miscarriage is a process that can progress through four stages but may not always go through each stage. The natural progression of a miscarriage is **threatened, inevitable, incomplete, and complete**.

Threatened miscarriage

Approximately 25% of all pregnant women have some degree of vaginal bleeding during the first two trimesters. Only half of these cases progress to an actual miscarriage.

A threatened miscarriage (Fig. 29.1) consists of vaginal bleeding, with or without mild abdominal/pelvic pain, in the presence of a

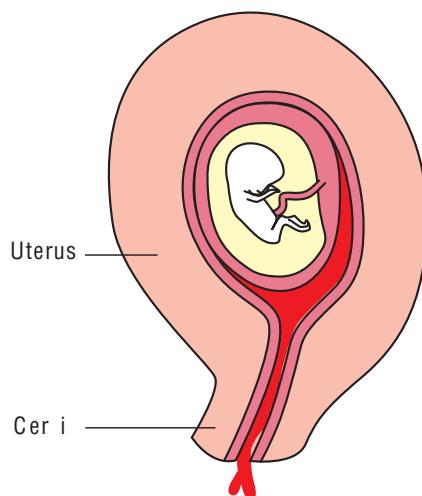


Figure 29.1 Threatened miscarriage. Vaginal bleeding is present, the cervix is closed, and the pregnancy appears normal on ultrasound.

live pregnancy. On abdominal examination, the uterus might be diffusely tender. On vaginal examination, the definitive diagnostic sign is a closed cervical os. The uterine size corresponds to period of gestation. Movement of the cervix does not elicit significant pain, thus ruling out ectopic pregnancy. The bleeding accompanying a threatened miscarriage is usually not very significant and is rarely severe (Box 29.3). An ultrasound examination will reveal an intrauterine pregnancy consistent with the gestational age. If the gestational age is 6 weeks or more, cardiac activity will be identified.

Inevitable miscarriage

Like the name suggests, this stage of a miscarriage cannot be stopped and will inevitably proceed

to an incomplete or complete miscarriage (Fig. 29.2a). The vaginal bleeding is significant and is accompanied with cramping pelvic pains. The uterine size may or may not correspond to the gestational age. The cervical os is open, and the products of conception are felt at the level of the internal os or even in the cervical canal (Box 29.4). The ultrasound examination will reveal the pregnancy in the lower portion of the uterus (close to the internal os) or in the cervical canal (Fig. 29.2b).

Incomplete miscarriage

When a miscarriage occurs but portions of the products of conception are still retained in the

Box 29.3 Diagnosis of threatened miscarriage

- Abdominal examination
 - Diffuse uterine tenderness
- Vaginal examination
 - Vaginal bleeding (usually mild)
 - Closed cervical os
 - Uterine size corresponding to period of gestation
 - No products of conception passed
 - No tenderness on movement of cervix
- Ultrasound examination
 - Intrauterine pregnancy with cardiac activity

Box 29.4 Diagnosis of inevitable miscarriage

- Abdominal examination
 - Uterine tenderness
 - Uterus intermittently hard and globular (contracting)
- Vaginal examination
 - Vaginal bleeding
 - Open cervical os and cervical canal
 - Products of conception felt
 - through the internal os
 - in the cervical canal
- Ultrasound examination
 - Products of conception entering or lying in cervical canal (Fig. 29.3)

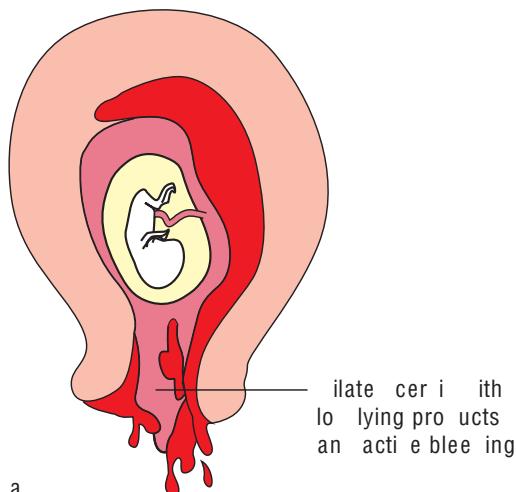


Figure 29.2 Inevitable miscarriage. **a.** Cervix is dilated and products are felt at the internal os or in the cervical canal. **b.** Ultrasound image showing the products of conception lying in the cervical canal. (Photo courtesy: Mediscan Systems, Chennai).

uterus, it is called an incomplete miscarriage. Since the uterus is not able to contract down completely, these retained bits may result in severe bleeding that can sometimes be massive enough to cause hypovolemic shock. In an effort to push out the retained products of conception, the uterus may continue to contract and this results in abdominal pain.

Incomplete miscarriages tend to occur after 12 weeks. In earlier pregnancies, the entire gestation will be expelled. After 12 weeks, the membranes may rupture and the fetus expelled but the placental tissue may still be retained, resulting in an incomplete miscarriage (Fig. 29.3a).

An incomplete miscarriage is diagnosed from the history of passage of tissue with continued bleeding. Examination of the uterus will reveal a uterine size smaller than expected for the gestational age, but the uterus may still be bulky and boggy (not well contracted). The cervical os may be open with products of conception being passed, or the internal cervical os may be closed.

Ultrasonography will help confirm the presence of retained products of conception in the uterus (Fig. 29.3b). Retained products are suspected if the endometrium is >5 mm and a variable amount of echogenic or heterogeneous material is imaged within the endometrial cavity. There will be vascularity that confirms the diagnosis and helps to differentiate it from an intrauterine blood clot (Box 29.5).

Box 29.5 Diagnosis of incomplete miscarriage

- History
 - Bleeding and pain
 - Passage of tissue
- Abdominal examination
 - Uterine tenderness
- Vaginal examination
 - Uterine size smaller than expected
 - Open or closed internal os
 - Partial products of conception
 - Being passed
 - Lying in the vagina
- Ultrasound examination
 - Retained products of conception
 - Endometrium >5 mm
 - Echogenic or heterogeneous material
 - Vascularity present

Complete miscarriage

In a complete miscarriage, the products of conception have been totally expelled from the uterine cavity and cervix. The woman usually gives a history of several hours of vaginal bleeding with severe pelvic cramping, followed by passage of tissue, which eases the bleeding and cramping (Box 29.6). Commonly, this event happens at home.

On examination, the uterus is smaller than the gestational age and well contracted. The cervix is closed. Since the process has resolved, vaginal

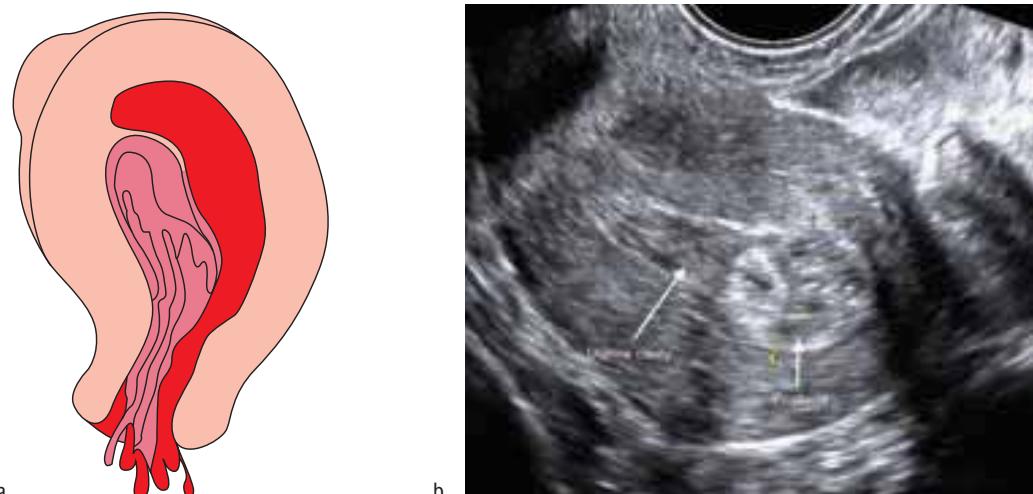


Figure 29.3 Incomplete miscarriage. **a.** Products of conception have been partially expelled. **b.** Ultrasound image showing retained products of conception in the upper part of the uterine cavity. (Photo courtesy: Mediscan Systems, Chennai.)

Box 29.6 Diagnosis of complete miscarriage

- History
 - Several hours of bleeding and pain
 - Easing off of pain after passage of tissue
- Abdominal examination
 - Mild uterine tenderness
- Vaginal examination
 - Uterus small and contracted
 - Cervix closed
- Ultrasound examination
 - Empty uterine cavity
- Examination of abortus

bleeding might be minimal and the abdominal pain may have subsided. Ultrasonography reveals an empty uterine cavity. Diagnosis may also be confirmed by examining the abortus.

Missed miscarriage

A missed miscarriage in the first trimester is characterized by the arrest of embryonic or fetal development. The cervix is closed and there is no or only slight bleeding. Usually the bleeding is in the form of brownish altered blood. The symptoms of pregnancy (nausea, breast tenderness, tiredness) may persist for some time after the fetal demise, but soon the woman may find that they disappear (Box 29.7). It is better termed *delayed miscarriage* or *silent miscarriage*, although this terminology has not been adopted widely.

The diagnosis is made on routine ultrasonography when the fetus is found to be less



Figure 29.4 Missed miscarriage with an empty sac on ultrasound examination. The sac diameter is >25 mm with no yolk sac or embryo seen within the sac. (Image courtesy: Mediscan Systems, Chennai).

developed than its calculated gestational age and has no cardiac activity. It may also present as an empty gestational sac.

Empty sac (anembryonic pregnancy, blighted ovum)

A missed abortion could present sonographically as an empty sac (Fig. 29.4). This is defined as a gestational sac >25 mm without evidence of embryonic tissues (yolk sac or embryo). The term 'blighted ovum' should not be used any longer.

Differences between different types of miscarriage are given in Table 29.4.

Box 29.7 Diagnosis of missed miscarriage

- History
 - There are minimal or no symptoms of bleeding/pain
 - Symptoms of pregnancy may disappear
- Abdominal examination
 - Uterus may or may not be palpable
 - Fetal heart tones are inaudible
- Vaginal examination
 - Uterine size is smaller than expected
- Ultrasound examination
 - Empty sac is present
 - If fetus present
 - Undeveloped or smaller than dates
 - Cardiac activity is absent

Diagnosis and evaluation

The diagnosis of miscarriage necessitates careful elicitation of history. A clinical examination along with an ultrasound examination will help define the type of miscarriage (Box 29.8).

History

It is important to obtain a detailed history regarding abdominal pain and its severity, amount of bleeding and color of blood, passage of products, and disappearance of symptoms of pregnancy such as nausea and vomiting.

Table 29.4 Differences between various stages types of miscarriage

	Threatened miscarriage	Inevitable miscarriage	Incomplete miscarriage	Complete miscarriage	Missed miscarriage
Bleeding	Mild	Heavy/profuse	Heavy/profuse	Heavy/profuse	Minimal (brownish)
Abdominal pain	Mild	Moderate	Moderate	Moderate	Absent
Uterine size \leq gestational age	Corresponds to gestational age	Corresponds to gestational age	Gestational age	<Gestational age	<Gestational age
Cervical os	Closed	Open	Open	Closed/open	Closed
Ultrasound	Live fetus	Products low in cavity	Small bits of products seen in the cavity	Cavity empty	Dead fetus/anembryonic sac

Box 29.8 Examination and investigations in miscarriage

- History
 - Abdominal pain
 - Bleeding
 - Amount
 - Color
 - Symptoms of pregnancy
- Physical examination
 - Vital signs
 - Uterine size
 - Condition of cervical os
 - Presence of products of conception
- Investigations
 - Hemoglobin and hematocrit
 - Severe anemia may indicate need for transfusion
 - Rh type
 - Rh negative
 - Anti-D to prevent Rh alloimmunization
 - Serology
 - VDRL/RPR
 - HIV 1 and 2
- Ultrasound examination

, human immunodeficiency virus; P, rapid plasma reagins test for syphilis; D, venereal disease research laboratory test for syphilis.

Clinical evaluation

Initial signs

Initial examination should include recording of pulse rate and blood pressure, especially if bleeding is heavy.

Blood tests

Certain blood tests are essential when a woman presents with a miscarriage. If she has not recently

had an antenatal checkup where these tests have already been done, it is important to check hemoglobin and hematocrit because severe anemia due to ongoing bleeding may indicate need for transfusion. The Rh type should be known since a woman who is Rh negative will require anti-D to prevent Rh alloimmunization. Serology should be done to rule out the presence of syphilis or human immunodeficiency virus (HIV).

Ultrasound examination

An ultrasound examination plays an important role in diagnosing and classifying miscarriages.

Ultrasound diagnosis of miscarriage

In early pregnancy a failed pregnancy can be suspected when certain sonographic criteria are not met using transvaginal scan (TVS). This is called '**discriminatory level**' and the absence of a finding at the discriminatory level predicts a nonviable pregnancy (Table 29.5).

Table 29.5 Discriminatory levels for early pregnancy events

Time of visualization	Expected finding on transvaginal scan
5 menstrual weeks	Gestational sac
5.5 menstrual weeks	Embryonic pole
Mean sac diameter 8–10 mm	Yolk sac
Crown–rump length >5 mm	Cardiac activity

Ultrasound criteria for failed early pregnancy

The diagnosis of a failed early pregnancy can be based on the following criteria:

- **Gestational sac**

- No fetal pole or yolk sac in a gestational sac with mean sac diameter (MSD) ≥ 25 mm
- No change in MSD on consecutive scans 7 days apart

- **Crown-rump length (CRL)**

- Either of the following findings
 - No heartbeat in an embryo with CRL ≥ 7 mm
 - CRL < 7 mm and no interval growth over 5–7 days

If there is any doubt about the viability of the fetus, it is better to give the pregnancy the benefit of the doubt. The ultrasound should be repeated after 5–7 days, unless there is heavy bleeding and signs of an inevitable miscarriage. If there is no growth, or if cardiac activity does not appear, then the final diagnosis of missed miscarriage is made.

Ultrasound findings that may predict miscarriage

Certain ultrasound findings are predictors of a failed pregnancy.

Abnormal gestational sac

The following abnormalities in the gestational sac may predict a poor outcome and an increased risk of miscarriage:

- A gestational sac that is abnormally small (the amnion is snug around the embryo) or abnormally large (the embryo seems to be floating in the fluid)
- A gestational sac with an irregular contour
- Absence of the double decidual sac sign
- Low sac position in the uterus

Abnormal yolk sac

A yolk sac with the following characteristics may be predictive of a pregnancy loss:

- Large for gestational age
- Irregular

- Free floating in the gestational sac rather than at the periphery
- Calcified

Fetal bradycardia

When a first trimester ultrasound is done, cardiac activity can be identified at ≥ 6 weeks' gestation. The normal fetal heart rate in early pregnancy is 120–140 bpm. A fetal heart rate < 100 bpm at 6–7 weeks is considered to be bradycardia. This is associated with a 40% risk of fetal loss. When the fetal heart rate is < 70 bpm at 6–8 weeks, it predicts a 100% risk of fetal loss.

When fetal bradycardia is observed in early pregnancy, it is important to perform a follow-up ultrasound examination in 1 week to confirm or rule out early fetal demise.

Subchorionic hematoma

A subchorionic hematoma is a collection of blood between the chorion and the endometrium (Fig. 29.5). This may occur spontaneously and is usually associated with vaginal bleeding. In the presence of vaginal bleeding, an important finding on ultrasound examination is a subchorionic hematoma (Fig. 29.6). Although a small hematoma does not increase the risk of miscarriage, larger hematomas have been implicated in an increased risk of miscarriage and other poor pregnancy outcomes such as placental abruption, preterm prelabor rupture of membranes, preterm labor, and stillbirth (Box 29.9).

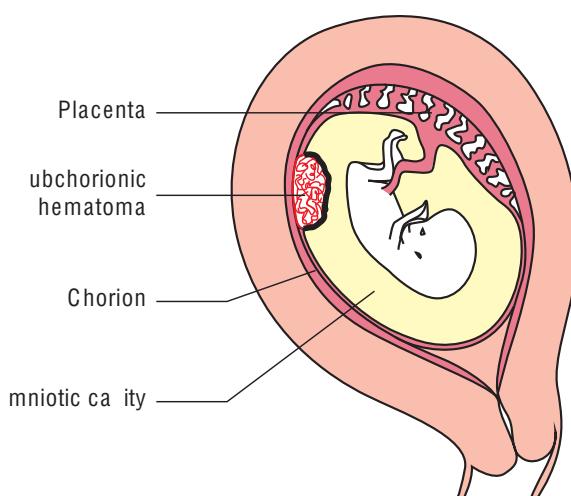


Figure 29.5 Subchorionic hematoma: Collection of blood between the chorion and the endometrium.



Figure 29.6 Ultrasound image of a large subchorionic hematoma lying adjacent to the gestational sac. (Image courtesy: Mediscan Systems, Chennai).

Box 29.9 Subchorionic hematoma

- Small hematoma
 - No increased risk of miscarriage
- Large hematoma $\geq 25\%$ of gestational sac
 - Increased risk of
 - miscarriage
 - placental abruption
 - preterm/prelabor rupture of membranes
 - preterm labor
 - stillbirth

Management of miscarriage

In women with threatened miscarriage, the presence of cardiac activity with a fetal heart rate ≥ 120 bpm is a strong predictor that the pregnancy will proceed normally.

The management of a threatened miscarriage is expectant.

- The patient is reassured. She is placed on restricted physical activity and advised to avoid sexual intercourse for 2 weeks. She is also asked to report back if the bleeding becomes heavy, or if there is increasing abdominal/pelvic cramping or passage of tissue.
- Progestogens have been used for threatened miscarriage. However, since many miscarriages

are caused by fetal chromosomal abnormalities, it seems unlikely that progestogens could prevent a miscarriage. At present there is no strong evidence to support its use.

- Human chorionic gonadotropin and uterine muscle relaxants (e.g., tocolytics, β -agonists) have not been found to be useful and are not recommended.

Inevitable and incomplete miscarriage

Women with an inevitable or incomplete miscarriage may present with profuse bleeding.

emodynamic instability and hypovolemic shock

If the woman is in hypovolemic shock, resuscitation with intravenous fluids should be started and blood products may be required. After the patient is stabilized, surgical evacuation should be proceeded with, as described later.

Expectant management

If the bleeding is minimal and the ultrasound reveals a negligible amount of products in the cavity or cervical canal, expectant management may be advised. The miscarriage will become complete in a few days. The bleeding will reduce or stop, and the abdominal discomfort will disappear. The complete expulsion of the products should be confirmed with an ultrasound.

Medical evacuation

If the patient is not bleeding heavily, is not in pain, and products are seen in the uterine cavity, then medical evacuation with misoprostol is recommended as an outpatient procedure (Box 29.10; see Chapter 13, *Medical termination of pregnancy*).

Surgical evacuation of uterus

Surgical evacuation is indicated when there is no spontaneous expulsion of products or medical evacuation has failed.

- The aim of intervention is to remove the products of conception and empty the uterine cavity

Box 29.10 Medical evacuation for inevitable, incomplete, or missed miscarriages

- Misoprostol
 - 600–800 µg vaginally
- Ultrasound evaluation after 48–72 hours
 - Cavity empty
 - No further intervention
 - Products retained
 - Misoprostol repeated
 - Products still retained after 7–10 days
 - Surgical evacuation
- Medications for
 - nausea and vomiting
 - diarrhea
 - pain

so that further bleeding does not occur. If the products are accessible (lying in the cervical canal or partly in the vagina), they are grasped with an artery forceps or sponge holding forceps and gently teased out. If the products are mostly expelled, evacuation of the uterus can even be done on an outpatient basis.

- If the gestational age is <6 weeks and the products are not easily accessible or very small amounts of products are left in the uterus, manual vacuum aspiration can be performed (see Chapter 13, *Medical termination of pregnancy*).
- If a large amount of products are retained in the uterine cavity, suction curettage may be utilized (Fig. 29.7).
 - The uterine evacuation can be done in an operating room or procedure room.

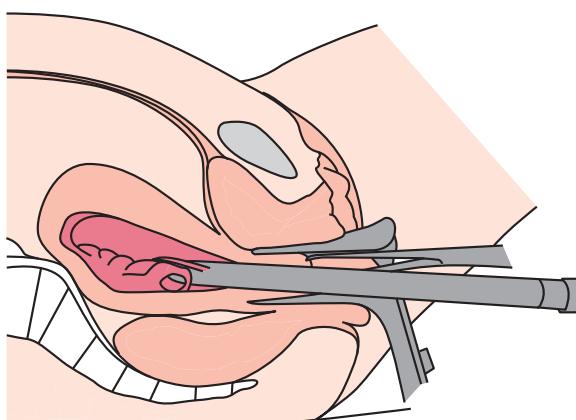


Figure 29.7 Suction curettage for inevitable, incomplete, or missed miscarriage.

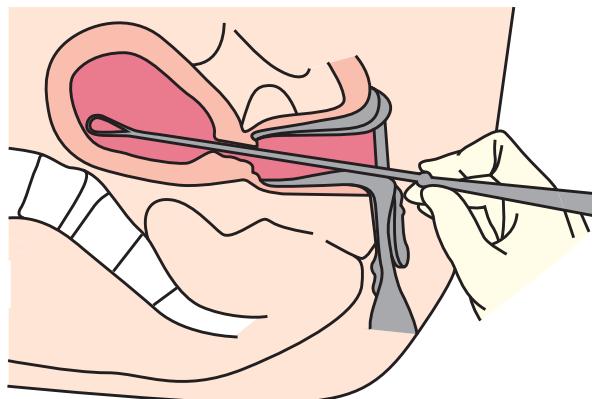


Figure 29.8 Gentle curettage.

- The procedure should be performed under intravenous sedation, spinal, or short general anesthesia.
- After all the tissue is suctioned out, a gentle sharp curettage may be performed to ensure that the uterine cavity is completely empty (Fig. 29.8). A single dose of prophylactic antibiotic is administered (Box 29.11).

Missed miscarriage

Medical evacuation

The same protocol is used for medical evacuation of a missed miscarriage as for inevitable or incomplete miscarriage (see above). This is the

Box 29.11 Surgical evacuation of inevitable or incomplete miscarriage

- Gestational age <6 weeks
 - MVA as outpatient procedure
- Gestational age >6 weeks
 - Inpatient procedure
 - Intravenous sedation/spinal/general anesthesia
- Dilatation not required (os open)
- Evacuation of products
 - Simple removal of products
 - Suction evacuation
 - Sharp curettage if needed
- Single dose of prophylactic antibiotic
- Watch for
 - perforation
 - cervical trauma
 - infection
 - intrauterine adhesions (late complication)

A, manual vacuum aspiration.

preferred method unless there is heavy bleeding or the patient is not willing to wait for expulsion of the products.

Surgical evacuation

Three methods can be used to dilate the cervix, prior to suction curettage:

- Manual dilatation using cervical dilators
- Mechanical dilatation using osmotic dilators (e.g., laminaria)
- Physiological dilatation using prostaglandins

Since the latter two require a few hours to a day to accomplish, in early pregnancy, cervical dilatation is usually done with manual dilators (Fig. 29.9). After the dilatation is accomplished, surgical evacuation is carried out in the same way as for inevitable or incomplete miscarriage.

Complete miscarriage

Clinical examination will confirm a complete miscarriage by the normal or slightly bulky size of the uterus, a closed cervix, minimal or no vaginal bleeding, and cessation of abdominal pain. If there is any doubt about retained tissue, an ultrasound examination will confirm the presence or absence of products in the uterine cavity.

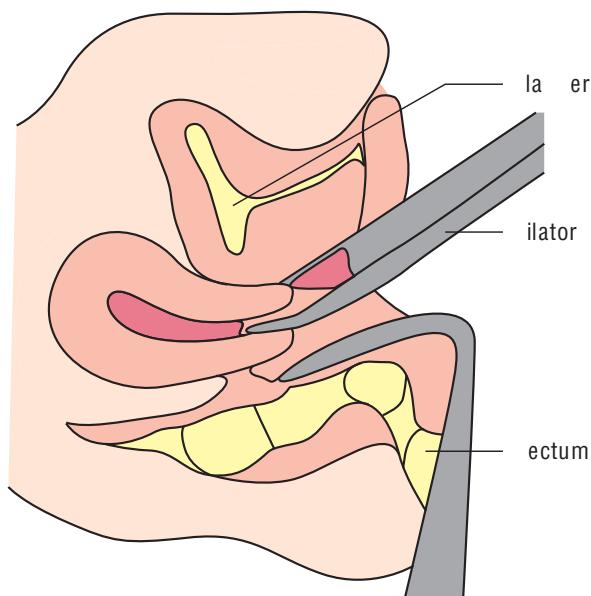


Figure 29.9 Dilatation of the cervix using cervical dilators.

A complete miscarriage does not require any intervention. The woman is reassured that she has expelled the products completely. An oral uterotonic may be prescribed for 24–48 hours.

Prevention of Rh alloimmunization

If a woman is Rh negative and undergoes a miscarriage, there is a small chance of developing Rh alloimmunization. The requirement for anti-D immunoglobulin following miscarriage is as given in Box 29.12.

A dose of 50 µg of anti-D immunoglobulin is effective through the 12th week of gestation, although the standard 300 µg dose may also be given, because it is more readily available.

Postmiscarriage instructions

Postmiscarriage instructions include the following:

- Activity is restricted for 2 weeks.
- Intercourse is avoided for 2 weeks.
- Review is performed after 4–6 weeks.
- Counseling is provided regarding contraception. Intrauterine devices may be inserted or oral contraceptives initiated 4 weeks after the miscarriage.
- Interval to next pregnancy may be 2–3 months.
- Iron supplementation is recommended for 4–12 weeks.
- Emotional support is required for all women after the miscarriage.
- Reassurance to the woman that she is not responsible for the event is essential.

Box 29.12 Recommendations for anti-D immunoglobulin following miscarriage

- No anti-D immunoglobulin is required for
 - gestational age <12 weeks
 - spontaneous miscarriage with no instrumentation
 - threatened miscarriage with live fetus
- 50 µg of anti-D immunoglobulin is recommended for
 - gestational age <12 weeks with recurrent/ heavy bleeding or instrumentation
- Anti-D immunoglobulin is recommended for
 - all pregnancies at gestational age >12 weeks

Complications of miscarriage

The risk of complications following a miscarriage increases as the gestational age increases. It is <1% in pregnancies at 6 weeks or below and increases to 3%–6% at the end of the first trimester.

The complications may arise due to the following etiologies (Box 29.13):

- Incomplete evacuation of the uterus with retained products may lead to hemorrhage, lower abdominal cramping and pain, and, occasionally, low-grade fever.
- Injury may result from instruments used during the procedure. Forceful dilatation of the cervix can lead to cervical trauma and uterine perforation may occur because the pregnant uterus has a soft myometrium that does not require much force to pierce or perforate.
- Infection may result from retained products and may lead to septic abortion. Infection usually begins as endometritis (involving the endometrium). Untreated, the infection may spread further into the myometrium and parametrium. Parametritis may rapidly progress to peritonitis. The patient may develop bacteraemia and sepsis at any stage of septic abortion.
- Vigorous curettage may damage the basal layer of the endometrium leading to formation of granulation tissue that causes intrauterine synechiae (Asherman syndrome). This can result in secondary amenorrhea and infertility.

Box 29.13 Complications of miscarriage

- Incomplete evacuation of the uterus
 - Hemorrhage
 - Abdominal pain
 - Low-grade fever
- Injury due to instruments
 - Cervical trauma
 - Uterine perforation
- Infection
 - Septic abortion
 - Endometritis, parametritis, peritonitis
 - Septicemia
- Vigorous curettage
 - Intrauterine synechiae (Asherman syndrome)
 - Secondary amenorrhea
 - Infertility

Recurrent pregnancy loss

Definition

The term **recurrent pregnancy loss** is used when miscarriage occurs consecutively in three or more pregnancies, prior to the 20th week of pregnancy. Many experts consider two consecutive losses as sufficient for the diagnosis of recurrent miscarriage because the recurrence rate is similar to that after three losses.

When the miscarriages occur before 10 weeks' gestation, they are classified as recurrent 'early' pregnancy loss. A smaller proportion of women with recurrent miscarriage have a 'late' miscarriage (after 10 weeks' gestation and usually before 20 weeks). Causes and recurrence rates may differ between recurrent early miscarriage and recurrent late miscarriage.

Incidence

Recurrent miscarriage occurs in 1% of couples attempting to have a baby. If the definition of RPL is reduced to two consecutive miscarriages, then 2%–5% of couples will face this problem. In women older than 35 years of age, the risk increases even more.

Evaluation is commonly started after the third pregnancy loss but, depending on the nature of the losses and presence of other factors such as maternal age, can start after two pregnancy losses, as the prevalence and frequency of causes found are similar in both groups.

Primary and secondary PL

Two major groups of RPL patients can be identified and they should be assessed separately, because the risk of subsequent miscarriage among these groups varies.

Primary PL

Primary RPL patients are those with at least three consecutive miscarriages with no pregnancy being carried to viability.

Secondary PL

Secondary RPL patients are those with at least three miscarriages who have had a live birth at some time. These patients have a better prognosis for a successful pregnancy.

The majority of investigations and treatments offered to women with RPL are not evidence based. Some contributing factors are known, but in several couples it is difficult to identify the specific problem leading to RPL.

Factors implicated in recurrent miscarriage

There are several factors which have been implicated in the causation of RPL (Box 29.14).

Box 29.14 Factors implicated in recurrent miscarriage

- Epidemiological factors
 - Maternal age ≥ 35
 - Previous history of miscarriage
 - Obesity
- Antiphospholipid antibody syndrome
 - In 15% of women with RPL
 - Untreated can cause 90% fetal loss
- Genetic factors
 - Parental
 - Balanced reciprocal translocation
 - Balanced Robertsonian translocation
 - Embryonic aneuploidy
- Uterine factors
 - Structural abnormalities
 - Intrauterine adhesions
 - Submucous fibroid
 - Cervical laceration
 - Congenital uterine malformations
 - Septate uterus
 - Defective implantation
 - Cervical insufficiency (incompetence)
 - Second trimester RPL
- Endocrine factors
 - Uncontrolled diabetes
 - Untreated thyroid dysfunction
- Immune factors
 - Not proven
- Infections
 - Not implicated in RPL
- Inherited thrombophilias
 - Not proven

P recurrent pregnancy loss.

Epidemiological factors

Maternal age

The risk of miscarriage increases with increasing maternal age. Paternal age has also been implicated. The risk of miscarriage is highest when the maternal age is ≥ 35 years and the paternal age is ≥ 40 years.

Previous history of miscarriage

The risk of further miscarriage increases with each pregnancy loss and can be as high as 40% after three consecutive pregnancy losses.

Besity

Recent studies have linked a BMI $\geq 30 \text{ kg/m}^2$ with recurrent miscarriage.

Antiphospholipid antibody syndrome

Antiphospholipid antibody syndrome is the association between antiphospholipid antibodies and several adverse pregnancy outcomes. This is the most important treatable cause of RPL.

Adverse pregnancy outcomes include the following:

- Three or more unexplained consecutive spontaneous abortions before the 10th week of gestation
- One or more morphologically normal fetal loss at or beyond the 10th week of gestation
- One or more premature births of a morphologically normal neonate before the 34th week of gestation because of placental disease

Antiphospholipid antibodies may be present in 2%–5% of women with uncomplicated pregnancies as compared with 15% of women with recurrent miscarriage. Fetal losses rise from 25%–30% in the absence of APA to 90% in cases of untreated APA syndrome. Evaluation and management of APA syndrome is discussed in Chapter 54, *Thromboembolic disorders*.

Genetic factors

Parental chromosomal rearrangement

Two to five percent of couples with recurrent miscarriage exhibit a balanced reciprocal or Robertsonian translocation in one partner. Reciprocal translocation occurs between homologous chromosomes. Robertsonian translocation is a form of chromosomal rearrangement that occurs in the five acrocentric chromosome pairs, namely, 13, 14, 15, 21, and 22. A balanced Robertsonian translocation results in no excess or deficit of genetic material and therefore causes no abnormalities in the parent who has it. When this translocation is passed on to the fetus, it might be unbalanced. In unbalanced forms, Robertsonian translocations cause chromosomal deletions or additions, resulting in trisomies (Fig. 29.10). When this happens consistently, it results in recurrent miscarriage.

Embryonic aneuploidy

Embryonic aneuploidy is usually implicated in sporadic miscarriages. However, it can also result in recurrent miscarriage. In couples with recurrent miscarriage, 30%–60% of embryos exhibit aneuploidies in further miscarriages.

Uterine factors

Structural uterine abnormalities can interfere with implantation and early pregnancy during the first or second trimester. This may lead to fetal loss.

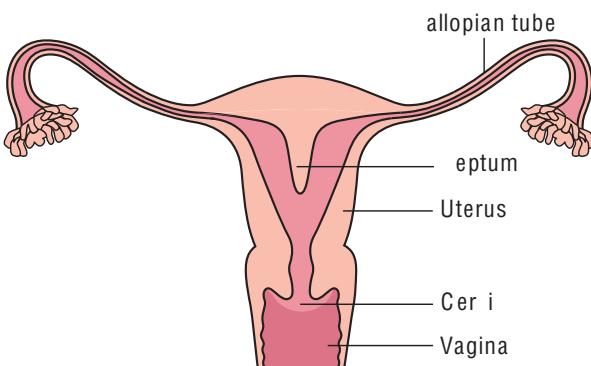


Figure 29.11 Septate uterus. Uterine septum is the commonest uterine abnormality associated with recurrent pregnancy loss.

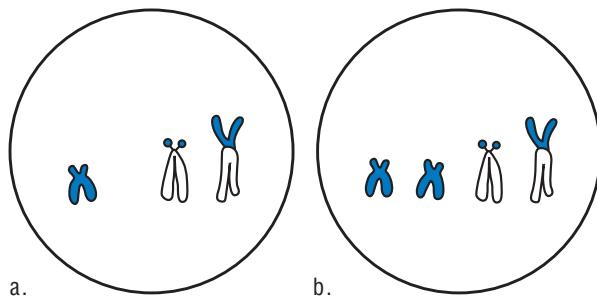


Figure 29.10 Robertsonian translocations. **a.** Balanced Robertsonian translocation between chromosomes 14 and 21 in parent. **b.** The extra chromosomal material on 14 is passed on to the fetus and results in trisomy 21 (Down syndrome).

Congenital uterine malformations

Congenital uterine anomalies are implicated in 10%–15% of women with RPL. The septate uterus (Fig. 29.11) is the most common uterine abnormality associated with RPL, although other Müllerian anomalies such as bicornuate and unicornuate uterus have also been implicated. The longer the uterine septum, the greater is the chance of pregnancy loss. The mechanism by which a septate uterus causes pregnancy loss is not clearly understood, but defective implantation into the poorly vascularized septum is a possibility.

Cervical insufficiency (incompetence)

Cervical insufficiency is defined as the inability of the uterine cervix to retain pregnancy in the second trimester, in the absence of uterine contractions. Congenital or acquired structural weakness of the cervix contributes to cervical insufficiency (earlier known as cervical incompetence). Although this tends to be a congenital condition, cervical injury during a surgical procedure or laceration in a previous pregnancy may also lead to cervical insufficiency.

Cervical insufficiency can lead to recurrent second trimester losses/preterm births. It is not associated with early pregnancy loss.

The typical history is of painless expulsion of the fetus in the second trimester. The expulsion could be preceded by pelvic heaviness/pressure, profuse mucous discharge, or preterm prelabor rupture of membranes. Preterm labor is

also known to occur with cervical insufficiency. Miscarriage typically occurs at 16–24 weeks.

Causes of cervical insufficiency

Cervical insufficiency may be congenital or acquired following surgical procedures on the cervix (Box 29.15).

Diagnosis

The diagnosis of cervical insufficiency is primarily clinical, based on history.

- Speculum examination may reveal a short cervix, evidence of prior surgery, or old tears. If the process of abortion has begun, bulging membranes may be visible through the external os
- Criteria used for ultrasonographic diagnosis of cervical insufficiency:
 - Cervical length of <25 mm between 16 and 24 weeks' gestation
 - Funneling at the internal os
 - Funneling in response to fundal pressure

Endocrine factors

Endocrine disorders have been associated with RPL.

- Uncontrolled diabetes mellitus with high hemoglobin A1c levels can give rise to RPL.
- Untreated thyroid dysfunction is also a known etiological factor.

Since symptomatic women with diabetes or thyroid dysfunction will seek treatment or will be treated after a miscarriage, it is unusual for them to have recurrent miscarriage.

Box 29.15 Causes of cervical insufficiency

- Congenital
- Acquired
 - Forceful dilatation of cervix
 - Cervical tears
 - Cervical amputation
 - Conization
 - Trachelectomy
 - Fothergill surgery
 - LEEP

P loop electroexcision procedure.

Although certain other endocrine factors have been associated with miscarriage, it is difficult to implicate them in recurrent miscarriage.

- Progesterone deficiency is not predictive of pregnancy outcome, and there is no high-quality evidence to support the use of oral or vaginal progesterone to prevent early miscarriage.
- Women with polycystic ovarian syndrome have a higher rate of miscarriage. This may be related to insulin resistance, hyperinsulinemia, and hyperandrogenemia.

Immune factors

Since the fetus is a foreign graft, it is tempting to implicate a host-versus-graft reaction as a reason for RPL. However, there is no evidence to support the hypothesis of human leucocyte antigen (HLA) incompatibility between couples. Therefore, this should not be offered routinely in the investigation of couples with recurrent miscarriage.

Infections

Although any bacterial or viral infection that spreads to the uterus may potentially cause sporadic miscarriage, there is no proven infectious cause of recurrent miscarriage. Thus, screening tests for ureaplasma, chlamydia, and other infectious agents such as toxoplasmosis, rubella, cytomegalovirus, herpes, and listeria are not recommended in the evaluation of recurrent miscarriage. Routine screening for TORCH infections (toxoplasmosis, other, rubella, cytomegalovirus and herpes simplex) should be abandoned in the investigation of RPL.

Inherited thrombophilias

Inherited thrombophilias include activated protein C resistance (most commonly due to factor V Leiden mutation), deficiencies of protein C, protein S, and antithrombin III, hyperhomocysteinaemia, and prothrombin gene mutation. They are associated with venous thromboembolism and also have been associated with adverse outcomes in pregnancies, including fetal loss, preeclampsia, fetal growth restriction, and placental abruption.

However, it is controversial whether there is an association between inherited thrombophilias

and uteroplacental thrombosis that leads to recurrent early pregnancy loss.

Box 29.16 summarizes factors implicated in recurrent miscarriage.

Evaluation of a couple with PL

The evaluation of a couple with RPL aims to

- find factors that have contributed to the RPL,
- provide prognostic value in the subsequent pregnancy, and
- help choose treatment of proven benefit to improve live birth rates.

In spite of detailed evaluation, a significant proportion of cases of recurrent miscarriage

Box 29.16 Factors implicated in PL

- Epidemiological factors
 - Maternal age 35
 - Previous history of miscarriage
 - Obesity
- Antiphospholipid antibody syndrome
 - In 15% of women with RPL
 - Untreated can cause 90% fetal loss
- Genetic factors
 - Parental
 - Balanced reciprocal translocation
 - Balanced Robertsonian translocation
 - Embryonic aneuploidy
- Uterine factors
 - Structural abnormalities
 - Intrauterine adhesions
 - Submucous fibroid
 - Cervical laceration
 - Congenital uterine malformations
 - Septate uterus
 - Defective implantation
 - Cervical insufficiency (incompetence)
 - Second trimester RPL
- Endocrine factors
 - Uncontrolled diabetes
 - Untreated thyroid dysfunction
- Immune factors
 - Not proven
- Infections
 - Not implicated in RPL
- Inherited thrombophilias
 - Not proven

P, recurrent pregnancy loss.

remain unexplained. These couples can be reassured that the chance for a successful future pregnancy with supportive care alone is close to 70%.

History and physical examination

A careful history will contribute information that may help in diagnosing the cause of RPL. The history should include the following:

- *Gestational age at which the previous pregnancy losses occurred:* This is of importance because RPL typically occurs at a similar gestational age in consecutive pregnancies and the most common causes of RPL vary by trimester.
- *The specifics of each pregnancy (anembryonic pregnancy or live embryo):* A live abortus is indicative of structural uterine malformation, whereas in conditions interfering with placental blood flow such as APA syndrome, the fetus is usually dead.
- *Associated pain:* A painless expulsion of the fetus occurring consistently in the second trimester is suggestive of cervical insufficiency.

Physical examination should include a general physical assessment with attention to BMI and pelvic organ abnormalities (e.g., uterine malformation or cervical laceration).

Testing for APA syndrome

It is recommended that all women with recurrent first trimester miscarriage and all women with one or more second trimester miscarriages should be screened before pregnancy for the presence of antiphospholipid antibodies. Anticardiolipin antibody, lupus anticoagulant, and anti- β -2 glycoprotein I are antiphospholipid antibodies that have established assays.

Antiphospholipid syndrome is confirmed when the woman has two positive tests at least 12 weeks apart for either lupus anticoagulant or anticardiolipin antibodies. This is discussed in detail in Chapter 54, *Thromboembolic disorders*.

Structural uterine abnormalities

Anatomic causes of RPL are typically diagnosed using hysterosalpingography (HSG) or

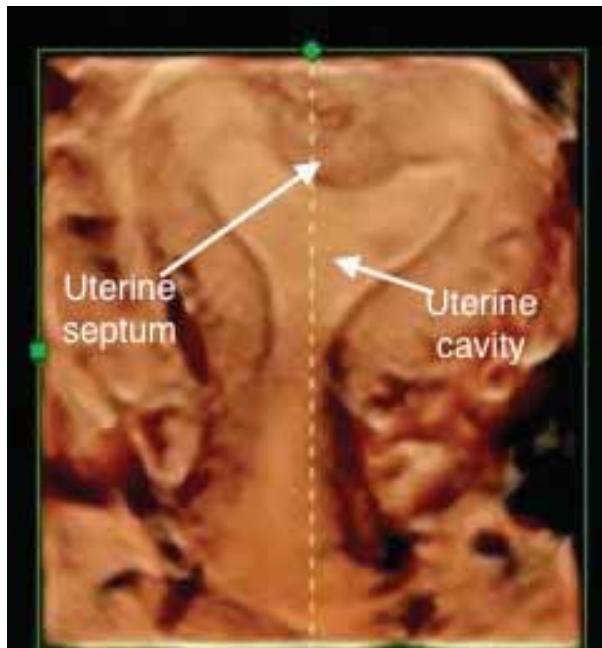


Figure 29.12 3D ultrasound image of a septate uterus.

The septum is splitting the upper part of the cavity into two.
(Photo courtesy: Mediscan Systems, Chennai).

sonohysterography (Fig. 29.12). *Sonohysterography* is a technique in which saline is injected through the cervix into the uterus, and an ultrasound image is obtained of the uterine cavity. The fluid reveals more detail of the uterine cavity than when ultrasound is used alone.

Hysteroscopy, 3D ultrasound, or magnetic resonance imaging (MRI) may also be useful in defining the abnormality but are more expensive modalities.

Parental karyotype and karyotype of the abortus

If the previous two tests are normal, then genetic testing may be done.

- **Karyotyping of both partners** has been found to be helpful in predicting future RPL. Chromosomal abnormalities implicated in RPL are balanced reciprocal or Robertsonian translocation in one partner. Couples found to have these should receive genetic counseling.
- **Chromosomal analysis of the products of conception** is debatable, as some conditions may occur spontaneously. Although controversial, some experts recommend karyotype analysis of the conceptus in couples with

recurrent miscarriage. This recommendation is based on the argument that if the abortus is aneuploid, the physician and the patient can conclude that a maternal cause is excluded.

Screening for diabetes and thyroid dysfunction

Routine testing for diabetes is **not recommended** in the evaluation of recurrent miscarriage unless symptoms or clinical findings warrant testing. Some studies have shown an increased risk of RPL in women with subclinical hypothyroidism and presence of thyroid peroxidase (TPO) antibodies. Therefore, some centers perform thyroid function tests and TPO antibody testing, but these are **not routinely recommended**.

Inherited thrombophilias

Screening for inherited thrombophilias is **not recommended** as their role in recurrent early pregnancy loss is uncertain, and there is no evidence that antithrombotic therapy for this reason effectively prevents miscarriage.

Evaluation of a couple with recurrent miscarriage is given in Box 29.17.

Box 29.17 Evaluation of couple with recurrent miscarriage

- History
 - Obstetric
 - Gestational age at miscarriage
 - Live/dead fetus
 - Associated pain
 - Family/past history
 - Diabetes
 - Thyroid dysfunction
- Physical examination
 - Body mass index
 - Pelvic examination
 - Genital tract anomalies
- Antiphospholipid antibodies
 - Lupus anticoagulant
 - Anticardiolipin IgG and IgM
 - Anti- β -2 glycoprotein1
- Hysterosalpingography or sonohysterography
- Chromosomal assessment
 - Parental karyotyping
 - Karyotyping of abortus controversial

g immunoglobulin G; g immunoglobulin M.

Treatment options for PL

It is important to remember that the prognosis for a successful future pregnancy, even after three early pregnancy losses, is generally good. With or without a known cause for the RPL, the overall live birth rates are still 70%. This means that three out of four couples with RPL will succeed when they try for a live birth. Increasing maternal age and a higher number of miscarriages at the time of initial visit decrease the likelihood of having a live birth.

One of the important lessons that has emerged is that providing emotional support from the beginning of pregnancy enhances the effect of therapeutic measures.

Treatment of APA syndrome

Combined therapy with low-dose aspirin and prophylactic dose heparin is the choice for recurrent miscarriage caused by APA syndrome.

Low-dose aspirin (50–100 mg/day) is started at the earliest confirmation of pregnancy. The heparin is started on ultrasound confirmation of viable intrauterine pregnancy. Either unfractionated or low-molecular-weight heparin (LMWH) may be used (Table 29.6).

Treatment of uterine abnormality

Septate uterus, intrauterine adhesions, and submucous fibroid can be treated with hysteroscopic resection.

Septate uterus

Of the congenital uterine anomalies, uterine septum is the only one that can be treated and corrected by hysteroscopic surgery. A resectoscope is introduced into the uterine cavity, and the location as well as the length of the septum is confirmed. The septum is then incised by needle electrode till a single uterine cavity results.

Cervical insufficiency

Ultrasonography should be performed to confirm intrauterine pregnancy. Infection should be excluded. Cervical cerclage is the recommended treatment for cervical insufficiency. The indication for the cerclage helps in classifying cerclages.

- *History-indicated cerclage:* A history-indicated cervical cerclage is offered between 12 and 14 weeks' gestation in women with a history suggestive of cervical insufficiency. There are no tests that can be done prior to pregnancy to confirm this diagnosis.
- *Ultrasound-indicated cerclage:* This is performed at 14–24 weeks in women with cervical length <25 cm before 24 weeks' gestation, with prior pregnancy loss or preterm labor.
- *Physical examination-indicated cerclage:* This is performed at 16–28 weeks when the cervix is >1 cm dilated and membranes have prolapsed.
- *Emergency cerclage:* This is indicated in women in whom the diagnosis was not made or suspected earlier and who present with the cervix dilated <4 cm and bulging membranes. Rupture of membranes, cervical dilatation >4 cm, and evidence of infection are contraindications to this procedure.

Table 29.6 Drugs for the treatment of antiphospholipid antibody syndrome causing recurrent pregnancy loss

Medication	Dosage	Time of initiating treatment
Low-dose aspirin	50–100 mg oral daily	At the earliest confirmation of pregnancy
Unfractionated heparin	5000 Units SC 12 hourly	On ultrasound confirmation of viable intrauterine pregnancy
LMWH	Enoxaparin, 40 mg SC once daily Dalteparin, 5000 Units SC once daily	On ultrasound confirmation of viable intrauterine pregnancy

Low-molecular-weight heparin; SC subcutaneous.

Techniques for cervical cerclage are as follows:

- Transvaginal cerclage
 - McDonald suture
 - Shirodkar procedure
- Transabdominal cerclage

McDonald procedure

McDonald procedure is the procedure of choice for cervical cerclage (Fig. 29.13). The procedure is performed under spinal or general anesthesia.

- The patient is placed in a dorsolithotomy position.
- The lips of the cervix are held with sponge holding forceps.
- A purse string suture is applied around the cervix, the suture passing through the substance of the cervix, using a nonabsorbable synthetic suture such as polypropylene (Prolene). The knot is tied anteriorly or posteriorly.
- In an emergency cerclage, if the cervix is dilated and the membrane is bulging, it is pushed up gently with a sponge on a holder. Head-down tilt may also be useful in this situation.
- Tocolytics are not administered in a history-indicated cerclage. They may be given for 48 hours in a physical examination–indicated

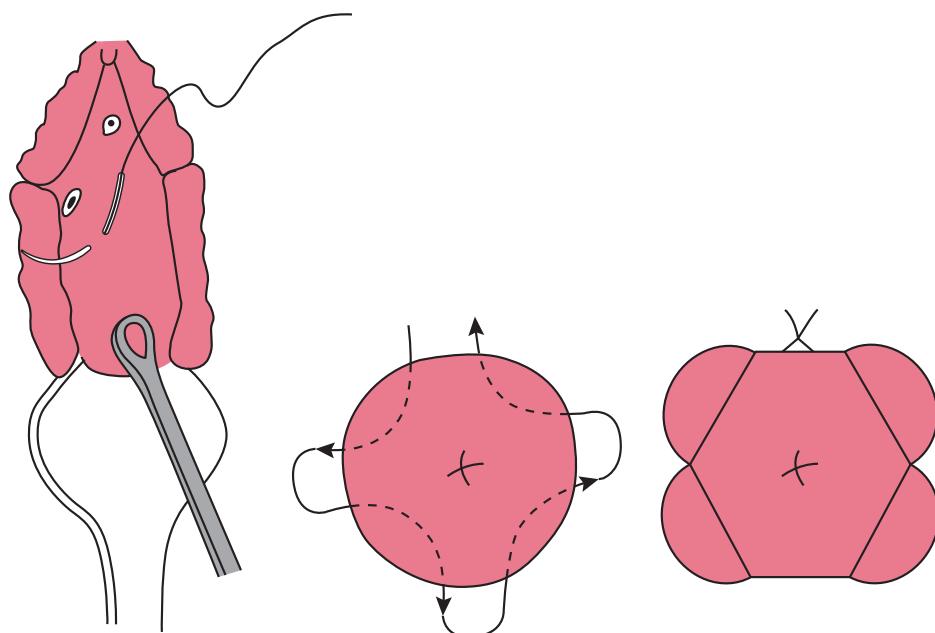


Figure 29.13 A McDonald suture. It is a purse string suture using nonabsorbable synthetic suture placed transvaginally high on the cervix (as close to the level of the internal os as possible). It is removed at 37–38 weeks' gestation.

cerclage or an emergency cerclage done in the second trimester.

- The suture is usually removed at 38 weeks' gestation.

Shirodkar procedure

A Shirodkar cerclage (Fig. 29.14) is indicated in women with previous failed McDonald cerclage. In this procedure, the bladder is dissected and pushed up and the suture is placed at the level of the internal os. A Mersilene tape is used and is passed around the cervix using a specially designed Shirodkar needle.

Transabdominal cerclage

Transabdominal cerclage (Fig. 29.15) is used when vaginal procedures fail or are difficult to perform due to unfavorable cervical anatomy (e.g., a very short cervix). Delivery after transabdominal cerclage is by cesarean section.

Management of parental karyotype abnormality

When one of the parents is found to have a balanced translocation, genetic counseling must be offered.

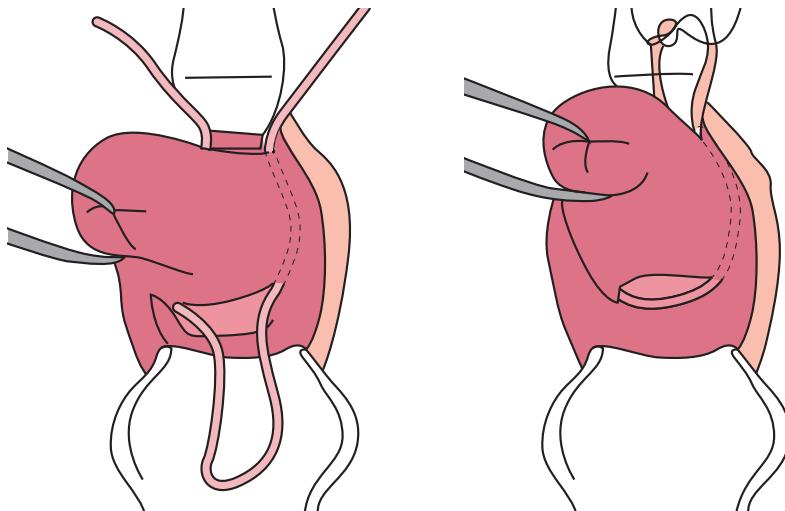


Figure 29.14 A Shirodkar suture. It is placed at the level of the internal os after dissecting the vaginal mucosa upwards. The bladder is retracted and a Mersilene tape is placed under the vaginal mucosa, tightened and knotted.

The following pregnancy outcomes are possible:

- Normal pregnancy and normal fetus
- Normal pregnancy with fetus having a balanced translocation (carrier)
- Fetus with trisomy (e.g., trisomy 21 or Down syndrome)
- Failure to establish a pregnancy
- Pregnancy loss

Couples with balanced translocation should be offered prenatal diagnostic procedures, such as amniocentesis or chorionic villus sampling,



Figure 29.15 Transabdominal cerclage. The suture is placed at the level of the internal os, using a Mersilene tape. It can be done by laparotomy (at 11–12 weeks' gestation) or laparoscopically (preconceptual). The suture is permanent and delivery is always by cesarean section.

to determine fetal karyotype. If the fetus has a trisomy, the couple may choose termination. In vitro fertilization (IVF) with preimplantation genetic diagnosis (PGD) can be used to select a normal embryo.

Treatment modalities of doubtful value

Bed rest

There is insufficient evidence to support a policy of bed rest in order to prevent miscarriage in women who have had RPL. Neither bed rest in hospital nor bed rest at home shows a significant difference in the prevention of miscarriage.

Empirical aspirin with or without heparin

The empirical use of low-dose aspirin, with or without heparin, in the absence of established APA syndrome, has shown no benefit in improving live birth rates in women with RPL. Thus, there is no evidence for this treatment in unexplained RPL. Aspirin and LMWH have also not been shown to be of therapeutic benefit in women with thrombophilia.

Human chorionic gonadotropin

Currently, the use of hCG to prevent pregnancy loss in women with a history of unexplained RPL is not recommended.

Progesterone

In women with recurrent miscarriage, there is not enough evidence to evaluate the effect of progesterone supplementation in pregnancy to prevent a miscarriage. It is of no benefit after 10 weeks' gestation, after the placental production of progesterone begins.

Immunotherapy

Immunotherapy (e.g., paternal cell immunization, third-party donor leucocytes, trophoblast membranes, and intravenous immunoglobulin) has not been shown to be of benefit in women with unexplained recurrent miscarriage.

Treatment options for RPL are given in Box 29.18.

Box 29.18 Treatment options for recurrent pregnancy loss

- Emotional support
- Antiphospholipid antibody syndrome
 - Low-dose aspirin
 - Heparin
 - Unfractionated heparin
 - Low-molecular-weight heparin
- Uterine abnormalities
 - Hysteroscopic resection
 - Intrauterine adhesions
 - Submucous fibroid
 - Septum
 - Cervical insufficiency
 - McDonald suture
 - Shirodkar suture
 - Transabdominal cerclage
- Parental karyotyping abnormality
 - Genetic counseling
 - Amniocentesis or CVS for trisomy
 - IVF and PGD
- Treatment modalities of doubtful or no value
 - Bed rest
 - Aspirin ± heparin in
 - Unexplained RPL
 - Thrombophilias
 - Human chorionic gonadotropin
 - Progesterone
 - Immunotherapy

C S chorionic villus sampling; ICSI in vitro fertilization; P D preimplantation genetic diagnosis; RPL recurrent pregnancy loss.

Key points

Miscarriage

- The loss of a pregnancy before 20 weeks is called miscarriage, early pregnancy loss, or spontaneous abortion.
- The World Health Organization (WHO) defines miscarriage as expulsion or extraction of an embryo (at or before 10 weeks) or fetus (after 10 weeks), weighing 500 g or less.
- Biochemical loss is a pregnancy loss that occurs after a positive pregnancy test but before ultrasound or histological verification.
- Missed miscarriage in the first trimester is characterized by the arrest of embryonic or fetal development. The cervix is closed and there is no or only slight bleeding.
- Known earlier as habitual abortion, recurrent miscarriage is defined as three or more consecutive pregnancy losses before 22 weeks' gestation.
- A spontaneous miscarriage is a process that can progress through four stages but may not always go through each stage. The natural progression of miscarriage is threatened, inevitable, incomplete, and complete.

- Ultrasound findings that may predict a miscarriage include abnormal gestational sac, abnormal yolk sac, fetal bradycardia, and large subchorionic hematoma.
- If there is any doubt about the viability of the fetus, the ultrasound should be repeated after 5–7 days, unless there is heavy bleeding and signs of an inevitable miscarriage.
- Management of miscarriage depends on what stage it is at. Threatened miscarriage can be managed expectantly. Inevitable, incomplete, and missed miscarriages can be managed medically or surgically.
- Postmiscarriage care includes emotional support, iron supplementation, Rh prophylaxis, and contraception.
- Complications of miscarriage include hemorrhage, injury, and infection.

Recurrent pregnancy loss

- The term recurrent pregnancy loss (RPL) is used when miscarriage occurs consecutively in two or three or more pregnancies, prior to the 20th week of pregnancy.

(Continued)

Key points *Continued*

- Patients with primary RPL have had no pregnancy being carried to viability.
- Patients with secondary RPL have had a live birth at some time. These patients have a better prognosis for a successful pregnancy.
- Factors implicated in the etiology of RPL are maternal age, previous miscarriage, obesity, anticardiolipin antibody syndrome, parental balanced translocation, embryonic aneuploidy, and uterine abnormalities.
- Cervical insufficiency (incompetence) is implicated in recurrent second trimester miscarriages.
- Evaluation of RPL includes a thorough history and physical examination, tests for the presence of anti-cardiolipin antibodies, lupus anticoagulant, and anti- β -2 glycoprotein1, uterine cavity evaluation, and parental karyotyping. Karyotyping of the abortus is recommended by some.
- Treatment of RPL depends on the underlying cause. Cervical insufficiency will require cervical cerclage.

Self-Assessment

Case-based questions

Case 1

Mrs. YT, 25, a primigravida, presented at 8 weeks' gestation with moderate vaginal bleeding and mild pelvic cramping. On examination, the cervix was closed and uterine size corresponded to gestational age. Bleeding was minimal.

1. What is the next step in the evaluation?
2. How will you manage her?
3. What would the findings be if this were missed miscarriage? What ultrasound findings would be expected?
4. How will you manage missed miscarriage?

Case 2

Mrs. HR, 31, gravida 3, para 0, Ab 3, live 0, had three second-trimester miscarriages, all painless and with live abortuses. She reported no medical problems or previous surgeries.

1. What are the causes of a second trimester miscarriage?
2. What is the likely cause in this woman? Why?
3. How will you confirm the diagnosis?
4. How will you manage this case of RPL?

Answers

Case 1

1. Ultrasonography should be done to confirm a live fetus with a normal heart rate.
2. Reassure the patient; advise restricted activity and no sexual intercourse for 2 weeks. No medications are required, and follow-up should be advised after 2 weeks.
3. The uterus would be smaller than expected for the gestational age, os will be closed, and the discharge is usually brownish and not fresh blood. Ultrasonography may reveal an empty sac, dead fetus, or fetus smaller than the gestational age.

4. A missed miscarriage can be managed with medical evacuation using misoprostol. If the bleeding is heavy or the patient is unwilling to wait, then a suction evacuation can be done.

Case 2

1. Antiphospholipid antibody syndrome, parental balanced translocation, cervical insufficiency, chromosomal abnormalities, and uterine malformations are the important causes of second trimester miscarriages.
2. The diagnosis is cervical insufficiency since the miscarriages were in the second trimester, painless and the abortuses were live.
3. Diagnosis is by history. Clinical examination may reveal a short cervix, evidence of prior surgery, or old tears. Ultrasonography may be performed between 14 and 24 weeks to measure the cervical length.
4. Cervical insufficiency is treated with a McDonald cerclage at 12–14 weeks' gestation. A Shirodkar cerclage or an abdominal cerclage can be done if a McDonald cerclage fails.

Sample questions

Long-answer questions

1. What are the causes of second trimester miscarriage? How do you diagnose and manage a case of cervical insufficiency?
2. Discuss the etiology, evaluation, and management of recurrent pregnancy loss in first and second trimesters.

Short-answer questions

1. Incomplete miscarriage
2. Missed miscarriage
3. Cervical cerclage
4. Suction evacuation

30

Ectopic Pregnancy

Case scenario

Mrs. HG, 29, had been attempting to conceive for the past 3 years. She had a missed miscarriage 2 years ago and underwent surgical evacuation. She presented at 6 weeks' amenorrhea with intermittent, cramping abdominal pain on the left side. She also had some vaginal spotting and fainted once when she tried to stand up. She was brought to the hospital to check if the pregnancy was proceeding normally.

Introduction

Ectopic pregnancy, though infrequent, can be a life-threatening obstetric condition. Without prompt diagnosis and treatment, it can lead to significant maternal morbidity and mortality. Newer diagnostic methods and a more conservative therapeutic approach have led to lesser mortality and better future fertility.

Definition

A pregnancy that occurs in a site outside the uterine cavity is called ectopic pregnancy. Almost all ectopic pregnancies (98%) are sited in the fallopian tube (Fig. 30.1). The remaining 2% occur in the abdominal cavity, the ovary, or the cervix. With the increasing rate of cesarean sections, ectopic pregnancy in a previous

cesarean scar is reported more often now. It occurs in approximately 1 in 2000 pregnancies and accounts for 6% of ectopic pregnancies among women who have undergone a previous cesarean section.

In the fallopian tube, approximately 80% of pregnancies occur in the ampullary region, and the remaining in other sites, including the isthmus and the interstitial (cornual) portion of the fallopian tube. The interstitial portion of the fallopian tube is the proximal segment that is embedded within the muscular wall of the uterus. A **heterotopic pregnancy** is one in which there is an intrauterine pregnancy as well as an ectopic pregnancy.

Incidence

The incidence of ectopic pregnancies is increasing worldwide, partly due to increasing incidence of

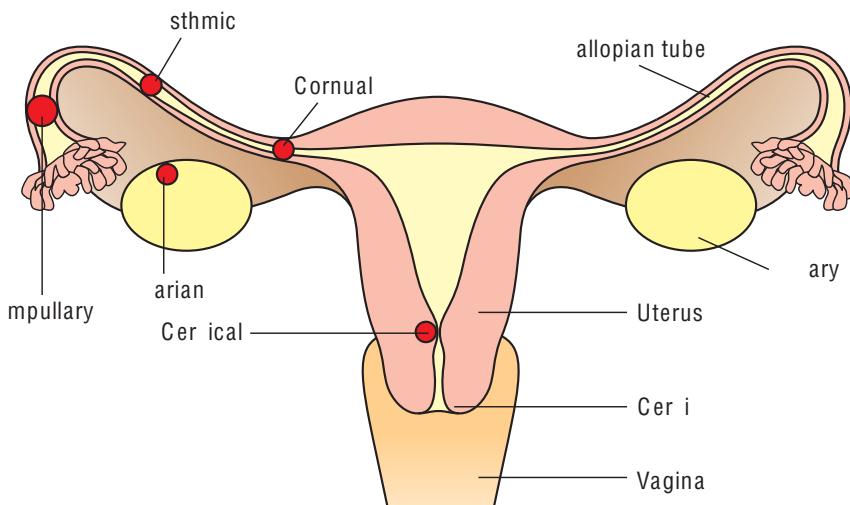


Figure 30.1 Sites of ectopic pregnancy.

pelvic infections and partly due to increasing numbers of assisted reproductive techniques being utilized. The incidence ranges from 6 per 1000 in India to 16 per 1000 in developed countries.

Risk factors

Even though some women with ectopic pregnancy will have no identifiable risk factors, several conditions increase the probability of its occurrence.

Previous ectopic pregnancy

The history of treatment for a previous ectopic pregnancy increases the risk for an ectopic pregnancy in the next pregnancy. One-third of pregnancies following a previous ectopic pregnancy are in an ectopic location. The risk also is modified by whether the ectopic pregnancy was treated medically with methotrexate (MTX) or surgically.

Pelvic infection

Nonspecific salpingitis and chlamydial and gonorrhreal infections (especially when recurrent) lead to tubal damage and therefore have been implicated in the causation of ectopic pregnancy. The rise in chlamydial infection worldwide has been reflected in the increasing numbers of ectopic pregnancy.

After acute salpingitis, the risk of an ectopic pregnancy is increased sevenfold. In addition to

structural damage to the tube (obstruction or adhesions), pelvic infections alter tubal function, thus delaying the passage of the blastocyst, which then implants in the tube.

Infertility

Women undergoing treatment for infertility have a fourfold increase in the incidence of ectopic pregnancy. This is partly due to the higher incidence of tubal abnormality in infertile women. There is also an association between fertility drugs and an increased occurrence of ectopic pregnancy.

In vitro fertilization

Women undergoing in vitro fertilization (IVF) have a two to three times increased risk of both ectopic and heterotopic pregnancy. Cervical and interstitial (cornual) pregnancies are more often seen following IVF.

Tubal surgery

Since ectopic pregnancies result from tubal damage, it follows that tubal surgery will increase the incidence of tubal ectopic pregnancy.

Tubal reconstructive surgery

Women who have undergone reconstructive surgery for obstructed tubes have an increased risk of tubal implantation. The previous infection or ectopic pregnancy that caused the obstruction,

rather than the surgery itself, is believed to be the main reason for an ectopic pregnancy following tubal surgery.

Tubal sterilization

Although the failure rate following tubal sterilization is low, 30% of tubal failures are ectopic implantations. Bipolar coagulation is associated with a much higher risk of ectopic pregnancy than the traditional postpartum tubal ligation.

Intrauterine devices

Since the incidence of any pregnancy is lower in women using intrauterine contraceptive devices (IUDs), the incidence of ectopic pregnancy is also lower in these women. However, if a pregnancy does occur, the risk of ectopic pregnancy is higher. The incidence is higher with levonorgestrel IUDs as compared with copper IUDs.

Tubal conditions

Developmental anomalies of the tube such as a diverticulum can be associated with a tubal pregnancy. Salpingitis isthmica nodosa, an inflammatory condition associated with nodularity and hyperplasia of the muscular layer of the tube, also increases the risk of ectopic pregnancy.

Risk factors for ectopic pregnancy are summarized in Box 30.1.

Pathology

An ectopic pregnancy demonstrates not only tubal changes but will also be accompanied by uterine changes (Box 30.2).

Tubal changes

When implantation occurs in the tube, there is minimal decidual reaction and increase in vascularity. The blastocyst burrows into the tubal wall. The engorged blood vessels are eroded by the chorionic villi, and there is hemorrhage

Box 30.1 Risk factors for ectopic pregnancy

- Previous ectopic pregnancy
- Pelvic infection
 - Nonspecific salpingitis
 - Chlamydia
 - Gonorrhea
- Infertility
 - Tubal factors
 - Fertility drugs
- In vitro fertilization
 - Heterotopic pregnancy
 - Cervical pregnancy
 - Interstitial (cornual) pregnancy
- Tubal surgery
 - Tubal reconstructive surgery
 - Tubal sterilization
- IUD
 - Levonorgestrel IUD
 - Copper IUD
- Tubal pathology
 - Developmental anomalies
 - Salpingitis isthmica nodosa

D, intrauterine device.

around the gestational sac. The tubal wall is stretched and thinned out, and finally ruptures, resulting in hemoperitoneum.

Intermittent pain occurs when the tube distends; when blood escapes into the peritoneal cavity, the pain is acute and severe.

Uterine changes

The uterus enlarges marginally under the influence of progesterone and human chorionic gonadotropin (hCG). The endometrium undergoes decidualization. However, since the implantation is ectopic, chorionic villi are not found in the decidua. A fall in progesterone levels leads to bleeding into the uterine cavity and the appearance of a pseudosac. The decidua may be expelled, leading to external hemorrhage. Occasionally, the entire decidua is expelled as a decidual cast.

In 10%–15% of cases, the endometrial glands undergo adenomatous changes under the influence of progesterone. The lining cells are pleiomorphic, with vacuolated cytoplasm and hyperchromatic nuclei. This is known as the **Arias-Stella reaction**.

Box 30.2 Pathology of ectopic pregnancy

- Tubal changes
 - Minimal decidual reaction
 - Increased vascularity
 - Blastocyst burrows into tubal wall
 - Stretching and thinning of the tubal wall
 - Erosion of the vessels by chorionic villi
 - Tubal rupture
- Uterine changes
 - Enlargement
 - Decidualization of endometrium
 - Expulsion of decidua
 - Pseudosac formation
 - Arias–Stella reaction

natural progression of tubal pregnancy

Complete expulsion absorption

Very early in gestation, the pregnancy may be absorbed entirely or expelled through the uterus. Some intraperitoneal bleeding may occur, but the hemoperitoneum gets absorbed gradually.

Tubal abortion

When implantation occurs in the infundibulum of the tube, the products are extruded into the abdomen through the tubal ostium. This is known as tubal abortion. Blood collects in the pouch of Douglas, leading to the formation of a **pelvic hematocoele**.

Tubal rupture

As already described, the tubal wall is stretched and thinned out and may ultimately rupture. This is common with pregnancies implanted in the isthmus since the lumen is narrow. Rupture occurs by 6 weeks or sometimes earlier when implantation is in the isthmus, and there may be no history of a missed period. Ampullary pregnancies usually rupture by 8–10 weeks because there is more space to expand. Blood collects in the pouch of Douglas and a **large pelvic hematocoele** is usually formed. Continued bleeding can give rise to hemoperitoneum, shock, and collapse.

Occasionally, the rupture is between the layers of the broad ligament, with formation of a **broad ligament hematoma**. Rarely, the pregnancy that is extruded into the abdomen attaches itself to other organs and continues as a **secondary abdominal pregnancy**.

Chronic ectopic pregnancy

The tubal pregnancy may perforate through the wall but be walled off by omentum and loops of bowel, forming a pelvic mass. Acute pain and bleeding may subside, but the woman continues to have chronic pain and a pelvic mass.

The natural progression of a tubal pregnancy is summarized in Box 30.3.

Presenting symptoms

Physicians must have a high degree of suspicion for ectopic pregnancy if a woman presents with amenorrhea, abdominal pain, and vaginal bleeding. In other words, any sexually active woman presenting with abdominal pain and vaginal bleeding after an interval of amenorrhea should be presumed to have an ectopic pregnancy until proved otherwise. Very often with an ectopic pregnancy, the usual symptoms of pregnancy (nausea, vomiting, breast tenderness, fatigue) may not be pronounced.

Amenorrhea

Women with ectopic pregnancy typically present 6–8 weeks after the last normal menstrual period. However, if the pregnancy is in an extrauterine site other than the fallopian tube, the symptoms may occur later than 8 weeks.

Box 30.3 The natural progression of tubal pregnancy

- Complete expulsion or absorption
- Tubal abortion
- Rupture
 - Pelvic hematocoele
 - Broad ligament hematoma
 - Secondary abdominal pregnancy
- Formation of chronic ectopic pregnancy

Abdominal pain

The majority of women (95%) with ectopic pregnancy present with abdominal pain. Abdominal pain associated with ectopic pregnancy may be diffuse but could also be localized to one side. The woman may give a history of mild cramping pain that slowly increases in intensity. The onset of the pain may be acute. The pain may be continuous or intermittent, dull, or sharp. Often, rupture of the tube may be accompanied by a sudden increase in the severity of pain. It may also be accompanied by fainting (syncope).

Accompanying symptoms

When the tube has ruptured and there is increasing collection of blood in the peritoneal cavity, the pain may start radiating upward to the middle or upper abdomen.

When the collection of intraperitoneal blood irritates the inferior surface of the diaphragm, **pain may be referred to the tip of the shoulder**. Pooling of blood in the pouch of Douglas (pelvic hematocoele) may cause an urge to defecate.

Vaginal bleeding

Since vaginal bleeding occurs in other conditions in early pregnancy, it is not specific to ectopic pregnancy. It may vary from brownish staining to heavy bleeding and may also be intermittent or continuous.

Women may misinterpret vaginal bleeding as a normal period, and an ectopic pregnancy may only be suspected when they present with abdominal pain, fainting, and/or shoulder pain.

The presenting symptoms of ectopic pregnancy are listed in Box 30.4.

Signs suggestive of ectopic pregnancy

General examination and vital signs

The general condition of the woman depends on whether the ectopic pregnancy is unruptured or ruptured at the time of presentation.

Box 30.4 Presenting symptoms of ectopic pregnancy

- Amenorrhea
 - Usually 6–8 weeks
- Abdominal pain
 - Diffuse or localized
 - Onset slow or acute
 - Dull or sharp
 - Maybe accompanied by
 - Fainting
 - Shoulder pain
 - Urge to defecate
- Vaginal bleeding
 - Variable quantity
 - May be mistaken for menstrual period

In the early stages, when the bleeding from the tube into the peritoneal cavity is not significant enough, the woman will have stable vital signs. As the bleeding increases, there may be an increase in the pulse rate (tachycardia) and hypotension. She may appear pale.

Since most women with ectopic pregnancy are young and healthy, compensatory mechanisms may keep the vital signs stable. If intra-abdominal bleeding is suspected, postural changes in blood pressure should be checked for. With significant bleeding, the woman may have normal blood pressure while lying down, but she will have hypotension when she is made to sit up (postural hypotension).

A ruptured ectopic pregnancy can result in life-threatening intra-abdominal hemorrhage. Acute rupture of the tubal pregnancy can result in acute hypotension and hypovolemic shock. It is important to remember that most women will have prodromal symptoms and a high index of suspicion will help diagnose an ectopic pregnancy before it ruptures.

Abdominal palpation

Abdominal tenderness is elicited in 90% of women. Unilateral iliac fossa pain is common in an ectopic pregnancy, but due to peritoneal irritation from the blood, bilateral pain is not unusual. Abdominal guarding, rigidity, and rebound tenderness are signs of peritoneal irritation. When hemoperitoneum is present, shifting dullness may be elicited.

Vaginal examination

The uterus may feel soft and slightly enlarged in the presence of an ectopic pregnancy. This is a consequence of the raised levels of progesterone in pregnancy leading to myometrial hyperplasia.

Adnexal tenderness may be elicited, although care must be taken not to palpate too deeply because that might lead to rupture of an unruptured ectopic pregnancy. **The classic sign of a tubal pregnancy is elicitation of pain on the affected adnexal side on movement of the cervix.**

Boggy fullness can be felt in the posterior fornix when blood is collected in the pouch of Douglas. This may push the uterus up and anteriorly against the bladder and cause urinary retention.

Signs suggestive of ectopic pregnancy are summarized in Box 30.5.

Diagnosis of ectopic pregnancy

The aim of good clinical practice is to diagnose an ectopic pregnancy before it ruptures. An

Box 30.5 Signs suggestive of ectopic pregnancy

- General examination
 - Vital signs
 - Early unruptured
 - Stable in early stages
 - Postural hypotension
 - Ruptured
 - Frank hypotension
 - Hypovolemic shock
- Abdominal palpation
 - Tenderness
 - Diffuse
 - Unilateral
 - Bilateral
 - Peritoneal irritation from bleeding
 - Abdominal guarding
 - Rigidity
 - Rebound tenderness
 - Shifting dullness
- Vaginal examination
 - Uterus
 - Soft
 - Slightly enlarged
 - Adnexal tenderness
 - Pain on movement of cervix
 - Bogginess/fullness in posterior fornix

unruptured ectopic pregnancy can be treated conservatively, whereas a ruptured ectopic pregnancy will require surgical intervention. When an ectopic pregnancy ruptures, it becomes a life-threatening emergency.

Early diagnosis

Diagnosing an ectopic pregnancy before it ruptures requires a high index of suspicion. Every sexually active reproductive-aged woman who presents with abdominal pain or vaginal bleeding should be screened carefully for history suggestive of pregnancy symptoms, history that places her at high risk for an ectopic pregnancy, and history suggestive of intra-abdominal bleeding (abdominal pain, feeling faint).

A combination of serum hCG and transvaginal ultrasonography is the best method for diagnosing an ectopic pregnancy.

Serum hCG and discriminatory one

If the urine pregnancy test is positive but an intrauterine pregnancy is not demonstrated on transvaginal ultrasonography (TVUS), then it is mandatory to obtain a serum hCG level.

Commonly, with a serum hCG level of 1500 or 2000 mIU/mL, an intrauterine pregnancy should be demonstrated using TVUS. This is known as the **discriminatory zone** of serum hCG level.

If the serum hCG level is lower than 1500 mIU/mL, the test is repeated in 48 hours. In a normal intrauterine pregnancy, the hCG level will double in 48 hours. At this point an intrauterine pregnancy should be demonstrable. If the hCG level does not double, TVUS must be repeated to demonstrate a failing intrauterine pregnancy (miscarriage) or an ectopic pregnancy.

Transvaginal ultrasonography

Transvaginal ultrasonography is the gold standard for the evaluation of suspected ectopic pregnancy. A transvaginal ultrasound examination may demonstrate an intrauterine pregnancy or an extrauterine pregnancy, or may be nondiagnostic.

Intrauterine pregnancy

The visualization of an intrauterine pregnancy rules out an ectopic pregnancy. However, in a woman who has undergone IVF, a heterotopic pregnancy must be excluded.

Extrauterine pregnancy

A mass lying between the ovary and the uterus is the most common finding in an ectopic pregnancy. The mass could be cystic or solid.

- **Pseudogestational sac:** In the presence of an ectopic pregnancy, the uterine cavity may contain a pseudogestational sac (Fig. 30.2). A pseudogestational sac is a small fluid collection that is centrally located within the endometrial cavity and is surrounded by a thick decidual reaction. This may be demonstrated in up to 20% of women with an ectopic pregnancy.
- **Decidual cysts:** These can be present in both intrauterine and ectopic pregnancies and mimic a gestational sac. They have a thin wall, can be multiple, and are generally located in the peripheral endometrium at the myometrial junction.
- **Empty gestational sac or tubal ring:** This is an adnexal finding that is suggestive, but not diagnostic, of a tubal pregnancy. The cystic center represents the sac and the echogenic ring represents the trophoblastic tissue (Fig. 30.3).
- **Gestational sac with yolk sac and embryo:** Tubal pregnancy may also be identified by



Figure 30.2 Transvaginal ultrasound image of the uterine cavity. The centrally located fluid collection without an echogenic ring (arrow) represents a pseudogestational sac. (Photo courtesy: Mediscan Systems, Chennai.)



Figure 30.3 Transvaginal ultrasound image of adnexa. Empty gestational sac or tubal ring (arrow) seen in the adnexa. No yolk sac or embryo can be identified in the sac. (Photo courtesy: Mediscan Systems, Chennai.)

seeing a gestational sac in the adnexa that contains a yolk sac and embryo (Fig. 30.4). Cardiac activity may or may not be seen. Identification of cardiac activity in an adnexal cystic lesion is 100% pathognomonic of an ectopic pregnancy.

- **Solid adnexal mass:** An ectopic pregnancy may also be seen as a solid mass in the adnexa. This usually happens because of hemorrhage into the ectopic pregnancy, which then loses its cystic appearance and appears solid (Fig. 30.5).
- **Peritoneal fluid:** If echogenic fluid is seen in the cul-de-sac in a pregnant woman with no



Figure 30.4 Transvaginal ultrasound image of adnexa. Viable tubal pregnancy seen with yolk sac. S gestational sac; YS yolk sac. (Photo courtesy: Mediscan Systems, Chennai.)



Figure 30.5 Transvaginal ultrasound image of adnexa. Ectopic pregnancy seen as a solid mass (indicated by arrows) lying adjacent to the ovary. (Photo courtesy: Mediscan Systems, Chennai.)

evidence of an intrauterine pregnancy, it could be suggestive of an ectopic pregnancy. Clear fluid can be considered physiologic, but complex or echogenic fluid is always pathological (Fig. 30.6). With a ruptured ectopic pregnancy, a large quantity of echogenic fluid can be demonstrated in the peritoneal cavity and the pelvic organs and bowel can be seen floating in the fluid.

Doppler imaging

Due to the increased vascularity in an ectopic pregnancy, color flow Doppler may demonstrate



Figure 30.6 Transvaginal ultrasound image. Echogenic peritoneal fluid seen in the cul-de-sac is suggestive of unruptured or ruptured ectopic pregnancy. (Photo courtesy: Mediscan Systems, Chennai.)

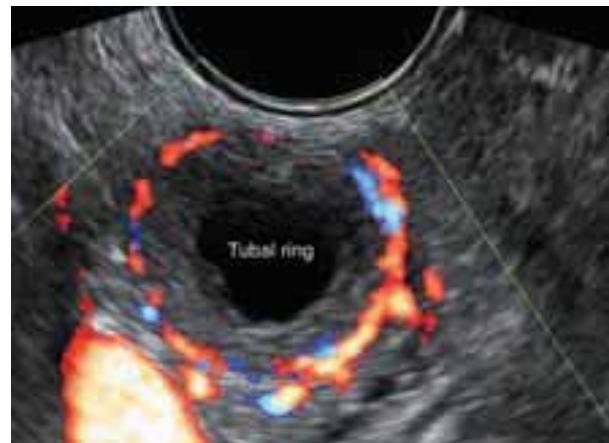


Figure 30.7 Transvaginal ultrasound with color flow Doppler imaging. Increased blood flow ('ring of fire' appearance) seen around the ectopic pregnancy. (Photo courtesy: Mediscan Systems, Chennai.)

increased blood flow around an ectopic pregnancy. This is called the 'ring of fire' appearance (Fig. 30.7). However, this does not help differentiate a tubal pregnancy from a corpus luteum, since a 'ring of fire' appearance can be seen in either condition.

The ultrasonographic findings suggestive of an ectopic pregnancy are listed in Box 30.6.

Culdocentesis

Culdocentesis is aspiration of the contents of the cul-de-sac (pouch of Douglas) to determine whether blood is present. It is a diagnostic procedure where a long 18-gauge needle is inserted

Box 30.6 Ultrasound findings suggestive of ectopic pregnancy in a serum hCG-positive (1500–2000 mU mL) woman

- *uterus*
 - Empty uterine cavity/no evidence of intrauterine pregnancy
 - Pseudogestational sac/decidual cyst
- *Adne ae*
 - Simple adnexal cyst
 - Empty gestational sac (tubal ring)
 - Gestational sac with yolk sac and embryo
 - Cardiac activity: 100% specific
 - Complex/ solid adnexal cyst/mass
- *Peritoneal cavity*
 - Echogenic peritoneal fluid in the cul-de-sac
 - *Doppler color flow imaging*
 - 'Ring of fire' sign: not specific

through the posterior vaginal fornix into the cul-de-sac and fluid is withdrawn (Fig. 30.8). This is performed when pelvic hematoma is detected clinically or on ultrasonography.

A culdocentesis that is positive for nonclotting bloody fluid strongly suggests the presence of a bleeding ectopic pregnancy. The finding of yellow or straw-colored fluid is more suggestive of a ruptured ovarian cyst rather than of an ectopic pregnancy.

Culdocentesis is not commonly performed now because ultrasonography can demonstrate the presence of fluid in the pelvis. The procedure is used when ultrasonography is not readily available or when a rapid confirmation of diagnosis is required in a woman in shock from intra-peritoneal hemorrhage.

Diagnostic laparoscopy

If the ultrasound examination does not give a specific diagnosis or is unable to differentiate between an ectopic pregnancy and a bleeding ovarian cyst, or the woman's condition is hemodynamically unstable, a laparoscopy can be performed to confirm the diagnosis (Fig. 30.9). If there is an unruptured or ruptured ectopic

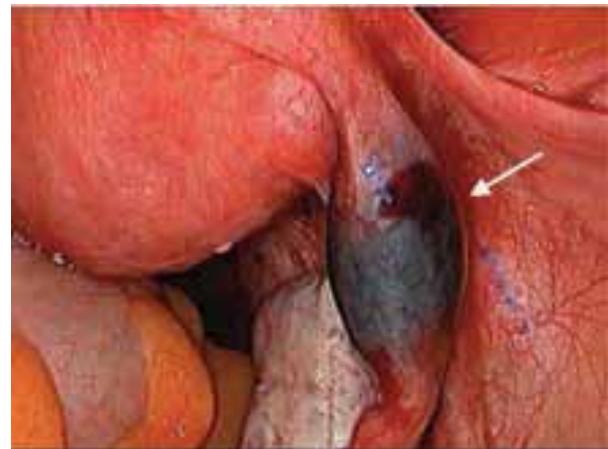


Figure 30.9 Unruptured ectopic pregnancy (arrow) in the right fallopian tube seen on laparoscopy. (Photo courtesy: Dr Sandip Dutta Roy.)

pregnancy, surgical treatment can be carried out laparoscopically (see the section, *Surgical management of tubal ectopic pregnancy*).

Curettage

Presence of trophoblastic villi on endometrial curetting is diagnostic of an intrauterine pregnancy. This may help in diagnosis when a viable

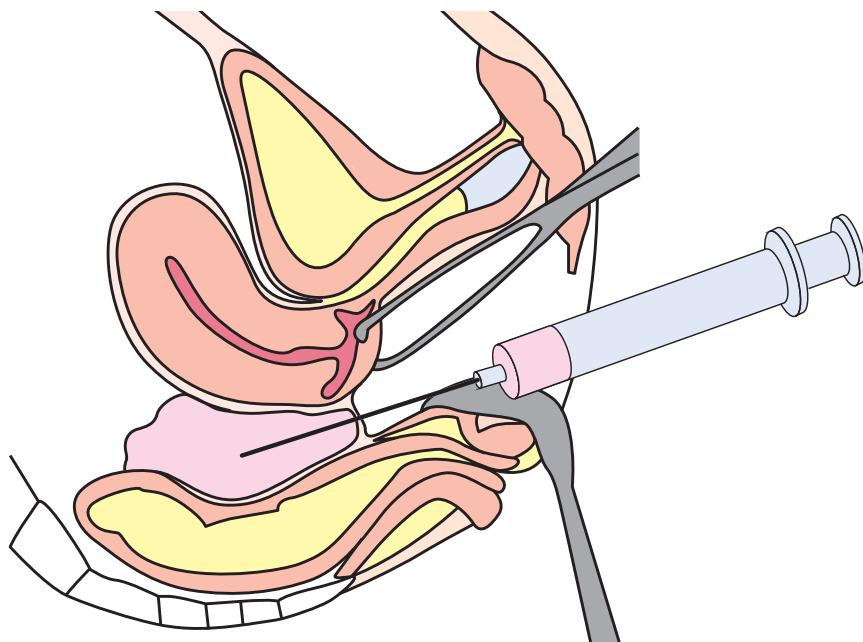


Figure 30.8 Culdocentesis. A long needle is introduced into the cul-de-sac through the posterior vaginal fornix.

intrauterine pregnancy has been excluded. If chorionic villi are present, in the presence of falling hCG levels, a diagnosis of failing intrauterine pregnancy may be made and unnecessary interventions avoided. Curettage, however, is not often used in the diagnosis of an ectopic pregnancy.

Serum progesterone

Serum progesterone level of >25 ng/mL suggests an intrauterine pregnancy. Levels <5 ng/mL indicate a nonviable intrauterine pregnancy or an ectopic pregnancy. The clinical usefulness of this test is limited.

The suggested algorithm for the diagnosis of an ectopic pregnancy is given in Figure 30.10.

Management of ectopic pregnancy

There are three options for the management of an ectopic pregnancy:

- Expectant management
- Medical management with methotrexate (MTX)
- Surgical management

The choice of modality of management depends on the clinical situation. Women who are hemodynamically unstable must be operated upon immediately, whereas in women with an unruptured ectopic pregnancy, other methods may be appropriate. The decision is based on initial evaluation.

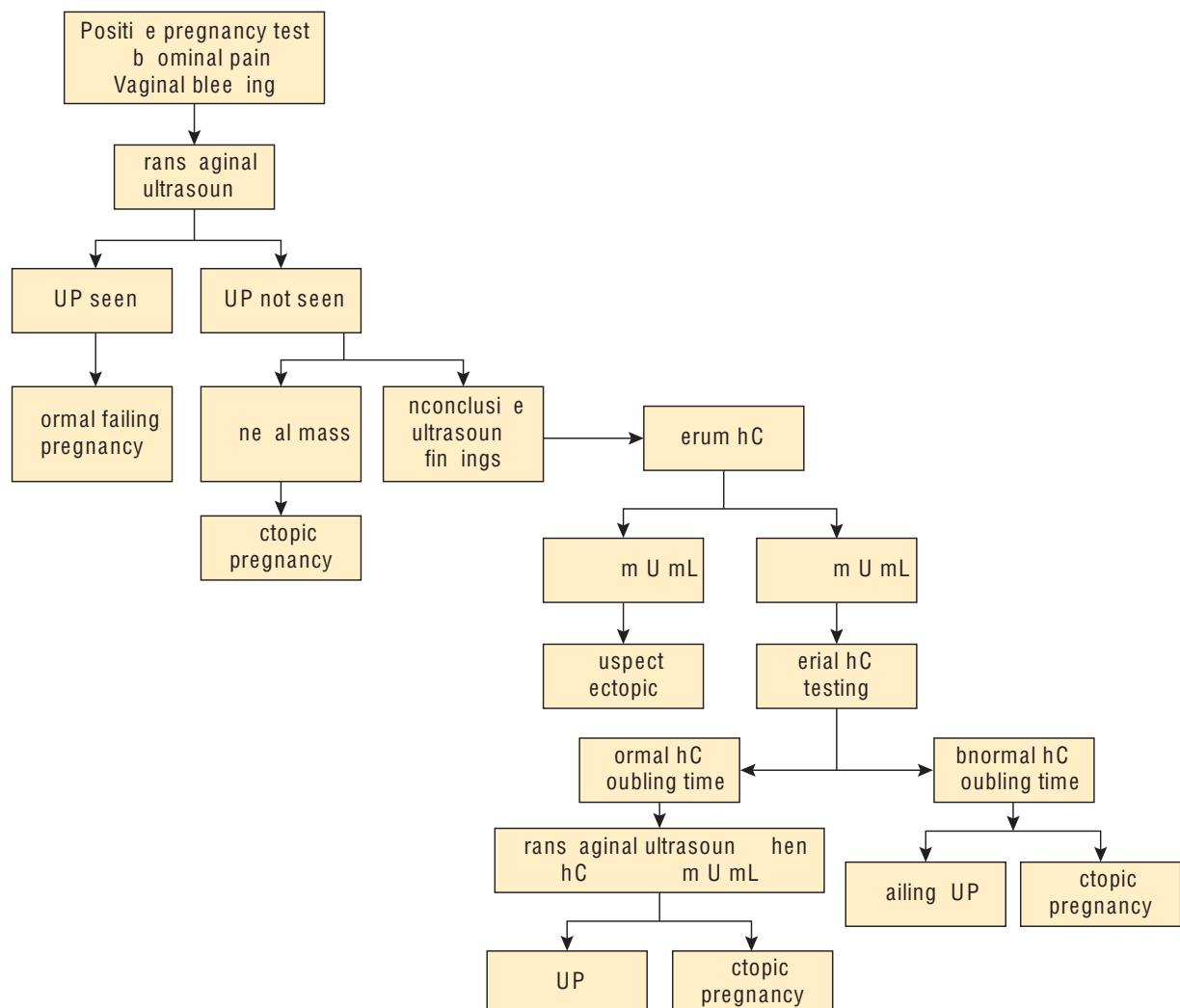


Figure 30.10 Diagnostic pathway for ectopic pregnancy. hC, human chorionic gonadotropin; UP, intrauterine pregnancy.

Box 30.7 Initial evaluation in ectopic pregnancy

- History
 - Risk factors
 - Duration of symptoms
 - Amenorrhea
 - Bleeding
 - Pain
 - Severity
 - Syncope
 - Urinary/bowel symptoms
- Examination
 - Pulse/BP/respiration
 - Abdomen
 - Tenderness/rigidity/shifting dullness
 - Abdominal mass
 - Pelvic examination
 - Adnexal mass/tenderness
 - Fullness in pouch of Douglas
- Ultrasonography
 - Hemoperitoneum
 - Adnexal mass with or without embryo
 - Fetal pole with cardiac activity
- Serum β hCG levels

BP, blood pressure; hC , human chorionic gonadotropin.

Initial evaluation

Initial evaluation consists of history, clinical examination, and investigations as given in Box 30.7.

Following the initial evaluation, women may be categorized as given in Table 30.1. This helps in choosing the appropriate management option.

Management of women who are hemodynamically unstable

Management of women who are hemodynamically unstable includes concomitant supportive and definitive measures.

- If the woman has tachycardia and hypotension, intravenous access should be obtained with a large-bore needle, and IV fluids must be started.
- Blood should be sent for hematocrit, grouping, and cross-matching.
- Transfusion of packed cells or whole blood must be started as soon as possible.
- TVUS, if readily available, should be performed to confirm diagnosis. Culdocentesis may be performed if TVUS is not available.
- The woman should be prepared for laparotomy.

Management options in women who are hemodynamically stable

Women with an ectopic pregnancy who are hemodynamically stable can be managed expectantly if the hCG levels are low. Medical management is indicated in women with hCG levels <5000 mIU/mL and who are compliant with instructions.

Expectant management

Some ectopic pregnancies resolve spontaneously. In hemodynamically stable women, expectant management is a good option.

Table 30.1 Categorization of women according to hemodynamic stability, status of ectopic pregnancy, and hCG levels

Hemodynamic stability	Status of ectopic pregnancy	Serum β hCG level
Stable	No gestational sac or adnexal mass	Low
	Gestational sac/adnexal mass present	Moderately high
	Unruptured ectopic gestation with cardiac activity	Moderately high
Hemodynamically Unstable	Ruptured ectopic pregnancy	Variable

hC , human chorionic gonadotropin.

The cases selected for expectant management are not chosen by the size of the ectopic pregnancy on TVUS. The decision depends on the initial hCG titer and whether repeated hCG titers are trending down.

It is important, therefore, to serially monitor serum titers of hCG in women who are being managed expectantly. The higher the serum concentration, the more likely that expectant management will fail.

The candidates for expectant management are chosen if:

- transvaginal ultrasonography does not show a gestational sac or demonstrates an extrauterine mass suspicious for an ectopic pregnancy and
- the hCG concentration is low (≤ 200 mIU/mL) and declining on serial monitoring.

The woman must be informed about signs of impending rupture and asked to report back immediately at the appearance of any symptoms or signs of rupture. If hCG levels are increasing or if there are signs of tubal rupture, the woman should be treated medically or surgically.

The prerequisites for expectant management are listed in Box 30.8.

Medical management with methotrexate

The advantage of early diagnosis of an unruptured ectopic pregnancy is that it can be managed medically with MTX. Selecting the right candidates for medical management can yield a success rate of nearly 90%.

Methotrexate is a folic acid antagonist that inhibits DNA synthesis and cell reproduction, primarily in actively proliferating cells such as malignant cells, trophoblasts, and fetal cells. Its cytotoxic effect prevents further proliferation

of trophoblastic cells and leads to tubal abortion. Since it is used at a much lower dose than that used for treatment of malignancy, the side effects are fewer than with higher doses.

In spite of giving MTX, some ectopic pregnancies may go on to rupture. This must be explained to the woman, and she should be counseled about the symptoms of impending rupture (sudden increase in abdominal pain, fainting). She should have rapid access to a medical institution with surgical facilities.

Selection of women for treatment with methotrexate

The criteria for the optimal candidate for MTX treatment of ectopic pregnancy are enumerated in Box 30.9.

Contraindications to the use of methotrexate

The contraindications for the use of MTX are listed in Box 30.10.

Treatment protocols for methotrexate

Two regimens have been described: single-dose and multidose. Both have a success rate of 90%, although the multidose regimen results in more side effects.

Box 30.9 Optimal candidate for methotrexate therapy

- Hemodynamically stable
- Willing and compliant with follow-up
- Serum hCG level ≤ 5000 mIU/mL
- No fetal cardiac activity
- Ectopic mass size $< 3-4$ cm

hCG, human chorionic gonadotropin.

Box 30.8 Prerequisites for expectant management of woman with ectopic pregnancy

- Hemodynamically stable
- On TVUS
 - No gestational sac
 - No extrauterine mass
- hCG level ≤ 200 mIU/mL and declining

hCG, human chorionic gonadotropin; *S*, transvaginal ultrasound.

Box 30.10 Contraindications to methotrexate

- Hemodynamic instability
- Signs of impending or ongoing rupture
 - Severe or persistent abdominal pain
 - > 300 mL of free peritoneal fluid outside the pelvic cavity
- Hepatic, renal, or hematologic dysfunction
- Poor access to medical facilities
- Not compliant with follow-up

Single dose regimen

A single intramuscular (IM) dose of MTX is the simplest and most convenient protocol for MTX therapy. Although 15%–20% of women will require a second dose, <1% of women need more than two doses.

Calculation of dose

The dose of MTX is based on body surface area (in m^2). An average Indian woman has a body surface area of 1.5–1.6 m^2 . The dose given for a tubal ectopic pregnancy is 50 mg/ m^2 . For the average Indian woman the dose of MTX is 75–80 mg IM, based on the body surface area.

Protocol

The following protocol is used for the single-dose regimen (Table 30.2):

- The baseline hCG level prior to administering MTX is an important number because further management is based on this value.
- The day the first dose is given is counted as Day 1.
- The commonest protocol measures the serum hCG levels on Days 4 and 7.
- If the decrease in hCG between Days 4 and 7 is <15%, a second dose of MTX 50 mg/ m^2 IM is administered. It is not uncommon to observe an increase in hCG levels until Day 4. This is due to continued hCG production by the syncytiotrophoblast despite cessation of production by the cytotrophoblast.
- Some protocols recommend only one measurement of serum hCG on Day 7. In that case, a second dose of MTX is administered if the serum hCG concentration on Day 7 has not declined by at least 25% from the Day 1 level.

Single multidose regimen

In the most common protocol used for the multidose regimen, MTX is alternated with folinic acid ('folinic acid rescue'). Folinic acid bypasses the metabolic block induced by MTX, and thus rescues normal cells from toxicity.

Protocol

The following protocol is used for the multidose regimen (Table 30.3):

- MTX at the dose of 1 mg/kg IM or IV is given on Days 1, 3, 5, and 7.
- Oral folinic acid at the dose of 0.1 mg/kg is given on Days 2, 4, 6, and 8.
- Serum hCG levels are checked on Days 1, 3, 5, and 7 (the days on which MTX is given).
- If the serum hCG declines >15% from the previous measurement, treatment is stopped and hCG levels are checked weekly.
- If the hCG declines <15% from the previous level, the woman is given an additional dose of MTX (1 mg/kg IM) followed by a dose of oral folinic acid (0.1 mg/kg) the next day.
- The hCG levels are checked till a nonpregnant level is reached.

Monitoring the woman on methotrexate therapy

The woman is monitored for the following:

- Signs of worsening disease
 - Abdominal pain
 - Fluid in pelvis on TVUS
 - Fall in hemoglobin levels to <10 g/dL
- Effectiveness of therapy
- Side effects of MTX

Table 30.2 Single-dose regimen of methotrexate therapy for tubal ectopic pregnancy

Day	Serum hCG level	Methotrexate
Day 1	Note the base-line level	50 mg/ m^2 (approximately 75–80 mg IM)
Day 4	Check the level (remained the same/increased/ decreased)	Methotrexate not given
Day 7	Check the level ($\geq 15\%$ decrease from Day-4 level/ $\geq 25\%$ decrease from Day-1 level)	Repeat dose if hCG level decreases <15% from Day-4 level or <25% from Day-1 level
Weekly	Check levels until nonpregnant levels are reached	If hCG levels plateau or increase, dose may be repeated

hCG, human chorionic gonadotropin; IM, intramuscular.

Table 30.3 Multidose regimen of methotrexate therapy with folic acid rescue for tubal ectopic pregnancy

Day on which methotrexate given (1 mg/kg IM or I)	Days on which folic acid given (0.1 mg/kg orally)	Days on which hCG checked	Stop treatment	Follow-up
1, 3, 5, 7	2, 4, 6, 8	1, 3, 5, 7	When hCG level drops ≥ 15% from previous level	Weekly until hCG level is not detected

hC, human chorionic gonadotropin; I, intramuscular.

Signs of worsening disease

It is important to remember that with MTX therapy, the woman may experience increase in pain from days 4–7 of therapy. This is usually due to tubal abortion or hemorrhage into the ectopic pregnancy. The pain can be managed with paracetamol. Nonsteroidal anti-inflammatory drugs (NSAIDs) should not be used along with MTX due to significant drug interaction.

If the abdominal pain is severe, the woman must be evaluated with TVUS for intra-abdominal bleeding or rupture.

Therapy with MTX is summarized in Box 30.11.

Side effects of methotrexate

The single-dose regimen has fewer side effects than the multidose regimen. However, due to the low dose of MTX used (as compared with the dose used for malignancy), the side effects are usually mild and transient.

Box 30.11 Therapy with methotrexate

- Methotrexate
 - Folic acid antagonist
 - Inhibits DNA synthesis and cell reproduction
 - Affects trophoblasts and fetal cells
- Single-dose therapy
 - 50 mg/m² IM
 - hCG level checked on Days 4 and 7
 - Dose repeated if needed
- Multidose therapy
 - Methotrexate on Days 1, 3, 5, and 7
 - Folinic acid on Days 2, 4, 6, and 8
- hCG levels followed weekly till undetectable
- Signs of tubal rupture watched for

The common side effects of MTX are listed in Box 30.12.

Surgical management of tubal ectopic pregnancy

Medical therapy is the treatment of choice for an unruptured tubal ectopic pregnancy. However, there are clinical situations where surgical intervention is required. The indications for surgical therapy are summarized in Box 30.13.

Box 30.12 Side-effects of methotrexate

- Nausea and vomiting
- Stomatitis
- Conjunctivitis
- Rare side effects
 - Gastritis
 - Enteritis
 - Dermatitis
 - Pneumonitis
 - Alopecia
 - Elevated liver enzymes
 - Bone marrow suppression

Box 30.13 Indications for surgical therapy

- Hemodynamic instability
- Suspected rupture
- When MTX is likely to fail
 - hCG >5000 mIU/mL
 - Sac size >4 cm
 - Cardiac activity demonstrated
- Other contraindications to MTX
- Failed medical therapy

Surgical options for unruptured ectopic pregnancy

The two surgical options for the management of an unruptured tubal ectopic pregnancy are as follows:

- Salpingostomy
- Salpingectomy

Both procedures can be done either by laparoscopy or by laparotomy.

Salpingostomy

A salpingostomy involves the following steps:

- To minimize bleeding, a dilute solution containing vasopressin may be injected into the mesosalpinx just below the ectopic pregnancy and on the overlying serosa (Fig. 30.11a).

- A 1- to 2-cm incision (called a linear salpingostomy) is made through the antimesenteric wall of the tube, overlying the ectopic pregnancy (Fig. 30.11b).
- The products of conception are then flushed out of the tube with gentle mechanical pressure (Fig. 30.11c).
- Alternatively, aquadissection (pressurized irrigation) is used. The aquadissector, or a syringe filled with saline, is inserted deep into the incision. The pressurized fluid dissects and dislodges the ectopic pregnancy and clots.
- Any bleeding sites are treated by applying pressure with forceps or by cauterizing the bleeding points. The incision is not sutured but instead left to heal on its own (closure by secondary intent (Fig. 30.11d).

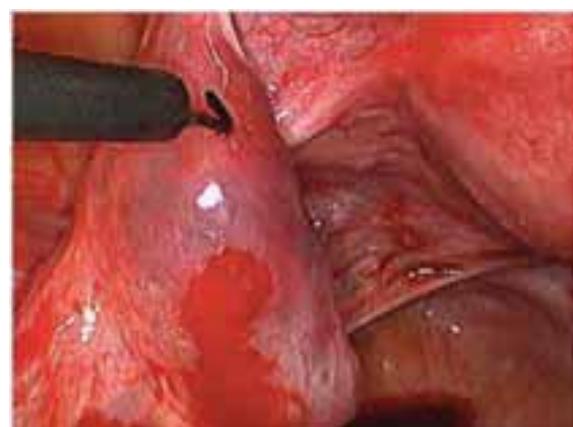


Figure 30.11 Salpingostomy. **a.** Vasopressin being infiltrated into the serosa. **b.** Incision being made with monopolar L-hook on anti-mesenteric border. **c.** Ectopic mass extruding through the salpingostomy. **d.** The incision is left unsutured. (Photo courtesy: Dr Sandip Dutta Roy.)

Drawbacks of salpingostomy

Although salpingostomy conserves the tube, there are some drawbacks associated with the procedure. These drawbacks are summarized in Box 30.14.

Salpingectomy

Excision of the affected tube is called salpingectomy. The procedure is usually done laparoscopically but may require a laparotomy in certain situations.

Salpingectomy may be

- total or
- partial.

Total salpingectomy

Total salpingectomy is preferred to partial salpingectomy. This can be achieved by progressively coagulating or clamping and cutting the mesosalpinx, starting from the fimbrial end and advancing toward the proximal isthmic portion of the tube (Fig. 30.12a and b). At this point, the tube is separated from the uterus by coagulating or ligating and excising with scissors.

Partial salpingectomy

A partial salpingectomy is sometimes done by removing only the ectopic pregnancy and the portion of the tube distal to it. Since there is a risk of recurrent ectopic pregnancy in the same tube, a complete salpingectomy is a better option.

The indications for salpingectomy are listed in Box 30.15.

Box 30.14 Drawbacks of salpingostomy

- 20% converted to salpingectomy because of uncontrolled bleeding
- Increased risk of recurrent ectopic pregnancy in the same tube
- No increase in fertility when compared with salpingectomy
- Small risk of persistent trophoblastic tissue in tube

Box 30.15 Indications for salpingectomy

- Ruptured ectopic pregnancy
- Uncontrolled hemorrhage
- Further fertility not desired by the woman
- Failed tubal sterilization/reconstruction followed by ectopic pregnancy
- Chronic tubal pregnancy
- Severely damaged tube

In ications or laparotomy

Although laparoscopy is the preferred route for the surgical management of a tubal ectopic pregnancy, there are certain situations where a laparotomy is the better choice.

The indications for a laparotomy are enumerated in Box 30.16.

Surgical management for ectopic pregnancy is summarized in Box 30.17.

Management of ectopic pregnancy is outlined in Figure 30.13.

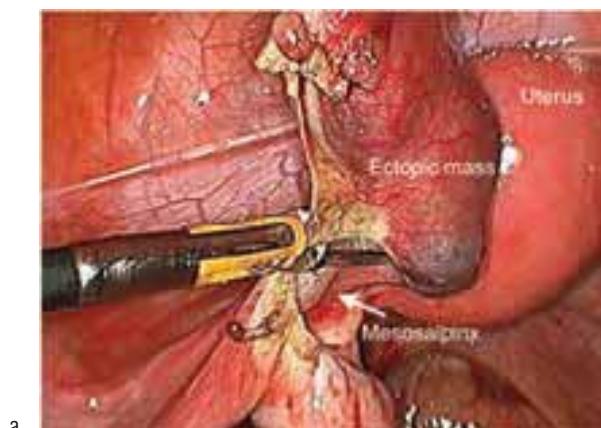


Figure 30.12 Laparoscopic salpingectomy. **a.** The mesosalpinx is being progressively coagulated. **b.** The mesosalpinx is being cut till the proximal isthmic end of the tube is reached. (Photo courtesy: Dr Sandip Dutta Roy.)

Box 30.16 Indications for laparotomy

- Hemodynamically unstable woman
 - Severe intra-abdominal bleeding
- Cornual ectopic pregnancy
- Laparoscopic approach technically difficult due to
 - Multiple dense adhesions
 - Obesity

Box 30.17 Surgical therapy for ectopic pregnancy

- Laparoscopy or laparotomy
- Salpingostomy
 - Unruptured tubal ectopic pregnancy
 - Conserves tube
- Salpingectomy
 - Ruptured tubal ectopic
 - Hemodynamically unstable woman
 - Preferred option if other tube is healthy
 - Total salpingectomy preferred to partial

Follow-up of surgery for ectopic pregnancy

The incidence of persistent trophoblastic tissue is greater with salpingostomy, especially if the initial hCG level was >3000 mIU/mL. After salpingostomy, the woman should be followed with serum hCG levels till the level becomes undetectable.

Contraceptive advice should be given and effective contraception should be used for 3–6 months.

Interstitial (cornual) pregnancy

Pregnancy may be implanted in the portion of the tube that traverses the myometrium. Diagnosis may be delayed due to its unusual location. These women present later in gestation than those with pregnancy in the other parts of

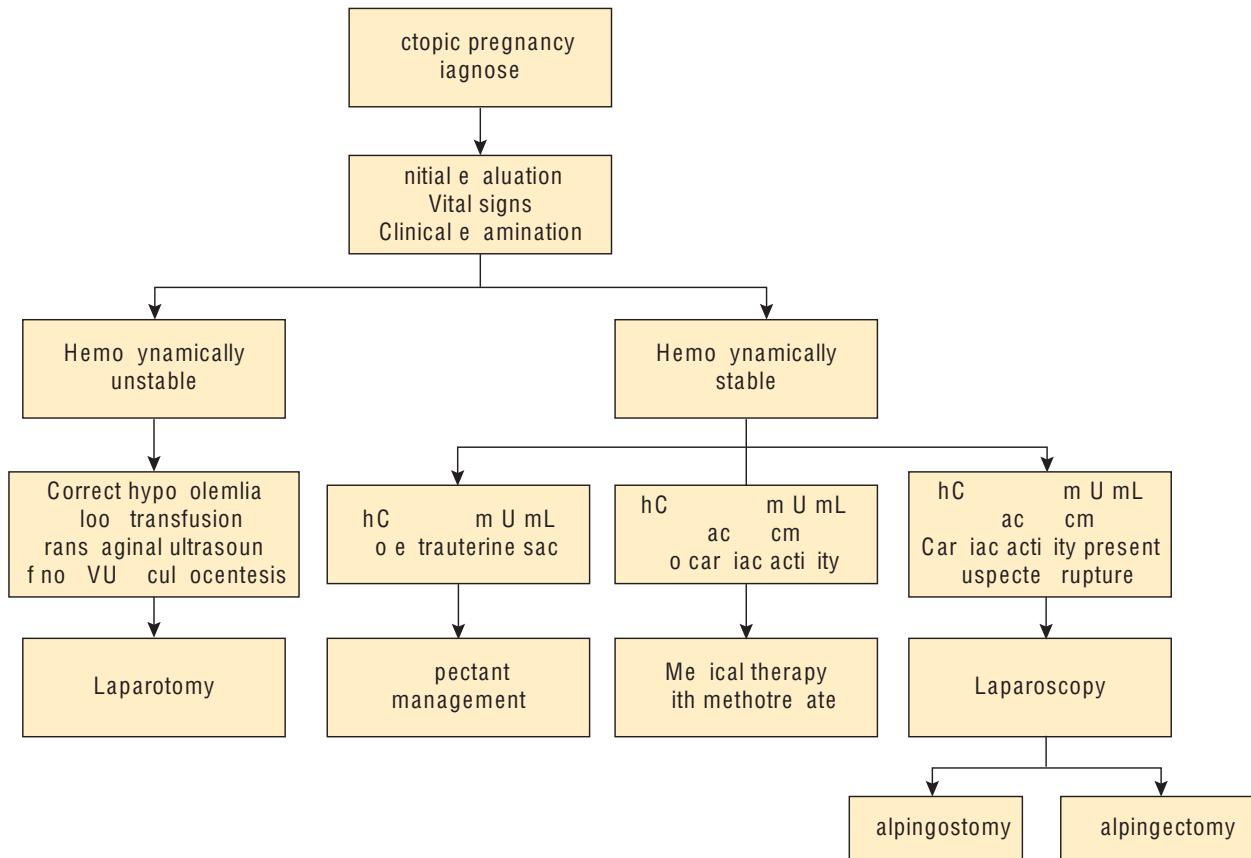


Figure 30.13 Suggested management algorithm for ectopic pregnancy. hCG, human chorionic gonadotropin; VUG, transvaginal ultrasonography.

the tube. Rupture with profuse intra-abdominal bleeding is the usual clinical presentation. Laparotomy is indicated in most, although some women may be managed by laparoscopic surgery. Cornuostomy or removal of the interstitial portion of the tube should be performed. Rupture of the uterus is known to occur during subsequent pregnancy.

Cervical pregnancy

Cervical pregnancy is rare. Women usually present with massive hemorrhage. Diagnosis is

difficult and may be mistaken for other lesions in the cervix. Management is with MTX. Uterine artery embolization may be required for control of bleeding. Hysterectomy is an option in multiparous women.

Pregnancy in other sites

Ovarian, broad ligament, and secondary abdominal pregnancies have been reported but are uncommon.

Key points

- A pregnancy that occurs in a site outside the uterine cavity is called *ectopic pregnancy*. The majority of ectopic pregnancies (98%) are sited in the fallopian tube.
- In the fallopian tube, approximately 80% of the pregnancies occur in the ampullary region.
- The history of treatment for a previous ectopic pregnancy increases the risk for an ectopic pregnancy in the next pregnancy.
- Nonspecific salpingitis and chlamydial and gonorrhreal infections (especially when recurrent) lead to tubal damage and therefore have been implicated in the causation of ectopic pregnancy.
- Women undergoing treatment for infertility have a fourfold increase in the incidence of an ectopic pregnancy.
- Women undergoing in vitro fertilization (IVF) have a two to three times increased risk of both ectopic and heterotopic pregnancies.
- Tubal surgery increases the incidence of a tubal ectopic pregnancy.
- Any sexually active woman presenting with abdominal pain and vaginal bleeding after an interval of amenorrhea should be considered to have an ectopic pregnancy until proved otherwise.
- The aim of good clinical practice is to diagnose an ectopic pregnancy before it ruptures. An unruptured ectopic pregnancy can be treated conservatively, whereas a ruptured ectopic pregnancy will require surgical intervention. When an ectopic pregnancy ruptures, it becomes a life-threatening emergency.
- A combination of serum human chorionic gonadotropin (hCG) and transvaginal ultrasonography (TVUS) is the best method for diagnosing an ectopic pregnancy.
- With a serum hCG level of 1500 or 2000 mIU/mL, an intrauterine pregnancy should be demonstrated using

- TVUS. This is known as the *discriminatory one* of serum hCG level.
- TVUS is the gold standard for the evaluation of a suspected ectopic pregnancy. A TVUS examination may demonstrate an intrauterine pregnancy, or an extrauterine pregnancy, or could be nondiagnostic.
- Culdocentesis is a diagnostic procedure where a long 18-gauge needle is inserted through the posterior vaginal fornix into the cul-de-sac and fluid is withdrawn to test for the presence of blood. It is done only if ultrasound imaging is not available.
- There are three options for the management of an ectopic pregnancy: expectant management, medical management with methotrexate (MTX), or surgical management.
- Methotrexate is a folic acid antagonist that inhibits DNA synthesis and cell reproduction, primarily in actively proliferating cells such as malignant cells, trophoblasts, and fetal cells.
- The optimal candidates for MTX treatment of an ectopic pregnancy should be hemodynamically stable, willing, and compliant with follow-up, and have serum hCG level ≤ 5000 mIU/mL, no fetal cardiac activity, and an ectopic mass size $<3\text{--}4$ cm.
- Two regimens have been described: single-dose and multidose. Both have a success rate of 90%, although the multidose results in more side effects.
- Surgical therapy is indicated in the following situations: hemodynamic instability, suspected rupture, contraindications to MTX, or failed medical therapy.
- The two surgical options for the management of an unruptured tubal ectopic pregnancy are *salpingostomy* and *salpingectomy*. Both procedures can be done either by laparoscopy or by laparotomy.

Self-Assessment

Case-based questions

Case 1

Mrs. HG, 29, had been attempting to conceive for the past 3 years. She had a missed miscarriage 2 years ago and underwent surgical evacuation. She presented at 6 weeks' amenorrhea with intermittent cramping abdominal pain on the left side. She also had some vaginal spotting. The pain worsened and she fainted once when she tried to stand up.

1. What is the diagnosis and why?
2. How will you confirm the diagnosis?
3. If she is pale, BP is 100/70 at admission, and TVUS revealed 1000 mL of blood in the peritoneal cavity, what is the management?
4. What are the indications for surgical management with laparoscopy?

Case 2

Mrs. DS, 24, gravida 1, para 0, presented with acute abdominal pain. Her last period was scanty. She had done a home pregnancy test that was positive. A TVUS showed an unruptured left tubal pregnancy. The serum hCG level was 1200 mIU/mL.

1. What would be the optimal treatment for this woman?
2. How does methotrexate act?
3. Describe the single-dose regimen for methotrexate therapy.
4. What are the surgical options for treatment of a tubal ectopic pregnancy?

Answers

Case 1

1. Ruptured ectopic pregnancy: the history of amenorrhea, with worsening abdominal pain, vaginal bleeding, and fainting episode indicate that the pregnancy is probably ectopic and there is intra-abdominal bleeding.
2. The diagnosis is confirmed by clinical examination to check pulse, blood pressure, abdominal tenderness, rigidity, and guarding. A vaginal examination

is done for adnexal mass, tenderness, and fullness in the pouch of Douglas. Ultrasonography is performed to look for free fluid and adnexal mass with gestational sac.

3. IV access should be established, blood transfusion started, and TVUS performed. She should be taken for laparotomy and salpingectomy.
4. Women with gestational sac >4 cm and hCG >5000 mIU/mL, with a live embryo, and who are hemodynamically stable need surgical intervention with laparoscopy. Other indications for laparoscopy are failed medical therapy and contraindications to methotrexate.

Case 2

1. Medical therapy with methotrexate would be the ideal treatment for an unruptured tubal ectopic pregnancy.
2. Methotrexate is a folic acid antagonist that inhibits DNA synthesis and cell reproduction, primarily in actively proliferating cells such as trophoblasts and fetal cells.
3. Single-dose therapy: 50 mg/m² of methotrexate is given IM. The serum hCG level is checked on Days 4 and 7. There should be a drop of 15% from Day 4 to 7 or 25% from Day 1 to 7. The dose is repeated if needed. The serum hCG levels are monitored weekly till undetected.
4. The two surgical options for the management of an unruptured tubal ectopic pregnancy are *salpingostomy* and *salpingectomy*. Both procedures can be done either by laparoscopy or by laparotomy.

Sample questions

Long-answer question

1. Discuss the etiology, clinical features, and management of unruptured tubal pregnancy.

Short-answer questions

1. Pelvic hematocoele
2. Medical management of ectopic pregnancy
3. Laparoscopic surgery in ectopic pregnancy
4. Decidual cast

31

Intrauterine Fetal Death

Case scenario

Mrs. RT, 25, a pregestational insulin-dependent diabetic, presented at 37 weeks' gestation with loss of fetal movement for 2 days. She and her husband were extremely anxious and wanted to know if there was a problem.

Introduction

Intrauterine fetal death (IUFD), like miscarriage, is a traumatic and devastating event for the couple, their families, and the obstetrician. An empathetic approach to the couple and their families, counseling, emotional support, and a systematic approach to finding the cause are essential. The neonatologist and geneticist must also be involved in counseling. The cause of death must be identified and explained, and further management must be discussed.

Definition

Intrauterine fetal death refers to a fetus with no signs of life in utero. The terms fetal death, fetal demise, stillbirth, and stillborn are used interchangeably.

Early fetal deaths refer to death of fetuses between 20 and 27 weeks' gestation (>500 g). **Late fetal deaths** refer to fetal deaths after 28 weeks, birth weight of 1000 g or more, or crown-heel length of 35 cm. Although some countries define stillbirth as fetal death occurring as early as 16 weeks' gestation, developing countries such as India classify deaths after 28 weeks as stillbirth.

Causes of I FD

Though all cases of IUFD should be investigated, often the cause is unknown.

Explained I FD

A significant percentage of stillbirths (25%–60%) may not have a defined etiology. The closer IUFD occurs to term, the more likely it is to have no

identifiable fetal, placental, maternal, or obstetric etiology.

Fetal growth restriction

Fetal growth restriction (FGR) is the second most common cause of IUFD. When growth restriction goes unrecognized, it is the single largest risk factor for stillbirth. Fetal growth restriction increases the risk of stillbirth five-fold to seven-fold.

Placental dysfunction

Placental dysfunction may result from various etiologies such as hypertensive disorders, antiphospholipid antibody syndrome, or pregestational insulin-dependent diabetes. It can result in fetal demise.

Congenital anomalies

Stillborn fetuses have a high rate of major structural congenital anomalies. Routine second trimester targeted scan with termination of lethal anomalies will lower this rate.

Chromosomal abnormalities

Lethal chromosomal abnormalities will result in early pregnancy loss. However, trisomies involving chromosomes 13, 18, and 21 and aneuploidies of the sex chromosomes commonly result in late fetal death. A stillborn fetus with a congenital anomaly is more likely to have a chromosomal abnormality.

Infections

Infections play an important role in the etiology of IUFD, accounting for almost 50% of stillbirths in developing countries. Parvovirus, cytomegalovirus (CMV), toxoplasmosis, *Listeria*, and herpes simplex virus are established causes of intrauterine fetal demise. Maternal malaria and hepatitis are more commonly implicated in developing countries.

Placental abruption

Though uncommon, placental abruption results in 10%–20% of all stillbirths. The larger the area of placental separation, the greater is the risk of fetal demise.

Immune or nonimmune hydrops

Hydrops fetalis, of both immune and nonimmune etiologies, may lead to IUFD.

Cord complications (cord accident)

Complications involving the cord (entanglement, tight nuchal cord, true knots) are often blamed for an unexplained fetal death. Nuchal cord occurs in one out of three pregnancies, but very rarely causes fetal death. Postnatal examination of the umbilical cord around the neck will allow assessment of how tight it was and if it could have been the cause of death. True knots are sometimes seen. Nuchal cord or knots in the cord must be considered the cause of fetal death only after thorough assessment and elimination of other etiologies.

Causes of IUFD are listed in Box 31.1.

Box 31.1 Causes of I FD

- Unexplained IUFD
- Unrecognized fetal growth restriction
 - Single largest risk factor
- Placental dysfunction
 - Hypertensive disorders
 - Antiphospholipid antibody syndrome
 - Pregestational insulin-dependent diabetes
- Congenital anomalies
 - Major structural anomalies
 - Lethal anomalies
- Chromosomal abnormalities
 - Trisomies 21, 13, 18
 - Aneuploidy of sex chromosomes
 - Strong association with congenital anomalies
- Infections
 - Parvovirus, CMV, toxoplasmosis, *Listeria*, and herpes simplex
 - Maternal malaria and hepatitis
- Placental abruption
- Immune or nonimmune hydrops
- Cord complications
 - Entanglement
 - True knot
 - Tight nuchal cord
 - After eliminating other causes

Risk factors for I FD

Certain factors in pregnancy can increase the risk of stillbirth. These are enumerated in Box 31.2.

Diagnosis of I FD

When the pregnant woman presents with absence of previously perceived fetal movements, it should raise suspicion of IUFD. Intrauterine fetal death may also be suspected when fetal heart sounds are not audible on auscultation at a routine antenatal checkup. Occasionally the woman may present with vaginal bleeding, with or without uterine contractions. Auscultation of the fetal heart by stethoscope or Doppler is insufficient to confirm IUFD.

An ultrasound examination is essential to confirm fetal death by noting the absence of fetal cardiac activity.

Other ultrasound features of IUFD have also been described. The ultrasound features that may help confirm the diagnosis are given in Box 31.3.

Box 31.2 Risk factors for intrauterine fetal death

- Prolonged pregnancy (>42 weeks)
- Multiple gestation
- Diabetes (poorly controlled)
- Antiphospholipid syndrome
- Hypertensive disorders
- Advanced maternal age
- Obesity
- Uterine rupture

Box 31.3 Ultrasound features to confirm diagnosis of intrauterine fetal death

- Absence of fetal cardiac activity
- Spalding's sign
 - Collapse of fetal skull with overlapping bones (Fig. 31.1)
- Hydrops
- Robert's sign
 - Intrafetal gas (within the heart, great vessels, joints)
- Hyperflexion of the spine
- Crowding of the rib shadow
- Retroplacental clots in the presence of a massive abruption



Figure 31.1 Spalding's sign in intrauterine fetal death. Collapse and overlapping of the skull bones (arrow) are seen on ultrasound imaging. (Photo courtesy: Mediscan Systems, Chennai.)

Breaking the news to the couple

Intrauterine fetal death is a devastating event for the couple and their family. The obstetrician must display great sensitivity and empathy. The woman and her husband should be informed about the problem in privacy. It is common for the couple and the family to feel that the obstetrician has been negligent. However, it is important to not take on a defensive tone. There should be no attempt to place the blame on the woman, even by insinuation.

All the proceedings should aim to support the couple's choices. The following points must be discussed:

- Establishing cause of death by evaluation
- Expectant management and its complications
- Mode of delivery
- Timing of delivery
- Importance of autopsy and other postnatal tests on the fetus
- Timing and management of subsequent pregnancy

Evaluation of cause of I FD

An identifiable etiology for fetal demise may not be found in up to 60% of stillbirths, even after complete evaluation. However, every attempt must be made to determine the cause of fetal death because it will assist in deciding on recurrence risk, preconceptional counseling, future pregnancy management, the need for prenatal diagnostic procedures with the next pregnancy, and future neonatal management.

When clinical findings strongly suggest a cause for the fetal demise, further testing may not be required or may be limited to a fewer number of tests. For example, an obvious cause could include cord prolapse, a true knot, or anencephaly. In that case, no further evaluation would be required.

Complete evaluation consists of a thorough history of current and past illnesses, a clinical evaluation, laboratory tests if indicated, and a fetal autopsy that should include examination of the placenta.

Clinical evaluation

Clinical evaluation is the first step in coming to a conclusion about the cause for the IUDF. The components of clinical evaluation are listed in Box 31.4.

Box 31.4 Clinical evaluation of intrauterine fetal death

- History
 - Hypertension
 - Diabetes
 - Bleeding with or without pain
 - Rupture of membranes
 - Fever with or without rashes
- Past obstetric history
 - Previous stillbirths
 - Previous macrosomic/small babies
- Family history of diabetes
- Examination
 - Blood pressure
 - Proteinuria
 - Uterine size
 - Bleeding
- Ultrasonography
 - Evaluation for fetal growth restriction
 - Fetal structural anomalies

Laboratory investigations

Women who have had a late IUDF should have laboratory investigations to

- identify the cause of the fetal death,
- rule out disseminated intravascular coagulation (DIC) that may result from fetal demise. However, DIC occurs only in 10%–25% of IUDFs and usually occurs 3–4 weeks after the event or later. Coagulation workup is therefore not required immediately after IUDF (*see Chapter 45, Nonhemorrhagic shock in pregnancy*).

Tests can be divided into those that should be done generally for all women with IUDF and specific tests that are indicated by a suspected cause of IUDF.

Tests for all women with I FD

The tests that should be done for all women with IUDF are listed in Box 31.5.

Specific tests for suspected cause of I FD

In certain women with IUDF, a cause could be suspected from the clinical evaluation. These women should undergo specific tests for the suspected cause of IUDF.

- Anticardiolipin antibodies and lupus anticoagulant should be tested to rule out antiphospholipid antibody (APA) syndrome since unrecognized APA syndrome is associated with late fetal demise.
- If the maternal clinical picture, ultrasound findings, or histopathologic findings of the fetus or placenta suggest a specific infection, serologic testing for cytomegalovirus titer, toxoplasmosis titer, parvovirus B19 titer, and *Listeria* culture are obtained.

Box 31.5 Tests for all women with intrauterine fetal death

- Complete blood count
- Screening for diabetes (if not done during pregnancy)
- Kleihauer test to rule out massive fetal–maternal hemorrhage
- Indirect Coombs test to rule out Rh alloimmunization

- Tests for inherited thrombophilia are not indicated.
- To identify chromosomal abnormalities leading to fetal demise, an amniocentesis or chorionic villus sampling may be indicated. An amniocentesis done immediately after fetal death allows successful cytogenetic studies, whereas the culture of fetal tissues after delivery is not as successful. Polymerase chain reaction (PCR) for viral infection and amniotic fluid culture may also be carried out in suspected cases of intrauterine infection.
- If ultrasonography reveals hydrops and the woman is not Rh negative or alloimmunized, causes of nonimmune hydrops and minor blood group incompatibilities must be looked for.

Specific tests for suspected cause of IUFD are given in Box 31.6.

Box 31.6 Specific tests for suspected cause of intrauterine fetal death

- Anticardiolipin antibodies (IgG, IgM)
- Lupus anticoagulant
- Tests for specific infection
 - Cytomegalovirus titer
 - Toxoplasmosis titer
 - Parvovirus B19 titer
 - *isteria* culture
 - PCR for viral infection
 - Amniotic fluid culture
- Fetal karyotyping
 - Amniocentesis immediately after diagnosis
 - Chorionic villus sampling
- Minor blood group incompatibilities
 - In the presence of fetal hydrops

g immunoglobulin G; *g* immunoglobulin M; *PC* polymerase chain reaction.

Postmortem and placental examination

A postmortem examination is a very important part of the investigation for the etiology of stillbirth. The need for it must be discussed with the parents with great sensitivity and compassion. Cultural values must be kept in mind. Many families may hesitate to proceed with a postmortem examination if they feel that the fetus will not

be handled with respect. Following the autopsy, some parents may want to follow rituals specific to their culture or religion. If it is explained to the parents that the autopsy may contribute information that will help in calculating the recurrence risk, most parents will agree to the examination.

A specialized perinatal pathologist should ideally perform the postmortem. If facilities are not available, then the fetus or organs can be sent to a center where these facilities are available. The fetus and placenta should be examined as soon as possible after delivery.

Fetal examination

A detailed external examination of the fetus is essential. Fetal weight, length, head, and abdominal circumference and measurement of the limbs should be recorded. Abnormalities, dysmorphic features, and relevant negative findings must be documented. Detailed photographs of the entire fetus and a facial photograph will be useful for future reference (Box 31.7).

Gross and histological examination of the placenta

Gross and histological examination of the placenta is an essential part of the autopsy. Any relevant gross findings should be documented. Histological examination of the placenta may yield findings of clinical relevance. Diffuse placental infarction may explain FGR leading to fetal demise and may also point to the possibility of antiphospholipid antibody syndrome.

Box 31.7 Fetal findings to be documented during postmortem

- Weight
- Length
- Head circumference
- Abdominal circumference
- Measurement of limbs
- Abnormalities
- Dysmorphic features
- Relevant negative findings
- Detailed photographs of entire fetus including face
- Gross and histological examination of the placenta

Leukocyte infiltration may be present with chorioamnionitis.

If the parents do not permit an autopsy, the following may be performed, although they are not substitutes for a complete postmortem:

- Photographs of the fetus
- Whole-body radiography
- Ultrasonography
- Needle biopsies
- Magnetic resonance imaging (MRI)

Delivery issues

An extremely difficult diagnosis to accept, parents usually struggle to come to terms with fetal demise. If there is no immediate medical complication putting the mother's health at risk, the couple should be allowed to make an informed decision about the timing of the delivery. At the same time, the couple should be reassured that the fetal demise would not place the mother's health at risk. However, in the presence of obstetric complications, pregnancy must be terminated immediately.

- The majority of women (85%–90%) will deliver spontaneously within 3 weeks of IUFD. However, expectant management may lead to severe maternal anxiety.
- A small number of women (25%–30%) may develop DIC if undelivered 4 weeks after IUFD.
- Vaginal delivery is the preferred route of delivery unless there are definite indications for a cesarean section.

Indications for immediate delivery

Immediate delivery, as soon as the diagnosis is made, is indicated in conditions which jeopardize maternal well-being (Box 31.8).

Box 31.8 Indications for immediate delivery

- Severe preeclampsia/eclampsia
- Placental abruption
- Chorioamnionitis
- Ruptured membranes

Induction of labor

Most women with IUFD opt for delivery within 24–48 hours. The majority of women (90%) deliver within 24 hours of induction and complications are minimal. The two advantages of immediate induction are as follows:

- Postmortem examination will be more informative since autolysis or maceration of the baby is less.
- The risk of DIC is low.

Methods of induction

At term, and with a favorable cervix, labor can be induced with oxytocin. If the cervix is not favorable, cervical ripening can be achieved with prostaglandins or mechanically with a Foley catheter (Box 31.3).

Misoprostol and prostaglandin E2 (PGE2) are equally effective, but misoprostol is cheaper and safe. Vaginal misoprostol is given at the dose of 100 µg 6 hourly, for a maximum of four doses, before 26 weeks. After 27 weeks, the dose is reduced to 25–50 µg 4 hourly. Misoprostol usage may be associated with uterine rupture in a previous uterine scar. It should therefore be avoided.

In women at 24–28 weeks' gestation, the addition of mifepristone shortens expulsion time. A dose of 200 mg of oral mifepristone is followed by misoprostol 48 hours later.

The methods for induction in the presence of IUFD are listed in Box 31.9.

Box 31.9 Induction for intrauterine fetal death

- Oxytocin
 - At term with favorable cervix
 - Preceded by cervical ripening if needed
- Misoprostol
 - <26 weeks
 - 100 µg 6 hourly
 - Maximum of 4 doses
 - >27 weeks
 - 25–50 µg 4 hourly
 - Maximum of 6 doses
 - Avoid in case of previous cesarean section
- Mifepristone + misoprostol
 - 24–28 weeks
 - 200 mg of mifepristone
 - Followed by misoprostol 48 hours later

Indications for cesarean section

In the presence of IUFD, it is best for the woman to have a vaginal delivery. However, a cesarean section may be indicated for specific obstetric indications (Box 31.10).

Determining time of fetal demise

When a fetal demise occurs remote from labor, it is not always easy to determine when the event happened. Soon after fetal demise, the fetus starts undergoing changes, including desquamation and maceration. Table 31.1 gives guidelines for estimating an approximate time of death prior to delivery.

Postnatal management

Postnatal management is an important part of handling IUFD.

Box 31.10 Indications for cesarean section in intrauterine fetal death

- Major degree of placenta previa
- Transverse lie
- 2 or more previous scars on the uterus
- Significant macrosomia

- It is very important to talk to the couple and the family and discuss with them the possible cause for the fetal demise. Emotional support and psychological counseling should be provided for whatever extent possible.
- Lactation should be suppressed with cabergoline. Cabergoline 0.25 mg bid × 2 days will suppress lactation.
- Women who are Rh negative should receive the full dose (300 µg) of anti-D immunoglobulin because it might not always be possible to ascertain if the fetus is Rh positive or not.
- At the follow-up visit, the couple should be counseled regarding risks of recurrence and plans for future pregnancy. Preventive measures, if any, should be discussed. Contraceptive advice should be given.

The essential components of postnatal management are summarized in Box 31.11.

Box 31.11 Postnatal management

- Counseling for couple and family
 - Possible cause for the fetal demise
 - Risk in next pregnancy
- Suppression of lactation
 - Cabergoline 0.25 mg bid × 2 days
- Rh negative women
 - 300 µg of anti-D immunoglobulin
- Follow-up visit
 - Plans for future pregnancy
 - Preventive measures, if any
 - Contraceptive advice

Table 31.1 Guidelines for estimating approximate time of death prior to delivery

Finding	Estimated time of fetal demise prior to delivery
Brown or red discoloration of the umbilical cord or desquamation ≥1 cm	At least 6 hours
Desquamation of the face, back, abdomen	At least 12 hours
Desquamation ≥5% of the body or ≥2 body zones*	At least 18 hours
Skin color brown or tan	At least 24 hours
Mummification (i.e., reduced soft tissue volume, leathery skin, deeply brown-stained tissues)	At least 2 weeks

*Body zones: Scalp, face, neck, chest, back, arms, hand, leg, foot, and scrotum.

Key points

- Intrauterine fetal death (IUFD) refers to a fetus with no signs of life in utero. The terms fetal death, fetal demise, stillbirth, and stillborn are used interchangeably.
- A significant percentage of stillbirths (25%–60%) may not have a defined etiology. The closer IUFD occurs to term, the more likely it is to have no identifiable fetal, placental, maternal, or obstetric etiology.
- The causes implicated in stillbirths include unrecognized fetal growth restriction, placental dysfunction, congenital anomalies, chromosomal abnormalities, infections, placental abruption, hydrops (immune and nonimmune), and cord complications.
- An ultrasound examination is essential to confirm fetal death by noting the absence of fetal cardiac activity.
- Intrauterine fetal death is a devastating event for the couple and their family. The obstetrician must display great sensitivity and empathy. The woman and her husband should be informed about the problem in privacy.
- An identifiable etiology for fetal demise may not be found in up to 60% of stillbirths. However, every attempt must be made to determine the cause of fetal death because it will assist in deciding on recurrence risk, preconceptional counseling, future pregnancy management, the need for prenatal diagnostic procedures with the next pregnancy, and future neonatal management.
- A postmortem examination is a very important part of the investigation for the etiology of stillbirth.
- The majority (85%–90%) of women will deliver spontaneously within 3 weeks of IUFD. However, expectant management may lead to severe maternal anxiety.
- A small number (25%–30%) of women develop disseminated intravascular coagulation (DIC) if undelivered 3–4 weeks after IUFD. Vaginal delivery is the preferred route of delivery unless there are definite indications for cesarean section.
- Most women with IUFD opt for delivery within 24–48 hours. The majority of women (90%) deliver within 24 hours of induction and complications are minimal.
- At the follow-up visit, the couple should be counseled regarding risks of recurrence and plans for future pregnancy. Preventive measures, if any, should be discussed. Contraceptive advice should be given.

Self-Assessment

Case-based question

Mrs. RT, 25, a pregestational insulin-dependent diabetic, presented at 37 weeks' gestation with loss of fetal movement for 2 days.

1. How is IUFD confirmed?
2. What laboratory investigations should be ordered?
3. What would be the best method of delivering the patient?
4. What postnatal investigations are essential?

Answers

1. Intrauterine fetal death is confirmed by the absence of fetal heart motion on ultrasound. Other signs of IUFD on ultrasound include collapse of the fetal skull with overlapping bones, hydrops, intrafetal gas, hyperflexion of the spine, and crowding of the rib shadow.

2. In addition to checking her blood sugar levels, a baseline coagulation profile should be ordered to rule out DIC.
3. Vaginal delivery is the preferred route of delivery unless there are definite indications for a cesarean section.
4. A postmortem fetal examination is advised.

Sample questions

Long-answer question

1. What are the causes of intrauterine fetal death? How do you evaluate a patient after a intrauterine fetal death at 37 weeks?

Short-answer questions

1. Intrauterine fetal death
2. Ultrasonographic findings in intrauterine death of fetus

32

Multifetal Pregnancy

Case scenario

Mrs. RN, 30, was referred at 32 weeks' gestation from a primary health center since the uterine size was larger than the gestational age. She hailed from a local village and had antenatal care by the village health worker who had prescribed iron tablets. She was referred to the doctor since the health care worker felt her abdomen was too big. She also had swelling of both feet.

Introduction

Multifetal pregnancies are on the increase globally due to several factors, the most important being the use of assisted reproductive techniques (ART). Early diagnosis is important for proper counseling and management so as to optimize maternal and perinatal outcome.

Currently the global incidence is 32/1000 (3.2%), but it is thought to be less in the developing world. Triplet and higher-order pregnancies increased till the year 1998 but have decreased to 1.43/1000 since then. This is due in part to stringent guidelines restricting transfer of multiple embryos into the uterus during IVE.

Twin pregnancy

Twin pregnancy is the most common form of multifetal pregnancy.

ygosity

Twin pregnancies can be monozygotic (MZ) or dizygotic (DZ). Dizygotic twins result from fertilization of two ova by two sperms, whereas MZ twins arise from a single fertilized ovum which subsequently divides into two embryos. 70% of twin pregnancies are DZ. Incidence of MZ twins has remained stable globally, but the incidence of DZ twins has increased in recent

Incidence

The incidence of twin pregnancy rose sharply from 1980 to 2004 but has stabilized after that.

years and varies among different ethnic groups. Assisted reproductive techniques have markedly increased the incidence of DZ twins but have had only a marginal effect on the incidence of MZ twins. Differences between MZ and DZ twins are given in Table 32.1.

Etiology

Monozygotic twins occur in 1 in 250 (0.4%) pregnancies, whereas DZ twins are more common. The etiology of MZ twins is not well understood.

Dizygotic twins occur due to multiple ovulation resulting from an increase in follicle-stimulating hormone (FSH) levels. The etiological factors causing DZ twins are listed in Box 32.1. The increased FSH level that is usually found in older women, multiparas, certain races, and obese women is thought to be the causative factor.

Assisted reproductive techniques give rise to multifetal pregnancies depending on the number of embryos transferred. Ovulation induction and ART account for the increase in incidence of DZ twins in recent years. Guidelines have emerged regarding the number of embryos that can be transferred, and this has led to the reduction in and stabilization of the incidence in the

Table 32.1 Differences between monozygotic and dizygotic twins

	Monozygotic	Dizygotic
Phenotype	Identical	Nonidentical
Genotype	Identical	Nonidentical
Gender	Same	Same or different
Incidence		
Ethnic variation	Absent	Present
Increase with ART	Minimal	Marked
Adverse perinatal outcomes	High	Low

A = assisted reproductive techniques.

past decade. ART can also increase cleavage of the embryo, thereby increasing the incidence of MZ to some extent.

Placentation

Dizygotic twins are always dichorionic (DC) and diamniotic (DA) with either two separate placentas or one fused placenta.

In MZ twins, placentation depends on the timing of division of the embryo. If the division occurs early, the amnion and chorion develop later and individually cover the fetuses resulting in DC/DA pregnancies. If the division occurs late, the fetuses may be partially fused resulting in conjoined twins. Four types of MZ twin pregnancies are described, depending on the placentation (Table 32.2) (Fig. 32.1).

Box 32.1 Risk factors for dizygotic twin pregnancy

- Increase in FSH levels
 - Maternal age
 - Multiparity
 - Race
 - Maternal obesity
- Past h/o dizygotic twins
- Maternal family h/o twins
- Ovulation induction
 - Clomiphene
 - Gonadotropins
- ART
 - IVF

A = assisted reproductive technique; S = follicle-stimulating hormone; IVF = in vitro fertilization.

Determination of chorionicity

Perinatal mortality in twins varies with chorionicity. Determination of chorionicity is, therefore, essential for risk assessment and planning

Table 32.2 Types of placentation in monozygotic twins

Type of placentation	Timing of cleavage after fertilization	Frequency
Diamniotic dichorionic (DA/DC)	<72 hours	25%–30%
Diamniotic monochorionic (DA/MC)	4–7 days	70%–75%
Monoamniotic monochorionic (MA/MC)	8–12 days	1%–2%
Conjoined twins	>12 days	Rare

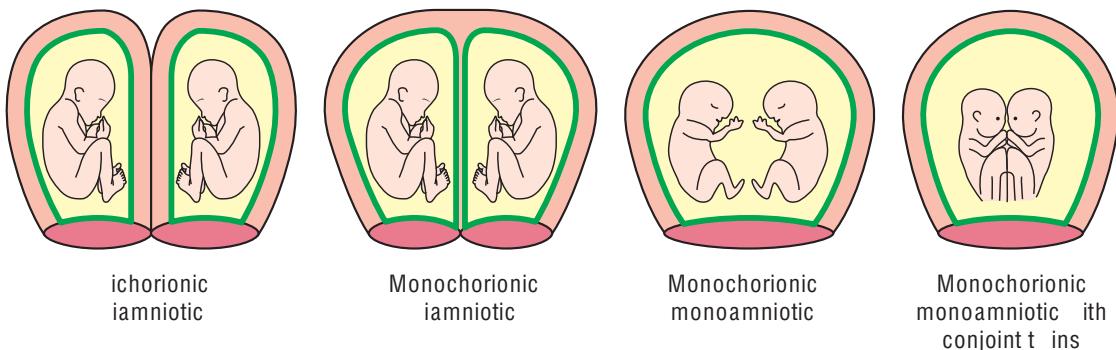


Figure 32.1 Placentation of monozygotic twins. Four types of monozygotic pregnancies can occur, depending on the time of cleavage.

management. Chorionicity is determined by ultrasonography and is most reliable in the first trimester (Table 32.3). **Transvaginal ultrasonography (TVUS) in the first trimester is 95%–100% sensitive in determining the chorionicity and amnionicity.**

Between 6 and 10 weeks' gestation, the presence of two gestational sacs indicates DC twins. (Fig. 32.2). The dividing membrane is also thick in DC twins. A single sac with a single yolk sac but two fetuses indicates monoamniotic (MA) twins. (Fig. 32.3). In late first or early second trimester, the number of placentas should be identified and documented. A single placenta may be seen in DC or monochorionic (MC) twins, but two placentas definitely indicate dichorionicity. Similarly, fetuses of different genders indicate dichorionicity. The number of layers in the dividing membrane can be counted near the insertion into the placenta.

In DC twins, examination of the placental membranes at delivery will reveal two amnions

and two chorions (four layers) or two amnions and one fused chorion (three layers). In MC twins, only two layers are seen.



Figure 32.2 Dichorionic twins. Ultrasonography shows two fetuses with a thick membrane in between. (Photo courtesy: Mediscan Systems, Chennai.)



Figure 32.3 Monoamniotic twins. Ultrasonography shows two fetuses in the same gestational sac with no dividing membrane. (Photo courtesy: Mediscan Systems, Chennai.)

Table 32.3 Determination of chorionicity

	Dichorionic	Monochorionic
First trimester		
Gestational sacs	Two	One
Dividing membrane	Thick (>2 mm)	Thin (<2 mm)
Second trimester		
Placenta	Two	One
Fetal gender	Discordant	Concordant or discordant
Twin peak sign	Present	Absent
T sign	Absent	Present
Dividing membrane	Three or four layers	Two layers

Between 11 and 14 weeks' gestation, a triangular projection of placenta can be seen between the two layers of the dividing membrane near the placental surface. This is called the *twin peak sign* or *lambda sign* and is seen only in DC twins (Fig. 32.4). In MC twins, there is no extension of tissue between the layers of the dividing membrane, and the membrane joins the placenta at right angles, giving rise to the *T sign* (Fig. 32.5).



Figure 32.4 Lambda sign or twin peak sign. A triangular projection of the placenta is seen between the layers of the membrane in dichorionic twins. (Photo courtesy: Mediscan Systems, Chennai.)



Figure 32.5 T sign. There is no extension of placental tissue between the layers of the dividing membrane in monochorionic twins. (Photo courtesy: Mediscan Systems, Chennai.)

Clinical features of twin pregnancy

Twin pregnancy may be suspected on the basis of history and physical examination, and confirmation of diagnosis is by ultrasonography. Diagnosis in the first trimester is essential for appropriate management so that optimal perinatal and maternal outcome can be achieved.

istory

Particular details in history that indicate a possibility of twin pregnancy are listed in Box 32.2.

Box 32.2 istory

- Advanced maternal age
- High parity
- History of ovulation induction
 - Clomiphene citrate
 - Gonadotropins
- Assisted reproduction therapy
- Family history of twins
- Parents one of twins
- Past history of twins
- Symptoms
 - First trimester
 - Hyperemesis
 - Second and third trimester
 - Overdistended uterus
 - Pressure symptoms
 - Breathlessness
 - Backache
 - Gastrointestinal symptoms

Physical examination

Physical examination in early and late pregnancy usually reveals a uterus larger than what is appropriate for gestational age and appears overdistended in third trimester (Fig. 32.6). Other findings include anemia, signs of preeclampsia, polyhydramnios, and pedal edema (Box 32.3).

Obstetric examination reveals fundal height at least 4–5 cm more than what corresponds to the gestational age. Multiple fetal parts can be felt. Though four poles (two cephalic and two podalic) may be felt, palpation of three poles or two heads is considered adequate for clinical diagnosis of twins. Polyhydramnios may be present. Malpresentations of the first and second twin are common. Auscultation of two fetal



Figure 32.6 Overdistended uterus. In third trimester, the abdomen is overdistended due to the presence of twin fetuses and polyhydramnios.

Box 32.3 Physical examination in twin pregnancy

- General examination
 - Anemia
 - Pedal edema
 - High blood pressure
- Obstetric examination
 - Uterine size larger than dates in first trimester
 - Fundal height more than expected (by 4–5 cm)
 - Multiple fetal parts
 - Three or four fetal poles
 - Polyhydramnios
 - Two fetal hearts
 - Malpresentations

hearts, with a minimum difference of 10 bpm, heard simultaneously (by two examiners) is considered diagnostic of twins.

Ultrasonography in twin pregnancy

Ultrasonography is an essential tool in the management of twin pregnancy. It is useful for diagnosis in early and late pregnancy and subsequently for monitoring the pregnancy and for guiding procedures (Box 32.4).

When the scan is performed in early first trimester, the following should be noted:

- Number of fetuses, gestational sacs, and yolk sacs
- Presence of membrane between fetuses

Box 32.4 Ultrasonography in twin pregnancy

- Diagnosis of twins
- Determination of chorionicity and amniocity
- Detection of fetal anomalies
- Evaluation of fetal growth
- Evaluation of fetal well-being
- Measurement of cervical length
- Guiding procedures
 - Selective termination
 - Selective fetoreduction
 - Amniocentesis
 - Septostomy
 - Amnioreduction
 - Diagnosis of malpresentation
 - Assistance in labor

This will help in the determination of gestational age, chorionicity, and amniocity. The membrane is visualized best in early pregnancy. Accurate assignment of gestational age is important for decisions regarding the timing of delivery.

Maternal adaptation to twin pregnancy

All the physiological changes of pregnancy are magnified and multiplied in twin pregnancy. The uterus is larger, levels of human chorionic gonadotropin (hCG) and human placental lactogen (hPL) are higher, and there is a greater increase in blood volume and cardiac output. These physiological changes give rise to problems in the mother as discussed later in the chapter.

Maternal complications

Maternal complications should be anticipated antenatally, intrapartum and postpartum.

Antenatal complications

Complications that are seen in singleton pregnancy occur more frequently in twin pregnancy, and they are more severe. The antenatal maternal complications are listed in Box 32.5.

Spontaneous miscarriage is more common in MZ twins. **Hyperemesis** is considered to be due to higher than usual levels of β hCG.

Box 32.5 Antenatal maternal complications in twin pregnancy

Antenatal

- First trimester
 - Hyperemesis
 - Spontaneous miscarriage
- Second trimester
 - Hypertensive disorders
 - Gestational diabetes
 - Anemia
- Third trimester
 - Preterm labor
 - Polyhydramnios
 - Antepartum hemorrhage
 - Placental abruption
 - Placenta previa
 - Pressure symptoms
 - Respiratory difficulty
 - Gastrointestinal symptoms
 - Edema

Anemia is common in twin pregnancies, especially in developing countries. Increase in plasma volume is responsible for the exaggerated physiological anemia, but the increased demands of the growing fetuses cause iron and folic acid deficiency. The resultant anemia is usually dimorphic (*see Chapter 49, Hematological disorders*).

Polyhydramnios occurs in 5%–8% of twin pregnancies and is more common in MZ twins with complications such as twin-to-twin transfusion syndrome (TTTS). Acute polyhydramnios can occur at or after 28 weeks' gestation. Increased levels of hPL lead to a higher incidence of **gestational diabetes**.

Gestational hypertension is much more common in multifetal pregnancies. **Preeclampsia** is three to four times more common, occurs earlier in gestation, and tends to be more severe. The relative risk of eclampsia is also three times higher.

The incidence of **placental abruption** is higher and is probably due to the higher incidence of hypertension. One of the placentas may be implanted in the lower segment or part of a large fused placenta may extend to the lower uterine segment, giving rise to **placenta previa**.

The overdistended uterus gives rise to discomfort and **pressure symptoms**. Vague aches and pains, backache due to exaggerated lordosis,

pedal edema due to pressure on the iliac veins/ vena cava, gastrointestinal symptoms such as dyspepsia, early satiety due to displacement and pressure caused by the expanding uterus, and respiratory difficulty due to upward displacement and splinting of the diaphragm are seen often in twin pregnancies.

retterm labor

Twin pregnancy is a well-known cause of preterm labor and accounts for 10% of all preterm labors. The mean gestational age at delivery of twins is 36 weeks. Preterm labor occurs in 50% of twin pregnancies. The risk is higher in MC pregnancies. This is the most important cause of perinatal mortality in multifetal pregnancy.

Prediction of preterm labor

Identification and management of women at high risk for preterm labor improves perinatal mortality. Dilatation of the internal os can be assessed by digital examination and has been found to be useful as a predictor of preterm labor. The two tests useful in the prediction of preterm labor are measurement of cervical length by TVUS and fetal fibronectin (fFN) levels in maternal serum (Box 32.6). When the results of the two tests are combined, the predictive value is higher. In a woman who has a cervical length >25 mm at 24 weeks with negative fFN, the risk of preterm delivery prior to 32 weeks would be low. The monitoring of cervical length by TVUS should begin by 16–18 weeks in multifetal pregnancies.

Box 32.6 Prediction of preterm labor in twin pregnancy

- Digital examination
 - Dilatation of internal os
- Cervical length by TVUS
 - At 24–28 weeks
 - <25 mm: High risk
 - >25 mm: Low risk
- Fetal fibronectin
 - At 28 and 32 weeks
 - Positive: High risk
 - Negative: Low risk
- Combination of both
 - Higher predictive value

S transvaginal ultrasonography

Prevention of preterm labor

Several interventions have been tried but none have been found useful in randomized controlled trials in the prevention of preterm labor in twin pregnancies. The interventions are listed in Table 32.4. Bed rest and hospitalization are recommended only if there is hypertension, preeclampsia, or other complications. Cervical cerclage was not found to be useful even when the cervical length was <25 mm and may actually lead to preterm labor. Tocolytics are useful in established preterm labor to prolong pregnancy by a few days but not recommended for prophylaxis. The physiological changes in cardiovascular system are exaggerated in multifetal pregnancy, and this predisposes to pulmonary edema. This risk increases particularly with betamimetics which, therefore, are not recommended. Progestins have also not been found to be beneficial. **Corticosteroid for acceleration of pulmonary maturity is indicated in women diagnosed to be in preterm labor.**

Measures that may reduce the risk of preterm labor are limited to physical activity with rest for 1–2 hours in the afternoon and 6–8 hours at night, light work, frequent and regular antenatal visits, and serial ultrasonographic evaluation for cervical length and other complications.

Intrapartum and postpartum complications

Intrapartum and postpartum complications are also higher in twin pregnancy (Box 32.7).

The overdistended uterus does not contract adequately; therefore, labor may be prolonged and require augmentation. Malpresentations are

Box 32.7 Intrapartum and postpartum complications

- First stage
 - Prolonged labor
 - Malpresentations
 - Need for augmentation
 - Prelabor rupture of membranes
 - Cord prolapse
- Second stage
 - Operative vaginal deliveries
 - Forceps
 - Vacuum extraction
 - Assisted breech delivery
 - Internal podalic version
 - Cesarean section
 - Abruptio of placenta of second twin
- Third stage
 - Atonic postpartum hemorrhage
 - Retained placenta
- Postpartum
 - Secondary postpartum hemorrhage
 - Thromboembolism
 - Lactational difficulties

common, either in the first or the second twin. The second twin may present by vertex to begin with but change to breech or transverse lie after the delivery of the first twin. Operative vaginal delivery with forceps or vacuum extraction, assisted breech delivery (especially of the second twin), internal podalic version, and breech extraction may be required. Incidence of cesarean section is much higher than in singleton pregnancies. The inadequate uterine contractions due to overdistension lead to atonic postpartum hemorrhage and retained placenta. Secondary postpartum hemorrhage due to endometritis or retained placental tissue is more

Table 32.4 Measures for prevention of preterm labor

Preventive measure	Efficacy
Bed rest and hospitalization	If there is hypertension/preeclampsia
Cervical cerclage	Not effective even in short cervix
Tocolytics	In established preterm labor To prolong pregnancy for few days
Progestins	Not been found effective
Limited physical activity Light work Regular antenatal visits Serial TVUS for cervical length	Found to be effective; recommended

S, transvaginal ultrasonography.

likely. Thromboembolism also occurs more frequently than in singleton pregnancy.

Fetal complications

Fetal complications are much higher in twin pregnancy and account for the high perinatal mortality and morbidity. They occur in both DZ and MZ twins, but there are certain complications unique to MZ twins.

Fetal complications common to both mono- and di ygotics twins

Fetal complications common to both MZ and DZ twins are listed in Box 32.8.

Congenital anomalies are much more common in multifetal pregnancy compared to singleton pregnancy. There is a two-fold increase in congenital anomalies in twins compared to singletons (2% vs. 4%). Congenital anomalies are more common in MZ twins. There can be discordance in anomalies, with one fetus being normal, even in MZ twins.

Fetal growth restriction (FGR) is another cause of perinatal mortality in twins. Twin fetuses grow normally till 30–32 weeks' gestation, but the growth rate beyond this slows even in an uncomplicated twin pregnancy. The slowing down of the growth trajectory may be due to crowding, uteroplacental insufficiency, or abnormal placental implantation.

50% of twin fetuses weigh <2500 g at birth and 10% weigh <1500 g. Fetal growth restriction in twins cannot be suspected or evaluated by clinical examination. Serial ultrasonography from 28 weeks' gestation is essential for identifying FGR.

Discordant growth leading to a difference in birth weight is another cause of mortality and morbidity. (Discordancy is defined as >20% difference in birth weight.) A difference in

abdominal circumference of >20 mm between the two fetuses is also diagnostic of discordant growth. The percentage of discordancy is calculated as follows:

$$\text{Percentage of discordancy} = \frac{\text{Weight of larger twin} - \text{Weight of smaller twin}}{\text{Weight of larger twin}}$$

Discordancy can be due to difference in growth potential of the two fetuses, placental insufficiency, or fetal malformation. Discordancy of more than 25%–30% is associated with higher perinatal mortality. Discordancy usually becomes manifest after 24 weeks' gestation. Ultrasonography is the only tool available for diagnosis of discordancy. In discordant twins, the growth-restricted twin has a poorer perinatal outcome and should be monitored closely.

Prematurity is the most important cause of perinatal mortality in multifetal pregnancy. Prematurity may be due to spontaneous preterm labor or iatrogenic prematurity due to early induction for obstetric indications. Preterm neonates are prone to hypothermia, intracranial hemorrhage, respiratory distress syndrome, necrotizing enterocolitis, and sepsis (*see Chapter 24, Common problems of the newborn*).

Complications unique to M twins

Dichorionic diamniotic MZ twins behave very similar to DZ twins. Due to the sharing of the placenta, MC/DA and MC/MA twins are prone to some unique complications. These arise due to vascular communications in the placenta. In addition, MA twins tend to have other specific problems. Perinatal mortality is, therefore, significantly higher in MZ twins. Complications unique to MZ twins are listed in Box 32.9.

Box 32.8 Fetal complications in mono ygotic and di ygotic twin pregnancies

- Congenital anomalies
- Fetal growth restriction
- Growth discordancy
- Prematurity

Box 32.9 Complications unique to mono ygotic twins

- Monoamniotic twins
- Twin-to-twin transfusion syndrome (TTTS)
- Twin reversed arterial perfusion sequence (TRAP)
- Twin anemia-polycythemia sequence (TAPS)
- Conjoined twins

monoamniotic twins

Of all MZ twins, 1% are MA, and the perinatal mortality in this situation is 20%. Diagnosis of MA twins can be made if ultrasonography in early pregnancy shows a single gestational sac with a single yolk sac and two fetuses. Perinatal mortality is higher than in diamniotic twins due to cord entanglement.

Close monitoring by ultrasonography and cardiotocography is mandatory from the time of viability. Elective delivery by cesarean section at 32–34 weeks is recommended for MA twins. Betamethasone should be administered prior to delivery to accelerate pulmonary maturity (Box 32.10).

in utero twin-to-twin transfusion syndrome

Vascular communications exist between the two placentas in all MC twins. These communications

are usually artery-to-artery or vein-to-vein. Since the pressure is equal on both sides with no gradient, the blood supply to the fetuses is not compromised.

Occasionally, the artery of one fetus communicates with the vein of the other fetus, giving rise to a pressure gradient and hence twin-to-twin transfusion syndrome (TTTS) occurs (Fig. 32.7). This occurs in 15% of MC twins. Blood from one fetus flows to the other unidirectionally, leading to hyperperfusion of the recipient twin and hypoperfusion of the donor twin (Box 32.11). Polyhydramnios leads to uterine overdistension and preterm labor.

With severe oligohydramnios, the dividing membrane appears attached to the fetal body, a condition called *stuck twin*. When one twin dies, the sudden hypotension in the surviving twin

Box 32.10 Monoamniotic twins

- 1% of all monozygotic twins
- Associated with several complications
- High (20%) perinatal mortality rate
- Cord entanglement is the most important cause of perinatal mortality
- Close monitoring by
 - Ultrasonography
 - Cardiotocography
- Deliver by cesarean section
- Deliver at 32–34 weeks
- Betamethasone prior to delivery

Box 32.11 Changes in the donor and recipient twins in twin-to-twin transfusion syndrome

- Donor twin
 - Oligohydramnios
 - Fetal growth restriction
 - Pulmonary hypoplasia
 - Contractures
- Recipient twin
 - Polyhydramnios
 - Cardiac failure
- If one fetus dies, the surviving twin may have
 - Multorgan failure
 - Neurological damage

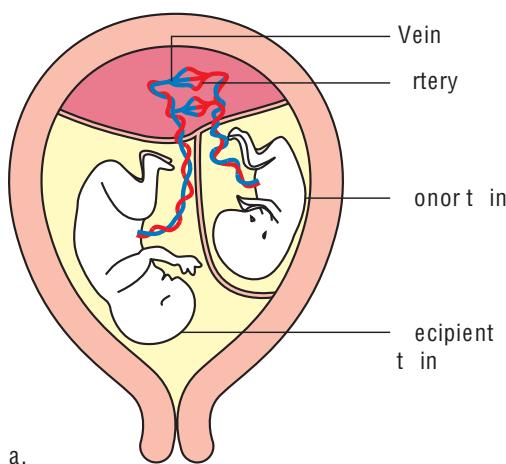


Figure 32.7 Twin-to-twin transfusion syndrome. **a.** Anastomosis between the arteries of the donor twin and veins of the recipient twin. Perfusion from the donor to the recipient occurs due to pressure gradient. **b.** The donor fetus is hypoperfused with fetal growth restriction, and the recipient twin is hyperperfused and plethoric. (Photo courtesy: Dr Rajnish Samal, Bangalore.)

leads to neurological damage. This may also result from thromboplastins released from the dead fetus.

Diagnosis of TTTS is by sonography and the criteria are listed in Box 32.12. None of the findings are pathognomonic. The most reliable finding is the discrepancy in amniotic fluid volume.

The Quintero staging system is useful in categorizing severity of disease (Box 32.13). In addition, evaluation of the cardiovascular function of the fetuses using fetal echocardiography is useful in management.

Management of TTTS

Management depends on the gestational age and the severity (stage) of the disease. The therapeutic options currently available are listed in Box 32.14. Best results are obtained when treated at Stage II.

Box 32.12 Sonographic criteria for diagnosis of twin-to-twin transfusion syndrome

- Monochorionicity
- Same gender
- Significant growth discordance
- Discrepancy in
 - Size of umbilical cord
 - Amniotic fluid volume
 - Polyhydramnios (single deepest pocket >8 cm) in one
 - Oligohydramnios (single deepest pocket <2 cm) in other
- Cardiac dysfunction in recipient twin

Box 32.13 Quintero staging system for TTTS

- Stage I: Donor twin bladder visible
- Stage II: Donor twin bladder not visible, normal Doppler
- Stage III: Discordant amniotic fluid volumes, donor twin bladder not visible, and abnormal Doppler studies of the umbilical artery, ductus venosus, or umbilical vein
- Stage IV: Ascites or frank hydrops in either twin
- Stage V: Demise of either fetus

Box 32.14 Therapeutic options for twin-to-twin transfusion syndrome

- Expectant management
- Serial amnioreduction
- Laser ablation of vascular anastomosis
- Septostomy
- Selective feticide

Expectant management is usually resorted to in Stage I disease, but close monitoring is mandatory. **Serial amnioreduction** involves removing amniotic fluid by amniocentesis repeatedly from the recipient twin under ultrasonic guidance. **Laser ablation** of communicating vessels is performed using fetoscope and requires technical expertise. This procedure is performed for TTTS occurring early in gestation and has the highest survival rate. **Septostomy** refers to the puncture of the septum between the two sacs to create an iatrogenic monoamniotic sac. The fluid volume equalizes between the two sacs. **Selective feticide** is not used often except in TTTS that occurs before 20 weeks' gestation. The procedure is associated with high risk of death for the other twin since vascular communications exist.

If left untreated, the mortality rate is 80%–100%. Laser ablation has the best survival rate compared to other modalities of therapy and is currently recommended for all except TTTS Stage I.

in reverse arterial perfusion sequence

Twin reversed arterial perfusion (TRAP) sequence is a rare condition (1/36,000 deliveries) in which large placental arteries of both twins communicate. Often a large vein-to-vein shunt is also present.

The donor twin pumps deoxygenated blood into the umbilical vessels of the second twin and supplies mainly to the lower half of the body. The heart and other structures of the upper half of the body do not develop in the recipient (acardiac) twin (Fig. 32.8). The donor twin develops cardiac failure since it has to pump blood into both fetuses. Mortality rate is high for the donor twin. Management is expectant or by laser ablation of communicating vessel (Box 32.15).

in anemia–polycythemia sequence

Twin anemia–polycythemia sequence (TAPS) is an uncommon condition that affects 5% of MC twins. It occurs due to a few arteriovenous anastomoses of small vessels in the placenta. It can be considered a variant of TTTS with a significant difference in hemoglobin levels between the fetuses but no major difference in amniotic fluid volume. One twin will be pale due to severe anemia and the other will

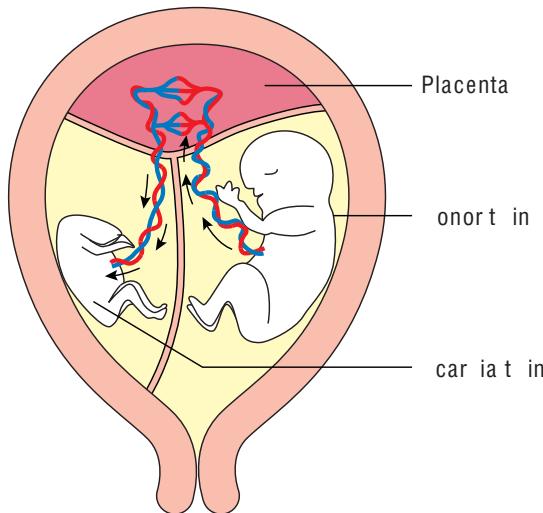


Figure 32.8 Twin reverse arterial perfusion. The donor twin pumps deoxygenated blood into the umbilical vessels of the second twin and supplies mainly to the lower half of the body. The upper half of the second twin does not develop, giving rise to an acardiac twin.

Box 32.15 Twin reversed arterial perfusion

- Rare condition
- Large placental arterial communication
- Recipient (acardiac) twin
 - Receives deoxygenated blood
 - Blood flow mainly to lower half of body
 - Lacks heart and other structures
- Donor twin
 - Cardiac failure
 - High mortality
- Treatment
 - Expectant
 - Laser ablation of communicating vessel

have a suffused appearance due to polycythemia. It can also occur following laser therapy in TTTS. Antenatally, TAPS may go undiagnosed. Ultrasonographic measurement of peak systolic blood flow in the middle cerebral arteries (MCA) will detect anemia in one twin and can be used for diagnosis. When severe, intrauterine death of one or both fetuses can occur. Management is expectant; severe cases may need laser ablation of communicating vessels (Box 32.16).

Conjoined twins

Conjoined twins are the result of incomplete division of the embryo, taking place between 13 and 15 days after fertilization. These are very rare (1/50,000 deliveries), and mortality is very high.

Box 32.16 Twin anemia polycythemia sequence

- Occurs in 5% of monochorionic twins
- Minor variant of TTTS
- Arteriovenous anastomoses of small vessels
- Significant difference in hemoglobin levels
- One twin anemic, other twin polycythemic
- No difference in amniotic fluid volume
- Most cases undiagnosed
- Diagnosis
 - Peak systolic flow in MCA
- Management
 - Expectant
 - Laser occlusion of communicating vessels

CA, middle cerebral artery; S, twin-to-twin transfusion syndrome.



Figure 32.9 Conjoined twins. The conjoined twins are joined at the lower thorax and abdomen. *Photo courtesy: Dr Rajnish Samal, Bangalore.)*

The twins may be connected at any level and may share varying number of organs (Fig. 32.9). Diagnosis is by ultrasonography. When diagnosed early, termination of pregnancy is advised. If diagnosed in the third trimester, delivery is by cesarean section. Surgical separation may be possible depending on the number and the nature of organs shared (Box 32.17).

Box 32.17 Conjoined twins

- Extremely rare
- High mortality rate
- Can be connected at any level
- May share vital organs
- Diagnosis
 - Ultrasonography
- Management
 - Termination of pregnancy
 - If late in pregnancy, cesarean section
 - Surgical separation if possible

Management of twin pregnancy

Antenatal care

Diet

Appropriate maternal nutrition and weight gain are crucial to achieve optimal perinatal and maternal outcome. Since the dietary requirements are increased in twin pregnancy, dietary advice is mandatory. Calories should be increased by 300 kcal/day over and above that recommended for a singleton pregnancy. Carbohydrates, protein, fat, and micronutrient requirements are also higher. Iron and folic acid deficiency are common and supplementation of these along with calcium is essential.

Weight gain

Recommended weight gain in twin pregnancy is almost twice that recommended for singletons. For women with normal body mass index (19–25 kg/m²), recommended weight gain is 16.8–24.5 kg.

Goals of management

Management of twin pregnancy is aimed at early diagnosis of twins, early identification of complications, and timely intervention for optimal maternal and perinatal outcome (Box 32.18).

Box 32.18 Goals of management in twin pregnancy

- Early diagnosis of twins
- Determination of chorionicity
- Detection of congenital anomalies
- Monitoring fetal growth
- Identification of discordancy
- Prevention of preterm labor
- Early diagnosis of maternal complications
 - Preeclampsia
 - Anemia
- Decision regarding
 - Timing of delivery
 - Mode of delivery
- Advise regarding
 - Breastfeeding
 - Contraception

Management First trimester

Once twin pregnancy is suspected clinically, confirmation of diagnosis is by ultrasonography. At 11–13 weeks, chorionicity should be determined, nuchal translucency measured, and congenital anomalies looked for. Basic investigations including hemoglobin and blood grouping should be ordered. The mother should be counseled regarding risks, outcomes, nutritional needs, and weight gain. Recommended cumulative weight gain is almost twice that recommended for singletons. Prenatal supplementation of folic acid must be given, as shown in Box 32.19.

Management Second trimester

ee s

Routine antenatal visits are scheduled every 2–3 weeks, which is more frequently than for singletons. Iron, calcium, and micronutrient supplementation should be started. Ultrasonography should be performed at 18 weeks for fetal morphology and cervical length.

ee s

The blood pressure should be monitored closely since early onset preeclampsia can occur. Oral glucose tolerance test must be performed at 24 weeks. Hemoglobin level must be rechecked. Ultrasonography must be repeated at 24 and

Box 32.19 Management of twin pregnancy First trimester

- Ultrasonography
 - 6–8 weeks
 - Number of fetuses
 - Number of gestational sacs
 - Number of yolk sacs
 - Gestational age
 - 11–13 weeks
 - Chorionicity
 - Nuchal translucency
 - Congenital anomalies
- Counseling
 - Diet
 - Weight gain
 - Pregnancy outcome
- Supplementation
 - Folic acid

Box 32.20 Management in twin pregnancy Second trimester

- 14–20 weeks
 - Iron, calcium, zinc, magnesium supplementation
 - Antenatal visits 2–3 weekly
 - Ultrasonography at 18 weeks
 - Morphology
 - Cervical length
- 20–28 weeks
 - Monitor blood pressure
 - Oral GTT at 24 weeks
 - Repeat hemoglobin
 - Ultrasonography 24 and 28 weeks
 - Fetal growth
 - Discordancy
 - TTTS
 - Cervical length
 - fFN if cervical length <25 mm

f , fetal fibronectin; *GTT*, glucose tolerance test; *TTTS*, twin-to-twin transfusion syndrome.

28 weeks for fetal growth, early detection of discordancy, TTTS, and cervical length. If available, fFN levels, may be checked if cervical length is <25 mm. (Box 32.20).

Management Third trimester

The mother must be seen every 2 weeks till 36 weeks and every week thereafter (Box 32.21). A rise in blood pressure, polyhydramnios, and pressure symptoms are watched for. Physical activity must be restricted. Serial ultrasonography must be performed to check fetal growth.

In uncomplicated twin pregnancies (DA twins, normal fetal growth, no discordancy, no poly/oligohydramnios, and no maternal complications), routine antenatal testing has no proven benefit. In complicated twin pregnancies, fetal surveillance must begin by 32 weeks. Weekly testing is recommended. Assessment of amniotic volume is important in the evaluation of fetal well-being. The deepest vertical pocket can be measured in each sac. This may be difficult in some women; therefore, amniotic fluid index can be calculated by measuring four quadrants, disregarding the membrane. Doppler velocimetry of the umbilical vessels is useful in FGR.

Presentation of both twins should be ascertained clinically and confirmed by ultrasonography, if necessary, so that mode of delivery can be planned.

Box 32.21 Management of twin pregnancy Third trimester

- Uncomplicated twin pregnancy
 - Antenatal check
 - 2 weekly till 36 weeks
 - Weekly till delivery
 - Monitor blood pressure
 - Restrict physical activity
 - Watch for
 - Polyhydramnios
 - Pressure symptoms
 - Ascertain presentation of both fetuses
 - Ultrasonography 2 weekly
- Complicated twin pregnancy
 - Weekly antenatal check
 - Weekly ultrasonography
 - Fetal growth
 - Biophysical profile
 - Doppler velocimetry
 - Presentation of first and second twin
 - Confirmed by ultrasonography

Timing of delivery

Most twin pregnancies go into spontaneous labor by 37–38 weeks. Studies have shown that fetuses in twin pregnancy mature faster; the stillbirth rate at 39 weeks is equivalent to the stillbirth rates for singletons at 42 weeks. It is recommended, therefore, that uncomplicated DC twins should be delivered by 38 weeks. Monochorionic diamniotic twins have a higher late pregnancy death rate and should be delivered by 36 weeks. Complicated twin pregnancies should be delivered earlier, depending on the fetal and maternal status.

Mode of delivery

In uncomplicated twins, the mode of delivery is determined by the presentation of the fetuses, especially the first twin. If the first twin is in vertex presentation, the twins could be vertex–vertex (42%) or vertex–nonvertex (38%). If the first twin is not a vertex presentation, it is referred to as nonvertex–vertex (20%) (Box 32.22).

Box 32.22 Mode of delivery

Fetal presentation	Mode of delivery
Vertex–vertex (42%)	Vaginal
Vertex–nonvertex (38%)	Vaginal
Nonvertex–vertex (20%)	Cesarean section

Elective cesarean section

Elective cesarean section is indicated in some situations as listed in Box 32.23.

Management of labor

Complications can occur at any stage of labor as already discussed. In anticipation of problems, preparations should be made for twin delivery as listed in Box 32.24.

The mother should be kept on oral fluids because the need for administration of anesthesia may arise. Intravenous fluid with a large bore needle must be started when the woman is in active labor. Intravenous access is essential to administer oxytocin for augmentation of labor and prevention of postpartum hemorrhage, and to transfuse blood if required. Electronic fetal monitoring of both fetuses is recommended. Uterine contractions and cervical dilatation should be monitored and plotted on a partogram. If uterine contractions are inadequate, labor should be augmented with oxytocin.

Box 32.23 Indications for elective cesarean section in twin pregnancy

- Absolute indications
 - First twin in transverse lie
 - Monoamniotic twins
 - FGR with abnormal Doppler velocimetry
 - Conjoint twins
 - Relative indications
 - First twin in breech/ other non-vertex presentations
 - Previous cesarean section
- , fetal growth restriction.

Box 32.24 Preparations for twin delivery

- Keep the patient on oral fluids
- Start intravenous infusion with large bore needle
- Delivery team should consist of
 - Obstetrician
 - Assistant
 - Pediatrician
 - Anesthetist
- Ensure availability of
 - Cross-matched blood
 - Electronic fetal monitoring
 - Two delivery sets
 - Oxytocin and methyl ergometrine
 - Ultrasonography

Delivery of first twin

Delivery of the first twin is completed as in singleton fetus. The cord should be clamped with a single clamp to indicate the first twin.

Delivery of second twin

Twenty to thirty minutes was considered to be the optimal interval between the delivery of the first and second twin. Later studies have shown that, as long as the fetal heart rate of the second twin remains normal on electronic monitoring, this interval can be longer.

- As soon as the first twin is delivered, the maternal abdomen should be palpated to ascertain the lie and presentation of the second twin.
- Fetal heart rate should be monitored.
- If the presentation is vertex and the uterine contractions are adequate, artificial rupture of membranes should be performed and the second twin delivered.
- If uterine contractions are not adequate, augmentation of labor is done by adding oxytocin to the infusion.
- If the presentation of the second twin is breech, when adequate uterine contractions are present, membranes may be ruptured artificially and the second twin delivered by assisted breech delivery.
- If the lie is transverse, external version should be performed to convert to longitudinal lie and delivery proceeded with.
- If external version is unsuccessful, internal podalic version and breech extraction should be performed (Fig. 32.10).
- Ultrasonography may be used to assist in external and internal version.
- If there is vaginal bleeding indicating placental abruption of the second twin or fetal distress, delivery should be expedited.
- Occasionally, cesarean section may be required for these indications or if the cervix clamps down after delivery of first twin.
- Two clamps should be applied to the cord of the second twin to identify it as belonging to the second twin.

Procedure to be followed for vaginal delivery of the twins is given in Figure 32.11.

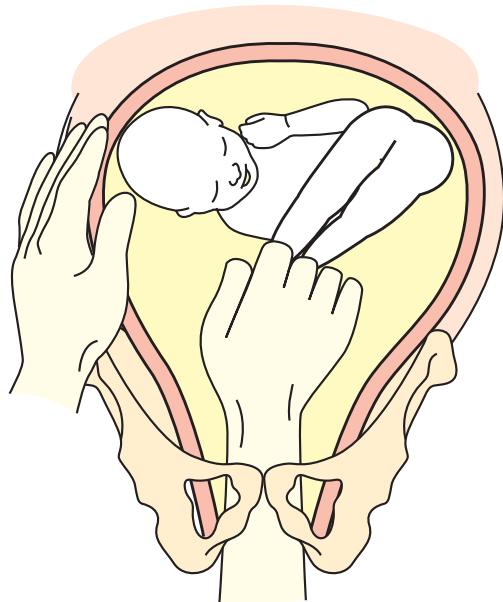


Figure 32.10 Internal podalic version and breech extraction. The right hand is introduced into the uterus and the feet of the fetus are grasped and pulled down and the baby is delivered by breech extraction.

Management of third stage

As soon as the second twin is delivered, 10 units of oxytocin should be added to the infusion to prevent postpartum hemorrhage. The placentas should be delivered when signs of placental separation are visible. Once delivered, the placentas should be examined. If it is a fused single placenta, the number of layers in the inter-twin membrane must be counted. Presence of three or four layers indicates DC/DA twins; presence of two layers indicates MC/DA twins (Box 32.25; Fig. 32.12).

Puerperium

Breastfeeding should be encouraged. Mothers must be counseled to breastfeed both babies since milk secretion is usually adequate for both. Since feeding two babies is tiring and challenging, help, guidance, and support are essential.

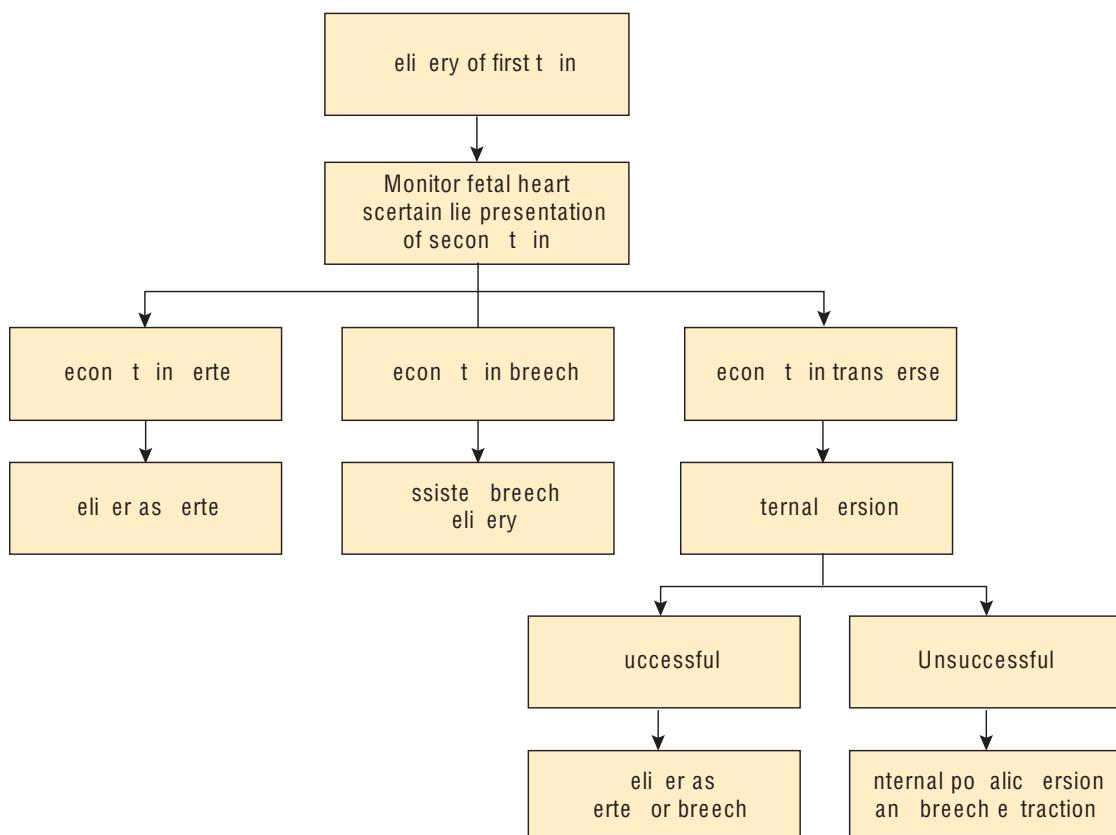


Figure 32.11 Vaginal delivery of twins.

Box 32.25 Management of third stage in twin pregnancy

- Add 10 units of oxytocin to infusion
- Deliver placenta(s)
- Examine placenta(s)
- Examine inter-twin membrane
 - Three or four layers—dichorionic diamniotic
 - Two layers—monochorionic diamniotic

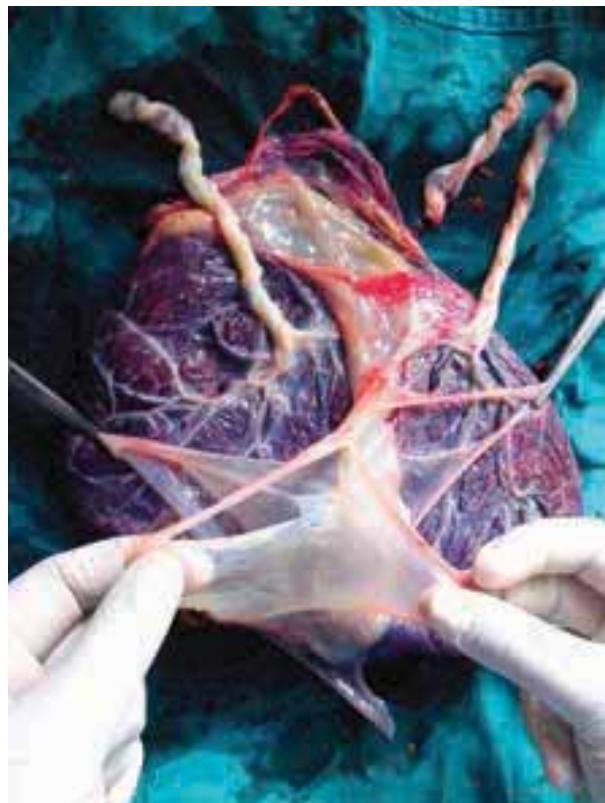


Figure 32.12 Dichorionic diamniotic placenta. Examination of the membrane between the two fetuses reveals four layers, two amnions and two chorions.

Special situations

During the course of the pregnancy or delivery, situations may arise that are uncommon and need expertise in management.

Vanishing twin

Vanishing twin is the term used when twin pregnancy is identified early in gestation but one sac disappears. The cause of death of the fetus is not known. It occurs in about 20%–30% of twin

gestations diagnosed in the first trimester. The frequency is more before fetal cardiac activity is identified. If this happens later in pregnancy, the dead fetus may get absorbed or be seen as a flattened structure attached to the placenta or membranes, and is known as *fetus papyraceus*.

Death of one fetus

Single fetal demise in the second or third trimester occurs in 5% of twin pregnancies and is more often seen in MC twins. Due to placental vascular communications in MC twins, demise of one twin can cause sudden hypotension, anemia, and ischemia in the second twin, resulting in multicystic encephalomalacia in the surviving twin. In DC twins, the condition that led to the death of one fetus may also affect the second twin, but the overall risk is not very high. Preterm labor can occur. Coagulation defect due to the release of thromboplastin from the dead fetus is possible, but is rare (Box 32.26).

Management depends on the chorionicity. Monochorionic twins must be monitored by ultrasonography for fetal well-being and detection of multicystic lesion in the brain. Steroids must be administered if delivery is required before 34 weeks. Monochorionic twins may have to be delivered when the gestational age crosses 34 weeks. Dichorionic twins may be monitored and delivered at term (Box 32.27).

Box 32.26 Death of one fetus in twin pregnancy

- Fetal death in second or third trimester
 - Occurs in 5% of twin pregnancies
 - More common in monochorionic twins
- Etiology
 - Anomalies
 - Placental insufficiency
 - Infections
 - Maternal conditions
 - Cord abnormalities
 - Twin-to-twin transfusion syndrome
- Problems in the surviving twin
 - Monochorionic twins
 - Multicystic encephalomalacia
 - Multiorgan damage
- Complications
 - Preterm labor
 - Coagulopathy

Box 32.27 Management of surviving twin

- Monochorionic twins
 - Close monitoring
 - Nonstress test
 - Ultrasonography
 - Biophysical profile
 - Multicystic lesions in brain
 - Steroids if <34 weeks
 - Deliver after 34 weeks
- Dichorionic twins
 - Monitor by biophysical profile
 - Deliver at term

Interlocking of twins

This is an extremely rare complication that occurs in labor. One pole or body of the second fetus obstructs the delivery of the first twin. The most common situation is where the after coming head of the first twin during breech delivery interlocks with the leading head of the second twin. The head of the second twin may be pushed up, but it is difficult. Survival of the first twin may be compromised. Delivery by cesarean section is recommended when interlocking occurs.

Multifetal pregnancy reduction

Pregnancies with more than two fetuses are associated with several risks to the fetuses and the mother. Selective reduction of higher-order multifetal pregnancy is performed to improve perinatal outcome. The procedure may be performed transabdominally, between 10 and 13 weeks. Two to three mL of potassium chloride is injected into the fetal thorax. The transvaginal or transcervical approach is used when abdominal approach is not feasible. It should not be

Box 32.28 Multifetal pregnancy reduction

- Done in higher order multiple pregnancies
- Transabdominal approach
- At 10–13 weeks
- Should not be done in monochorionic twins
- Ultrasonography to detect anomalies mandatory
- Select the fetus most easily accessible
- 2–3 mL of potassium chloride into fetal thorax
- Fetal death due to cardiac asystole

performed in MC twins since there are vascular communications. Ultrasonography is mandatory to detect anomalies and to guide the procedure (Box 32.28).

Selective termination

When one or more anomalous fetuses are terminated, the term *selective termination* is used. This procedure is performed at a later gestational age than fetal reduction (Box 32.29).

Box 32.29 Selective termination in multifetal pregnancy

- Congenital/chromosomal anomalous fetus
- Confirmed by
 - ultrasonography
 - chorion villous sampling
 - amniocentesis
- Performed in second trimester
- Transabdominal procedure
- Potassium chloride into selected fetus

Triplets and higher-order multiple pregnancies

Incidence of triplets is 14–15/1000; higher-order births are less common (Fig. 32.13). The incidence of triplets rose with the increase in use of assisted reproductive technologies but has reduced after guidelines regarding the number



Figure 32.13 The triplets. The fetuses are preterm and growth restricted. (*Photo courtesy: Dr. Rajnish Samal, Bangalore.*)

of embryos that can be transferred have been enforced. All maternal complications seen in twins occur more frequently and are more severe. Prematurity is the most important cause of perinatal mortality (Box 32.30).

The woman must have more frequent check-ups; the mother and fetus should be monitored closely. Serial weekly ultrasonography is recommended from 28 weeks. Prophylactic corticosteroids must be administered between 28 and 34 weeks. Delivery by cesarean section at 32–34 weeks is recommended for triplets.

Box 32.30 Higher order multifetal pregnancies

- Incidence
 - Triplets: 14–15/1000
 - Higher order: Less frequent
- Maternal complications
 - More severe
- Perinatal mortality and morbidity
 - Preterm labor and prematurity
 - Congenital anomalies
 - PROM
 - FGR
 - Vascular communications

, fetal growth restriction; *P* , prelabor rupture of membranes.

Key points

- The incidence of multifetal pregnancies, especially dizygotic (DZ) twin pregnancy, has increased globally due to the increased use of assisted reproductive techniques (ARTs).
- According to placentation, four types of twin pregnancies are described. Dizygotic twins are always dichorionic and diamniotic (DC/DA). Placentation depends on the timing of division of the embryo.
- Determination of chorionicity is essential for risk assessment and planning management. Chorionicity can be determined in the first and/or second trimester by ultrasonography.
- Diagnosis of twins is by clinical suspicion and confirmation is by ultrasonography.
- All the physiological changes of pregnancy in the mother are exaggerated in multifetal pregnancies.
- Maternal complications seen in singleton pregnancies occur more frequently and in a more severe form in twin pregnancies. The most important complications are anemia, preeclampsia, preterm labor, antepartum hemorrhage, and polyhydramnios.
- Intrapartum complications include malpresentations, increase in operative vaginal and abdominal delivery, and postpartum hemorrhage.
- Perinatal mortality is higher in twin pregnancy due to fetal complications such as prematurity, fetal growth restriction (FGR), congenital anomalies, and growth discordancy.
- Prematurity is the most important cause of perinatal mortality. Preterm labor can be predicted by cervical length measurement using ultrasonography at 24–28 weeks and maternal levels of fetal fibronectin (fFN).
- Clinical features of multifetal pregnancies include history of ART and maternal symptoms. Examination reveals overdistended uterus and multiple fetal parts. Three fetal poles must be palpated to clinically diagnose twins.

- Ultrasonography is an extremely useful tool in the diagnosis of multifetal pregnancy, identification of complications, and management.
- Monozygotic twins are prone to unique complications such as monoamniotic twins, twin-to-twin transfusion syndrome, twin reverse arterial perfusion, twin anemia–polycythemia sequence, and conjoined twins.
- Monoamniotic twins have a high perinatal mortality rate due to cord complications, preterm labor, congenital anomalies, and FGR. They should be closely monitored by ultrasonography and delivered by cesarean section at 32–34 weeks.
- Twin-to-twin transfusion syndrome occurs due to communication between the artery of one fetus and the vein of the other fetus in the placenta. It can give rise to oligohydramnios and FGR in the donor twin and polyhydramnios and cardiac failure in the recipient.
- The goals of management are to diagnose the multifetal pregnancy early, determine chorionicity, diagnose fetal complications, prevent preterm labor, diagnose and treat maternal complications, decide timing and mode of delivery, and provide contraceptive advise.
- Supplementation of iron and calcium, frequent antenatal visits, and timely and judicious use of ultrasonography to monitor fetal growth and well-being are essential components of antenatal management.
- Uncomplicated twins must be delivered by 37–38 weeks.
- If the first twin presents by vertex, vaginal delivery is recommended; if nonvertex, cesarean section is advisable.
- When the woman is in labor, everything must be kept ready for twin delivery.
- If the second twin presents in transverse lie, external version should be performed and if unsuccessful, internal podalic version and breech extraction are recommended.

(Continued)

Key points *Continued*

- Active management of the third stage is recommended. The placenta should be examined to confirm chorionicity.
- Intrauterine death of one fetus can cause problems in the other twin in MC twin pregnancies. The surviving twin should be monitored and delivered at term if DC or earlier if monochorionic.
- Multifetal pregnancy reduction is the selective reduction of higher-order pregnancy to twins, to improve perinatal outcome.

- Selective termination is performed when one or more fetuses are anomalous.
- Triplets and higher-order multiple births are rare and are associated with high perinatal mortality and maternal complications. Triplets should be monitored by ultrasonography and delivered by cesarean section at 32–34 weeks.

Self-Assessment

Case-based questions

Case 1

Mrs. RN, 30, is referred at 32 weeks from a primary health center since examination revealed a uterus larger than the gestational age and has been diagnosed to have twin pregnancy.

1. What details will you ask for in the history?
2. What will you look for on clinical examination?
3. What other complications do you anticipate?
4. How will you monitor the mother and the fetus?

Case 2

Mrs. SM, 28, is referred in labor with twin pregnancy.

1. How will you decide on the mode of delivery?
2. If the first twin presents by vertex, how will you deliver?
3. After the delivery of the first twin, there is a gush of fresh bleeding and fetal heart deceleration of the second twin. What is your diagnosis?
4. What complications do you anticipate after the delivery of twins?

Answers

Case 1

1. a. History of infertility, use of ovulation-inducing drugs, family history of twins.
b. History of pressure symptoms, acute abdominal distension.
2. a. General examination: Pallor, blood pressure, pedal edema.
b. Obstetric examination: Fundal height, multiple fetal parts, three fetal poles, two fetal hearts, polyhydramnios.
3. Preeclampsia, preterm labor, anemia, gestational diabetes, polyhydramnios, antepartum hemorrhage.

4. a. Investigations: Hemoglobin, other routine tests if not already done, oral glucose tolerance test if not already done.
b. Ultrasonography: For fetal size, biometry, discordancy, amniotic fluid volume, number of placentas, inter-twin membrane if visible, fetal anomalies.
c. If uncomplicated, two placentas visible or fetuses of different gender: 2 weekly antenatal checkup till 36 weeks, weekly thereafter.

Case 2

1. a. General examination: Pallor, blood pressure.
b. Obstetric examination: Presentation of first twin, polyhydramnios.
c. Ultrasonography: Presentation of first and second twins, fetal weights.
2. Vaginal delivery, if no severe FGR or discordancy.
3. Placental abruption of second twin.
4. Atonic postpartum hemorrhage, retained placenta, traumatic postpartum hemorrhage if operative vaginal delivery.

Sample questions

Long-answer questions

1. Discuss the diagnosis and antenatal complications of multifetal pregnancy.
2. Discuss the management of second stage in delivery of twins.
3. What are the maternal and fetal complications of twin pregnancy?

Short-answer questions

1. Conjoined twins
2. Maternal complications of twin pregnancy
3. Twin-to-twin transfusion syndrome
4. Delivery of second twin
5. Vanishing twin

33

Fetal Growth Disorders: Growth Restriction and Macrosomia

Case scenarios

Mrs. HJ, 26, gravida 2, para 1, live 1, weighed 43 kg and had gained only 4 kg during her pregnancy. She was 34 weeks by dates. Clinical examination showed the uterine size to be smaller than expected for the gestational period. She was suspected to have fetal growth restriction. She had been referred for further evaluation and management.

Mrs. KL, 29, gravida 2, para 1, live 1, weighed 103 kg and had gestational diabetes. She was 36 weeks by dates. Estimated fetal weight at 36 weeks was 3900 g. She and her husband were concerned that the baby was big and so they had come for a discussion of mode of delivery and possible complications.

Introduction

Fetal growth restriction (FGR) and macrosomia are two extremes of fetal growth disorders. In FGR, the fetus fails to reach its full growth potential. In macrosomia, the fetus exhibits inappropriate and excessive growth, especially disproportionate fat deposition (Fig. 33.1).

Fetal growth restriction is linked to an increased risk of perinatal morbidity and mortality. Growth-restricted fetuses are more prone to intrauterine hypoxia/asphyxia. Stillbirth and hypoxic-ischemic encephalopathy (HIE) are more likely to occur in growth-restricted fetuses.

Macrosomia, on the other hand, is associated with both maternal and fetal morbidity. It is



Figure 33.1 A growth restricted infant (SGA) is flanked on its right by an infant of normal growth and on its left by a large-for-gestational-age (LGA) infant.

associated with fetal complications such as perinatal asphyxia, death, and shoulder dystocia. Maternal risks of macrosomia are cesarean section, prolonged labor, postpartum hemorrhage, and perineal trauma.

14–15 weeks' gestation to 10 g/day at 20 weeks, and to 30–35 g/day at 32–34 weeks. Between 32 and 34 weeks the fetus gains approximately 230–285 g/week. The rate of weight gain decreases after that. After 41 weeks, there may even be a slight loss of weight.

Fetal growth and determinants of birth weight

The natural growth potential of the fetus is dictated, on one hand, by the fetal genome and, on the other, by the intrauterine environment (Fig. 33.2). The intrauterine environment is under the influence of both maternal and placental factors. Fetal growth is dependent on satisfactory transport of essential nutrients and oxygen across the placenta. Both maternal nutrition and placental perfusion play a major role in the ability of the placenta to transfer substrates across to the fetus. Fetal hormones also play a role in promoting normal growth. In the third trimester, insulin-like growth factors (IGFs) coordinate a precise and orderly increase in growth. Insulin and thyroxine (T4) are required through late gestation to regulate appropriate growth in both normal and abnormal nutritional circumstances.

The total substrate needs of the fetus are relatively small in the first half of pregnancy. The rate of fetal growth is much more in the late third trimester as compared with that in early pregnancy. Fetal weight increases from 5 g/day at

Fetal growth restriction

Definition

A fetus with an estimated weight below the 10th percentile for a given gestational age is considered to have fetal growth restriction (FGR), also called intrauterine growth restriction (IUGR), caused by a pathologic process that inhibits intrinsic growth potential. The World Health Organization (WHO) defines FGR as birth weight <2500 g for developing countries, but this definition is not universally accepted.

The term small for gestational age (SGA) is sometimes used for a fetus exhibiting less than expected growth (<10th percentile), but this includes both constitutionally small but healthy fetuses (50%–70%) and fetuses that are actually growth restricted (20%).

To avoid confusion, the term FGR should be used with regard to the fetus, whereas SGA should be used only in reference to the newborn (Box 33.1).

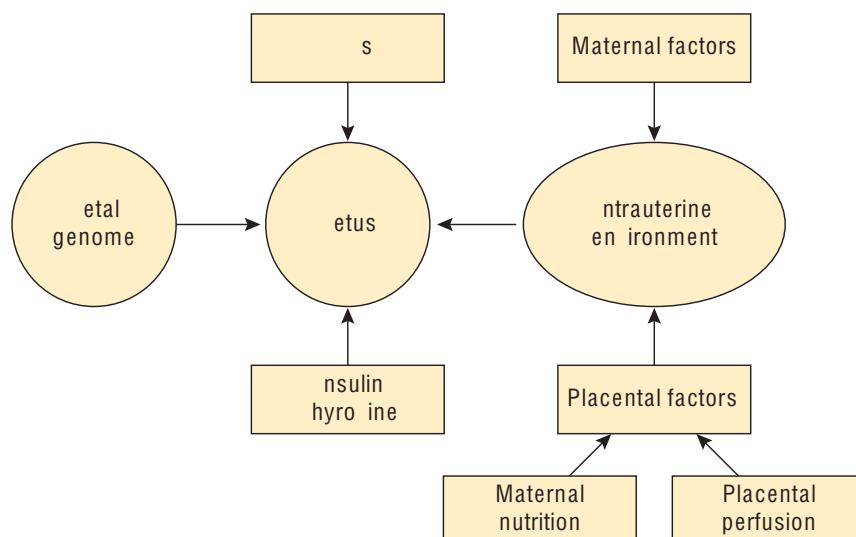


Figure 33.2 Determinants of birth weight and fetal growth.

insulin-like growth factor.

Box 33.1 Definitions for growth-restricted fetuses and SGA infants

- Fetal growth restriction
 - Estimated weight <10th percentile
 - Not achieved growth potential
 - Pathologic process involved
- SGA
 - 50%–70% small but healthy
 - 20% growth restricted

S A small for gestational age.

Constitutionally small fetus

Constitutionally small fetuses are SGA babies that weigh >10th percentile for the gestational age but are small due to constitutional factors such as maternal ethnicity, body mass index (BMI), or female gender. The perinatal outcome is normal.

Late-onset FG

Fetuses with late-onset FGR weigh >10th percentile but have not achieved their growth potential since the growth restriction sets in after 34 weeks. This may account for perinatal deaths that occur in fetuses of ‘normal’ weight. The condition is difficult to diagnose except by Doppler studies of the middle cerebral artery (MCA) and umbilical artery. Routine screening for this condition is not warranted.

Classification of FGR

Symmetric FG

Symmetric FGR comprises 20%–30% of growth-restricted fetuses. This is a growth pattern in which there is a proportionate decrease in growth of all fetal organs. The head size and abdominal size are proportionately small. **This is due to the universal impairment of early fetal cellular hyperplasia, caused by infection, teratogens, or chromosomal abnormality.** This insult usually happens early in fetal development and therefore affects the fetus uniformly.

Asymmetric FG

Asymmetric FGR occurs in 70%–80% of growth-restricted fetuses. **When the insult (usually placental insufficiency) to the fetus**

happens in the late second trimester or in the early third trimester, it results in asymmetric FGR. The fetal head size stays normal but the abdominal circumference (AC) decreases. The decrease in abdominal size is due to the decrease in liver volume (caused by reduced glycogen storage in the liver) and subcutaneous fat. Faced by a hostile environment, the fetus compensates by redistributing blood flow to vital organs such as the brain, heart, and placenta, and decreases flow to nonvital fetal organs such as abdominal viscera, lungs, skin, and kidneys.

The key differences between symmetric and asymmetric FGR are listed in Table 33.1.

Table 33.1 Comparison between symmetric and asymmetric growth restriction

	Symmetric FG	Asymmetric FG
Distribution	20%–30%	70%–80%
Insult	Early	Late
Growth pattern	Proportionate	Disproportionate
Head circumference	Decreased	Normal

fetal growth restriction.

Incidence

FGR is a major health concern in developing countries such as India. The incidence of FGR is 23%, or approximately 30 million term newborns per year in developing countries. Nearly 75% of all affected newborns are born in Asia, mainly in South-Central Asia.

On the other hand, the prevalence of FGR is approximately 10% of the general population in developed countries.

Risk factors for FG

A single risk factor or a combination of risk factors can result in FGR. Maternal, placental, and fetal causes have been implicated in the pathophysiology of FGR.

Maternal factors

Maternal factors that can result in poor fetal growth can act by

- reducing uteroplacental perfusion,
- inducing hypoxemia, and
- providing decreased nutritional substrates.

Reduced uteroplacental perfusion can occur in maternal medical conditions associated with vascular disease. Placental microthrombi, occlusion of vessels and infarcts may decrease placental perfusion. Placental underperfusion is the most common cause of FGR in the fetus with no congenital anomalies.

Chronic maternal hypoxemia can lead to fetal hypoxemia and FGR.

If the mother is undernourished, there is decreased nutrition for the fetus.

The maternal factors that can result in FGR are enumerated in Box 33.2.

Box 33.2 Maternal factors leading to FG

Reduced uteroplacental perfusion

- Pregnancy-related hypertensive diseases
 - Chronic hypertension
 - Gestational hypertension
 - Preeclampsia
- Pregestational diabetes mellitus
- Renal insufficiency
- Autoimmune disease
 - Systemic lupus erythematosus (SLE)
- Antiphospholipid antibody (APA) syndrome
- Hypoemria
- Cyanotic cardiac disease
- Pulmonary disease (including severe, uncontrolled asthma)
- Severe anemia
- Living at a high altitude
- Smoking

Decreased nutritional substrates

- Low prepregnancy weight
- Poor weight gain in pregnancy
- Pregnancy at the extremes of reproductive age
- Short interpregnancy interval

fetal growth restriction.

Fetal factors

Fetal factors usually result in early and symmetric IUGR. This means that the growth restriction may be identified in the first and second trimesters. Since fetal factors cause global decrease in fetal growth, all fetal measurements are below expected, resulting in symmetric growth restriction.

Genetic factors

Fetal weight is influenced greatly by the fetal genome. Although maternal genes contribute

more to the final fetal weight, paternal genes also have an effect. Chromosomal abnormalities contribute to 20% of all FGR. This usually affects fetal growth early in gestation, rather than late.

The common chromosomal abnormalities associated with FGR are as follows:

- Aneuploidy (e.g., trisomy 18 or 13, Turner 45 X, triploidy)
- Partial deletions, duplications, and mutations
- Ring chromosomes
- Confined placental mosaicism

Congenital anomalies

In the presence of major or multiple structural congenital anomalies, the fetus is unable to keep up normal growth velocity. Many congenital anomalies associated with FGR result from chromosomal abnormalities.

Multiple pregnancy

In multiple pregnancy, FGR is usually seen in the third trimester, when fetal nutritional requirements are not met. Fetal growth in multiple pregnancy depends on the following:

- Number of fetuses present
- Type of placentation (monochorionic vs. dichorionic)
- Presence of complications such as
 - Twin-twin transfusion
 - Congenital anomalies

Congenital infection

Transplacental transmission of maternal infection early in pregnancy may result in FGR. This accounts for 5% of all cases of FGR. Congenital infections associated with FGR are rubella, toxoplasmosis, cytomegalovirus, varicella-zoster, malaria, syphilis, and herpes simplex.

Placental factors (including umbilical cord abnormalities)

Abnormal placentation

Abnormal placentation resulting in poor placental perfusion and placental insufficiency is the most common pathophysiology associated with FGR.

Table 33.2 Risk factors for fetal growth restriction

Maternal factors	Placental factors	Fetal factors
Decrease placental perfusion		Genetic disorders
<ul style="list-style-type: none"> Hypertensive disorders Diabetes Antiphospholipid antibody syndrome Systemic lupus erythematosus Renal disorders 	<ul style="list-style-type: none"> Abnormal placentation Structural abnormalities Abnormalities of the cord 	<ul style="list-style-type: none"> Aneuploidy Deletions, duplications Ring chromosomes Mosaicism
Maternal hypotension		Congenital malformations
<ul style="list-style-type: none"> Cyanotic heart disease Anemia Pulmonary disease High altitude 		Multi-fetal pregnancy infections
Decrease nutrition		<ul style="list-style-type: none"> Toxoplasma Rubella Cytomegalovirus Syphilis Herpes simplex Varicella-zoster
<ul style="list-style-type: none"> Low prepregnancy weight Poor weight gain Short interpregnancy interval 		

Structural placental abnormalities

Placental abnormalities such as abruption, infarction, circumvallate placenta, hemangioma, and chorioangioma have also been associated with FGR.

Umbilical cord abnormalities

Cord abnormalities such as velamentous or marginal cord insertion and single umbilical artery have been associated with FGR.

Risk factors for FGR are listed in Table 33.2.

Impact of FG

A growth-restricted fetus faces an increased risk of perinatal mortality and morbidity. As the fetal weight decreases, perinatal mortality and morbidity increase exponentially. Almost 50% of stillbirths are associated with FGR. When growth restriction goes unrecognized, it accounts for 10% of perinatal mortality. However, the morbidity and mortality are more significant if the fetal weight is <5th percentile.

There are also long-term health consequences for survivors. Long-term consequences for growth-restricted infants in adulthood include hypertension, type 2 diabetes, heart disease, stroke, and osteoporosis, (discussed in detail later in this chapter).

Box 33.3 Perinatal risks for infants with FG

- Increase in perinatal mortality
- Increase in perinatal morbidity
 - Nonreassuring fetal status
 - Operative vaginal delivery
 - Cesarean section
 - Prematurity
 - Hypoxic-ischemic encephalopathy
 - Meconium aspiration
 - Neonatal hypothermia
 - Hypoglycemia
 - Necrotizing enterocolitis
 - Bronchopulmonary dysplasia
- Long-term consequences
 - Metabolic syndrome

fetal growth restriction.

Perinatal complications of growth-restricted neonates are listed in Box 33.3.

Screening for FG

In low-risk pregnancies

Clinical assessment is enough for screening for growth restriction in low-risk pregnancies. In a low-risk pregnancy, further diagnostic tests are required only when there is clinical suspicion of FGR on routine clinical examination.

Symphysio-fundal height

Abdominal palpation alone is not a reliable clinical tool to assess FGR. Measuring the symphysio-fundal height (*see Chapter 8, History taking and examination of the obstetric patient*) may raise a suspicion of FGR when the fundal height in centimeters is at least 3 cm below the gestational age in weeks. For example, if at 36 weeks' gestation, the symphysio-fundal height is only 32 cm, FGR is suspected.

Uterine artery Doppler

Notching or increased pulsatility index in uterine artery Doppler in the first or second trimester has been studied as a screening test. A positive test is associated with a threefold increase in the risk for FGR, but the sensitivity of the test is higher for predicting FGR with preeclampsia. The test is not recommended for routine screening (*see Chapter 10, Obstetric ultrasound and other imaging*).

In high-risk pregnancies

Certain pregnancies are at increased risk for the occurrence of FGR, based on factors in the past or present history. These pregnancies should be screened for FGR by both clinical assessment and serial ultrasonography.

The factors that place a pregnancy at high risk for FGR are summarized in Box 33.4.

Box 33.4 High-risk factors for FG

- Presence of clinical risk factors
 - Preeclampsia
 - Maternal hypertension
 - Systemic lupus erythematosus
 - Insulin-dependent diabetes with vascular disease
 - Cyanotic heart disease
- Previous birth of a growth-restricted infant
- First trimester screening for Down syndrome with
 - Low PAPP-A
- Triple or quadruple screening for Down syndrome with
 - Elevated levels of hCG, inhibin, or AFP
 - Associated with fivefold increase in FGR

A *P* alpha fetoprotein; *FGR* fetal growth restriction; *hCG* human chorionic gonadotropin; *PAPP-A* pregnancy-associated plasma protein A.

Diagnosis of FG

The diagnosis of FGR depends on history of risk factors mentioned earlier and clinical suspicion arising during physical examination, which is then confirmed or excluded by an ultrasound examination.

Ultrasound imaging in FG

Ultrasound is the best tool for the diagnosis and evaluation of FGR as it is highly reliable and reproducible. The role of ultrasound in FGR is fourfold (Box 33.5).

Ultrasound diagnosis of FG

Ultrasound diagnosis of FGR depends on the following:

- Establishment of accurate gestational age
- Assessment of fetal size and rate of growth
- Growth charts

Establishment of accurate gestational age

Gestational age is best established in the first trimester using crown-rump length (CRL) measurement. Once established in the first trimester, the estimated date of delivery should not be changed. This is particularly important in high-risk pregnancies where follow-up is required to identify FGR. Accurate gestational age helps in plotting an accurate growth chart.

Box 33.5 Role of ultrasound in FG

- Identification of FGR
 - By using growth charts
- Identification of type of FGR
 - Symmetric
 - Asymmetric
- Identification of cause
 - Infections
 - Structural abnormalities
 - Aneuploidy
- Antenatal surveillance
 - Amniotic fluid assessment
 - Biophysical profile

fetal growth restriction.

Assessment of fetal size and rate of growth

The four biometric measurements of the fetus include the following:

- Biparietal diameter (BPD)
- Head circumference (HC)
- Fetal abdominal circumference (AC)
- Femur length (FL)

The serial measurements of these parameters, especially of the AC, help in identifying the growth-restricted fetus (*see Chapter 10, Obstetric ultrasound and other imaging*). FGR cannot be diagnosed by ultrasound unless the AC is measured.

The ultrasound methods used for diagnosing FGR include the following:

- Measurement of the AC
- Calculation of the estimated fetal weight (EFW)
- Head-to-abdomen ratio (HC/AC ratio)
- Serial observation of biometric growth patterns (growth velocity)

Abdominal circumference

Of the four biometric parameters, decreased AC is the most sensitive single indicator of FGR. If previous ultrasound scans are done at 11–13⁺⁶ and 18–22 weeks, the optimal time to screen for FGR is at 32 weeks' gestation. If clinical suspicion arises before that, an ultrasound examination should be done to confirm or rule out FGR.

The fetal growth curve can be extrapolated from the previous readings. If the curve maintains the expected growth velocity, then FGR can be ruled out. A fetus that is constitutionally small but otherwise healthy will maintain the growth velocity. This is also called a fetus with a **low growth profile** (Fig. 33.3). If the AC falls below the expected curve, then FGR can be diagnosed. If the FGR has to be confirmed, an ultrasound should be repeated after an interval of 2 weeks.

When the AC and EFW are **less than the 10th percentile**, FGR can be diagnosed accurately. Conversely, an AC within the normal range reliably excludes growth restriction. Although FGR is considered to exist when the AC is <10th percentile, fetal morbidity increases when the AC is <5th percentile.

Estimated fetal weight

Fetal weight estimation has become one of the reliable methods of identifying the growth-restricted fetus. Most commonly, the formula for estimating EFW uses a combination of BPD, HC, AC, and FL. These formulas are usually included in the software package in the ultrasound machine. Fetal weight distribution by gestational age is also provided in standardized tables, and the percentile can be calculated.

Head to abdomen ratio

In early pregnancy the HC is larger than the AC. As the pregnancy progresses, this proportion changes and at term the AC is larger than the HC. In growth-restricted fetuses with asymmetric FGR, the HC will be equal to or greater than the AC. Therefore, an elevated HC/AC ratio helps in the diagnosis of FGR.

Serial observation of biometric growth patterns (growth velocity)

Growth charts are available using ultrasound biometric parameters. Preferably, the growth curves should be based on a homogeneous fetal population. Customized growth charts take into consideration factors that normally influence fetal growth. They make adjustments for maternal height, weight, parity, ethnic origin, and fetal sex, giving an individual growth chart for every patient. These are more accurate than population-based growth charts in the diagnosis of FGR and exclusion of the constitutionally small fetus.

Figure 33.4 shows the growth chart for symmetric FGR where the growth restriction has started early and has affected both the head size (BPD and HC) and the AC.

Figure 33.5 shows the growth chart for asymmetric FGR where the growth restriction has started later and affects the AC, with sparing of the head size.

Antenatal interventions in IUGR

Very few prenatal interventions have shown to reduce the perinatal outcome in the presence of FGR. Treatment of infections such as malaria

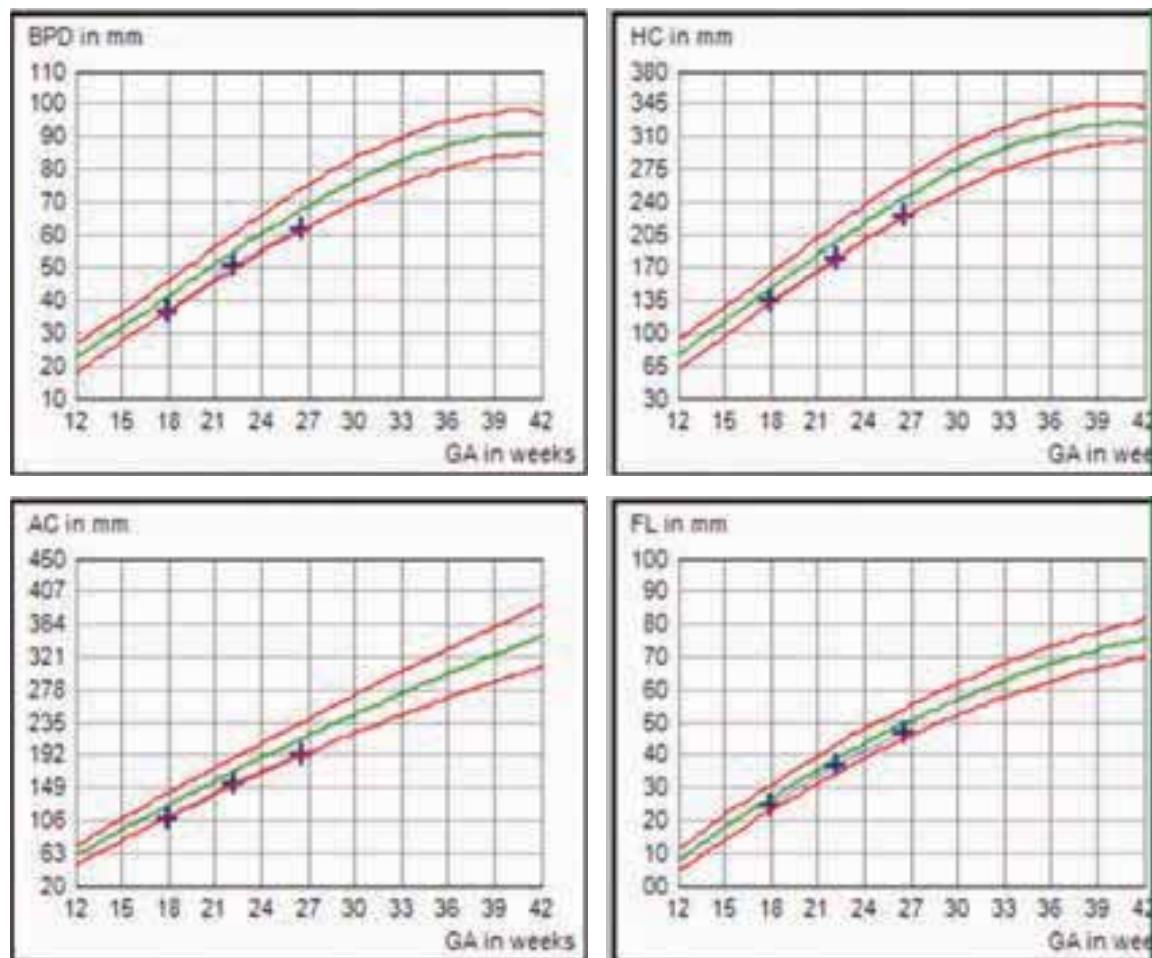


Figure 33.3 Fetal growth chart of a fetus with low growth profile. The fetal biometric parameters (BPD, HC, AC, and FL) are all at the low normal percentile but are maintaining the growth velocity. The fetus is constitutionally small but otherwise healthy. AC abdominal circumference; BPD biparietal diameter; FL femur length; GA gestational age; HC head circumference.

in endemic areas has been shown to be of some benefit. Discontinuation of smoking may be effective in preventing FGR. Low-dose aspirin has been extensively studied and has been found to reduce FGR associated with pre-eclampsia when started before 16 weeks.

Interventions with no benefit

Bed rest, protein supplementation, IV fluids, Fructodex, L-arginine, zinc supplementation, calcium supplementation, plasma volume expansion, maternal oxygen therapy, heparin, and low-dose aspirin are **not** beneficial and may be potentially harmful in the prevention and treatment of FGR.

Management of pregnancy complicated by FG

Initial evaluation

Initial evaluation aims at differentiating the healthy SGA fetus from the growth-restricted fetus (Box 33.6).

Subsequent management

Once the diagnosis of FGR is made, subsequent management of the pregnancy involves a two-pronged approach:

- Evaluation of fetal health
- Decision about timing of delivery

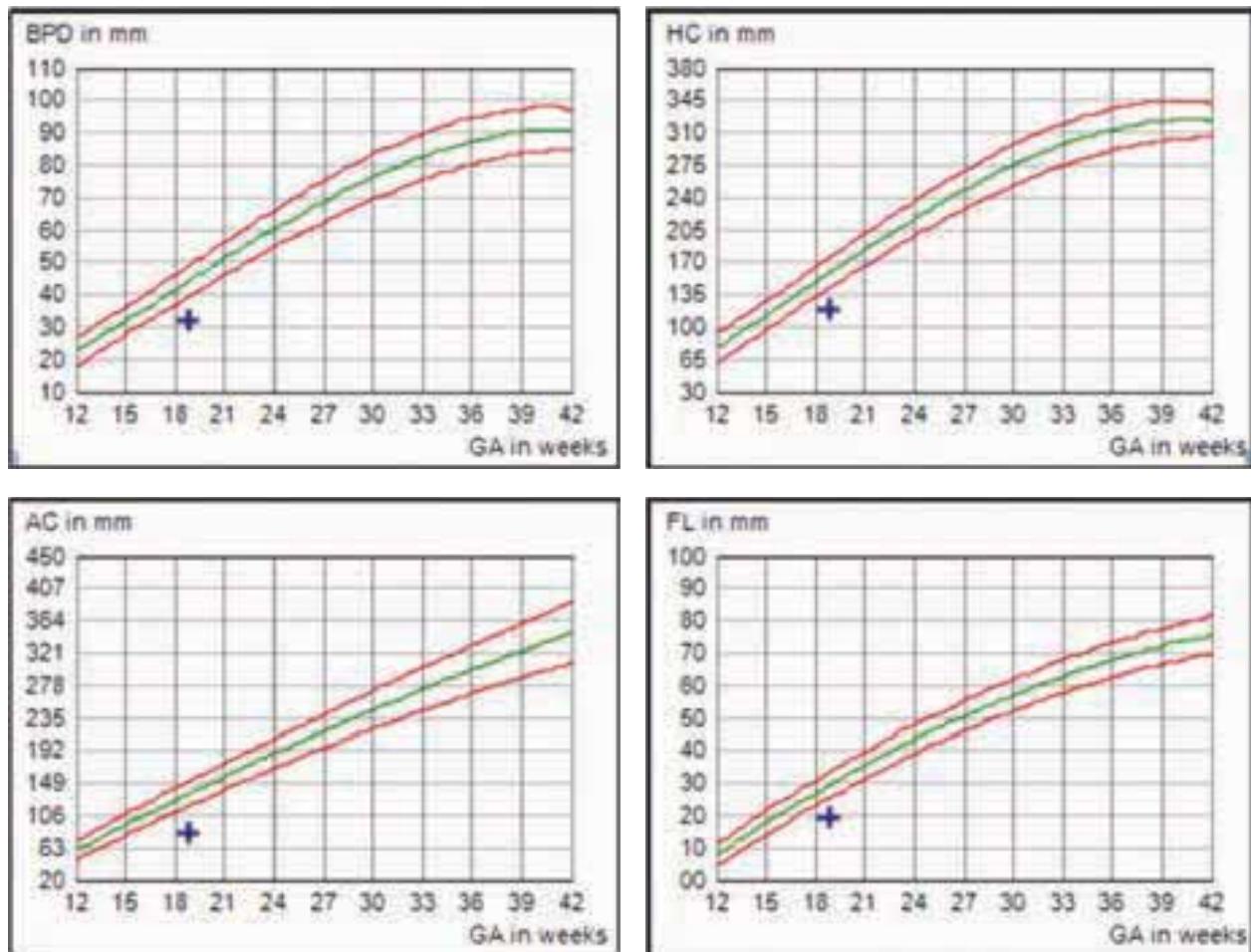


Figure 33.4 Fetal growth chart showing symmetric fetal growth restriction. All fetal biometric parameters are below the 5th centile at 19 weeks' gestation. *AC* abdominal circumference; *BPD* biparietal diameter; *FL* femur length; *HC* head circumference; *GA* gestational age.

Box 33.6 Initial evaluation in FG

- Healthy SGA fetus (constitutionally small)
 - Normal detailed ultrasound
 - Normal umbilical artery Doppler
 - Normal AFV
 - Follow with
 - Routine antenatal care
- Growth-restricted fetus
 - Abnormal umbilical artery Doppler
 - Decreased AFV
 - Follow with
 - Enhanced fetal surveillance
 - May require
 - Preterm delivery

A , Amniotic fluid volume; fetal growth restriction; S A small for gestational age.

Evaluation of fetal health helps determine whether the fetus is tolerating or not tolerating the hostile intrauterine environment. The decision on the timing of the delivery depends on both the fetal status and the maternal condition.

Evaluation of fetal health

Amniotic fluid volume

Amniotic fluid volume is important both in diagnosis and in prognostication in fetuses with FGR. Oligohydramnios is highly suggestive of FGR and is associated with an increased risk of perinatal mortality.

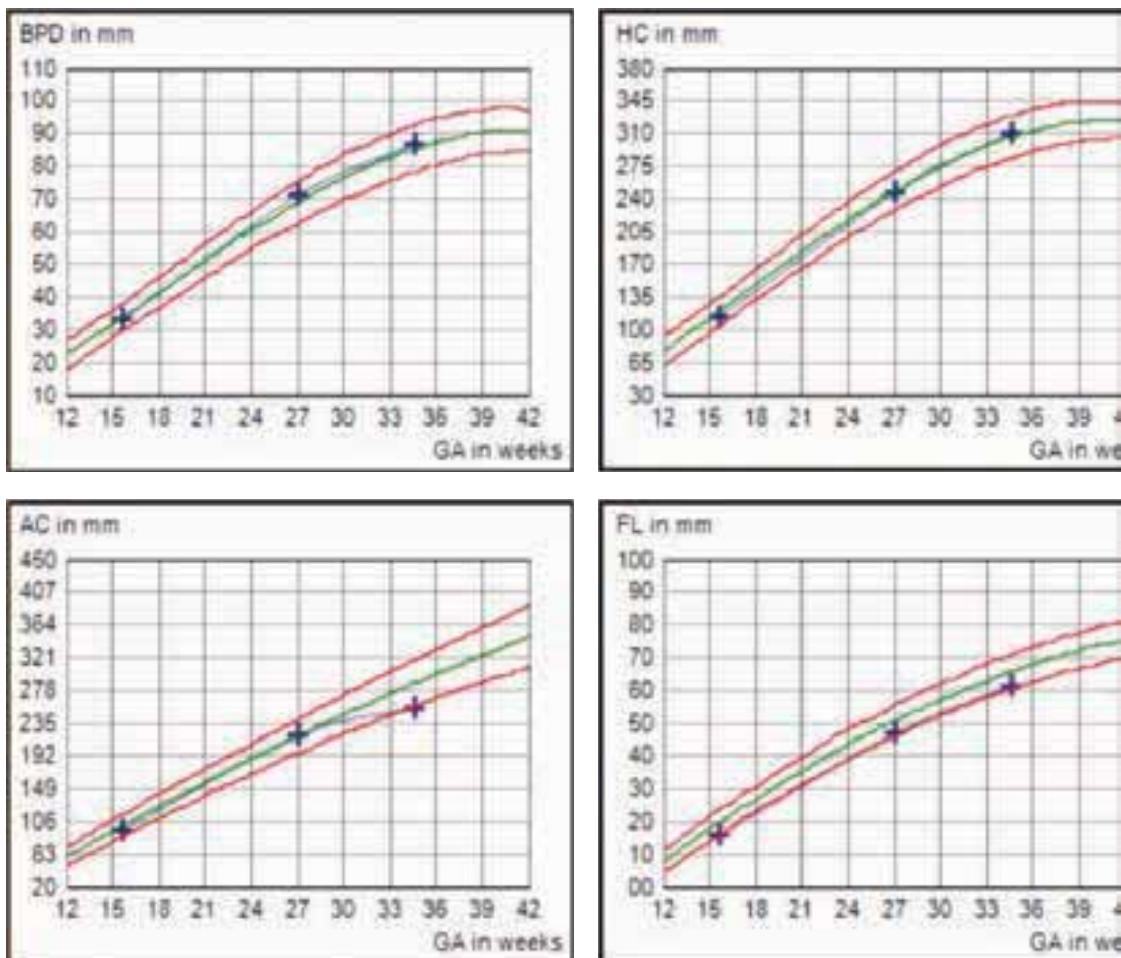


Figure 33.5 Fetal growth chart showing asymmetric fetal growth restriction. The AC has not kept up the growth velocity and has fallen below the 5th centile at 34–35 weeks' gestation (red arrow). AC abdominal circumference; BPD biparietal diameter; FL femur length; GA gestational age; HC head circumference.

Biophysical profile

BPP is useful in determining the timing of delivery in the presence of FGR (see Chapter 11, *Antepartum fetal surveillance*).

Doppler velocimetry

Doppler studies of the umbilical artery, the middle cerebral artery and the ductus venosus help in making a decision about the timing of delivery.

Umbilical artery

Doppler velocimetry of the umbilical artery is the primary surveillance tool for monitoring pregnancies where growth restriction is caused by placental dysfunction (asymmetric FGR). Antepartum surveillance with Doppler of the

umbilical artery and MCA is initiated when FGR is suspected.

Umbilical artery Doppler waveform represents increased placental resistance. Pulsatility Index values increase as peripheral resistance increases. Umbilical artery Doppler is considered abnormal if diastolic flow is **reduced, absent, or reversed** after 20 weeks' gestation (see Chapter 11, *Antepartum fetal surveillance*).

Reduced end-diastolic flow in the fetal umbilical artery indicates that

- 30% of the villus vasculature has ceased to function,
- perinatal morbidity is still low, and
- it is safe to manage pregnancy expectantly.

Absent or reversed flow in the umbilical artery

- indicates 60%–70% obliteration of placental arteries, and
- is associated with
 - fetal hypoxia and
 - significant increase in perinatal morbidity and mortality.

Prompt delivery is indicated in the presence of absent or reversed flow in the umbilical artery

i Middle cerebral artery

As the FGR leads to progressive hypoxia, the fetus compensates by cerebral vasodilatation (brain-sparing effect). The MCA Doppler demonstrates high diastolic flow.

Ductus venosus

An absent or reversed ductus venosus A-wave indicates cardiovascular damage and may be a sign of impending fetal acidemia and death.

Fetal evaluation in a growth-restricted fetus is summarized in Box 33.7.

Box 33.7 Further evaluation in FG

- AFV
 - Oligohydramnios
 - Highly suggestive of FGR
 - Increased risk of perinatal mortality
- BPP
 - Helps in timing of delivery
- UA Doppler
 - Reduced end diastolic flow
 - 30% of villus vasculature has ceased to function
 - Perinatal morbidity still low
 - Safe to manage pregnancy expectantly
 - Absent or reversed flow
 - 60%–70% obliteration of placental arteries
 - Fetal hypoxia
 - Significant increase in perinatal morbidity and mortality
 - Should be delivered
- MCA Doppler
 - High diastolic flow (brain-sparing effect)
 - Fetal hypoxia
- Ductus venosus Doppler
 - Absent or reversed ductus venosus a-wave
 - Impending acidemia and death

A amniotic fluid volume; BPP biophysical profile; CA middle cerebral artery; A umbilical artery.

Temporal sequence of events

The sequence of events that occur in fetal deterioration is given in Figure 33.6.

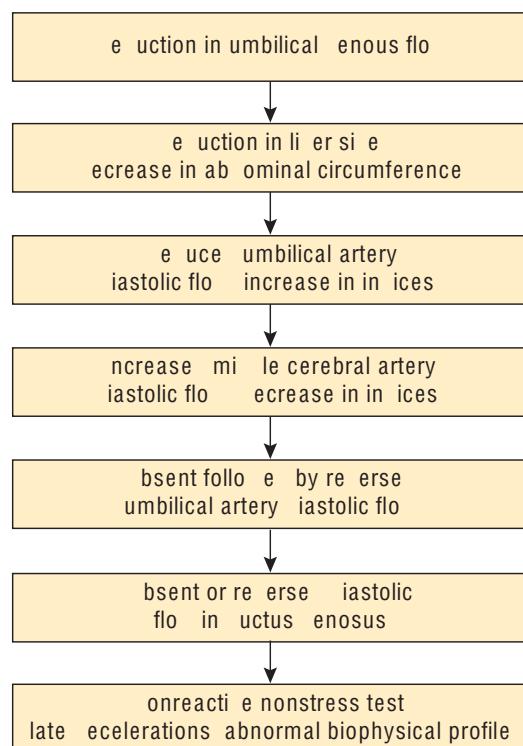


Figure 33.6 Sequence of events in fetal deterioration.

Timing of delivery

Symmetric FG

The fetus with symmetric FGR is frequently associated with structural and/or chromosomal abnormality. The outcome is usually poor. The pregnancy is commonly terminated after evaluating the fetus for cause of the FGR.

Asymmetric FG

The timing of delivery of the fetus with asymmetric FGR depends on the underlying etiology of the growth restriction and the gestational age. The fetus should be delivered when the chance of intrauterine death exceeds that of neonatal death.

Fetuses with growth restriction are hypoxic, leading to metabolic deterioration. Therefore, the timing of delivery becomes

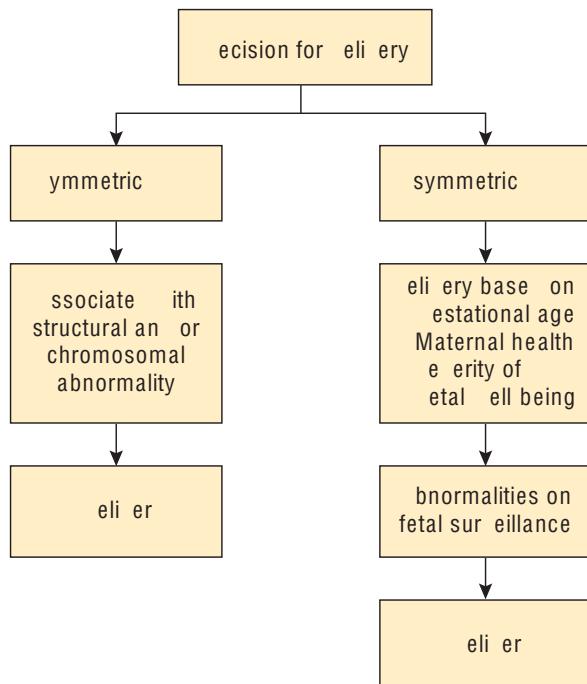


Figure 33.7 Schematic representation of decision for delivery in fetal growth restriction (FGR).

critical. A fine balance needs to be achieved between premature delivery and an increasingly hostile intrauterine environment.

Decision for delivery is individualized (Fig. 33.7) and is based on the following:

- Gestational age of the fetus
- Maternal health
- Severity of FGR
- Fetal well-being

Gestational age 28 weeks

The prognosis is very poor in fetuses that have developed growth restriction in the second trimester. It is usually secondary to severe maternal disease, for example, early onset severe pre-eclampsia. In this situation, delivery is dictated by the maternal condition.

Gestational age 28–34 weeks

Morbidity and mortality remain relatively high in growth-restricted fetuses under 32–34 weeks' gestation.

- Decision to deliver must be based on firm evidence of fetal compromise.

- Antenatal steroids should be administered (see Chapter 36, *Prelabor rupture of membranes*).
- Magnesium sulfate is also recommended for neuroprotection (see Chapter 36, *Prelabor rupture of membranes*).
- BPP and Doppler studies should be performed weekly and fetal growth evaluation once in 2 weeks.
- Normal umbilical artery flow by Doppler velocimetry is reassuring and allows for continuation of pregnancy, with close surveillance.
- Although pregnant women with absent umbilical artery diastolic flow can be watched closely especially if <32 weeks, reversal of diastolic flow warrants termination. When diastolic flow is absent, it is likely to progress to reversal in a few days; therefore, daily monitoring is essential.

Gestational age 34 weeks

Beyond 34 weeks, since survival is better, the threshold for delivery is lower.

- BPP and Doppler studies should be performed twice weekly and fetal growth assessed once in 2 weeks.

Box 33.8 Gestational age and timing of delivery

ee s

- Secondary to maternal disease
- Prognosis poor
- Delivery based on maternal condition

ee s

- Prognosis remains poor
- Steroids for pulmonary maturation
- Magnesium for neuroprotection
- BPP weekly
- Doppler studies weekly
- Delivery based on fetal compromise

ee s

- BPP weekly
- Doppler weekly
- Delivery if
 - UA absent diastolic flow
 - BPP abnormal
 - No interval growth
- Delay delivery to 38 weeks if
 - FGR mild
 - Doppler studies stay normal

BPP, biophysical profile; FGR, fetal growth restriction; UA, umbilical artery.

- Delivery is recommended if umbilical artery diastolic flow is absent, BPP is abnormal, or there is no interval growth.
- If all parameters are normal and FGR is mild, deliver at 38 weeks.

Decision making regarding timing of delivery is summarized in Box 33.8.

Mode of delivery

The mode of delivery depends on the fetal condition (Box 33.9).

The suggested management of the pregnancy with FGR is given in Figure 33.8.

Intrapartum management

In the presence of FGR, intrapartum fetal distress should be anticipated. Electronic fetal monitoring is mandatory. A cesarean section is recommended if there is thick meconium in early labor or a nonreassuring fetal heart pattern.

Box 33.9 Mode of delivery in the growth-restricted fetus

- Vaginal delivery
 - In mild to moderate FGR
 - At 37–38 weeks' gestation
 - Careful monitoring of the fetal heart rate
 - Growth-restricted fetus chronically hypoxic
 - During labor, oxygenation may be compromised
- Cesarean section
 - FGR associated with
 - absent or reversed UA diastolic flow
 - oligohydramnios
 - decelerations on NST

fetal growth restriction; S nonstress test; A umbilical artery.

Neonatal care for the growth-restricted infant

At birth, the growth-restricted infant has a typical appearance (Box 33.10; Fig. 33.9).

Infants with FGR have a higher risk of neonatal morbidity and mortality, particularly among

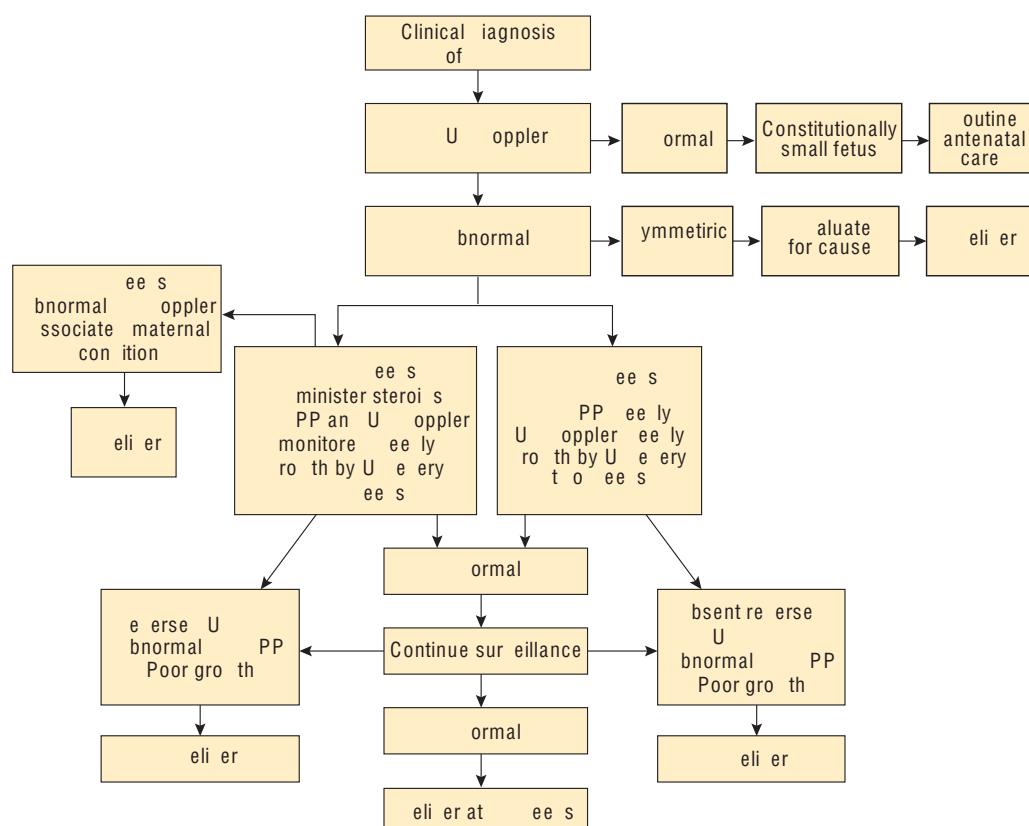


Figure 33.8 Suggested management of pregnancy with FGR. A amniotic fluid index; BPP biophysical profile; D end-diastolic waveform; FGR fetal growth restriction; UA umbilical artery; S ultrasound.

Box 33.10 Appearance of the growth-restricted infant at birth

- Thin
- Loose, peeling skin
- Decreased skeletal muscle mass
- Depleted subcutaneous fat tissue
- Face shrunken
 - Lacks chubbiness of the normal newborn
- Umbilical cord often thin
- Meconium staining may be present
- Head larger in relation to size of the trunk (asymmetric fetal growth restriction)



a.



b.

Figure 33.9 A growth-restricted infant at birth. **a.** It shows decreased skeletal muscle mass, depleted subcutaneous fat tissue, and a shrunken face. **b.** The head is larger in relation to the trunk. (Photo courtesy: Dr. Padmapriya Dore, Vellore.)

those born very preterm, as discussed earlier in this chapter. A neonatologist should be available for skilled resuscitation and careful evaluation of the fetus for fetal infections/abnormality. The neonate needs to be stabilized and screened for the following:

- Hypothermia
- Hypoglycemia
- Hypocalcemia
- Coagulation defects

Long-term sequelae

More than 30 years ago, Barker hypothesized that growth-restricted infants with low birth weight exhibit an increased risk of obesity, hypertension, dyslipidemia, insulin resistance (leading to type 2 diabetes mellitus), and cardiovascular morbidity in adult life (Box 33.11). These diseases are collectively called the **metabolic syndrome** and are associated with an increased risk of premature death. Small body size at birth and during infancy, followed by accelerated weight gain in childhood, has a significant impact on these chronic diseases. This has been termed **the fetal origin of adult disease**. The adverse intrauterine environment at critical periods of growth causes permanent programming of fetal tissues (known as *thrifty phenotype*). This results in fixed functional capacity of the tissues and when exposed to better nutrition later in life, leads to obesity and metabolic syndrome.

In addition, short stature in children and adults, premature adrenarche, and the polycystic ovarian syndrome (PCOS) are endocrine

Box 33.11 Barker's hypothesis Fetal origin of adult disease

- Growth-restricted, low-birth-weight infants
 - As adults develop metabolic syndrome
 - Obesity
 - Hypertension
 - Dyslipidemia
 - Insulin resistance (type 2 diabetes mellitus and PCOS)
 - Cardiovascular morbidity
- Metabolic syndrome leads to
 - increased risk of premature death

PC S polycystic ovarian syndrome.

sequelae of FGR. The combination of early onset growth delay and prematurity significantly increases the risk for neurological sequelae and motor and cognitive delay.

The worst outcomes are observed in the more severely growth-restricted infants who are preterm, and who exhibit the most overt evidence of impaired umbilical flow. However, neurological sequelae can be minimized in the fetus with FGR by

- Carefully selecting timing of delivery.
- Keeping the fetus well oxygenated during labor.
- Providing skilled neonatal care at birth.

Macrosomia

Definition

A **macrosomic or large-for-gestational-age (LGA)** infant is one whose birth weight is equal to or greater than the 90th percentile for a given gestational age. This definition is based on the average birth weight at each gestational age, and is country specific.

For example, an infant born at term and weighing ≥ 4500 g is considered to have macrosomia in the United States. However, a WHO study has shown that in India, an infant weighing ≥ 3250 g at term would be greater than the 90th percentile and therefore, by definition, has macrosomia.

The definition of macrosomia differs in countries, and, within the country, it may differ between the urban and the rural population. In developing countries, as the prevalence of obesity and diabetes increases, the prevalence of fetal macrosomia will also rise.

Incidence

The incidence of macrosomia varies with the incidence of risk factors. The incidence of birth of babies weighing >4000 g is approximately 9%. Globally there is a 15%–20% increase in macrosomia due to the increase in obesity and diabetes. The incidence in India is difficult to estimate since the definition and birth weight cutoff vary. Diabetes is a common problem in India, and the incidence of obesity is on the increase; hence, there is a 15% increase in macrosomia in India as well.

Risk factors for macrosomia

The two strongest factors for macrosomia are high BMI and maternal diabetes. As these two problems increase in developing countries, more cases of obstetric complications resulting from macrosomia are seen. The other risk factors are excessive weight gain in pregnancy, maternal impaired glucose tolerance, multiparity, parental height, previous macrosomic baby, male fetus, and postdated pregnancy (Box 33.12).

Macrosomia can occur in all diabetic pregnancies, but the incidence appears to be greater in infants born to mothers with pregestational diabetes. The macrosomic infant of a diabetic mother has a significant increase in fat mass and a different body morphology as compared with other macrosomic infants (Box 33.13; Fig. 33.10).

Box 33.12 Risk factors for macrosomia

- High BMI (≥ 30 kg/m 2)
- Maternal diabetes
- Excessive weight gain in pregnancy
- Maternal impaired glucose tolerance
- Parental height
- Previous macrosomic baby
- Male fetus
- Postdated pregnancy

B = body mass index.

Box 33.13 Macrosomic infant of diabetic mother

- Growth is disproportionate
- Chest much larger than the head
- Significantly large shoulders
- Increased skin folds in the upper extremities
- Typical appearance
 - Barrel-chested infant
 - Short neck
 - Broad shoulders
 - At high risk for shoulder dystocia.



Figure 33.10 Macrosomic infant. Note barrel chest, short neck, and broad shoulders.

Pathophysiology of macrosomia

Macrosomia is caused by the increased supply of nutritional substrate resulting from certain associated maternal conditions such as poorly controlled diabetes or maternal obesity (Fig. 33.11). Hyperglycemia in the fetus results in the production of insulin, insulin-like growth factors (IGFs), growth hormone, and other growth factors. These, in turn, stimulate fetal growth and excessive deposition of fat and glycogen. In postdated pregnancy, the growth process continues in utero, resulting in a larger birth weight at delivery.

Obstetric significance of macrosomia

Macrosomia can be a more significant obstetric risk in developing countries, where poor nutrition in adolescence can inhibit complete pelvic growth, early marriages lead to pregnancy before the pelvis is fully developed, and facilities for operative delivery of women with obstructed labor are not reliably available (Box 33.14).

Box 33.14 Obstetric significance of macrosomia

- Bigger obstetric risk in developing countries
 - Poor nutrition leading to poor pelvic growth
 - Pregnancy before full pelvic development
 - Unreliable facilities for operative delivery

Consequences of fetal macrosomia

The delivery of a macrosomic infant is an obstetric challenge. Since clinical diagnosis of

macrosomia is usually not accurate, the diagnosis of macrosomia may be overlooked, resulting in potentially serious consequences for the infant and the mother.

Fetal consequences

Difficulty and delay in delivery may result in perinatal asphyxia and rarely death. Shoulder dystocia is a feared complication of macrosomia. Up to 25% of infants with shoulder dystocia experience brachial plexus or facial nerve injuries, and fractures of the humerus or clavicle. Brachial plexus injuries, such as Erb–Duchenne palsy, are ordinarily attributed to delivery complicated by shoulder dystocia.

Neonatal hypoglycemia, hypoxic encephalopathy, respiratory distress, hyperbilirubinemia, and other complications associated with maternal diabetes are also common in a macrosomic infant.

Long-term consequences for macrosomic infants

There are long-term consequences for the infant born with macrosomia. These infants are at increased risk of developing impaired glucose tolerance and obesity as adults. They are also at risk for developing metabolic syndrome (including an abnormal lipid profile).

The consequences for the macrosomic infant are enumerated in Box 33.15.

Maternal consequences

Pregnancies complicated by macrosomia are at an increased risk for cesarean section. The incidence of prolonged labor and postpartum

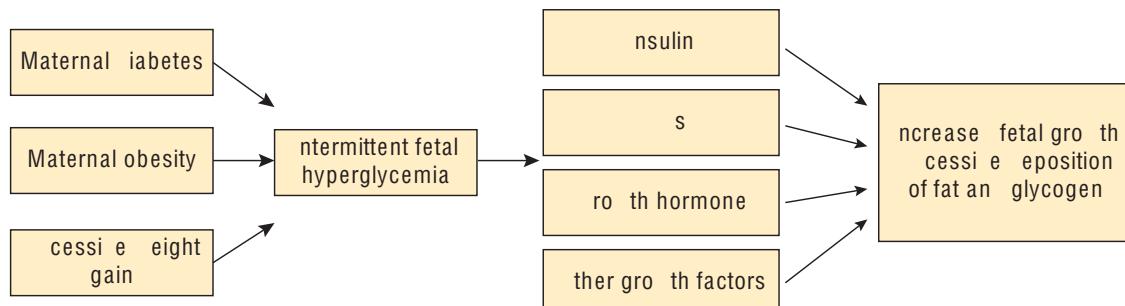


Figure 33.11 Pathophysiology of macrosomia in maternal diabetes and obesity.

insulin-like growth factor.

Box 33.15 Fetal, neonatal, and long-term consequences in macrosomia

- Fetal consequences
 - Perinatal asphyxia
 - Death
 - Shoulder dystocia
 - Humerus/clavicular fracture
 - Brachial plexus injury
 - Facial nerve injury
- Neonatal consequences
 - Hypoglycemia
 - Hypoxic-ischemic encephalopathy
 - Respiratory distress
 - Hyperbilirubinemia
- Long-term consequences in adulthood
 - Impaired glucose tolerance and obesity
 - Metabolic syndrome
 - Abnormal lipid profile

hemorrhage increases with macrosomia. Vaginal delivery of a macrosomic infant increases the risk of third- or fourth-degree lacerations fivefold.

Maternal consequences of macrosomia are given in Box 33.16.

Box 33.16 Maternal consequences of macrosomia

- Prolonged labor
- Cesarean section
- Postpartum hemorrhage
- Perineal trauma

Diagnosis of macrosomia

Macrosomia can be accurately diagnosed only by weighing the newborn after delivery. The prenatal diagnosis of fetal macrosomia continues to remain inaccurate. Methods that have been conventionally used to predict birth weight are

- Assessment of maternal risk factors
- Clinical examination
- Ultrasound measurement of the fetus

Assessment of maternal risk factors

The presence of risk factors for macrosomia should alert the clinician to the possibility of macrosomia.

Clinical assessment

The prediction of fetal weight by clinical assessment is notoriously difficult. The quantity of amniotic fluid, uterine size, and maternal body fat make it difficult to accurately assess fetal size by palpation through the abdominal wall.

Ultrasonography prediction of macrosomia

Although ultrasonography enables the direct measurement of various fetal body parts, its accuracy in predicting macrosomia is poor. Estimated fetal weight is calculated using different formulas. The larger the fetus, the less accurate is the ultrasound estimation of fetal weight. It is also poor in predicting fetal weight in multiple gestation and diabetic pregnancies. Measurement of the AC and calculation of the EFW using fetal biometry are the common ultrasonographic methods to assess macrosomia.

Abdominal circumference

AC is the most common single parameter used to assess risk of macrosomia.

Estimated fetal weight

The formula for calculating EFW commonly includes a combination of BPD, HC, AC, and FL.

Soft tissue measurements

Measurement of subcutaneous fat at mid-humerus, abdominal wall, thigh, and other areas has been evaluated but has not been found to be any more accurate than estimated body weight.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) is superior to ultrasonography in the diagnosis of macrosomia and prediction of shoulder dystocia, but it is expensive and not recommended for routine use.

Prenatal prediction of macrosomia is summarized in Box 33.17.

Box 33.17 Prenatal prediction of macrosomia

- Assessment of maternal risk factors
- Clinical examination
 - Difficult
 - Complicated by
 - amniotic fluid volume
 - maternal body fat
- Ultrasound measurement of the fetus
 - Abdominal circumference
 - Estimated fetal weight
 - Formulae using biometric parameters
- Soft tissue measurements
 - Measurement of subcutaneous fat
 - Midhumerus
 - Abdominal wall
 - Thigh
- MRI
 - Expensive
 - Not recommended for routine use

magnetic resonance imaging.

Management of suspected fetal macrosomia

In the presence of suspected macrosomia (by history of risk factors, clinical assessment, or ultrasound estimation), clinicians would like to

accurately predict serious complications such as shoulder dystocia and its attendant sequelae. Such complications, however, do not depend on fetal weight alone, but on multiple factors including maternal and fetal anatomy. The majority of macrosomic infants do well with vaginal delivery, even if there is shoulder dystocia. Vaginal delivery can be offered for women with suspected macrosomia. The woman's obstetric history, her progress during labor, the adequacy of her pelvis, and other evidence suggestive of fetopelvic disproportion should be used to determine whether a cesarean section would be required (Fig. 33.12).

Role of elective induction of labor

The fetus gains approximately 200 g/week after 37 weeks. It has been suggested that early induction of labor before or at term will prevent further growth of the fetus and therefore avoid the complications of macrosomia. Unfortunately, induction of labor has not shown to be beneficial and actually increases the rate of cesarean section.

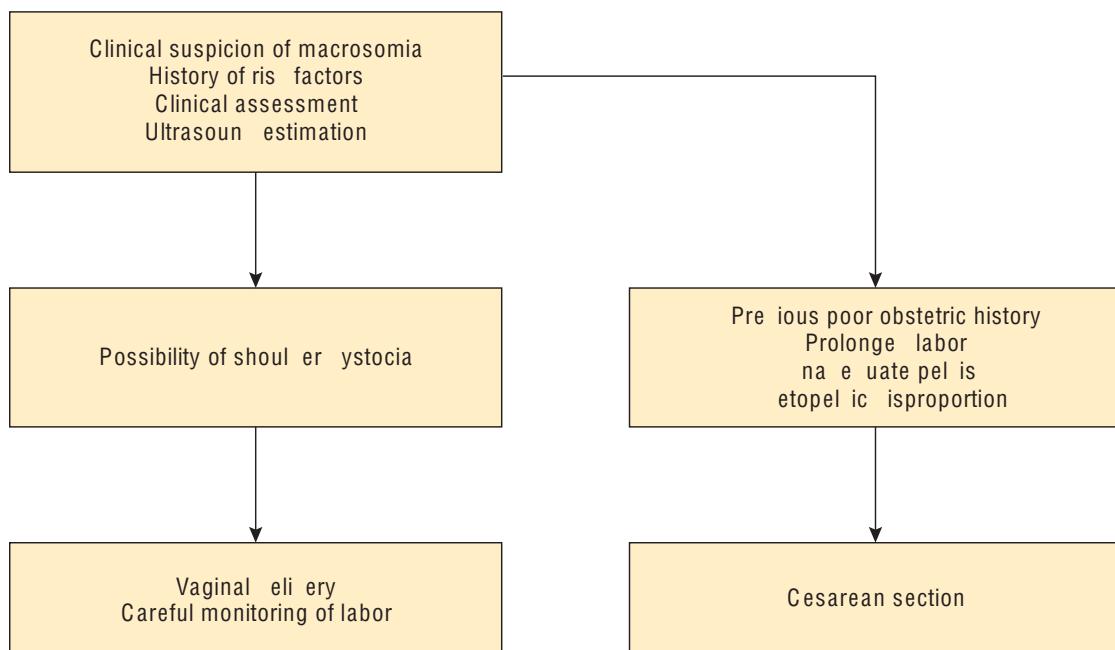


Figure 33.12 Delivery options in suspected macrosomia.

Role of elective cesarean section

Prophylactic cesarean delivery for suspected fetal macrosomia <4000 g (in Indian women) may not be effective for pregnancies without diabetes. Even in pregnancies complicated by diabetes, elective cesarean section to reduce the risks of birth trauma is not cost-effective and is not routinely recommended.

Fetal macrosomia in special situations

Previous cesarean section

In a woman with a previous cesarean section, macrosomia has to be taken into consideration when discussing vaginal birth after cesarean (VBAC) with the patient. If the fetus is considered to have macrosomia, especially in the presence of maternal diabetes, VBAC should be

offered with great caution or an elective cesarean section may be offered directly.

Maternal diabetes

Vaginal delivery can be offered to a woman with gestational diabetes. When macrosomia is suspected in a mother with gestational diabetes, a cesarean section may be offered electively if the EFW is >4000 g. The risk of shoulder dystocia is higher in infants of diabetic mothers because of the abnormal fat distribution. The labor should be monitored carefully for signs of fetopelvic disproportion.

Previous shoulder dystocia

Since the recurrence of shoulder dystocia in the subsequent pregnancy is low, a woman with a previous history of shoulder dystocia may be allowed to deliver vaginally.

Key points

- Fetal growth restriction (FGR) and macrosomia are two extremes of fetal growth disorders.
- The natural growth potential of the fetus is dictated by the fetal genome and by the intrauterine environment.
- Maternal nutrition, placental perfusion, and fetal hormones play a role in promoting normal growth.
- Maternal factors that can result in poor fetal growth can act by reducing uteroplacental perfusion, inducing hypoxemia and providing decreased nutritional substrates.
- Fetal factors that can result in FGR include chromosomal abnormalities, congenital anomalies, congenital infections, and multiple pregnancy.
- Placental factors causing FGR include abnormal placentation, structural placental abnormalities, and umbilical cord abnormalities.
- Screening for FGR is only by clinical assessment in low-risk pregnancies.
- Certain pregnancies are at increased risk for the occurrence of FGR, based on factors in the past or present history. These pregnancies should be screened for FGR by both clinical assessment and serial ultrasonography.
- Ultrasound is the best tool for the diagnosis and evaluation of FGR as it is highly reliable and reproducible.

Fetal growth restriction

- A fetus with an estimated weight below the 10th percentile for a given gestational age is considered to have FGR.
- The term small for gestational age (SGA) includes both constitutionally small but healthy fetuses (50%–70%) and fetuses that are actually growth restricted (20%).
- The term FGR should be used with regard to the fetus, whereas SGA should be used only in reference to the newborn.
- A fetus with growth restriction faces an increased risk of perinatal mortality and morbidity.

(Continued)

Key points *Continued*

- FGR is classified into symmetric and asymmetric growth restriction.
- In *symmetric*, the insult usually happens early in fetal development and therefore affects the fetus uniformly.
- When the insult (usually placental insufficiency) to the fetus happens in the late second trimester or in the early third trimester, it results in *asymmetric*.
- FGR is diagnosed and followed up with ultrasound examinations. Abdominal circumference and estimated fetal weight are the two important measurements for diagnosis.
- The decision on timing of delivery are based on the findings on Doppler velocimetry.
- The decision to deliver also depends on the gestational age and the fetal and maternal condition.
- There are short-term and long-term consequences of FGR. Low-birth-weight, growth-restricted fetuses have an increased risk of developing the metabolic syndrome as adults.

Macrosomia

- A macrosomic or large-for-gestational-age infant is one whose birth weight is $\geq 90^{\text{th}}$ percentile for a

- given gestational age. This is based on the average birth weight at each gestational age, and is country specific.
- Macrosomia is an important risk factor for fetal complications such as perinatal asphyxia, death, and shoulder dystocia. Maternal risks of macrosomia are cesarean section, prolonged labor, postpartum hemorrhage, and perineal trauma.
 - The two strongest factors for macrosomia are maternal obesity and maternal diabetes.
 - Methods that are used for the prenatal diagnosis of fetal macrosomia are assessment of maternal risk factors, clinical examination, and ultrasound measurement of the fetus.
 - Abdominal circumference and estimated fetal weight are the two important ultrasound measurements for diagnosis of macrosomia.
 - The majority of macrosomic infants do well with vaginal delivery, even if there is shoulder dystocia.
 - The woman's obstetric history, progress during labor, adequacy of the pelvis, and other evidence suggestive of fetopelvic disproportion should be used to determine whether a cesarean section would be required.
 - Elective preterm induction of labor and elective cesarean section have not been shown to be effective in reducing complications of macrosomia.

Self-Assessment

Case-based questions

Case 1

Mrs. HJ, 26, gravida 2, para 1, live 1, weighed 43 kg and had gained only 4 kg in this pregnancy. She was 34 weeks by dates. Clinical examination showed the uterine size to be smaller than expected for the gestational period.

1. How will you make a clinical diagnosis of growth restriction?
2. What is symmetric and asymmetric growth restriction?
3. How will you confirm the diagnosis?
4. How will you manage this pregnancy?

Case 2

Mrs. KL, 29, gravida 2, para 1, live 1, weighed 103 kg and had gestational diabetes. She was 36 weeks by dates. Estimated fetal weight at 36 weeks was 3900 g.

1. What is macrosomia?
2. What are the risk factors for macrosomia?

3. What are the fetal complications of macrosomia?
4. How will you manage this pregnancy?

Answers

Case 1

1. History of previous baby with growth restriction, maternal risk factors such as hypertension, diabetes, renal disorder, or APA syndrome must be considered. Examination may reveal uterine size less than the period of gestation and symphysio-fundal height less by 3 cm or more for appropriate gestational age.
2. In symmetric FGR, the insult usually happens early in fetal development and therefore affects the fetus uniformly. When the insult (usually placental insufficiency) to the fetus happens in the late second trimester or in the early third trimester, it results in asymmetric FGR. The abdominal size is smaller than the head size.
3. Diagnosis is confirmed by ultrasound scan using abdominal circumference, estimated fetal weight, HC/AC ratio, and serial growth charts.

4. If FGR is confirmed, fetal well-being assessment is by BPP, Doppler study of the umbilical and middle cerebral arteries, and serial growth chart. Since she is 34 weeks pregnant, if the BPP, Doppler study, and growth are normal, deliver at 38 weeks. If BPP is abnormal or umbilical artery Doppler shows absent or reversed diastolic flow, deliver immediately.

Case 2

1. A macrosomic infant is one whose birth weight is $=/ >$ 90th percentile for a given gestational age. It is country specific.
2. The two strongest factors for macrosomia are maternal obesity and maternal diabetes. Other risk factors are excessive weight gain in pregnancy, previous macrosomic baby, ethnicity, postdated pregnancy, and male fetus.
3. Shoulder dystocia is a major complication of macrosomia and can lead to brachial plexus or facial nerve injuries, and fractures of the humerus or clavicle. Perinatal asphyxia and rarely death can occur

due to delayed delivery. Neonatal hypoglycemia, HIE, respiratory distress, and hyperbilirubinemia are the other complications.

4. The mother's blood sugars should be monitored and controlled. She should be delivered at term. Elective cesarean section is not indicated. Watch for shoulder dystocia.

Sample questions

Long-answer question

1. Define fetal growth restriction. Describe the etiology, diagnosis, and management of fetal growth restriction.

Short-answer questions

1. Symmetric and asymmetric growth restriction
2. Doppler velocimetry in FGR
3. Barker's hypothesis
4. Fetal macrosomia

34

Disorders of Amniotic Fluid

Case scenario

Mrs. DA, 30, multigravida, was referred from a primary health center. She was 31 weeks' pregnant and complained of difficulty in breathing. Her abdomen looked tense and overdistended. On further questioning, Mrs. DA said that her primary care doctor had informed her that she had excessive fluid in the uterine cavity. The baby could be at risk and there was a possibility of complicated delivery. She was asked to go to a tertiary care center.

Introduction

Amniotic fluid volume (AFV) may be higher or lesser than normal in some pregnancies. Women with a decrease in fluid may not be symptomatic but when there is gross excess of fluid, distension of abdomen is obvious and other symptoms due to overdistension of the abdomen are also evident. In addition, the underlying cause of gross increase or decrease in fluid can be detrimental to the fetus.

Normal amniotic fluid

Amniotic fluid surrounds the fetus from early pregnancy. It has several functions as highlighted in Chapter 5, *Placenta, fetal membranes, and amniotic fluid*.

Amniotic fluid production and clearance

Amniotic fluid is produced and reabsorbed continuously. The entire volume of fluid is replaced several times a day. The major sources of amniotic fluid are fetal urine and fetal lung fluid, and clearance is by fetal swallowing and by intramembranous transfer to fetal blood. These are discussed in detail in Chapter 5, *Placenta, fetal membranes, and amniotic fluid*. The volume of inflow and clearance at term are given in Box 34.1. It is evident from the data given in Box 34.1 that the fluid is in *dynamic equilibrium* because net inflow and net clearance are equal.

Changes that affect fetal urine production, lung fluid secretion, and fetal swallowing or an

Box 34.1 Volume of amniotic fluid inflow and clearance day at term

Production

- Fetal urine: 800–1200 mL
- Fetal lung secretion: 170 mL
- Oral–nasal secretions: 25 mL

Clearance

- Fetal swallowing: 500–1000 mL
- Intramembranous transfer: 200–400 mL
- Transmembranous transfer: 10 mL

alteration in intramembranous flow can affect the AFV drastically.

Normal amniotic fluid volume

The volume of amniotic fluid increases with gestational age and reaches a peak at 34–36 weeks. Thereafter, it reduces and the rate of reduction is more rapid after 40 weeks.

Amniotic fluid volume increases at high altitudes and with maternal hydration; it decreases with fluid restriction and dehydration.

Evaluation of amniotic fluid volume

Gross increase or decrease in AFV can be suspected on clinical examination. Accurate methods of measurement such as dye dilution techniques are not used in routine practice. The most practical method of assessment is by ultrasonography. Two techniques are commonly used:

- Single deepest pocket (SDP)
- Amniotic fluid index (AFI)

Amniotic fluid index is more commonly used and is more sensitive. The values can be affected by differences in ultrasound techniques and pressure of transducer on the abdomen. Techniques for evaluation of AFV are described in Chapter 11, *Antepartum fetal surveillance*.

Polyhydramnios

Polyhydramnios or hydramnios is defined as excessive volume of amniotic fluid. Diagnosis of polyhydramnios is made when the AFI is >25 cm or LVP (SDP) is >8 cm. Polyhydramnios is classified into mild, moderate, and severe as given in Box 34.2. Mild hydramnios is the most common and occurs in 80% of cases.

Incidence

The incidence of polyhydramnios is 1%–2%.

Etiology and pathogenesis

Most cases of polyhydramnios are considered idiopathic (no known cause). Undetected congenital and/or chromosomal anomaly may be present in these cases and perinatal mortality is increased two- to five-fold.

Polyhydramnios may be caused by fetal anomalies that interfere with fetal swallowing, absorption of fluid, or an increase in fetal urine production. Maternal diabetes is also a common cause.

An etiological factor can be identified in most cases of *severe* polyhydramnios but only in 15% of *mild* polyhydramnios. The possibility of chromosomal anomaly and perinatal mortality is higher as the severity of hydramnios increases.

Conditions associated with polyhydramnios and the pathogenesis in each condition are listed in Table 34.1.

Clinical features

Mild hydramnios may be detected only by ultrasonography. Moderate and severe polyhydramnios are associated with overdistension of the abdomen (Fig. 34.1). Uterine overdistension causes dyspnea by pushing the diaphragm upward.

Box 34.2 Classification of polyhydramnios

- Mild (80%): Vertical pockets of 8–11 cm or AFI of 25–30
- Moderate (15%): Vertical pockets of 12–15 cm or AFI of 30–35
- Severe (5%): Vertical pockets of >15 cm or AFI of >35 ; free-floating fetus

A = amniotic fluid index.

Table 34.1 Etiology and pathogenesis of polyhydramnios

Etiology	Pathogenesis
<i>fetal conditions</i>	
<i>astrointestinal obstruction</i>	
• Esophageal atresia, duodenal atresia	Inhibition of fetal swallowing
<i>urological anomalies</i>	
• Anencephaly	
• Spina bifida	• Inhibition of swallowing
• Myotonic dystrophy	• Transudation from exposed meninges
• Lack of ADH from pituitary gland	
• Transudation from exposed meninges	
• Inhibition of swallowing	
<i>fetal aneuploidy</i>	
• Trisomy 18, 21	• Inhibition of swallowing
	• Intestinal abnormalities
<i>nonimmune hydrops</i>	
• Twin-to-twin transfusion syndrome	
• Rh isoimmunization	Increased urine output due to fetal anemia
• Parvovirus infection	and cardiac failure
<i>Alpha thalassemia</i>	Fetal anemia and cardiac failure
<i>Bartter syndrome</i>	Polyuria due to renal hypokalemic alkalosis
<i>maternal conditions</i>	
• Diabetes mellitus	Polyuria due to fetal hyperglycemia
• diopathic	No cause can be found

AD antidiuretic hormone.



Figure 34.1 Overdistended abdomen due to polyhydramnios.

Pedal, vulval, and abdominal wall edema result from uterine pressure on the inferior vena cava. Rarely, pressure on the ureter leads to oliguria.

Polyhydramnios usually develops gradually but can be acute and very symptomatic.

Differential diagnosis

Differential diagnosis for polyhydramnios includes multiple pregnancy, ovarian cyst with pregnancy, and maternal ascites, all conditions where the abdomen is overdistended. Acute hydramnios must be differentiated from placental abruption with concealed hemorrhage.

Complications

Overdistension of the uterus leads to premature uterine contractions and preterm labor. Sudden release of fluid due to rupture of membranes can cause placental abruption. In the presence of overdistension, uterine contractions are poor, leading to dysfunctional labor and postpartum hemorrhage. Malpresentations and malpositions are common. There is a considerably increased risk of operative vaginal delivery and cesarean sections due to malpresentations, malpositions, and hypotonic uterine action.

Box 34.3 Complications associated with polyhydramnios

- Maternal
 - Dyspnea, respiratory distress
 - Prelabor rupture of membranes
 - Preterm labor
 - Placental abruption
 - Dysfunctional labor
 - Operative vaginal delivery
 - Cesarean section
 - Atonic postpartum hemorrhage
- Fetal
 - Macrosomia
 - Chromosomal anomalies
 - Malpresentations
 - Malpositions
 - Cord prolapse
 - High perinatal mortality

Cord prolapse occurs because malpresentations and malpositions prevent proper apposition of the presenting part in the lower uterine segment; with membrane rupture and sudden gush of amniotic fluid, the cord slips past the presenting part.

Fetal macrosomia may be present due to associated diabetes. Perinatal mortality is increased two- to fivefold due to fetal congenital and chromosomal anomalies, abruption, prematurity, and operative delivery (Box 34.3).

Diagnosis

Diagnosis begins with history and physical examination (Box 34.4). In acute hydramnios, the woman complains of sudden abdominal distension. Pedal and vulval edema is usually present. The uterus is overdistended, tense, and filled with fluid. Fetal parts are difficult to palpate and the fetus may be in transverse lie or other malpresentation. Fetal heart sounds are muffled and fluid thrill can be elicited.

Investigations

The single most diagnostic evaluation is ultrasonography (Fig. 34.2). As discussed earlier, SDP (LVP) of >8 cm or AFI of >25 cm is used for confirmation of diagnosis (Fig. 34.2a). Once the diagnosis is confirmed, classification into mild, moderate, or severe polyhydramnios should be done.

Box 34.4 History and physical examination in polyhydramnios

- History
 - Gradual or sudden abdominal distension
 - Dyspnea
 - Pedal/vulval edema
 - Tight feeling in the uterus
- Physical examination
 - Inspection
 - Overdistended uterus
 - Palpation
 - Uterine size larger than gestational age
 - Uterus tense
 - Fluid thrill
 - Difficulty in palpation of fetal parts
 - Malpresentations
 - Auscultation
 - Muffled fetal heart sounds

A comprehensive ultrasonographic evaluation is then performed to look for fetal gastrointestinal



a.



b.

Figure 34.2 Polyhydramnios on ultrasonography.

a. Large pockets of amniotic fluid with fetal limbs floating in fluid. b. Polyhydramnios with an anencephalic fetus.

(Photo courtesy: Mediscans Systems, Chennai.)

anomalies, anencephaly (Fig. 34.2b), spina bifida, hydrops, signs of chromosomal anomalies, multifetal pregnancy, and *twin-to-twin transfusion syndrome (TTTS)*. Amniocentesis or cordocentesis for fetal karyotyping should be performed in the presence of structural abnormalities or if chromosomal anomalies are suspected.

If hydrops is detected, it is important to evaluate for immune or nonimmune causes. Parvovirus infection and thalassemia can be diagnosed from a fetal blood sample.

Glucose tolerance test should be ordered to exclude maternal diabetes.

Evaluation of polyhydramnios is shown in Figure 34.3.

Management

In most women with polyhydramnios, no cause is found; therefore management is directed at relieving symptoms and optimizing timing of delivery.

Specific treatment

If an etiological factor is identified, management should address the specific cause. Maternal diabetes should be well controlled. If the fetal anomaly is incompatible with life, for example, anencephaly, pregnancy should be terminated. If aneuploidies or other congenital anomalies are diagnosed, the parents should be counseled and neonatologists and pediatric surgeons consulted.

Nonspecific treatment

Idiopathic polyhydramnios is the most common and is managed with measures to relieve symptoms and prevent complications. Treatment depends on the following:

- Severity of polyhydramnios
- Gestational age
- Symptoms

How to manage polyhydramnios

These patients may be followed by serial ultrasonography. The AFI stabilizes or normalizes in many women. In women with symptomatic moderate polyhydramnios, hospitalization and indomethacin may occasionally be required (refer to section *Medical management* on the next page).

Severe polyhydramnios

In women with severe polyhydramnios, management depends on gestational age.

Gestational age <34 weeks

- Decompression amniocentesis (amnioreduction) to reduce AFV to normal
- Indomethacin for maintenance of normal AFV
- Betamethasone 12 mg intramuscular every 12 hours × 2 doses to accelerate pulmonary maturity
- Serial monitoring of AFV by ultrasonography
- Deliver as close to term as possible

Gestational age >34 weeks

- Deliver

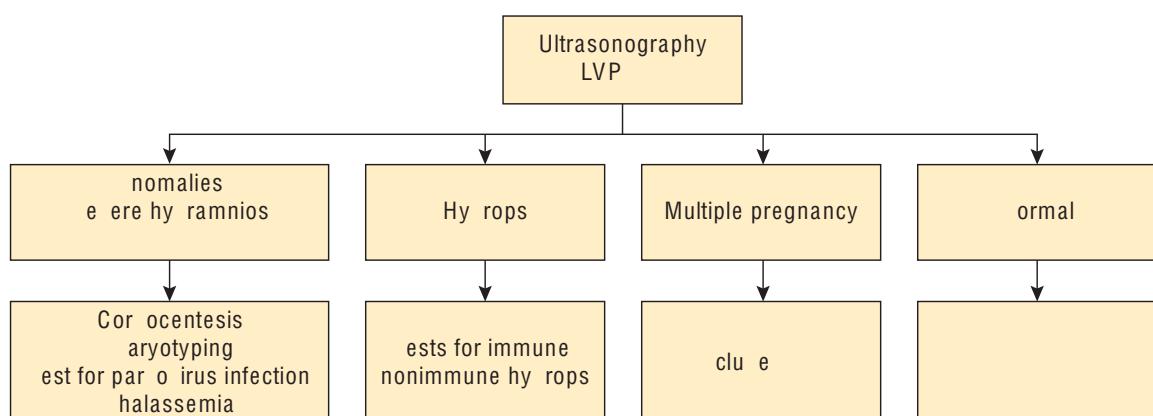


Figure 34.3 Evaluation of clinical polyhydramnios. A, amniotic fluid index; LVP, largest vertical pocket; P, glucose tolerance test; S, twin-to-twin transfusion syndrome.

Amnioreduction

In moderate-to-severe polyhydramnios, removal of amniotic fluid (amnioreduction) may be performed for decompression. This is beneficial when the woman is symptomatic, the hydramnios is severe or in TTTS. Medical therapy with indomethacin is more effective after amnioreduction.

Procedure

- Ultrasonography is performed to locate the placenta and to choose the site of amniocentesis, avoiding the placenta.
- The selected area of the abdomen is painted and draped.
- Local anesthetic is infiltrated.
- An 18-gauge spinal needle is inserted into the amniotic fluid in the lower quadrants to allow for decrease in uterine size as the fluid is removed.
- A sterile tubing with a three-way stopcock is attached to the hub of the needle and the other end of the tube to a vacuum suction bottle or other suction device. It should not be allowed to drain by gravity alone.
- Fluid can be removed as rapidly as possible. Enough fluid is removed to achieve an SDP of 8 cm or AFI of 15 cm. However, not more than 5 L is removed at one sitting.
- If the fluid stops draining, the needle tip is adjusted.
- The fetal heart beat is documented at the end of the procedure.
- Antibiotics and tocolytics are not required.

Amniotic fluid volume should be monitored weekly following amniocentesis. If fluid accumulates again, the procedure may have to be repeated.

Complications of amniocentesis

Complications of amniocentesis are listed in Box 34.5.

Box 34.5 Complications of amniocentesis

- Preterm labor
- Prelabor rupture of membranes
- Placental abruption
- Intra-amniotic infection (rare)

Medical management

Mild idiopathic polyhydramnios may respond to medical therapy. In moderate-to-severe polyhydramnios, amnioreduction is performed before starting medical therapy.

In indomethacin

Indomethacin is a prostaglandin synthetase inhibitor (Box 34.6). When administered to mothers, it crosses the placenta and reduces fetal renal blood flow and urine output and also stimulates fetal vasopressin secretion. This in turn reduces the AFV since fetal urine production is an important source of amniotic fluid. Dosage and side effects of indomethacin are listed in Box 34.6.

Amniotic fluid volume should be monitored closely since oligohydramnios may develop. Closure of fetal ductus arteriosus and fetal renal compromise are major side effects. As the risk of these problems increases dramatically after 32–34 weeks, the drug should not be used beyond 34 weeks' gestation. Indomethacin is also used as a tocolytic.

In Sulindac

Sulindac is a nonsteroidal anti-inflammatory agent. It also reduces the AFV and has less effect on fetal ductus arteriosus. Its usefulness in polyhydramnios has not been adequately evaluated.

Box 34.6 Indomethacin in polyhydramnios

- Prostaglandin synthetase inhibitor
- Mechanism of action
 - Stimulates fetal vasopressin production
 - Reduces fetal urine production
- Dosage
 - 25 mg four times daily, oral
 - Can increase to 2–3 mg/kg/day
- Maternal side effects
 - Nausea, gastritis, vomiting
 - Oligohydramnios
- Fetal complications
 - Closure of ductus arteriosus
 - If used for >48 hours
 - Worsens with advancing gestation
 - Renal damage and renal failure
- Should not be used after 32–34 weeks' gestation

Timing of delivery

Women with mild or moderate polyhydramnios can be delivered at term. If hydramnios is severe, planned delivery with abdominal decompression at 37 weeks is safer. Preinduction cervical ripening with prostaglandins (PG) and labor induction with oxytocin can be used if needed and are certainly not contraindicated.

Management of labor

Fetal lie and presentation must be checked to ensure vertex presentation. Sudden decompression due to spontaneous rupture of membranes can cause placental abruption or cord prolapse. Therefore, gradual decompression by amniocentesis or controlled amniotomy by needle puncture is recommended. Pelvic examination

must be performed as soon as membranes rupture. Hypotonic uterine dysfunction is common and oxytocin augmentation may be required. Prophylactic uterotronics must be used in the third stage to prevent atonic postpartum hemorrhage.

Management of polyhydramnios is summarized in Figure 34.4.

Oligohydramnios

Definition

Oligohydramnios is defined as reduced amniotic fluid as evidenced by an AFI of <5 cm or SDP <2 cm. An AFI between 5 and 8 cm is considered borderline/low normal AFV.

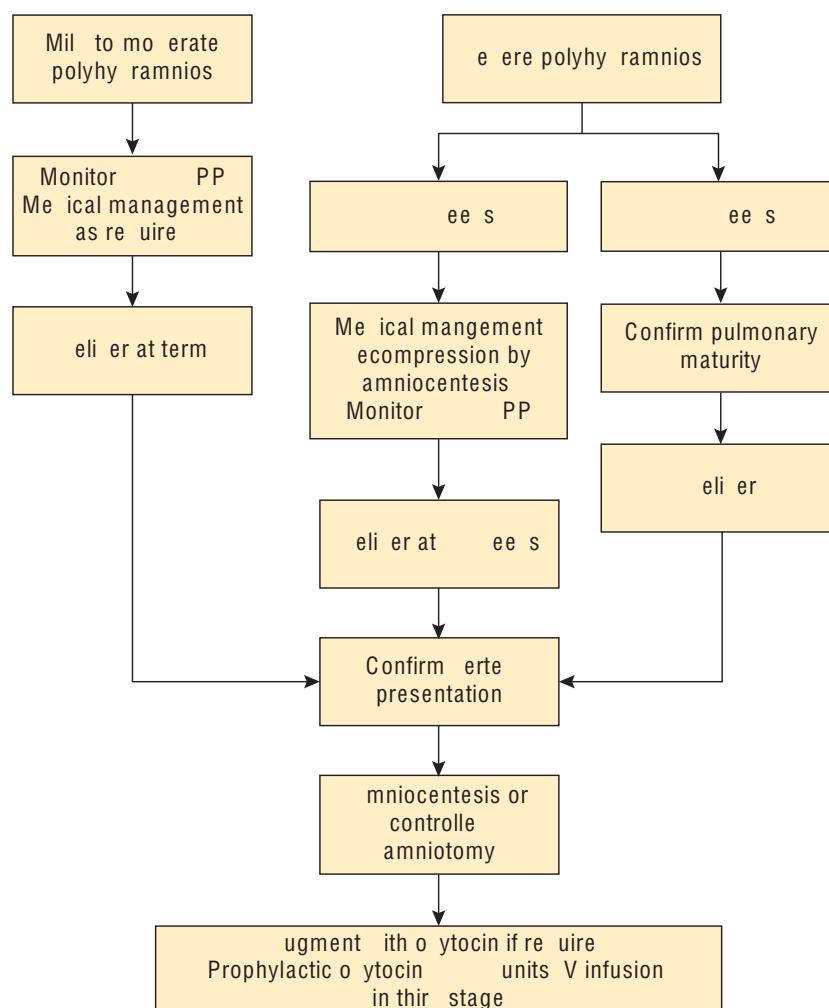


Figure 34.4 Management of polyhydramnios. BPP, biophysical profile; S, nonstress test.

Incidence

The incidence of idiopathic oligohydramnios at term is 11%–12%. Beyond 41 weeks, AFI decreases by 25% per week. In conditions causing placental insufficiency, the incidence is much higher.

Etiology and pathogenesis

Conditions that reduce fetal urine production result in oligohydramnios. This may occur due to renal agenesis or outflow obstruction in the fetal urinary tract. Chromosomal anomalies and polycystic kidneys are also associated with oligohydramnios. Decreased renal blood flow in fetal growth restriction and placental insufficiency result in decreased urine output and oligohydramnios. Postterm pregnancy and rupture of membranes are common causes. Maternal dehydration also results in reduced AFV as seen in hot summer months. Maternal ingestion of prostaglandin synthetase inhibitors (ibuprofen, indomethacin, nimesulide) can result in oligohydramnios. Causes of oligohydramnios are listed in Box 34.7.

Box 34.7 Causes of oligohydramnios

- Maternal
 - Prelabor rupture of membranes
 - Postterm pregnancy
 - Placental insufficiency
 - Preeclampsia
 - Pregestational diabetes
 - Placental abruption
 - Dehydration
- Fetal
 - Fetal growth restriction
 - Twin-to-twin transfusion
 - Congenital anomalies
 - Renal agenesis
 - Outflow obstruction to urinary tract
 - Polycystic kidneys
 - Chromosomal anomalies
 - Triploidy
 - Trisomy 18
 - Turner syndrome
- Drugs
 - Prostaglandin synthetase inhibitors
 - ACE inhibitors
- Idiopathic

AC , angiotensin-converting enzyme.

In the *first trimester*, oligohydramnios or reduced gestational sac fluid may occur but the etiology is usually unknown. The criterion for diagnosis is a difference of <5 mm between the mean gestational sac size and the crown-rump length. Reduced fluid prior to 10 weeks is generally associated with a poor outcome.

In the *second trimester*, the common causes of oligohydramnios are chromosomal and congenital anomalies, rupture of membranes, placental abruption, and fetal growth restriction. Oligohydramnios can also be idiopathic. An elevated maternal serum alpha fetoprotein in association with oligohydramnios carries a poor prognosis.

In the *third trimester*, oligohydramnios is usually due to fetal growth restriction, placental insufficiency, prelabor rupture of membranes, or postmaturity.

Complications and outcome

Perinatal mortality is increased in the presence of oligohydramnios. This can be due to the causative factors or the effects of reduced AFV. All the maternal and fetal conditions that cause oligohydramnios such as congenital anomalies, chromosomal defects, fetal growth restriction, placental insufficiency, and postmaturity are associated with an increase in perinatal mortality.

In addition, the reduction in AFV in the second trimester leads to skeletal deformities, contractures, and amniotic bands. *Pulmonary hypoplasia* is a common problem when oligohydramnios occurs in the second trimester. The pathogenesis has been postulated to be thoracic compression, lack of fetal breathing movements, and failure to retain intrapulmonary amniotic fluid. The prognosis is poor with pulmonary hypoplasia.

In the third trimester, adverse outcome is due to cord compression, meconium aspiration, fetal heart rate abnormalities, or fetal hypoxia. Maternal complications include chorioamnionitis due to prelabor rupture of membranes, higher risk of labor induction, instrumental delivery, and cesarean section. Maternal and fetal complications are listed in Box 34.8.

Outcome is poorer when oligohydramnios occurs earlier in pregnancy. First trimester reduction in fluid volume results in spontaneous miscarriage in 95% of women. Severe second trimester oligohydramnios results in fetal

Box 34.8 Maternal and fetal complications in oligohydramnios

- Maternal
 - Chorioamnionitis
 - Induction of labor
 - Instrumental delivery
 - Cesarean section
- Fetal
 - Due to etiological factors
 - Congenital anomalies
 - Chromosomal abnormalities
 - Fetal growth restriction
 - Intrauterine death
 - Intrauterine infection following ROM
 - Prematurity
 - Due to reduced AFV
 - Skeletal deformities
 - Contractures
 - Amniotic bands and autoamputation
 - Pulmonary hypoplasia
 - Umbilical cord compression
 - Meconium aspiration
 - Fetal heart rate abnormalities
 - Low Apgar scores
 - Intrapartum death

A , amniotic fluid volume; ROM , rupture of membranes.

or neonatal death in 80%. Oligohydramnios in the third trimester is associated with higher cesarean section rates, low Apgar scores, and hypoxic ischemic encephalopathy. Perinatal mortality is 15%.

Clinical features

Oligohydramnios is usually suspected when the uterine size is less than what is appropriate for the gestational age. Women with prelabor rupture of membranes may present with history of vaginal discharge. In women presenting with hypertension, preeclampsia, gestational age >40 weeks, and other maternal risk factors for placental insufficiency, ultrasonography should be performed to look for oligohydramnios.

Differential diagnosis

Differential diagnosis includes wrong dates and fetal growth restriction.

Diagnosis

History

When reduced AFV is suspected clinically, history of rupture of membranes, watery discharge, uterine contractions, hypertension, and history suggestive of antiphospholipid antibody syndrome should be asked for.

Physical examination

Blood pressure should be checked to exclude hypertension/preeclampsia. Obstetric examination reveals uterine size less than what is appropriate for gestational age. The uterus may be felt hugging the fetus with very little amniotic fluid surrounding the fetus. (Box 34.9). Speculum examination may reveal watery or blood-stained discharge in the presence of ruptured membranes.

Box 34.9 History and physical examination in oligohydramnios

- History
 - Watery/blood-stained vaginal discharge
 - Hypertension
 - Preeclampsia
 - Pregestational hypertension
 - Antiphospholipid antibody syndrome
 - Family history
 - Congenital anomalies
 - Chromosomal abnormalities
 - Medications
 - ACE inhibitors
 - Prostaglandin synthetase inhibitors
- Physical examination
 - Blood pressure
 - Uterine size less than gestational age
 - Reduced amniotic fluid on palpation
- Speculum examination
 - Watery/blood-stained discharge
 - Pooling of fluid in the posterior fornix

AC , angiotensin-converting enzyme.

Investigations

Ultrasonography should be performed to confirm the diagnosis and to estimate AFI (Fig. 34.5). If oligohydramnios is confirmed, targeted ultrasonography is recommended to



Figure 34.5 Oligohydramnios on ultrasonography. Only two small pockets of amniotic fluid (white arrows) are seen. (Photo courtesy: Mediscan Systems, Chennai.)

detect fetal anomalies such as renal agenesis, polycystic kidneys, outflow obstruction, markers of chromosomal abnormalities, and fetal growth restriction. Doppler ultrasonography of renal arteries may confirm renal agenesis. Fetal MRI can also be used to confirm diagnosis. If structural anomalies are detected, fetal blood sampling and karyotyping are recommended. The placenta should be localized and abruption should be ruled out (Fig. 34.6).

If there is history of watery vaginal discharge, rupture of membranes must first be excluded by speculum examination. If there is no obvious

watery discharge, microscopic examination of vaginal swab for ferning or detection of vaginal pH of >7.5 by nitrazine test will confirm rupture of membranes (see Chapter 36, *Prelabor rupture of the membranes*). Management is as for preterm prelabor rupture of membranes.

Management

Management depends on the gestational age at diagnosis, the cause of oligohydramnios, and fetal prognosis.

First trimester

If reduced gestational sac fluid is found in the first trimester, the woman should be counseled regarding the risk of spontaneous miscarriage. Follow-up with serial ultrasonography is recommended.

Second trimester

Since prognosis is poor in second trimester oligohydramnios, counseling is important. The underlying cause should be determined. Amnioinfusion may be required to visualize the fetus on ultrasonography and perform proper evaluation. Termination of pregnancy is recommended if the fetal anomaly is lethal. Follow-up with serial ultrasonography is recommended for others.

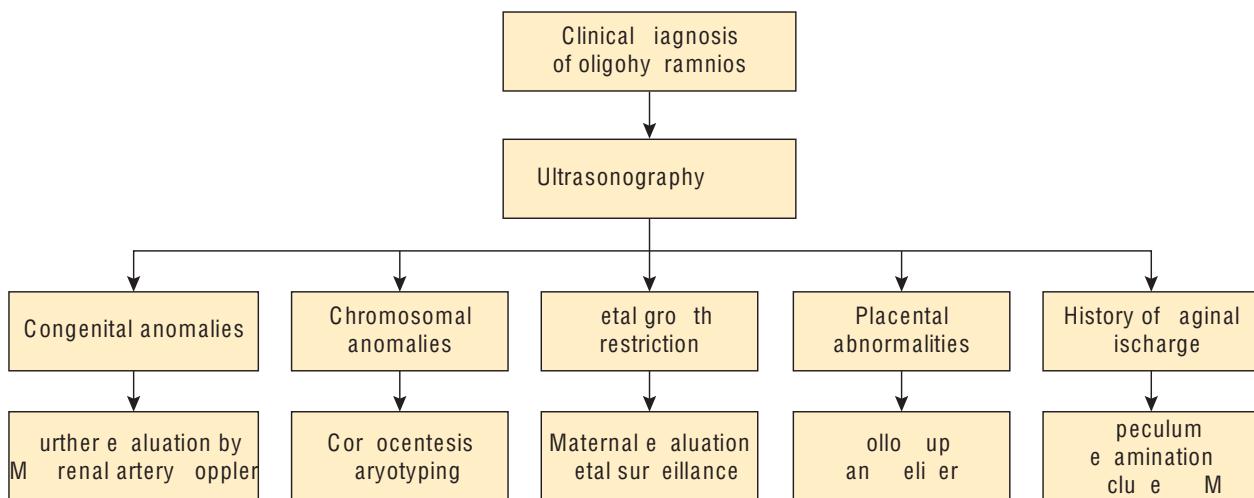


Figure 34.6 Evaluation of oligohydramnios. A, amniotic fluid index; M, membrane; R, ruptured.

Third trimester

Management depends on the cause of oligohydramnios.

- Postterm pregnancy with reduced AFI should be delivered.
- If the fetus is growth restricted, management should be directed toward the underlying maternal condition. The fetus should be monitored by serial ultrasonography combined with umbilical and middle cerebral artery Doppler. Delivery should be dictated by fetal condition.
- Women with preterm prelabor rupture of membranes should be managed conservatively till 34 weeks with close monitoring and delivered if leakage of fluid persists (see Chapter 36, *Prelabor rupture of membranes*).

Women with idiopathic oligohydramnios should be observed and monitored by nonstress test, serial ultrasonography, and biophysical profile.

Specific measures to increase AF

Maternal hydration

Review of randomized trials has shown that oral hydration with 1500–2000 mL of fluid per day increases AFV. This is particularly useful in women with dehydration and in hot summer months. Intravenous infusion of hypotonic fluid has also been found to be useful but the effect is similar to oral hydration.

Amnioinfusion

Amnioinfusion refers to the instillation of fluid into the amniotic cavity, either abdominally or transcervically. Transcervical amnioinfusion is usually performed in labor and is discussed in Chapter 17, *Intrapartum fetal surveillance*. Abdominal amnioinfusion is performed in the second trimester:

- To facilitate visualization of anomalies on ultrasonography

- Rarely, in preterm prelabor rupture of membranes, after the leak is sealed

Procedure

- Ultrasonography is performed to localize the placenta and identify a pocket of amniotic fluid.
- The abdomen is painted and draped.
- A 20-g needle is inserted, taking care to avoid fetal parts.
- The needle is connected to sterile tubing, a three-way stopcock, and a 50-mL syringe.
- Normal saline is injected under ultrasound guidance till normal AFV is achieved.
- Antibiotics are not recommended. Anti-D globulin must be administered to Rh-negative women.

In women with preterm prelabor rupture of membranes, if the leakage stops spontaneously, pulmonary hypoplasia can be prevented and outcome improved with amnioinfusion.

Timing of delivery

When an etiological factor is detected, timing of delivery is guided by the specific condition such as preeclampsia, growth restriction, or fetal anomaly. Pregnancies with idiopathic oligohydramnios are delivered at 38 weeks or when there is nonreassuring fetal status.

Management of labor

Close monitoring is essential in labor. Electronic fetal monitoring is recommended. Membranes should be ruptured when the woman enters active phase of labor, to look for meconium. If meconium staining and/or fetal heart decelerations are present, transcervical amnioinfusion should be considered (see Chapter 17, *Intrapartum fetal surveillance*). If fetal heart rate abnormalities persist, immediate cesarean section is indicated. Management of oligohydramnios is outlined in Figure 34.7.

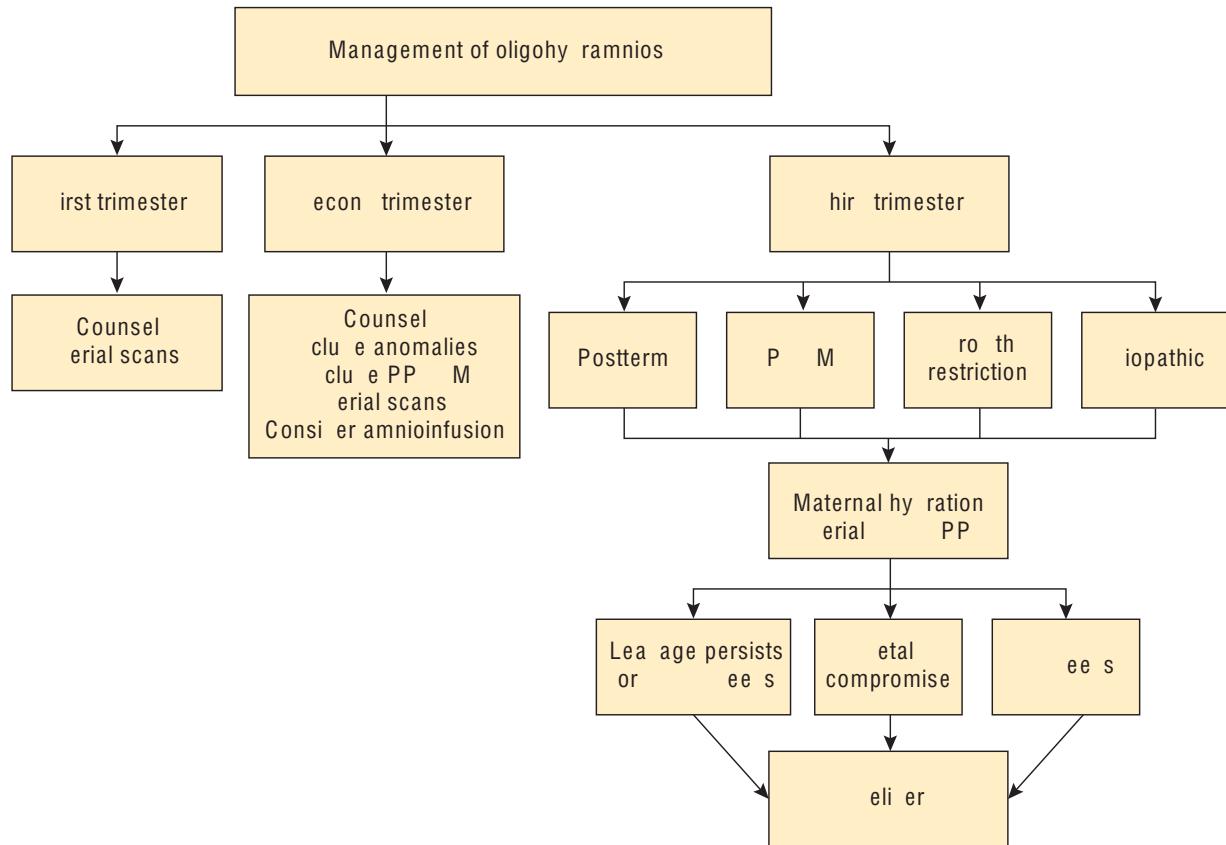


Figure 34.7 Management of oligohydramnios. *BPP*, biophysical profile; *S*, nonstress test; *PP*, preterm prelabor rupture of membranes.

Key points

- Amniotic fluid surrounds the fetus from early pregnancy. Changes that affect the production or clearance of amniotic fluid can affect the amniotic fluid volume (AFV) drastically.
- Evaluation of AFV is by ultrasonography. Single deepest pocket and amniotic fluid index are the techniques used.
- Excessive AFV is known as *polyhydramnios*. It may be mild, moderate, or severe.
- Polyhydramnios is caused by conditions that inhibit fetal swallowing and conditions that increase fetal urine production.
- Polyhydramnios is most often idiopathic. The common causes are fetal gastrointestinal tract obstruction, neurological anomalies such as anencephaly, chromosomal anomalies, and maternal diabetes.
- Women with polyhydramnios present with overdistension of abdomen. It may be chronic or acute.
- Polyhydramnios is associated with maternal and fetal complications.
- Polyhydramnios may be suspected clinically and is confirmed by ultrasonography, which is the single most important diagnostic evaluation. Congenital and chromosomal anomalies of the fetus and other causative factors should also be evaluated on ultrasonography.
- Management consists of amnioreduction in acute and severe cases and indomethacin in moderate hydramnios <34 weeks.
- Mild-to-moderate polyhydramnios should be delivered at term but severe hydramnios requires planned delivery at 37 weeks. Amniocentesis or controlled amniotomy is required to prevent complications in labor.
- Reduced amniotic fluid is known as *oligohydramnios*.
- Oligohydramnios is caused by conditions that reduce urine output such as renal agenesis, placental insufficiency, postmaturity, preterm prelabor rupture of membranes, and chromosomal anomalies.
- Oligohydramnios in the second trimester has poor prognosis due to the high risk of pulmonary

(Continued)

Key points *Continued*

- hypoplasia, skeletal malformations, and fetal anomalies.
- Cord compression, meconium aspiration, and fetal hypoxia are the problems encountered in the third trimester.
- When oligohydramnios is clinically suspected, ultrasonography should be performed to confirm diagnosis and determine the cause.
- Management depends on gestational age and cause of oligohydramnios.

- Oligohydramnios in the second trimester should be followed up with serial scans after counseling.
- Oligohydramnios in the third trimester should be initially treated by maternal oral hydration. Fetal surveillance includes nonstress test and biophysical profile. The woman should be delivered depending on the level of fetal jeopardy (when the tests become abnormal).

Self-Assessment

Case-based questions

Case 1

Mrs. DA, 30, multigravida, was referred from a primary health center. She was 31 weeks' pregnant and complained of difficulty in breathing. Her abdomen looked tense and overdistended.

1. What is the diagnosis?
2. How will you evaluate this woman?
3. What complications do you expect?
4. How will you manage her condition?

Case 2

Mrs. PM, 28, primigravida, came for routine antenatal checkup at 32 weeks' gestation. Abdominal examination revealed uterus corresponding to 28 weeks' gestation.

1. What is the provisional diagnosis?
2. How will you evaluate her?
3. What is the management?
4. How will you manage her in labor?

Answers

Case 1

1. Acute polyhydramnios. Placental abruption must be excluded.
2. a. History of bleeding, abdominal pain, and reduced fetal movements—for placental abruption.
b. Clinical examination—fluid thrill, difficulty in palpation of fetal parts, malpresentation, muffled heart sounds.
3. a. Maternal complications—preterm labor, prelabor rupture of membranes, dysfunctional labor, atonic postpartum hemorrhage, cesarean section, instrumental delivery, placental abruption.
b. Fetal complications—anomalies, malpresentations, cord prolapse.

4. a. Ultrasonography to exclude lethal anomalies such as anencephaly, other anomalies such as esophageal atresia, placental localization; GTT for diabetes.
- b. Amnioreduction to relieve respiratory distress.
- c. Close follow-up and planned delivery at 37 weeks.

Case 2

1. Wrong dates, fetal growth restriction, oligohydramnios.
2. History and review of previous scans to confirm dates, blood pressure and urine protein to exclude preeclampsia; ultrasonography to look for fetal growth restriction and oligohydramnios. If oligohydramnios is diagnosed, targeted scan for fetal anomalies.
3. If no fetal anomaly is detected and there is no growth restriction, mother should be given oral hydration. Fetus should be monitored with weekly NST and BPP. Deliver at 38 weeks if there is no complication. If not, deliver when the tests become abnormal.
4. Electronic fetal monitoring, early amniotomy to look for meconium, cesarean section if fetal status is nonreassuring.

Sample questions

Long-answer question

1. Discuss the etiology, clinical features, and management of polyhydramnios.

Short-answer questions

1. Acute polyhydramnios
2. Oligohydramnios in second trimester
3. Amniotic fluid index
4. Amnioreduction for polyhydramnios
5. Amnioinfusion

35

Preterm Labor and Birth

Case scenario

Mrs. VC, 29, gravida 3, para 2, had two preterm births and her previous babies were delivered at 36 and 34 weeks. The second one needed admission to the newborn nursery due to complications of prematurity. At 33 weeks, she was admitted with mild uterine contractions.

Introduction

Preterm labor leading to preterm birth (PTB) is a major clinical problem, especially in developing countries that have limited resources to handle the problems of the premature neonate. Globally, every year, an estimated 15 million babies are born preterm and more than 1 million deaths are directly attributable to preterm birth (before 37 completed weeks of gestation). This number is rising.

Preterm birth is a major contributor to neonatal mortality and morbidity and has long-term adverse consequences for health. In comparison to children born at term, children who are born prematurely have a higher risk of cerebral palsy, sensory deficits, learning disabilities, and respiratory illnesses. Complications related to preterm birth are the leading cause of death among children younger than 5 years of age.

Definition

Preterm labor is defined as the presence of uterine contractions of sufficient frequency and intensity to result in progressive effacement and dilatation of the cervix, between fetal viability and 37 weeks.

Fetal viability may be defined as gestational age between 20 and 28 weeks' gestation, depending on the facilities available and the prevailing neonatal survival rate. In developed countries, 20 weeks is considered to be a viable gestational age, whereas in India, 28 weeks would be acceptable. Those between 24 and 28 weeks may be described as being at the threshold of viability, but survival depends on institutional neonatal care facilities.

The classification of preterm birth can be by gestational age at birth or birth weight (Box 35.1).

Box 35.1 Classification of preterm birth

- By gestational age at birth
 - Extremely preterm: <28 weeks
 - Very preterm: 28 to <32 weeks
 - Moderate to late preterm: 32 to <36⁺6 weeks
- By birth weight
 - Low birth weight (LBW): <2500 g
 - Very low birth weight (VLBW): <1500 g
 - Extremely low birth weight (ELBW): <1000 g

Incidence

The rate of preterm births ranges from 5% to 18% globally. Currently the rate of preterm births in India is approximately 20%. According to the World Health Organization (WHO), India has the greatest number of preterm births in the world (approximately 3.6 million). This includes spontaneous and iatrogenic (induced) preterm births. The incidence has been rising, largely due to

- increase in assisted reproductive technology;
- increase in multiple pregnancies; and
- increase in preterm labor inductions.

Prematurity is one of the leading causes of perinatal mortality and morbidity in India, as in other countries.

Risk factors for preterm labor

Many preterm births occur among women with no risk factors. This makes it difficult to specifically prove the cause of preterm labor. However, the following are known risk factors and may predict PTB.

Prior preterm labor

Prior preterm labor is the strongest risk factor for future preterm birth. The risk of preterm birth increases two-fold with every subsequent preterm delivery. Preterm births tend to occur at the same gestational age as the previous birth. **A spontaneous preterm birth before 34 weeks is the best predictor for recurrence of early spontaneous preterm birth.**

Previous miscarriages

Previous spontaneous miscarriages, especially if recurrent and in the second trimester, are associated with an increased risk of preterm labor. There is a small but significant increase in risk with prior induced abortion as well.

Demographic factors

Demographic factors for preterm labor include extremes of maternal age (<17 or >35 years), low socioeconomic status, and low prepregnancy weight.

Lifestyle issues

Inadequate maternal weight gain, obesity, smoking, stress, excessive physical activity, and psychological factors have also been implicated.

Uterine overdistension

Multiple pregnancy or polyhydramnios causing uterine overdistension may precipitate preterm birth. Excessive uterine stretch due to overdistension causes activation of the endocrine cascade responsible for initiation of labor. Multiple gestation accounts for almost 25% of preterm births under 32 weeks. A prior preterm twin birth is associated with an increased risk of preterm birth in a subsequent singleton pregnancy.

Vaginal bleeding

Vaginal bleeding in the first and second trimesters, especially recurrent episodes, is associated with an increased risk of preterm birth. Placenta previa and placental abruption in the late third trimester are associated with vaginal bleeding and frequently lead to preterm birth.

Infections

Malaria is associated with preterm birth, low birth weight, and neonatal morbidities. Treatment of maternal malaria decreases the risk.

Genital tract infections by *Mycoplasma hominis*, *Ureaplasma urealyticum*, and bacterial vaginosis have been implicated, but treatment for any of these potential risk factors has not been shown to result in a decreased risk of preterm birth.

Chorioamnionitis is an important cause of preterm labor. The infection is often subclinical and amniotic fluid cultures may be negative. It is possible that the bacteria have invaded the maternal tissues but not entered the amniotic fluid. The endotoxins stimulate uterine contractions through release of cytokines.

Asymptomatic bacteriuria and **urinary tract infections** (UTIs), especially pyelonephritis, have been implicated in the causation of preterm birth.

Cervical and uterine factors

Short cervix

A short cervix on ultrasound examination at 16–28 weeks' gestation is predictive of preterm birth. Since cervical shortening (effacement) precedes labor, a high Bishop score on digital examination is also indicative of risk for preterm birth. Cervical length screening is discussed later in this chapter.

Cervical surgery

Ablative and excisional procedures on the cervix can lead to late miscarriage and preterm birth. When planning cervical surgery on women in the childbearing age group, the consequences of extensive surgery should be kept in mind and the least amount of intervention should be undertaken.

Uterine abnormalities

Preterm labor is associated with unicornuate uterus and uterine duplication abnormalities (uterus didelphys, bicornuate uterus, septate uterus). A large fibroid distorting the cavity may also result in preterm birth. Women who have preterm birth due to uterine septum, bicornuate uterus, or large fibroids will have a good response to surgical correction of the abnormality.

Pregnancies following assisted reproductive techniques

Preterm labor is more common in pregnancies conceived after induction of ovulation, in vitro fertilization, and donor or frozen embryo transfer.

Fetal factors

Fetal growth restriction and congenital anomalies of the fetus are associated with increased risk of preterm labor.

Periodontal disease

Although a causative relationship between periodontal disease and preterm labor has not been established, treatment of periodontal disease has been shown to reduce the risk of preterm labor.

Maternal medical disorders

Planned preterm birth may occur in situations where maternal medical disorders such as anti-phospholipid antibody syndrome, hypertensive disorders, or diabetes necessitate the early delivery of a fetus that is unable to tolerate the intrauterine environment. Other medical conditions such as asthma and seizure disorder have also been implicated in the increased risk of preterm labor.

The risk factors for preterm birth are listed in Box 35.2.

Complications of prematurity in the neonate

Complications resulting from prematurity contribute to the higher rate of infant mortality and morbidity in preterm infants, compared with that in infants born at term. The greater the immaturity, the greater is the risk of complications.

Complications of the premature infant are divided into the following:

- Short-term complications in the neonatal period
- Long-term sequelae in neonates who survive and are discharged from the neonatal intensive care unit (NICU; Box 35.3).

The neonatal complications of prematurity are discussed in Chapter 24, *Common problems of the newborn*.

Box 35.2 Risk factors for preterm birth

- Prior preterm labor
 - Strongest predictor
 - <34 weeks
 - Risk increased twofold
 - Usually occurs at the same gestational age
 - Risk increased with increasing number of preterm births
- Prior miscarriage
 - Spontaneous
 - Recurrent, second trimester
 - Induced
- Demographic factors
 - Maternal age <17 or >35 years
 - Low socioeconomic status
 - Low prepregnancy weight
- Uterine overdistension
 - Multiple pregnancy
 - Polyhydramnios
- Vaginal bleeding
 - Recurrent episodes
 - Placenta previa
 - Placental abruption
- Infections
 - Malaria
 - Genital tract infections
 - Asymptomatic bacteriuria/UTI (pyelonephritis)
- Cervical factors
 - Short cervix
 - Previous cervical surgery
- Uterine abnormalities
 - Unicornuate uterus
 - Uterine duplication abnormalities
 - Uterus didelphys
 - Bicornuate uterus
 - Septate uterus
 - Large fibroid distorting the cavity
- Pregnancies following assisted reproductive techniques
- Fetal factors
 - Fetal growth restriction
 - Congenital anomalies
- Periodontal disease
- Maternal medical disorders
 - Antiphospholipid antibody syndrome
 - Hypertensive disorders
 - Diabetes
 - Obesity
 - Chronic bronchitis and asthma
 - Seizure disorder

urinary tract infection.

Box 35.3 Neonatal complications of prematurity

- Immediate or short-term complications in the neonatal period
 - Hypothermia
 - Respiratory abnormalities
 - Cardiovascular abnormalities
 - Intracranial hemorrhage
 - Hypoglycemia
 - Necrotizing enterocolitis
 - Infection
 - Retinopathy of prematurity
- Long-term sequelae in neonates who survive and are discharged from the NICU
 - Neurodevelopmental disabilities such as cerebral palsy
 - Increase in infant mortality

C = neonatal intensive care unit.

Assessment of risk of preterm birth during pregnancy

Since most women who have preterm birth do not have any risk factors, it is difficult to anticipate them. However, certain factors may be assessed in women who are at risk for preterm birth (Box 35.4).

Box 35.4 Assessment of the risk of preterm birth during pregnancy

- History
 - Prior preterm birth
 - Gestational age at which it occurred
 - Prior cervical surgery
 - Known uterine abnormalities
 - Other risk factors listed in Box 35.1
- Physical examination
 - General examination
 - Estimation of body mass index
 - Vaginal examination
 - Cervical tears
 - Scarred cervix
 - Short cervix
- Cervical length screening
 - Ultrasonography

Cervical length screening

The risk of spontaneous preterm birth increases as cervical length decreases. The risk is highest when a short cervix is detected before 24 weeks' gestation.

Routine assessment of cervical length by ultrasound is not recommended in singleton pregnancies in low risk women, that is, women who have not had a prior preterm birth. It is only indicated in the presence of certain risk factors (Box 35.5).

In women who have had a previous preterm birth, cervical length assessment may be done serially from the 16th to 28th week of gestation to decide whether there is risk of recurrence of preterm birth in the current pregnancy. Cervical length assessment may also be done when a woman is admitted with suspected preterm labor.

Definition of short cervix

The diagnosis of a short cervix is made when cervical length on transvaginal ultrasound (TVUS) at 16–28 weeks' gestation is

- ≤20 mm in women with no prior preterm delivery
- <25 mm in women with a prior preterm delivery

Cervical length <25 mm between 16 and 28 weeks' gestation by TVUS examination is reliably associated with an increased risk of spontaneous preterm birth. On the other hand, if the cervix is

>25 mm at 24–28 weeks, the risk of preterm birth is extremely low.

Measuring cervical length by ultrasound

Transvaginal ultrasound examination is performed to measure cervical length (Fig. 35.1). Transvaginal ultrasound is reproducible, dependable, and a very sensitive approach to measuring cervical length. The woman's bladder should be empty for the TVUS. Transabdominal ultrasound (TAUS) examination is not reliable for the detection of a short cervix.

The cervix is measured from the internal os to the external os (Fig. 35.1a and 35.1b). If the internal os is open (Fig. 35.2), cervical length is measured from the tip of the funnel to the external os (Box 35.6).



a.



b.

Figure 35.1 Measurement of the cervix with transvaginal ultrasonography. **a.** The length of the cervix measured from the internal os to the external os is 34.3 mm at 19 weeks (normal). **b.** A short cervix measuring 20.3 mm at 24 weeks. (Photo courtesy: Mediscan Systems, Chennai.)

Box 35.5 Indications for cervical length assessment

- Previous preterm labor
- History of cervical surgery
 - LEEP
 - Amputation/Fothergill's surgery
 - Conization
- Recurrent bleeding in first or second trimester
- Uterine overdistension
 - Multifetal pregnancy
 - Polyhydramnios
- Uterine anomalies
 - Unicornuate uterus
 - Septate uterus
 - Bicornuate uterus
- Pregnancies following ART



Figure 35.2 Transvaginal ultrasonography of a cervix demonstrating funneling of the amniotic membrane protruding into the internal os and shortened cervical length of 21.5 mm. (Photo courtesy: Mediscan Systems, Chennai.).

Box 35.6 Measurement of cervical length

- TVUS used
 - Reproducible
 - Dependable
 - Sensitive
- TAUS not reliable
- Bladder emptied
- Cervix measured
 - From internal os to external os
 - Tip of funnel to external os

A S transabdominal ultrasound; S transvaginal ultrasound.

Other ultrasound signs of preterm labor

Other signs seen on ultrasound that are associated with preterm birth are as follows:

- Funneling: Protrusion of amniotic membranes into the cervical canal (Fig. 35.2)
- Debris/sludge (hyperechoic matter in the amniotic fluid close to the internal cervical os)

Prevention of preterm labor

Due to the morbidity and mortality associated with preterm labor, strategies have been tried to prevent preterm birth. Some of these have been clearly shown to be of no use. Other strategies are of proven benefit.

Interventions with no proven benefit

Several strategies have been tried without evidence of success in the prevention of preterm labor (Box 35.7).

Interventions with proven benefit

Some interventions that have proved to be effective in preventing preterm birth are listed in Box 35.8.

Diagnosis and treatment of asymptomatic bacteriuria

Pregnant women with asymptomatic bacteriuria should be treated with antibiotics to reduce the risk of preterm birth. Women with recurrent UTIs, diabetes mellitus, or underlying renal disease are at high risk for asymptomatic bacteriuria and should be screened regularly during pregnancy.

Cervical cerclage

Cervical cerclage has proved useful in women with known cervical insufficiency (see Chapter 29, *Miscarriage and recurrent pregnancy loss*).

Box 35.7 Interventions with no proven benefit

- Enhanced antenatal care
- Modification of maternal activity (bed rest)
- Supplementation with various nutrients and vitamins
- Screening for genital tract infections
- Empirical use of antibiotics
- Cervical cerclage in
 - women with prior preterm labor with normal cervical length
 - women with a short cervix with no history of preterm labor
 - multiple pregnancy
 - may actually precipitate preterm labor

Box 35.8 Interventions with proven benefit

- Diagnosis and treatment of asymptomatic bacteriuria
- Cervical cerclage
- Progesterone therapy
- Periodontal care
- Cessation of smoking
- Increasing interpregnancy interval
- Avoidance or treatment of malaria

In women with a previous preterm birth who have an ultrasound-proved short cervix between 18 and 24 weeks, cervical cerclage is effective in the prevention of preterm birth.

Progesterone therapy

Progesterone therapy administered in the second trimester may reduce the risk of preterm birth. The effect of progesterone is dependent on the preparation, dosage, and route of administration.

The indications for and the effects of progesterone therapy in preterm birth are enumerated in Box 35.9.

Dosage

Progesterone is started at 16–20 weeks' gestation and continued through 36 weeks' gestation or until delivery. The dosage for the different indications are summarized in Box 35.10.

Other interventions

Periodontal care, cessation of smoking, weight optimization, spacing of pregnancies, and treatment of infections such as malaria in endemic areas can reduce the risk of preterm labor.

Diagnosis of preterm labor

Suspected preterm labor is a common reason for hospitalization of pregnant women. Cervical change (dilatation and/or effacement) in the presence of regular painful uterine contractions

Box 35.9 Progesterone therapy in preterm birth

- Indicated in
 - asymptomatic women with previous preterm birth
 - asymptomatic women with a short cervix (≤ 20 mm)
- Progesterone therapy reduces
 - preterm births
 - perinatal/neonatal deaths
 - respiratory distress syndrome in the neonate

Box 35.10 Dosage of progesterone for prevention of preterm labor

- Asymptomatic women with previous preterm birth
 - 17 α -hydroxyprogesterone caproate 250 mg IM weekly or
 - Micronized progesterone 100 mg daily vaginally
- Asymptomatic women with a short cervix (≤ 20 mm)
 - Micronized progesterone 200 mg daily vaginally

is the most important clinical criterion for the diagnosis of preterm labor. The diagnosis can be made with greater confidence if in addition there is vaginal bleeding and/or ruptured membranes. Overdiagnosis of preterm labor is common.

Not all preterm labors will end with preterm birth. Approximately 30% of preterm labor resolve spontaneously. Of the women who are hospitalized for preterm labor, 50% continue their pregnancy till term.

Diagnostic criteria

Adherence to certain clinical criteria can help classify and diagnose preterm labor with certainty (Box 35.11). With threatened preterm labor, contractions are monitored and cervical changes reassessed 30–60 minutes later. If there is progressive effacement and dilatation, it must be treated as preterm labor. Women who have had threatened preterm labor have a greater incidence of late preterm labor (34 to < 37 weeks).

Fetal fibronectin

Testing for fetal fibronectin (fFN) may be done to determine whether preterm labor will lead to preterm birth.

Fetal fibronectin is a fibronectin protein produced by fetal cells. It is found at the interface of the chorion and the decidua. It is thought to be a 'trophoblast glue' that acts as an adhesive between the fetal membranes and the uterine decidua. It is released into cervicovaginal secretions when there is disruption of the chorion/decidual interface that may occur at the time of

Box 35.11 Diagnostic criteria for preterm labor

- threatened preterm labor*
- Irregular or regular uterine activity
 - Associated with
 - cervical length > 10 mm
 - cervical dilatation 1–2 cm

Preterm labor

- Regular uterine activity
 - Contraction frequency of
 - at least 1 every 10 minutes or
 - 6 per hour
- Associated with
 - cervical length < 10 mm
 - cervical dilatation > 2 cm
 - vaginal bleeding or rupture of membranes

preterm labor. The presence or absence of fFN is used to predict preterm birth. Testing for fFN is expensive and not done routinely in India.

Testing for fFN, if done, should be used as an additional test only in women who have preterm contractions and whose cervical length falls between 20 and 30 mm. In this situation it is difficult to predict preterm labor with cervical length alone.

The test is done by obtaining a swab from the posterior vaginal fornix. No digital examination should be done prior to obtaining the swab.

Interpretation of results of fFN testing is summarized in Box 35.12.

Insulin-like growth factor-binding protein-1

Phosphorylated insulin-like growth factor-binding protein-1 (IGFBP-1) is secreted by decidual

Box 35.12 Interpretation of fFN levels

- Cervical length between 20 and 30 mm
 - fFN positive
 - Increased risk of preterm birth in the next 7 days
 - fFN negative
 - Low risk of preterm birth

f , fetal fibronectin.

cells and may leak into cervical secretions during detachment of the fetal membrane.

A bedside dipstick method is now commercially available for this test. It seems to be more useful for its negative predictive value, that is, the absence of IGFBP-1 is a reassuring sign that the likelihood of preterm birth is low.

The management of preterm uterine contractions is given in Figure 35.3.

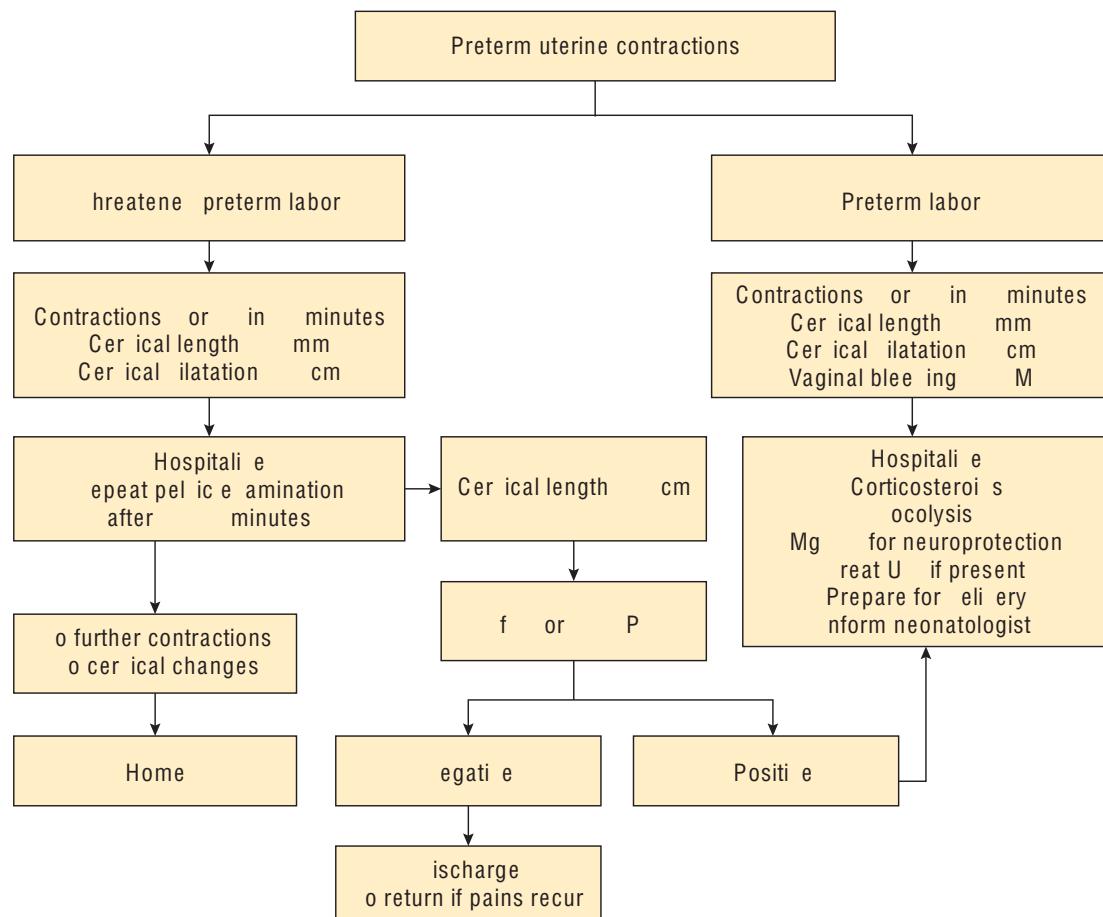


Figure 35.3 The evaluation and management of preterm uterine contractions at <34 weeks' gestation. f = fetal fibronectin;

BP- = insulin-like growth factor-binding protein-1; gS = magnesium sulphate; S = spontaneous rupture of membrane; U = urinary tract infection.

Management of preterm labor

A woman in preterm labor at <34 weeks' gestation should be hospitalized to initiate certain interventions (Fig. 35.3).

The management of preterm labor is summarized in Box 35.13.

Administration of corticosteroids

Liggin and Howie, in 1972, demonstrated that a single course of antenatal corticosteroid therapy administered between 24 and 34 weeks' gestation to women at risk for preterm birth reduced the incidence and severity of respiratory distress syndrome (RDS) and mortality in the neonate by 50%. Since then, this therapy has saved countless preterm neonates globally.

Other benefits of corticosteroid therapy that have been demonstrated more recently are the reduction in risk for

- intraventricular hemorrhage;
- necrotizing enterocolitis; and
- systemic infection in the first 48 hours of life.

Box 35.13 Management of preterm labor

- Corticosteroids for fetal lung maturity
- Tocolysis to delay delivery
 - Facilitates in utero transfer to tertiary center
 - Gives time for corticosteroids and magnesium sulfate to act
- Magnesium sulfate for fetal neuroprotection
- Antibiotic therapy for women with UTI
- Interventions with no benefit
 - Complete bed rest
 - Hydration
 - Maintenance therapy with tocolytics
 - Antibiotics
 - To prolong gestation
 - To decrease neonatal morbidity

, urinary tract infection.

mechanism of action

The mechanisms of action of antenatal steroids are summarized in Box 35.14.

gestational age of administration

Corticosteroids may be administered **between 24 and 34 weeks' gestation** to a woman in whom preterm birth is anticipated. In places where neonatal salvage is poor prior to 28 weeks, it might be prudent to administer the dose after 28 weeks' gestation.

The risk of severe respiratory morbidity after 34 weeks' gestation is low and the efficacy of corticosteroid therapy after this age is doubtful. The American College of Obstetricians and Gynecologists (ACOG) has not recommended antenatal corticosteroids for gestations >34 weeks. However, the Royal College of Obstetricians and Gynaecologists (RCOG) guidelines recommend routine administration of antenatal glucocorticoids for all women at risk of preterm birth <35 weeks' gestation and all women undergoing elective cesarean delivery up to and including 38⁺⁶ weeks' gestation.

Drugs and dosage

Both betamethasone and dexamethasone may be used. Betamethasone is preferred because of the lesser number of doses required. Dexamethasone is less expensive.

The course of therapy is listed in Table 35.1.

Box 35.14 Action of antenatal steroids

- Accelerating development of type 1 and type 2 pneumocytes
 - Improved maximal lung volume
 - Improved compliance
 - Improved gas exchange
- Induction of type 2 pneumocytes
 - Increased surfactant production
 - Enhanced neonatal response to postnatal surfactant treatment
- Induction of pulmonary β -receptors
 - Release of surfactant
 - Absorption of alveolar fluid

Table 35.1 Course of therapy for antenatal corticosteroids

Drug	Number of doses	Dosage	Interval
Betamethasone	2	12 mg IM	24 hours apart
Dexamethasone	4	6 mg IM	12 hours apart

Rescue salvage or booster dose

Evidence suggests that multiple courses of steroids can have deleterious effects on the fetus, most importantly growth restriction. Repeated courses are therefore not recommended.

However, if the last dose of steroids was given more than 2 weeks prior to expected delivery, and the gestational age at administration of the initial course was <28 weeks' gestation, a single repeat dose of 12 mg of betamethasone may have some benefit.

The recommendations for corticosteroid therapy are summarized in Box 35.15.

Tocolysis

It is often difficult to differentiate true preterm labor from false or threatened preterm labor. Of the total number of women thought to be in preterm labor, only 50% go on to deliver at term.

In women with true preterm labor (in whom progressive cervical changes are documented), tocolytic therapy helps by inhibiting and stopping contractions temporarily. However, the underlying stimulus that initiated the process of labor is not affected. Therefore, tocolytic therapy may only provide short-term prolongation of pregnancy. This is particularly useful when corticosteroids are administered for fetal lung maturity. Tocolysis provides time for the steroids to act.

Women with preterm contractions without cervical change, especially those with a cervical dilatation of <2 cm, should not be treated with tocolytics.

The characteristics of tocolytics are enumerated in Box 35.16.

Box 35.15 Administration of antenatal corticosteroids

- In women at risk for preterm labor
- Between 24 and 34 weeks
 - Preferably after 28 weeks
- Effective for 7 days
- Repeat courses not recommended
 - Associated with fetal growth restriction
- Rescue or salvage dose, if indicated
 - 2 weeks elapsed since last dose
 - Gestational age at first dose <28 weeks
 - Single 12-mg dose of betamethasone

Box 35.16 Characteristics of tocolytics

- Effective in
 - reducing or abolishing contractions
 - for an average of 48 hours
 - may prolong pregnancy up to 7 days
- Most useful in women with
 - preterm labor at gestational age 28–34 weeks

The mechanism of action, dose, and maternal and fetal side effects of tocolytic agents are enumerated in Table 35.2.

Calcium channel blockers nifedipine

Nifedipine is the first-line therapy for tocolysis since it performs best for the following outcomes:

- Delivery delayed by 48 hours
- Decreased neonatal mortality
- Decreased neonatal RDS

Nifedipine is more effective than β -agonists and has fewer side effects. Currently, this is the drug of choice in most centers.

Cyclooxygenase inhibitors

Indomethacin

Indomethacin is the second line of treatment for tocolysis. If given for not more than 48 hours, it is most effective in abolishing preterm contractions, with the least maternal side effects. However, it does not perform as well in decreasing neonatal mortality and RDS as compared with nifedipine.

Indomethacin is not recommended beyond 32 weeks' gestation. When used for more than 48 hours, it can cause fetal renal failure and oligohydramnios. Premature closure of ductus arteriosus is also a known complication.

β Agonists ritodrine and terbutaline

The β -mimetic drugs, ritodrine and terbutaline, can cause severe maternal hypotension and tachycardia. In multiple gestation, maternal pulmonary edema and maternal mortality have been reported with the use of these drugs. They were introduced as the first line of tocolytics, but now their use is not recommended because of the unacceptably high maternal side effects.

Table 35.2 Mechanism of action, dose, and maternal and fetal side effects of tocolytic agents

Drug	Class of drug	Mechanism of action	Dose	Maternal side effects	Fetal side effects
Nifedipine (first-line treatment for tocolysis)	Calcium channel blocker	<ul style="list-style-type: none"> Decreases intracellular free calcium Results in myometrial relaxation 	<ul style="list-style-type: none"> 30 mg loading dose Then 10–20 mg every 4–6 hours 	Dizziness, flushing, and hypotension	No known adverse effects
Indomethacin (should not be given for >48 hours due to fetal side effects)	Cyclooxygenase inhibitor	<ul style="list-style-type: none"> Inhibits cyclooxygenase production Decreases prostaglandin production 	<ul style="list-style-type: none"> 50–100 mg loading dose (oral or per rectum) Followed by 25 mg orally every 4–6 hours 	Nausea, esophageal reflux, gastritis, and emesis; platelet dysfunction	In utero constriction of ductus arteriosus, renal dysfunction, oligohydramnios, necrotizing enterocolitis in preterm newborns, and PDA in neonate
Ritodrine (currently not recommended due to maternal side effects)	β-Mimetic (β-adrenergic receptor agonist)	<ul style="list-style-type: none"> Inhibits interaction between actin and myosin Diminishes myometrial contractility 	<ul style="list-style-type: none"> IV infusion 0.05–0.1 mg/min Increased at 15-minute intervals to 0.35 mg/min 	Tachycardia, hypotension, tremor, palpitations, shortness of breath, chest discomfort, pulmonary edema, hypokalemia, hyperglycemia	Fetal tachycardia
Terbutaline	β-Mimetic (β-adrenergic receptor agonist)	<ul style="list-style-type: none"> Inhibits interaction between actin and myosin Diminishes myometrial contractility 	<ul style="list-style-type: none"> 0.25 mg SC every 20–30 minutes for 4 doses Then 0.25 mg SC every 3–4 hours for 24 hours 	Same as ritodrine	Same as ritodrine
Atosiban	Oxytocin receptor antagonist	Selective oxytocin–vasopressin receptor antagonist	<ul style="list-style-type: none"> IV bolus 6.75 mg Then 300 µg/min infusion for 3 hours Then 100 µg/min for up to 45 hours 	Hypersensitivity, injection site reactions	Minimal

PDA, patent ductus arteriosus; SC, subcutaneous.

Terbutaline is used when immediate short-term tocolysis is needed as in uterine hyperstimulation or prior to external cephalic version.

tric o i e onors glyceryl trinitrate

Transdermal glyceryl trinitrate has been used as a tocolytic as well. Its efficacy in preventing preterm labor is limited.

agnesium sulfate

Magnesium sulfate has been extensively studied as a tocolytic due to its inhibition of myometrial contractility. However, it has not been found to be effective in preterm labor.

Oxytocin antagonists Atosiban

Atosiban is as effective as β -mimetics for preventing preterm birth within 48 hours of initiating treatment. Use of atosiban is associated with a significantly lower risk of maternal side effects than β -mimetics. However, this drug is available only in Europe and not in other countries, including India.

Contraindications to tocolysis are listed in Box 35.17.

Maintenance therapy with tocolytics

There is not enough evidence to continue tocolytics after 48 hours. Maintenance therapy with tocolytics is ineffective for preventing preterm birth and improving neonatal outcomes, and is not recommended for this purpose.

Tocolysis in women with multiple pregnancy

The use of tocolytics to inhibit preterm labor in multiple pregnancy has been associated with a greater risk of maternal complications, such as pulmonary edema, especially with the use of β -mimetics. Nifedipine is considered safe in multiple pregnancy.

Box 35.17 Contraindications to tocolysis

- Intrauterine fetal demise
- Lethal fetal anomaly
- Nonreassuring fetal status
- Severe preeclampsia or eclampsia
- Maternal bleeding with hemodynamic instability
- Chorioamnionitis
- Preterm prelabor rupture of membranes
- Maternal contraindications to tocolysis (agent specific)

Magnesium sulfate for fetal neuroprotection

Cerebral palsy refers to a heterogeneous group of disorders of movement and/or posture. It is the most common cause of severe motor disability in childhood. Compared with term infants, the incidence of cerebral palsy, sensory deficits, and learning disabilities is very high in children born before 34 weeks, and even higher in children born before 32 weeks.

For women at risk of preterm birth, antenatal administration of magnesium sulfate provides good neuroprotection. Maternal administration of magnesium sulfate in women expected to have a preterm delivery within 24 hours has consistently demonstrated a decreased risk of cerebral palsy and severe motor dysfunction in offspring.

gestational age of administration

Magnesium sulfate for neuroprotection is administered when delivery is expected in the next 24 hours

- due to preterm labor;
- due to preterm prelabor rupture of membranes;
- before an elective preterm delivery (induction or cesarean delivery for maternal or fetal indications).

Magnesium sulfate for neuroprotection is most effective in pregnancies between 24 and 32 weeks' gestation.

Dose of magnesium sulfate or neuroprotection

Dose of magnesium sulfate for neuroprotection is given as follows:

- Magnesium sulfate is given as
 - 4 g intravenous loading dose followed by
 - 1 g/hour infusion
- The therapy is discontinued 24 hours after initiation if delivery has not occurred
- The dose may be repeated if labor does not progress and the woman returns later in preterm labor

Magnesium sulfate by itself provides a certain degree of tocolysis. However, if the pain is not subsiding with magnesium sulfate alone, tocolysis may be initiated to allow the magnesium sulfate enough time to provide neuroprotection.

Indomethacin is the tocolytic of choice when magnesium sulfate is being used. **It is better to avoid nifedipine and β -mimetics in conjunction with magnesium sulfate because of the potential for serious maternal complications.**

The use of magnesium sulfate for fetal neuroprotection is summarized in Box 35.18.

Role of antibiotics in prolonging pregnancy or improving neonatal outcome

Antibiotics have **no role** in prolonging gestation or improving neonatal outcome in women with preterm labor with membranes intact.

Management of preterm delivery

If labor progresses in spite of tocolysis, all precautions should be taken for safely delivering the baby (Box 35.19).

Box 35.18 Magnesium sulfate for neuroprotection

- When preterm delivery expected in next 24 hours
- Decreases risk of cerebral palsy
- Most effective between 24 and 32 weeks' gestation
- Dosage
 - 4 g intravenous loading dose followed by
 - 1 g/hour infusion
- Discontinued 24 hours after initiation
- Tocolysis with indomethacin, if required

Box 35.19 Management of preterm delivery

- Cephalic presentations may be delivered vaginally
- Vaginal delivery
 - Carefully controlled
 - Nontraumatic
- Breech presentations at <34 weeks' gestation
 - Cesarean section
- Early AROM should be avoided
- EFM is recommended during labor
- A neonatologist and team should be available at the time of birth

A = artificial rupture of membranes; EFM = electronic fetal monitoring.

Key points

- Preterm birth is a major contributor to neonatal mortality and morbidity and has long-term adverse consequences for health.
- Preterm labor is defined as the presence of uterine contractions of sufficient frequency and intensity to result in progressive effacement and dilatation of the cervix, between fetal viability and 37 weeks.
- Prior preterm labor is the strongest risk factor for future preterm birth.
- Cervical length screening by ultrasound is useful in assessing risk in women with previous preterm birth.
- The risk of spontaneous preterm birth increases as cervical length decreases. The risk is highest when a short cervix is detected before 24 weeks' gestation.
- The diagnosis of a short cervix is made when cervical length on transvaginal ultrasound (TVUS) at 16–28 weeks' gestation is ≤ 20 mm in women with no prior preterm delivery and <25 mm in women with a prior preterm delivery.
- Certain interventions help in preventing preterm labor: Treatment of asymptomatic bacteriuria, cervical cerclage, cessation of smoking, and progesterone therapy.
- Progesterone therapy administered in the second trimester may reduce the risk of preterm birth. 17- α -Hydroxyprogesterone caproate 250 mg IM is started at 20 weeks and given weekly till 36 weeks. Vaginal micronized progesterone can also be given.
- Fetal fibronectin and insulin-like growth factor-binding protein-1 can be used to predict if preterm birth will occur in a woman with preterm labor.
- Management of preterm labor includes administration of corticosteroids, tocolysis, and magnesium sulfate for neuroprotection.
- If labor progresses in spite of tocolysis, all precautions should be taken to safely deliver the baby.
- Complications of the premature infant are divided into short-term complications in the neonatal period and long-term sequelae.

Self-Assessment

Case-based questions

Case 1

Mrs. VC, 29, gravida 3, para 2, had two preterm births and her previous babies were delivered at 36 and 34 weeks. The second one needed admission to the newborn nursery due to complications of prematurity. At 33 weeks she was admitted with mild uterine contractions.

1. After two prior preterm births, what is the risk of this woman having another preterm birth?
2. How could she have been screened for recurrence of preterm birth in this pregnancy?
3. What are the steps you will take to manage her at 33 weeks?
4. What are the complications that her infant can face?

Case 2

Mrs. WE, 22, gravida 2, para 1, live 1, at 32 weeks' gestation, presented to the hospital with complaints of increased low back pain and pelvic pressure. She stated that she had painful and frequent micturition and had 'menstrual-type cramping. On examination, there was scant blood from the cervix, which appeared old. The cervix was 2-cm dilated, <1-cm long, and soft in consistency. She was having contractions every 10 minutes. The fetus was in breech presentation and appropriately grown for the gestation.

1. What is the diagnosis and what could be the cause?
2. How would you manage this patient?
3. What would be your choice for tocolytic agent?
4. If the contractions do not subside and she goes into labor, what would be the best mode of delivery?

Answers

Case 1

1. The risk of recurrent preterm birth after two consecutive preterm births is approximately 30%.

2. Because she has had previous preterm birth, cervical length assessment should have been done from 16 weeks. A short cervix <25 mm can be treated with 17-alpha hydroxyprogesterone caproate or micronized progesterone.
3. Hospitalize the patient; start on corticosteroids and tocolytics. Perform urine culture and treat if positive. The neonatologist should be informed.
4. The complications her premature neonate can face are respiratory distress, intraventricular hemorrhage, sepsis, hypothermia, hypoglycemia, necrotizing enterocolitis, and retinopathy.

Case 2

1. Diagnosis is preterm labor since the cervix is <1-cm long and 2-cm dilated, and contractions are 1 in 10 minutes. She also appears to be having a urinary tract infection which could be precipitating the preterm labor.
2. Urine should be sent for culture and sensitivity; empirical antibiotic therapy should be started; corticosteroids should be administered and tocolysis given for 48 hours.
3. Oral nifedipine would be the first choice for tocolysis.
4. Since it is a breech presentation at 32 weeks, a cesarean section would be the choice for mode of delivery.

Sample questions

Long-answer question

1. Define preterm labor. Explain etiology and management of preterm labor.

Short-answer questions

1. Causes of preterm labor
2. Neonatal complications of prematurity
3. Prevention of preterm labor
4. Tocolytic therapy

36

Prelabor Rupture of the Membranes

Case scenario

Mrs. HK, 30, a primigravida at 30 weeks of pregnancy, was referred from a peripheral hospital with history of watery discharge. The discharge had begun 12 hours ago but Mrs. HK and her husband had not realized that it was a problem. On arrival at the local hospital, they were told that the membranes had ruptured spontaneously and since she was preterm, she had to be in a tertiary center.

Introduction

Rupture of membranes before the onset of labor, whether it occurs at term or preterm, is a cause for worry because it is associated with perinatal and maternal complications. The important goals of management are optimizing timing of delivery and minimizing perinatal mortality and morbidity.

Definition

Prelabor rupture of membranes (PROM) is defined as rupture of membranes before the onset of regular uterine contractions.

- When PROM occurs at or after 37 weeks' gestation, it is referred to as *term PROM*.
- *Preterm PROM* (PPROM) is defined as PROM between 24 and 37 weeks.

- Midtrimester or *previable PROM* is defined as PROM between 16 and 24 weeks' gestation.

Incidence

Prelabor rupture of membranes occurs in 10% of all pregnancies, of which 7%–8% occur after 37 weeks. The incidence of PPROM is 2%. Midtrimester PROM occurs in 0.3%–0.7% of pregnancies.

Pathophysiology

The fetal membranes consist of an inner amnion and outer chorion. The amnion surrounds the amniotic cavity and is lined by a single layer of cuboidal epithelium. The chorion is thicker, adherent to the maternal decidua, and consists

of reticular and trophoblastic layers. There is compact spongy connective tissue between the amnion and chorion.

With advancing gestational age, remodeling of membranes occurs through changes in collagen and intercellular matrix. This results in weakening of the membranes and susceptibility to rupture. These changes are mediated through *matrix metalloproteinases* (MMP). Any condition that causes increase in MMP levels or decrease in tissue inhibitors of MMP (TIMP) can give rise to membrane weakening and PROM. Increase in local *cytokines* and *collagenase* also causes membrane weakening. *Increase in intrauterine pressure* due to polyhydramnios and/or multiple pregnancy acts as a mechanical factor leading to membrane rupture (Box 36.1).

Risk factors

In most cases of PROM, no etiological factor is identified. Risk factors for PROM are listed in Box 36.2. Urogenital infection and microbial colonization lead to preterm labor by causing an increase in local cytokine or an imbalance between MMPs and TIMPs. The organisms implicated are *Chlamydia trachomatis*, *Trichomonas vaginalis*, group B beta-hemolytic streptococci (GBS), and *Neisseria gonorrhoeae*. Bacterial vaginosis also predisposes to PROM and preterm labor. Amniotic fluid cultures are positive in 25%–35% of women with PROM. Several risk factors have been known to be associated with

Box 36.2 Risk factors of prelabor rupture of membranes (P M)

- Urogenital infections
 - *Chlamydia trachomatis*
 - *richomonas vaginalis*
 - Bacterial vaginosis
 - Group B beta-hemolytic streptococcus
 - *escherichia gonorrhoeae*
- Uterine overdistension
 - Polyhydramnios
 - Multifetal pregnancy
- Connective tissue disorders
 - Ehlers–Danlos syndrome
- Others
 - Prepregnancy
 - Low socioeconomic status
 - Low BMI
 - Previous PROM/preterm birth
 - Cervical conization
 - During pregnancy
 - Bleeding in first or second trimester
 - Maternal smoking
 - Nutritional deficiencies (copper, vitamin C)
 - Preterm labor
 - Cervical cerclage
 - Invasive procedures
 - Amniocentesis
 - Cordocentesis
 - Fetoscopy

PROM. Risk factors may be present prior to pregnancy or may be identified during pregnancy. Previous preterm birth with or without PROM is an important risk factor. Cervical cerclage as well as invasive procedures such as amniocentesis, cordocentesis, and fetoscopy are well-recognized risk factors for midtrimester PROM.

Box 36.1 Pathophysiology of rupture of membranes

- Physiological remodeling
 - Changes in collagen
 - Changes in intercellular matrix
- Mediated by
 - increase in
 - cytokines
 - MMP
 - collagenase
 - decrease in TIMP
 - increase in intrauterine pressure
 - polyhydramnios
 - multiple pregnancy

P, matrix metalloproteinase; *P*, tissue inhibitors of matrix metalloproteinases.

Complications

Maternal and fetal complications increase with duration of rupture of membranes and fetal prematurity.

Maternal complications

Ascending infection resulting in maternal *chorioamnionitis* is the most common complication. This occurs in 25% of women with PROM. The risk increases as the duration of rupture of membranes increases. The risk is higher in preterm PROM than

Box 36.3 Maternal complications of prelabor rupture of membranes

- Chorioamnionitis
- Placental abruption
- Retained placenta
- Puerperal endometritis
- Maternal sepsis
- Cesarean section

in term PROM. The risk of infection decreases with increasing gestational age. Fever, malodorous vaginal discharge, uterine tenderness, and fetal tachycardia are the signs of clinical chorioamnionitis. *Placental abruption, retained placenta, puerperal endometritis, and maternal sepsis* are other known complications (Box 36.3).

Fetal complications

Chorioamnionitis leads to *fetal pneumonia, septicemia, and perinatal death*.

Prelabor rupture of membranes can be associated with cord prolapse. *Oligohydramnios* can cause cord compression, meconium passage and aspiration, fetal distress, and fetal hypoxia. *Prematurity, respiratory distress syndrome, necrotizing enterocolitis, and intraventricular hemorrhage* are common following PPROM. *Perinatal mortality* is higher in preterm birth associated with PROM compared to preterm birth with intact membranes. Prelabor rupture of membranes in the second trimester, leading to oligohydramnios, can result in *pulmonary hypoplasia* and *limb deformities*. Long-term sequelae such as *cerebral palsy, mental retardation, periventricular leukomalacia, visual and hearing disabilities, and chronic lung disease* also result from this condition (Box 36.4).

Prediction and prevention

Previous PROM is a strong risk factor for PROM in the current pregnancy. However, prediction is difficult. Cervical length <25 mm on ultrasound and positive fetal fibronectin test in maternal plasma at 22–24 weeks' gestation indicate higher risk.

Since it is not possible to predict or prevent PROM in most women, routine screening tests and preventive measures are not currently recommended.

Box 36.4 Fetal and neonatal complications of prelabor rupture of membranes (P M)

- Fetal infection
 - Pneumonia
 - Septicemia
 - Perinatal death
- Cord prolapse
- Preterm PROM
 - Prematurity
 - Respiratory distress syndrome
 - Necrotizing enterocolitis
 - Intraventricular hemorrhage
- Second trimester PROM
 - Pulmonary hypoplasia
 - Limb deformities
- Long-term sequelae
 - Periventricular leukomalacia
 - Cerebral palsy
 - Hearing and visual defects
 - Mental retardation
 - Chronic lung diseases

Clinical features

Most women with PROM present with history of watery discharge per vaginum. This usually occurs in a gush and continues as a trickle. It can also occur as intermittent discharge of small amounts of fluid which may be mistaken for urinary incontinence. Occasionally, the woman may be unaware of any discharge. Uterine contractions may begin a few hours later, especially in women at term. In women with prolonged rupture of membranes, fever, uterine tenderness, and/or malodorous discharge are indicative of chorioamnionitis. The uterus may be felt hugging the fetus if the volume of amniotic fluid is remarkably reduced.

Amniotic fluid may be seen draining through the introitus, especially when the woman is asked to cough. Speculum examination reveals clear fluid flowing through the cervical os or fluid collected in the posterior fornix (Box 36.5).

Clinical course

- Prelabor rupture of membranes is usually followed by the onset of labor. The latent period between rupture of membrane and onset of

Box 36.5 Clinical features of prelabor rupture of membranes

- Watery discharge per vaginum
 - Gush of fluid
 - Continuous trickle
 - Intermittent discharge
- Uterine contractions few hours later
- Chorioamnionitis
 - Fever
 - Uterine tenderness
 - Malodorous amniotic fluid
- Fluid draining through introitus
- Speculum examination
 - Fluid draining through cervical os
 - Fluid collected in posterior fornix

labor increases as gestational age decreases. When membranes rupture at term, 50% deliver within 5 hours, 85% within 48 hours, and 95% within 72 hours. However, in PROM before 34 weeks, 50%–60% deliver within 1 week.

- Occasionally, the leakage may stop due to sealing of the rent in the membranes, fluid may reaccumulate, and pregnancy may continue. This occurs in 2–3% of women. It is commonly seen in PROM associated with amniocentesis in the second trimester.

Clinical evaluation

This consists of history, physical examination, confirmatory tests, assessment of gestational age, and maternal/fetal complications.

History

As already discussed, history of sudden gush of watery discharge per vaginum, continuous trickle, or intermittent discharge is the most common presentation. Gestational age should be assessed and history of uterine contractions or symptoms of chorioamnionitis should be obtained.

Physical examination

On physical examination, height of uterine fundus, presence of uterine contractions, presentation of the fetus, signs of chorioamnionitis, and fetal heart rate abnormalities should be noted. Vulva should be examined for visualization of

gush of watery discharge through the introitus spontaneously or on coughing. Speculum examination usually reveals draining of fluid through the cervical os or fluid in the posterior fornix. If leakage of amniotic fluid is not seen, a vulval pad may be applied and the pad examined after a few hours (Box 36.6).

Digital vaginal examination should be avoided for the following reasons:

- It shortens the latency period between membrane rupture and delivery.
- It increases the risk of infection.

Digital vaginal examination should not be performed in PROM unless delivery is imminent.

Confirmatory tests for diagnosis of P M

- **Nitrazine test:** The normal vaginal pH is between 4.5 and 5.5. When the vaginal fluid shows a pH >6–6.5 on testing with nitrazine paper (color changes to blue), it confirms the presence of alkaline amniotic fluid. The test has a sensitivity of 90%. False positive test may be obtained if the fluid is contaminated by urine or blood.

Box 36.6 Clinical evaluation

- History
 - Watery discharge per vaginum
 - Duration of discharge
 - Gestational age
 - Uterine contractions
 - Symptoms of chorioamnionitis
 - Fetal movements
- Physical examination
 - Fever, tachycardia
 - Uterine height
 - Presentation
 - Fetal heart rate
 - Uterine tenderness
- Examination of the vulva
 - Gush of amniotic fluid
- Speculum examination
 - Draining of fluid through the cervical os
 - Fluid collected in posterior fornix
 - Color of amniotic fluid
 - Malodorous discharge
 - Cervical effacement
 - Cervical dilatation
 - Cord/fetal limb prolapse

- **Fern test:** Fluid from the posterior fornix is smeared on a glass slide using a swab and allowed to dry. When examined under the microscope, fern pattern is seen due to interaction between proteins and salts in the amniotic fluid. This test also has a sensitivity of 90%. Contamination by cervical mucus can yield a false positive result.
- **Ultrasonography:** This may reveal oligohydramnios. When the history is suggestive of ruptured membranes and other tests are equivocal, this may be used as an aid to diagnosing PROM.
- **Indigo carmine test:** After intra-amniotic injection of indigo carmine, the vulval pad is stained blue if there is PROM. This test is now obsolete and not in use.
- **Other tests:** When membranes rupture, there is an increase in fetal fibronectin (fFN) and insulin-like growth factor binding protein 1 (IGF BP1) in cervicovaginal secretions. Tests to detect fFN and IGF BP1 have been found to have high sensitivity and specificity. A rapid immunoassay to identify placental alpha-I microglobulin in the vaginal fluid is an accurate test with a sensitivity and specificity of nearly 99%–100%. This test is not routinely available for clinical use in India.

Confirmatory tests are listed in Box 36.7.

Box 36.7 Confirmatory tests for prelabor rupture of membranes

- Nitrazine test
 - pH of amniotic fluid >6–6.5 (nitrazine paper turns blue)
- Fern test
 - Arborization on glass slide
 - Interaction between proteins and salts
- Ultrasonography
 - Oligohydramnios
- Indigo carmine test
 - Injection of dye into amniotic fluid
 - Obsolete
- Other tests
 - Examination of cervicovaginal secretions
 - Increase in fFN
 - Increase in IGF BP1
 - Placental alpha-I microglobulin
 - Sensitivity and specificity 99%–100%

f , fetal fibronectin; *BP* insulin-like growth factor binding protein 1.

Management

Management consists of initial evaluation, confirmation of diagnosis, and decision regarding delivery.

Initial evaluation

When the woman is admitted with a history suggestive of PROM, history and physical examination should proceed as given in Box 36.6. If obvious discharge of fluid is not seen, a speculum examination should be performed.

The crucial decision to be made is whether to deliver immediately or opt for expectant management. This decision is based on potential risks and benefits of waiting as opposed to immediate delivery. Management depends on gestational age, duration of rupture of membranes, fetal well-being, and presence of infection.

- Establish gestational age using last menstrual period and early ultrasonography.
- Ascertain duration of rupture of membranes by history.
- Avoid digital vaginal examination.
- Perform a speculum examination if needed to confirm PROM.
- Document history of digital vaginal examination, if performed elsewhere before admission to hospital.
- Look for presence of chorioamnionitis.
 - Clinical evaluation should be performed daily.
 - Signs of infection (fever, uterine tenderness) should be looked for.
 - Leukocytosis and elevated C-reactive protein levels have low sensitivity and therefore are not of much use.
 - Routine vaginal swab cultures are not recommended as they have not been proved to be useful.
 - Amniocentesis and culture of amniotic fluid has been used for diagnosis of infection but there is insufficient evidence of benefit to recommend its routine use.
- Perform ultrasonography to
 - confirm gestational age
 - evaluate fetal well-being

- estimate fetal weight
- exclude
 - multiple pregnancy
 - polyhydramnios
 - fetal anomalies.
- Perform nonstress test to assess fetal well-being.
- Ascertain carrier status for group B streptococcus (GBS) by prior vaginal swab/urine culture.
- Ascertain fetal presentation and position.
- Ascertain if woman is in labor.

Box 36.8 Indications for immediate delivery

- Woman in active labor
- Nonreassuring fetal status
- Chorioamnionitis
- Fetal death
- Significant vaginal bleeding

Subsequent management

Subsequent management may be immediate delivery based on obstetric indications or based on gestational age.

Immediate delivery

Indications for immediate delivery irrespective of gestational age are listed in Box 36.8.

Gestational age-based management

If there is no indication for immediate delivery, management depends on gestational age.

Initial evaluation is outlined in Figure 36.1.

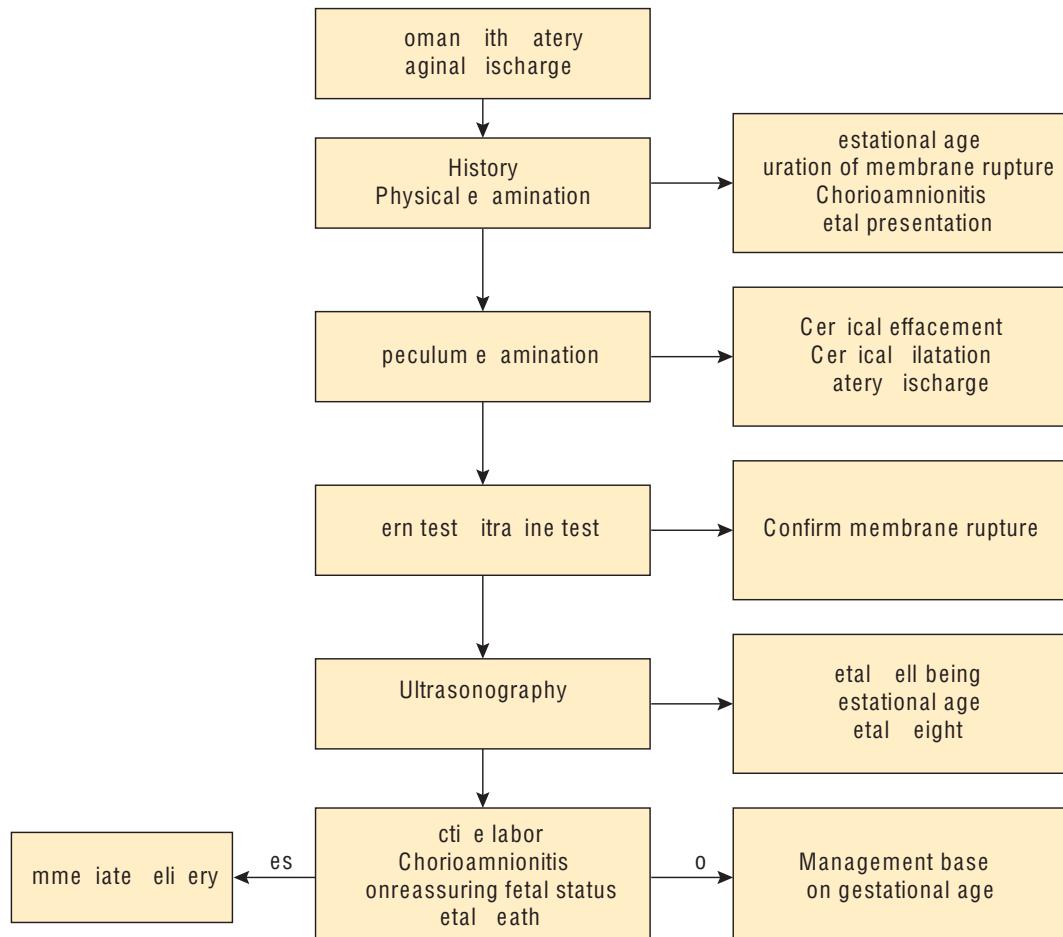


Figure 36.1 Initial evaluation of prelabor rupture of membranes. *N*, nonstress test.

Management of Oxytocin at or near term

Two options are available for women who present with PROM after 36 weeks' gestation:

1. Immediate induction of labor
2. Expectant management

Immediate induction of labor

Current recommendation for management of women in this group is immediate induction of labor with oxytocin.

- Earlier observational studies had shown an increase in cesarean section rates with induction, especially in women with an unfavorable cervix. However, subsequent studies and meta-analysis have shown that immediate delivery, compared to expectant management, has the following advantages:
 - Reduced incidence of chorioamnionitis and endometritis
 - Reduced rates of neonatal ICU admissions
 - Reduced cost of treatment
 - No increase in cesarean section rates
- In randomized controlled trials, preinduction cervical ripening with prostaglandins has no advantage over oxytocin induction alone. However, if vaginal misoprostol 25/50 µg 6 hourly or prostaglandin E₂ is used in women with an unfavorable cervix, a significant proportion of women in this category deliver within 24 hours, without additional oxytocin
- Women who deliver within 12 hours of rupture of membranes do not develop maternal or neonatal sepsis and therefore do not need prophylactic antibiotics as a routine.
- Prophylactic antibiotics (Inj. ampicillin 1 g and Inj. gentamicin 140 mg IV) are used only if duration of rupture of membranes is ≥18 hours.

Expectant management

Expectant management may be acceptable in women who refuse induction because 75%–80% will deliver within 24 hours and the incidence of cesarean section, operative vaginal delivery, and neonatal infection is not significantly increased.

Criteria to be satisfied before deciding on expectant management are as follows:

- There should be no fetal distress.
- The liquor should not be meconium stained.

- There should be no clinical evidence of chorioamnionitis.
- There should be no colonization by GBS.

Management guidelines

- The woman should be hospitalized.
- Prophylactic broad-spectrum antibiotics should be administered if duration of membrane rupture exceeds 18 hours.
- Fetal surveillance is mandatory. Daily fetal movement count, nonstress test, and biophysical profile are recommended.
- Amniotic fluid volume should be assessed by ultrasonography every 24 hours.
- Clinical signs of chorioamnionitis should be watched for.
- Duration of expectant management varies with the center but the risk of chorioamnionitis increases after 24 hours. Hence, most centers induce labor after 24 hours.

Management of PROM at/or after 36 weeks is summarized in Figure 36.2.

relabor rupture of membranes at 36 weeks

The management of PROM at this gestational age is based on the following observations:

- Acute and severe neonatal complications are uncommon after 34 weeks' gestation.
- The specific gestational age beyond which neonatal morbidity is definitely reduced is 34 weeks.
- The risk of chorioamnionitis increases by waiting.
- Expectant management prolongs pregnancy by only a few days.

Management

- Immediate delivery is recommended at this gestational age.
- Preinduction cervical ripening by prostaglandins followed by induction with oxytocin is the recommended management.
- Cesarean section is performed only if there are specific indications.
- Corticosteroids are not recommended after 34 weeks.
- Broad-spectrum antibiotics are administered if the duration of rupture exceeds 18 hours.

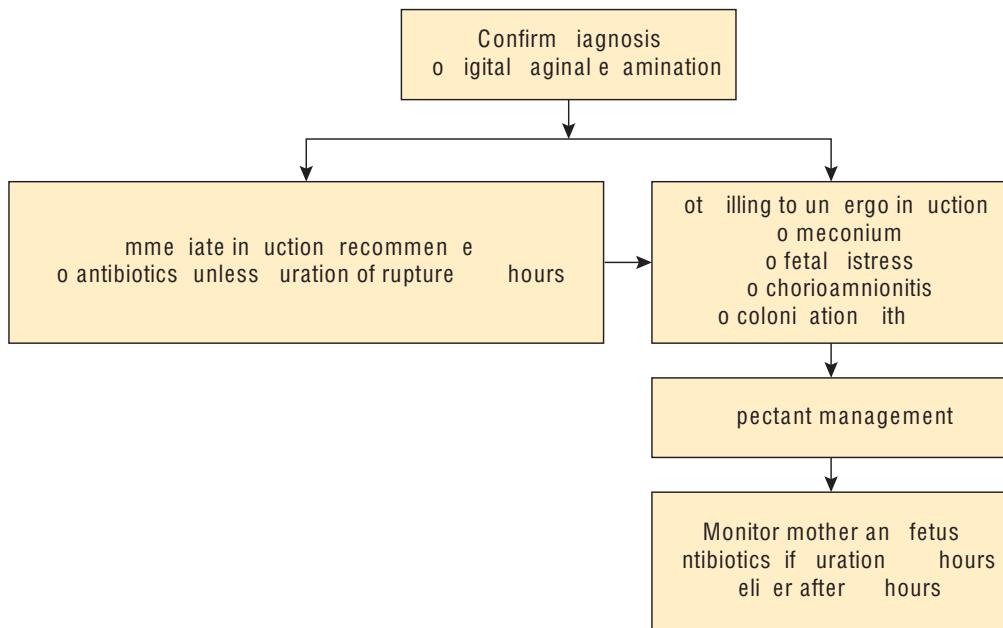


Figure 36.2 Management of prelabor rupture of membranes at/or after 36 weeks. BS, Group B streptococcus.

relabor rupture o membranes at ee s

Management at this gestational age is based on the following facts:

- Delivery before 32 weeks is associated with high risk of perinatal mortality and long-term sequelae due to prematurity.
- Prolongation of pregnancy can reduce these risks.
- Latency period is shorter in women with
 - low amniotic fluid index (<5 cm)
 - shorter cervix (length <3 cm)
- Pregnancy has been prolonged for a mean duration of 7 days by expectant management in different clinical trials.
- The woman should be transferred to a center with facility for management of preterm babies.

Management

- *Expectant management is recommended for women without maternal or fetal complications.*
- Immediate induction is undertaken if there are signs of fetal compromise, chorioamnionitis, placental abruption, or established labor.
- The woman should be hospitalized and advised bed rest with minimal activity. Broad-spectrum antibiotics for chorioamnionitis and

betamethasone for enhancing fetal lung maturity are administered.

- If facilities for the care of preterm neonates are inadequate, the woman should be transferred to a higher center.
- On admission,
 - cord compression should be excluded and fetal well-being evaluated by continuous fetal heart rate monitoring and biophysical profile.
 - occult uterine contractions should be excluded by external tocography.
- Subsequent monitoring:
 - Clinical signs of sepsis: Fever, uterine tenderness, foul smelling discharge.
 - Fetal well-being: Ultrasonography and biophysical profile on alternate days.

Corticosteroids

Two doses of betamethasone (12 mg IM at 24 hour interval) should be administered. This does not increase the risk of maternal or neonatal infection. Use of corticosteroids is discussed in detail in Chapter 35, *Preterm labor*.

Corticosteroids reduce the neonatal risk of the following:

- Respiratory distress syndrome
- Intraventricular hemorrhage
- Necrotizing enterocolitis

Antibiotics

Prophylactic antibiotics are recommended in PROM before 34 weeks and should be administered as soon as rupture of membranes is confirmed. Antibiotics have the following beneficial effects:

- Increase the latency period
- Reduce the incidence of maternal and neonatal sepsis and intraventricular hemorrhage

According to a review of randomized trials, the use of antibiotics has the following benefits:

- Reduction in chorioamnionitis
- Reduction in neonatal infection
- Reduced need for oxygen therapy to the newborn
- Reduced need to use surfactant for improving fetal pulmonary maturity
- Delivery between 3 and 7 days of the intervention

Recommended drugs and dosage

Recommendations of the National Institute of Child Health and Human Development-Maternal and Fetal Medicine Units (NICHD-MFMU) are given in Box 36.9. Ampicillin is effective against group B streptococcus and aerobic gram-negative bacilli, and erythromycin targets *Mycoplasma*. **Amoxicillin with clavulanic acid should not be used since it increases the risk of necrotizing enterocolitis.** A single dose of azithromycin (1 g oral at admission or 250 mg oral once daily for 5 days) may be used instead of erythromycin.

Magnesium sulfate for neuroprotection

According to randomised trials, administration of magnesium sulfate to mothers at risk for preterm delivery at <34 weeks, gestation reduces the risk of cerebral palsy and gross motor dysfunction. Magnesium sulfate is said to act through its vasodilator and anti-inflammatory

Box 36.9 IC D-MFM recommendation for antibiotics

- Inj. ampicillin 2 g IV 6 hourly and
- Inj. erythromycin 250 mg IV 6 hourly } for 48 hours

Followed by

- T. amoxicillin 250 mg oral 8 hourly and
- T. erythromycin 333 mg oral 8 hourly } for 5 days

C D- National Institute of Child Health and Human Development-Maternal and Fetal Medicine Units.

effects on the brain cells. It should be given when preterm delivery is anticipated in the next 12 hours and the fetus is viable. Benefit is seen even when administered for 2 hours prior to delivery. Magnesium sulfate is safe, inexpensive, and easily available. Dosage and administration are discussed in Chapter 35, *Preterm labor*.

Tocolysis

Tocolysis has not been found to be beneficial in PPROM. It can increase the risk of sepsis by delaying delivery in women with subclinical infection.

Timing and mode of delivery

- Labor should be induced at 34 weeks.
- Continuation of pregnancy beyond 34 weeks may be considered only if the drainage of amniotic fluid stops and amniotic fluid volume returns to normal.
- Cesarean section is performed only for obstetric indications.
- Cervical ripening with prostaglandins and labor induction with oxytocin is the recommended mode of delivery.

Management of PROM at 28–34 weeks is summarized in Figure 36.3.

O be ore ee s

Management at this gestational age is based on the following facts:

- Pregnancies before 24 weeks are considered previable even in developed countries. In India, pregnancies up to 28 weeks have a poor prognosis in most centers and may be considered previable.
- Associated abnormal placentation is found in many women and has a poor prognosis.
- Prolongation of pregnancy may range from 1 to 5 weeks with conservative management.
- Risk of intrauterine death, neonatal complications such as pulmonary hypoplasia, respiratory distress, sepsis, intraventricular hemorrhage, necrotizing enterocolitis, and long-term complications including bronchopulmonary dysplasia, limb deformities, and retinopathy are increased.
- Maternal and fetal complications correlate with oligohydramnios.
- Risks and benefits vary with gestational age and risks are higher before 24 weeks.

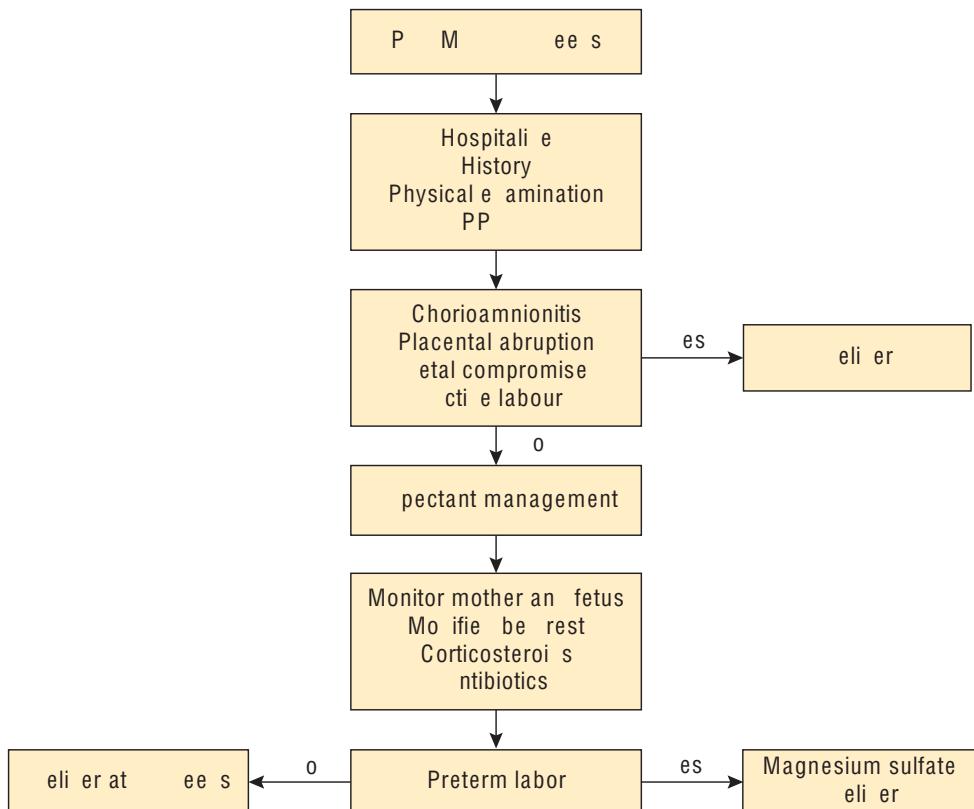


Figure 36.3 Prelabor rupture of membranes at 28–34 weeks. BPP, biophysical profile; NST, nonstress test.

- Midtrimester PROM can occur following invasive procedures such as amniocentesis, fetoscopy, and cordocentesis. The site of puncture is small and most often closes spontaneously.
- Risks and benefits should be discussed with the couple and management decided upon accordingly.
- Antibiotics
- Corticosteroids
- Deliver when labor sets in or if complications occur

Management

- Termination of pregnancy may be considered in women with preivable (<24–26 weeks) PROM. This option should be discussed with the couple
- In women who opt for continuation of pregnancy and those >26 weeks' gestation, expectant management is on the same lines as in 28–32 weeks. This includes the following:
 - Hospitalization and bed rest with toilet privileges
 - Initial assessment of fetal status and uterine contractions
 - Subsequent serial monitoring of mother and fetus

therapeutic modalities in P M

Other modalities of treatment have been tried in the management of PROM. These include the following:

- Amnioinfusion to increase the amniotic fluid volume
- Tissue sealants to close the defect in the membranes
 - Fibrin patch
 - Platelets
 - Cryoprecipitate
 - Gelfoam

These methods of management are considered experimental and need not always successful.

Key points

- Prelabor rupture of membranes (PROM) is defined as rupture of membranes before onset of regular uterine contractions.
- Physiological remodeling of collagen in the fetal membranes, alteration in cytokines, matrix metalloproteinases and collagenase, and increase in intrauterine pressure can lead to PROM.
- Risk factors for PROM are urogenital infections, uterine overdistension, connective tissue disorders, invasive procedures, and nutritional deficiencies.
- The most important maternal complication of PROM is chorioamnionitis. Placental abruption, retained placenta, puerperal endometritis, and maternal sepsis can also occur.
- Fetal/neonatal complications are fetal infection, cord prolapse, and prematurity and its complications. Second trimester PROM can lead to pulmonary hypoplasia and limb deformities and long-term sequelae.
- Women with PROM present with watery vaginal discharge. Uterine contractions may follow.
- Fluid can be seen discharging through the vulva, and through the cervix on speculum examination.
- Digital vaginal examination should be avoided in PROM since it increases the risk of infection.
- Several tests are used to confirm PROM. These are nitrazine test, fern test, ultrasonography, and indigo carmine test.
- Management consists of initial evaluation to establish gestational age and ascertain duration of membrane rupture and ultrasonography to evaluate fetal well-being, estimate fetal weight, exclude multiple pregnancy, and ascertain fetal presentation and position. Subsequent management depends on gestational age.
- Diagnosis of chorioamnionitis is usually clinical. The signs are uterine tenderness, malodorous discharge, fever, and tachycardia. Leukocyte count, C-reactive protein, amniotic fluid culture, and vaginal swab cultures are not sensitive and not used.
- The recommended management of PROM at or after 36 weeks is immediate induction of labor since this reduces the risk of chorioamnionitis, endometritis, and neonatal intensive care admissions. Expectant management is reserved for those who are not willing for labor induction.
- For women with PROM between 34 and 36 weeks, immediate delivery is recommended since acute and severe neonatal complications are rare after 34 weeks and waiting increases the risk of chorioamnionitis.
- Prelabor rupture of membranes at 28–34 weeks is managed expectantly since delivery before 32 weeks is associated with prematurity and its complications.
- Expectant management of PROM at 28–32 weeks consists of modified bed rest, close monitoring of mother and fetus, and administration of corticosteroids and antibiotics. Tocolytics are not recommended.
- Prelabor rupture of membranes before 28 weeks' gestation is associated with poor fetal survival. Fetal complications, long-term sequelae, and perinatal mortality are higher. Risks and benefits should be discussed with the couple before management decisions are made.

Self-Assessment

Case-based questions

Case 1

Mrs. HK, 30, primigravida at 30 weeks' pregnancy, was referred from a peripheral hospital with history of watery discharge for 12 hours. On arrival at the local hospital, she was told that the membranes had ruptured and, since she was preterm, she had to be in a tertiary center.

1. How will you confirm the diagnosis?
2. How will you evaluate the woman at admission?
3. Why should the woman be shifted to a tertiary level center?
4. What is the management and why?

Case 2

Mrs. AN, 28, third gravida, was admitted to the labor room at 39 weeks' gestation with history of watery discharge for 3 hours. There were no uterine contractions.

1. What would you like to know by history?
2. Describe the physical examination.
3. What is the management? Why?
4. Is there an alternative method of management?

Answers

Case 1

1. Diagnosis is by history of watery vaginal discharge. Visualization of discharge at the vulval outlet and through the cervical os on speculum examination will confirm the diagnosis. If in doubt, nitrazine test can be performed. A drop of discharge may be collected from the posterior fornix and smeared on a glass slide to look for ferning. Ultrasonography may reveal oligohydramnios.
2. Assess gestational age, fetal presentation and position. At admission, perform cardiotocography to exclude cord compression. Look for uterine contractions. Check maternal pulse and temperature and look for uterine tenderness and malodorous discharge to exclude chorioamnionitis.
3. Since the gestational age is 30 weeks, facilities for neonatal care of preterm should be available.
4. Expectant management is the treatment of choice since delivery at 30 weeks has high perinatal mortality due to prematurity.

Expectant management is by modified bed rest, maternal and fetal monitoring, corticosteroids for accelerating fetal pulmonary maturity, and prophylactic antibiotics. Administer of magnesium sulfate for fetal neuroprotection if labor begins before 34 weeks.

Case 2

1. Duration of watery discharge, any digital vaginal examination performed elsewhere, fever, malodorous discharge, fetal movements.

2. a. Maternal temperature, pulse, uterine tenderness, contractions, and fetal presentation and position.
- b. Speculum examination—cervical effacement, dilatation, color of amniotic fluid, presence of foul-smelling discharge, and cord prolapse. AVOID digital vaginal examination.
- c. Nonstress test for fetal heart pattern.
3. Immediate delivery is the recommended management. This reduces the risk of chorioamnionitis, endometritis, and neonatal intensive care admission. Labor should be induced with oxytocin. Antibiotics should be given if duration exceeds 18 hours.
4. Expectant management is an alternative if the woman is not willing for labor induction.

Sample questions

Long-answer questions

1. Define prelabor rupture of membranes (PROM). Discuss the etiology and management of PPROM at 29 weeks, gestation.
2. How will you evaluate and manage PROM at term?

Short-answer questions

1. Risk factors for PROM
2. Complications of PROM
3. Tests for diagnosis of rupture of membranes

37

Postterm Pregnancy

Case scenario

Mrs. DS, 26, a primigravida, had regular menstrual cycles. According to her LMP, she was 41 weeks. She and her husband were anxious that she had not delivered even a week after the expected date of confinement.

Introduction

A pregnancy that is prolonged beyond the expected date of delivery causes great anxiety for the pregnant couple. Although the gestation at which the mother should be delivered after the due date varies in different guidelines, it is accepted that postterm pregnancies should be closely monitored and delivered before complications arise.

Definition

The term **late-term** pregnancy is used to define a pregnancy between 41 weeks and 41^{+6} weeks, while pregnancies at 42 weeks (294 days) and beyond are defined as **postterm**, **postdated**, or **prolonged**.

- *Late term: 41 weeks to 41^{+6} weeks*
- *Postterm: 42 weeks and beyond*

The concern with late-term and postterm pregnancies is the association with perinatal morbidity and mortality. It is essential that the gestational age be accurately confirmed in early pregnancy to help in the correct diagnosis and appropriate management of late-term and postterm pregnancies.

Although 42 weeks is used as a cutoff for the definition of postterm pregnancy, it does not represent an absolute threshold. The risk of meconium and perinatal complications increases beyond 41 weeks' gestation in all countries. The South Asian fetus (including Indian) is known to mature 1 week earlier, and the rates of antepartum stillbirth begin to rise 1 week earlier than in the Western population. Therefore, management of postterm pregnancies must be tailored to suit the population.

Based on this evidence, it is prudent, in the Indian context, to apply the term postterm or postdated to pregnancies at 41 weeks or beyond.

Incidence

The incidence of postterm pregnancy varies with the approach to management, criteria for dating of pregnancy, and the population. Approximately 2% of pregnancies go beyond 42 weeks in India and 10% beyond 41 weeks. The incidence of postterm pregnancy (>42 weeks) is approximately 6%–7% in Western countries.

Risk factors for postterm pregnancy

There is no identifiable etiological cause for the majority of postterm pregnancies. The most consistent risk factor for postterm pregnancy is a previous postterm pregnancy. There is a two to threefold increase in the risk of another postterm pregnancy following a previous postterm pregnancy. This risk of recurrence becomes fourfold after two postterm pregnancies. The risk factors for postterm pregnancy are listed in Box 37.1.

Other risk factors for postterm pregnancy are **obesity**, **nulliparity**, and **male fetus**. **Genetic predisposition** has been found in some ethnic groups, and the risk is higher if the mothers of women have had postterm pregnancies.

The fetal hypothalamic–pituitary–adrenal (HPA) axis plays a major role in the initiation of

Box 37.1 Risk factors for postterm pregnancy

- History of postterm birth
 - 1 previous postterm birth
 - Twofold to threefold increase in risk
 - 2 previous postterm births
 - Fourfold increase in risk
- Nulliparity
- Male fetus
- $BMI \geq 30 \text{ kg/m}^2$
- Older maternal age
- Fetal disorders
 - Anencephaly
 - Placental sulfatase deficiency
- Genetic predisposition

B body mass index.

parturition (see Chapter 6, *Physiology of labor*). The absence of the fetal brain causing dysfunction of the HPA axis is considered responsible for prolonged pregnancy in anencephalic pregnancies. Placental sulfatase converts dehydroepiandrosterone sulfate (DHEAS) to estrogen, which is involved in triggering parturition. Deficiency of placental sulfatase has also been implicated in prolonged pregnancy.

Consequences of postterm pregnancy

Late-term and postterm pregnancies are associated with fetal, neonatal, and maternal risks. Placental dysfunction and insufficiency occurs with placental aging and is the cause of perinatal mortality and morbidity. Placental infarcts, calcification, fibrin deposits around the villi, and intervillous and arterial thrombosis are seen in the placentae of postterm pregnancies. Placental apoptosis or programmed cell death increases significantly. These changes lead to placental insufficiency, which in turn results in oligohydramnios and cord compression.

Meconium passage may be a function of fetal maturity but also occurs due to cord compression and hypoxia. The changes of postmaturity syndrome (described later) are also attributed to placental senescence.

On the other hand, the placenta may continue to function and the fetus continues to grow, though at a lower rate. Postterm pregnancy is associated with a twofold increased risk of macrosomia.

Postterm pregnancies are also known to be associated with an increased risk of neonatal convulsions, meconium aspiration syndrome, and low Apgar scores.

The pathophysiology of fetal complications in postterm pregnancies is summarized in Figure 37.1.

Perinatal mortality

Birth at ≥ 41 weeks' gestation is associated with 30% greater neonatal mortality than at 38–40 weeks' gestation.

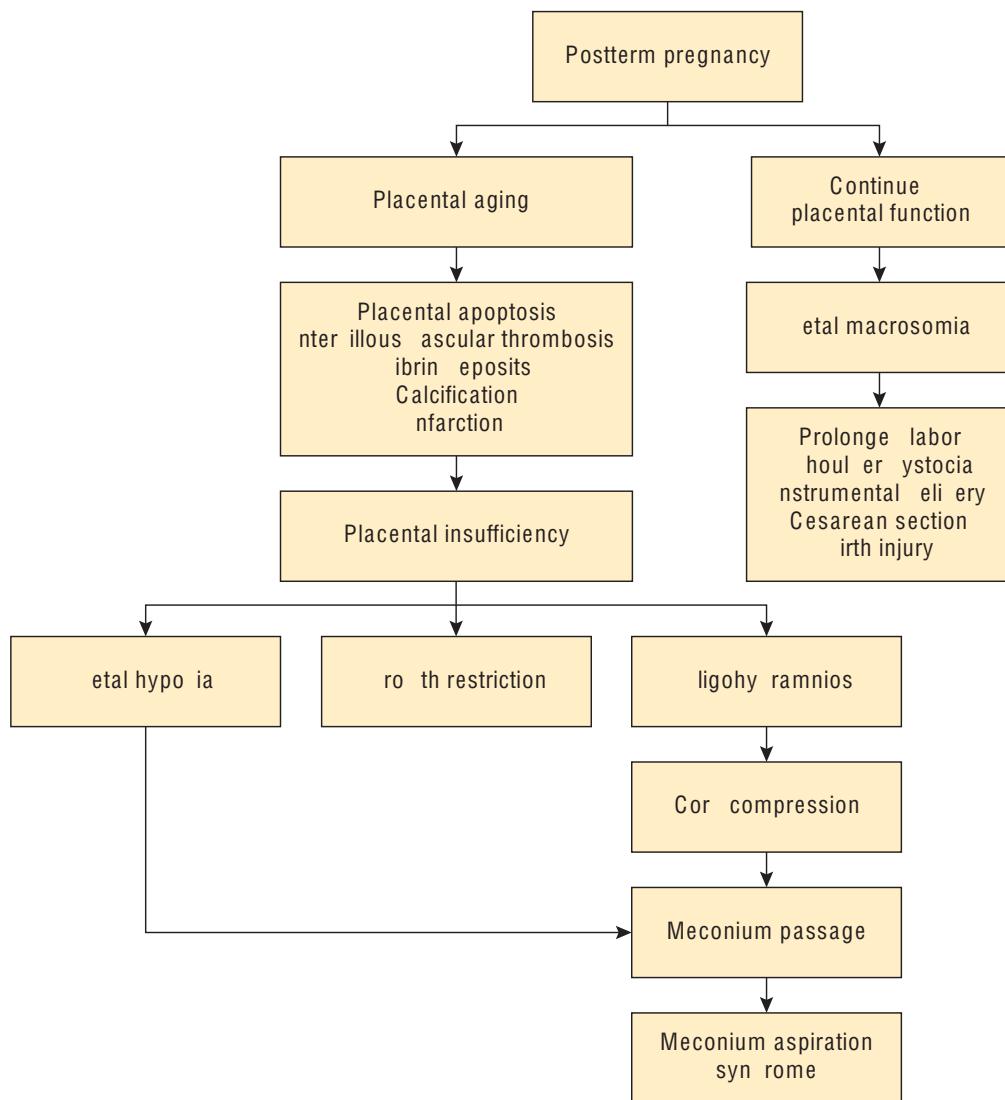


Figure 37.1 Pathophysiology of fetal complications in postterm pregnancy.

Fetal risks due to placental aging

As the placenta ages, its function decreases, resulting in several risks to the fetus (Box 37.2).

Placental insufficiency

The placental changes described earlier give rise to placental insufficiency and fetal hypoxia. Placental dysfunction leads to decreased fetal renal blood flow and reduced urine production. This results in oligohydramnios.

Oligohydramnios

Decreased amniotic fluid or oligohydramnios is a sign of placental insufficiency and

is often associated with postterm pregnancy. Oligohydramnios is associated with an increased risk of the following:

- Umbilical cord compression
- Fetal heart rate abnormalities
- Lower Apgar scores

Meconium passage

Meconium staining of the amniotic fluid, skin, membranes, and umbilical cord is commonly seen with the postmature newborn. Meconium passage may be a sign of the following:

- Physiological maturation of the gut
- Fetal hypoxia which may result from

Box 37.2 Fetal risks due to placental aging

- Placental insufficiency
 - Oligohydramnios
- Oligohydramnios
 - Umbilical cord compression
 - Fetal heart rate abnormalities
 - Lower Apgar scores
- Meconium passage
 - Maturation of gut
 - Fetal hypoxia
 - Cord compression
 - Placental insufficiency
- Meconium aspiration syndrome
 - Chemical pneumonitis
- Fetal distress
 - Nonreassuring fetal heart tracings
- Increased risk of cesarean section
- Postmaturity syndrome

- cord compression
- placental insufficiency

In the presence of oligohydramnios, the meconium is thick since it is not diluted by the amniotic fluid.

Meconium aspiration syndrome

The fetus may aspirate meconium before, during, or after birth. In some newborns, the aspirated meconium causes chemical pneumonitis, airway obstruction, and pulmonary hypertension, a syndrome known as meconium aspiration syndrome. This is associated with a high risk of perinatal death.

Fetal distress

Intrapartum fetal distress is common in post-term fetuses. Variable decelerations and prolonged decelerations occur in labor due to cord compression. This increases the risk of a cesarean section.

Postmaturity syndrome

Placental insufficiency can lead to the postmaturity (or dysmaturity) syndrome. This occurs in 10%–20% of postterm pregnancies. These infants exhibit characteristics of chronic intrauterine malnutrition (Fig. 37.2). The distinctive appearance of the postmature fetus is summarized in Box 37.3.



Figure 37.2 The postterm infant. There is very little subcutaneous tissue. The skin is dry and peeling and has prominent creases.

Box 37.3 Appearance of the postterm infant

- Small for gestational age
- Long, thin body with long nails
 - Minimal subcutaneous tissue
- Skin
 - Dry
 - Meconium stained
 - Parchment-like and peeling
 - Loose over the thighs and buttocks
 - Prominent creases
- Sparse or absent lanugo
- Increased scalp hair

Fetal risks due to continued placental function

As described earlier, some fetuses continue to grow postterm due to continued placental function. This can result in macrosomia (see Chapter 33, *Fetal growth disorders: Growth restriction and macrosomia*).

Macrosomia

Macrosomia is associated with an increased incidence of the following:

- Prolonged labor
- Operative vaginal delivery
- Cesarean section
- Shoulder dystocia
- Birth injury

Maternal risks

Maternal risks are a consequence of macrosomia and other fetal complications. Late-term and postterm pregnancies are associated with several maternal risks (Box 37.4).

Box 37.4 Maternal risks in the postterm pregnancy

- Severe perineal lacerations
- Infection
- Postpartum hemorrhage
- Instrumental delivery
- Cesarean section
- Parental anxiety

Management of the late-term and postterm pregnancy

As gestational age advances, the perinatal mortality increases. As discussed earlier, the gestational age at which the increase in mortality occurs varies with ethnicity. The mortality is lowest at 40 weeks in Caucasian populations and at 39 weeks in South Asian countries (including India). The rate of antepartum stillbirths increases significantly after 41 weeks. **Hence, it is recommended that women should be induced by 41 completed weeks of gestation and be delivered not later than 41⁺³ weeks.**

The management of the late-term and postterm pregnancies involves a three-pronged approach:

- Prevention of postterm pregnancy
- Antenatal surveillance for fetal well-being
- Cervical ripening and induction of labor

Prevention of postterm pregnancy

Accurate determination of gestational age

Using the woman's recall of the last menstrual period (LMP) alone to assign gestational age and the estimated date of delivery has been proved to be unreliable. Often a pregnancy is incorrectly classified as late term or postterm because of wrong dates. Some women may conceive later in the cycle because of delayed ovulation, and this may also alter the due date calculated by LMP

alone. When ultrasonography is used to confirm LMP dating, the rate of postterm pregnancies drops (see Chapter 10, *Obstetric ultrasound and other imaging*).

- Accuracy of estimation of gestational age by ultrasonography in the first trimester is ±5–7 days.
- The first trimester gestational age assignment significantly reduces the incidence of induction for pregnancy of >41 weeks.

Membrane sweeping

Membrane sweeping (or stripping) is associated with a significant reduction in the number of pregnancies that go beyond 41 weeks' gestation (see Chapter 16, *Induction of labor*). Sweeping the membrane from the uterine wall causes increased local production and release of prostaglandin F_{2α} from the decidua and adjacent membrane, thereby leading to onset of labor. It should be offered to women commencing at 40 weeks.

The steps taken to prevent postterm pregnancy are listed in Box 37.5.

Antenatal surveillance for fetal well-being

Since there is an increased risk of oligohydramnios and fetal hypoxia/asphyxia in the late-term and postterm pregnancy, it is advisable to start the fetal surveillance (see Chapter 11, *Antepartum fetal surveillance*) from 40 weeks, although Western guidelines recommend starting from 41 weeks. The recommended tests are listed in Box 37.6.

Box 37.5 Prevention of postterm pregnancy

- Accurate determination of gestational age
 - Best done in the first trimester
 - Accuracy ±5–7 days.
 - Reduces incidence of induction for postterm
- Membrane sweeping or stripping
 - Should be offered to women from 40 weeks
 - Increases local production and release of prostaglandin F_{2α}
 - Leads to onset of labor

Box 37.6 Fetal surveillance in the late-term and postterm pregnancy

- Daily fetal movement count
- Assessment of amniotic fluid volume
- NST
- Frequency of NST and AFI
 - Twice weekly till delivery

A = amniotic fluid index; NST, nonstress test.

Cervical ripening and induction of labor

Induction of labor at 41 completed weeks is recommended over expectant management. Women in this situation also prefer induction over waiting for spontaneous labor. It has been shown that induction of labor

- does not increase cesarean section rate and
- lowers perinatal mortality.

If the cervix is not ripe, cervical ripening is indicated prior to induction (see Chapter 16, *Induction of labor*). Induction has not been shown to increase the cesarean section rate and

may actually decrease the risk of a cesarean section with postterm pregnancy.

Intrapartum management

Due to the increased risk of perinatal morbidity and mortality, the fetus must be monitored carefully during labor.

- In labor, early artificial rupture of membranes is suggested to check for meconium.
- Early amniotomy helps in identifying thick meconium. If meconium is present in very early labor in a nullipara, a cesarean section is recommended. In multiparas and those in active labor, the treatment must be individualized.
- Electronic fetal monitoring is recommended for all postterm pregnancies in labor.
- In case of nonreassuring fetal heart patterns (prolonged or variable decelerations), delivery should be expedited depending on the stage of labor.
- If the fetus is macrosomic, prolonged labor and shoulder dystocia should be anticipated.

Management of late-term and postterm pregnancies is summarized in Figure 37.3.

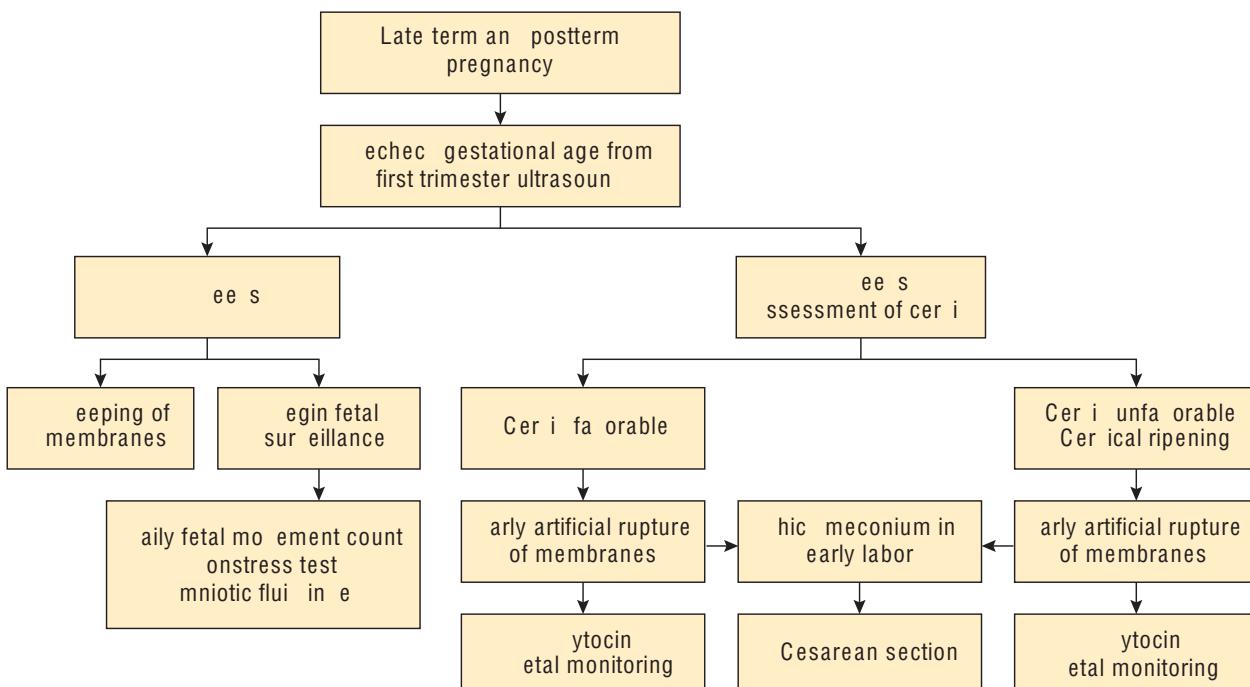


Figure 37.3 Management of late-term and postterm pregnancies.

Key points

- The term ***late term*** pregnancy is used to define a pregnancy between 41 weeks and 41^{+6} weeks.
- Pregnancies at 42 weeks (294 days) and beyond are defined as ***postterm, post ate***, or ***prolonge***.
- Late-term and postterm pregnancies are associated with perinatal morbidity and mortality.
- The risk of meconium and perinatal complications increases beyond 41 weeks' gestation in all countries. Based on evidence, it is prudent, in the Indian context, to apply the term postterm or postdated to pregnancies at 41 weeks or beyond.
- The most consistent risk factor for postterm pregnancy is a previous postterm pregnancy.
- Postterm pregnancy is associated with a twofold increased risk of macrosomia.
- Placental insufficiency leads to the postmaturity (or dysmaturity) syndrome, which occurs in 10%–20% of postterm pregnancies.
- Meconium staining of the amniotic fluid, skin, membranes, and umbilical cord is commonly seen with a postmature newborn.
- Decreased amniotic fluid or oligohydramnios is a sign of placental insufficiency and is often associated with postterm pregnancy.
- Oligohydramnios leads to cord compression and meconium passage.
- Birth at ≥ 41 weeks' gestation is associated with 30% greater neonatal mortality than at 38–40 weeks' gestation.
- Postterm pregnancy can be prevented by accurate determination of gestational age and by sweeping of membranes.
- Antenatal surveillance including antenatal fluid index and nonstress test is recommended after 40 weeks.
- It is recommended that women should be induced by 41 completed weeks of gestation and be delivered not later than 41^{+3} weeks.
- In labor, early artificial rupture of membranes is suggested to check for meconium.
- Electronic fetal monitoring is recommended for all postterm pregnancies in labor.

Self-Assessment

Case-based questions

Case 1

Mrs. DS, 26, is a primigravida. Her menstrual cycles were regular and according to her LMP, she is now 41 weeks.

1. How will you confirm her gestational age?
2. When will you deliver her?
3. How will you deliver her?
4. How will you manage her intrapartum?

Case 2

Mrs. GH, 31, is a gravida 2, para 1, live 1. Labor was induced at 41 weeks in her last pregnancy. She is now 41^{+3} weeks and has been referred from a primary center.

1. What are the risks to the fetus?
2. What are the features of postmaturity syndrome?
3. Does postterm pregnancy pose any increased risk to the mother?
4. What would be the appropriate management plan for her?

Answers

Case 1

1. The gestational age of 41 weeks is confirmed by rechecking the LMP and the gestational age assigned by the first trimester ultrasound scan, if available. If not, gestational age assigned by the second trimester scan is used.
2. Since she is 41 weeks, she can be induced immediately and delivered.
3. Pelvic examination should be performed to assess Bishop score. If unfavorable, preinduction ripening should be followed by rupture of membranes and oxytocin infusion.
4. Intrapartum electronic fetal monitoring is essential. If there is thick meconium in early labor with an unfavorable cervix, a cesarean section should be done. Watch for prolonged labor and fetal heart decelerations. If the fetus is macrosomic, watch for shoulder dystocia.

Case 2

1. Postterm pregnancies are known to be associated with an increased risk of perinatal morbidity and mortality. The common risks are macrosomia, postmaturity syndrome, oligohydramnios, and fetal hypoxia/asphyxia.
2. The postmaturity syndrome results in loss of subcutaneous fat resulting in a long, thin body; long fingernails; dry, peeling, and wrinkled skin; and increased scalp hair.
3. Maternal risks are severe perineal laceration, infection, postpartum hemorrhage, cesarean section, and parental anxiety.
4. Immediate induction of labor with cervical ripening, rupture of membranes, and oxytocin. A cesarean section is recommended if the liquor is meconium stained and cervix is unfavorable.

Sample questions

Long-answer question

1. What is postterm (postdated) pregnancy? How is it managed?

Short-answer questions

1. Postmaturity syndrome
2. Antenatal surveillance in postterm pregnancy

38

Red Cell Alloimmunization

Case scenario

Mrs. MN, 26, gravida 2, para 0, had a miscarriage a year ago. Her blood group and Rh typing were not done. She did not receive anti-D after the miscarriage. In the current pregnancy, she was found to be Rh negative and her husband was Rh positive. An indirect Coombs test showed a titer of 1: 32. The couple did not know the implications of the test and were worried about its effect on the current pregnancy. They came to the clinic for counseling and antenatal care.

Introduction

Hemolytic disease of the newborn (HDN) or erythroblastosis fetalis used to be a major cause of fetal loss and infant mortality. A major cause of HDN is an incompatibility of the rhesus (Rh) blood group factor between the mother and the fetus, also known as red cell alloimmunization. Most commonly, hemolytic disease is triggered by the D antigen. The discovery of anti-D immunoglobulin to prevent alloimmunization, along with early and accurate diagnosis of fetal red cell hemolysis using amniocentesis and ultrasonography has reduced mortality remarkably.

Definition

A mother mounts an immune response when exposed to a blood group factor (red cell antigen) that is not present in her blood. The immune response results in the production of immunoglobulin G (IgG) antibodies. This is called red cell alloimmunization.

The transplacental passage of these antibodies attacks the fetal red blood cells (RBCs) that are positive for these surface antigens, resulting in hemolytic disease of the fetus and newborn (HDFN).

Red cell alloimmunization may occur as a consequence of either of the following:

- Fetomaternal hemorrhage (FMH) in a pregnancy where the fetus has inherited a blood group factor from the father that the mother does not have
- Maternal transfusion with blood or blood products containing blood group factors that the mother does not have

The h blood group system

There are 50 different red cell surface antigens capable of causing maternal alloimmunization and fetal hemolytic disease. Of these, the Rh blood group system is the most common. The Rh system was named after rhesus monkeys whose blood was used in making the discovery.

The Rh system was discovered in 1940 when Landsteiner and Weiner injected rhesus monkey erythrocytes into rabbits and guinea pigs. The antisera that resulted from this caused agglutination in 85% of blood samples of white individuals. Agglutination denotes the presence of Rh antigens, and the individual is Rh positive (Fig. 38.1). Absence of agglutination denotes that the individual is Rh negative. Subsequently, a causal relationship was found between the presence of these antibodies in Rh-negative women and the development of hemolytic disease in the neonate.

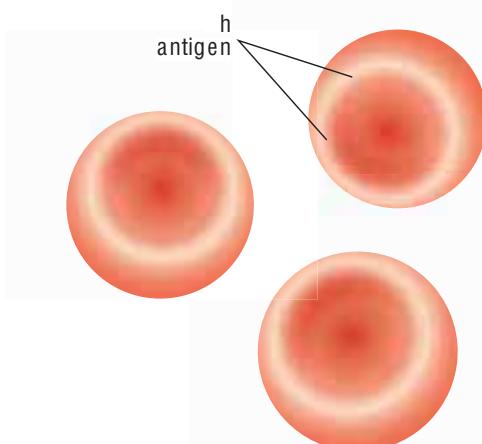


Figure 38.1 Diagrammatic representation of Rh surface antigens. Individuals with the surface antigens are Rh positive and those without the antigens are Rh negative.

Incidence of h-negative individuals

The incidence of Rh-negative individuals varies by race. It is the lowest in Asians, with an incidence of 0.3% in the Chinese and Japanese. It is the highest in the Basques of Spain with an incidence of 30%–35%. In Caucasians, the incidence of Rh-negative genotype is 15%. In India, the incidence is approximately 8%–10% of the population.

h factor

The Rh blood system is collectively called the Rh factor and includes the D, c, C, e, and E antigens. It should be remembered that no d (little d) antigen exists and therefore d denotes the absence of the D antigen. The D (big D) antigen of the Rh blood group system (Rh D) causes most cases of severe hemolytic disease.

The chronology of discovery of the Rh factor and HDN is summarized in Box 38.1.

Inheritance of the h factor

The Rh antigens are encoded by three sets of allelomorphic genes—D(d), Cc, and Ee—in all humans. Every individual inherits one of each set (three each) from each parent. However, Rh positivity is determined only by the presence of the D antigen. If D is inherited from only one parent, the individual is Rh-positive heterozygous (e.g., Cde/cDe). On the other hand, if D is

Box 38.1 Timeline of discovery of h factor and D

1939: HDN (erythroblastosis fetalis) described by Levine and Stetson; cause not known
1940: Rh factor discovered by Landsteiner and Weiner
1941: HDN linked to Rh factor by Levine, Ketrin, and Burnham
1953: Verification by Chown that transplacental passage of Rh D-positive erythrocytes into the maternal circulation caused Rh immunization
1960: The administration of Rh D IgG (anti-D immunoglobulin) demonstrated to prevent Rh D alloimmunization

inherited from both parents, the individual is Rh-positive homozygous (e.g., cDe/CDe). Those who are homozygous recessive (dd) are Rh negative (lacking Rh antigens).

Despite the genetic complexity, a simple model using the two alleles *D* and *d* usually can predict the inheritance of this trait (Box 38.2).

Chance of having h-positive fetus for h-positive father and h-negative mother

If the father is Rh positive and the mother is Rh negative, the fetus will be affected by Rh allo-immunization only if it is Rh positive. The risk of the fetus being Rh positive depends on whether the father is homozygous (DD) or heterozygous (Dd). The homozygous father will have 100% chance of having an Rh-positive baby with an Rh-negative mother (Fig. 38.2a), whereas a heterozygous father has a 50% chance of having an Rh-positive baby (Fig. 38.2b).

Regardless of the father's genotype, if he is Rh positive and the mother is Rh negative, it is assumed that there will be an incompatibility issue, and the pregnancy is managed accordingly. After birth, the Rh factor of the infant is checked.

	ather	h positi	e homo	ygous
Mother				
h negati				
e homo				
ygous				

	ather	h positi	e hetero	ygous
Mother				
h negati				
e homo				
ygous				

Figure 38.2 Inheritance of Rh factor. **a.** A homozygous Rh-positive father will have 100% Rh-positive babies with an Rh-negative mother. **b.** A heterozygous Rh-positive father will have 50% Rh-positive babies with an Rh-negative mother. The other 50% will be Rh negative.

caused by prior transfusion if Kell compatibility was not checked for when the blood was cross-matched. Anti-c and anti-E antibodies can also cause hemolytic disease. Women with sensitization to antigens other than D that are known to cause hemolytic disease are uncommon and are managed in the same way as women with D alloimmunization.

ther minor antibodies

Other than D, the most frequently encountered antibodies are Lewis antibodies (Le^a and Le^b) and I antibodies, but they are not implicated in HDN. Kell antibodies (anti-K) can produce HDN. Kell alloimmunization is frequently

Box 38.2 Inheritance of the h factor

- Three sets of allelomorphic genes
 - *D d*, *Cc*, and *e*
- One of each set inherited
 - Three each (e.g., *cDe/CDe*)
- If *D* present
 - Rh positive
 - *DD* present
 - Homozygous Rh positive (35% of individuals)
 - *D(d)* present
 - Heterozygous Rh positive (65% of individuals)

h alloimmunization in pregnancy

Rh alloimmunization in pregnancy is a consequence of Rh-positive fetal blood leaking into the circulation of an Rh-negative mother.

Pathophysiology

If an Rh-positive mother is pregnant with an Rh-negative fetus, then there is opportunity for the Rh-positive fetal blood to mix with the maternal blood (Fig. 38.3).

The conditions in which transplacental leakage of fetal blood can occur are listed in Box 38.3.

When the maternal immune system is presented with a foreign protein (Rh antigen), it mounts a response by producing immunoglobulin M (IgM) and later IgG antibodies (Fig. 38.4). IgG antibodies cross the placenta. The

Box 38.3 Conditions in which transplacental leakage of fetal blood can occur

- FMH
 - Antepartum
 - Intrapartum
- Abortion
 - Therapeutic
 - Spontaneous
 - Molar pregnancy
- Ectopic pregnancy
- Placental abruption
- Abdominal trauma
- Obstetric procedures
 - Amniocentesis
 - Chorionic villus sampling (CVS)
 - Fetal blood sampling (FBS)
 - External cephalic version
 - Manual removal of the placenta

fetomaternal hemorrhage.

woman will carry these antibodies throughout her life. This may happen even before a pregnancy if an Rh-negative woman receives a transfusion of an Rh-positive blood product (RBCs or platelets).

In the first affected pregnancy, the fetal effects of alloimmunization either are nonexistent or tend to be less severe. The exception is a woman who has developed antibodies following a blood transfusion and is pregnant for the first time. The fetal effects worsen with each subsequent affected pregnancy.

In the subsequent pregnancy (if the fetus is Rh-positive), the antibodies cross into the fetus, attack them and cause hemolysis (Fig. 38.5).

Fetomaternal hemorrhage

Fetomaternal hemorrhage (FMH) or leaking of fetal blood into the maternal circulation occurs in as many as 75% of women during delivery. The frequency and volume of spontaneous FMH increase with advancing gestational age and are highest at delivery. The quantity of FMH is the same whether it is a vaginal delivery or a cesarean section. The majority will have a leak of <3 mL. The risk of sensitization depends on the volume of FMH (Table 38.1).

Hemorrhage volumes sufficient to cause alloimmunization are produced in 15%–50% of births. However, only <1% of women will have FMH of >15 mL.

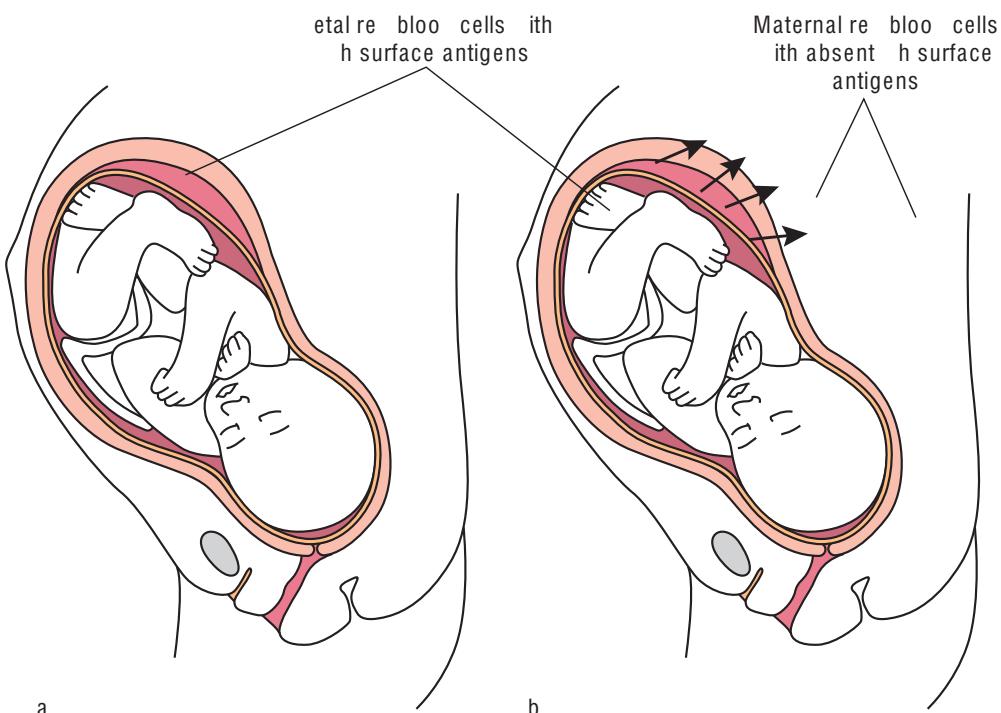


Figure 38.3 Transplacental transmission of fetal blood cells. **a.** The Rh-positive fetus in the Rh-negative mother. **b.** Blood cells with the Rh surface antigen can cross the placenta into the maternal circulation in certain clinical situations.

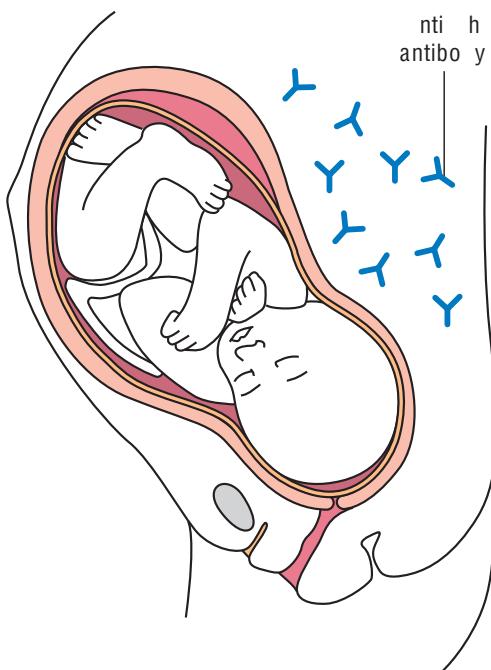


Figure 38.4 Maternal production of Rh antibodies (IgG).
g = immunoglobulin G.

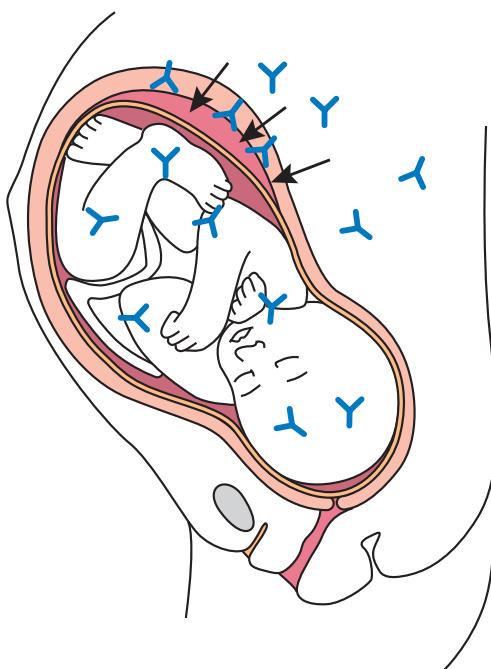


Figure 38.5 Maternal antibodies identify fetal red cells as foreign protein and destroy them, causing hemolysis.

Antibody response to FMH varies considerably in individuals and depends on gestational age, volume of hemorrhage, antigenicity of RBCs, and immunogenic response capacity

Table 38.1 The risk of sensitization in relation to the volume of FMH

Volume of FMH (mL)	Risk of sensitization (%)
0.1	3
0.2–1	25
>5	65

, fetomaternal hemorrhage.

of the mother. ABO incompatibility confers substantial protection against the primary Rh immune response. In spite of the FMH, there are factors that prevent alloimmunization in some Rh-negative women (Box 38.4). ABO incompatibility protects against Rh alloimmunization.

The risk of FMH can be reduced in the antenatal period as well as during delivery (Box 38.5).

natural history of red cell alloimmunization

The first pregnancy is referred to as the primary sensitizing pregnancy. The maternal primary immune response to the D antigen takes an average of 12–16 weeks but may take up to 12 months. The response is usually weak, consisting predominantly of IgM that does not cross the placenta. The weak response, combined with the fact that most of the significant FMH occurs during delivery, protects most first pregnancies from severe disease.

Box 38.4 Fetomaternal hemorrhage and alloimmunization

- FMH
 - Increases with gestational age
 - 30% in third trimester
 - Occurs in 75% of women at delivery
 - Majority <3 mL
 - Sufficient to cause alloimmunization
 - 15%–50% of women
 - Factors affecting alloimmunization
 - Frequency and volume of FMH
 - ABO incompatibility
 - Protects against primary Rh immune response
 - Immunogenicity of fetal RBCs
 - Maternal capacity for immunogenic response

fetomaternal hemorrhage; BC red blood cell; h, rhesus.

Box 38.5 Reducing the risk of FM in the Rh-negative mother

- Antenatal period
 - Invasive tests only if absolutely indicated
 - Extrauterine/intrauterine manipulations only if absolutely indicated
 - Force avoided during all extrauterine/intrauterine manipulations
 - Abdominal palpation minimized in placental abruption
- Vaginal delivery
 - Immediate cord clamping
 - Methylergometrine avoided
 - Manual removal of placenta avoided
- Cesarean delivery
 - Blood spill into the peritoneal cavity minimized/avoided
 - Manual removal of placenta avoided
 - Uterus to be handled gently

fetomaternal hemorrhage; *h* rhesus.

The exceptions to this are as follows:

- A woman who has developed antibodies following a blood transfusion and is pregnant for the first time
- An Rh-negative woman whose mother was Rh positive and was exposed to maternal Rh antigens in utero—known as the *grandmother theory*

Subsequent pregnancies are considered sensitized pregnancies. In the subsequent pregnancy with an Rh-positive fetus, when fetal blood leaks into the maternal circulation, an amnestic response is generated from the previously primed RBCs. This is a rapid response and consists almost exclusively of IgG. IgG antibodies cross the placenta, destroy the Rh D-positive fetal red cells, and cause the following:

- Fetal anemia
- Fetal hydrops
- Hyperbilirubinemia in the newborn

The natural history of Rh alloimmunization is summarized in Box 38.6.

Natural history of DF

The old term for this condition is erythroblastosis fetalis. HDFN can be mild, moderate, or severe depending on the rate of hemolysis. In mild HDFN, the fetus is able to metabolize the

Box 38.6 Natural history of Rh alloimmunization

- First pregnancy
 - Primary sensitizing pregnancy
 - Immune response takes
 - 12–16 weeks
 - Up to 12 months
 - Immune response weak
 - Mostly IgM antibodies
- Subsequent pregnancies
 - Amnestic response
 - Rapid response
 - IgG antibodies
 - Cross placenta
 - Destroy fetal red cells

g immunoglobulin G; *g* immunoglobulin M; *h* rhesus.

small amount of bilirubin produced by hemolysis and no intervention is needed.

In moderate HDFN, the placenta metabolizes the bilirubin but hyperbilirubinemia can be accelerated after birth and may lead to kernicterus with neurological damage unless treated promptly.

In severe cases, there can be fetal anemia and ultimately fetal hydrops (Box 38.7). Fetal hydrops is due to cardiac failure resulting from the anemia.

Box 38.7 Hemolytic disease of the fetus and the newborn

Mild cases

- Hemolysis tolerated by fetus
- Mild anemia and jaundice at birth
- Usually resolves without treatment

Moderate cases

- Increased circulating bilirubin cleared by placenta
- After birth bilirubin not cleared by immature liver
 - Hyperbilirubinemia
 - Bilirubin encephalopathy (kernicterus)
 - Moderate anemia
 - Postnatal treatment required

Severe cases

- Severe fetal anemia
- Hepatosplenomegaly
- Erythroblasts (immature RBCs) in circulation
- Liver dysfunction
- Fetal cardiac failure
- Fetal hydrops
 - Stillbirth
 - Neonatal death

BC, red blood cell.

Effects of Rh alloimmunization on the mother

Rh alloimmunization is associated with a large placenta. This hyperplacentosis can cause pre-eclampsia. A syndrome (Ballantyne syndrome), in which the mother has edema, mild albuminuria, and elevated blood pressure, mirroring the features of hydrops, has been described. Other maternal problems are related to invasive procedures such as cordocentesis and amniocentesis, done as part of fetal therapy. Maternal effects of Rh alloimmunization are given in Box 38.8.

Box 38.8 Maternal effects of Rh alloimmunization

- Hyperplacentosis
 - Preeclampsia
- Ballantyne syndrome
 - Edema
 - Mild albuminuria
 - Elevated blood pressure
- Problems related to
 - Cordocentesis
 - Amniocentesis

h, Rhesus.

Screening for alloimmunization in women

On the first prenatal visit, all pregnant women should be tested for ABO blood group and Rh-D type. If the mother is Rh negative, and her husband/partner is Rh positive she should be screened for the presence of Rh antibodies. This is done even if the woman is a multigravida who has received anti-D immunoglobulin in her previous pregnancies, since postpartum administration of anti-D does not guarantee prevention of Rh alloimmunization.

Indirect Coombs test

The test most commonly used to detect unbound Rh antibodies in the maternal serum is the indirect Coombs test (ICT). This blood test most accurately

- detects the presence of antibodies in the maternal serum and
- indicates the degree of alloimmunization by quantitative titer.

Procedure

ICT is performed in the following manner:

- Maternal plasma is incubated with known Rh-positive RBCs. The antibody in maternal plasma coats the RBCs.
- Antihuman globulin serum is added to the red cells.
- The red cells coated with antibodies are agglutinated by the antihuman globulin.
- This is considered a positive ICT.
- A positive test indicates that the fetus is at risk of developing hemolytic disease, but it is not a diagnostic test.

Titration is done for the quantity of the antibody present in the serum. Using doubling dilutions of the serum, the maximum dilution of the test serum that is able to produce agglutination is calculated. The Rh antibody titer is expressed as 1:8, 1:16, 1:32, etc.

It is important to remember that there is no direct relationship between the antibody titer and the severity of the disease.

Critical titer

A critical titer is defined as the titer that indicates a significant risk for fetal hydrops. This value varies between laboratories as does the critical titer level associated with hydrops. Therefore, the same laboratory should be used when repeat titers are done. For most centers, critical titer values vary between 1:8 and 1:32.

The frequency of testing is listed in Box 38.9.

Determining fetal Rh factor

If the fetal Rh factor is known, then management of an alloimmunized pregnancy is easier. If the fetus is Rh negative, then no investigation or intervention would be required. Though not currently available on a routine basis, two tests are possible to identify the fetal Rh factor:

- Noninvasive fetal testing for the Rh D gene: Sorting of maternal blood for fetal cells using

Box 38.9 Frequency of screening**In the first pregnancy**

- At first booking
- At 20 weeks
- At 28 weeks (before antenatal administration of anti-D)

In subsequent pregnancies

- Previous pregnancy with no or mild hemolytic disease
 - At first booking
 - Every 4–6 weeks subsequently
- Previous pregnancy with severe hemolytic disease
 - Titer not required
 - Testing for fetal anemia beginning from 16–18 weeks

flow cytometry has been reported to be successful in identifying an Rh D-positive fetus.

- Cell-free fetal DNA (cfDNA) in the maternal plasma or serum has been used to detect Rh D sequences in the case of an Rh D-positive fetus.

Management of pregnancy in a nonimmunized mother

If the ICT is reported as being negative, then the mother is not alloimmunized. The aim of management would be to prevent alloimmunization by ensuring the following:

- Minimizing the chances of FMH as already discussed (Box 38.5)
- Preventing alloimmunization by administration of anti-D immunoglobulin

Anti-D immunoglobulin for prophylaxis against alloimmunization

Anti-D immunoglobulin or Rho(D) immunoglobulin is a derivative of human plasma. It is extracted by cold alcohol fractionation from the sera of individuals with high titers. Anti-D immunoglobulin binds to D antigen sites on fetal erythrocytes present in the maternal circulation; thus, the maternal immune system does not recognize the foreign antigen. This prevents the formation of antibodies. The important features of anti-D immunoglobulin are listed in Box 38.10.

Box 38.10 Anti-D immunoglobulin

- Anti-D immunoglobulin
 - Polyclonal or monoclonal
 - Polyclonal antibodies used currently
- Dose
 - 300 µg (1 µg = 5 IU)
 - Will neutralize 15 mL of Rh-positive RBCs
 - 50 µg
 - Will neutralize 2.5 mL of Rh-positive RBCs
- Half-life of 16–24 days.
- Administered deep IM
 - Deltoid muscle
 - Anterolateral aspect of the thigh
- Given within 72 hours of delivery or incidence of FMH
- Can be omitted if husband/partner is Rh negative

fetomaternal hemorrhage; RBCs, red blood cells;
h rhesus.

Antenatal anti-D prophylaxis

Initially, anti-D prophylaxis was administered only postnatally. However, a small number of women have been found to develop alloimmunization due to FMH that occurs antenatally. When anti-D immunoglobulin is administered early in the third trimester, it is possible to reduce the incidence of antenatal alloimmunization from 1% to 0.1%.

- It is, therefore, recommended that all Rh-negative women with no evidence of alloimmunization (ICT negative) should be administered 300 µg of anti-D immunoglobulin at 28 weeks' pregnancy. However, the cost and supply of antenatal anti-D is a major consideration in some developing countries.
- A second dose at 34 weeks is used in some countries, but is not recommended by all and is not used in centers in India.
- Postnatal anti-D prophylaxis is mandatory unless antenatal prophylaxis was administered within 3 weeks of delivery.

Postnatal and other indications for anti-D prophylaxis

Postnatal and other indications for anti-D prophylaxis are given as follows:

- Administration of anti-D postnatally is mandatory to all Rh-negative women who are

nonalloimmunized. A dose of 300 µg should be administered within 72 hours of delivery. This provides protection against 15–20 mL of FMH.

- If the dose is omitted after delivery, it may be given as late as within 13 days postpartum since it provides partial protection.
- If delivery occurs within 3 weeks of antenatal prophylaxis, postnatal dose is not required.
- In addition to postpartum prophylaxis, there are several obstetric indications for anti-D prophylaxis. These indications for and dosage of anti-D prophylaxis are listed in Table 38.2.

In a multigravida undergoing sterilization after a pregnancy, anti-D is considered neither necessary nor cost-effective and therefore the woman should be given the option of an informed choice for anti-D prophylaxis.

In certain situations, >15 mL of fetal blood may enter the maternal circulation. Risk factors for large FMH are enumerated in Box 38.11.

When large FMH is suspected, quantitative assessment is done by

- Rosette test
- Kleihauer–Betke acid elution test

A positive rosette test indicates a larger volume of hemorrhage but does not quantify it accurately. Hence, when this test is positive, Kleihauer–Betke test is essential. The

Box 38.11 Risk factors for large FMH

- Operative vaginal delivery
- Cesarean section
- Manual removal of placenta
- Postterm pregnancies

fetomaternal hemorrhage.

Kleihauer–Betke test identifies the percentage of fetal cells in the maternal circulation and helps in assessing the volume of FMH so that an appropriate dose of anti-D may be administered. In places where a Kleihauer–Betke test is not available, it is suggested that higher doses be administered in order to protect the majority of women in highrisk situations.

Management of pregnancy in an alloimmunized mother

Management of pregnancy in an alloimmunized mother includes the following steps:

- A positive anti-D titer at the booking visit only indicates that the fetus is at risk for hemolytic disease. It does not indicate that hemolytic disease has occurred or will develop.

Table 38.2 Obstetric indications for and dosage of anti-D prophylaxis

Sensitizing event	Dosage of anti-D (mg)	
	Before 12 weeks gestation	After 12 weeks gestation
Therapeutic termination of pregnancy (first trimester)	50–100	
Spontaneous miscarriage with instrumentation	50–100	
Ectopic pregnancy	50–100	
Vaginal or cesarean delivery	300	
Invasive prenatal diagnosis (amniocentesis, chorionic villus sampling, fetal blood sampling)	100	300
Intrauterine procedures (e.g., insertion of shunts, embryo reduction)	100	300
Antepartum hemorrhage	—	300
External cephalic version	—	300
Closed abdominal injury	100	300

- A detailed history regarding the severity of disease in the previous fetuses is important. Gestational age at which the fetus was delivered, treatment given, and the fetal outcome should be noted.
- The zygosity of paternal blood may be tested. If the father is heterozygous, there is a 50% chance of the fetus being Rh negative. This is not performed as a routine in most centers.

Determining fetal h factor

Currently, fetal Rh factor testing is not done.

Determining the severity of fetal anemia

Once the titers are documented, further follow-up includes screening for fetal anemia using serial amniocentesis, ultrasound, and Doppler.

- In women with a history of mild or moderate hemolytic disease of the fetus, monitoring for fetal anemia should begin by 20 weeks' gestation.
- In a woman who has had severe HDFN in a previous pregnancy, a severe degree of fetal anemia is expected (if this fetus is also Rh

positive). Such women are monitored for evidence of fetal anemia starting at 16–18 weeks' gestation.

Serial amniocentesis and Liley curve

In the past, if the mother had a critical titer (1:16 or higher), serial amniocentesis was done to plot the Liley curve. Since fetuses affected by hemolytic disease secrete abnormally high levels of bilirubin into the amniotic fluid, amniocentesis is done to obtain the amniotic fluid. The amount of bilirubin is quantitated by spectrophotometrically measuring delta optical density (DOD) at 450 nm wavelength in the specimen of amniotic fluid. This value is then plotted on the Liley curve. Depending on whether the value falls in zone 1, 2, or 3 (Fig. 38.6), a decision is made to watch expectantly, deliver the baby, or proceed with intrauterine fetal transfusion.

This test can be used only after 27 weeks' gestation since the original data included only pregnancies after this period of gestation. This method of evaluation was routinely used until recently. However, Doppler velocimetry of the middle cerebral artery (MCA) is a more sensitive, specific, and noninvasive method of determining fetal anemia. Liley curve, therefore, is no longer used.

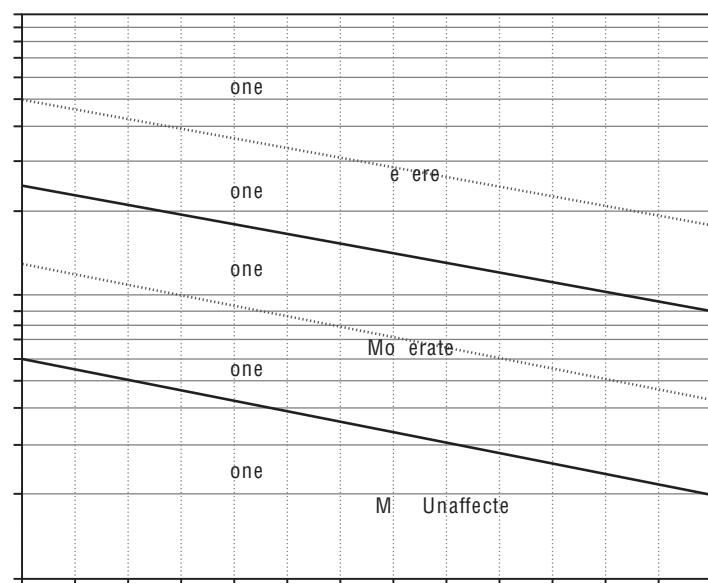


Figure 38.6 Liley curve. The optical density (DOD) at 450 nm wavelength is plotted against gestation in weeks.

Fetal middle cerebral artery peak systolic velocity

Currently, the severity of fetal anemia is assessed by Doppler velocimetry of the fetal middle cerebral artery peak systolic velocity (MCA-PSV; Fig. 38.7). This has become the standard of care in the management of Rh alloimmunization. Measurement of MCA-PSV is usually initiated at 20 weeks' gestation since intravascular transfusions (IVTs) are difficult to perform before 20 weeks. However, if there is a past history of severe hemolytic disease, measurements can be started at 16 weeks.

The sensitivity of increased MCA-PSV [above 1.5 multiples of the median (MoMs)] for the prediction of moderate or severe anemia is 100%. Conversion calculators are available to convert the actual MCA-PSV (in cm/second) to MoMs, to correct for gestational age. The technique of performing MCA Doppler is important and the guidelines must be followed.

Other ultrasonographic signs of fetal anemia

Other signs of fetal anemia are listed in Box 38.12.

Management of the first affected pregnancy

The approach to an alloimmunized pregnancy differs for the first alloimmunized pregnancy as

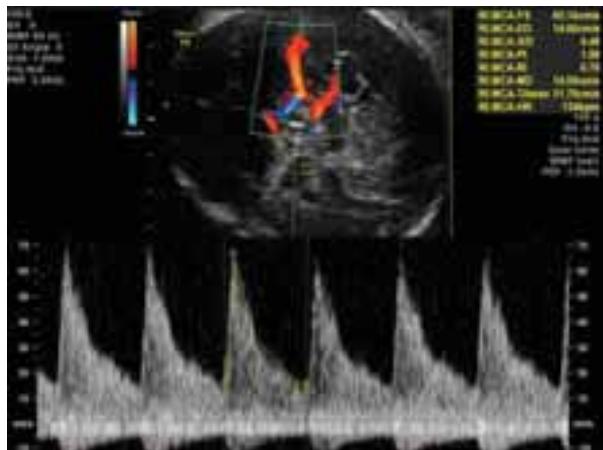


Figure 38.7 Doppler waveform of increased middle cerebral artery peak systolic velocity (MCA-PSV). (Photo courtesy: Mediscan Systems, Chennai.)

compared with a subsequent one. Generally, the fetal effects are milder with the first alloimmunized pregnancy and worsen with each subsequent one.

- ICT should be repeated once a month till 28 weeks and every 2–3 weeks thereafter.
- If the titer remains below the critical level (1:16 or 1:32), the mother may be delivered at term.
- If the titer rises above the critical level, surveillance with MCA-PSV Doppler should be initiated.
- If the MCA-PSV is <1.5 MoM, the woman may be monitored and delivered at 37–38 weeks.
- If the MCA-PSV is >1.5 MoM, fetal blood transfusion will be required.

The management of the first affected Rh alloimmunized pregnancy is summarized in Figure 38.8.

Management of pregnancy with previously affected fetus

In pregnancies with a previously affected fetus, Coombs test will be positive in high titers. Management is based on MCA-PSV and not on the ICT titers.

- In women with a history of mild or moderate hemolytic disease of the fetus, monitoring for fetal anemia should begin by 20 weeks' gestation or 2 weeks prior to the onset of fetal disease in the previous pregnancy.
- In a woman who has had severe HDFN in a previous pregnancy, a severe degree of fetal anemia is expected (if the present fetus is also Rh-positive). Such women are monitored by ultrasound starting at 16–18 weeks' gestation.

Box 38.12 Other signs of fetal anemia

- Polyhydramnios
- Hepatosplenomegaly
- Increased placental thickness
- Increased right atrial size
- Fetal hydrops (due to severe anemia and cardiac failure)
 - Ascites
 - Pleural effusion
 - Pericardial effusion
 - Subcutaneous edema

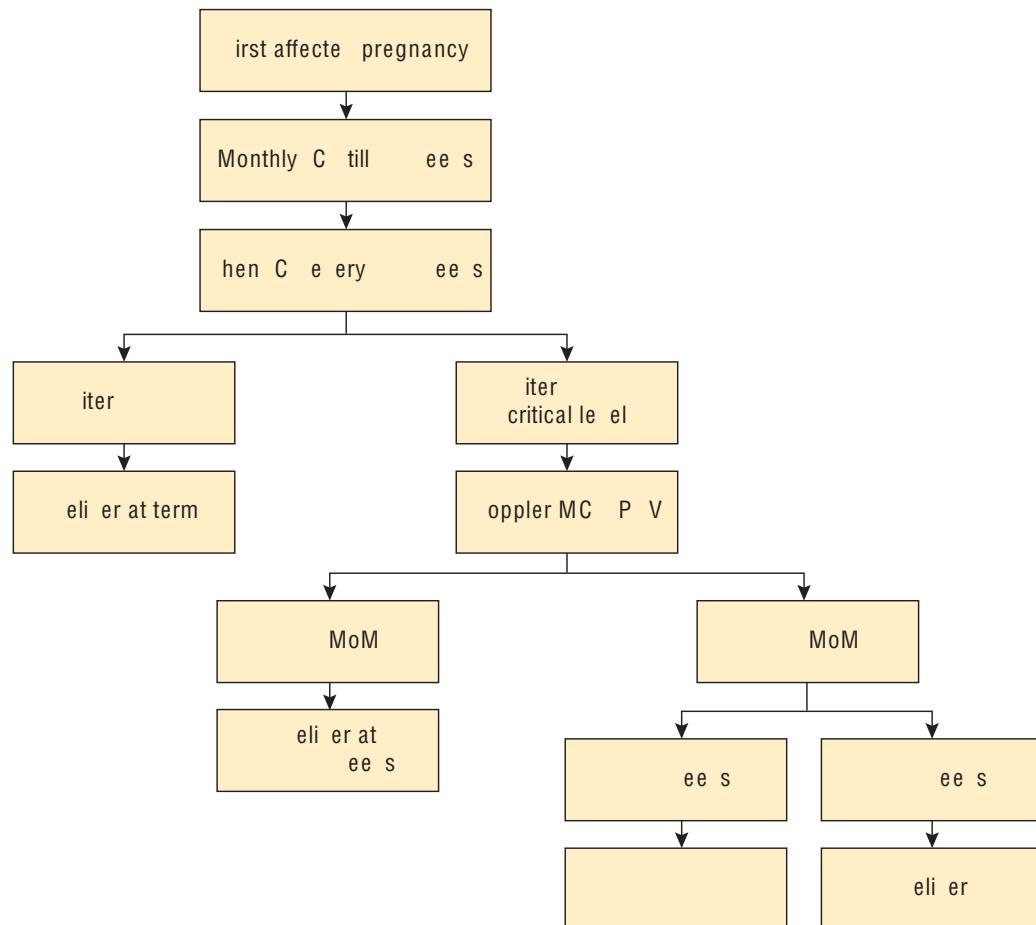


Figure 38.8 The management of the first affected Rh alloimmunized pregnancy. BS fetal blood sampling; C indirect Coombs test; CA-PS middle cerebral artery peak systolic velocity; o multiples of median.

- Monitoring should be done once in 2 weeks. If the MCA-PSV remains $<1.5 \text{ MoM}$, monitoring can continue and delivery may be planned between 34 and 36 weeks. Antenatal corticosteroids should be administered if <34 weeks.
- If MCA-PSV is $>1.5 \text{ MoM}$, FBS should be done by cordocentesis.
- If cord blood hematocrit is $>30\%$, FBS should be repeated once a week. Delivery should be planned between 34 and 36 weeks.
- If fetal hematocrit is $<30\%$, intrauterine transfusion (IUT) is indicated.

Management of Rh alloimmunized pregnancy with a previously affected fetus is summarized in Figure 38.9.

Intrauterine blood transfusion

Severe fetal anemia is defined as a hematocrit below 30% or 2 standard deviations below the mean hematocrit for the gestational age.

Once fetal anemia is confirmed, a decision is made to either deliver the baby or proceed with an IUT. Intrauterine transfusion is generally done between 18 and 35 weeks' gestation. It is technically difficult to perform an IUT before 18 weeks. After 34 weeks, it is safer to deliver the baby and treat with postnatal transfusion.

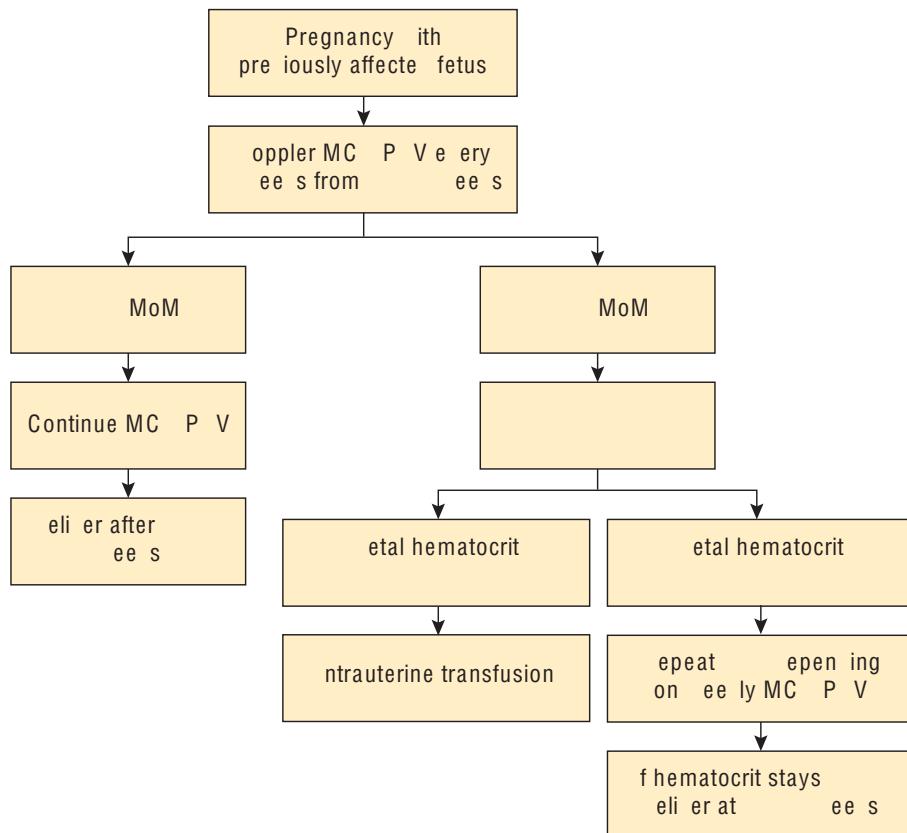


Figure 38.9 The management of Rh alloimmunized pregnancy with a previously affected fetus. BS fetal blood sampling; CA-PS middle cerebral artery peak systolic velocity; MoM multiples of the median.

Fetal blood sampling

When the MCA-PSV is increased and the decision has been made to proceed with an IUT, FBS is done to document the severity of anemia and plan the volume of IUT. This is usually done at the time of IUT.

Preparation for intrauterine transfusion

Blood for transfusion

Blood for transfusion should be

- type O Rh(D) negative blood,
- cross-matched to the mother's blood, and
- tightly packed to achieve a final hematocrit of 75%–85%.

Volume of blood for IUT

The hematocrit obtained with the FBS at the initiation of the procedure helps calculate the volume of blood to be transfused into the fetus.

There are prescribed formulas and charts to calculate the volume for infusion. The volume of blood is calculated based on the following:

- Initial fetal hematocrit
- Size of the fetus
- Hematocrit of the donor blood
- Target hematocrit

Sites of transfusion

The following are the sites of transfusion:

- *Intrapерitoneal transfusion (IPT)*: The transfused blood cells are absorbed through the diaphragmatic lymphatics. Transfusion into the peritoneal cavity is not effective in fetuses with severe anemia and hydrops.
- *Intravascular transfusion (IVT)*: This is much more effective than IPT, particularly in hydropic fetuses, and is the preferred route of transfusion. The two sites used for direct vascular access are as follows:
 - The intrahepatic portion of the umbilical vein (ductus venosus)

- The umbilical vein at the site of cord insertion into the placenta
- **Combined IPT and IVT:** The combined direct intravascular/intraperitoneal approach produces a stable hematocrit between procedures and offers the possibility of performing IUT at less frequent intervals.

The prerequisites and the sites of transfusion are summarized in Box 38.13.

Procedure of intrauterine transfusion

The procedure of IUT consists of the following steps:

- The procedure is done under sterile conditions, preferably in the operation theater, with everything set up for an emergency cesarean section in case it is needed.
- Maternal sedation is usually administered to alleviate anxiety.
- The procedure is done under ultrasound guidance.
- Fetal movement is minimized with an injection of a paralyzing agent (such as vecuronium bromide or pancuronium bromide) into the fetal thigh.

Box 38.13 Prerequisites and sites of intrauterine transfusion

- Initial fetal blood sampling
 - Severity of anemia
 - Plan volume of IUT
- Blood for transfusion
 - O Rh(D) negative blood
 - Cross-matched to maternal blood
 - Hematocrit of 75%–85%
- Volume of blood to be transfused
 - Depends on
 - Initial fetal hematocrit
 - Size of the fetus
 - Hematocrit of donor blood
 - Target hematocrit
- Sites of transfusion
 - Intraperitoneal
 - Intravascular
 - Ductus venosus
 - Cord insertion
 - Mixed (intraperitoneal +IVT)

intrauterine transfusion; intravascular transfusion.

- A 20-gauge needle is inserted through the maternal and fetal abdominal wall, and a blood sample is obtained from the fetal umbilical vessel. The blood is immediately processed to check for fetal hematocrit. Using a standard formula, the volume of blood to be transfused is calculated.
- Using the same needle, blood is pushed into the fetal circulation (Figs 38.10–38.12).
- The transfusion is continued till the target hematocrit is obtained. After 24 weeks' gestation, the target fetal hematocrit is 40%–50%.

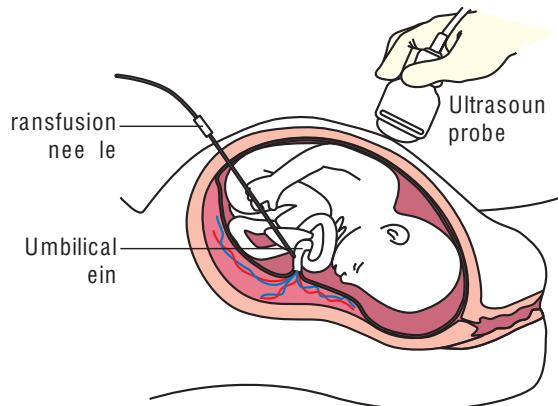


Figure 38.10. Graphic representation of intrauterine transfusion of blood. Under ultrasound guidance, a long 20-gauge needle is placed in the umbilical vein and blood transfused into the fetal circulation.



Figure 38.11 Ultrasound of intravascular intrauterine transfusion. The needle tip is seen in the intrahepatic portion of the umbilical vein (ductus venosus). (Photo courtesy: Mediscan Systems, Chennai.).



Figure 38.12 Intrauterine transfusion being performed under ultrasound guidance. The needle can be seen entering the abdomen and into the uterus (yellow arrow). The blood is being pushed in with a syringe (white arrow). (Photo courtesy: Mediscan Systems, Chennai.).

Posttransfusion follow-up and subsequent transfusions

Posttransfusion, the fetus is followed up with ultrasound imaging to document the decrease in hydrops. Doppler velocimetry of the MCA is done to note the improvement in fetal anemia. A repeat transfusion is planned based on the following:

- The final hematocrit achieved during the last transfusion
- The rate of drop of hematocrit

After the first IUT, the fetal hematocrit will decrease approximately at the rate of 1% per day. This can be more rapid in a hydropic fetus. The second IUT is usually planned 10–14 days after the first IUT. After two or three transfusions, fetal erythropoiesis is suppressed and the drop in hematocrit slows down. The interval between transfusions can be extended to 3–4 weeks (Box 38.14).

Management of the neonate

All newborns of Rh-negative, nonisoimmunized mothers should undergo the following:

- Blood grouping, Rh typing
- Direct Coombs test (DCT)

Box 38.14 Posttransfusion follow-up and subsequent transfusions

- Ultrasonography
 - To assess hydrops
 - MCA Doppler to assess anemia
- Subsequent transfusions
 - Hematocrit decreases 1% per day
 - Second IUT after 10–14 days
 - After 2–3 transfusions
 - Every 3–4 weeks

CA middle cerebral artery.

This helps in deciding if the mother requires anti-D immunoglobulin or not (Box 38.15).

Box 38.15 Follow up with neonatal h type and DCT

- Baby Rh positive and DCT negative
 - Postnatal dose of anti-D immunoglobulin for mother
- Baby Rh positive and DCT positive
 - Mother alloimmunized
 - No benefit from anti-D immunoglobulin
- Baby Rh positive and weak positive DCT
 - Evaluate further to exclude
 - Other minor group
 - ABO incompatibility

DCT direct Coombs test.

emolytic disease of the fetus and newborn

Clinical presentation

As discussed earlier in this chapter, HDFN may be mild, moderate, or severe.

At delivery, if HDFN is anticipated, cord blood should be collected and sent for the following tests:

- Hematocrit
- Reticulocyte count
- DCT
- Bilirubin

Clinically, the neonates have one or more of the following:

- Hyperbilirubinemia
- Hydrops fetalis
- Anemia

Hyperbilirubinemia

Hyperbilirubinemia was formerly known as icterus gravis neonatorum. It occurs within the first 24 hours after birth. Hemolysis of the fetal red blood cells continues after birth and the unconjugated bilirubin level increases. If the level rises above 20 mg/dL, it crosses the blood-brain barrier and gives rise to bilirubin encephalopathy (**kernicterus**). This is more common in preterm babies since the liver is immature.

Treatment of hyperbilirubinemia involves the following:

- Phototherapy
- Exchange transfusion

Treatment of hyperbilirubinemia is discussed in detail in Chapter 23, *The newborn*.

Hydrops fetalis

Hydrops fetalis is also known as erythroblastosis fetalis or immune hydrops. This is the most severe form of HDFN where hemolysis sets in in-utero. There is severe anemia with congestive cardiac failure, ascites, and pleural and pericardial effusions. The diagnosis of hydrops is made when fluid is present in two cavities (e.g., peritoneal, pericardial, or pleural). There is subcutaneous and scalp edema and marked enlargement of the placenta. Extramedullary hematopoiesis causes hepatosplenomegaly. Prognosis is poor and fetuses with severe hydrops are stillborn, if left untreated.

Antenatal ultrasonography demonstrates fluid in pleural, peritoneal, and pericardial cavities, 'halo' around the head due to scalp edema, a large placenta, and hepatosplenomegaly. Due to early diagnosis using ultrasonography and treatment with IUT, this condition is seen less often now.

Features of hydrops fetalis are listed in Box 38.16. Treatment postnatally is by exchange transfusion.

Anemia

Anemia is usually referred to as congenital anemia of the newborn. It is usually seen at birth (early onset anemia). There is pallor, tachycardia, and tachypnea at birth. Associated hydrops

Box 38.16. Features of hydrops fetalis

- Severe anemia
- Congestive cardiac failure
 - Ascites
 - Pleural and pericardial effusions
 - Subcutaneous and scalp edema
- Placental enlargement
- Hepatosplenomegaly
- Stillbirth
- Ultrasonography
 - Fluid in pleural, peritoneal, and pericardial cavities
 - 'Halo' around the head due to scalp edema
 - Large placenta
 - Hepatosplenomegaly

may cause respiratory distress. Treatment is by transfusion if anemia is moderate or by exchange transfusion if there is accompanying hydrops or cardiac failure.

Indications for exchange transfusion are listed in Box 38.17.

The process of exchange transfusion is summarized in Box 38.18.

Following exchange transfusion, the baby should be monitored for immediate and late complications such as congestive cardiac failure, hyperkalemia, hypocalcemia, and necrotizing enterocolitis.

Box 38.17 Indications for exchange transfusion

- Cord blood bilirubin >5 mg/dL
- Hemoglobin <10 g/dL
- Hydrops fetalis
- Rise in bilirubin by >1 mg/dL/hour
- Total bilirubin >20 mg/dL

Box 38.18 Process of exchange transfusion

- Usually double-volume transfusion
- 160 mL of 'O' negative blood
 - Cross-matched with mother's and baby's serum
 - Packed cells suspended in maternal fresh frozen plasma
 - For every 15 mL blood removed, 10 mL transfused

Key points

- There are 50 different red cell surface antigens capable of causing maternal alloimmunization and fetal hemolytic disease. Of these, the rhesus (Rh) blood group system is the most common.
- In Caucasians, the incidence of Rh-negative genotype is 15%. In India, the incidence is approximately 8%–10% of the population.
- The Rh blood system is collectively called the Rh factor and includes the D, c, C, e, and E antigens. It should be remembered that no d (little d) antigen exists and therefore d denotes the absence of the D antigen.
- The risk of the fetus being Rh positive depends on whether the father is homozygous (*DD*) or heterozygous (*Dd*). The homozygous father will have 100% chance of an Rh-positive baby with an Rh-negative mother, whereas a heterozygous father has a 50% chance of having an Rh-positive baby.
- Anti-Kell, anti-c, and anti-E antibodies can also cause hemolytic disease.
- If an Rh-positive mother is pregnant with an Rh-negative fetus, then there is opportunity for the Rh-positive fetal blood to mix with the maternal blood.
- When the maternal immune system is presented with a foreign protein (Rh antigen), it mounts a response by producing immunoglobulin M (IgM) and later immunoglobulin G (IgG) antibodies.
- In the first affected pregnancy, the fetal effects of alloimmunization either are nonexistent or tend to be less severe.
- In the subsequent pregnancy (if the fetus is Rh positive), the antibodies cross into the fetus, attack them, and cause hemolysis, fetal anemia, and hydrops.
- Hemolytic disease of the fetus and newborn (HDFN) can be mild, moderate, or severe depending on the rate of hemolysis.
- On the first prenatal visit, all pregnant women should be tested for ABO blood group and Rh-D type. If the mother is Rh negative, and her husband/partner is Rh positive, she should be screened for the presence of Rh antibodies.
- The test most commonly used to detect unbound antibodies in the maternal serum is the indirect Coombs test (ICT).
- Anti-D immunoglobulin is mandatory in a nonsensitized woman who undergoes a sensitizing event. The dosage depends on the gestational age at the time of the event.
- Routine antenatal prophylactic dose is recommended at 28 weeks.
- The first affected pregnancy in an alloimmunized woman is managed by serial ICT titers monthly till 28 weeks and once in 2–3 weeks thereafter. If the titer is more than the critical level, middle cerebral artery peak systolic velocity (MCA-PSV) is required. Most of these women can be delivered at 37–38 weeks.
- In pregnancies with a previously affected fetus, management is based on MCA-PSV. If <1.5 MoM, serial monitoring and delivery at 34–36 weeks are recommended.
- Fetal anemia (hematocrit $<30\%$) is treated with intrauterine transfusion.
- HDFN may present as hyperbilirubinemia, anemia, or hydrops fetalis. Severe disease may require exchange transfusion.

Self-Assessment

Case-based questions

Case 1

Mrs. MN, 26, gravida 2, para 0, at 20 weeks' gestation, had a miscarriage a year ago. Her blood group and Rh typing were not done. She did not receive anti-D after the miscarriage. In the current pregnancy, she was found to be Rh negative and her husband was Rh positive. An indirect Coombs test showed a titer of 1:8.

1. How is the Rh factor inherited?
2. What is the indirect Coombs test and critical titer?
3. How will you manage this patient?

4. If the ICT titer begins to rise and reaches 1:32, how will you manage her?

Case 2

Mrs. VC, 28, gravida 1, para 0, was Rh negative. Her husband was Rh positive. She was 24 weeks' pregnant.

1. What is antenatal prophylaxis?
2. When should postnatal prophylaxis be given? What dosage should be given?
3. What is a Kleihauer–Betke test?
4. What are the risk factors for a large fetomaternal hemorrhage?

Answers

Case 1

1. Every individual inherits one of each set (three each) from each parent. If at least one D antigen is present, the individual will be Rh positive.
2. ICT is used to detect unbound Rh antibodies in the maternal serum. It is performed by first mixing the maternal plasma with Rh-positive cells, and later exposing the red cells to antihuman globulin serum and looking for agglutination of cells.
3. A critical titer is defined as the titer that indicates a significant risk for fetal hydrops.
4. This is the first affected pregnancy. She can be managed by serial ICT monthly till 28 weeks and once in 2–3 weeks thereafter. If the titer does not rise above the critical level, she can be delivered at 37–38 weeks.
5. If the level rises above 1:32 (critical level), she should be monitored by Doppler assessment of middle cerebral artery peak systolic velocity (MCA-PSV). If it is <1.5 MoM, she can be monitored and delivered after 34–36 weeks. If the level is >1.5 MoM, fetal blood sampling is required to assess fetal anemia.

Case 2

1. In spite of giving postnatal anti-D prophylaxis, a small number of women have been found to develop allo-

immunization. Antenatal anti-D immune globulin can be administered early in the third trimester to reduce the incidence of antenatal alloimmunization from 1% to 0.1%.

2. Postnatal anti-D prophylaxis is given within 72 hours of delivery. The dosage given is 300 µg, although a larger dose may be required with a greater amount of fetomaternal hemorrhage.
3. A Kleihauer–Betke acid elution test identifies fetal cells in the maternal circulation and will allow assessment of the volume of fetomaternal hemorrhage that has occurred.
4. Operative vaginal delivery, cesarean section, manual removal of placenta, and postterm delivery.

Sample questions

Long-answer question

1. Outline the management of the red cell alloimmunized woman in pregnancy.

Short-answer questions

1. Rh alloimmunization prophylaxis
2. Fetal complications of Rh alloimmunization
3. Intrauterine transfusion for hemolytic diseases of the fetus

39

Antepartum Hemorrhage

Case scenario

Mrs. AN, 22, primigravida, was admitted to the labor room at 32 weeks' pregnancy with sudden onset of profuse vaginal bleeding. There was no associated abdominal pain. On examination, she had tachycardia, pulse was 110/min and blood pressure was 100/70 mm Hg. The uterus was 32 weeks size, not tense or tender, and the fetus was in breech presentation. She had gone to the primary health center and was referred to a tertiary center for management. Her parents and husband, who accompanied her, were extremely worried about the condition of the mother and baby.

Introduction

Obstetric hemorrhage can occur in the first, second, or third trimester. It is one of the leading causes of maternal mortality and accounts for 25% of maternal deaths. It is also the most preventable cause of maternal mortality. Prompt diagnosis, resuscitation, and management are essential to save the mother and fetus.

Definition

Antepartum hemorrhage (APH) is defined as **bleeding from or into the genital tract after 24 weeks' gestation (period of fetal viability) and prior to delivery of the baby**. Some guidelines define APH as bleeding occurring after 20 weeks' pregnancy. It is also referred to as *bleeding in the second half of pregnancy* or *late pregnancy bleeding*.

Quantification

- Minor hemorrhage: Blood loss <50 mL that has settled (includes spotting)
- Major hemorrhage: Blood loss of 50–1000 mL
- Massive hemorrhage: Blood loss of >1000 mL

Incidence

Antepartum hemorrhage occurs in 3%–5% of all pregnancies.

Causes of antepartum hemorrhage

The two most common conditions causing APH are placenta previa and placental abruption. Causes of APH are listed in Box 39.1.

Initial management of antepartum hemorrhage

Women who present with APH must be evaluated initially to assess the condition of the mother and fetus and supportive measures should be initiated. Measures to establish the diagnosis of cause of hemorrhage and specific management should follow.

Initial assessment

- When a pregnant woman presents with bleeding after 20 weeks' gestation, she should be admitted to labor and delivery unit.
- History should include gestational age, amount of bleeding, preexisting obstetric problems such as hypertension, presence of risk factors for APH, uterine contractions, rupture of membranes, trauma, and other relevant details.

Box 39.1 Causes of antepartum hemorrhage

- Placenta previa
- Placental abruption
- Vasa previa
- Rupture of marginal sinus
- Local lesions in the vulva, vagina, or cervix
- Unclassified

- Physical examination should assess maternal pulse, blood pressure, pallor, and signs of shock such as sweating, tachypnea, and restlessness. Abdominal examination should include uterine size, tenderness, contractions, lie and presentation of fetus, station, and fetal heart sounds.
- Vaginal examination should not be performed unless placenta previa is excluded or considered extremely unlikely by clinical examination.

Immediate management

- An intravenous line should be inserted with a wide bore needle and infusion of normal saline or colloids should be started.
 - Blood sample should be drawn for hematocrit, cross-matching, and other tests depending on initial diagnosis (discussed later in this chapter).
 - The bladder should be catheterized and hourly urine output monitored.
 - Blood should be transfused as required.
 - Once the patient is stabilized hemodynamically, ultrasonography should be performed to diagnose the cause of bleeding and assess fetal status.
- Initial assessment and immediate management of APH are summarized in (Fig. 39.1).
- Subsequent management depends on the cause of bleeding.

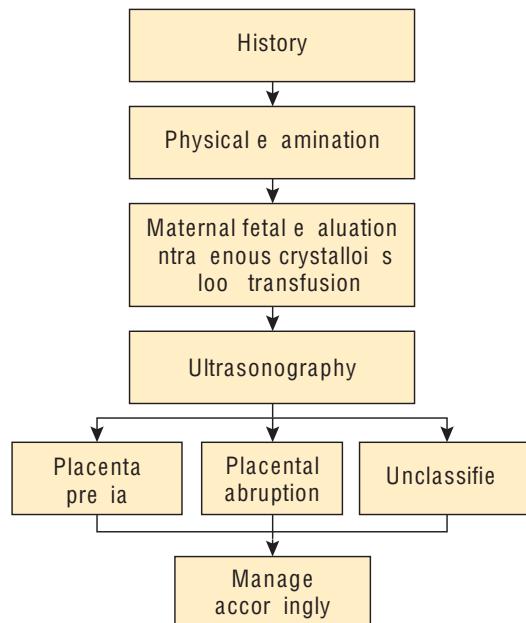


Figure 39.1 Antepartum hemorrhage: Immediate management.

Placenta previa

A placenta that is implanted low down in the uterine cavity in such a manner that it lies ‘in the way’ of the fetus during delivery is referred to as placenta previa. Since the placenta lies in the lower segment, it can separate before or in early labor and cause significant hemorrhage.

Definition

Placenta previa is defined as a placenta that is implanted over or adjacent to the internal os. The placenta, therefore, is entirely or partially implanted in the lower uterine segment.

Incidence

Incidence varies from 3–5/1000 at term. The incidence is much higher in the second trimester.

Pathogenesis

The placenta normally implants in an area of good blood supply and decidualization, which is the uterine fundus. Suboptimal decidualization or blood supply in the upper segment can be responsible for implantation in the lower segment, leading to placenta previa. The placenta may also extend to the lower segment when the surface area is large, such as in multifetal pregnancy.

Risk factors

Risk factors for placenta previa are listed in Box 39.2.

Increasing maternal age, parity, male fetus, and nonwhite race are associated with an increased risk. Smoking and cocaine use cause reduced uteroplacental oxygenation, thereby increasing the placental surface area. The larger the placenta, the more likely it is to extend into the lower segment. Multifetal pregnancy is associated with larger placentae or more than one placenta. Part of a large placenta or one of the placentas may be in the lower segment. Previous curettage and prior intrauterine surgery can cause endometrial scarring leading to implantation of the placenta at the site of

Box 39.2 Risk factors for placenta previa

- Increasing maternal age
- Multiparity
- Nonwhite race
- Male fetus
- Multifetal gestation
- Previous cesarean section
- Previous placenta previa
- Prior curettage/intrauterine surgery
- Maternal smoking/cocaine use

scarring. This also accounts for the increased risk in women with a previous cesarean section. The incidence of previa increases with the number of cesarean sections: 1% with one cesarean section, 1.7% with two cesarean sections, and 3% with three or more cesarean sections. The reason for the increased incidence in women with previous placenta previa is not clear.

Classification

The original classification

The original classification of placenta previa is as given below:

- Type I: Placenta just dips into the lower segment.
- Type II: Placenta reaches the edge of the internal os but does not cover it.
- Type III: Placenta covers the internal os completely when the cervix is not dilated but only partially when the cervix is dilated.
- Type IV: Placenta covers the internal os completely even when the cervix is fully dilated.

The above classification is not relevant in modern obstetrics for the following reasons:

- The classification is based on pelvic examination, which is dangerous and not performed in women with placenta previa.
- The diagnosis of placenta previa is now made by ultrasonography and exact localization is possible.
- Type II placenta can become type III when the cervix is 8 cm dilated; similarly, type IV placenta previa can become type III when the cervix is dilated.

Current classification

On the basis of ultrasonographic findings, placenta previa is classified into four types (Fig. 39.2):

- Total placenta previa: Internal os is completely covered by the placenta.
- Partial placenta previa: Internal os is partially covered by the placenta.
- Marginal placenta previa: The placental edge comes up to the internal os but does not cover it.
- Low-lying placenta: The placenta is in the lower segment but the placental edge is $</= 2$ cm from the internal os.

Placental migration

The majority (90%) of placenta previa diagnosed in the second trimester resolves by term. This is known as *placental migration*. This occurs due to (a) differential growth of upper and lower segment of the uterus and (b) growth of the placenta implanted in the lower segment toward the more vascular upper segment, along with atrophy of the distal part. Migration depends on the following:

- Gestational age at diagnosis: Earlier the gestational age at diagnosis, more the chances of migration.

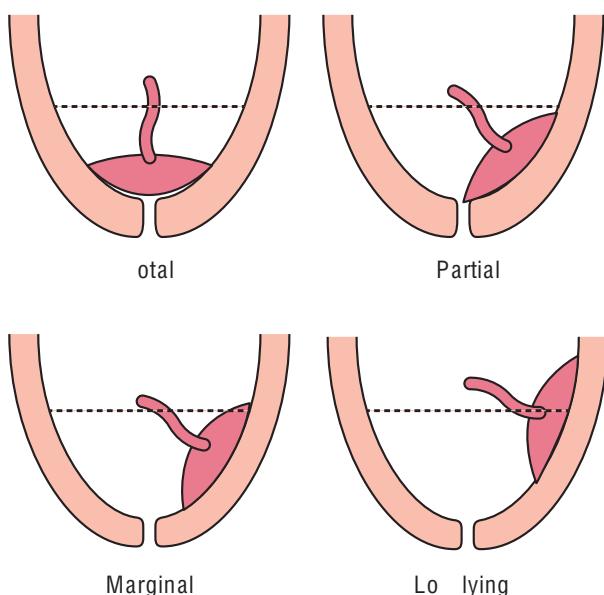


Figure 39.2 Classification of placenta previa. On the basis of ultrasonographic localization, placenta previa is classified into four types—total, partial, marginal, and low lying.

- Extent covering the os: Placentae covering the os are less likely to migrate; 25% persist as previa. Marginal placenta previa diagnosed in early gestation are more likely to migrate and only 2.5% persist as previa.
- Location: Placentae in the anterior wall are less likely to migrate than those in the posterior wall.

Clinical features

Clinical features of placenta previa are listed in Box 39.3.

The most common clinical presentation of placenta previa is painless vaginal bleeding. Bleeding is usually spontaneous but can be provoked by digital examination or coitus.

Timing of initial episode of bleeding

- One-third of affected pregnant mothers have their first bleed *prior to 30 weeks'* gestation. These women are
 - more likely to require blood transfusions,
 - at greater risk of preterm delivery and perinatal mortality.
- One-third of patients bleed *between 30 and 36 weeks*.
- The remaining have the initial episode *after 36 weeks*.
- 10% of women bleed at onset of labor at term.

Bleeding is due to uterine contractions, formation of the lower uterine segment leading to detachment of the placental tissue from the

Box 39.3 Clinical features of placenta previa

- Painless vaginal bleeding
- May occur in
 - second trimester
 - third trimester
 - at the onset of labor
- Bleeding may be
 - small amounts
 - recurrent
 - profuse
- May be associated with
 - premature uterine contractions
 - malpresentations

myometrium, and shearing of maternal blood vessels. The bleeding, therefore, is maternal. When bleeding is profuse, the lower uterine segment cannot contract to occlude the vessels. Massive hemorrhage, which causes reduced uteroplacental flow and separation of placental cotyledons, results in fetal compromise.

Uterine contractions occur along with bleeding in 20% of women. Malpresentations, especially breech or transverse lie, are common since the lower segment is occupied by the placenta. For the same reason, the presenting part is high and deviated to one iliac fossa or the other.

Complications

The complications of placenta previa are listed in Box 39.4.

Maternal complications

Profuse hemorrhage can lead to maternal hypovolemic shock.

Preterm labor is a common complication of placenta previa. Thrombin produced at the site of placental separation stimulates uterine contractions. Prelabor rupture of membranes may also occur.

Due to poor decidualization in the lower uterine segment, placenta accrete occurs in 1%–5% of cases of placenta previa. **Placenta previa in a woman with a previous cesarean section is**

Box 39.4 Complications of placenta previa

- Maternal
 - Hemorrhagic shock
 - Preterm labor
 - Prelabor rupture of membranes
 - Postpartum hemorrhage
 - Operative vaginal delivery
 - Cesarean section
 - Placenta accreta
 - Amniotic fluid embolism
 - Maternal mortality
- Fetal
 - Prematurity
 - Fetal growth restriction
 - Congenital anomalies
 - Malpresentations
 - Hypoxia
 - Perinatal death

associated with a significant risk of placenta accreta.

Cesarean section is the recommended route of delivery in most cases. Malpresentations also contribute to the high cesarean section rates.

In cases of marginal or low-lying placenta, especially associated with malpresentations, operative vaginal delivery may be required.

Amniotic fluid embolism may occur because the maternal venous sinuses are open once the hemorrhage occurs and uterine contractions favor entry of amniotic fluid into the maternal venous circulation.

Postpartum hemorrhage is common since the lower uterine segment does not contract and retract to close the placental bed vessels. Placenta accreta aggravates the situation.

Fetal complications

Prematurity was the most common cause of perinatal mortality before the introduction of expectant management. Bleeding occurs in two-thirds of women before 34 weeks and when the bleeding persists, delivery may be the only option. As already mentioned, preterm labor and prelabor rupture of membranes can also occur.

Fetal growth restriction is seen in 15% of women with placenta previa. This may be due to recurrent episodes of bleeding and associated placental insufficiency.

The incidence of congenital anomalies of the central nervous system, cardiovascular, gastrointestinal, and respiratory systems is increased in placenta previa.

Malpresentations are common. Bleeding during labor and operative delivery can lead to perinatal hypoxia and asphyxia. Perinatal mortality is increased due to all the causes mentioned before.

Diagnosis

Traditionally, the diagnosis is by history, physical examination, and ultrasound evaluation. However, since second trimester ultrasonography has become a routine in most centers, placenta previa may be identified in many women. The majority of previa diagnosed in the 18–20 weeks scan will migrate upwards. In a woman in whom a previa is diagnosed in the second trimester, ultrasound should be repeated at 28–32

weeks and 36 weeks to confirm or rule out the persistence of previa.

History

Painless vaginal bleeding is the most important presenting symptom. As already mentioned, bleeding may be mild or moderate and recurrent. Placenta previa should be suspected in any woman who presents with painless bleeding after 20 weeks' gestation, unless proved otherwise. History of pain due to uterine contractions may be present in some cases.

Physical examination

Presence of pallor and signs of shock should be looked for. Uterine size, presence of uterine contractions, and fetal presentation should be noted (Box 39.5).

Pelvic examination should not be performed in women presenting with bleeding after 20 weeks' pregnancy.

Investigations

Ultrasonography

Ultrasonography is the simplest, safest, and most accurate method of diagnosis of placenta previa. Transabdominal and transvaginal ultrasonography are used. Occasionally, translabial imaging is used (Box 39.6).

Box 39.5 History and physical examination

- History
 - Gestational age
 - Painless bleeding
 - Amount of bleeding
 - Mild/moderate/profuse
 - Previous episodes
 - Uterine contractions
- Physical examination
 - General examination
 - Pallor
 - Pulse/BP/respiratory rate
 - Obstetric examination
 - Uterine size
 - Contractions
 - Fetal lie
 - Fetal presentation
 - Station of presenting part
 - Fetal heart rate

Box 39.6 Ultrasonography in placenta previa

- Transabdominal
 - Used for quick screening
 - Fundal placenta excludes placenta previa
 - 95% accuracy
 - False positive
 - Full bladder
 - False negative
 - Fetal head low in the pelvis
- Transvaginal
 - Used for confirmation
 - 100% accuracy
 - Does not provoke bleeding
 - Tip of transducer placed 2–3 cm below cervix
- Translabial (transperineal)
 - Alternative to transvaginal

Transabdominal ultrasonography

This is used for quick initial screening (Fig. 39.3). If the placenta is in the upper segment, placenta previa can be excluded. Accuracy for diagnosis of placenta previa by ultrasonography is 95%. If the maternal bladder is full, a false positive result is common because the anterior and posterior uterine walls are compressed together by the bladder. The patient should be asked to empty the bladder before confirming the diagnosis.

Transvaginal ultrasonography

Transvaginal ultrasonography (TVUS) is the most accurate (100%) modality of imaging for previa (Fig. 39.4). It does not provoke bleeding,



Figure 39.3 Abdominal ultrasonography of total placenta previa. The placenta (PL) is seen covering the cervical os (cx). (Photo courtesy: Mediscan Systems, Chennai.)

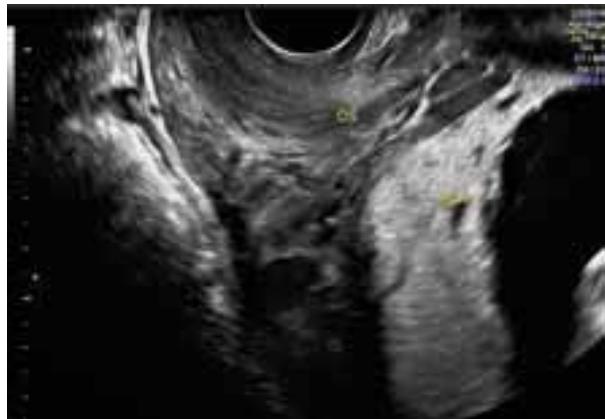


Figure 39.4 Transvaginal ultrasonography of placenta previa. The placenta (PLA) is seen covering the cervical os (OS). (Photo courtesy: Mediscan Systems, Chennai.)

if performed carefully. To prevent slippage of probe into the cervix, the tip of the probe should be placed at an angle to the cervix and 2–3 cm below the cervix. Cervical dilatation and placental location can also be determined.

Translabial ultrasonography

Translabial (transperineal) ultrasound is also an accurate method and is used as an alternative to TVUS.

- Transabdominal scan should be performed first and if placenta previa is suspected, TVUS should be proceeded with.
- If placenta previa is diagnosed in the second trimester, ultrasonography should be repeated at 28–32 weeks with a final evaluation at 36 weeks.

Two measurements should be made during ultrasonography:

1. The actual distance between the placental edge and internal os (Fig. 39.5):

When the placental edge is touching the internal os, the distance is 0 mm. When the placental edge stops at a distance of 2 cm from the internal os, it is considered to be a low-lying placenta. In this condition, vaginal delivery may be offered, in the absence of torrential bleeding.

2. If the placenta is covering the os, the extent that the placenta covers the internal os should be documented. If it reaches across the internal os, it is a partial previa. If it crosses the internal os and goes to the other side of the cervix, it is a total previa.



Figure 39.5 Distance of placental edge from the cervical os. Ultrasonographic image shows the cervical os (cx), fetal head (HD), and placenta extending to the margin of the os. The distance from the cervical os is marked (1.61 cm). (Photo courtesy: Mediscan Systems, Chennai.)

In women with previous cesarean section and anterior placenta previa, evaluation with color-flow Doppler is essential to exclude placenta accreta. The ultrasonographic appearance of placenta accreta is given in detail in Chapter 43, *Complications of the third stage of labor*.

Magnetic resonance imaging

Magnetic resonance imaging (MRI) has been studied and found to be useful but since TVUS is safe, accurate, and easily accessible, MRI is not recommended for this purpose.

Management

With accurate diagnosis of placenta previa by ultrasonography and practice of expectant management, the perinatal mortality in placenta previa has been reduced considerably.

Initial management

Initial management is as described earlier in this chapter.

- Maternal condition should be assessed, maternal shock should be corrected, and the mother must be stabilized.
- Ultrasonography should be performed for placental localization.
- Fetal status should be assessed by biophysical profile and nonstress test.

Subsequent management

Subsequent management (Fig. 39.6) depends on gestational age and severity of hemorrhage as given below:

- Placenta previa diagnosed in second trimester
- Placenta previa diagnosed in early third trimester with spontaneous cessation of bleeding
- Placenta previa with profuse hemorrhage in second or third trimester

Placenta previa diagnosis in the second trimester

- Diagnosis is usually by routine ultrasonography at 18–20 weeks
- Counseling is important
 - Reassure that most placentae will migrate
 - To report immediately if there is bleeding
 - Repeat ultrasonography is essential
 - No restriction of activity or sexual intercourse
- Repeat ultrasonography at 28 weeks; if still in lower segment, rescan at 4-weekly intervals till 36 weeks
- If persistent at 36 weeks, decide on mode of delivery

Placenta previa diagnosis in early third trimester with spontaneous cessation of bleeding

- *Expectant management* is the choice of treatment. This is based on the following facts:
 - Perinatal mortality is due to prematurity. Prolongation of pregnancy reduces perinatal mortality
 - Initial bleeds are usually minor and self-limiting, and not fatal for the mother or fetus
- If gestational age is <34 weeks, administer two doses of betamethasone 12 mg IM 24 hours apart
- If Rh negative, administer anti-D immunoglobulin
- Tocolytics are not recommended as a routine
- Cervical cerclage is not recommended
- Patient can be discharged if there is no bleeding for 1 week and
 - the patient understands the risks associated with outpatient management
 - has emergency transport to hospital
 - lives within 20–30 minutes from hospital
- Follow-up visits

- Serial ultrasound scans and nonstress tests for fetal growth and surveillance
- Hemoglobin and/or hematocrit
- Iron supplementation
- Counseling
 - To avoid sexual intercourse
 - To report if there is bleeding

Placenta previa with profuse hemorrhage in second or third trimester

- When initial bleeding is profuse and uncontrolled, immediate resuscitation of the mother and cesarean section is indicated irrespective of gestational age. If during expectant management, bleeding recurs or is profuse, admit, evaluate, transfuse blood if needed, and assess fetal well-being. Continue monitoring and follow-up. If bleeding increases progressively and gestational age is >34 weeks, deliver.

Timing of delivery

If there is no recurrent episode of bleeding and fetal growth is normal, delivery should be planned at 37 weeks.

Mode of delivery

Indications for cesarean section

- Complete placenta previa, even if the fetus is dead or malformed
- Marginal placenta previa
- Internal os to placental margin distance of <2 cm
- Malpresentations with any type of placenta previa
- Fetal compromise—growth restriction, fetal heart decelerations
- Profuse bleeding at any gestational age irrespective of type of placenta previa

Vaginal delivery

Vaginal delivery is attempted only when the placental margin is >2 cm from the internal os. There is controversy regarding the mode of delivery when the placental edge is between 0 and 2 cm but since the incidence of cesarean section is almost 90% in these cases, elective cesarean section is recommended.

Intrapartum management

- In women with low-lying placenta, labor should be induced at 38–39 weeks by cervical ripening with prostaglandins.

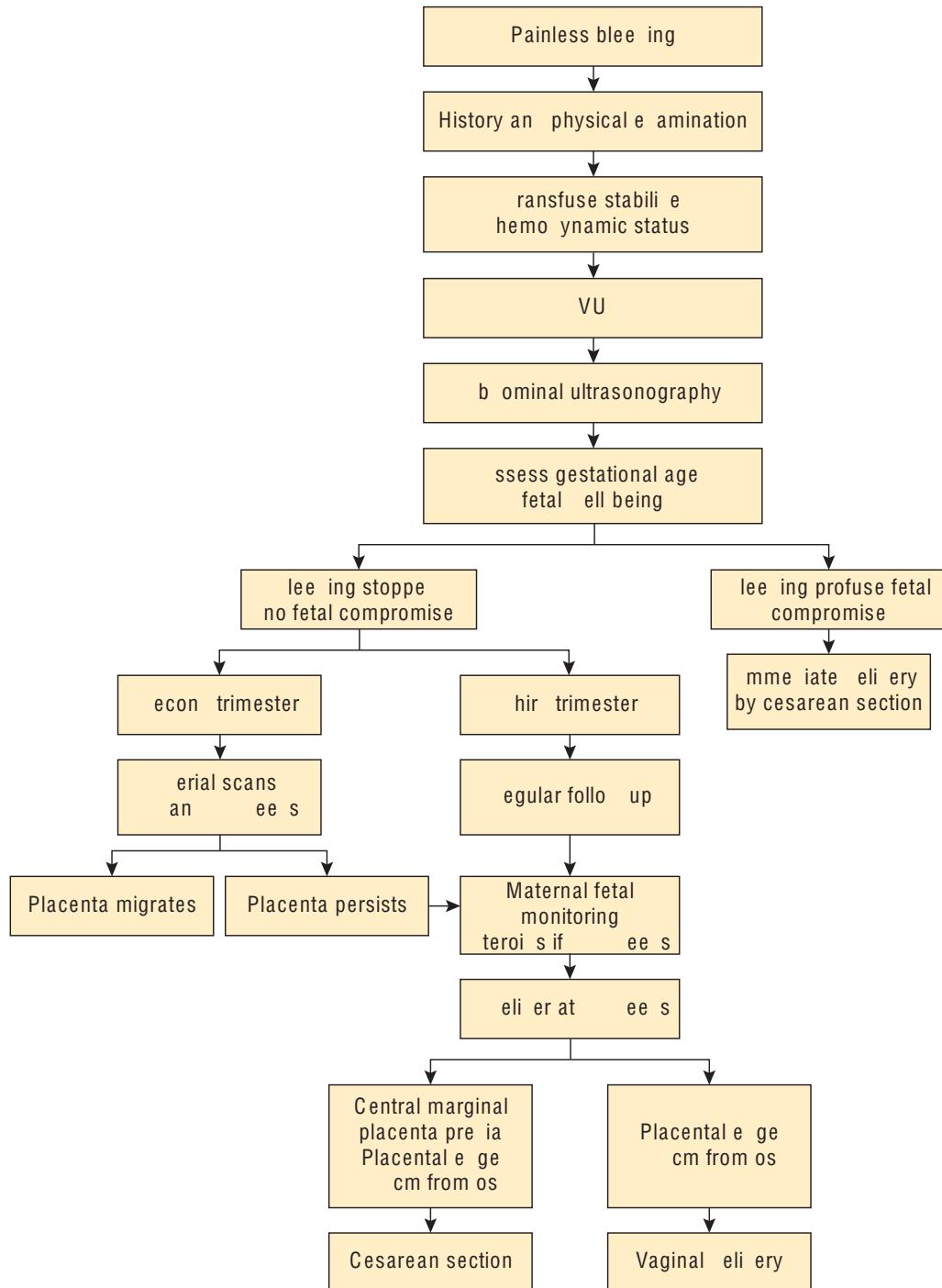


Figure 39.6 Management of placenta previa. \downarrow S transvaginal ultrasonography.

- Pelvic examination should be performed gently. Fornices should be palpated for bogginess, indicating presence of placenta. If no bogginess is felt, fingers are introduced into the os and amniotomy is performed.
- Intrapartum electronic fetal monitoring is recommended.
- Prophylactic uterotronics must be administered in the third stage.
- Postpartum hemorrhage should be watched for.

Cesarean section in placenta previa

Cesarean section in placenta previa is associated with difficulties and complications as given below:

- Fetal malpresentation may make extraction of the fetus difficult.
- Poorly developed and vascular lower uterine segment may lead to an extension of the incision and hemorrhage.
- Difficulty may be encountered in uterine entry with an anterior placenta. There may be a need to cut through the placenta or separate it partially.
- Excessive blood loss may occur that further compromises the condition of the fetus and mother.
- Placenta accreta and percreta (encountered in about 5% of cases with no previous scar in the uterus, and in up to 67% of cases with multiple cesarean sections) may necessitate peripartum hysterectomy.
- Postpartum hemorrhage may occur due to inability of the lower uterine segment to contract efficiently.

roce ure

- Cesarean section for placenta previa should be performed by a senior obstetrician.
- Preoperative ultrasonography should be performed to determine the exact location of the placenta and to exclude placenta accreta.
- Adequate blood (two to four units) should be cross-matched and kept available.
- Fetal lie, presentation, and position of the fetal back and limbs (if breech or transverse lie) should be determined prior to surgery.
- Regional or general anesthesia may be used.
- A transverse incision on the lower segment should be used if the lower segment is formed. A vertical lower-segment incision may be required if the lower segment is not formed or is vascular.
- If the placenta is anterior, one of two approaches is used:
 - Cut through the placenta
 - Find the plane between the placenta and the uterine wall, separate the placenta and push it upward, and enter below the placenta

Both approaches may be associated with profuse bleeding.

- The fetus should be delivered as cephalic or breech, depending on the presentation. If the fetus is in transverse lie, the feet should be identified first. Traction may be applied to the feet and the fetus delivered as breech.
- If there is profuse bleeding from the lower segment, hemostatic mattress sutures can be used to control hemorrhage. If bleeding continues, internal iliac artery ligation or a B-Lynch procedure may be required (see Chapter 43, *Complications of the third stage of labor*).

Placental abruption

Approximately one-third of all antepartum hemorrhages are due to placental abruption. The risk of maternal complications and fetal compromise is high; therefore, prompt delivery is indicated in most cases.

Definition

Placental abruption, also known as *abruptio placenta*, is defined as premature separation of normally implanted placentae, after 24 weeks' gestation. The bleeding occurs between the decidua and maternal surface of placenta.

Incidence

The incidence of placental abruption ranges from 1/100 to 1/230 deliveries. Milder degrees are more common but severe abruption associated with fetal and/or maternal complications occur less frequently. The incidence peaks at 24–26 weeks' gestation. Placental abruption accounts for one-third of all APH.

Classification

Traditionally, placental abruption is classified into four grades according to the severity of abruption and associated maternal and fetal complications (Box 39.7). **Abdominal pain and**

vaginal bleeding are the predominant symptoms, but external bleeding may be absent in concealed hemorrhage.

Pathogenesis

In placental abruption, hemorrhage occurs at the placental-decidua interphase. The blood seeps between the membranes and uterine wall and finally escapes through the cervix into the vagina in *revealed abruption* (Fig. 39.7a). In some cases, blood may be trapped behind the placenta or membranes even after total separation of placenta occurs. There is no external bleeding and the condition is known as *concealed abruption* (Fig. 39.7b). This can occur due to the following:

- Placental margin remains attached though the rest of the placenta is separated
- Placental membranes remains attached
- Blood enters the amniotic cavity through a rent in the membranes.
- The outflow of bleeding is obstructed by the fetal head.

Most often the revealed abruption and concealed abruption coexist and this is referred to as *mixed abruption*.

Box 39.7 Classification (grading) of placental abruption

Grade 0	Asymptomatic, small retroplacental clot
Grade 1	Vaginal bleeding Abdominal pain—mild Uterine tenderness or tetany No fetal distress No maternal complications
Grade 2	Vaginal bleeding present/absent Abdominal pain—moderate Uterine tenderness and tetany Fetal distress No maternal complications
Grade 3	Vaginal bleeding present/absent Abdominal pain—severe and persistent Marked uterine tenderness and tetany Fetal death Maternal shock/coagulopathy/renal failure

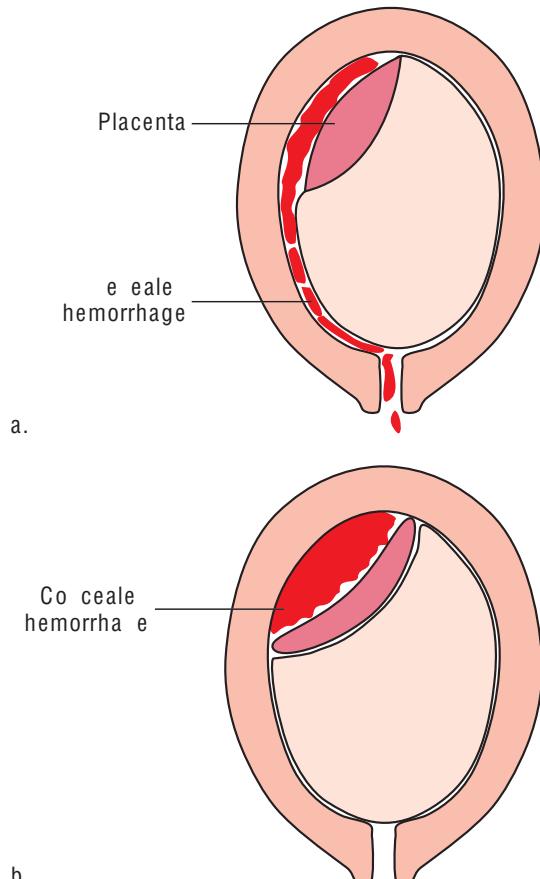


Figure 39.7 Placental abruption. **a.** Revealed hemorrhage. The blood enters the space between the membranes and the uterine wall and escapes through the cervix. **b.** Concealed hemorrhage. The blood is trapped behind the placenta.

In abruption, the bleeding is from the maternal vessels in the decidua; therefore, *the blood loss is maternal*. A retroplacental hematoma is formed initially that enlarges and expands, resulting in total or near total separation of the placenta (Fig. 39.8). Occasionally, bleeding is from feto-placental vessels.

The pathological process leading to hemorrhage is vasospasm of abnormal arterioles. This results in thrombosis and decidual necrosis. There is also poor trophoblastic invasion. This leads to inadequate uteroplacental circulation demonstrated by abnormal uterine artery Doppler flow. These pathological changes in the placenta occur in hypertension, preeclampsia, and thrombophilias. Shearing forces resulting from trauma can also cause hemorrhage.



Figure 39.8 Specimen of placenta shows retroplacental clots formed in concealed hemorrhage. (Photo courtesy: Dr Rajnish Samal, Bangalore.)



Figure 39.9 Couvelaire uterus. Blood has seeped into the myometrium and the uterus appears bluish black. (Photo courtesy: Dr Rajnish Samal, Bangalore.)

Retroplacental hemorrhage and separation of cotyledons interfere with nutrient and oxygen supply to the fetus, resulting in *fetal hypoxia* and ultimately *fetal death*.

Profuse bleeding, concealed or revealed, causes maternal hypotension and *hypovolemic shock*. Reduced renal perfusion causes acute renal cortical necrosis and/or tubular necrosis and *renal failure* (see Chapter 55, *Renal and urinary tract disorders*).

The coagulation cascade is activated due to the release of thromboplastin resulting in *disseminated intravascular coagulation* (DIC) (see Chapter 45, *Nonhemorrhagic shock in pregnancy*).

Thrombin, produced during the process of coagulation, is a uterotonic agent and causes uterine hypertonus and tetany, preterm labor, and prelabor rupture of membranes. Blood seeps into the uterine myometrium resulting in *Couvelaire uterus* (Fig. 39.9). The Couvelaire uterus appears purplish due to the effusion of blood through the myometrium and under the uterine serosa.

In some women, abruption occurs in the first, second, or early third trimester. There is a small amount of retroplacental hemorrhage but the bleeding is arrested and pregnancy continues. This is referred to as *chronic abruption*. Maternal serum alpha fetoprotein is elevated in these cases and *fetal growth restriction* is common.

Pathogenesis of placental abruption is given in Figure 39.10.

isk factors

Risk factors for placental abruption are listed in Box 39.8. The exact etiology is not known but presence of risk factors is associated with an increased incidence of abruption.

Advanced maternal age and multiparity increase the risk due to damaged endometrium and poor decidualization.

Smoking and cocaine abuse cause placental hypoperfusion due to vasospasm of decidual vessels.

Risk of abruption increases five-fold with chronic hypertension and eight-fold with pre-eclampsia. Poor secondary trophoblastic invasion, poor placental perfusion, decidual necrosis, and hemorrhage which are common in these conditions increase the risk of abruption. Acquired thrombophilias (antiphospholipid antibody syndrome) and some hereditary thrombophilias (hyperhomocysteinemia, factor C deficiency) also increase the risk by reducing placental perfusion.

Uterine anomalies and myoma are associated with inadequate decidualization.

Abdominal trauma causes shearing of placenta and tearing of vessels, leading to abruption.

External cephalic version, if not performed carefully, can cause traction on the cord and premature separation of placenta.

Previous abruption is an important risk factor and the recurrence rate is about 5%. Grade 3 abruption has a higher recurrence rate (12%).

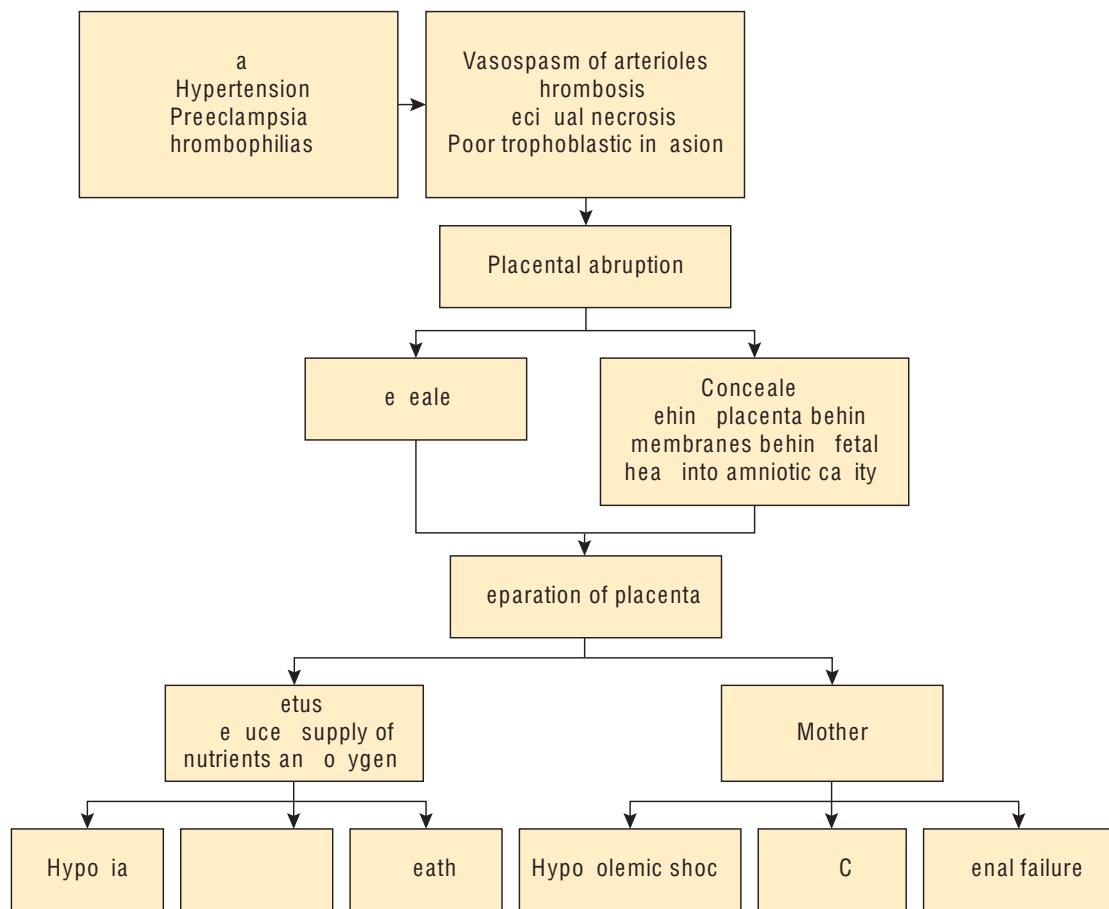


Figure 39.10 Pathogenesis of placental abruption. *DIC*, disseminated intravascular coagulation; *FGR*, fetal growth restriction.

Rapid uterine decompression by sudden release of amniotic fluid can lead to placental separation. This usually happens in polyhydramnios and multifetal pregnancy, both of which are risk factors as well.

Abrupton in preterm prelabor rupture of membranes may be due to release of thrombin, which is a uterotonic. Membrane rupture may also be the consequence of abrupton.

Clinical features

Clinical features vary with the following:

- Acute abrupton
 - Revealed hemorrhage
 - Concealed hemorrhage
- Chronic abrupton

Box 39.8 Risk factors for placental abruption

- Inadequate decidualization
 - Maternal age
 - Increasing parity
 - Uterine anomalies/fibroids
- Vasospasm and placental hypoperfusion
 - Hypertension
 - Preeclampsia
 - Thrombophilias—acquired and inherited
 - Smoking/cocaine use
- Rapid decompression of the uterus
 - Polyhydramnios
 - Multifetal gestation
 - Preterm prelabor rupture of membranes
- Shearing of placental vessels
 - Abdominal trauma
 - External cephalic version
- Other causes
 - Previous abrupton

Acute placental abruption

Revealed abruption is more common and occurs in 90% of cases. The most important symptom is vaginal bleeding with abdominal pain. When the placenta is located on the posterior uterine wall, back pain may be predominant. The uterus is tense and tender. Uterine contractions may be present.

Bleeding may be mild or profuse. There is maternal tachycardia and hypotension. The severity of pain and uterine tenderness may progressively worsen.

As more and more cotyledons separate, fetal heart decelerations occur. When >50% of the placenta separates, fetal death results. Fetal heart trace may reveal variable or late decelerations, prolonged bradycardia, poor variability, or a sinusoidal pattern prior to fetal death.

Maternal urine output drops as renal failure sets in. Disseminated intravascular coagulation ensues and worsens the renal failure and hemorrhage (Box 39.9).

Concealed hemorrhage occurs in 10% of cases. The degree of hypotension is out of proportion to the amount of bleeding seen externally. Bleeding may be mild, moderate, or absent. The uterus is overdistended when the blood collects behind the placenta and membranes, or enters the amniotic cavity. This makes palpation of fetal parts difficult. The uterus may become woody hard when blood infiltrates the myometrium (Couvelaire uterus).

Chronic placental abruption

Chronic placental abruption is usually due to chronic placental ischemia and presents with recurrent episodes of bleeding. It results in growth restriction and oligohydramnios. Coagulation abnormalities do not occur.

Complications of placental abruption

Maternal and fetal complications of abruption are listed in Box 39.10.

Box 39.9 Clinical features of acute placental abruption

- Vaginal bleeding
 - Mild/profuse
- Abdominal pain
 - Mild/severe/persistent
- Backache
- Uterine tenderness
- Uterine tetany
- Uterine contractions
- Overdistended uterus
- Maternal
 - Hypotension
 - Tachycardia
 - Decreased urine output
 - Signs of disseminated intravascular coagulation
- Fetal heart rate abnormalities
 - Variable/late decelerations
 - Poor variability
 - Prolonged bradycardia
 - Sinusoidal pattern

Box 39.10 Complications of placental abruption

- Maternal
 - Hypovolemic shock
 - Renal failure
 - Disseminated intravascular coagulation
 - Preterm labor
 - Prelabor rupture of membranes
 - Instrumental delivery
 - Cesarean section
 - Postpartum hemorrhage
 - Rh sensitization
 - Sheehan syndrome
 - Maternal death
- Fetal
 - Fetal hypoxia
 - Prematurity
 - Fetal growth restriction
 - Fetal death

Maternal complications

Since the bleeding is from the decidua vessels, hypotension, hypovolemia, and shock are common complications. Preexisting hypertension may mask the effects of blood loss but eventually hypotension becomes evident. Acute renal failure may result from hypotension and underperfusion and/or DIC. Acute tubular necrosis is more

common and manifests as oliguria. Acute bilateral cortical necrosis can also occur but is rare.

Disseminated intravascular coagulation is due to release of thromboplastin from the placental bed, activating the coagulation cascade (see Chapter 45, *Nonhemorrhagic shock in pregnancy*). Fibrinogen is consumed during this process, resulting in fall in plasma fibrinogen levels. Increase in fibrinolysis leads to elevated levels of fibrin degradation products and/or D-dimers.

Nonreassuring fetal heart status often necessitates delivery by forceps, vacuum extraction, or cesarean section.

Postpartum hemorrhage may be a consequence of a Couvelaire uterus that does not contract adequately or DIC. Excessive bleeding, either antepartum or postpartum and the attendant severe hypotension can cause necrosis of the physiologically enlarged pituitary (Sheehan syndrome).

Preterm prelabor rupture of membranes is commonly associated with placental abruption. As already mentioned, release of thrombin and the resultant uterine contractions probably play a role.

Maternal mortality in abruption may be due to irreversible shock, respiratory distress syndrome, renal failure, or multiorgan failure. Mortality is higher in women with preeclampsia and preexisting anemia.

Fetal complications

As discussed earlier in the chapter, placental separation leads to fetal hypoxia and fetal death. Prematurity is another cause of perinatal mortality. The incidence of congenital anomalies has been found to be higher in placental abruption (4.4%). Chronic abruption causes fetal growth restriction.

Prediction of placental abruption

Attempts have been made to use the tests for Down syndrome screening and prediction of preeclampsia, to identify women at high risk for placental abruption (Box 39.11). The tests lack adequate sensitivity and positive predictive value for abruption, and therefore are not recommended routinely for this purpose.

Box 39.11 Screening tests for placental abruption

- First trimester
 - Decreased PAPP-A levels
- Second trimester
 - Uterine artery Doppler at 11–14 weeks
 - High pulsatility index
 - Diastolic notch
 - Elevated hCG
 - Elevated serum alpha fetoprotein

hC human chorionic gonadotropin; *PAPP-A*, pregnancy-associated plasma protein A.

Diagnosis

The diagnosis of placental abruption is clinical since investigations may be noncontributory.

istory

A history should be obtained of bleeding, associated pain, uterine contractions, rupture of membranes, hypertension or preeclampsia, and reduced fetal movements. Symptoms such as restlessness, anxiety, tachypnea, thirst and fainting, are indicative of hypovolemia (Box 39.12).

Box 39.12 istory in placental abruption

- Gestational age
- Presenting symptoms
 - Vaginal bleeding
 - Mild/profuse
 - Pain
 - Abdominal pain
 - Backache
 - Pain of uterine contractions
 - Vaginal discharge
 - Symptoms of blood loss and hypovolemia
 - Fainting
 - Restlessness
 - Palpitation
 - Tachypnea
 - Thirst
 - Sweating
 - Decreased fetal movements
- Past history
 - Hypertension
 - Obstetric history
 - Preeclampsia
 - Previous abruption
 - Recurrent episodes of bleeding

Physical examination

Severity of bleeding, uterine size, and condition of the mother and fetus should be assessed on physical examination (Box 39.13). Vaginal examination should not be performed until placenta previa is excluded by ultrasonography. However, if rupture of membranes is evident, the presenting part is engaged or well-fixed, and definite clinical signs of abruption are present, careful pelvic examination may be undertaken. The presence of clots in the vagina, dilatation and effacement of cervix, the presence or absence of membranes, presentation, station of presenting part, and draining of blood-stained amniotic fluid should be documented.

Placenta previa versus placental abruption

The most important differential diagnosis for placental abruption is placenta previa, since these two conditions are the most common causes of APH. The differentiating features are given in Table 39.1. However, confirmation of the diagnosis is finally by ultrasonography.

Investigations

Ultrasonography

Ultrasonography is the most important step in evaluation. **This is more useful in excluding placenta previa rather than confirming abruption.**

Box 39.13 Physical examination in placental abruption

- General examination
 - Pulse
 - Blood pressure
 - Amount of bleeding
- Abdominal examination
 - Uterine size
 - Consistency
 - Tenderness
 - Contractions
 - Palpation of fetal parts
 - Presentation
 - Fetal heart sounds
- Local examination
 - Vaginal bleeding
 - Leaking of amniotic fluid
- Vaginal examination (if performed)
 - Clots in the vagina
 - Cervical effacement
 - Cervical dilatation
 - Presence or absence of membranes
 - Presentation/station
 - Blood-stained amniotic fluid

The two may coexist in 10% of cases. Findings on ultrasonography are variable (Fig. 39.11).

- A retroplacental hematoma is not always seen. Early retroplacental clot is isoechoic or hyper-echoic and may be interpreted as thickened placental tissue. The clot becomes hypoechoic and sonoluent after 1–2 weeks.

Table 39.1 Differences between placenta previa and placental abruption

	Placenta previa	Placental abruption
Bleeding	<ul style="list-style-type: none"> • Painless • Recurrent, small bouts 	<ul style="list-style-type: none"> • Associated with pain • Usually single bout
Shock	Proportionate to blood loss	Out of proportion to blood loss (if concealed)
Uterine size	Corresponds to gestation	Larger than gestation
Uterus	Relaxed	Tense and tender
Malpresentations	Common	Not common
Presenting part	High and mobile	Fixed or engaged
Fetal parts	Well felt	Difficult to palpate
Fetal heart rate and trace	Normal	Abnormal
Renal failure and DIC	Not common	Common
Placenta accreta	Common	Not common

D C, disseminated intravascular coagulation.



Figure 39.11 Abdominal ultrasonography of placental abruption. Preplacental hematoma seen on the fetal surface of the placenta.

- If a retroplacental hematoma can be identified, it indicates massive bleeding and the woman will be in shock.
- Subchorionic and preplacental hematomas may be seen located between membranes and the uterine wall or on the fetal surface of the placenta.
- Intrauterine clots may be seen floating in amniotic fluid which 'jiggle' on maternal movement or on bouncing with the transducer ('Jello' sign).
- The sensitivity of ultrasonography in identifying placental abruption is 25%–50%.

Magnetic resonance imaging

Magnetic resonance imaging can be used to diagnose abruption when in doubt but is not recommended routinely.

Management

Management depends on the following:

- Severity of abruption
- Gestational age
- Maternal condition
- Condition of the fetus

Initial management

Initial management is as described earlier in this chapter.

- Evaluate mother for amount of blood loss and correct maternal shock.
- Catheterize the bladder and monitor hourly urine output.

- Stabilize the patient with crystalloids and colloids as required.
- Send blood for coagulation profile—platelet count, prothrombin time, partial thromboplastin time, plasma fibrinogen levels, and fibrinogen and fibrin degradation products.
- Perform ultrasonography to exclude placenta previa and, if possible, to confirm abruption.
- Assess fetal status by biophysical profile and nonstress test.
- Perform a bedside clotting test if facilities for DIC workup are not available.
- If hourly urine output is <30 mL/hour, insert a central venous line.

Subsequent management

This depends on fetal condition, gestational age, presence of uterine contractions, and rupture of membranes. Management options are as follows:

- Immediate delivery
 - Vaginal delivery
 - Cesarean section
- Expectant management

Immediate delivery

Most women with placental abruption require immediate delivery since the bleeding is moderate to severe and maternal complications and/or fetal distress are usually present.

Indications for immediate delivery are listed in Box 39.14.

Mode of delivery

After the initial treatment to stabilize the mother's condition, the fetal heart rate pattern is evaluated by electronic fetal monitoring and a decision is taken regarding mode of delivery (Box 39.15).

Box 39.14 Indications for immediate delivery in placental abruption

- Irrespective of gestational age
 - Moderate-to-severe bleeding
 - Maternal complications
 - Fetal distress
 - Fetal death
- Gestational age >34 weeks
 - Mild bleeding

Box 39.15 Mode of delivery in placental abruption

- Cesarean section, if
 - the abruption is severe and bleeding persistent
 - nonreassuring fetal status
 - maternal renal failure or DIC
- Vaginal delivery, if
 - the fetus is alive, fetal heart rate pattern is normal
 - bleeding is mild to moderate
 - fetus is dead but maternal condition is stable

D C disseminated intravascular coagulation.

Cesarean section

Immediate cesarean section is indicated if the bleeding is profuse and persistent indicating severe abruption, if the fetal heart trace is abnormal, or if maternal complications such as DIC or renal failure are present. Correction of DIC with blood and blood products must proceed simultaneously with preparations for cesarean section.

A Couvelaire uterus may be found at cesarean section. A Couvelaire uterus does not contract adequately because of extravasation of blood into the myometrium, and atonic postpartum hemorrhage is common. Prophylactic uterotronics must be administered and bleeding must be managed aggressively.

Vaginal delivery

Vaginal delivery may be an option in certain situations (given in Box 39.15). The steps are as follows:

- Vaginal examination to assess the cervical effacement and dilatation
- Amniotomy
- Continuous electronic fetal monitoring mandatory
- Oxytocin augmentation, if required
- If fetal heart trace shows abnormality, immediate cesarean section
- If delay in second stage, instrumental delivery undertaken
- Prophylactic uterotronics (oxytocin) mandatory after delivery of the placenta

With a dead fetus, delivery is achieved following amniotomy in most cases, as long as the maternal condition is stable. Oxytocin augmentation may be required in a few but hyperstimulation should be watched for.

When the fetus is alive, a close watch should be kept on the fetal status. Partial abruption can progress rapidly to complete separation of the placenta and fetal death; therefore, continuous fetal heart rate monitoring is essential. Immediate cesarean section is warranted in the presence of fetal heart rate abnormalities.

When the fetal heart pattern becomes abnormal, and a decision for a cesarean section has been made, the decision-to-delivery time should not exceed 20 minutes, to avoid fetal asphyxia.

Postpartum management

- Maternal pulse, blood pressure, and urine output should be monitored.
- 20 units of oxytocin should be administered in 500 mL of normal saline.
- If the uterus is atonic, ergometrine and prostaglandin F_{2-a} should be administered (see Chapter 43, *Complications of the third stage of labor*).

Expectant management

There is only a limited role for expectant management in placental abruption since fetal growth restriction, oligohydramnios, preterm labor, or progresses of abruption are common. The indications are listed in Box 39.16.

Expectant management consists of the following:

- Discharge after 48 hours
- Counseling regarding immediate return to hospital if
 - fetal movements decrease
 - bleeding recurs
 - uterine contractions begin
- Weekly biophysical profile and estimation of fetal growth and weight
- Betamethasone two doses 24 hours apart to accelerate pulmonary maturity
- Role of tocolysis in the event of preterm labor controversial; not recommended as routine
- Kleihauer-Betke test and administration of anti-D immunoglobulin, if Rh negative

Box 39.16 Indications for expectant management in placental abruption

- Nonsevere abruption at <34 weeks
- No maternal complications
- Fetal surveillance tests are normal

- Deliver if fetal growth restriction, oligohydramnios or recurrent bleeding
- Induction of labor 37–38 weeks by cervical ripening with prostaglandin E₂, amniotomy, and oxytocin
- Management of placental abruption is given in Figure 39.12

Vasa previa

Vasa previa is rare cause of antepartum hemorrhage. Bleeding occurs intrapartum and can be profuse; therefore, fetal hypoxia is common.

Definition

Vasa previa is defined as the presence of umbilical vessels running through the membranes across the internal os below the presenting part, before reaching the placenta.

Since the vessels are not protected by Wharton's jelly, they are prone to rupture and compression and torrential bleeding during labor.

This can be of two types:

1. Velamentous insertion of cord (Fig. 39.13)
2. Vessels running between placenta and its succenturiate lobe

Clinical features and management of vasa previa are summarized in Box 39.17.

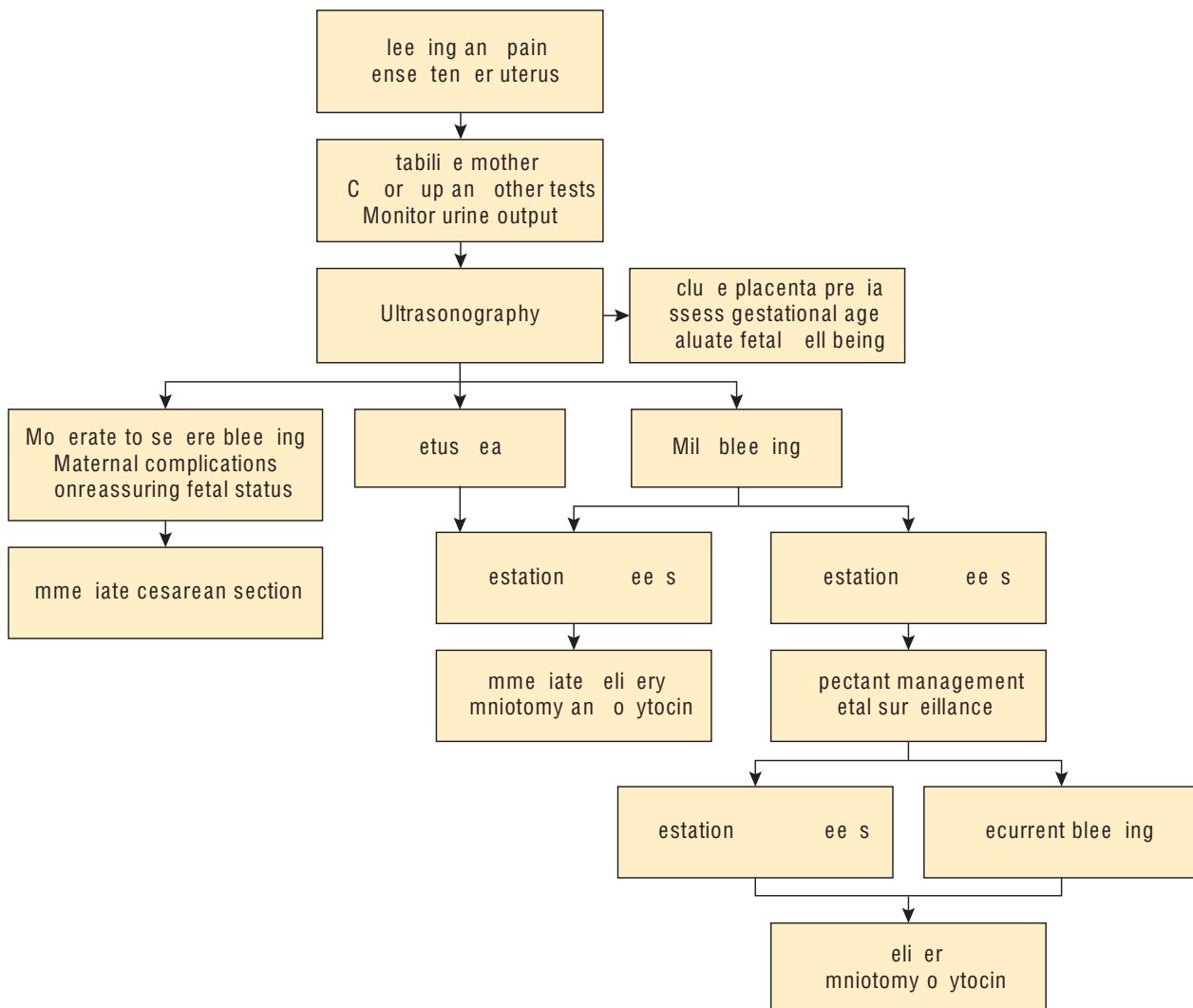


Figure 39.12 Management of placental abruption. D C, disseminated intravascular coagulation; FGR, fetal growth restriction.

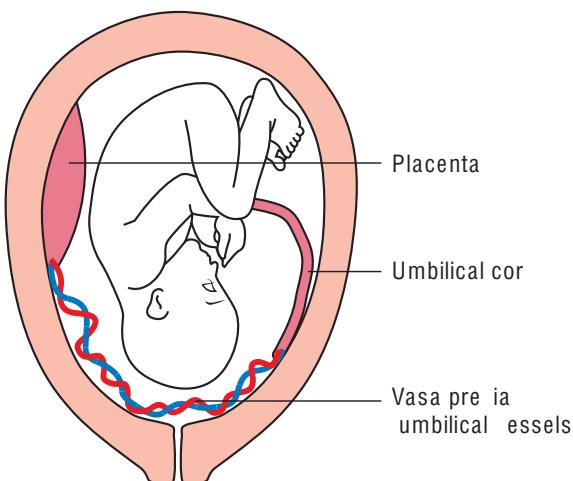


Figure 39.13 Vasa previa. Velamentous insertion of the cord with umbilical vessels running along the membranes across the internal os before entering the placenta.

Box 39.17 Clinical features and management of vasa previa

- The condition is rare
- Bleeding is from fetal vessels
- Occurs when membranes rupture
- High perinatal mortality (75%)
- Difficult to diagnose antenatally
- If diagnosed antenatally
 - Elective cesarean section
- If diagnosed intrapartum
 - Expedite delivery
 - Resuscitate neonate

Unclassified hemorrhage

Unclassified hemorrhage is APH with no evidence of placental abruption or placenta previa. Clinical course and management are summarized in Box 39.18.

Box 39.18 Unclassified hemorrhage

- No evidence of placenta previa or abruption
- Most commonly due to
 - marginal sinus rupture
 - tumors of the cervix/infections
 - exaggerated show
- Diagnosis
 - Exclude placenta previa and abruption
 - Speculum examination after bleeding stops
- Management
 - Evaluate fetal status
 - If gestation >37 weeks—deliver
 - If gestation <37 weeks
 - Fetal surveillance
 - Deliver at 38 weeks/term

Key points

- Antepartum hemorrhage (APH) is bleeding from the genital tract after 24 weeks' gestation prior to delivery of the baby.
- The important causes are placenta previa and placental abruption.
- Initial assessment consists of history and physical examination to assess maternal status, amount of bleeding, gestational age, and fetal status.
- After the mother is stabilized, ultrasonography should be performed to determine the cause of bleeding and evaluate fetal status.
- Placenta previa is defined as a placenta that is implanted over or adjacent to the internal os. It is classified into total, partial, marginal and low-lying placenta previa.
- Transvaginal and translabial ultrasonography have close to 100% accuracy in the diagnosis of placenta previa.
- The typical presentation is painless vaginal bleeding. The uterus is relaxed, malpresentations are common, and the presenting part is high up.
- Vaginal examination should not be performed in women presenting with bleeding in the third trimester, until placenta previa is excluded.
- Initial bleeding is usually mild and occurs before 32 weeks' gestation.
- Expectant management is the option if placenta previa is diagnosed in early third trimester and there is spontaneous cessation of bleeding.
- If bleeding is profuse, immediate delivery is indicated.

(Continued)

Key points *Continued*

- If the placenta is total or marginal or the placental edge is <2 cm from the os, cesarean section is indicated. If the placental edge is >2 cm from os, vaginal delivery may be attempted.
- Placenta accreta and postpartum hemorrhage are common complications.
- Placental abruption is the premature separation of a normally implanted placenta. It is classified as grade 0, 1, 2, and 3. It may be concealed, revealed, or mixed.
- The usual presentation of placental abruption is bleeding and pain. Uterine contractions and rupture of membranes may be present. The uterus is tense and tender, uterine size is larger than gestational age, and fetal parts are difficult to palpate.
- Shock is out of proportion to amount of blood loss in concealed hemorrhage. Maternal renal failure and disseminated intravascular coagulation are other major complications.
- Fetal distress and fetal death are common in severe abruption.
- Ultrasonography is not a sensitive method to diagnose abruption. It is used mainly to exclude placenta previa rather than confirm abruption.
- If bleeding is moderate to severe, maternal complications are present, or there is nonreassuring fetal status, immediate cesarean section is indicated. If bleeding is mild and gestation is >34 weeks, or if the fetus is dead and maternal status is stable, vaginal delivery can be tried.

Self-Assessment

Case-based questions

Case 1

Mrs. AN, 22, primigravida, was admitted to the labor room at 32 weeks' pregnancy with sudden onset of vaginal bleeding. There was no associated abdominal pain. On examination, she had tachycardia, pulse rate was 110/min, and blood pressure was 100/70 mm Hg. The uterus was 32 weeks size, not tense or tender, and the fetus was in cephalic presentation.

- What is the differential diagnosis?
- How will you confirm the diagnosis?
- How will you manage?
- What complications do you anticipate?

Case 2

Mrs. SK, 30, multigravida, was admitted to the labor room at 36 weeks' gestation with vaginal bleeding, abdominal pain, and absent fetal movements since the onset of bleeding. She was pale, restless and sweating, had tachycardia, and the blood pressure was 80/60 mm Hg. Fetal heart tones were not recordable.

- What is the likely diagnosis?
- What are the maternal complications? What complication does this woman have?
- What would be the management?
- If the fetus was alive and bleeding was moderate, how would you manage the case?

Answers

Case 1

1. Placenta previa and placental abruption. Other conditions such as vasa previa and unclassified bleeding are unlikely and should be considered only if the first two are excluded.
2. a. History: Painless bleeding.
b. Physical examination: Tachycardia and drop in blood pressure.
c. Abdominal examination: Relaxed uterus, size corresponding to gestation, malpresentation, floating head.
d. Abdominal ultrasonography followed by transvaginal ultrasonography (TVUS).
3. Initial management: Start IV line, send blood for hematocrit and cross-match, transfuse if hematocrit is low.
If the bleeding stops and fetal evaluation is normal, expectant management. Regular fetal surveillance and delivery at 37 weeks. If total or marginal placenta previa or if placental edge is <2 cm from the os, cesarean section. If placental edge is >2 cm from the os, vaginal delivery.

4. Maternal complications: Preterm labor, placenta accreta, postpartum hemorrhage, cesarean section, instrumental delivery.
Fetal complications: Prematurity, malpresentations, fetal hypoxia, fetal death.

Case 2

1. Placental abruption with fetal demise.
2. Hypovolemic shock, DIC, renal failure, cesarean section, maternal mortality.
This patient has hypovolemic shock.
3. Initial management: IV line, blood transfusion, maternal stabilization. Monitor urine output, perform DIC workup.
Since the fetus is dead, immediate delivery is indicated. If the patient stabilizes after resuscitation, amniotomy with oxytocin may result in vaginal delivery. If profuse bleeding persists, cesarean section should be performed.
4. With moderate bleeding and a live fetus, stabilize the patient, perform amniotomy and administer oxytocin with electronic fetal monitoring. If nonreassuring fetal status, immediate cesarean section. If trace normal throughout, vaginal delivery.

Sample questions

Long-answer questions

1. Discuss the etiology and classification of placenta previa. How would you manage a third gravida with painless vaginal bleeding at 32 weeks' gestation?
2. Discuss the clinical features, diagnosis, and management of placenta previa.
3. Define APH. What are its causes? How do we manage a case of placental abruption at 32 weeks' gestation?

Short-answer questions

1. Expectant management in placenta previa
2. Cesarean section in placenta previa
3. Complication of abruptio placenta
4. Couvelaire uterus
5. Differential diagnosis of bleeding at 32 weeks' gestation

Section 6

Obstetric Complications: Intrapartum

40

Abnormal Labor: Abnormalities in Passage and Powers

Case scenario

Mrs. BN, 28, primigravida, at 40⁺³ weeks' gestation, was admitted to the labor room with pains. On examination, she had regular uterine contractions once every 5 minutes, lasting for 40 seconds. The vertex was three-fifth palpable abdominally, and fetal heart sounds were normal. She was diagnosed to be in labor; on pelvic examination, the cervix was fully effaced and 4-cm dilated. The vertex was at -2 station. She was expected to deliver in the next 6 hours. But, on examination after 4 hours, the contractions were once every 8–10 minutes, lasting for 30 seconds. The vertex was still three-fifth palpable, cervix was 5-cm dilated, and vertex was at -2 station. The mother and her relatives were worried about the lack of progress in labor.

Introduction

The process of labor proceeds normally in most women. However, abnormalities of labor do occur. These may be due to abnormalities of the pelvis, uterine contractions, malpresentations or large size of the fetus. A thorough knowledge of the conditions leading to labor abnormalities, is essential for optimal maternal and perinatal outcome.

Definition

Labor is considered abnormal when it is prolonged or does not progress as expected and

the labor curve falls outside the normal. The abnormality may be in the latent or active phase of the first stage or in the second stage of labor.

Causes of abnormal labor

Causes of abnormal labor may be in the passage, powers, or passenger (Box 40.1). Most often, they occur in combination and one abnormality can lead to another. This chapter deals with abnormalities of the passage and powers.

Box 40.1 Causes of abnormal labor

- Abnormalities in passage
 - Bony pelvis
 - Contracted pelvis
 - Pelvic configuration
 - Soft tissues
 - Noncompliant cervix (cervical dystocia)
 - Congenital anomalies of uterus, cervix, and vagina
 - Myoma, ovarian mass
- Abnormalities in powers
 - Abnormal uterine action
 - Hypotonic uterine action
 - Hypertonic uterine action
 - Precipitate labor
 - Inadequate maternal powers
- Abnormalities in passenger (fetus)
 - Large size
 - Abnormal presentation
 - Face, brow
 - Breech
 - Shoulder
 - Compound
 - Abnormal position
 - Occipitoposterior
 - Asynclitism
 - Fetal anomalies
 - Hydrocephalus
 - Meningocele/meningomyelocele
 - Fetal abdominal distension

Box 40.2 Pelvic diameters in contracted pelvis

- Inlet contraction
 - Anteroposterior diameter <10 cm
 - Transverse diameter <12 cm
 - Diagonal conjugate <11.5 cm
- Midpelvic contraction
 - Transverse + posterior sagittal diameter ≤ 13.5 cm
 - Transverse (interischial spinous) diameter <8 cm
- Outlet contraction
 - Interischial tuberous diameter =/≤ 8 cm

Diagnosis of contracted pelvis is made when the pelvic diameters are as given in Box 40.2.

When there is inlet contraction, the head does not descend until onset of labor or may not enter the pelvis at all. This can result in floating head at term, deflexion or extension of fetal head (leading to face or brow presentation) or transverse lie.

Midpelvic contraction is more common than inlet contraction. Interischial spinous (transverse) diameter at midpelvis is the narrowest diameter of the pelvis and is normally 10 cm; when this is less than 8 cm, the head cannot pass through and results in obstructed labor.

Interischial tuberous diameter of <8 cm is diagnostic of outlet contraction and is associated with a narrow subpubic arch. This pushes the head posteriorly and results in third- and fourth-degree perineal tears. Isolated outlet contraction is rare; it is usually associated with midpelvic contraction (Box 40.3).

Box 40.3 Contracted pelvis

- Definition
 - One or more diameters < normal
 - At one or more levels
- Occur in
 - Short women (height <146 cm)
 - Rickets/osteomalacia
 - Pelvic trauma
 - Abnormalities of vertebral column
 - Lower limb deformities
- Inlet contraction
 - Nonengagement of head
 - Face/brow/shoulder presentation
 - Floating head at term
- Midpelvic contraction
 - Prolonged labor
 - Obstructed labor
- Outlet contraction
 - Isolated outlet contraction is rare
 - Usually associated with midpelvic contraction
 - Causes third- or fourth-degree perineal tears

Abnormalities of passage

As already mentioned, abnormalities of passage include those of the bony pelvis or soft tissues.

Abnormalities of bony pelvis

Contracted pelvis and abnormal pelvic configuration are the usual abnormalities of the bony pelvis. These abnormalities of the bony pelvis lead to cephalopelvic disproportion.

Contracted pelvis

The pelvis is said to be contracted if one or more diameters of the pelvis at one or more planes is less than normal. Contraction may be at the inlet, midpelvis, or outlet. Combinations of contraction at various levels may be present. Contraction in one diameter may be compensated by slight increase in another diameter.

A pelvis that is of normal configuration but has smaller diameters is often seen in short, small-built women (height <146 cm). The fetus is also smaller in these women; therefore, labor proceeds normally. But, if the baby is large, labor is prolonged or may even be obstructed.

Contracted pelvis is also seen in the following conditions:

- Rickets/osteomalacia
- Pelvic fractures
- Abnormalities of vertebral column such as kyphosis, scoliosis, and spina bifida
- Lower limb deformities, for example, poliomyelitis

Pelvic configuration

Four major types of pelvis have been described—**gynecoid, android, anthropoid, and platypelloid** (see Chapter 2, *Anatomy of the bony pelvis and fetal skull*). The gynecoid pelvis is the normal female type and all normal pelvic diameters are described with reference to this. The normal pelvic configuration is such that the fetal presentation is usually vertex in left occipitotransverse (OT) or occipito anterior (OA) position and cardinal movements of labor proceed normally.

The android pelvis has converging sidewalls, contraction at the midpelvis, a narrow interschial spinous diameter, and beaked forepelvis. Obstructed labor, persistent occipitoposterior (OP) position, and deep transverse arrest are common.

The anthropoid pelvis is anteroposteriorly oval and has increased anteroposterior (AP) diameter at all levels. Occipitoposterior positions and face-to-pubis delivery are more common.

The platypelloid or flat pelvis is transversely oval and has increased transverse diameters and narrow AP diameters. Asynclitic engagement, deflexion and extension of head, and arrest in the transverse diameter are the problems encountered (Table 40.1).

Cephalopelvic disproportion

Anatomical disproportion between the fetal head and maternal pelvis, known as *cephalopelvic disproportion* (CPD), can lead to abnormal labor. Cephalopelvic disproportion may be due to the following:

- Contracted pelvis
- Pelvic configuration
- Large size of the fetus
- Fetal malposition

abor in omen ith C D

Normal labor and delivery are possible in women with mild to moderate CPD because of the following reasons:

- Contraction in one diameter may be compensated by increase in another diameter.
- Good uterine contractions assist in overcoming obstruction.

Table 40.1 Effects of pelvic configuration on labor

Type of pelvis	Shape and diameters	Effects on labor
Gynecoid	Normal female	<ul style="list-style-type: none"> • Vertex presentation • OA/OT position • Normal labor
Android	Converging side walls	Prolonged labor
	Midpelvic contraction	Obstructed labor
	Beaked forepelvis	<ul style="list-style-type: none"> • Persistent OP position • Deep transverse arrest
Anthropoid	Anteroposteriorly oval	OP position
	Smaller transverse diameters	Face-to-pubis delivery
Platypelloid	Transversely oval	Asynclitism
	Smaller AP diameters	<ul style="list-style-type: none"> • Extended head (face) • Transverse arrest

AP, anteroposterior; A, occipitoanterior; P, occipitoposterior; , occipitotransverse.

- The pelvic diameters increase slightly in labor due to uterine contractions and pressure of the presenting part ('give' of the pelvis).
- The fetal head molds and the fetal diameters reduce, facilitating descent of the head.

Complications o C D

The fetal head does not fit well in the lower uterine segment and cervix. The intrauterine pressure is transmitted to the forewaters, leading to prelabor rupture of membranes. Cord prolapse is also common for the same reason. Cervical dilatation may not occur since the vertex does not press against it during contraction. Malpresentations are common. Labor may be prolonged with associated increase in risk of fetal asphyxia, intrauterine infection (maternal and fetal), operative vaginal delivery, and cesarean section. Obstructed labor and uterine rupture can occur where facilities for cesarean section are not available (Box 40.4).

Diagnosis o C D

Diagnosis of contracted pelvis is by history, physical examination, and pelvimetry. Tests have been evolved to assess the disproportion between the fetal head and the pelvis. However, monitoring the progress in labor is the best way to assess CPD.

Clinical evaluation

istory

Multiparous women with pelvic abnormalities have a history of previous difficult labor, difficult operative vaginal delivery, cesarean section, fetal asphyxia, or intrapartum death. Nulliparous women may give a history of rickets or poliomyelitis in childhood (Box 40.5).

Box 40.4 Complications of cephalopelvic disproportion

- Prelabor rupture of membranes
- Cord prolapse
- Lack of cervical dilatation
- Malpresentations
- Prolonged labor
 - Fetal asphyxia
 - Maternal and fetal infection
- Operative vaginal delivery
- Cesarean section
- Obstructed labor
- Uterine rupture

Box 40.5 istory

- Past history
 - Poliomyelitis
 - Rickets/osteomalacia
 - Pelvic trauma
 - Tuberculosis of the spine
- Obstetric history
 - Prolonged labor
 - Difficult operative vaginal delivery
 - Cesarean section
 - Fetal asphyxia
 - Intrapartum fetal death
 - History of large baby, weight >3.5 kg

Physical e amination

Women with a small pelvis are generally short. The abdomen may be pendulous. Obstetric examination may reveal a mobile head at term, deflexed head, occiput posterior position, or malpresentations such as face or breech. The mother's gait, vertebral column, and lower limbs should be examined (Box 40.6).

Clinical pelvimetry

Clinical internal pelvimetry by pelvic examination is the only method commonly used to assess the type and dimensions of the pelvis. Predictive values of clinical pelvimetry are poor. An idea about the pelvic configuration and

Box 40.6 Physical examination

- General examination
 - Height <146 cm
 - Gait
 - Spine
 - Kyphosis
 - Scoliosis
 - Spina bifida
 - Lower limbs
 - Poliomyelitis
- Obstetric examination
 - Pendulous abdomen
 - Mobile head
 - Deflexed head
 - Occipitoposterior position
 - Malpresentations
 - Face
 - Brow
 - Breech
 - Shoulder

obvious reduction in diameters can be obtained by estimation of diagonal conjugate, interischial spinous diameter, intertuberous diameter, subpubic arch, and subpubic angle (*see Chapter 2, Anatomy of the bony pelvis and fetal skull*).

Procedure

The bladder and bowel should be empty for proper assessment of the pelvis. An enema is not necessary but a mild laxative may be administered the previous night. The mother should be asked to void before the procedure. Pelvic examination is performed under aseptic precautions, with the mother in dorsal position. The index and middle fingers of the right hand are introduced into the vagina and the pelvis assessed systematically as described in Box 40.7.

The diagonal conjugate is measured as described in Chapter 2, *Anatomy of the bony pelvis and fetal skull*. The sacral promontory is not easily reached ('tipped') in the normal gynecoid pelvis. Hence, the diagonal conjugate cannot be measured. The AP diameter of the inlet (the true conjugate or obstetric conjugate) is estimated by subtracting 1.5–2 cm from the diagonal conjugate since this cannot be measured directly. The posterior sagittal diameter can be measured directly as the distance from the tip of coccyx to the midpoint of the line joining the two ischial tuberosities. This diameter, if adequate, can compensate

for a narrow subpubic angle in which the head emerges more posteriorly (android pelvis).

Assessment of CPD

Clinical assessment of the pelvis and diagnosis of contracted pelvis or abnormal pelvic configuration is possible, to some extent, with clinical pelvimetry. An assessment of CPD resulting from pelvic abnormalities or the size of the fetal head is difficult. Disproportion is best diagnosed in labor by poor progress or failure to progress.

The head fitting test and the Munro-Kerr-Muller test have been described and used in the past, but the sensitivity and predictive value of these tests are low, they are not reproducible, and they are difficult to perform in a woman who is not in labor. Moreover, they assess disproportion only at the inlet. **These tests are, therefore, not used in modern obstetric practice.**

Head fitting test

The woman is placed in the semirecumbent position with a 45 degree tilt. The legs are semiflexed at the thigh and knee. Standing on the woman's right, the obstetrician grasps the fetal head with the fingers of the left hand and pushes it downward and backward into the pelvis (Fig. 40.1). The right hand is placed on the lower abdomen, flush with the pubic bone. If the fetal head is felt to enter the pelvis, there is no CPD; if the head comes flush with or overrides the pubic bone, CPD is diagnosed.

Box 40.7 Clinical pelvimetry normal gynecoid pelvis

Assessment of inlet

- Diagonal conjugate: 12.5 cm
- Sacral promontory: Not easily tipped

Assessment of midcavity

- Sacral curvature
 - Above downward: Well curved
 - Side to side: Well curved
- Sacrosciatic notch: Admits 2 fingers
- Pelvic side walls: Parallel
- Ischial spines: Not prominent
- Interischial spinous diameter: >10 cm
- Forepelvis: Rounded

Assessment of the outlet

- Subpubic arch: Rounded
- Subpubic angle: Admits 2 fingers (>90°)
- Interischial tuberous diameter: Admits 4 knuckles
- Posterior sagittal diameter: >7.5 cm



Figure 40.1 Head fitting test. Woman is in semirecumbent position. The fetal head is pushed down into the pelvis with left hand and the right hand is kept flush with the pubic symphysis.

Munro-Kerr-Muller test

The Munro-Kerr-Muller test is an abdominovaginal examination (Fig. 40.2). The steps of the examination are as follows:

- The bladder and rectum should be empty.
- The woman is placed in the dorsal position.
- Aseptic precautions to be followed.
- The index and middle fingers of the gloved right hand are introduced into the vagina and clinical pelvimetry, if not already done, is performed.
- The fingers are placed at the level of ischial spines.
- The left hand is placed on the mother's abdomen.
- The fetal head is pushed into the pelvis (downward and backward) with the left hand.
- If the leading part of the vertex can be pushed down to the level of ischial spines (touches the fingers of the right hand), CPD is ruled out.
- If the vertex does not come down to the level of ischial spines, the right thumb is placed on the pubic symphysis:
 - Fetal head is flush with the symphysis—minor degree of disproportion.
 - Fetal head overrides the symphysis—major degree of disproportion.

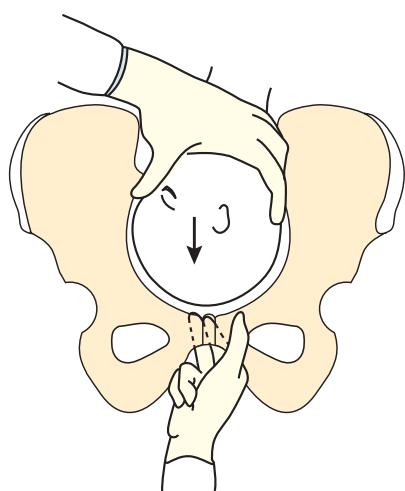


Figure 40.2 Munro-Kerr-Muller test. Index and middle fingers of the right hand are introduced into the vagina and placed at the level of ischial spines; thumb is placed flush with the pubic symphysis. Head is pushed down into the pelvis with the left hand.

-ray pelvimetry

X-Ray pelvimetry was used to measure the pelvic diameters and evaluate the type of pelvis in the past, but it has not been found to be more useful than clinical pelvimetry. Anteroposterior, superior, lateral, and inferior views were used to assess the shape of inlet and outlet and measure AP and transverse diameters at inlet, cavity, and outlet. However, X-ray pelvimetry is not useful for diagnosis or prediction of CPD. It may be used in women with a history of pelvic fractures to assess the extent of deformity.

Computerised tomographic pelvimetry

Computed tomographic (CT) pelvimetry is associated with far less radiation to the fetus and is easier to perform. The ability to predict CPD is similar to that of X-ray pelvimetry.

Magnetic resonance imaging

There is no risk of radiation exposure with magnetic resonance imaging (MRI) and the measurements are more accurate. However, prediction of dystocia and CPD is not superior to that in other methods.

Pelvimetry by imaging techniques is listed in Box 40.8.

Management of labor in women with CPD

In the past, when the clinical diagnosis of CPD was considered reliable, all women with a major

Box 40.8 Pelvimetry by imaging techniques

- X-ray pelvimetry
 - Risk of radiation to fetus
 - Can measure AP and transverse diameters
 - Can evaluate pelvic shapes
 - Not a good predictor of CPD
- CT pelvimetry
 - Less radiation risk to fetus
 - Easier to perform
 - More accurate measurement of pelvic diameters
 - Not a good predictor of CPD
- MRI pelvimetry
 - No risk of radiation to fetus
 - Accurate measurement of pelvic diameters
 - Not a good predictor of CPD/dystocia
 - Expensive

AP, anteroposterior; CPD, cephalopelvic disproportion; C computed tomography, MRI, magnetic resonance imaging.

degree of disproportion were delivered by cesarean section. Those with minor degree of CPD were subjected to '*trial of labor*.' Good uterine contractions were ensured and oxytocin administered, if required. With the 'give' of the pelvis and adequate uterine contractions, deflexion and malposition were corrected and vaginal delivery achieved. Cesarean section was undertaken when there was no progress in labor.

In current obstetrics, no special test is done to diagnose or predict CPD prior to onset of labor. A short primigravida or a macrosomic fetus may alert the obstetrician about the possibility of CPD in labor. Women with obvious pelvic abnormalities following trauma or spinal or limb deformities are delivered by cesarean section. All other women are managed as described in Chapter 15, *Management of normal labor and delivery*. If labor does not progress normally, a decision regarding augmentation with oxytocin, instrumental vaginal delivery, or cesarean section is taken as described later in this chapter.

Abnormalities of soft tissues

Dystocia due to abnormalities of soft tissues is uncommon. Most often, nondilatation of the cervix is due to CPD or poor uterine contractions.

oncompliant cervix (cervical dystocia)

Good uterine contractions and pressure by the bag of membranes and/or presenting part are important for cervical dilatation. In the absence of these, the cervix may not dilate. The cervix undergoes changes in preparation for dilatation during labor (*see Chapter 6, Physiology of labor*). Failure of these changes to occur can result in nondilatation of the cervix despite good uterine contractions. Scarring of the cervix due to prior surgeries such as conization, amputation, or Fothergill's surgery can also interfere with cervical dilatation (Box 40.9).

Congenital anomalies in the vagina, cervix, and uterus

Vertical septum in the vagina and cervix and vaginal reconstructive surgery with resultant scarring can cause obstruction to the passage of

Box 40.9 Causes of nondilatation of the cervix

- Poor uterine contractions
- Cervix not well applied to presenting part
 - Malpresentations
 - Malposition
- Previous surgery
 - Conization
 - Fothergill's operation
 - Amputation
- Lack of preparatory changes in cervix

the fetus. Uterine anomalies such as septate or bicornuate uterus may be associated with poor uterine contractions and lead to dysfunctional labor.

Myoma and ovarian mass

A myoma in the lower uterine segment, below the presenting part or an ovarian mass that lies in the pouch of Douglas or below the level of the fetal head, can also cause obstruction to the passage of the fetus.

Abnormalities in passenger

Labor abnormalities due to fetal malposition, deflexion, malpresentations, and fetal size are common. These can be overcome to some extent by good uterine contractions and a roomy pelvis. However, fetuses in abnormal presentations are commonly delivered by cesarean section.

Abnormalities of the passenger are dealt with in Chapter 41, *Abnormal labor: Malpositions and malpresentations* and Chapter 42, *Abnormal labor: Breech presentation and shoulder dystocia*.

Malposition

Occipitoposterior position is a common cause of abnormal labor. Prolongation of first and second stages of labor can occur and operative vaginal delivery or cesarean section rates are higher in this position. Spontaneous rotation to occipitoanterior (OA) position occurs in majority of women, and a smaller proportion

rotate posteriorly and deliver as face to pubis. Persistent occipitoposterior or arrest in the transverse diameter occurs in 5% of women (see Chapter 41, *Abnormal labor: Malpositions and malpresentations*).

Deflexion is another important cause of abnormal labor. Head is deflexed in occipitoposterior position and the engaging diameter is occipitofrontal, which is larger than suboccipitobregmatic diameter. With further extension of the head, brow or face may present (see Chapter 41, *Abnormal labor: Malpositions and malpresentations*). With good uterine contractions, in a proportion of women, the head flexes, bringing the smaller diameter to engage. This process takes longer and leads to prolonged labor. When flexion does not occur, cesarean section is required.

Other malpresentations such as breech and transverse lie are discussed in Chapter 41, *Abnormal labor: Malpositions and malpresentations* and Chapter 42, *Abnormal labor: Breech presentation and shoulder dystocia*.

Abnormalities in powers

Uterine action is the main force responsible for cervical effacement, dilatation, and flexion of the fetal head, descent, and rotation in the first and second stages of labor. Maternal voluntary expulsive efforts come into play in the second stage.

Normal uterine contractions

Normal uterine contractions begin at the cornu and move down in waves through the upper and lower segment of uterus. There is *fundal dominance* or a gradient of activity which is more at the fundus and less in the lower segment. During uterine contractions, the blood flow to the intervillous space diminishes. The temporary hypoxemia is well tolerated by normal healthy fetuses. However, if the interruption to the blood flow is prolonged as in excessive or prolonged uterine contractions, it can result in fetal hypoxia, acidosis, and asphyxia. The fetal heart rate patterns become abnormal. Assessment of uterine

contractions is, therefore, important in the management of labor.

Definitions and terminology

Standardization of terminology regarding uterine activity is essential for proper documentation and communication. The terminology used and their definitions are given in Box 40.10.

Strength of uterine contractions is expressed in **Montevideo units** (MVU). Montevideo units are calculated by the average strength of contraction (increase in uterine pressure above baseline) in mm Hg × number of contractions in 10 minutes.

In normal labor, frequency of contractions, duration, and intensity increase progressively during labor.

During the active phase, the variables are as follows:

- Basal tone: 10–12 mm Hg
- Intensity: 40–50 mm Hg
- Frequency: 3–5/10 min
- Duration: 60–90 seconds

Box 40.10 Definitions and terminology used for uterine activity

- Frequency
 - Time in minutes
 - From beginning of one contraction to the beginning of next contraction
 - Evaluated over 10 minutes
 - Normal if ≤ 5 contractions/10 min
- Duration
 - Time in seconds
 - From the beginning of one contraction to the end of contraction
- Relaxation time
 - Time in seconds or minutes
 - From end of one contraction to the beginning of next contraction
- Baseline tone
 - Intrauterine pressure during relaxation, in mm Hg
 - Expressed as soft or firm on palpation
- Intensity/strength
 - Intrauterine pressure during peak contraction, in mm Hg
 - Also expressed in Montevideo units
 - Expressed as mild, moderate, or severe on palpation

Assessment of uterine activity

Uterine activity is assessed by the following methods:

- Abdominal palpation
- External tocodynamometry
- Intrauterine pressure catheters (IUPC)

Abdominal palpation

Uterine contractions can be palpated by hands placed on the maternal abdomen, over the uterine fundus. The hands should be placed on the abdomen for a duration of three to four contractions. Estimation of duration of contraction may be inaccurate since the beginning and end of contraction are difficult to palpate. Contractions are palpable only after they reach 10 mm Hg. Assessment of the intensity of contractions is also arbitrary. If the contraction is of adequate intensity, the uterus cannot be indented by the examining fingers.

External tocodynamometry

The tocodynamometer is placed on the abdominal wall at the level of the uterine fundus. When the uterine muscle contracts, it raises the abdominal wall, causing pressure on the transducer. An electronic signal is sent to the fetal monitor and a uterine contraction wave form is displayed. The beginning of the contraction, its frequency, and its end can be made out with the help of external tocodynamometry (Fig. 40.3). The assessment of frequency and interval between contractions is more accurate than abdominal palpation. However, the precise strength of the contractions cannot be made out from the wave form. The measurement of intensity varies depending on the tightness of the elastic belt holding the transducer in place and the thickness of the abdominal wall.

Intrauterine pressure catheters

A fluid-filled or transducer-tipped catheter is placed inside the uterine cavity after amniotomy and is connected to a pressure sensor. The pressure is recorded in mm Hg (Fig. 40.4). The basal tone should be noted and pressure during and



Figure 40.3 External tocodynamometer. The tocodynamometer is placed on the abdomen at the level of the uterine fundus. The contraction is seen on the monitor and recorded on the trace.

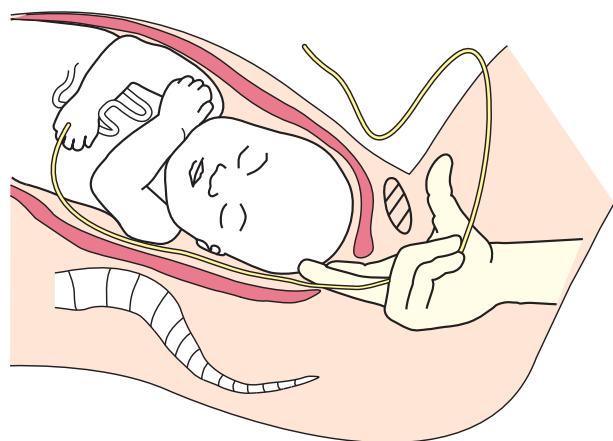


Figure 40.4 Intrauterine pressure catheter. The catheter is introduced into the uterine cavity and connected to a pressure sensor.

after contraction recorded. Recording of intrauterine pressure is accurate with IUPC and a quantitative assessment is possible. However, it is not recommended as a routine practice in the management of labor since it does not improve outcome. An IUPC is currently used only in some specific circumstances as given below:

- Obese women in whom palpation is difficult
- To titrate dose of oxytocin during augmentation
- Research purposes

Techniques to assess uterine activity are summarized in Box 40.11.

Box 40.11 Assessment of uterine activity

- Abdominal palpation
 - Most commonly used
 - Hands placed on uterine fundus
 - 3–4 contractions palpated
 - Cannot accurately delineate beginning/end of contraction
 - Cannot accurately assess intensity
- External tocodynamometer
 - Used with external fetal monitoring
 - Placed at uterine fundus
 - More accurate assessment of frequency and duration
 - Assessment of intensity can be inaccurate
- Intrauterine pressure catheter
 - Possible only after amniotomy
 - Assessment of intensity accurate
 - Basal tone can be assessed
 - Can be associated with complications
 - Abruptio, perforation, and infection
 - Not recommended as a routine practice



Figure 40.5 Hypotonic uterine action. Tracing from the external tocodynamometer shows uterine contractions which are infrequent and of short duration and low intensity.

Box 40.12 Hypotonic uterine dysfunction

- Characteristics
 - Frequency <3 in 10 minutes
 - Intensity <25 mm Hg
 - Duration <40 seconds
 - Low or absent basal tone
 - Normal gradient of contraction
- Causes
 - Cephalopelvic disproportion
 - Nulligravida
 - Chorioamnionitis
 - Overdistension of uterus
 - Multifetal pregnancy
 - Polyhydramnios
 - Epidural analgesia
- Management
 - Rule out cephalopelvic disproportion/malposition
 - If no cephalopelvic disproportion
 - Amniotomy
 - Augmentation with oxytocin

Abnormal uterine action

Abnormal uterine action is classified as

- Hypotonic dysfunction
- Hypertonic dysfunction
 - Tachysystole
 - Incoordinate uterine action
 - Precipitate labor

Hypotonic dysfunction

Hypotonic dysfunction is the most common abnormality of uterine action encountered in labor. **The uterine contractions are infrequent and of short duration and low intensity, and do not result in cervical dilatation** (Fig. 40.5). The basal tone is low or absent but the gradient of contraction is normal. The contractions are not very painful.

The most common cause of hypotonic uterine dysfunction is CPD. This should be excluded in all women with inadequate uterine contractions.

Causes and characteristics of hypotonic uterine dysfunction are listed in Box 40.12.

Management

Cephalopelvic disproportion and malposition should be ruled out by a pelvic examination. If

there is no disproportion and the woman is in active phase of labor, it is prudent to wait for 4 hours. If reassessment after 4 hours reveals no progress or poor progress, amniotomy and augmentation of labor with oxytocin are recommended. Low- or high-dose regimens of oxytocin may be used as described in Chapter 16, *Induction of labor*. High-dose regimens are associated with lower cesarean section rates, reduction in the duration of labor, and higher rate of vaginal delivery. However, frequency of tachysystole is higher.

Chorioamnionitis can interfere with cervical dilatation in spite of adequate uterine

contractions with oxytocin. Cesarean section may be required in this situation.

Hypertonic dysfunction

The most common hypertonic dysfunction is tachysystole and is caused by injudicious use of oxytocin. Fetal hypoxia is more common with hypertonic dysfunction.

Tachysystole

Tachysystole is defined as >5 contractions in 10 minutes (Fig. 40.6). The term *hyperstimulation* is not currently used. Fetal oxygenation suffers and fetal heart rate abnormalities and decelerations occur. The most common cause is oxytocin infusion, in high doses. Misoprostol can also cause tachysystole, if used in high doses (50 µg). Approximately 20% of tachysystoles occur in spontaneous labor.

Management

Oxytocin infusion should be stopped. Vaginal misoprostol should be removed. Changing maternal position and administration of a bolus of intravenous Ringer lactate 500 mL are also effective. Inj. terbutaline 0.25 mg administered subcutaneously relaxes the uterus. If fetal heart abnormalities persist, cesarean section may be required.

Clinical features and management of tachysystole are summarized in Box 40.13.

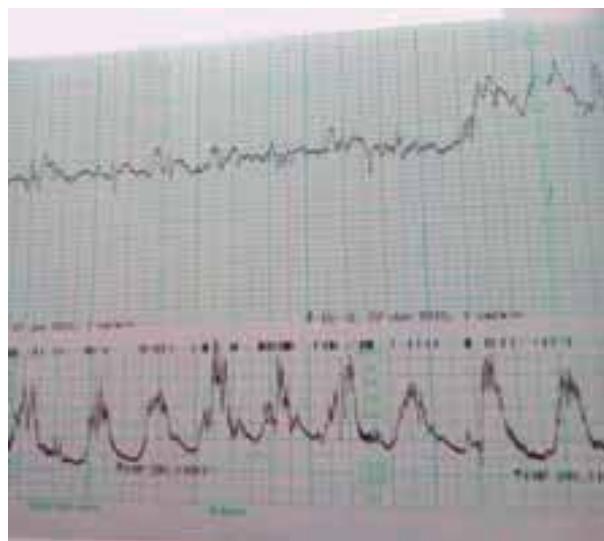


Figure 40.6 Tachysystole. Tracing shows >5 contractions in 10 minutes, characteristic of tachysystole.

Box 40.13 Clinical features and management of tachysystole

Clinical features

- >5 contractions/10 min
- Decrease in fetal oxygenation
- Fetal heart rate abnormalities
- Usually due to oxytocin/misoprostol
- 20% occur in spontaneous labor

Management

- Change maternal position
- Stop oxytocin
- Remove vaginal misoprostol
- IV bolus Ringer lactate 500 mL
- Inj. terbutaline 0.25 mg SC

SC subcutaneous.

Incoordinate uterine action

Incoordinate uterine action is a hypertonic dysfunction in which basal tone is elevated and the gradient of uterine contraction is distorted. The frequency, duration, and intensity of contractions are incoordinate (Fig. 40.7). The cervix does not dilate though the woman experiences painful contractions.

Management

Maternal sedation with 100 mg of intramuscular morphine 8 mg pethidine reduces the uterine contractions and basal tone. After a period of rest, the uterus may start contracting normally and can be augmented with oxytocin. Amniotomy should be performed to exclude meconium staining of amniotic fluid.

Clinical features and management of incoordinate uterine action are given in Box 40.14.



Figure 40.7 Incoordinate uterine action. The frequency, duration, and intensity of contractions are incoordinate.

Box 40.14 Clinical features and management of coordinate uterine action
Clinical features

- Elevated basal tone
- Distorted gradient of contractions
- No cervical dilatation
- Contractions painful

Management

- Maternal sedation
- Wait for 4–6 hours
- Amniotomy
- Oxytocin if required

recipitate labor

Precipitate labor is defined as an extremely short labor where the total duration of labor is <3 hours. This can occur due to low resistance of the soft tissues of the pelvis, hypertonic uterine contractions, or lack of pain sensation in the mother.

Precipitate labor may recur in subsequent pregnancies; therefore, it is important to anticipate and be prepared for it.

Complications

Vigorous uterine contractions can lead to lacerations of the cervix, vagina, and perineum. Placental abruption and meconium passage are also associated with precipitate labor.

Fetal oxygenation is impaired during tumultuous uterine contractions, leading to asphyxia and low Apgar scores. Brachial plexus injuries and injuries due to unexpected fall on the floor can also occur.

Abnormal labor patterns

Labor does not progress normally in all women. Obstetricians tend to use terms like 'failure to progress,' 'abnormal labor,' or 'dystocia' in these situations. In fact many cesarean sections are done for these indications. However, these terms are inexact and unclear. A labor pattern that does not follow the usual pattern of a normal labor are best described as *protraction disorders*, where labor progresses slowly, or *arrest disorders*, where labor comes to a stop. Abnormal labor patterns are classified as shown in Table 40.2.

Disorders of the first stage

Several factors contribute to abnormal labor patterns in the first stage. It is important to understand that usually a combination of factors are present and one factor can lead to the other. Management depends on a full understanding of the cause(s) in a given patient and the benefits and risks of various interventions must be balanced.

Prolonged latent phase

Prolonged latent phase is defined as that which exceeds 20 hours in a nullipara and 14 hours in a multipara, which is more than the 95th centile. Latent phase begins with onset of regular uterine contractions. However, the onset and end of latent phase cannot be established with accuracy. It is also difficult to differentiate latent phase of labor from false labor pains.

Table 40.2 Abnormal labor patterns

Abnormal pattern	Nullipara	Multipara
Disorders of first stage		
Prolongation disorder		
Prolonged latent phase	>20 hours	>14 hours
Protraction disorders		
Protracted active phase	<1.2 cm/hour	<1.5 cm/hour
Protracted descent	<1 cm/hour	<2 cm/hour
Arrest disorders		
Prolonged deceleration phase	>3 hours	>1 hour
Arrest of dilatation	>2 hours	>2 hours
Arrest of descent	>1 hour	>1 hour
Disorders of the second stage		
Protracted descent	<1 cm/hour	<2 cm/hour
Arrest of descent	>2 hours	>1 hour

Management

Expectant management is recommended. Sedation with intramuscular injection of 8–10 mg of morphine or 100 mg pethidine alleviates pain. False labor pains normally reduce and disappear after 6–8 hours. In 85% of women, regular contractions begin and active labor sets in. If mild contractions persist, augmentation with oxytocin is recommended. Increased risk of cesarean section, low Apgar scores, and meconium passage can occur in this group of women.

Protraction disorders

In protraction disorders, dilatation and descent occur but at a much slower pace.

Protracted active phase

The normal rate of cervical dilatation in the active phase is 1.2 cm/hour for nulliparas and 1.5 cm/hour for multiparas according to Friedman (see Chapter 15, *Management of normal labor and delivery*). A **rate of dilatation that is less than the minimum rate of cervical dilatation is called protracted active phase** (Fig. 40.8).

Protracted descent

Protracted descent of fetal head is descent at a rate less than 1 cm/hour in nulliparas and 2 cm/hour in multiparas (Fig. 40.9).

Causes of protracted active phase and protracted descent are hypotonic uterine dysfunction, malposition of the presenting part especially OP and CPD, maternal obesity, and epidural analgesia.

Management

Abdominal and pelvic examination should be performed to assess uterine contractions, descent of the presenting part, its position, and flexion/deflexion. Abnormalities of the bony pelvis must be excluded. Maternal hydration must be maintained by infusion of Ringer lactate solution.

If uterine contractions are inadequate, augmentation with oxytocin usually promotes flexion and rotation of the fetal head. Amniotomy, before oxytocin, shortens the duration of labor by 1–2 hours and helps to detect meconium. With good uterine contractions and 'give' of the pelvis, labor progresses normally.

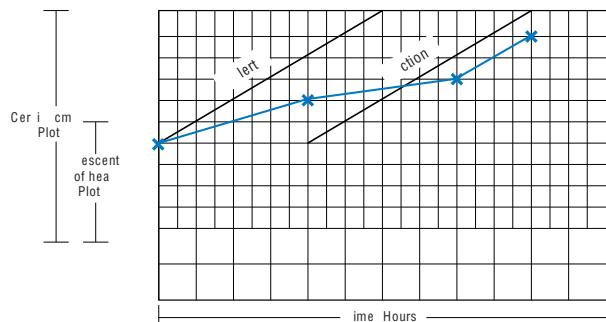


Figure 40.8 Protracted active phase. Partograph shows cervical dilatation of 2 cm in 4 hours.

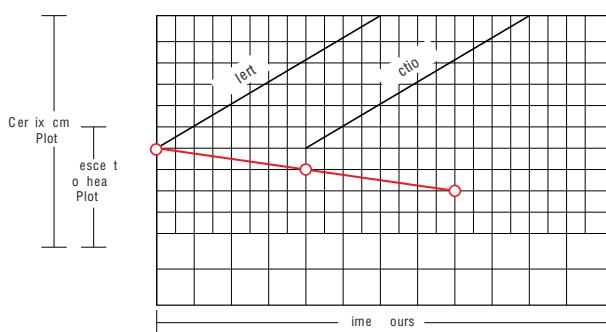


Figure 40.9 Protracted descent. Partograph shows descent of fetal head by 1 cm in 4 hours.

Arrest disorders

Arrest of dilatation is diagnosed when the cervix ceases to dilate in the active phase of labor, after rupture of membranes, despite adequate uterine contractions (>200 MVU) for >2 hours. The American College of Obstetricians and Gynecologists defines it as no cervical dilatation after 6 cm for >4 hours (Fig. 40.10). **Similarly, when descent of the fetal head does not occur for >1 hour despite good uterine contractions, arrest of descent is diagnosed** (Fig. 40.11).

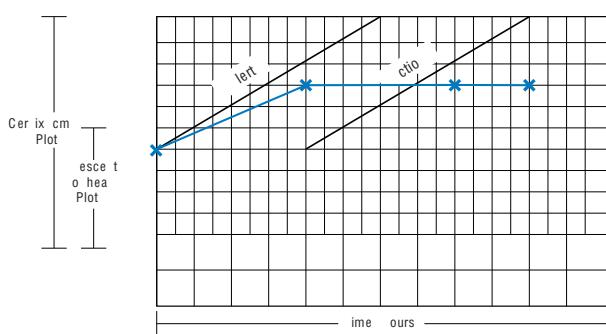


Figure 40.10 Arrest of dilatation. Cervical dilatation has arrested at 6 cm for 6 hours.

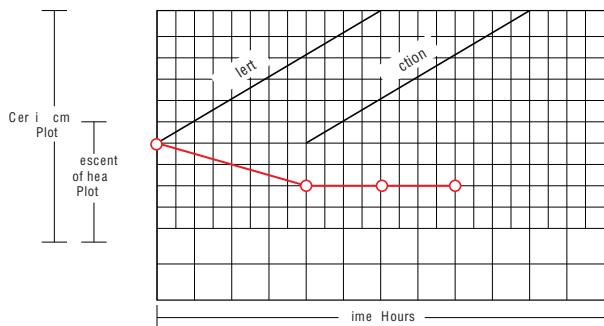


Figure 40.11 Arrest of descent. The descent of the fetal head is arrested at the same station for 4 hours.

Arrest of dilatation and descent are usually due to a large baby, malposition, and CPD. Hypotonic uterine dysfunction may be the result of obstruction; therefore, caution should be exercised before augmenting labor.

Management

Abdominal and vaginal examination to exclude malposition, large fetus, and CPD are mandatory. Augmentation with oxytocin achieves vaginal delivery in the absence of these factors.

Disorders of the first stage, their causes, and management are summarized in Table 40.3.

Disorders of second stage

The second stage starts with full dilatation of the cervix and ends with the delivery of the fetus. Most

of the descent of the fetus takes place in the second stage. The normal duration of the second stage in nulliparas is 2 hours if no regional anesthesia is used and 3 hours with regional anesthesia. In multiparas, it is 1 hour and 2 hours, respectively (Fig. 40.12).

Disorders of second stage may be due to the following:

- Protracted descent: <1 cm/hour in nullipara; <2 cm/hour in multipara
- Arrest of descent: No progress in descent >2 hours in nullipara; >1 hour in multipara

Disorders of the second stage are usually due to large size of the baby, malposition, or CPD. As in arrest disorders in active phase, hypotonic uterine dysfunction may be secondary. Poor

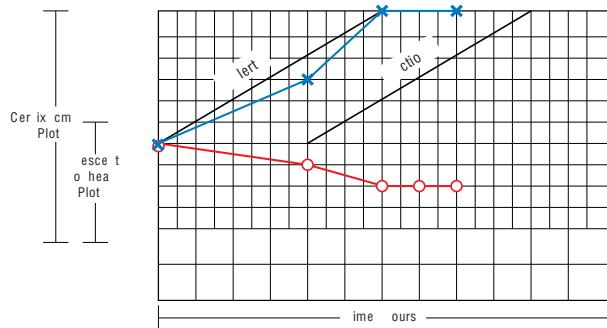


Figure 40.12 Arrest of descent in second stage. After full dilatation of the cervix, the descent of the fetal head has not progressed for 2 hours.

Table 40.3 Causes and management of disorders of first stage of labor

Disorder	Causes	Management
Prolonged latent phase	<ul style="list-style-type: none"> • Delayed cervical ripening • Asynchrony of contractions and cervical changes 	<ul style="list-style-type: none"> • Sedation • Amniotomy • Oxytocin augmentation
Protracted active phase and protracted descent	<ul style="list-style-type: none"> • Hypotonic uterine dysfunction • Large baby • Malposition, CPD • Obesity • Epidural analgesia 	<ul style="list-style-type: none"> • Exclude CPD • Amniotomy • Oxytocin augmentation
Arrest of dilatation and descent	<ul style="list-style-type: none"> • Large baby, malposition • CPD • Hypotonic uterine dysfunction 	<ul style="list-style-type: none"> • Exclude CPD • Oxytocin augmentation

CPD, cephalopelvicdisproportion.

maternal expulsive force is also a contributing factor.

Complications

Prolongation of the second stage is associated with maternal and perinatal morbidity. Risk of low 5-minute Apgar scores, asphyxia, and admission to the neonatal intensive care unit is increased. Chorioamnionitis, instrumental delivery, cesarean section, postpartum hemorrhage, perineal trauma, and pelvic relaxation leading to prolapse are the maternal complications.

Management

Excluding disproportion and malposition is, therefore, the most important first step in the management. Treatment should be individualized. Fetal heart rate should be closely monitored and delivery expedited if there is abnormality. If CPD is excluded with reasonable certainty, in a nullipara, judicious use of oxytocin and encouraging maternal expulsive efforts may achieve vaginal delivery. In a multipara, one needs to be careful about oxytocin augmentation, especially in case of undiagnosed CPD, due to the increased risk of uterine rupture. Instrumental delivery should be considered if the head is below the level of ischial spines. Cesarean section may be required if there is evidence of CPD or no response to oxytocin. Disorders of second stage and their management are summarized in Box 40.15.

Box 40.15 Disorders of second stage of labor

- Definition
 - Protracted descent
 - <1 cm/hour in nullipara
 - <2 cm/hour in multipara
 - Arrest of descent
 - No descent after full dilatation of cervix
 - >2 hours in nullipara
 - >1 hour in multipara
- Causes
 - Large baby
 - Malposition
 - CPD
 - Hypotonic uterine dysfunction
 - Poor maternal expulsive efforts
- Complications—fetal
 - Low 5-minute Apgar scores
 - Asphyxia
 - Admission to neonatal ICU
- Complications—maternal
 - Chorioamnionitis
 - Instrumental delivery
 - Cesarean section
 - Postpartum hemorrhage
 - Perineal trauma
 - Pelvic relaxation
- Management
 - Exclude CPD, malposition
 - Augment with oxytocin if no CPD
 - Encourage maternal expulsive powers
 - Monitor fetal heart rate
 - Instrumental delivery
 - Cesarean section

CPD, cephalopelvic disproportion.

Key points

- Labor is said to be abnormal if it is prolonged or does not progress. Abnormality can occur in first or second stage.
- Causes of abnormal labor may be in the passage, passenger, or powers.
- Cephalopelvic disproportion results from contracted pelvis, abnormal pelvic configuration, large fetus, or fetal malposition.
- The pelvis is said to be contracted if one or more diameters of the pelvis at one or more planes is less than normal.
- Midpelvic contraction is more common than inlet or outlet contraction.
- Four types of pelvis have been described—gynecoid, android, anthropoid, and platypelloid. Gynecoid pelvis is the most favorable.
- Contracted pelvis is diagnosed by history, physical examination, and clinical pelvimetry. X-ray, CT, and MRI pelvimetry are not used routinely.
- Malposition and deflection of the head and malpresentations are important causes of abnormal labor.
- Normal uterine action is essential for normal labor. Terminology used in defining normal and abnormal uterine contractions are frequency, duration, intensity, relaxation time, and baseline tone.
- Uterine contractions are assessed by palpation and external tocodynamometry. Intrauterine pressure catheter is not recommended in routine practice.
- Abnormal uterine action may be hypotonic dysfunction or hypertonic dysfunction. Hypotonic dysfunction is the most common abnormality and is managed by augmentation with oxytocin.

(Continued)

Key points *Continued*

- Abnormal labor patterns can occur in first and second stage and may be protraction or arrest disorders.
- Disorders of active phase are mostly due to malposition, large size of the baby, *cephalopelvic disproportion* (CPD), hypotonic uterine dysfunction, or a combination of these.
- Disorders of active phase are managed by exclusion of CPD and augmentation with oxytocin.
- Disorders of second stage are usually due to CPD. This has to be excluded before labor is augmented. Management must be individualized and instrumental delivery or cesarean section may be required when there is no response to oxytocin.

Self-Assessment

Case-based questions

Case 1

Mrs. BN, 28, primigravida, at $40+3$ weeks' gestation, was admitted to the labor room with pains. On examination, she had regular uterine contractions once every 5 minutes, lasting for 40 seconds. The vertex was three-fifth palpable abdominally, and fetal heart sounds were normal. On pelvic examination, the cervix was fully effaced and 4-cm dilated. The vertex was at -2 station. She was expected to deliver in the next 6 hours. But, on examination after 4 hours, the contractions were once every 8–10 minutes, lasting for 30 seconds. The vertex was still three-fifth palpable, the cervix was 5-cm dilated, and the vertex was at -2 station.

1. Mark this course of labor on a partograph. What is the diagnosis?
2. What is the next step in evaluation?
3. What is the management?

Case 2

Mrs. CN, a second gravida with previous difficult forceps delivery of a 3.8 kg baby, was admitted to labor room with pains. Her contractions were every 3 minutes, lasting for 40–60 seconds, vertex four-fifth palpable, estimated fetal weight 3.6 kg, cervix 4-cm dilated, and vertex at -3 station.

1. What is the significance of the history?
2. What evaluation will you do?
3. How will you manage her labor?

Answers

Case 1

1. On the partograph, the curve has crossed the alert line, and there is poor progress in labor. Uterine contractions have decreased in frequency and intensity; the diagnosis is hypotonic uterine dysfunction.
2. Abdominal examination to estimate the weight of the baby. Pelvic examination to exclude CPD, OP position, deflexion, caput, molding, and meconium.
3. If there is no clinical evidence of CPD, labor should be augmented with oxytocin. Pelvic examination should be repeated 4 hours later. Uterine contractions, descent of the head, and fetal heart rate should be monitored.

Case 2

1. A difficult forceps delivery could be due to a large baby or contracted pelvis. Weight of the baby was 3.8 kg, which could have been the reason for the difficult delivery.
2. Clinical pelvimetry to exclude contracted pelvis and determine pelvic configuration.
3. If the pelvic configuration and dimensions are normal, since the estimated fetal weight is 200 g less than the previous one, labor may be allowed to progress with close monitoring of uterine contractions, descent of vertex, dilatation of cervix, and fetal heart rate. All findings should be marked on a partograph. If the partograph is normal and the curve is to the left of alert line, spontaneous delivery can be awaited. If there is poor progress, despite good uterine contractions, assisted vaginal delivery or cesarean section will be required.

Sample questions

Long-answer questions

1. A primigravida at term is admitted in active labor. Uterine contractions became gradually less frequent, cervical dilatation progressed by only 2 cm in 4 hours, and there was no descent of vertex. How will you manage her labor?
2. What are the disorders of labor in first and second stage? Discuss their etiology, diagnosis and management.

Short-answer questions

1. Incoordinate uterine action
2. Trial labor
3. Precipitate labor
4. Secondary arrest of labor
5. Monitoring uterine activity during labor
6. Assessment of CPD
7. Causes of mobile head at term
8. Munro-Kerr-Muller method of assessment of CPD
9. Hypotonic uterine dysfunction

41

Abnormal Labor: Malpositions and Malpresentations

Case scenario

Mrs. DN, 29, a third gravida with previous normal deliveries, was admitted to the labor room with pains for 6 hours and ruptured membranes for 2 hours. She had gone to a nursing home for delivery but was told that the baby was lying across the abdomen and advised to go to a bigger center. Mrs. DN and her husband were frightened and confused and wanted to know what was wrong and what had to be done.

Introduction

Malpositions and malpresentations are common causes of abnormal labor. Malpresentations of the fetus complicate labor in about 5% of pregnancies and malpositions, especially the occipitoposterior position, complicates another 20%. Malpositions and malpresentations are associated with an increase in maternal and fetal complications, and perinatal and maternal morbidity and mortality. Anticipation, early identification, and prompt intervention can reduce the rate of complications and improve outcome.

Definitions

The presentation of the fetus may be cephalic but the head may be flexed, deflexed, or extended. The

fetus may also present as breech or with the shoulder as the leading part. These constitute malpositions and malpresentations.

Malpositions

The fetal presentation is usually vertex and the occiput may be anterior, transverse, or posterior. The vertex in the occipitotransverse positions will usually rotate to the anterior or posterior positions. **When the vertex presents with the occiput in the right or left posterior quadrant of the pelvis (LOP or ROP), it is referred to as malposition.**

Malpresentations

Presentations other than vertex are called malpresentations. These include face, brow, breech,

Box 41.1 Malpositions and malpresentations

- Malpositions
 - Right and left occipitoposterior
- Malpresentations
 - Presentation other than vertex
 - Face
 - Brow
 - Breech
 - Shoulder
 - Compound
 - Abnormal axial lie
 - Transverse lie
 - Oblique lie
 - Unstable lie

shoulder, and compound presentations. These are listed in Box 41.1.

Abnormal axial lie

Fetal lie is normally longitudinal; however, in certain conditions, the fetus may lie in the oblique or transverse axis, referred to as abnormal axial lie.

Transverse lie

The fetus is said to be in transverse lie when the long axis of the fetus is perpendicular to the long axis of the uterus.

Oblique lie

When the long axis of the fetus is at an angle to the long axis of the uterus, the lie is oblique. This

is usually transient and changes to longitudinal or transverse lie at the onset of labor.

Unstable lie

When the fetal lie and presentation change repeatedly, after 37 weeks' gestation, it is called unstable lie. The lie may be oblique, transverse, or longitudinal and presentation may be shoulder, breech, or cephalic.

Etiology

Malpresentations, abnormal lie, and malpositions have some common etiological factors.

Maternal factors

Multiparity is associated with a lax abdominal wall with loss of muscle tone. This results in failure to brace and maintain the fetal lie and presentation. The fetus moves freely and changes the lie and attitude in polyhydramnios. In placenta previa (Fig. 41.1a), the placenta occupies the lower uterine segment and prevents the head or breech from entering the pelvis, resulting in transverse lie. It can also lead to breech presentation because the bulky head does not have adequate space in the lower pole of the uterus. Abnormal pelvic configuration and cephalopelvic disproportion can prevent the head or breech from entering the pelvis and cause extension of the head or malposition. Therefore transverse or oblique lie, face or brow presentations, and occipitoposterior

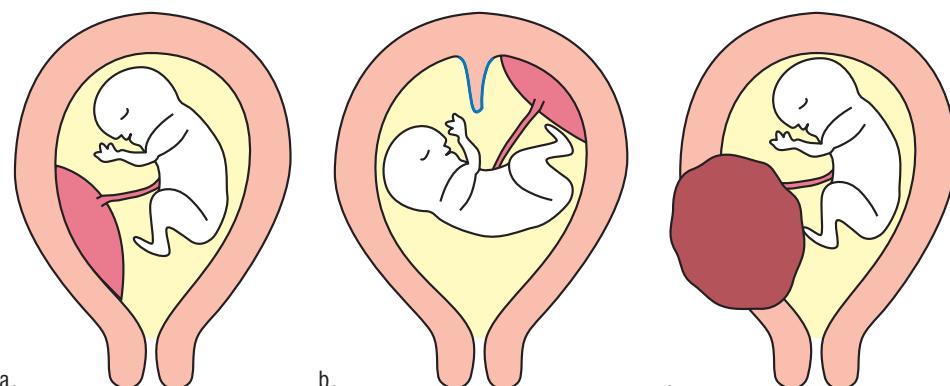


Figure 41.1 Uterine causes of malpresentations. **a.** Placenta previa reduces the space available in the lower segment for the bulky head, leading to breech presentation. **b.** Subseptate uterus causes transverse lie. **c.** A fibroid in the lower uterine segment reduces the space available for the bulky head and leads to breech presentation.

positions are common. Uterine malformations such as subseptate uterus are associated with transverse lie (Fig. 41.1b). Tumors in the pelvis such as fibroids or ovarian tumors (Fig. 41.1c) also prevent entry of head or breech into the pelvis (Box 41.2).

Fetal factors

Prematurity is the most common cause of abnormal lie and malpresentation. The amount of amniotic fluid is more relative to the size of the fetus and the fetus takes up any position or presentation till 37 weeks. In multifetal pregnancy, the first or second twin may be in an abnormal lie or malpresentation. There may be associated polyhydramnios which is an additional factor. Fetal macrosomia causes cephalopelvic disproportion. Fetal anomalies such as hydrocephalus, anencephaly, fetal hydrops, tumors in the fetal neck, and sacrococcygeal tumors also cause malpresentations.

Malpositions

Occipitoposterior position

Occipitoposterior positions occur usually as a variation of the normal but can also be due to abnormal pelvic configuration. **When the occiput occupies one of the posterior quadrants of the pelvis, the position is referred to as occipitoposterior.**

Incidence

Approximately 20% of fetuses are in the occipitoposterior position at the onset of labor. Of these, 75% rotate during labor and 25% deliver as occipitoposterior. About 75% of occipitoposterior deliveries occur in fetuses that were in the occipitoanterior position at the onset of labor. This is the result of malrotation. Overall, 5% of all deliveries occur as occipitoposterior.

Etiology

The most common causes of occipitoposterior position are nulliparity, obesity, older age

Box 41.2 Etiology of malpresentations, malpositions, and abnormal lie

- Maternal factors
 - Multiparity
 - Polyhydramnios
 - Placenta previa
 - Abnormal pelvic configuration
 - Cephalopelvic disproportion
 - Uterine anomalies
 - Tumors in the pelvis
- Fetal factors
 - Prematurity
 - Multifetal pregnancy
 - Macrosomia
 - Anomalies

(>35 years), increasing fetal weight, and obesity. Abnormal pelvic configuration is also known to be associated with occipitoposterior position. When the anteroposterior diameter of pelvic inlet is equal to or more than the transverse diameter, as in android and anthropoid pelvis, occipitoposterior position results. In addition, in android pelvis, the forepelvis is beaked and narrow and the posterior half of the pelvis is roomier; therefore, the bulky occiput occupies the posterior half of pelvis. High assimilation pelvis, in which the last lumbar vertebra is included in the sacrum, has a high angle of inclination at the inlet and favors the occipitoposterior position. Causes of occipitoposterior position are listed in Box 41.3.

Mechanism of labor

Mechanism of labor may proceed normally and the fetus may deliver in the occipitoanterior

Box 41.3 Etiology of occipitoposterior position

- Nulliparity
- Older age
- Obesity
- Birth weight of fetus >4 kg
- Anteroposterior diameter at inlet \geq transverse diameter
 - Android pelvis
 - Anthropoid pelvis
- High angle of inclination
 - High assimilation pelvis

Box 41.4 Key parameters in occipitoposterior position

- Denominator: The occiput
- Attitude: Deflexion
- Engaging diameter: Occipitofrontal (11 cm)
- Possible positions: Right occipitoposterior (ROP)
Left occipitoposterior (LOP)

position or the mechanism may be abnormal and cause problems during labor.

Denominator, attitude, engaging diameter, and positions are given in Box 41.4.

Normal mechanism of labor in occipitoposterior position

There are two occipitoposterior positions, ROP and LOP, where the occiput is in the right or left posterior quadrant of the pelvis, respectively (Fig. 41.2). As already mentioned, the majority of fetuses in the occipitoposterior position at the onset of labor will deliver as occipitoanterior.

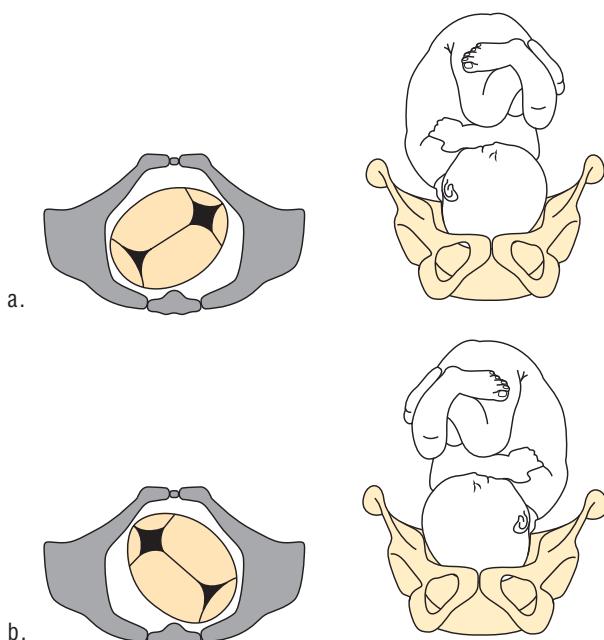


Figure 41.2 Right and left occipitoposterior positions. **a.** Right occipitoposterior position with the back of the fetus to the right and posterior and occiput in the right posterior quadrant of the pelvis. **b.** Left occipitoposterior position with the back of the fetus to the left and posterior and occiput in the left posterior quadrant of the pelvis.

The mechanism of labor is similar to occipitoanterior positions with some differences:

- The most common position is ROP. The sagittal suture occupies the same (right) oblique diameter of the pelvic inlet as in left occipitoanterior, since the left oblique diameter is occupied by the sigmoid colon.
- The head is deflexed; hence, the engaging diameter is occipitofrontal (11 cm) (Fig. 41.3). With good uterine contractions and increasing flexion, this changes to suboccipitobregmatic (9.5 cm).
- Internal rotation of the occiput is through 135 degrees (3/8th of a circle).

Abnormal mechanism of labor in occipitoposterior position

When anterior rotation of the head fails to occur, labor becomes abnormal. One of the following can happen (Fig. 41.4):

- Posterior rotation (malrotation)
- Short anterior rotation (transverse arrest)
- Nonrotation (persistent occipitoposterior)

Posterior rotation (malrotation)

The vertex rotates posteriorly through 45 degrees (1/8th of a circle) and the occiput is in the sacral hollow. The sagittal suture is in the anteroposterior diameter of the pelvis and delivery occurs

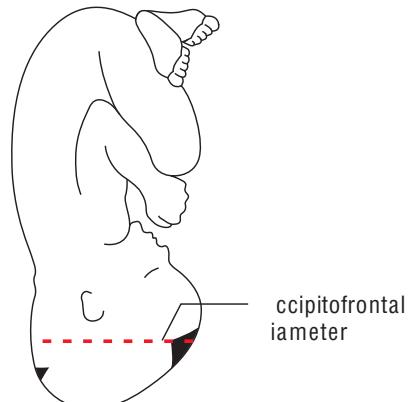


Figure 41.3 Occipitofrontal diameter. In occipitoposterior positions, the head is deflexed and the occipitofrontal diameter enters the pelvis.

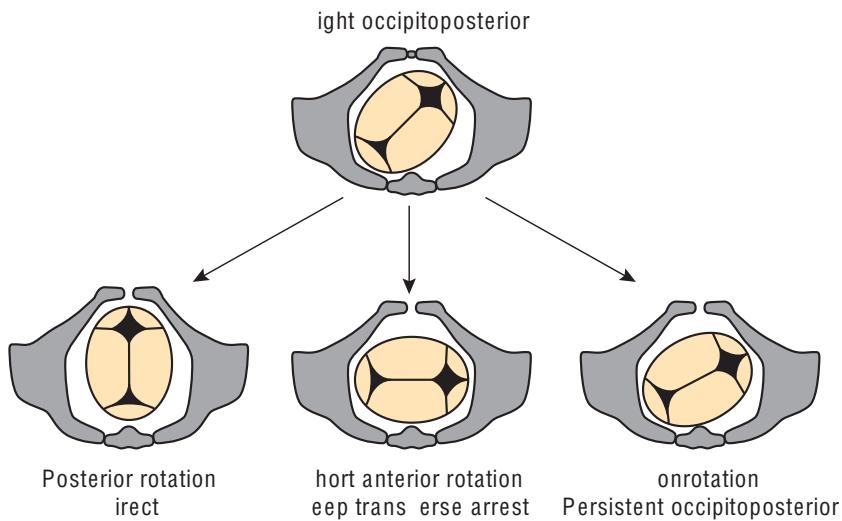


Figure 41.4 Abnormal mechanisms of labor in occipitoposterior position. The occiput, from right occipitoposterior position, can undergo posterior rotation, short anterior rotation, or remain as persistent occipitoposterior by nonrotation.

as *occipitoposterior* or *face to pubis*. This usually happens in anthropoid pelvis.

Short anterior rotation

The vertex rotates anteriorly by 45 degrees (1/8th of a circle). But further anterior rotation does not occur due to smaller interischial spinous diameter and converging sidewalls in android pelvis and anthropoid pelvis. Moreover, in android pelvis, the flat sacrum and reduced sacral hollow do not permit posterior rotation. The labor is arrested with the sagittal suture in the transverse diameter of the pelvis, resulting in *transverse arrest* or *deep transverse arrest*.

Nonrotation

The vertex does not rotate but persists in occipitoposterior position with the sagittal suture in the oblique diameter of the pelvis, that is, *persistent occipitoposterior*. Posterior rotation and vaginal delivery may occur in some but operative intervention is required in most.

Maternal and fetal complications

Maternal and fetal complications are due to prolonged labor and operative interventions. Since the deflexed vertex does not fit well in the lower segment, prelabor rupture of membranes and, occasionally, cord prolapse may occur. Delivery

as occipitoposterior can cause anal sphincter injuries and third or fourth degree perineal tears because the bulky occiput emerges posteriorly and stretches the perineum. The anteroposterior diameter of the OP fetal vertex that presents in the pelvic outlet is greater than the anteroposterior diameter that presents when the fetus is in the OA position. The head delivers by extension and this results in an even greater presenting anteroposterior diameter. This disproportion increases the risk of vaginal and perineal lacerations and operative birth.

Maternal and fetal complications are listed in Box 41.5.

Box 41.5 Maternal and fetal complications of occipitoposterior position

- Maternal complications
 - Prolonged labor
 - Prelabor rupture of membranes
 - Prolapse of the cord
 - Anal sphincter injuries
 - Oxytocin augmentation
 - Instrumental delivery
 - Cesarean section
- Fetal complications
 - Low 5-minute Apgar score
 - Meconium aspiration
 - Hypoxic ischemic encephalopathy
 - Birth trauma
 - Admission to neonatal intensive care unit

Diagnosis

Diagnosis of occipitoposterior position is done by physical examination.

Abdominal examination

There may be a depression between the head and the trunk, referred to as *suprapubic flattening*. Since the limbs are anterior, fetal movements are seen more clearly. On umbilical grip, the fetal back is posterior and difficult to palpate. On the second pelvic grip, the head is deflexed, with the occiput and sinciput at the same level. The fetal heart is heard at the flank, on the same side as the fetal back.

Pelvic examination

The anterior fontanel is felt easily since the head is deflexed. The sagittal suture is in the oblique diameter and the posterior fontanel is in the posterior quadrant of the pelvis. The position is ROP if the posterior fontanel is in the right posterior quadrant and LOP if the posterior fontanel is in the left posterior quadrant of the pelvis.

Diagnostic features of occipitoposterior position are listed in Box 41.6.

Box 41.6 Diagnosis of occipitoposterior position

- Abdominal examination
 - Inspection
 - Suprapubic flattening
 - Fetal movements clearly seen
 - Palpation
 - Umbilical grip
 - Fetal back posterior
 - Limbs anterior
 - Second pelvic grip
 - Sinciput and occiput at same level
 - Auscultation
 - Fetal heart at the flank
- Pelvic examination
 - Sagittal suture in oblique diameter
 - Anterior fontanel easily felt, in anterior quadrant
 - Posterior fontanel in posterior quadrant

Management

- When occipitoposterior position is diagnosed, assess
 - uterine contractions
 - descent and flexion of the presenting part
 - cervical dilatation
 - station of the vertex
 - pelvic configuration
 - fetal weight
 - fetal heart rate
- Administer epidural or parenteral analgesia since labor is likely to be prolonged
- Maintain hydration
- If contractions are inadequate, augment labor with oxytocin
- If prelabor rupture of membranes occurs, exclude
 - cord prolapse
 - meconium staining of amniotic fluid
- Maintain partograph
- If labor progresses normally, deliver vaginally

Management in the case of posterior rotation

- When the vertex rotates posteriorly, delivery takes place as *face to pubis* (Fig. 41.5).
- The sagittal suture is in the anteroposterior diameter of the pelvis and the occiput is felt in the hollow of the sacrum.
- The mother tends to push prematurely due to pressure on the rectum by the occiput. The anal opening dilates and appears stretched.
- With further uterine contractions, the sinciput hitches under the pubic symphysis and the forehead, vertex, and occiput are born by *flexion*.

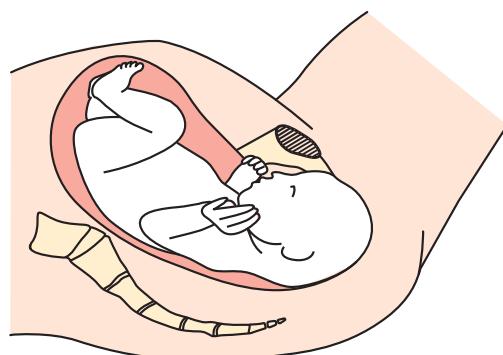


Figure 41.5 Face-to-pubis delivery. When the occiput rotates posteriorly, the fetus is delivered as face to pubis.

- The sinciput, nose, mouth, and chin are then born by extension.
- Since the bulky occiput is delivered posteriorly, a liberal episiotomy should be given to prevent perineal laceration and anal sphincter injury.
- Most cases require assisted delivery with forceps. The application of forceps and direction of traction are described in Chapter 19, *Operative vaginal delivery*.

Management in the case of short anterior rotation

- The vertex may rotate anteriorly by 45 degrees with the sagittal suture in the transverse diameter of the pelvis and the occiput on the left or right side.
- Assess uterine contractions, weight of the baby, flexion and descent of the vertex, and fetal heart rate.
- Perform pelvic examination to
 - exclude cephalopelvic disproportion
 - look for signs of obstruction such as caput and molding.
- Augment labor with oxytocin if there is (a) no cephalopelvic disproportion or sign of obstruction, (b) no fetal distress, and (c) uterine contractions are inadequate.
- Vertex may rotate anteriorly or posteriorly with good uterine contractions, and normal delivery may occur.
- If (a) the vertex descends below +2 station in traverse position, (b) the fetus is of average size, (c) there is no fetal distress, (d) the cervix is fully dilated, and (e) the pelvic configuration is normal, vaginal delivery may be attempted by
 - vacuum extraction
 - manual rotation and forceps delivery
 - forceps rotation and delivery.

Vacuum extraction

Vacuum extraction can be used to deliver the fetus. The cup should be applied close to the posterior fontanel to promote flexion during traction (Fig. 41.6).

With traction, the head flexes, rotates, and descends. Posterior cups for delivery of occipitoposterior/transverse are also available.

Manual rotation and forceps delivery

- This procedure requires expertise and should be undertaken only if the head is below +2 station.



Figure 41.6 Vacuum extraction in occipitoposterior position. The cup should be applied close to the posterior fontanel to promote flexion and apply traction.

- Epidural analgesia facilitates the procedure but pudendal block may also be used.
- The bladder should be emptied.
- The left hand is used for ROP and the right hand for LOP position.
- The hand is held with the palm facing upward. Four fingers are inserted behind the head into the hollow of the sacrum. The posterior ear should be felt.
- Method 1**
 - The head is grasped with the fingers over the posterior parietal bone and the thumb on the anterior parietal bone (Fig. 41.7).
 - The head is dislodged slightly and flexed by upward pressure close to the sinciput and rotated to bring the occiput anteriorly.
- Method 2**
 - The rotation may be performed using fingers. The tips of the index and middle fingers are placed on the lambdoid suture close to the posterior fontanel (Fig. 41.8).
 - The vertex is rotated by a movement of the forearm and simultaneously applying gentle pressure on the suture with the finger tips. The vertex flexes, moves slightly upward, and rotates.
- Once rotation is achieved, delivery is completed by forceps.

Forceps rotation and delivery

Forceps that are designed for rotation such as Kielland's forceps or Barton's forceps should



Figure 41.7 Manual rotation of the fetal head. The hand is held with the palm facing upwards, the four fingers are inserted into the hollow of the sacrum and head is grasped by the fingers on the posterior parietal bone and the thumb on the anterior parietal bone.

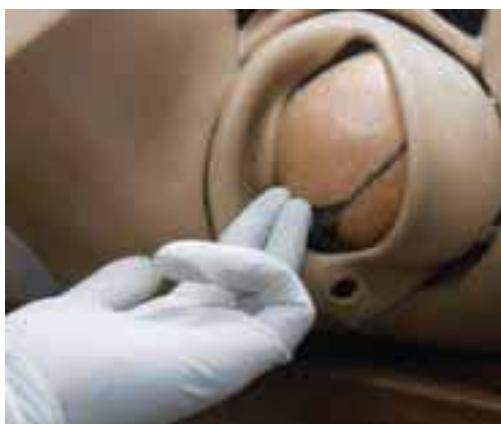


Figure 41.8 Digital rotation of the fetal head. The tips of the middle and index fingers are placed on the lambdoid suture close to the posterior fontanel and with gentle pressure the head is rotated.

be used. Forceps rotation requires training and expertise and is not used in modern obstetrics (see Chapter 19, *Operative vaginal delivery*).

- Cesarean section is indicated if (a) attempts at vaginal delivery are not successful, (b) there is fetal distress, (c) vertex is above +2 station, or (d) the pelvis is inadequate.
- If the vertex does not rotate or descend below the level of the ischial spines, in spite of good uterine contractions, after full dilatation of the cervix for 1 hour, a diagnosis of *deep transverse arrest* is made.

Deep transverse arrest

This usually occurs in women with android or anthropoid pelvis, where the transverse diameter is less or when there is cephalopelvic disproportion. A diagnosis of deep transverse arrest is made only when uterine contractions are adequate and the cervix is fully dilated. The duration of the arrest of descent should be 1 hour or more (Box 41.7).

Management of deep transverse arrest

Due to obstruction at the level of the ischial spines, there is usually molding and caput formation. Since the pelvic configuration is abnormal and the arrest of descent occurs above +2 station, vaginal delivery is usually not attempted. Delivery is by cesarean section.

Indications for cesarean section in occipitoposterior position

These are listed in Box 41.8.

Box 41.7 Deep transverse arrest

- Etiology
 - Android pelvis
 - Anthropoid pelvis
 - Cephalopelvic disproportion
- Diagnosis
 - Cervix fully dilated
 - Vertex at the level of ischial spines
 - Sagittal suture in the transverse diameter of pelvis
 - Good uterine contractions
 - Arrest of descent for 1 hour
- Management
 - Cesarean section

Box 41.8 Indications for cesarean section

- Persistent occipitoposterior position
- Deep transverse arrest
- Failed vaginal delivery with vacuum/forceps/manual rotation
- Fetal distress
- Grossly abnormal pelvic configuration

Malpresentations

Malpresentations are associated with higher maternal and fetal risks; therefore, they should be diagnosed early and progress in labor should be monitored carefully.

Face presentation

Face presentation results when the head is hyperextended with the occiput touches the fetal back. In face presentation, all parts of the face, from the chin to the glabella (the smooth area between the eyebrows just above the root of the nose), present in the pelvis.

Incidence

Face presentation occurs in 1/200–1/500 deliveries.

Etiology

Face presentation can be primary or secondary. Primary face presentation occurs in fetal malformations such as anencephaly, meningocele, or dolichocephaly. Tumors in the anterior aspect of the neck, spasm of extensor muscles of neck, and loops of cord around the neck cause extension of the fetal head. Polyhydramnios and prematurity, by increasing the space available and allowing the extended head to descend, can also cause face presentation (Box 41.9).

Secondary face presentation occurs in labor. Extension of the head usually results when there is abnormal pelvic configuration with a narrow anteroposterior diameter, as in platypelloid pelvis. The biparietal diameter is caught in the anteroposterior diameter of the inlet and acts as a fulcrum with the occiput and sinciput on either side. With uterine contractions, when the fetal trunk and occiput are pushed into the pelvis, the sinciput moves upward, the head extends gradually, and face presentation results.

Mechanism of labor

The denominator, attitude, engaging diameter, and positions are given in Box 41.10. The four positions are shown in Figure 41.9.

Box 41.9 Etiology of face presentation

- Primary face presentation
 - Multiparity
 - Fetal anomalies
 - Anencephaly
 - Meningocele
 - Dolichocephaly
 - Tumors in the neck
 - Thyroid enlargement
 - Other tumors
 - Loops of cord around the neck
 - Polyhydramnios
 - Prematurity
- Secondary face presentation
 - Abnormal pelvic configuration
 - Large baby/contracted pelvis

Box 41.10 Key parameters and positions in face presentation

- Denominator: The mentum (chin)
- Attitude: Complete extension
- Engaging diameter: Suboccipitobitemental (9.5 cm)
- Possible positions: Right mentoanterior (RMA)
Left mentoanterior (LMA)
Right mentoposterior (RMP)
Left mentoposterior (LMP)

Cardinal movements

Engagement

The submentobregmatic diameter engages in the left or right oblique diameter. The vertical distance between the face and biparietal diameter is 7 cm. This is more than the vertical distance between the pelvic brim and ischial spines. Therefore, when the biparietal diameter crosses the brim, the face is well below the ischial spines. Hence, the head is palpable per abdomen even after the face has descended below the level of ischial spines.

Descent

The fetus descends with good uterine contractions.

Increasing e tension

As the fetal trunk descends, extension of the head increases.

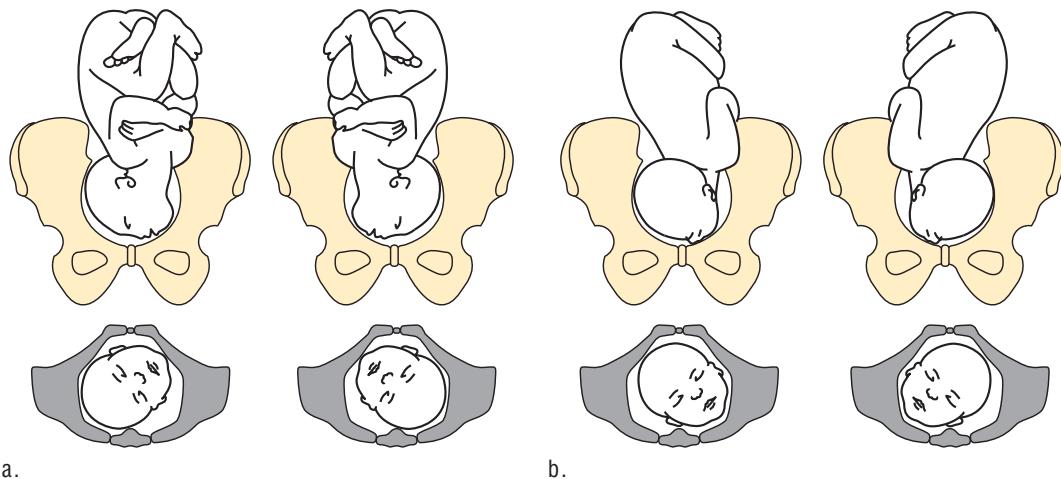


Figure 41.9 The four positions in face presentation. **a.** Left mentoanterior and right mentoanterior positions. **b.** Left mentoposterior and right mentoposterior positions.

Internal rotation

The mentum rotates anteriorly toward the pubic symphysis through 45 degrees (1/8th of a circle) in mentoanterior positions and through 135 degrees (3/8th of a circle) in mentoposterior positions. The rotation takes place at a lower level than in vertex presentation.

Inion

The chin hitches under the pubic symphysis and the mouth, nose, glabella, forehead, and occiput are born, in that order, by flexion.

Restitution

The neck untwists toward the opposite side.

External rotation

External rotation of the head follows restitution as the shoulders rotate toward the pubic symphysis.

Complications

Maternal and fetal complications in face presentation are listed in Box 41.11.

Diagnosis

Diagnosis of face presentation is by physical examination.

Box 41.11 Complications of face presentation

- Maternal
 - Prelabor rupture of membranes
 - Prolapse of the cord
 - Prolonged labor
 - Operative vaginal delivery
 - Cesarean section
- Fetal
 - Congenital anomalies
 - Fetal heart rate abnormalities
 - Facial edema
 - Laryngeal/tracheal edema
 - Admission to neonatal intensive care unit

Abdominal examination

The back is anterior in mentoanterior positions but is felt posteriorly at the flank in mentoposterior positions (Box 41.12). The sinciput is at a higher level than the occiput. The cephalic prominence (the most prominent part of the fetal head) is the occiput and is felt on the same side as the fetal back (Fig. 41.10). A groove may be felt between the occiput and the back.

Vaginal examination

On vaginal examination, all structures between the chin and glabella—mentum, mouth, nose, glabella, and malar eminences—are felt. The mentum occupies one of the four quadrants of the pelvis. On vaginal examination, the face may be mistaken for breech and is differentiated by the features listed in Table 41.1.

Box 41.12 Diagnosis of face presentation

- Abdominal examination
 - Umbilical grip
 - Back anterior in mentoanterior positions
 - Back posterior, at the flank in mentoposterior positions
 - Second pelvic grip
 - Sinciput at higher level than occiput
 - Groove felt between occiput and back
 - Cephalic prominence on same side as back
 - Auscultation
 - Fetal heart heard clearly in mentoanterior position
 - Toward the flank in mentoposterior position
- Vaginal examination
 - Chin, mouth, malar eminences, nose, glabella felt
 - Mentum in anterior or posterior quadrant

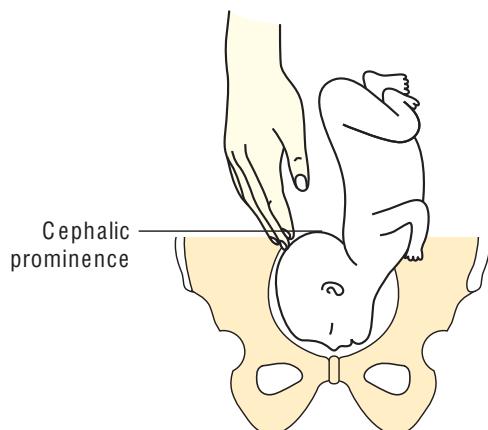


Figure 41.10 Cephalic prominence. In face presentation, the cephalic prominence which is the most prominent part of the fetal head is the occiput and is felt on the same side as the back.

Table 41.1 Differentiating face from breech presentation

Face	Breech
Mouth and malar eminences not in same line	Anus and ischial tuberosities in same line
If finger introduced, sucking movements felt	If finger introduced, gripping by anal sphincter felt
No meconium on finger	Meconium present on finger
External genitalia not felt	External genitalia felt

Progress in labor

The mentum is anterior in >60% of cases of face presentation, transverse in 10–15% of cases, and posterior in only 20–25% of cases. Labor progresses normally in mentoanterior positions since the engaging diameter is similar to that in vertex presentation. It is important to remember that internal rotation of the mentum takes place at a much lower level than in vertex.

The majority of mentoposterior positions also rotate anteriorly and deliver normally. However, 25% may remain as mentoposterior or rotate to direct posterior. **A persistent mentoposterior position cannot deliver vaginally.** This is because, with uterine contractions, the fetal chest also enters the pelvis and results in an impacted mentoposterior position, causing obstructed labor (Fig. 41.11).

Management

Management of the first stage is the same as in vertex presentation. Uterine contractions, descent of the presenting part, fetal heart rate, cervical dilatation, station, and rotation of mentum should be monitored and marked on a partograph. If the mentum rotates anteriorly, the baby is delivered normally. If there is a delay in the second stage, forceps can be used, provided the mentum has rotated anteriorly. However, vacuum extraction cannot be used.

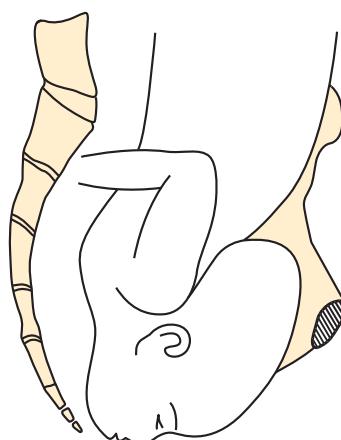


Figure 41.11 Impacted mentoposterior. If mentoposterior does not rotate anteriorly, with uterine contractions, the chest also enters the pelvis.

If the position is mentoposterior and rotates to mentoanterior, normal delivery ensues. If uterine contractions are not adequate, oxytocin augmentation may be considered, provided the baby is of average weight and pelvic configuration is normal.

Cesarean section is required if

- the fetus is large;
- the mentum does not rotate anteriorly 1 hour after full dilatation;
- fetal heart rate abnormalities occur.

The incidence of cesarean section is 60% in face presentation. In mentoposterior position, at cesarean section, the head should be flexed with the hand to facilitate delivery.

Management of face presentation is summarized in Box 41.13.

Brow presentation

Brow presentation is a position of partial extension, halfway between complete flexion and complete extension. **In brow presentation, all structures from the orbital ridges to the anterior**

Box 41.13 Management of face presentation

- Estimate weight of baby
- Perform internal pelvimetry
- Monitor
 - Uterine contractions
 - Descent of presenting part
 - Fetal heart rate
 - Cervical dilatation
 - Station of presenting part
 - Rotation
- Mentoanterior
 - If rotation is complete
 - Normal delivery
 - Forceps delivery
 - If no rotation
 - Cesarean section
- Mentoposterior
 - If rotates anteriorly: Deliver
 - If no rotation: Cesarean section
- Oxytocin augmentation
 - Only if
 - baby weight average
 - pelvic configuration normal

fontanel present in the pelvis. Incidence is 1 in 1500 deliveries.

Etiology

Prematurity, multiparity, and cephalopelvic disproportion are the most common causes of brow presentation. Other conditions that give rise to face presentation such as tumors in the neck, spasm of the extensor muscles, and polyhydramnios can also cause brow presentation.

Course in labor

The denominator, engaging diameter, and positions are given in Box 41.14. Frontal bone or 'frontum' is the denominator. The four positions are left and right frontum anterior and frontum posterior.

The engaging diameter is verticomental (13.5 cm) which is the largest diameter of the fetal head. **Vaginal delivery, therefore, is not possible unless the fetus is very small or premature or the pelvis is very roomy.**

Brow presentation is usually found early in labor. With good uterine contractions, it usually flexes to vertex or extends further to face presentation. If brow presentation persists in established labor, there is no mechanism of labor and delivery. If undiagnosed, it can result in uterine rupture, especially in multigravida.

Complications

Prelabor rupture of membranes and prolapse of the cord can occur. If undiagnosed, uterine rupture is a known complication. Fetal complications are related to the associated anomalies, operative delivery, and obstructed labor.

Box 41.14 Key parameters and positions in brow presentation

Denominator: The frontum

Attitude: Partial extension

Engaging diameter: Verticomental (13.5 cm)

Positions: $\left\{ \begin{array}{l} \text{Left frontoanterior (LFA)} \\ \text{Left frontoposterior (LFP)} \\ \text{Right frontoanterior (RFA)} \\ \text{Right frontoposterior (RFP)} \end{array} \right.$

Diagnosis

On abdominal examination, the head feels broader. The sinciput is higher than the occiput but not as high as in face presentation (Fig. 41.12). Diagnosis can be made with certainty only on vaginal examination. The anterior fontanel, forehead, and orbital ridges are felt (Fig. 41.13).

Management

If brow presentation is diagnosed in early labor, the mother may be monitored closely and vaginal examination repeated after 4–6 hours to see if flexion to vertex or extension to face presentation has occurred. Oxytocin augmentation is not recommended. Once the woman is in active labor, if brow presentation persists, cesarean section is indicated. A summary of brow presentation is given in Box 41.15.

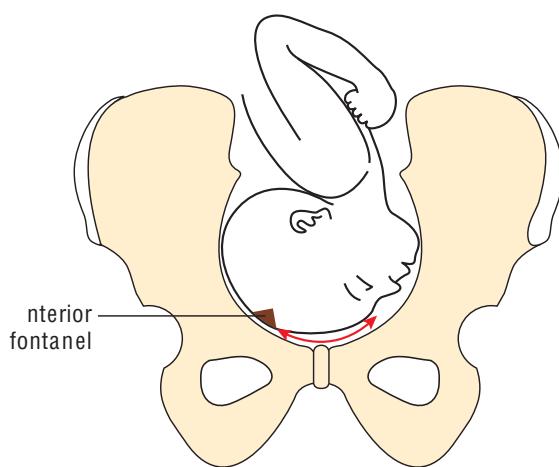


Figure 41.12 Brow presentation. On abdominal examination, the sinciput is higher than occiput.

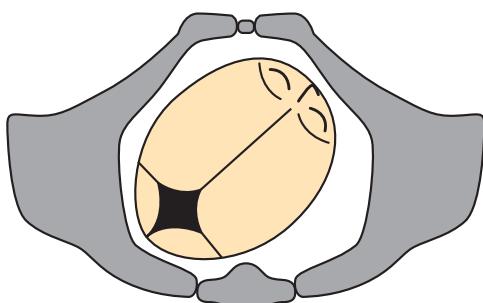


Figure 41.13 Brow presentation, vaginal examination. The orbital ridges, forehead, and anterior fontanel are felt.

Transverse lie

When the longitudinal axis of the fetus is perpendicular to the long axis of the uterus, the lie is said to be transverse. If the long axis of the fetus is at an angle to the long axis of the uterus, it is known as *oblique lie*. This usually becomes transverse lie or longitudinal lie once uterine contractions begin. The presenting part is the shoulder in transverse lie.

Incidence

Transverse lie is seen in 1/300 deliveries at term.

Etiology

Conditions that prevent the fetal head or breech from entering the pelvis predispose to transverse lie. These may be placenta previa, contracted pelvis, cephalopelvic disproportion, or tumors in the lower uterine segment such as myomas. Prematurity, polyhydramnios, multifetal pregnancy, uterine anomalies such as subseptate

Box 41.15 Brow presentation

- Incidence
 - 1/1500 deliveries
- Etiology
 - Prematurity
 - Multiparity
 - Cephalopelvic disproportion
 - Polyhydramnios
 - Fetal anomalies
 - Tumors in the neck
 - Spasm of the extensor muscles
- Complications
 - Prelabor rupture of membranes
 - Cord prolapse
 - Uterine rupture
 - Fetal anomalies
 - Asphyxia
- Diagnosis
 - Abdominal examination
 - Fetal head feels large
 - Sinciput at higher level than occiput
 - Vaginal examination
 - Orbital ridges, forehead, anterior fontanel felt
- Management
 - Early labor: Monitor and wait
 - Late in labor: Cesarean section

uterus, and multiparity are also etiological factors (Box 41.16).

Course in labor

The fetal back may face upward, downward, anteriorly, or posteriorly; therefore, there are four positions (Fig. 41.14):

The denominator and positions are given in Box 41.17.

In addition, depending on the direction of the fetal back, four positions are described as follows:

- Dorsoanterior
- Dorsoposterior

Box 41.16 Etiology of transverse lie

- Maternal factors
 - Multiparity
 - Contracted pelvis
 - Cephalopelvic disproportion
 - Placenta previa
 - Subseptate uterus
 - Polyhydramnios
 - Pelvic tumors
- Fetal factors
 - Prematurity
 - Multifetal pregnancy

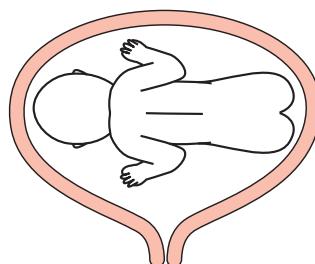
- Dorsosuperior
- Dorsoinferior

Spontaneous resolution to longitudinal lie can occur as gestation advances. When the lie persists toward term, conversion to vertex or breech is less likely.

There is no mechanism of labor in transverse lie and vaginal delivery is not possible. With uterine contractions, the shoulder enters the pelvis and labor does not progress. When membranes rupture, the cord or an arm may prolapse. As the uterus contracts further, obstructed labor results and a retraction ring or Bandl's ring is formed. In nulliparas, contractions may cease and result in hypotonic dysfunction. In multiparas, however, contractions continue and the uterus ruptures.

Box 41.17 Key parameters and positions in transverse lie

- Denominator: Acromion
 Lie: Transverse
 Possible positions: Left acromioanterior
 Right acromioanterior
 Left acromioposterior
 Right acromioposterior



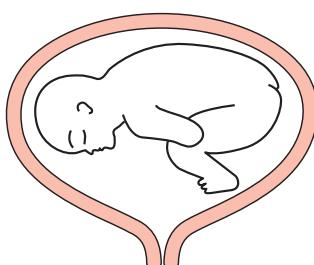
orsoanterior



orsoposterior



orsoinferior



orsosuperior

Figure 41.14 The four positions in transverse lie: Dorsoanterior, dorsoposterior, dorsosuperior, and dorsoinferior.

Complications

Transverse lie is associated with maternal and fetal complications (Box 41.18).

Diagnosis

Diagnosis of transverse lie can be made clinically in most cases.

Abdominal examination

On abdominal examination, the uterine ovoid is transverse. There is no pole palpable on fundal grip. On umbilical grip, the fetal back is felt easily in the dorsoanterior position and the limbs are felt in the dorsoposterior position. The fetal head is felt on one flank and the breech on the opposite flank. On pelvic grip, the lower pole is empty except late in labor when the shoulder occupies it. The fetal heart is easily heard below the umbilicus in the dorsoanterior position and heard with difficulty in the dorsoposterior position (Box 41.19).

Vaginal examination

If transverse lie is diagnosed or suspected on abdominal examination, vaginal examination should be performed only after ruling out placenta previa by ultrasound scan. On vaginal examination, a conical bag of membranes is felt if the cervix is dilated. The shoulder is high up and felt with difficulty in early labor. After rupture of membranes, the scapula, acromion, shoulder or elbow, and ribs can be felt. When membranes rupture, cord prolapse is common. One arm may also prolapse into the vagina or outside the introitus. In case of arm prolapse, shaking hands with the prolapsed hand helps in identifying whether it is the right or left arm (Fig. 41.15).

Box 41.19 Diagnosis of transverse lie

- Abdominal examination
 - Inspection: Uterine ovoid is transverse
 - Palpation
 - Fundal grip: No fetal pole felt
 - Umbilical grip
 - Fetal back felt in dorsoanterior position
 - Limbs felt in dorsoposterior position
 - Head in one flank, back on the other
 - Pelvic grip: Lower pole empty
 - Auscultation
 - Fetal heart below umbilicus
 - Easily heard in dorsoanterior position
 - Not easily heard in dorsoposterior position
- Vaginal examination
 - Bag of membranes felt
 - Presenting part high up
 - Shoulder, elbow, arm, ribs, acromion, scapula



Figure 41.15 Transverse lie with arm and cord prolapse. The left hand and forearm of the fetus and cord are seen lying outside the introitus. (Photo courtesy: Dr Rajnish Samal, Bangalore.)

Box 41.18 Complications in transverse lie

- Complications in transverse lie
 - Maternal
 - Prelabor rupture of membranes
 - Cord prolapse
 - Arm prolapse
 - Obstructed labor
 - Uterine rupture
 - Cesarean section
- Fetal
 - Asphyxia
 - Fetal death

Management

Management depends on the following:

- Gestational age
- Presence of placenta previa
- Stage of labor
- Rupture of membranes

Vaginal delivery is possible only if the transverse lie can be converted into longitudinal lie with cephalic presentation. This can be attempted only

if placenta previa is excluded. In most cases, cesarean section is the mode of delivery.

- If transverse lie is diagnosed in midtrimester or early third trimester, only follow-up is required.
- If it is diagnosed at or after 36 weeks' gestation, ultrasonography is performed to exclude placenta previa and polyhydramnios.
- If there is no placenta previa, external cephalic version is attempted at 37 weeks.
- If successful, onset of labor is awaited with weekly review to ensure that fetus has not reverted to transverse lie.
- If unsuccessful, delivery is by cesarean section after 38 weeks.
- If diagnosed early in labor and the membranes are not ruptured, external cephalic version is attempted after placenta previa has been excluded. If external cephalic version is unsuccessful, delivery is by cesarean section.
- If diagnosed early in labor after membranes rupture, cord prolapse should be ruled out. Delivery is by cesarean section.

- If the mother is seen late in labor with or without arm prolapse, deliver is by cesarean section.

Management of transverse lie is outlined in Figure 41.16.

Cesarean section in transverse lie

Cesarean section in a woman with transverse lie is not a simple procedure.

- The lower segment may be narrow and space may be insufficient for delivery of the fetus.
- With rupture of membranes and reduced amount of amniotic fluid, the uterus may be hugging the fetus and delivery may become difficult.
- There may be obstructed labor with the formation of Bandl's ring.
- If fetus is delivered through a traditional lower segment incision, the lateral ends of the incision can extend to involve the uterine vessels.

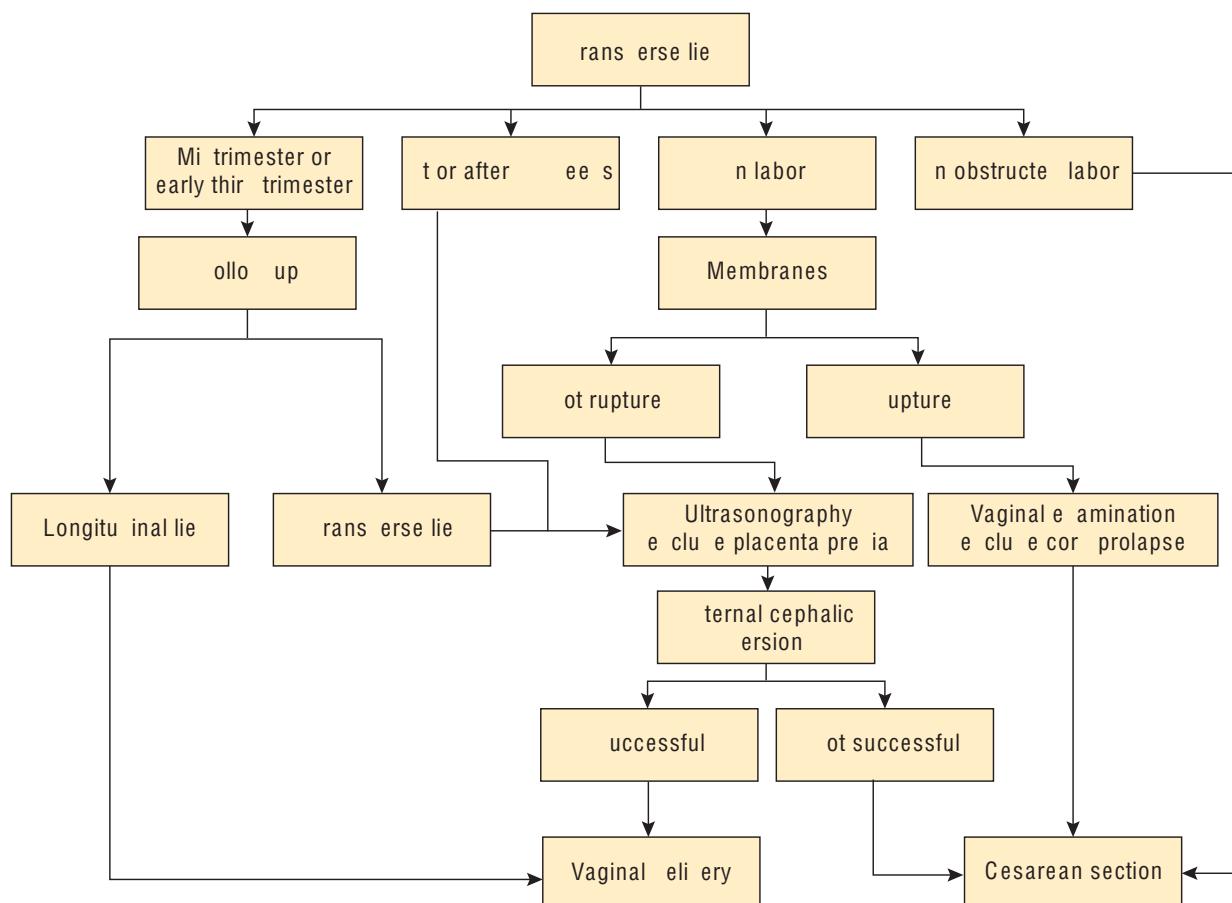


Figure 41.16 Management of transverse lie.

- The incision should be 'U' shaped, inverted T shaped, lower segment vertical, or an upper segment classical.
- Halothane anesthesia may be required to relax the uterus and deliver the fetus in obstructed labor.
- The fetal head and back must be located before uterine incision is made.
- The fetus should be delivered by traction on the feet and legs and not on the arm.
- Delivery may be difficult in the dorsoanterior and dorsoinferior positions.
- If there is placenta previa, the placenta should be cut through or partially separated and pushed away from the field of incision before delivery of the fetus.

Unstable lie

When the fetal lie and/or presentation changes repeatedly after 37 weeks' gestation, it is known as an unstable lie. Polyhydramnios and placenta previa are the usual causes. Ultrasonography should be performed to exclude these conditions. As term approaches, the lie may stabilize as longitudinal.

Stabilizing induction

- If unstable lie persists after 38–39 weeks' gestation, stabilizing induction is undertaken. Woman is admitted to the labor room.
- If the lie is transverse, external cephalic version is performed.

- Oxytocin infusion is started with 5 units of oxytocin in normal saline (see Chapter 16, *Induction of labor*).
- When contractions occur once every 10 minutes, vaginal examination is performed to ensure that presentation is cephalic and to exclude cord presentation.
- Artificial rupture of membranes is done, taking care to avoid cord prolapse.
- When amniotic fluid escapes, the head usually enters the pelvis.
- Oxytocin infusion is continued and labor managed accordingly.

Compound presentation

When one of the extremities present along with one of the fetal poles, it is known as compound presentation (Fig. 41.17). A foot or lower limb presenting with breech is not included in this definition.

Incidence

Compound presentation occurs in 1/1000–1/1200 deliveries. The combination of vertex and hand is the most common presentation.

Etiology

Prematurity is the most common cause since the small preterm head allows enough room for a limb to descend by the side of the head or breech. Other causes are maternal age, multiparity, contracted pelvis, and external cephalic version.

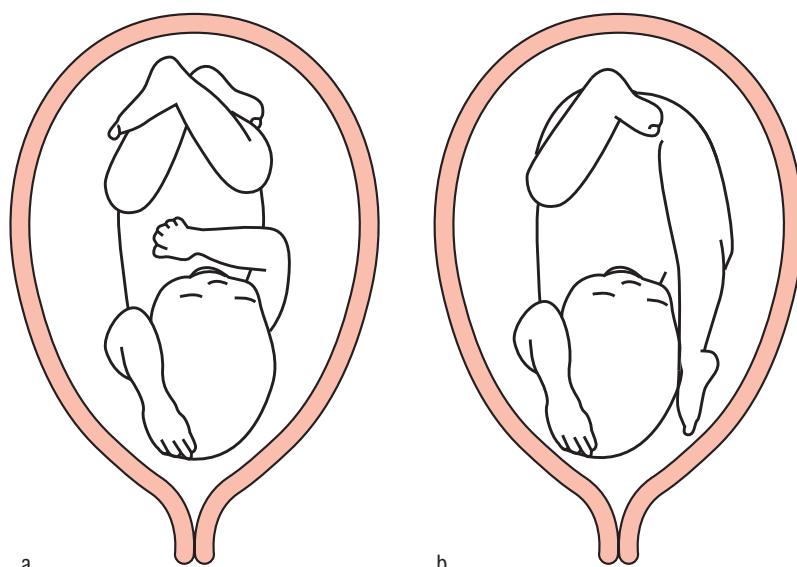


Figure 41.17 Compound presentation. **a.** Hand and head. **b.** Hand, foot, and head.

Mechanism of labor

The possible combinations are as follows:

- Vertex and hand/upper limb
- Vertex and foot
- Vertex, hand, and foot
- Breech and hand/upper limb

When labor begins, the limb usually moves up and normal delivery occurs in most cases. Labor may be prolonged but once the limb retracts, labor progresses normally. If the limb does not retract, labor may not progress and delivery by cesarean section is indicated.

Complications

Since the presenting part does not fit well in the lower uterine segment, cord prolapse is common. Fetal heart rate abnormalities and asphyxia are also common complications. Maternal and fetal complications are listed in Box 41.20.

Diagnosis

Diagnosis of compound presentation is usually made in labor by vaginal examination. The hand or the foot may be felt through the membranes or, if the membranes have ruptured, can be felt more readily. Presence of cord should always be looked for.

Box 41.20 Compound presentation

- Definition
 - One or other extremities with vertex or breech
 - Vertex with hand/foot or both
 - Breech with hand
- Incidence
 - 1 in 1000–1200
- Etiology
 - Prematurity, multiparity
 - Contracted pelvis, external cephalic version
- Complications
 - Maternal
 - Prolonged labor
 - Cesarean section
 - Fetal
 - Cord prolapse
 - Fetal heart rate abnormalities
 - Asphyxia
- Diagnosis
 - Vaginal examination
- Management
 - In early labor: Wait and watch
 - If no progress: Cesarean section

Management

Labor may be allowed to progress normally especially if the limb is at the same level or above the level of vertex. If the limb is below the level of vertex, it may not retract spontaneously. An attempt may be made to gently push the limb up, past the presenting part. The fetal heart should be monitored closely, preferably using electronic fetal heart rate monitoring. Cesarean section is indicated if (a) repeat vaginal examination reveals persistent compound presentation, (b) cord prolapse occurs, (c) progress of labor does not occur, or (d) there is fetal heart rate abnormality.

Umbilical cord presentation and prolapse

Umbilical cord presentation is one where the cord is felt alongside the presenting part or below it and the membranes have not ruptured.

When membranes rupture and the cord is felt alongside the presenting part, it is called **occult cord prolapse**. When it is felt below the presenting part, it is called **overtcord prolapse**. The cord may prolapse into the vagina or outside the introitus (Fig. 41.18).

Incidence

The incidence of cord prolapse is 0.6% of all deliveries.

Etiology

When the presenting part does not fit well in the lower uterine segment, cord prolapse can occur.

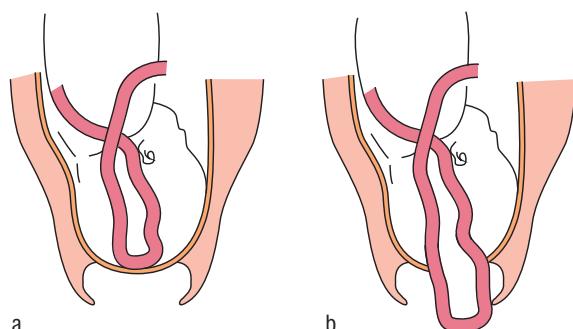


Figure 41.18 Cord presentation and prolapse. **a.** Cord prolapse with the membranes not ruptured. Cord is felt alongside the head. **b.** Cord prolapse with the membranes ruptured. The cord lies below the head.

The conditions include (a) malpresentations such as face, brow, breech, transverse lie, and compound presentation, (b) conditions where the presenting part is small as happens in prematurity and multifetal pregnancy, and (c) conditions where there is excessive amniotic fluid (polyhydramnios), cephalopelvic disproportion, multiparity, and long umbilical cord (Box 41.21).

Iatrogenic causes are artificial rupture of membranes, internal podalic version, external cephalic version, amnioinfusion, and application of scalp electrode, manual rotation of fetal head, and insertion of intrauterine pressure catheter.

Consequences of cord prolapse

The cord which prolapses may be compressed between the bony pelvis and the presenting part leading to fetal hypoxia, asphyxia, and fetal death. Exposure of the cord to atmospheric temperature leads to spasm of the umbilical vessels. Manipulation to replace the cord into the uterus

and handling of the cord also cause spasm. Spasm leads to hypoxia.

Diagnosis

It is not possible to diagnose cord presentation or prolapse by clinical examination antenatally. On ultrasonography, loops of cord may be visible below the presenting part, especially in malpresentations.

Cord prolapse should be suspected when there is sudden bradycardia or moderate to severe variable decelerations. Diagnosis is by vaginal examination. Occult cord may be difficult to palpate but must be looked for.

Cord presentation should be anticipated in the following situations:

- Malpresentations
- Preterm labor
- Polyhydramnios
- Mobile head
- Artificial rupture of membranes
- External cephalic version
- Internal podalic version
- When fetal heart abnormalities occur immediately after rupture of membranes

Box 41.21 Cord prolapse

- Definition
 - Cord alongside or below presenting part
 - Membranes ruptured
- Types
 - Occult
 - Cord alongside the presenting part
 - Overt
 - Cord below the presenting part
- Incidence
 - 0.6% of deliveries
- Etiology
 - Spontaneous
 - Malpresentations
 - Prematurity
 - Polyhydramnios
 - Multifetal pregnancy
 - Multiparity
 - Long cord
 - Cephalopelvic disproportion
 - Iatrogenic
 - Artificial rupture of membranes
 - Amnioinfusion
 - Insertion of intrauterine pressure catheter, scalp electrode
 - External cephalic version
 - Internal podalic version
- Consequences
 - Cord compression/spasm
 - Fetal hypoxia
 - Fetal death

Management

As soon as cord prolapse is diagnosed, it is important to determine if the cord pulsations are present or not. If the cord has prolapsed some time earlier and the pulsations are absent, there is no urgency for delivery. Usually vaginal delivery is recommended, except in situations such as transverse lie where it is not feasible.

If cord pulsations are present, in order to avert death or hypoxic injury, the fetus must be delivered as soon as possible. Diagnosis-to-delivery interval is crucial. Vaginal delivery is feasible only in a few, where the cervix is fully dilated and delivery is imminent. Most women need a cesarean section. Measures should be taken to prevent compression of the cord while waiting for cesarean section.

Management depends on the stage of labor.

Cord prolapse in the first stage of labor

- Delivery should be by immediate cesarean section. Alert operating room staff, anesthesiologists, and neonatologists.

- While waiting for cesarean section, manipulations of the cord must be avoided.
- Loops of cord may be replaced into the vagina if they are outside the introitus.
- Wrapping in towels soaked in warm saline has not been found useful.
- To reduce compression of the cord by the presenting part, various techniques may be followed:
 - Elevate the foot end of bed (steep Trendelenburg position)
 - Alternatively, use knee-chest position
 - Fill maternal bladder using Foley's catheter
 - Push up the presenting part with a hand in the vagina
 - Administer 0.25 mg of terbutaline subcutaneously for tocolysis
 - Monitor fetal heart rate continuously

Cor prolapse in the second stage o labor

- If cord prolapse occurs in the second stage of labor, vaginal delivery may be feasible.
- Assess presentation and station of the presenting part.

- If the fetus is in transverse lie or the presenting part is high (above 0 station), deliver by cesarean section.
- If the vertex is below the level of the ischial spine, vacuum extractor or forceps may be used to deliver vaginally.
- If presentation is breech, breech extraction is an option but cesarean section is usually resorted to in this situation.
- If the fetus is in transverse lie and the membranes have just ruptured, internal podalic version and breech extraction is an option in the following situations:
 - The fetal weight is average.
 - The fetus is the second of twins.

Internal podalic version and breech extraction in a singleton fetus is associated with high perinatal mortality and should be performed only by an experienced obstetrician and only if facilities for immediate cesarean section are not available.

Management of cord prolapse is outlined in Figure 41.19.

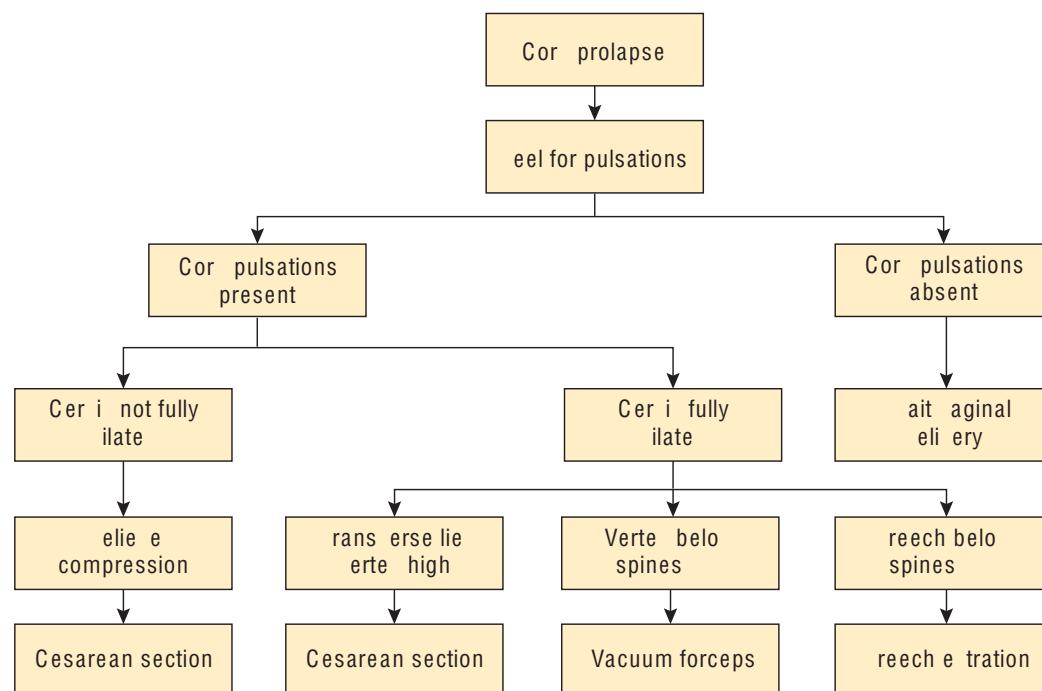


Figure 41.19 Management of cord prolapse.

Prevention

- Anticipate cord prolapse when membranes rupture in malpresentations, preterm labor, and polyhydramnios.
- Monitor fetal heart rate and perform a vaginal examination immediately if there are abnormalities.
- Take precautions when performing artificial rupture of membranes especially when the presenting part is high or when there is polyhydramnios. Use a needle rather than Kocher's forceps and perform 'controlled' rupture of membranes.

- Take precautions during amnioinfusion or inserting a fetal scalp electrode.

Cord presentation

Cord presentation may be an incidental finding on ultrasonography. This can be confirmed by color flow Doppler studies. If cord presentation is found remote from term, follow-up with ultrasonography is required. If it persists or is found after 38 weeks, elective cesarean section is usually performed.

Key points

- Malpresentations and malpositions are important causes of abnormal labor.
- Vertex presentations other than left occipitoanterior are referred to as malpositions. The most common is occipitoposterior position.
- Malpresentations are presentations other than vertex such as face, brow, breech, shoulder, and compound presentations.
- Abnormal axial lie can be transverse, oblique, or unstable lie.
- Malpresentations have some common etiological factors such as multiparity, polyhydramnios, placenta previa, abnormal pelvic configuration, cephalopelvic disproportion, uterine malformations, prematurity, multiple pregnancy, or fetal anomalies.
- Most fetuses in occipitoposterior position deliver normally. Abnormal mechanisms are posterior rotation, short anterior rotation, or nonrotation.
- Posterior rotation results in face-to-pubis delivery. Short anterior rotation can cause deep transverse arrest. If the vertex is below +2 station, instrumental delivery is possible. If not, cesarean section is required.
- Face presentation results when the head is hyperextended. The engaging diameter is submentobregmatic.
- Normal delivery occurs in mentoanterior presentations and most mentoposterior presentations that undergo rotation.
- A persistent mentoposterior position cannot deliver vaginally. If anterior rotation does not occur in mentoposterior position, cesarean section is required.
- Brow presentation is the result of partial extension of the head. The engaging diameter (vertical) is the largest diameter of fetal head; therefore, it cannot

- negotiate the pelvic diameters. Normal delivery is not possible unless the head extends further to face presentation or flexes to vertex presentation.
- When the longitudinal axis of the fetus is perpendicular to the uterine ovoid, it is referred to as transverse lie. When membranes rupture, cord or arm prolapse can result.
- There is no mechanism of labor in transverse lie. It has to be converted to cephalic presentation by external cephalic version after 37 weeks or early in labor. Placenta previa must be excluded in all cases of transverse lie.
- Neglected shoulder presentation can result in obstructed labor and uterine rupture. If external cephalic version is not successful, cesarean section is required.
- When one of the extremities present along with one of the fetal poles (except a combination of breech and foot), it is known as a *compound presentation*. If the limb is at the same level or above the level of the vertex, it usually retracts in labor. If there is no progress in labor, cesarean section is indicated.
- When a loop of cord is felt alongside the presenting part and the membranes are intact, it is known as *cord presentation*. If the membranes are ruptured, the cord enters the vagina ahead of the presenting part. This is known as *cord prolapse*.
- As soon as the cord is felt, it is important to determine if cord pulsations are present. If pulsations are present and delivery is not imminent, immediate cesarean section is mandatory.
- Cord should be replaced into the vagina and head elevated to relieve compression while preparing for cesarean section.

Self-Assessment

Case-based Questions

Case 1

Mrs. CN, 31, third gravida with previous normal deliveries, was admitted to the labor room with pains for 6 hours. The doctor who examined her in a primary center had diagnosed transverse lie and had referred her for further care.

1. How will you clinically diagnose transverse lie?
2. What is the next step in the evaluation?
3. What complications do you anticipate if labor is allowed to progress?
4. How will you manage the case?

Case 2

Mrs. AD, multigravida at term, was admitted in labor. The membranes ruptured at the time of admission and along with the gush of amniotic fluid, a loop of cord slipped out.

1. What is the immediate management?
2. How will you decide on mode of delivery?
3. What are the causes of cord prolapse?

Answers

Case 1

1. Abdominal examination—fundal grip does not reveal any fetal pole. Umbilical grip—head is felt in one flank and breech in the other. Back or limbs may be felt anteriorly. First pelvic grip reveals an empty lower pole. Fetal heart sounds are heard at or below the level of the umbilicus.
2. Ultrasonography to exclude placenta previa. If excluded, pelvic examination to assess dilatation and effacement of cervix, presence of bag of membranes. The shoulder, elbow or arm, acromion, and ribs will be felt high up.
3. Early rupture of membranes, cord prolapse, arm prolapse, fetal distress, fetal hypoxia, and fetal death. Obstructed labor and uterine rupture.
4. Since she is in early labor and membranes are not ruptured, external cephalic version may be

attempted. If unsuccessful, cesarean section should be performed.

Case 2

1. Check for cord pulsation. If pulsations are present, call for help. Replace the prolapse loops of cord into the vagina and push them up as high as possible. Push the presenting part up to prevent compression of the cord.
2. Pelvic examination should be done to assess cervical dilatation, fetal presentation, and station. If the cervix is fully dilated and the presenting part is below the ischial spines, vaginal delivery may be attempted using vacuum extraction or breech extraction depending on the presentation. If the cervix is not fully dilated, cesarean section should be performed.
3. Malpresentations such as breech, transverse lie, brow and face, artificial rupture of membranes when presenting part is high, polyhydramnios, multifetal pregnancy, external cephalic version, and internal podalic version.

Sample questions

Long-answer questions

1. Discuss the diagnosis and management of deep transverse arrest.
2. How will you diagnose right occipitoposterior position clinically? Discuss the management of labor in this situation.
3. Discuss the etiology, diagnosis, and management of a case of transverse lie in labor.

Short-answer questions

1. Face-to-pubis delivery
2. Mentoposterior position
3. Cord prolapse
4. Shoulder presentation with arm prolapse
5. Compound presentation
6. Etiology of malpresentations
7. Brow presentation

42

Abnormal Labor: Breech Presentation and Shoulder Dystocia

Case scenario

Mrs. RN, 29, multigravida at 40 weeks, was admitted with labor pains. On examination, the contractions were every 10 minutes, lasting for 20 seconds, and the presentation was breech. Fetal and maternal risks of both vaginal breech delivery and cesarean section were explained to Mrs. RN and her husband. They were worried and confused about which mode of delivery to opt for.

Introduction

Breech presentation is the most common malpresentation and is an important cause of abnormal labor. The perinatal mortality and morbidity are higher than in vertex presentation at all gestational ages. Mode of delivery in breech has also been a subject of controversy that has been influenced by the results of several randomized trials.

Shoulder dystocia is an obstetric emergency. Perinatal mortality is high when dystocia is severe or is inappropriately managed.

Breech presentation

Though the lie is longitudinal, the mechanism of labor, complications to the mother and fetus,

and the conduct of vaginal breech delivery are very different from cephalic presentation.

Definition

When the podalic pole or the buttocks present with the legs extended or flexed, it is termed breech presentation.

Incidence

The incidence is 3%–4% at term although it is 7% at 32 weeks. Most fetuses that present as breech before term turn spontaneously to cephalic presentation. The incidence decreases as the gestational age increases.

Etiology

The causes of breech presentation are listed in Box 42.1.

Prematurity is the most common cause and breech presentation in prematurity is due to the relative increase in the volume of amniotic fluid. Polyhydramnios is also an etiological factor, due to the increase in liquor volume. Placenta previa and cornuofundal insertion of placenta, uterine anomalies, especially bicornuate uterus and

septate uterus, myoma in the lower uterine segment, multiparity, and multiple pregnancy are other etiological factors. Previous breech presentation also increases the risk. Congenital anomalies of the fetus such as anencephaly, hydrocephalus, and neuromuscular disorders such as myotonic dystrophy, trisomy 13, 18, and 21 are also associated with increased risk.

Classification

The three types of breech presentation are as follows (Fig. 42.1):

- Frank (extended) breech
- Complete (flexed) breech
- Incomplete breech

Frank breech

- The fetus is flexed at the hips and extended at the knees.
- This constitutes 60%–70% of all breech presentations.
- Frank breech fits snugly in the lower uterine segment.
- The breech is compact and may be mistaken for the head on abdominal examination.
- The extended legs splint the body, making external version difficult.
- The head is less ballotable.

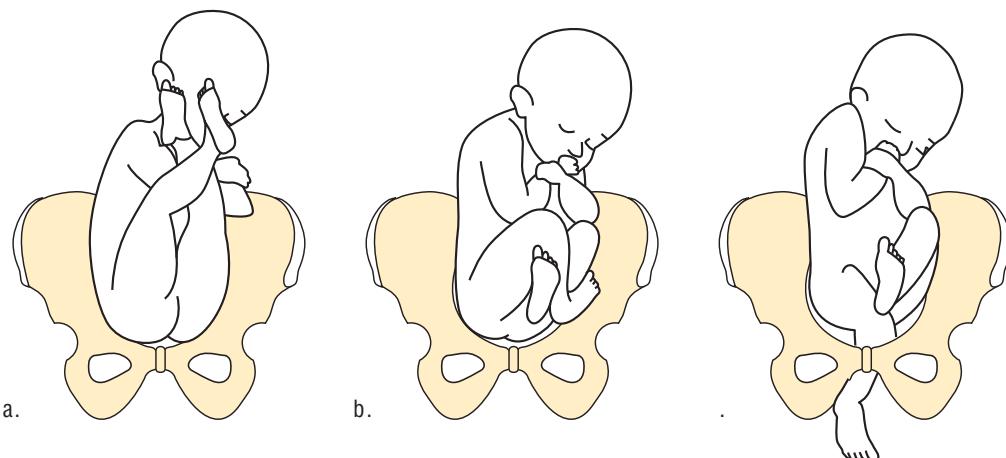


Figure 42.1 Types of breech presentation. **a.** Frank breech—flexed at the hips and extended at the knees. **b.** Complete breech—flexed at the hips and knees. **c.** Incomplete breech—extended at the hips and knees.

- Prognosis for vaginal delivery is better than for other types of breech.
- Cord prolapse is less common since the cervix is usually well applied to the compact breech.

Complete breech

- The fetus is flexed at the hip and knees.
- It constitutes 5%–10% of breech presentations.
- The irregular breech does not fit well in the lower uterine segment.
- Cord prolapse is more common.
- There is lesser chance of vaginal delivery than in the frank breech.

Incomplete breech

- One or both hips are extended and the knee or foot presents below the breech.
- When one or both feet are below the breech, it is known as footling breech.
- It constitutes 20%–25% of breech presentations.
- This has the highest risk of cord prolapse.
- There is a high risk of head entrapment.
- There is less chance of cervical dilatation.
- There is a high risk of cesarean section.

Breech presentation is also classified as *complicated* and *uncomplicated* depending on the presence of associated maternal complications that can affect perinatal outcome.

Complicated breech

When a breech presentation is associated with maternal factors which adversely influence the prognosis, such as gestational hypertension, preeclampsia, pregestational or gestational diabetes, or maternal cardiac disease are present, it is referred to as *complicated breech presentation*. These maternal complications can potentially increase perinatal and maternal morbidity associated with the maneuvers involved in vaginal breech delivery.

Uncomplicated breech

Breech presentation with no associated maternal complications is referred to as *uncomplicated breech presentation*.

Complications of breech presentation

Breech presentation and delivery are associated with higher perinatal morbidity and mortality. Some maternal complications can also occur.

Fetal complications

The increase in perinatal mortality and morbidity in breech presentations is due to the following reasons:

- **Inherent problems in the fetus in breech presentation:** These include complications of prematurity, congenital anomalies, chromosomal anomalies, and neuromuscular disorders. These may also be the cause of breech presentation.
- **Complications of breech presentation/delivery:** These occur during labor or delivery and are due to the malpresentation.

Fetal complications are listed in Box 42.2.

Prematurity is the most common cause of breech presentation and is associated with increase in perinatal mortality and morbidity. When the gestational age is >32 weeks and the fetal weight is >1500 g, mortality is low irrespective of the mode of delivery. However, when fetal weight is between 1000 and 1500 g, vaginal delivery is associated with a higher rate of complications. There is increased risk of intracranial hemorrhage, birth injuries, and entrapment of the aftercoming head. Therefore, cesarean section is recommended in these cases. These

Box 42.2 Fetal Complications of breech presentation

- Inherent problems in the fetus
 - Prematurity
 - Congenital anomalies
 - Chromosomal anomalies
 - Neuromuscular disorders
- Complications due to breech presentation/delivery
 - Cord accidents
 - Cord prolapse
 - Cord entanglement
 - Birth asphyxia
 - Entrapment of aftercoming head
 - Birth trauma

complications can occur during breech delivery by cesarean section as well.

When the breech does not fit well in the lower uterine segment, cord prolapse is common. The cord may get entangled during assisted breech delivery. Birth asphyxia is related to the interval between delivery of breech and delivery of the aftercoming head. Head entrapment occurs when the breech escapes through an incompletely dilated cervix as in preterm breech or in extended head. Birth injuries that can occur during breech delivery are listed in Box 42.3. Tentorial tears and intracranial hemorrhage occur during delivery of the head due to sudden decompression. Brachial plexus injuries, spinal cord injuries, and epiphyseal separation of bone may occur due to undue traction.

Maternal complications

Perineal tears and vaginal and cervical lacerations can occur during assisted breech delivery. The risk of cesarean section is high.

Mechanism of labor

The mechanism of labor with breech presentation is described in three stages:

1. Delivery of the breech
2. Delivery of the shoulders
3. Delivery of the head

The denominator, engaging diameters, and positions in breech presentation are given in Box 42.4.

There are four positions depending on the quadrant of the pelvis which the sacrum occupies (Fig. 42.2). Right sacroanterior is the most common position.

Box 42.3 Birth injuries in breech delivery

- Tentorial tears
- Intracranial hemorrhage
- Brachial plexus injury
- Spinal cord injuries
- Separation of epiphysis of femur or humerus
- Fracture femur or humerus
- Depressed fracture skull
- Injury to external genitalia
- Injury to abdominal viscera

Box 42.4 Denominator, engaging diameter, and positions in breech presentation

- Denominator: Sacrum
- Engaging diameter: Bitrochanteric (9.5 cm)
- Positions:

Left sacroanterior (LSA)
Right sacroanterior (RSA)
Left sacroposterior (LSP)
Right sacroposterior (RSP)

Delivery of breech

The cardinal movements are as follows:

- Engagement
- Descent with compaction
- Internal rotation of anterior buttock
- Delivery by lateroflexion

Engagement

The bitrochanteric diameter engages in the left oblique diameter of pelvis in RSA position.

Descent with compaction

With each uterine contraction, the fetus flexes and the fetal limbs and trunk come closer to each other and become compact, a process referred to as *compaction*.

Internal rotation

Irrespective of the position, there is always one anterior buttock. This rotates through 45 degrees or 1/8th of a circle and comes to lie under the pubic symphysis.

Lateroflexion

The anterior buttock hitches under the symphysis pubis, fetal trunk flexes laterally, and the posterior buttock is born first followed by the anterior buttock.

Delivery of the shoulders

- The bisacromial diameter engages in the same oblique diameter as the bitrochanteric diameter.
- Internal rotation of the anterior shoulder occurs by 45 degrees.
- The anterior shoulder hitches under the pubic symphysis.

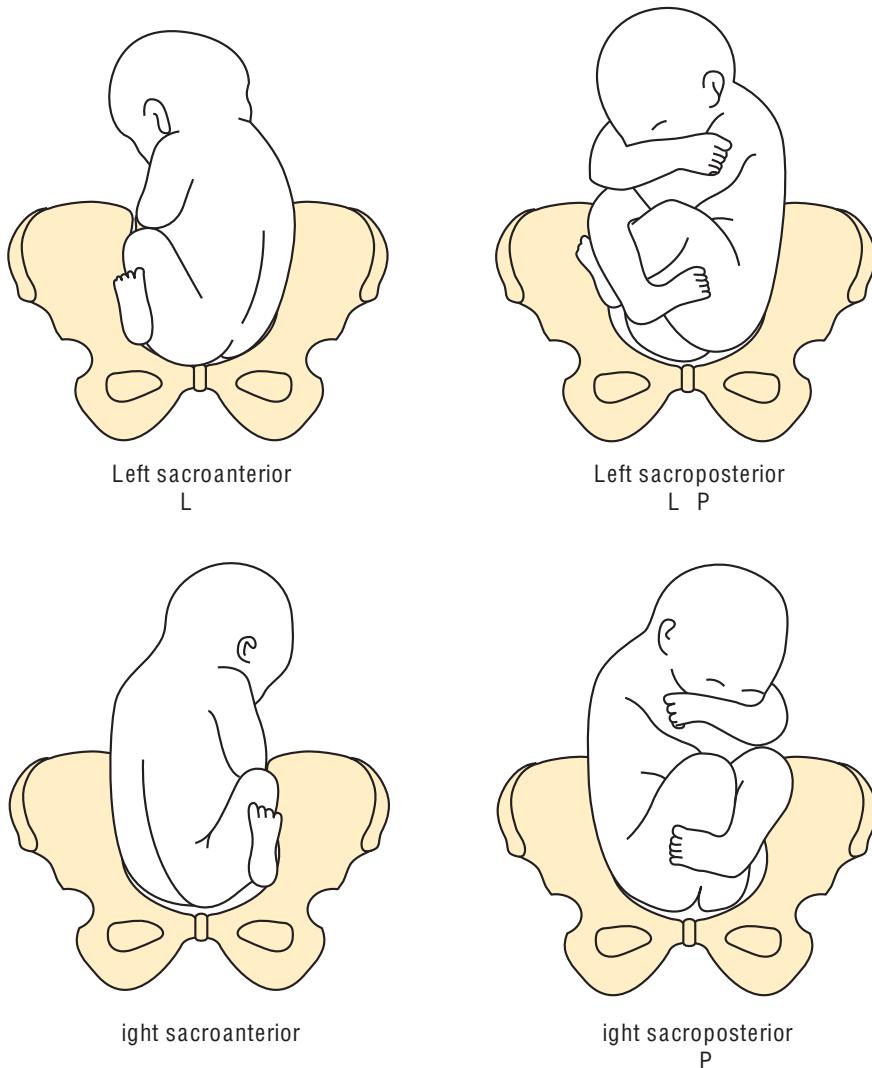


Figure 42.2 Fetal positions in breech presentation. Left and right sacroanterior and sacroposterior.

- The posterior shoulder sweeps the perineum and is born first followed by the anterior shoulder.

Delivery of the head

- The suboccipitofrontal diameter engages in the opposite (right) oblique diameter of the pelvis.
- The occiput rotates internally through 45 degrees and hitches under the pubic symphysis.
- The head is born by flexion. The face sweeps the perineum and is born first, followed by the occiput.

Mechanism of labor is shown in Figure 42.3.

Diagnosis

The diagnosis of breech presentation is usually by clinical examination.

Abdominal examination

On fundal grip, the hard, compact, globular head is felt at the uterine fundus and is ballotable independent of the fetal body (Fig. 42.4). In extended (frank) breech, the head may be mistaken for a breech since the head is not freely ballotable due to the splinting by the extended legs. On pelvic grip, the firm, irregular, broad breech is felt in the lower pole. This is not independently ballotable.

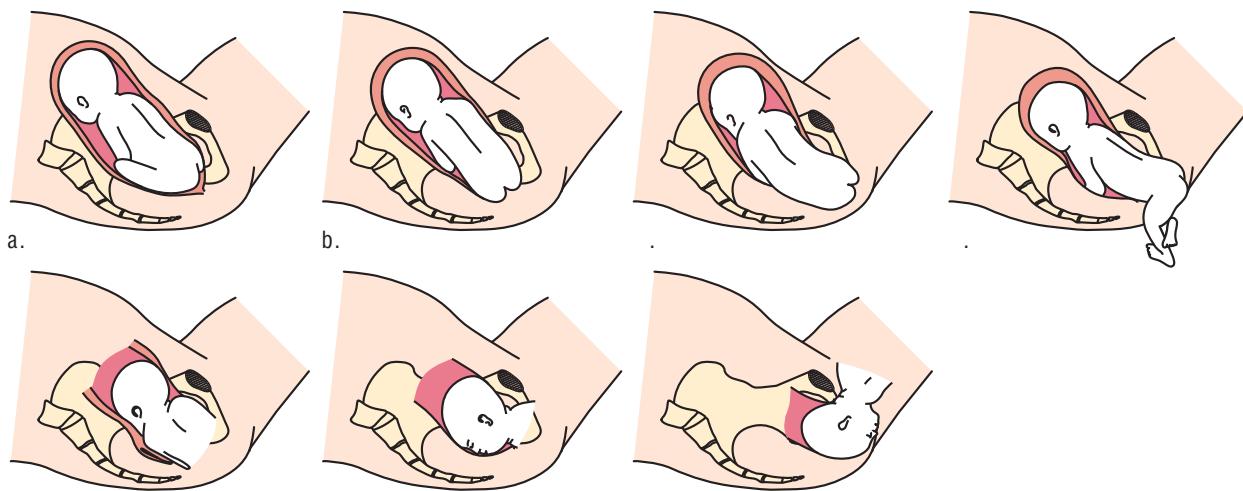


Figure 42.3 Mechanism of labor in breech presentation showing different movements (a–g) as described in the text.

Frank breech is also compact and may be mistaken for the head. The second pelvic grip helps in assessing the descent of the bitrochanteric diameter. The fetal heart sounds are heard above the umbilicus on the side of the back.

Vaginal examination

On vaginal examination, the sacrum, ischial tuberosities, anus, feet or knee, and external genitalia are felt (Box 42.5). The feet are not felt in frank breech, felt by the side of the buttocks in complete breech, and one or both

feet are felt below the buttocks in footling presentation.

The breech may be mistaken for a face on vaginal examination in early labor. The differentiating features are described in Chapter 41, *Abnormal labor: Malpositions and malpresentations*.

Ultrasonography

If breech presentation persists after 34 weeks, ultrasonography should be performed. It helps to ascertain the cause of breech presentation,

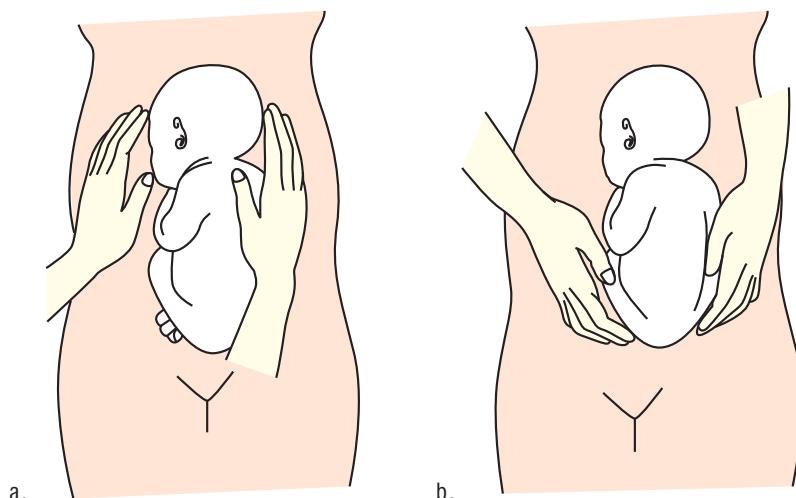


Figure 42.4 Abdominal examination in breech presentation. **a.** The ballotable head is felt at the fundus. **b.** The soft nonballotable breech is felt in the lower pole.

Box 42.5 Diagnosis of breech

- Abdominal examination
 - Fundal grip
 - Hard, globular, compact head
 - Ballotable
 - Umbilical grip
 - Back to one side
 - Limbs on the other side
 - First pelvic grip
 - Firm, broad, irregular breech
 - Not ballotable
- Vaginal examination
 - Sacrum
 - Ischial tuberosities
 - Feet/knee
 - Anus
 - External genitalia

locate the placenta, diagnose fetal anomalies, and estimate fetal weight (Box 42.6). Other imaging such as computerized tomography and radiopelvimetry are not recommended.

Management

Antenatal management

Breech presentation is common before 34 weeks' gestation and most of the cases convert spontaneously to cephalic presentation. If it persists as breech after 34 weeks, the mother should be reviewed 2 weeks later. Perinatal mortality and morbidity are higher in vaginal breech delivery; therefore, external cephalic version (ECV) should be performed at 36 weeks in nullipara and at 37 weeks in multipara. Spontaneous version is unlikely after this period of gestation and there is less chance of reversion to breech after version.

Box 42.6 Information obtainable from ultrasonography

- Type of breech
- Fetal weight
- Location of placenta
- Volume of amniotic fluid
- Confirmation of gestational age
- Flexion/extension of head
- Fetal anomalies
- Uterine anomalies

External cephalic version

Conversion of noncephalic presentation to cephalic presentation by abdominal manipulation is known as *external cephalic version*. Ultrasonography is mandatory before ECV is attempted. Several factors influence the success of the procedure, as listed in Box 42.7. Success rate is higher with multipara, complete breech with adequate liquor and placenta in the upper segment.

Complications of ECV

Fetal bradycardia can occur during or following ECV but is usually transient. Placental abruption and uterine rupture have been reported.

Contraindications

There are absolute and relative contraindications to ECV as listed in Box 42.8.

Procedure (fig. 42.1)

- Ultrasonography is mandatory before ECV.
- Cardiotocography is performed to ensure normal fetal heart rate.
- Sedation/epidural analgesia is not recommended.
- Tocolysis (0.25 mg terbutaline SC) should be given 30 minutes before the procedure.
- The mother is placed in supine position.
- The breech is disengaged from the pelvis.
- The fetal head is manipulated toward the pelvis. This may be in the direction that the fetus faces (forward roll) or backward (backward flip). Forward roll is easier and is normally preferred.
- Ultrasonography may be used during the procedure to guide the manipulation and monitor fetal heart rate.

Box 42.7 External cephalic version

- Performed at
 - 36 weeks in nullipara
 - 37 weeks in multipara
- Higher success rate in
 - Multiparous women
 - Complete breech
 - Adequate liquor volume
 - Average fetal weight
 - Placenta in upper segment

Box 42.8 External cephalic version complications and contraindications

- Complications
 - Fetal bradycardia
 - Placental abruption
 - Fetomaternal hemorrhage
 - Uterine rupture
- Contraindications
 - Absolute
 - Multifetal pregnancy
 - Gestational hypertension/preeclampsia
 - Placenta previa
 - Major uterine anomalies
 - Oligohydramnios
 - Rupture of membranes
 - Relative
 - Previous cesarean section
 - Fetal growth restriction
 - Major fetal anomaly
 - Fetal macrosomia
 - Abnormal cardiotocography

- The fetal head is held in position in the pelvis for a few minutes.
- Cardiotocography is performed to ensure normal fetal heart rate.
- The procedure can be repeated if presentation reverts to breech, even in early labor.

Mode of delivery in term breech

Until the mid 1990s, vaginal breech delivery was the norm, unless there was a clear indication for cesarean section. However, the perinatal mortality and morbidity associated with vaginal breech delivery was found to be higher compared to delivery by cesarean section, in several studies. Other observational studies revealed no difference. To resolve this controversy, a randomized multi-center trial known as the *Term Breech Trial* was undertaken and the results were published in the year 2000. The perinatal mortality and morbidity were significantly higher in the vaginal delivery

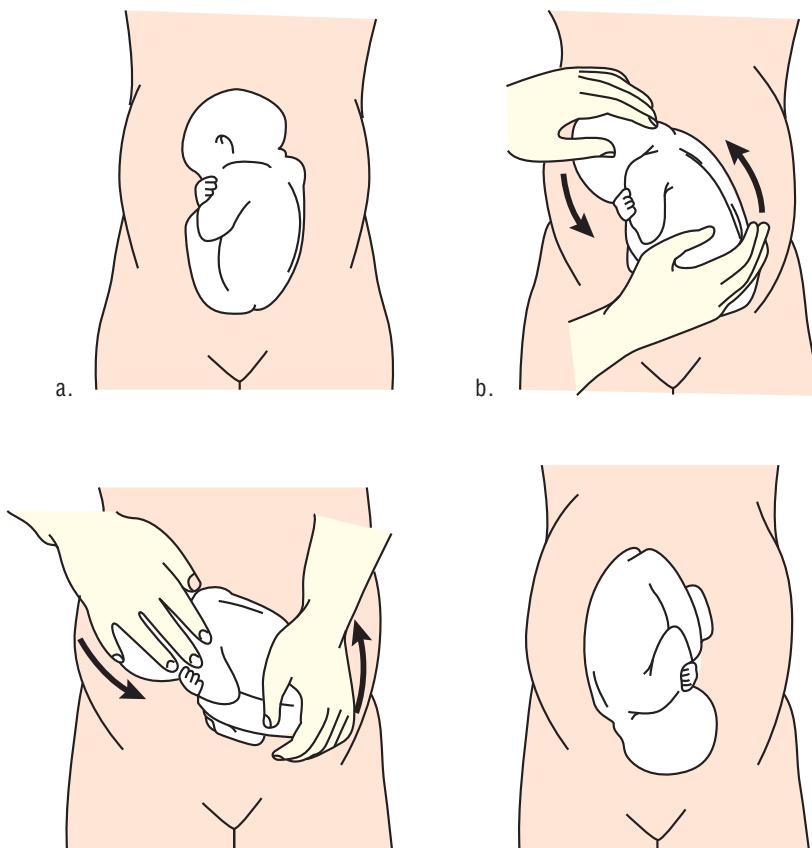


Figure 42.5 External cephalic version. **a-d.** The fetus in breech presentation is turned in the direction in which the fetus faces and converted into cephalic presentation.

group in this study. Following this, cesarean section rate for breech presentation has increased dramatically. However, subsequent trials did not confirm this observation. The American College of Obstetricians and Gynecologists (ACOG) has recommended that planned vaginal delivery of a term singleton breech fetus is reasonable and safe in experienced hands, if hospital-specific guidelines are followed.

Elective cesarean section

Indications for elective cesarean section are given in Box 42.9. Elective cesarean section should be a planned procedure, performed at 38–39 weeks' gestation.

Vaginal breech delivery

Vaginal breech delivery can be one of the following:

- Assisted breech delivery
- Total breech extraction
- Spontaneous breech delivery

Spontaneous breech delivery occurs only in very preterm fetuses. Most breech presentations are delivered by assisted breech delivery. Rarely, total breech extraction is performed.

Patient selection

The criteria for patient selection for vaginal breech delivery are listed in Box 42.10.

Management of labor

Breech delivery should be undertaken in centers where facilities for immediate cesarean section are available. Informed consent should be obtained. General principles of management of

Box 42.10 Criteria for patient selection for vaginal breech delivery

- Complete breech
- Estimated fetal weight between 2–3.5 kg
- Flexed head
- Uncomplicated breech

labor are the same as for cephalic presentation. Epidural analgesia is very useful.

General guidelines for intrapartum management

- Induction of labor is not recommended.
- Membranes should not be ruptured early.
- Electronic fetal monitoring is recommended.
- Oxytocin augmentation is usually not recommended. If used, it must be under close supervision.
- Partogram must be maintained.
- Intravenous line should be started when the woman enters the second stage of labor so that oxytocin may be added if required.

Assisted breech delivery

Assisted breech delivery is one where the fetus is delivered spontaneously up to the umbilicus and the rest of the body is delivered by various maneuvers.

The following personnel and equipment should be available:

- Skilled obstetrician
- Able assistant
- Neonatologist
- Facilities for lithotomy position
- Forceps for aftercoming head

Procedure

- When in the second stage, the mother should be placed in lithotomy position with the buttocks just over the edge of the couch.
- When the fetal anus is seen at the introitus between contractions, a generous episiotomy should be made (Fig. 42.6a)
- The fetus should be allowed to deliver spontaneously till the umbilicus. The feet may be hooked out if required.

Box 42.9 Indications for elective cesarean section in breech presentation

- Estimated fetal weight >3.5 kg
- Incomplete (footling) breech
- Hyperextended fetal head
- Complicated breech
- Placenta previa
- Contracted pelvis



Figure 42.6 Assisted breech delivery. **a.** Episiotomy is given when the anus is visible at the introitus and does not recede between contractions. **b.** The fetus is held by femoropelvic grip. **c.** When the scapula is visible, the anterior arm may be helped out by hooking it out over the face.

- The fetus is wrapped in a towel to avoid cutaneous stimulation. This also makes it easier to hold the baby.
- The fetus should be held by placing the thumbs on the sacrum and the index fingers on the iliac crests—known as the *femoropelvic grip* (Fig. 42.6b).
- The back of the fetus should face the obstetrician throughout the procedure.
- At this point, a loop of the umbilical cord is gently pulled down and kept to one side to prevent compression and traction.
- When the inferior angle of the scapula is visible, the anterior arm may be helped out by bringing it down over the chest (Fig. 42.6c)
- The aftercoming head is delivered by forceps. One of the manual methods may be tried before applying forceps but forceps can be applied electively as well.
- The duration between delivery of the fetus up to the umbilicus and delivery of the mouth is crucial to avoid asphyxia. This usually takes 2–3 minutes but should not exceed 5 minutes.

Delivery of the aftercoming head

This is usually performed by one of the maneuvers or using forceps. No attempt should be made to deliver the head till the nape of the neck (hairline) is visible. Undue traction can cause extension of the head and prevent delivery.

maneuvers

Burns–Marshall Technique

- After the shoulders are delivered, the baby is allowed to hang by its weight (Fig. 42.7a and b).

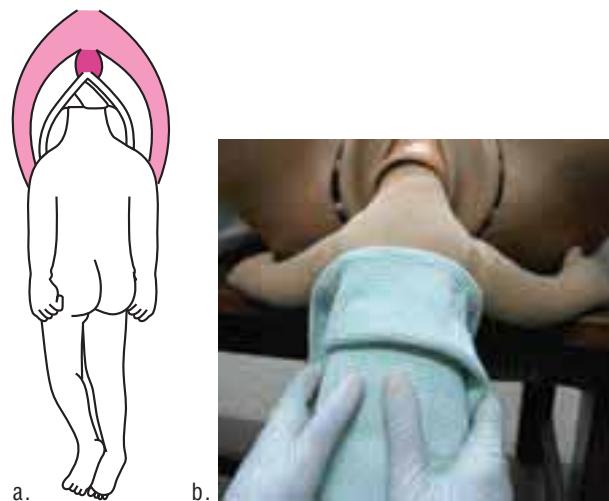


Figure 42.7 Burns–Marshall technique Step 1. **a.** and **b.** Illustration and image showing fetus hanging by its weight.

- When the hairline is visible under the pubic arch, the assistant should apply suprapubic pressure to flex the head.
- The baby should be held with thumb and ring finger on either side of the feet and the index and middle finger between the heels (Fig. 42.8a and b).
- The baby is swung in an arc over the mother's abdomen while the assistant provides perineal support.

Mauriceau Smellie Technique

- Once the shoulders are delivered, the baby is held astride the obstetrician's left forearm (Fig. 42.9).

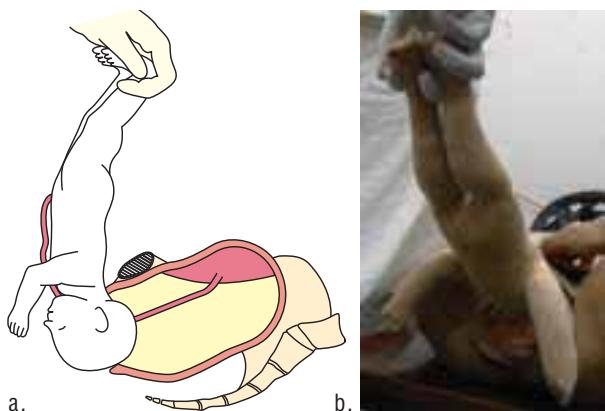


Figure 42.8 Burns-Marshall technique Step 2. **a** and **b**. Illustration and image showing the fetus is held by its feet with thumb and ring finger on either side and index and middle finger between the legs and swung in an arc over the mother's abdomen.

- The index and middle fingers of the left hand of the obstetrician should be placed on each maxilla.
- The index finger of the right hand is placed on one shoulder and the middle and ring fingers on the other shoulder and gentle downward traction is applied till nape of the neck is visible.
- The assistant should apply suprapubic pressure.
- The fetus is lifted toward the mother's abdomen; the mouth, nose, and forehead are delivered in that order.

Delivery by forceps

- The Piper's forceps has been designed with a good perineal curve for delivery of the aftercoming head. However, any low forceps can be used.
- Forceps delivery may be used as the method of choice. Most obstetricians try one manual technique and, if unsuccessful, use forceps.
- Since the forceps flexes the head and the traction is directly on the head rather than through the spinal column, the risk of injury to the spinal cord is less.
- Once the nape of the neck is visible, the baby is wrapped in a sterile towel (including the arms) and lifted up to the horizontal plane by the assistant (Fig. 42.10).
- The blades of the forceps are applied from below.

Difficulties encountered during assisted breech delivery

Difficulties may be encountered during the delivery of the breech, shoulders/arms, or aftercoming head (Table 42.1).

Extended legs

There may be difficulty in delivering the legs when they are extended at the knee as in frank breech presentation. The obstetrician's hand should be passed along the thigh to the popliteal fossa, gentle pressure applied to flex the legs, the foot grasped, and traction applied to deliver the

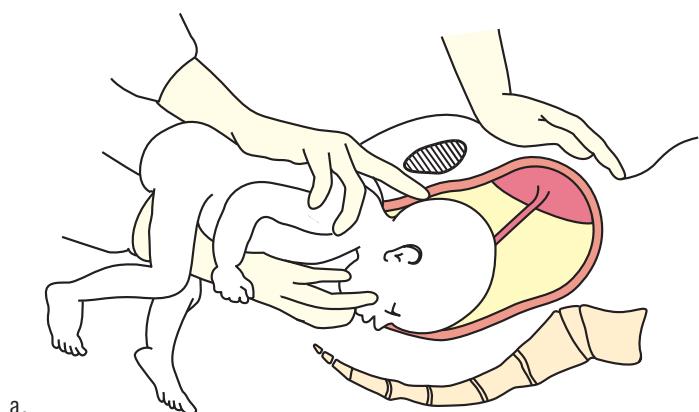


Figure 42.9 Mariceau-Smellie-Viet Technique. **a** and **b**. Illustration and image showing delivery of the aftercoming head by Mauriceau-Smellie-Viet technique.

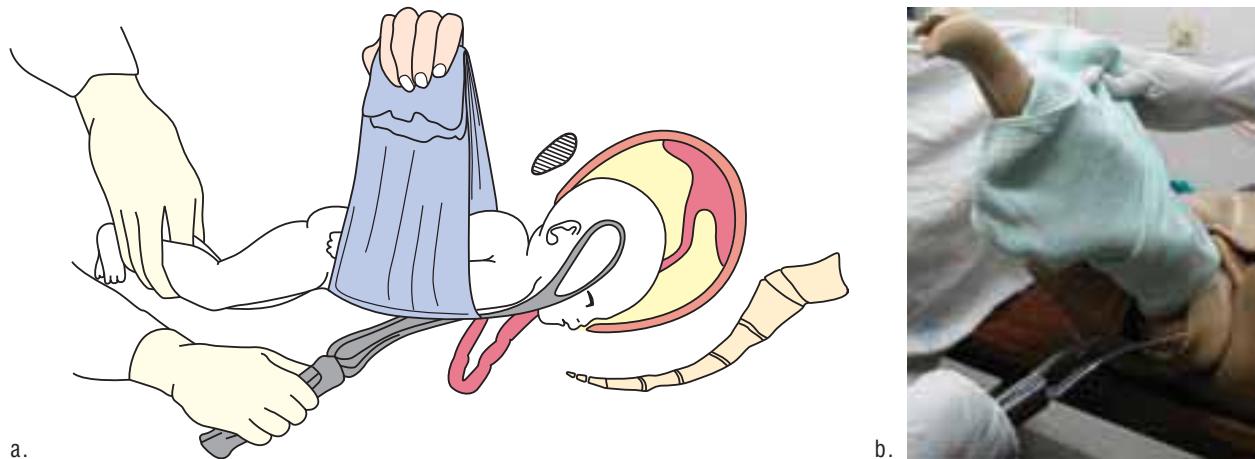


Figure 42.10 Delivery of the aftercoming head by forceps. **a.** and **b.** Illustration and image showing the fetus help up by wrapping in a towel and forceps applied from below.

Table 42.1 Difficulties in assisted breech delivery

Problem	Management
Extended legs	Gentle pressure on popliteal fossa
Extended arms	<ul style="list-style-type: none"> • Lovset's maneuver • Bringing down the posterior arm
Nuchal arm	Rotate in the direction of the nuchal arm
Entrapment of aftercoming head	Duhrssen's incisions
Posterior rotation of head	<ul style="list-style-type: none"> • Rotate trunk and head anteriorly • Prague maneuver

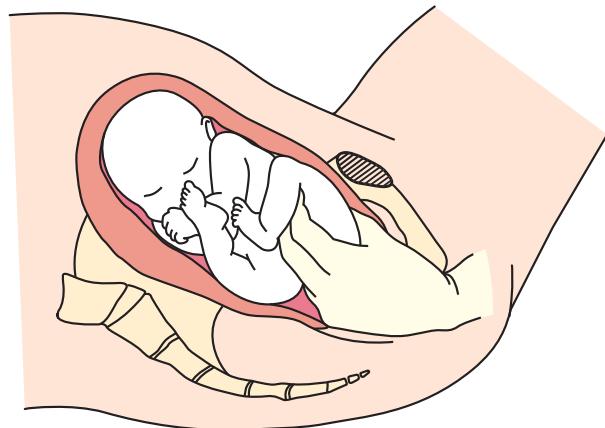


Figure 42.11 Delivery of the extended legs. The hand is passed along the thigh to the popliteal fossa, the knee is flexed and the leg is brought down.

leg. The other leg usually slips out or the same procedure can be repeated (Fig. 42.11).

Extended arms

If the arms are extended at the shoulders and elbow, one of the following two techniques may be used.

Lovset's maneuver

The fetus is rotated through 90 degrees and then in the opposite direction through 90 degrees to bring the other posterior arm anteriorly to lie under the pubic arch. The posterior arm is at a lower level than the anterior arm due to the pelvic inclination.

Hence, the posterior arm that is brought anteriorly usually slips out or can be helped out. The other arm can be delivered directly or the same procedure repeated (Fig. 42.12).

The fetus is held by the hips and turned half a circle, keeping the back uppermost. Downward traction is applied at the same time, so that the arm that was posterior becomes anterior and can be delivered under the pubic arch. The delivery of the arm is accomplished by placing one or two fingers on the upper part of the arm. The arm is drawn down over the chest as the elbow is flexed, with the hand sweeping over the face.

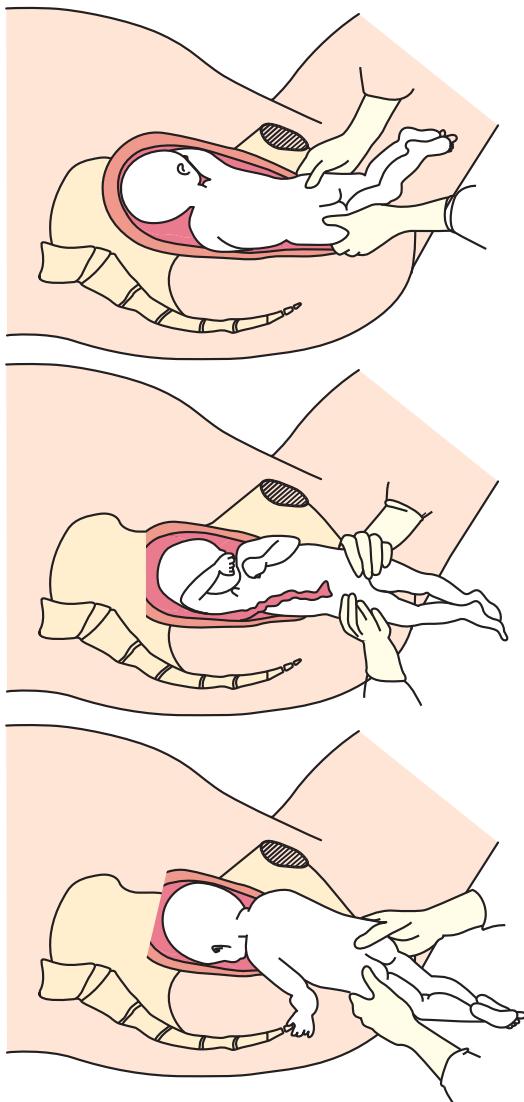


Figure 42.12 Lovset's maneuver. The fetus is rotated through 90 degree in one direction and then in the other direction to bring the arms down.

To deliver the second arm, the baby is turned half a circle in the opposite direction, keeping the back uppermost and applying downward traction, and the second arm is delivered in the same way under the pubic arch.

Bringing down the posterior arm

The fetus is grasped by the legs and pulled toward the mother's right thigh. The obstetrician's left hand is introduced into the sacral hollow along the left arm of the fetus, to the elbow (Fig. 42.13). The arm is flexed by gentle pressure at the cubital fossa, swept over the face, and delivered. The

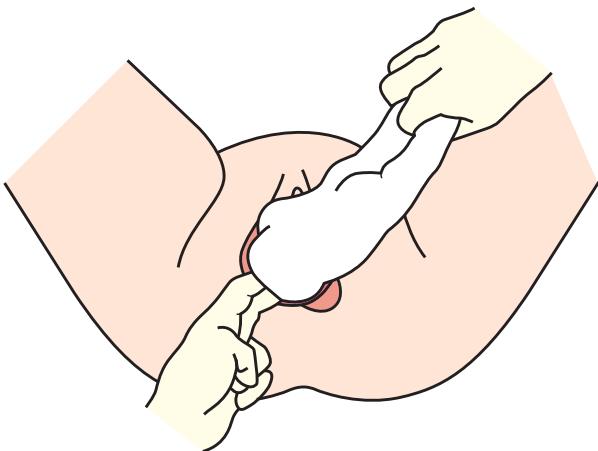


Figure 42.13 Delivery of the extended arms by bringing down the posterior arm. The fetus is pulled toward the mother's thigh and the hand introduced into the sacral hollow to flex the posterior arm and bring it down.

same procedure may be repeated to deliver the other arm.

Nuchal arms

When the arm is flexed at the elbow with the forearm behind the occiput, it is referred to as a nuchal arm. To relieve a *nuchal arm* when it is encountered, the infant is rotated so that the fetal face turns towards the pelvis side wall. The fetus should be rotated in the direction in which the nuchal arm points (Fig. 42.14). This maneuver causes friction to be exerted by the vaginal walls, allowing the elbow to be drawn toward the face, thus freeing the arm.



Figure 42.14 Delivery of nuchal arms. The fetus is rotated in the direction in which the arm points.

Entrapment of the head

When the breech and fetal body slip out through an incompletely dilated cervix, the head may be entrapped. This is common in preterm breech where the head is larger than the body or with premature bearing-down efforts. The cervix clamps down on the neck. Every effort should be made to prevent this complication since the fetal mortality is high. Incisions may be made at 4 o'clock and 8 o'clock positions on the cervix (*Duhrssen's incisions*) and head delivered. These incisions are rarely used in contemporary obstetric practice.

Posterior rotation of the head

Rarely, the back of the fetus may rotate posteriorly. Every effort should be made during assisted breech delivery to prevent this complication. When this happens, the trunk and fetal head should be rotated anteriorly. If this fails, Prague maneuver where fetus is delivered as occiputoposterior may be required to deliver the head. all these maneuvers are performed under general or regional anesthesia.

Total breech extraction

When the fetus is delivered entirely by the obstetrician, it is known as *breech extraction*. In modern obstetrics, it is performed only in case of second of twins, following internal podalic version. The procedure is usually performed under general anesthesia (Box 42.11).

Delivery of preterm breech

Since the head is larger relative to the body, the risk of entrapment of the head is more with vaginal delivery in preterm breech. Vaginal delivery is associated with high perinatal mortality and morbidity if the fetal weight is <1.5 kg or

gestational age <32 weeks; therefore, cesarean section is recommended in these cases. The mode of delivery should be individualized for preterm breeches >32 weeks' gestational age and weight >1.5 kg. Difficulties may be encountered even during cesarean section in preterm breech.

Shoulder dystocia

Shoulder dystocia is defined as failure of the shoulders to deliver after the head has delivered. There is a need for additional maneuvers, after the head is delivered and gentle traction has failed to deliver the shoulders. The delivery of the shoulders is prevented by impaction of the shoulders in the pelvis. Prolongation of head-to-body delivery time beyond 60 seconds is also used to define the condition, but since the duration is not often measured or documented, this definition is not widely accepted.

Incidence

Shoulder dystocia occurs in 0.6%–1.4% of deliveries. The reported incidence varies depending on the criteria used for diagnosis.

Pathophysiology

In vertex presentation, the head enters the pelvis in one of the oblique diameters and the shoulders engage with the bisacromial diameter in the opposite oblique diameter.

When external rotation of the head occurs after delivery, the anterior shoulder rotates internally, bringing the bisacromial diameter in the anteroposterior diameter of the pelvis. The posterior shoulder is at a lower level in the sacral hollow and is delivered first, followed by the anterior shoulder.

If the shoulders fail to rotate, both shoulders enter the pelvis together or if the bisacromial diameter is more than average, the anterior or the posterior shoulder, or both shoulders get impacted. Impaction of the anterior shoulder is more frequent. Brachial plexus injury results

Box 42.11 Total breech extraction

- Entire delivery by obstetrician
- General anesthesia required
- Indication
 - Second of twins, after internal podalic version

due to stretching of the nerves, especially during traction or manipulation.

Risk factors

Maternal diabetes and fetal macrosomia are the strongest risk factors for shoulder dystocia.

Fetal macrosomia is an important risk factor, especially when the fetal weight is >4.5 kg. Risk of shoulder dystocia increases as the fetal weight increases beyond 4000 g. However, the majority of fetuses weighing >4 kg do not have shoulder dystocia.

Diabetes, pregestational or gestational, is a risk factor since it brings about certain morphological changes in the fetus. Fetal growth is disproportionate with the chest being much larger than the head and with significantly large shoulders.

Maternal obesity or excessive weight gain in pregnancy and postmaturity are also risk factors. The fetal weight increases in all these conditions and the fetal chest and trunk grow larger relative to the head.

Labor abnormalities such as protracted active phase and prolonged second stage may be indicative of large fetus and after the head is delivered, shoulders may be impacted. Instrumental deliveries, especially the use of rotational forceps, also increase the risk. Oxytocin augmentation is also a risk factor. Oxytocin is most often used in hypotonic uterine dysfunction which could be due to large fetal size. Advanced maternal age and male fetal gender have also been found to increase the risk (Box 42.12). Previous shoulder dystocia is a major risk factor as well; the recurrence rate is 10%.

Box 42.12 Risk factors for shoulder dystocia

- Fetal macrosomia
- Pregestational or gestational diabetes
- Maternal obesity/excessive weight gain
- Postmaturity
- Labor abnormalities
 - Protracted active phase
 - Prolonged second stage
 - Oxytocin augmentation
 - Instrumental delivery
- Previous shoulder dystocia
- Advanced maternal age
- Male fetus

Combination of factors such as diabetes, macrosomia, and instrumental delivery increases the risk more than a single risk factor. Similarly, a combination of obesity, diabetes, and previous shoulder dystocia increases the risk significantly.

Diagnosis

In women with risk factors, shoulder dystocia should be anticipated and the obstetrician and nurses must be prepared. Signs of shoulder dystocia are as follows:

- Difficulty in delivering the face after delivery of the occiput
- Retraction of the neck and face against the vulva (turtle sign)
- Failure of restitution

Consequences

Perinatal morbidity and mortality increase significantly in shoulder dystocia. Brachial plexus injury is the most important fetal complication; it is seen in 21% of cases of shoulder dystocia. It resolves spontaneously in most cases, but permanent disability can occur in 10%. Fracture of the clavicle and humerus can occur during manipulations. Cord compression, hypoxia, asphyxia, and fetal death are known complications (Box 42.13).

Third and fourth degree perineal tears, vaginal lacerations, postpartum hemorrhage, and uterine rupture are the maternal complications associated with shoulder dystocia.

Box 42.13 Consequences of shoulder dystocia

- Fetal
 - Brachial plexus injuries
 - Fracture clavicle
 - Fracture humerus
 - Hypoxia
 - Asphyxia
 - Fetal death
- Maternal
 - Third and fourth degree perineal tears
 - Cervical and vaginal lacerations
 - Postpartum hemorrhage
 - Ruptured uterus

Prediction

Although there are known risk factors, in 50% of cases of shoulder dystocia none of the risk factors is present and the dystocia is an unanticipated event. It is, therefore, difficult to predict shoulder dystocia. It is also difficult to accurately estimate fetal weight even with ultrasonography.

Estimation of birth weight, measurement of fetal biparietal, abdominal, and chest diameters, and chest and abdominal circumference, and calculation of various ratios have been used to predict shoulder dystocia but they lack sensitivity and specificity. Abdominal circumference of 35 cm or more and difference between abdominal and biparietal diameters, in combination with fetal weight, have been found to be useful by small studies, but large randomized controlled trials have failed to prove the usefulness of these measurements.

Prevention

Since it is not possible to predict shoulder dystocia, prevention is also difficult.

- Induction of labor is not recommended for prevention of shoulder dystocia.
- Elective instrumental delivery is not recommended.
- Elective cesarean section to prevent shoulder dystocia is not recommended as a routine intervention.
- Cesarean section is recommended in selected situations:
 - According to ACOG guidelines, when estimated fetal weight is >5 kg in nondiabetics and >4.5 kg in diabetics, cesarean should be considered. For developing countries, the cut off weights are lower (4 kg), but there is no definite guideline.
 - In women with previous shoulder dystocia and brachial plexus injury with suspected macrosomia in current pregnancy, cesarean section may be considered.
- Prophylactic McRoberts' maneuver is not recommended.

Management

All members of the labor room team should have training in management of shoulder dystocia

using models and mannequins. A stepwise management algorithm should be displayed in the labor room.

There are several maneuvers to be used when shoulder dystocia occurs; some are less invasive and easier to perform than the others. Generally, the easier and effective maneuvers should be used first.

Immediate steps

- Call for help.
- Bring the woman to the edge of the bed to facilitate vaginal maneuvers.
- Ask the woman to stop pushing.
- Do not apply undue traction on the head.
- Do not apply fundal pressure.
- Perform a generous episiotomy.

The **HELPERR** mnemonic summarizes the steps required to deliver a mother with shoulder dystocia.

H. Call for help

E. Evaluate the need for an episiotomy

L. Elevate and hyperflex the legs (McRoberts' maneuver)

P. Suprapubic pressure

E. Enter maneuvers (internal rotation)

R. Remove the posterior arm

R. Roll the woman

First-line maneuvers

These maneuvers have a high rate of success and should be attempted first.

c oberts maneuver

McRoberts' maneuver is the first step. Remove the legs from stirrups and hyperflex the legs onto the mother's abdomen. This straightens the sacrum, rotates the pubic symphysis anteriorly, and reduces the angle of inclination. It may also increase the anteroposterior diameter marginally. The impacted anterior shoulder slips under the pubic symphysis (Fig. 42.15).

Suprapubic pressure

McRoberts' maneuver should be combined with suprapubic pressure. The pressure should be applied from the side of the fetal back and directed downward into the pelvis and laterally toward the opposite side in order to adduct the

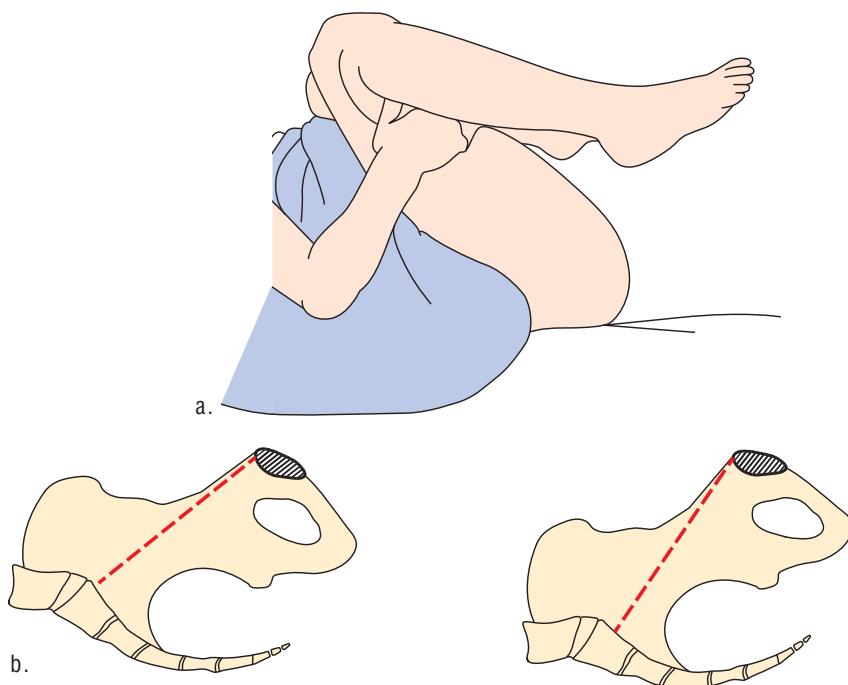


Figure 42.15 McRoberts' maneuver. **a.** Mother's legs are hyperflexed at the hips and knees. **b.** The sacrum straightens and the pubic symphysis tilts anteriorly, reducing the angle of inclination.

shoulders, reduce the bisacromial diameter, and bring the shoulders to the oblique diameter of the pelvis (Fig. 42.16).

If these two simple maneuvers do not succeed, the more complicated maneuvers must be attempted.

Second-line maneuvers

Second-line maneuvers should be attempted without delay when the first-line maneuvers fail. Skilled obstetricians should perform the second-line maneuvers as they are difficult to perform and may be associated with fetal injuries.

oo s cor scre maneuver (rotation o posterior shoul er)

The physician places at least two fingers on the anterior aspect of the fetal posterior shoulder, applying gentle upward pressure around the circumference of the arc and rotating the shoulder toward the fetal chest. If the back of the fetus is to the mother's left, the right hand should be used

and vice versa. The posterior shoulder should be rotated by 180 degrees and brought under the pubic symphysis, simultaneously adducting the shoulders (Fig. 42.17).

ubin s maneuver

The fingers of one hand are inserted anteriorly or posteriorly (whichever is the most accessible) on to the back of the fetal shoulder and rotated to bring the shoulders in the oblique diameter of the pelvis. Adduction of the shoulder also occurs with this maneuver. The bisacromial diameter decreases and is also brought to the large (oblique) diameter of the pelvis, facilitating delivery.

Delivery o the posterior arm (ac uemier maneuver)

The hand is passed into the sacral hollow and the posterior arm is identified and flexed by gentle pressure on the cubital fossa. The arm slips over the fetal face and chest. The forearm is grasped and the arm and posterior shoulder pulled down into the pelvis. The posterior shoulder may have

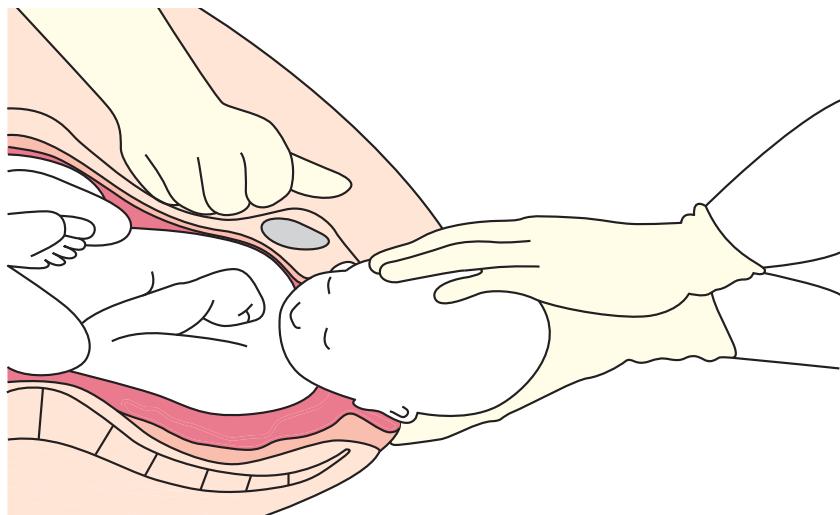


Figure 42.16 Suprapubic pressure. This is combined with McRoberts' maneuver and directed into the pelvis and laterally to adduct the shoulders.

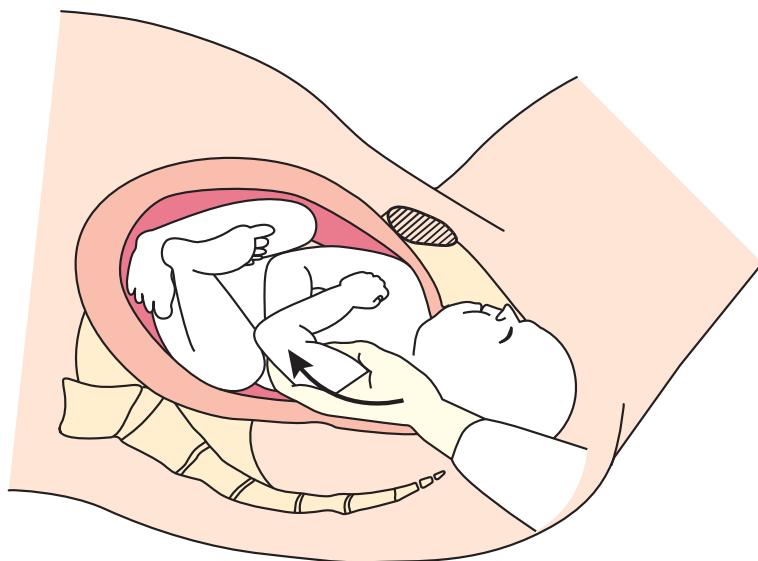


Figure 42.17 Wood's maneuver. The entire hand is passed into the sacral hollow and the posterior shoulder rotated by 180 degree to bring it under the pubic symphysis.

to be rotated using the arm to achieve delivery. The anterior shoulder can then be delivered or rotated posteriorly and the same procedure repeated. This procedure is associated with an increased risk of fracture humerus and brachial plexus injury.

Posterior axilla finger or sling traction

If the elbow cannot be reached by the hand in the sacral hollow, the middle finger can be used to hook the posterior axilla and apply traction.

Middle fingers of both hands may be used, one from the anterior aspect and another from the posterior aspect, to get better traction. Alternatively, a soft rubber catheter or tube can be used to hook the axilla and apply traction. This has the advantage of better hold and availability of more space since the hands are not inside the vagina/pelvis.

he all ours or as in technique

The mother is rolled onto the 'all fours' position, on her hands and knees. The Gaskin maneuver

is a safe, rapid, and effective technique for the reduction of shoulder dystocia. The change in position disimpacts the shoulders because of an increase in pelvic diameters by as much as 10 to 20 mm. The delivery is completed by downward traction on the posterior shoulder without any further maneuvers in a large number of cases.

Third-line maneuvers

The perinatal mortality increases as the first- and second-line maneuvers fail. The head-to-shoulder delivery time increases and the risk of asphyxia and fetal death is high.

The third-line maneuvers are used as a last resort and usually result in high maternal and fetal morbidity.

Cleidotomy: One or both clavicles are fractured.

Symphiotomy: The pubic symphysis is incised and separated to increase the anteroposterior diameter of the pelvis.

Zavanelli maneuver: The fetal head is replaced into the uterine cavity and the fetus delivered by cesarean section. In. terbutaline is used to relax the uterus; the head is rotated to the occipitoanterior position, flexed, and replaced into the uterus. This maneuver is most often associated with fetal demise and is done only to safeguard the mother's life.

Key points

- Breech presentation occurs in 3%–4% of all labors at term.
- Prematurity is the most common cause of breech presentation. Other etiological factors are the same as for other malpresentations.
- Types of breech presentations are complete, incomplete, and frank breech.
- Frank or extended breech has the best chance of vaginal delivery and the least risk of cord prolapse.
- Breech presentations may be complicated or uncomplicated depending on the presence or absence of maternal risk factors.
- Perinatal mortality and morbidity are high in breech presentation. These may be due to inherent problems in the fetus or the result of breech presentation and delivery.
- Mechanism of labor in breech is described in three stages—delivery of the breech, shoulders, and aftercoming head. The engaging diameter is bitrochanteric and the denominator is sacrum.
- Diagnosis is usually by clinical examination. Abdominal examination reveals the head at the fundus and breech in the lower pole.
- On vaginal examination, the breech may be mistaken for the face.
- If the breech presentation persists after 34 weeks, ultrasonography is mandatory to exclude fetal/uterine anomalies, locate the placenta, estimate fetal weight, and assess amniotic fluid volume.
- External cephalic version should be performed at 36 weeks in a nullipara and 37 weeks in a multipara.
- Mode of delivery in breech may be by elective cesarean section or vaginal breech delivery.
- Elective cesarean section should be performed at 38–39 weeks when indications are present.
- Vaginal breech delivery should be undertaken only in centers with facilities for immediate cesarean section and guidelines must be followed.
- Selection of patients for vaginal delivery should be based on specified selection criteria.
- Assisted breech delivery should be performed by skilled obstetrician.
- Mode of delivery of preterm breech should be individualized.
- Shoulder dystocia is defined as failure of the shoulders to deliver after the head has delivered. There is a need for additional maneuvers, after the head is delivered and gentle traction has failed to deliver the shoulders. It is associated with high risk of fetal asphyxia and fetal death.
- Risk factors for shoulder dystocia are fetal macrosomia due to diabetes, postmaturity, and maternal obesity; labor abnormalities such as protracted active phase and prolonged second stage; instrumental deliveries; and oxytocin augmentation.
- It is difficult to predict or prevent shoulder dystocia.
- Shoulder dystocia is an obstetric emergency. Management consists of various first-, second-, and third-line maneuvers. McRoberts' maneuver with suprapubic pressure is the immediate first step and has a high success rate.

Self-Assessment

Case-based questions

Case 1

Mrs. RN, 29, multigravida with two previous normal deliveries, at 40 weeks of gestation, was admitted with labor pains. On examination, the contractions were every 10 minutes, lasting for 20 seconds, and the presentation was breech.

1. How will you proceed to evaluate her?
2. What is the first step in the management?
3. What are the factors you will take into consideration for decision regarding vaginal delivery?
4. How will you deliver the aftercoming head?

Case 2

Mrs. JR, second gravida, with previous normal delivery, pregestational diabetic on insulin, presented in active labor at term. The estimated fetal weight was 3.8 kg. The first stage of labor was prolonged and oxytocin was used to augment labor. Forceps was applied since the second stage was prolonged (1 hour and 15 minutes). After delivery of the head, the shoulders could not be delivered.

1. What are the risk factors in this lady for occurrence of shoulder dystocia?
2. What are the immediate steps in the management as soon as difficulty is encountered in delivering the shoulders?
3. How will you deliver the shoulders?
4. What are the maternal and fetal complications?

Answers

Case 1

1. a. Abdominal examination: Check type of breech, descent of breech, fetal heart rate.
b. Vaginal examination: Check cervical effacement, dilatation, type of breech, station, presence of membranes, pelvic configuration.
c. Ultrasonography: Exclude fetal anomalies, placenta previa, and uterine anomalies; assess flexion of head, liquor volume, type of breech, and fetal weight.
2. External cephalic version is to be performed if membranes are intact, liquor volume is adequate, fetal weight is <3.5 kg, and placenta is in the upper segment.

3. Vaginal delivery is to be considered if frank or complete breech, fetal weight <3.5 kg, flexed head, and placenta in the upper segment.
4. Forceps can be applied electively. Alternatively, either Burns-Marshall or Mauriceau-Smellie-Veit technique can be tried and, if unsuccessful, forceps can be applied.

Case 2

1. Pregestational diabetes, fetal weight of 3.8 kg, prolonged first stage, prolonged second stage, oxytocin augmentation, and instrumental delivery.
2. Call for help, ask the patient to stop pushing, stop applying traction, bring the patient to the edge of the bed, and perform a liberal episiotomy.
3. McRoberts' maneuver with suprapubic pressure must be tried first. The legs should be taken off the stirrups and flexed toward the abdomen, hyperflexing the knee and hip. Suprapubic pressure should be directed into the pelvis and toward the front of the fetus in order to adduct the shoulders. If this fails, Woods corkscrew maneuver or Rubin's maneuver should be tried.
4. Third- and fourth-degree perineal tears, vaginal and cervical lacerations, postpartum hemorrhage, and uterine rupture are the possible maternal complications. Brachial plexus injuries, fracture clavicle or humerus, asphyxia, and fetal death are the fetal complications.

Sample questions

Long-answer question

1. Discuss the etiology, diagnosis, and management of breech presentation at 36 weeks' gestation.

Short-answer questions

1. External cephalic version
2. Mechanism of labor in breech presentation
3. Assisted breech delivery
4. Burns-Marshall technique
5. Shoulder dystocia
6. McRoberts' maneuver

43

Complications of the Third Stage of Labor

Case scenario

Mrs. GN, 29, third gravida, had a vaginal delivery of a baby boy weighing 2.9 kg. Following delivery of the placenta, there was continuous, profuse bleeding. She received parenteral uterotronics, the uterus was massaged, and blood transfusion was started. The bleeding however did not reduce. She looked pale and anxious, and her blood pressure dropped further. Her family was informed that she needed an emergency surgical procedure, and there was the possibility of a hysterectomy.

Introduction

The third stage of labor is the time of placental separation and subsequent arrest of bleeding by contraction and retraction of the uterus. In most women, this stage proceeds normally. However, complications can occur before and after the delivery of the placenta. Complications of the third stage are usually associated with blood loss, hypotension, and shock, which may be life threatening.

Postpartum hemorrhage (PPH), which is the most common complication encountered in the third stage, accounts for 25% of maternal deaths in India and in the developing

world. Other complications such as adherent placenta and uterine inversion, are also associated with a high risk of maternal mortality and morbidity. Most of these complications and deaths are preventable if the third stage of labor is managed in a timely and appropriate manner.

Complications of the third stage of labor are listed in Box 43.1.

Amniotic fluid embolism is discussed in Chapter 45, *Nonhemorrhagic shock in pregnancy*.

The majority of third stage complications are associated with hemorrhage. Clinical manifestations of blood loss in pregnancy are different from those in the nonpregnant state.

Box 43.1 Complications of third stage labor

- Postpartum hemorrhage
 - Primary
 - Atonic
 - Traumatic
 - Secondary
- Retained placenta
- Adherent placenta
 - Accreta
 - Percreta
 - Intra
- Uterine inversion
- Amniotic fluid embolism

Box 43.2 Causes of primary postpartum hemorrhage

- Uterine atony
- Retained placenta or membranes
- Trauma to the reproductive tract
- Disseminated intravascular coagulation

Postpartum hemorrhage

Definition

Postpartum hemorrhage is defined as blood loss of >500 mL following vaginal delivery and >1000 mL following a cesarean section. Postpartum haemorrhage can also be defined as blood loss that results in hemodynamic instability. A fall in hematocrit of >10% between admission and the postpartum period and excessive bleeding requiring blood transfusion are the other definitions used. Blood loss of 500–1000 mL after vaginal delivery is classified as *minor PPH* and >1000 mL as *PPH*. The incidence of PPH is 2.5%–3%.

PPH is divided into the following:

- Primary PPH: Bleeding occurring within 24 hours of delivery
- Secondary PPH: Bleeding occurring after 24 hours but before 12 weeks of delivery

Primary postpartum hemorrhage

Primary PPH is more common than secondary PPH. Incidence varies, depending on the management of the third stage and administration of prophylactic uterotonicics. The causes of primary PPH are listed in Box 43.2.

Disseminated intravascular coagulation is dealt with in Chapter 45, *Nonhemorrhagic shock in pregnancy*.

Atonic postpartum hemorrhage

Uterine atony or failure of the uterus to contract and retract effectively enough to occlude the spiral arterioles is the most common cause of PPH. This accounts for 80% of PPH and is seen in 1 in 20 deliveries. Risk factors are listed in Box 43.3.

Prevention

Active management of the third stage of labor as discussed in Chapter 15, *Management of normal labor and delivery* is the most important preventive step. Active management consists of controlled cord traction, administration of uterotonicics, and assessment of uterine tone and size. In randomized controlled trials, this has been proven to reduce PPH and need for additional uterotonicics. During a cesarean section, spontaneous separation of the placenta reduces risk of bleeding.

Box 43.3 Risk factors for atonic postpartum hemorrhage

- Antepartum
 - Advanced maternal age
 - Multiparity
 - Previous atonic postpartum hemorrhage
 - Uterine overdistension
 - Multifetal pregnancy
 - Polyhydramnios
 - Antepartum hemorrhage
 - Placental abruption
 - Placenta previa
- Intrapartum
 - Prolonged labor
 - Induced labor
 - Instrumental delivery
 - Precipitate labor
 - General anesthesia

Clinical features

Since the myometrium fails to contract, the uterus feels flabby and is filled with blood. The uterine fundus is palpable above the umbilicus. The bleeding is torrential and leads to hypotension and tachycardia. Depending on the amount of bleeding, tachycardia, tachypnea, and hypotension occur (Box 43.4).

Clinical manifestations of hemorrhage in pregnancy

The increase in blood volume, along with other hemodynamic adaptations in pregnancy, allow pregnant and parturient women to withstand moderate blood loss without manifesting the classic symptoms and signs of shock. This can lead to underestimation of blood loss and late recognition of shock.

Early symptoms of blood loss such as dizziness or palpitation are experienced only when the blood loss exceeds 1000 mL. As the blood loss increases, symptoms and signs appear rapidly (Table 43.1). It is important to be aware of the

symptoms associated with the amount of blood loss so that early treatment can be instituted.

Management of postpartum hemorrhage

Profuse bleeding and a relaxed uterus indicate atonic hemorrhage; however, bleeding due to retained placental tissue and cervical or vaginal lacerations should always be excluded. **As soon as the placenta is delivered, it should be inspected for missing cotyledons.**

When blood loss is estimated to be 500–1000 mL, the patient must be monitored closely. Blood loss at delivery is often underestimated.

Once blood loss is estimated to be >1000 mL, management has to be prompt and appropriate. It is important to ensure that the uterus is well contracted. Uterotonics are the first line of management of atonic PPH. Oxytocin infusion, (20 units in normal saline) may be started if the uterus is not well contracted. Injection methyl ergometrine 0.25 mg can be administered IV if there are no contraindications.

The first step in the management is to establish good IV access, infuse IV normal saline rapidly, send a sample for blood tests and cross-match, and get additional assistance. A senior obstetrician, senior midwives, and nurses should be called in for help; the anesthetist and blood bank should be alerted.

Evaluation, resuscitation, communication with the patient's relatives and the medical team, and procedures to arrest bleeding should proceed *simultaneously* as described below.

The management of PPH includes the following steps:

- Insert a large-bore intravenous line. If necessary, two lines can be started.

Table 43.1 Physiological response to hemorrhage in pregnancy

Class	Blood loss (mL)	Percentage of blood volume	Clinical features
Class 1	1000	15	Dizziness, palpitation
Class 2	1500	20–25	Tachycardia, tachypnea, sweating, narrow pulse pressure
Class 3	2000	30–35	Significant tachycardia and tachypnea, pallor, cold and clammy extremities, hypotension
Class 4	≥2500	40	Shock, air hunger, renal failure

Table 43.2 Uterotonics used in the management of postpartum hemorrhage

Drug	Dose route	Frequency	Comment
Oxytocin	IV: 20–40 units in 500 mL normal saline or lactated Ringer's solution	Continuous	Avoid undiluted rapid IV infusion, which causes hypotension
Methyl ergometrine	IV: 0.25 mg	Every 2–4 hours	Avoid if patient is hypertensive
PGF _{2α}	IM: 0.25 mg	Every 15–90 min, 8 doses maximum	Avoid in asthmatic patients; relative contraindication if hepatic, renal, and cardiac disease. Diarrhea, fever, tachycardia can occur
Misoprostol (PGE ₁)	800–1,000 µg rectally		Used only if injectable uterotonic not available

, intramuscularly; , intravenously; P , prostaglandin.

- Obtain blood sample for hematocrit and cross-match.
- Start normal saline infusion with 20 units of oxytocin.
- Monitor pulse, blood pressure, and respiratory rate.
- Insert Foley catheter and monitor urine output.
- Other uterotonic are used as second line (Table 43.2).
- Place a hand on the uterus to check for contraction and provide uterine massage.
- Continue volume resuscitation with normal saline/lactated Ringer's and colloids while awaiting blood.
- Transfuse blood and blood products as required. If specific group not available or in case of emergency, 'O' negative blood can be used.
- If bleeding continues, inspect the cervix and vagina for lacerations and explore the uterine cavity for retained placental tissue.

Mechanical interventions

- **Bimanual compression** This should be attempted next. The uterus should be compressed between the hand placed on the abdomen on the posterior surface of the uterine fundus while the fist of the other hand is placed in the vagina pushing against the anterior aspect of the uterus (Fig. 43.1).
- **Aortic compression** Aortic compression can be used as an alternative to bimanual uterine compression or if uterine compression fails to

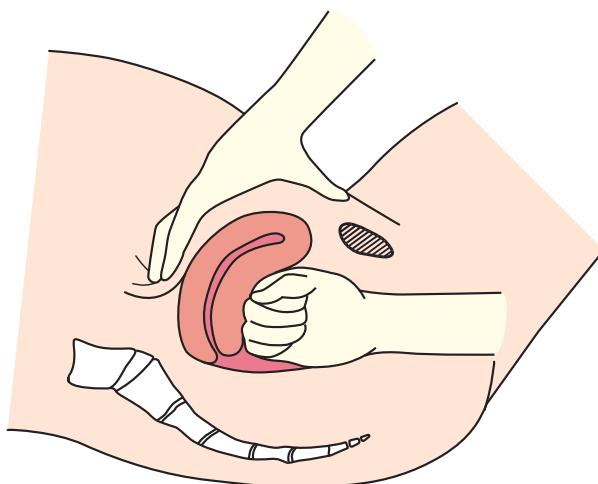


Figure 43.1 Bimanual uterine compression. The right hand is made into a fist and placed in the vagina and left hand is placed on the abdomen on the posterior surface of the uterus and the uterus should be compressed between the two hands.

control bleeding. This may be difficult in obese women. The aorta is compressed against the lumbosacral vertebrae. The obstetrician stands by the side of the woman and compresses the aorta against the spine with a fist placed on the abdomen, using sufficient pressure (Fig. 43.2).

If the above measures fail, other methods must be resorted to.

Uterine tamponade

The uterine cavity may be tightly packed with gauze or a fluid-filled balloon to compress the blood vessels and thereby stop the bleeding.

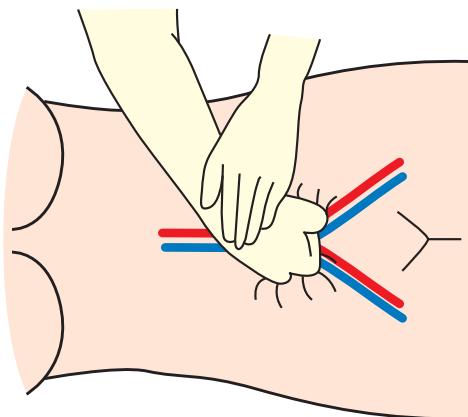


Figure 43.2 Aortic compression. The obstetrician should stand on the left side of the mother, make the hand into a fist and compress the aorta against the lumbosacral vertebrae.

uterine packing

Packing the uterine cavity is an effective way to control bleeding. This can be used while transporting the patient to a tertiary center.

- Use a gauze long enough to pack the entire cavity.
- Begin at the fundus and proceed downward, making sure that there is no dead space.
- Remove pack after 24 hours.
- Insert a Foley catheter in the bladder to prevent urinary retention.

Balloon tamponade

Intrauterine balloon tamponade is an effective method to stop bleeding. The catheter with the attached balloon is inserted into the uterine cavity and inflated with 500–600 mL of saline. The balloon adapts to the shape of the uterus and occludes the venous sinuses. It is removed after 8–12 hours.

Several types of balloons are available commercially (Bakri balloon, BT-Cath balloon). The Glenveigh Ebb Complete Tamponade System has two balloons and provides uterine and vaginal tamponades (Fig. 43.3). A Sengstaken-Blakemore tube (used for esophageal variceal bleeding) can be used depending on availability. **Condom tamponade** is simple, effective, easy to use, and ideally suited for resource-poor settings (Fig. 43.4). The procedure is described below.

- Foley catheter, Ryle's tube, or a simple rubber catheter can be used.

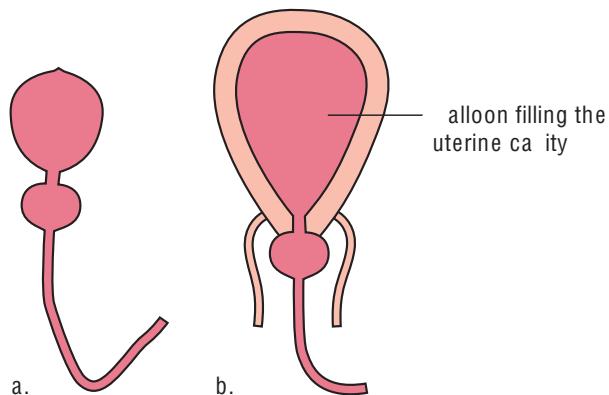


Figure 43.3 The ebb balloon tamponade. **a.** The Ebb balloon tamponade system. **b.** The double balloon is placed in the uterine cavity and vagina and inflated.

- The tube is inserted into a condom and securely tied with a sterile string.
- The tube with the condom is inserted into the uterine cavity.
- The condom is inflated by attaching a syringe or an IV infusion set to the catheter.
- 500–600 mL of saline is usually required.
- A portion of the catheter extends into the vagina and a vaginal pack is inserted to keep it in place.
- The condom is deflated and removed after 8–12 hours.

Surgical intervention

Surgical intervention is the next step when initial measures and uterine balloon tamponade fails. The patient is shifted to the operating room. Adequate blood and blood products must be kept available. The surgical options are listed in Box 43.5.

Arterial ligation

Ligation of the arteries supplying the uterus reduces pulse pressure and perfusion. Since the collaterals are abundant, the uterus does not undergo avascular necrosis.

Uterine artery ligation The uterine artery is ligated as it turns upward in the broad ligament, at the level of the uterovesical peritoneal reflection (O'Leary's technique). Care should be taken to avoid the ureter. The suture (polyglactin 910) should initially include part of the uterine myometrium and then go round the uterine vessel. Bilateral uterine artery ligation controls bleeding in 75% of cases (Fig. 43.5).

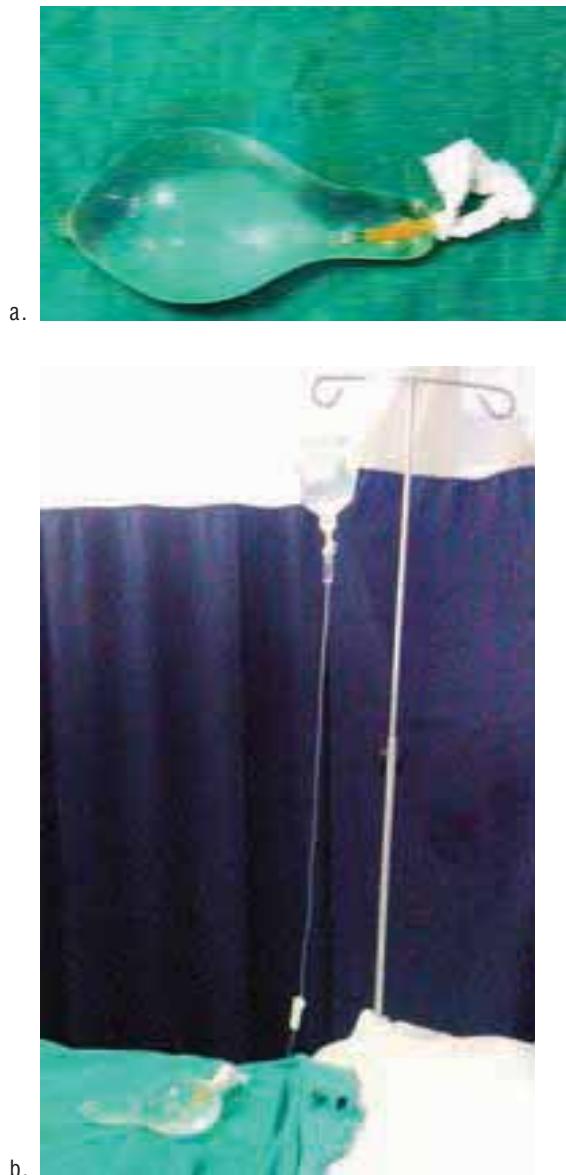


Figure 43.4 Condom tamponade. **a.** A Foley's catheter is inserted into the condom and securely tied. **b.** The condom is inserted into the uterine cavity (not shown in the image) inflated by attaching an IV infusion set with 500–600 mL of saline.

Stepwise devascularization If the bleeding continues, the ascending uterine artery is ligated at intervals as it ascends in the broad ligament. This reduces the blood flow through the branches that supply the uterus. Each suture should include the myometrium and the uterine vessel. The utero-ovarian vessel, which is the anastomosing branch of the uterine and ovarian vessels,

Box 43.5 Surgical procedures for atonic postpartum hemorrhage

- Arterial ligation
 - Uterine artery ligation
 - Stepwise devascularization
 - Internal iliac artery ligation
- Uterine compression sutures
 - B-Lynch suture
 - Pereira technique
 - Hayman technique
- Hysterectomy

should be ligated as well (Fig. 43.6). Ligating the ovarian artery in the infundibulopelvic ligament can reduce the blood flow to the ovary, and it should be undertaken with caution.

Internal iliac artery ligation Internal iliac artery ligation is more difficult than uterine artery ligation and stepwise devascularisation: this is undertaken only if bleeding is not controlled by the other two procedures. The posterior peritoneum is opened and the common iliac vessel identified. The internal iliac artery is located and the anterior division is ligated. Bilateral internal iliac artery ligation stops hemorrhage in 80% of cases.

uterine compression sutures

Uterine compression sutures are easier to perform than arterial ligation and very effective in arresting hemorrhage. The sutures compress the anterior and posterior atonic walls of the uterus, achieving hemostasis.

They are used as first line surgical procedures by many obstetricians. Several techniques are available, but the method most popular is the **B-Lynch suture**. Chromic catgut or polyglactin 910 sutures are used. The suture passes through the lower segment, passes over the fundus and returns again through the lower segment (as shown in Fig. 43.7). It is tied firmly to compress the uterus. Transverse and vertical sutures are placed in the **Pereira technique** (Fig. 43.8) and multiple vertical sutures are used in the **Hayman technique**

hysterectomy

Hysterectomy is the last resort when bleeding is not controlled by other measures. If blood loss is severe and the woman is not hemodynamically

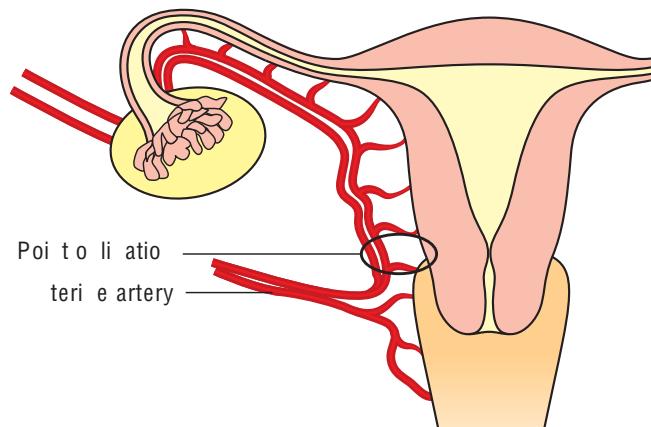


Figure 43.5 Uterine artery ligation. The uterine artery is ligated as it turns upward in the broad ligament. A part of the myometrium should be included in the stitch.

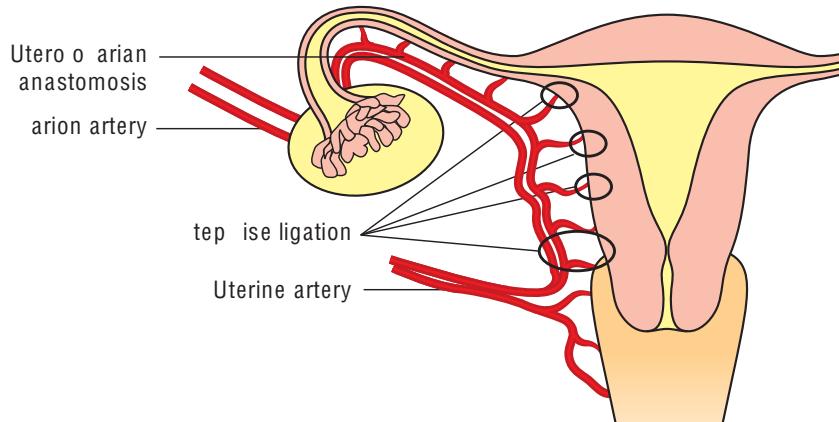


Figure 43.6 Stepwise devascularization. The uterine artery is ligated at intervals as it ascends in the broad ligament. The utero-ovarian vessels should also be ligated.

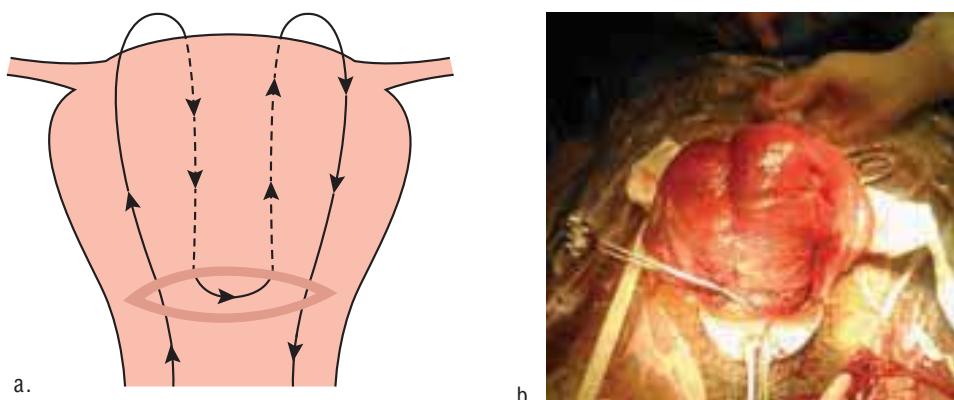


Figure 43.7 B-Lynch suture. **a.** The suture passes through the lower segment, goes over the fundus and again through the lower segment. **b.** The uterus is well compressed when the suture is tied.

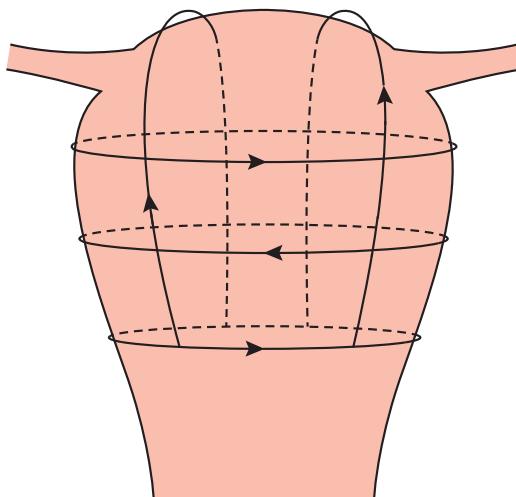


Figure 43.8 Pereira sutures. Multiple vertical and horizontal sutures placed on the uterus with multiple bites through the subserosa of the uterus.

stable, a subtotal supracervical hysterectomy may be performed to save time.

Selective arterial embolization

Occlusion of the uterine vessels with gelatin particles is effective in 90%–95% of cases. The patient must be hemodynamically stable; the procedure is expensive, needs expertise, and is available only in tertiary centers. The uterine artery is cannulated through the transfemoral approach and the gelatin particles are injected into the vessel.

Management of atonic PPH is summarized in Figure 43.9.

Traumatic postpartum hemorrhage

Bleeding from genital tract injuries is referred to as traumatic PPH. This is the second most common cause of PPH.

The common injuries that give rise to hemorrhage are listed in Box 43.6.

is actors

Rupture of an unscarred uterus may result from obstructed labor, high forceps, or rotational forceps deliveries. Rupture of a scarred uterus can occur in normal labor. Uterine rupture is discussed in Chapter 44, *Obstructed labor and uterine rupture*. Hematomas of the broad ligament or retroperitoneum can occur due to upward

Box 43.6 Injuries of the genital tract

- Lower genital tract
 - Perineal lacerations
 - Vaginal lacerations
 - Cervical tears
 - Vulvar hematoma
- Upper genital tract
 - Uterine rupture
 - Broad ligament/retroperitoneal hematoma

Box 43.7 Risk factors for lower genital tract injuries

- Episiotomy
- Instrumental delivery
- Malpresentations
 - Assisted breech delivery
 - Face to pubis delivery
- Fetal macrosomia
- Shoulder dystocia
- Prior surgery on the cervix
 - Conization
 - Cerclage
 - Amputation

extension of vaginal or cervical tears or they may follow uterine rupture.

Risk factors for lower genital tract injuries causing hemorrhage are listed in Box 43.7.

Clinical features of lower genital tract injuries

Unlike atonic PPH, the bleeding is a continuous trickle of fresh blood with the uterus well contracted. In case of broad ligament hematoma, retroperitoneal hemorrhage or vulvar hematoma, the bleeding may not be obvious but the patient shows signs of hemorrhagic shock. The clinical features of lower genital tract injuries are listed in Box 43.8.

Box 43.8 Clinical features of lower genital tract injuries

- Continuous, steady trickle of blood
- Uterus well contracted
- Shock without external hemorrhage
 - Broad ligament hematoma
 - Retroperitoneal hemorrhage
 - Vulvar hematoma

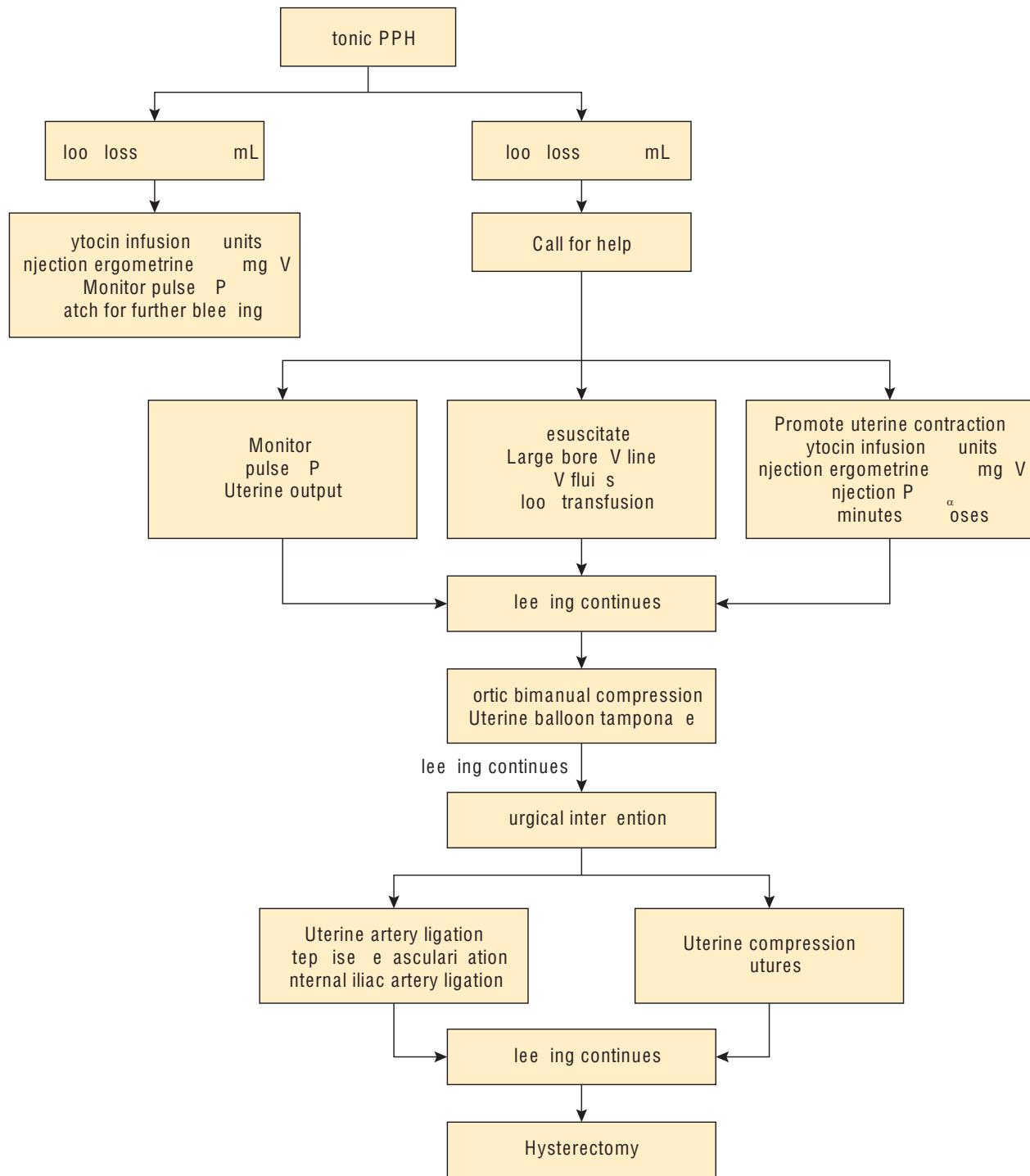


Figure 43.9 Management of atonic postpartum hemorrhage (PPH).

Diagnosis of lower genital tract injuries

The steps in the diagnosis of lower genital tract injuries are summarized in Box 43.9.

Management of lower genital tract injuries

Evaluation of the patient and supportive care should proceed simultaneously as in the case of atonic PPH. The patient's pulse, blood pressure, and respiration should be monitored; intravenous access should be obtained, and a blood sample should be collected for hematocrit and cross-matching.

Once the site of laceration is established, volume resuscitation, transfusion, and surgical management of the laceration should proceed together.

Diagnosis and management of individual lower genital tract injuries are described below.

Perineal lacerations

Perineal lacerations can result in a significant amount of blood loss unless prompt repair is undertaken.

Diagnosis and management

Diagnosis is by inspection of the lower genital tract under good light. Perineal lacerations can be easily visualized, but the extent of involvement of the anal sphincters and anal mucosa must be ascertained. Repair of perineal lacerations is dealt with in Chapter 15, *Management of normal labor and delivery*.

Box 43.9 Steps in the diagnosis of lower genital tract injuries

- Lithotomy position
- Adequate light
- Inspection of perineum
- Inspection of the vulva
- Inspection of vagina
 - Sims speculum
- Inspection of cervix
 - Sims speculum
 - Two sponge holding forceps
- Bimanual pelvic examination
- Ultrasonography

Vaginal lacerations

Vaginal lacerations usually occur in association with perineal lacerations but can also occur as isolated tears in the middle or upper vagina, or in the paraurethral area. Rotational forceps, assisted breech delivery, and vacuum extraction are common causes.

Vaginal lacerations extending to the fornix must be examined carefully to ensure that there is no intraperitoneal extension or broad ligament/retroperitoneal hematoma.

Diagnosis and management

The vaginal wall must be retracted with a Sims speculum, and the vagina should be inspected all around. The vaginal fornices should be visualized for extension of tears. Bimanual pelvic examination and ultrasonography may be required to exclude broad ligament or retroperitoneal hematoma.

Small lacerations that do not bleed can be left alone. Others must be sutured in layers. If intraperitoneal or retroperitoneal extension is suspected, laparotomy is indicated. In the absence of these, tears involving the fornix can also be sutured from below.

Cervical tear

Cervical tears commonly occur at the 3 o'clock and 9 o'clock positions on the cervix, though they can occur anywhere on the cervix.

Diagnosis and management

Inspection of the cervix Careful inspection of the cervix is most crucial for diagnosis of cervical tears. This is difficult since it is soft and thrown into folds after delivery. For best visualization of the cervix, the following procedure must be followed:

- The patient should be in the lithotomy position.
- Adequate light is mandatory.
- Two Sims speculums are used to retract the anterior and posterior vaginal walls.
- Two sponge holding forceps must be applied on the lips of the cervix, beginning anteriorly or posteriorly, at a distance of approximately 2 cm from each other (Fig. 43.10).
- The part of the cervix between the two sponge holding forceps should be inspected for tears.



Figure 43.10 Visualization of cervical tear. Two Sims speculums are used to retract the anterior and posterior walls of the vagina and two sponge holding forceps are applied to the cervix, about 2 cm apart, and the portion of the cervix between the forceps is visualized.

- The forceps should be moved in a circle around the edges of the cervix, and the entire cervix should be inspected.

Small cervical tears <2 cm can be left alone if there is no bleeding since they heal rapidly. Larger ones must be sutured. It is important to include the apex of the tear; therefore, suturing should begin above the apex. Absorbable sutures (chromic catgut/polyglactin 910) should be used; sutures may be interrupted or continuous (Fig. 43.11). If the tear extends to the lower segment, laparotomy is necessary.

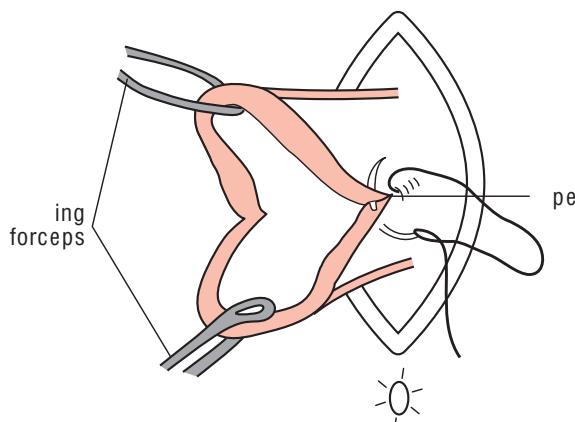


Figure 43.11 Repair of cervical tear. Suturing should begin at the apex of the tear and proceed downward.

Colporrhesis

Avulsion of the cervix from the vagina is known as colporrhesis (Fig. 43.12). This can cause intra-peritoneal bleeding.

Diagnosis and management

Diagnosis is by speculum examination and bimanual pelvic examination. Laparotomy is indicated, and the rent can be repaired if small. If it involves a large area of the cervix and vagina, hysterectomy may be required.

Laparotomy and repair of the tear is the treatment of choice.

Vulvar hematoma

Vulvar hematoma can occur following normal or instrumental delivery or episiotomy. Laceration of an underlying vessel is responsible for the hematoma (Fig. 43.13).

Diagnosis and management

Vulvar hematoma is associated with excruciating pain, urinary retention, rectal pain or tenesmus and sometimes hypovolemia (Box 43.10). A swelling that is fluctuant and covered with discolored skin may be visible. When the hematoma

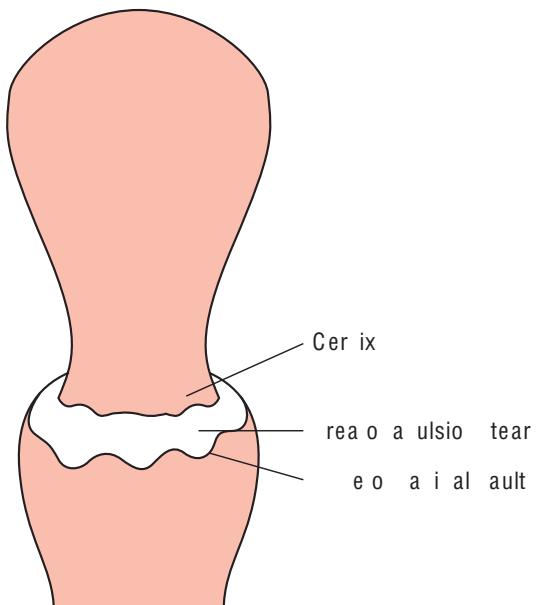


Figure 43.12 Colporrhesis. Cervix is avulsed from the vagina.

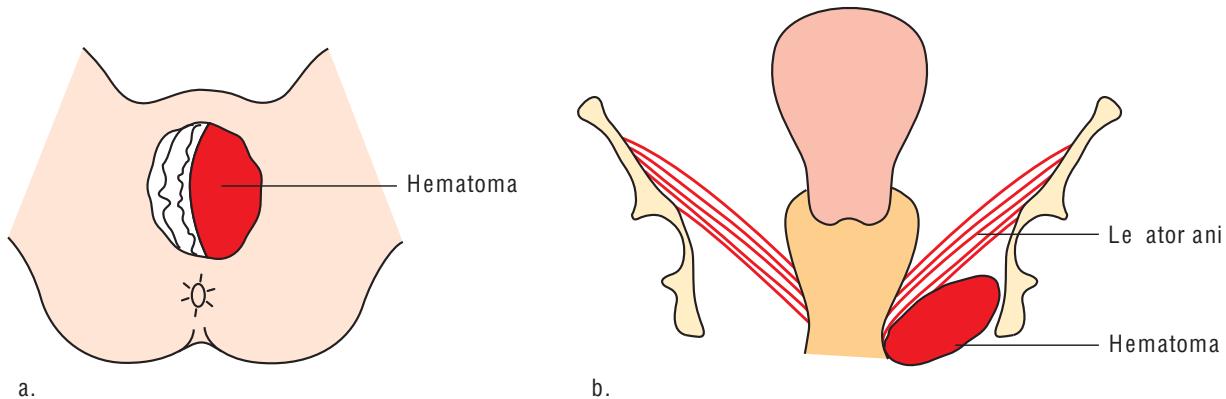


Figure 43.13 Vulvar hematoma. **a.** The hematoma can be visualized as a swelling on the labium majus. **b.** The hematoma is superficial to the levator ani muscle.

Box 43.10 Vulvar hematoma

- Caused by
 - laceration of underlying blood vessel
- Occurs following
 - normal delivery
 - instrumental delivery
- Clinical features
 - Excruciating pain
 - Urinary retention
 - Swelling
 - Fluctuant
 - Covered by discolored skin
 - Hypovolemia

is above the pelvic diaphragm, it may be diagnosed only by vaginal examination. **In women who complain of severe pain or inability to void, vulvar hematoma should be thought of and a prompt examination is indicated.**

Management is by incision and drainage. The clots must be evacuated and bleeding point, if any, ligated. Often, there is no definite bleeder that is identified. The cavity of the hematoma is closed with mattress sutures. *Selective angiographic embolization* of the blood vessel has been used in cases of intractable hematoma.

Broad ligament hematoma or retroperitoneal hemorrhage

These are upper genital tract injuries but may result from upward extension of vaginal or cervical tears or following colporrhesis. As already mentioned, external hemorrhage may not be profuse but the woman may be in shock.

Diagnosis and management

Pelvic examination may reveal a mass in the broad ligament.

When there is no external bleeding but the patient is in shock, emergency ultrasound may be performed to look for broad ligament or retroperitoneal hematoma.

Immediate laparotomy and repair of the rent is the recommended treatment.

Management of lower genital tract injuries is summarized in Box 43.11.

Box 43.11 Management of lower genital tract injuries

- Perineal lacerations
 - Ascertain the degree of tear
 - Suture in layers
- Vaginal tears
 - Intraperitoneal extension
 - Broad ligament hematoma
 - Retroperitoneal hematoma
 - No extension: Suture in layers
- Cervical tear
 - Extension to lower segment: Laparotomy and repair
 - Tears <2 cm, no bleeding: Leave alone
 - Tears >2 cm: Suture
 - Should include apex
 - Absorbable suture
 - Interrupted/continuous
- Colporrhesis: Laparotomy and repair/hysterectomy
- Vulvar hematoma
 - Incision and drainage
 - Selective arterial embolization

Laparotomy
and repair

Secondary postpartum hemorrhage

Secondary PPH is defined as excessive bleeding that occurs between 24 hours and 12 weeks postpartum. It most often occurs in the first 3–4 weeks. It is discussed in Chapter 22, *The abnormal puerperium*.

Complications of postpartum hemorrhage

As already discussed, PPH is a major cause of maternal mortality. The complications of PPH are listed in Box 43.12.

Sheehan's syndrome

Catastrophic PPH can result in Sheehan's syndrome (pituitary infarction). Severe hypotension can cause poor perfusion in the hypothalamo-hypophyseal portal system and consequent infarction of the anterior pituitary gland leading to moderate to severe hypopituitarism. The most common presentation is failure of lactation and secondary amenorrhea in a woman with a history of PPH (see Chapter 52, *Endocrine disorders*).

Retained placenta

The placenta is said to be retained if it is not expelled within 30 minutes of delivery of the fetus. When the placenta is retained for longer than normal, risk of hemorrhage increases.

Box 43.12 Complications of postpartum hemorrhage

- Hypovolemic shock
 - Renal failure
 - Multiorgan failure
- Transfusion-related complications
- Acute respiratory distress syndrome
- Infection and septicemia
- Venous thrombosis and embolism
- Postpartum pituitary necrosis (Sheehan's syndrome)
- Anemia
- Maternal death

Retained placenta occurs in 2%–3% of deliveries. There are three clinical situations:

- The placenta is detached but not expelled (*trapped placenta*).
- The placenta has not separated from the uterine wall but does not invade the myometrium (*placenta adhens*).
- The placenta is attached to or invades the myometrium (*adherent placenta*).

Adherent placenta is discussed later in this chapter. The first two conditions are discussed here.

Risk factors

The risk factors for retained placenta are listed in Box 43.13.

Prevention

Active management of the third stage, and avoiding ergometrine before placental expulsion, can reduce the risk of retained placenta.

Trapped placenta

Diagnosis

Trapped placenta usually occurs due to administration of injection ergometrine before placental expulsion or mismanagement of the third stage such as cord traction before signs of placental separation. The uterus may be well contracted and the os closed. The lower pole of the placenta may be felt through the os, on pelvic examination.

Management

The management of trapped placenta consists of measures to aid spontaneous expulsion failing which, manual removal is proceeded with.

Box 43.13 Risk factors for retained placenta

- Preterm birth
- Previous retained placenta
- Induced/Augmented labor
- IV ergometrine
- Mismanagement of third stage of labor
- Uterine anomalies

- The first step in the management is to empty the bladder.
- If the uterus is relaxed, stimulating uterine contractions with oxytocin may result in placental expulsion.
- If the uterus is contracted and os is closed, uterine relaxation is achieved with glyceryl trinitrate (400 µg sublingual or 50 µg intravenous). Close monitoring of blood pressure is mandatory since glyceryl trinitrate can cause hypotension. The placenta can be removed by controlled cord traction or manually.
- If these measures fail, manual removal of the placenta is required.

Placenta adherens

Diagnosis

Failure of placental separation is usually due to defective myometrial contractions in the area underlying the placenta. It may also be due to generalized uterine atony. The placenta may separate partially, giving rise to profuse bleeding. The uterus may be relaxed on palpation.

Ultrasonography can also be used to differentiate between trapped placenta and placenta adherens. In trapped placenta, the myometrium is thick all around and a clear demarcation is seen between the placenta and myometrium.

Management

The management of placenta adherens consists of the following steps:

- Oxytocin promotes uterine contractions and separation of the placenta. It is administered as IV infusion (20 units in 500 mL of saline) or intramuscular injection (10 units IM),
- The umbilical vein is catheterized with size 10 nasogastric tube and one of the following injected:
 - Normal saline
 - PGF_{2α} (20 mg in 20 mL of saline)
 - Oxytocin (50 units in 30 mL of saline)
 - Misoprostol (800 µg dissolved in 30 mL of saline)

Prostaglandin F_{2α} and misoprostol have been shown to be more effective than oxytocin when injected intraumbilically.

If these methods fail and/or if there is profuse bleeding, manual removal of the placenta should be resorted to.

Manual removal o placenta

Indications

The indications for manual removal of the placenta are as follows:

- Placenta adherens with profuse bleeding and/or not responding to other methods
- Trapped placenta not responding to other methods

Procedure

- Shift the patient to the operating theater.
- Administer prophylactic antibiotics (1 g of ampicillin +500 mg metronidazole IV, just before the procedure, followed by oral amoxicillin 500 mg 6 hours later).
- The procedure should be performed under general anesthesia, preferably with halothane for uterine relaxation.
- The patient should be in the lithotomy position.
- Hold the umbilical cord with the left hand and keep it taut. This helps in guiding the right hand up to the placenta (Fig. 43.14).
- Under aseptic precautions, insert the right hand with fingers kept close together (accoucher's hand) and proceed along the stretched cord into the uterine cavity to the placenta.
- Once the placenta is located, place the left hand on the uterine fundus.
- Insert the margin of the right hand into the plane between the placenta and the uterine wall. Proceed to separate the placenta from the uterine wall along this plane of cleavage.
- Once the placenta is fully separated, remove it by grasping it with the hand as the hand is withdrawn, keeping the left hand on the uterine fundus to ensure that the uterus is well contracted.
- Start oxytocin infusion (20 units in 500 mL of normal saline) to promote uterine contractions and prevent PPH or uterine inversion.

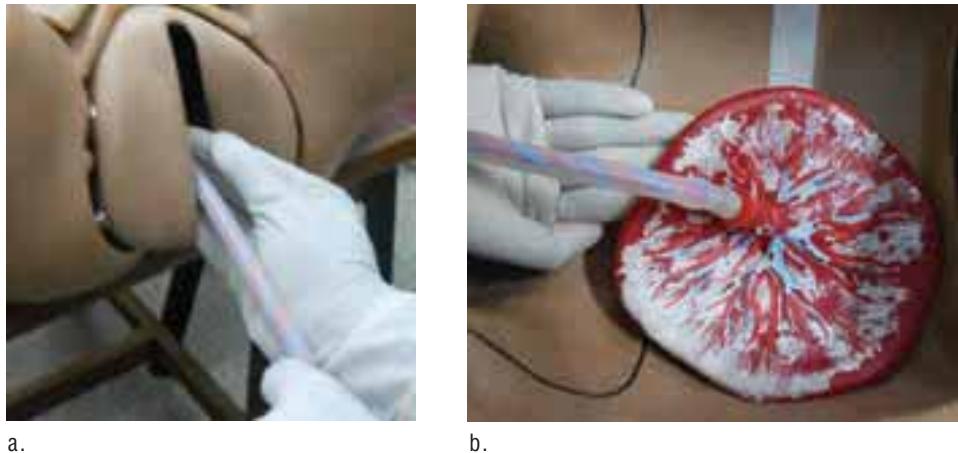


Figure 43.14 Manual removal of placenta. **a.** The cord is held taut by the left hand, the fingers of the right hand are kept close together (accoucher's hand) and inserted into the uterine cavity. **b.** The margin of the hand is inserted into the plane between the placenta and uterine wall.

Adherent placenta

Adherent placenta is an uncommon but dreaded complication. Morbidity and mortality are high, especially with placenta accreta.

Definition

Adherent placenta is an abnormality of placental implantation wherein part or all of the placenta is attached to or infiltrates the myometrium. This is due to the partial or total absence of decidua basalis and the fibrinoid (Nitabuch) layer. There are three grades of adherent placenta (Fig. 43.15):

- Placenta accreta: Anchoring villi attach to the myometrium.

- Placenta increta: The villi invade into the myometrium.
- Placenta percreta: The villi invade the entire depth of the myometrium and extend to the serosa.

Clinical differentiation between the three grades of adherent placenta is not possible and the management is essentially the same. Hence all grades of adherent placenta will be discussed together as placenta accreta.

Incidence

The incidence of placenta accreta is increasing due to the increase in cesarean section rates. It

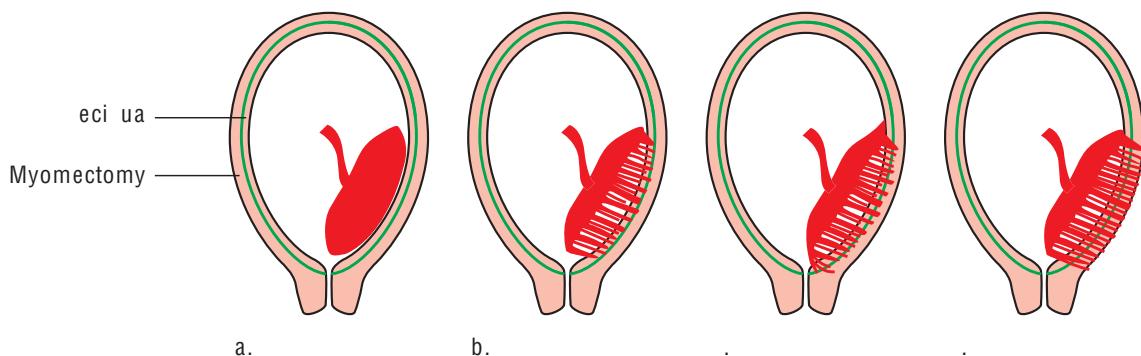


Figure 43.15 Adherent placenta. **a.** Normal placenta, the villi do not invade the myometrium. **b.** Placenta accrete, the villi attach to the myometrium. **c.** Placenta increta, the villi invade the myometrium. **d.** Placenta percreta, the villi invade the entire depth of the myometrium and extend to the serosa.

was 1 in 2500 earlier but has now increased to 1 in 250 deliveries in the West. The incidence in India is also on the increase. Placenta accreta is most common and occurs in 80%, placenta increta in 14%, and placenta percreta in 6% of cases of adherent placenta.

Etiology and risk factors

Defective decidualization is considered to be the most important causative factor. This may be primary but most often is secondary to a previous cesarean section or uterine curettage. In the absence of well-formed decidua, the anchoring villi attach to the myometrium or penetrate it to varying extents. When the placenta implants in the lower uterine segment (placenta previa), the risk of placenta accreta is increased. **Combination of a previous cesarean section and an anterior placenta previa increases the risk manifold.** The risk increases further as the number of cesarean sections increases.

The risk factors for adherent placenta are listed in Box 43.14.

Clinical features

Placenta accreta is usually diagnosed when the placenta fails to separate and there is profuse bleeding when manual removal is attempted. The plane of cleavage is not obtained and the placenta cannot be separated. This is one of the causes of massive PPH, shock, and maternal death.

Box 43.14 Risk factors for adherent placenta

- Placenta previa
- Prior uterine surgery
 - Cesarean section
 - Myomectomy
 - Curettage
- Multiparity
- Submucous fibroids
- Uterine anomalies
- Endometrial ablation
- Uterine irradiation

Occasionally, placenta percreta may infiltrate into the bladder, giving rise to hematuria antenatally. During surgery, separation of the bladder from the lower uterine segment is extremely difficult in these cases.

Diagnosis

Antenatal

Ultrasonography with color Doppler is a sensitive method of antenatal diagnosis of placenta accreta. Three-dimensional sonography improves the sensitivity further (Fig. 43.16).

The sonographic findings of placenta accrete are listed in Box 43.15.

Magnetic resonance imaging is also useful

- when ultrasonography is inconclusive,
- when the placenta is located posteriorly, and
- to determine the extent of invasion into the bladder and adjacent structures.



a.



b.

Figure 43.16 Placenta accreta. **a.** Ultrasonography shows loss of continuous white line at serosal–bladder interface (arrow). **b.** Color Doppler shows increase in the vascular lakes in the placenta (arrow). (Photo courtesy: Mediscan Systems, Chennai.)

Box 43.15 Sonographic findings of placenta accreta

- Myometrial thickness (from serosa to retroplacental vessels) <1 mm
- Large intraplacental blood lakes
- Loss or thinning of the normal hypoechoic area behind the placenta (clear space)
- Loss of normal continuous white line at serosal-bladder interface (bladder line)
- Focal nodular projections into the bladder
- Color Doppler
 - Increase in vascular lakes with turbulent flow
 - Hypervascularity of serosal-bladder interface

When inflated immediately after delivery of the baby, bleeding reduces.

- The baby is delivered by a classical cesarean section, avoiding the placental site.
- No attempt should be made to separate or deliver the placenta.
- The uterine incision should be closed and hysterectomy proceeded with.
- Pelvic arterial embolization or bilateral internal iliac artery ligation may be performed to control hemorrhage, before proceeding with hysterectomy.

Management

There are two clinical situations:

- Placenta accreta diagnosed antenatally
- Placenta accreta diagnosed during manual removal of placenta

Placenta accreta diagnosed antenatally

When diagnosed antenatally, maternal outcome is better. The management should be a well-planned team approach. A senior obstetrician, an anesthetist, and a urologist should work together.

roce ure

If placenta accreta has been diagnosed antenatally, an elective cesarean section is scheduled.

- The patient and relatives should be counseled regarding complications such as massive hemorrhage, need for blood transfusion, hysterectomy, and admission to intensive care unit.
- Blood and blood products must be kept ready.
- General anesthesia is usually preferred.
- The placenta should be localized and the extent of penetration of the myometrium and adjacent structures determined.
- The operative procedure, decision regarding the conservation of the uterus versus hysterectomy, site of incision, and measures to reduce bleeding should be planned.
- Preoperative placement of balloon catheters into the internal iliac arteries is controversial.

Placenta accreta diagnosed during manual removal

This situation is associated with profuse bleeding and shock. Prompt resuscitation is essential. Most women require hysterectomy to control bleeding. Pelvic arterial embolization, if available, is a useful adjunct.

Conservation of uterus

Conservation of the uterus is indicated

- when future fertility is desired and
- when maternal condition does not permit hysterectomy.

The measures that can be tried for uterine conservation are as follows:

- Removal of the placenta piecemeal and mattress sutures over the placental site
- Removal of placenta and tamponade by packing
- Selective arterial embolization
- Leaving the placenta in situ and administration of methotrexate
- Leaving the placenta in situ and follow-up

All uterine conservative techniques are associated with complications as listed in Box 43.16.

uterine inversion

Definition

Uterine inversion is the collapse of the uterine fundus into the uterine cavity. This is a rare

Box 43.16 Complications of uterine conservative techniques

- Hemorrhage
- Sepsis
- Fistula formation
- Uterine necrosis
- Need for hysterectomy later
- Maternal death

complication that occurs before or after placental separation and expulsion. Inversion causes profuse, life-threatening hemorrhage, shock, and maternal death.

Incidence

Incidence varies from 1 in 2,000 to 1 in 20,000 deliveries.

Classification

Uterine inversion is classified depending on the following:

- The extent of inversion
- Time of occurrence

Classification based on extent of inversion (Fig. 43.17)

- First-degree (complete) inversion: The uterine fundus descends into the cavity but does not protrude through the os.
- Second-degree (complete) inversion: The fundus protrudes through the os.
- Third-degree inversion: The fundus protrudes through the introitus.

- Fourth-degree inversion: There is complete inversion of the uterus and vagina.

Classification according to the time of occurrence

- Acute: Occurs within 24 hours of delivery
- Subacute: Occurs between 24 hours and 4 weeks after delivery
- Chronic: Occurs 4 weeks after delivery

Etiology and risk factors

The most common etiological factors are umbilical cord traction and fundal pressure when the uterus is relaxed especially when the placenta is attached at the fundus. The risk factors are listed in Box 43.17.

Clinical features

The usual clinical presentation is sudden profuse bleeding, hypotension, and shock, before or after placental delivery. The uterine fundus is either not palpable abdominally or an obvious dimple is felt over the fundus. Vaginal examination reveals the prolapsed inverted uterine fundus inside the

Box 43.17 Risk factors for uterine inversion

- Fundal attachment of the placenta
- Fetal macrosomia
- Short umbilical cord
- Uterine overdistension
- Nulliparity
- Rapid labor
- Uterine anomalies
- Placenta accreta

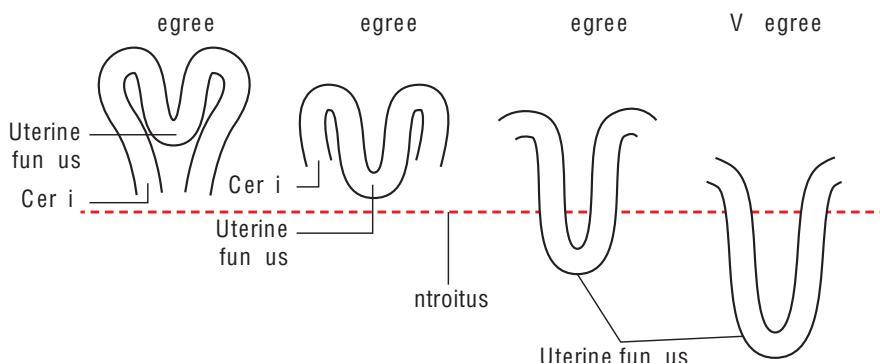


Figure 43.17 Classification of uterine inversion. The four degrees of uterine inversion are shown.

uterine cavity, in the vagina or outside the introitus. The placenta may be attached to the uterine wall. The shock is often out of proportion to the blood loss and is considered to be neurogenic, due to stretching of the parasympathetic nerves.

Ultrasonography reveals an abnormal uterine contour and the uterine fundus is seen within the cavity. Often there is no time to perform imaging since the patient bleeds profusely and is in shock.

Management

The definitive treatment consists of replacing the uterus to its original position by manual or hydrostatic manipulation. This controls the hemorrhage and restores hemodynamic instability.

General measures

General measures to resuscitate the patient and prepare for manual replacement must be instituted immediately.

- Call for help. A senior obstetrician, nurse, and anesthetist must be summoned.
- Stop oxytocin infusion.
- Insert a large-bore intravenous cannula and begin fluid resuscitation.
- Draw blood for hematocrit, coagulation workup, and cross-matching.
- Start blood transfusion as soon as possible.

Replacement of the uterus

Replacement of the uterus by manual or hydrostatic method should be attempted first. Surgical procedures are warranted only if these fail.

- The part that came down last should be replaced first. The uterine fundus should go in last.

- If the placenta is attached to the uterus, ensure the following:
 - It should not be separated till uterine relaxant is administered and replacement is about to begin.
 - The placenta can also be removed manually after replacing the uterus. This reduces bleeding but makes replacement more difficult.

Manual replacement

Immediate manual replacement should be attempted by placing a hand in the vagina with fingers around the inverted fundus and pushing the fundus toward the umbilicus along the axis of the vagina (Fig. 43.18).

If the cervix is felt as a constricting ring, one of the following uterine relaxants is administered:

- Glyceryl trinitrate 50–200 µg IV
- Terbutaline 0.25 mg subcutaneous or IV
- Magnesium sulfate 4–6 g IV
- Inhalational anesthetic such as halothane or enflurane

Once the uterus relaxes, manual replacement is performed.

Hydrostatic method (Sullivan's method)

The vagina is filled with warm saline from a bag that is placed at a height above the patient. The obstetrician's hand or a ventouse cup is used to close the introitus and retain the saline in the vagina. The hydrostatic pressure of saline distends the vagina, increases the circumference at the vaginal vault, and pushes the uterine fundus up. After the uterus is replaced, oxytocin (20 units in 500 mL of saline) is given as an infusion to promote uterine contraction and prevent recurrence of inversion.

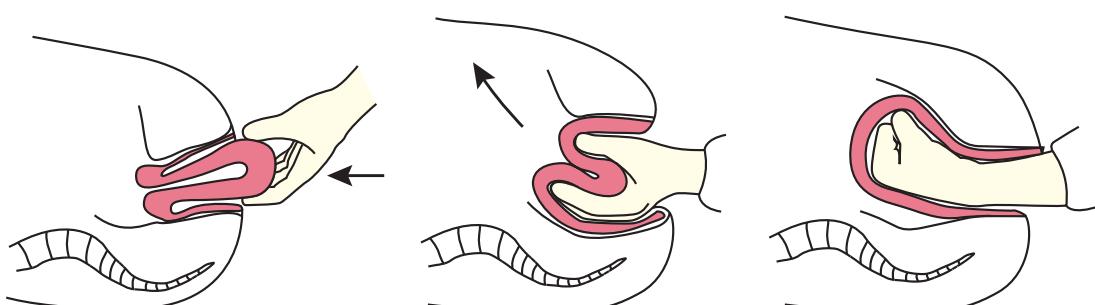


Figure 43.18 Manual replacement of inversion. Hand is introduced into the vagina with the fingers around the inverted uterine fundus and the fundus is pushed toward the umbilicus.

Surgical methods

If manual and hydrostatic methods fail, the patient must be shifted to the operating theater and one of the surgical methods must be resorted to. These are listed in Box 43.18.

Abdominal approach

If manual and hydrostatic methods fail, immediate laparotomy is warranted. The inverted uterus appears like a depression or cup within the constriction ring. The tubes, round ligaments and ovaries are pulled into the cup. In the *Huntington* procedure, the round ligament is held with a Babcock or Allis clamp and gentle traction applied to pull the fundus up. In the *Haultain* procedure, a vertical incision is made on the posterior uterine surface, the constriction ring is cut, and the uterine fundus is pulled up.

Box 43.18 Surgical interventions for uterine inversion

- Abdominal approach
 - Huntington procedure: Traction on round ligaments
 - Haultain procedure: Incision on the posterior uterine surface to cut the ring
- Vaginal approach
 - Spinelli procedure: Incision of constricting cervical ring anteriorly
 - Cascarides procedure: Incision of constricting cervical ring posteriorly

Vaginal approach

The constriction ring formed by the cervix is incised anteriorly (*Spinelli*) or posteriorly (*Cascarides*) to enable the uterus to be replaced. Vaginal surgical procedures are used in chronic inversion.

Key points

- Postpartum hemorrhage (PPH) is a major complication of the third stage of labor. It is a leading cause of maternal mortality and accounts for 25% of maternal deaths in India.
- Other complications of the third stage include retained placenta, adherent placenta, uterine inversion, and amniotic fluid embolism. These are less common than postpartum hemorrhage (PPH), but also cause hemorrhage, hypotension, shock, and maternal death.
- Postpartum hemorrhage is defined as blood loss >500 mL following vaginal delivery and >1000 mL following cesarean delivery. It may be primary or secondary.
- Primary PPH may be atonic or traumatic. Atonic PPH is the most common cause of PPH. Several risk factors have been identified.
- Prevention of atonic PPH is by active management of the third stage and prophylactic uterotronics.
- Once atonic PPH occurs, management should be prompt. Evaluation, resuscitation, and communication should proceed simultaneously.
- Administration of uterotronics should be followed by bimanual compression of the uterus and aortic compression. If there is no response, uterine tamponade must be attempted before surgical intervention.
- B-Lynch suture, stepwise devascularization, internal iliac artery ligation, and hysterectomy are the surgical interventions available for PPH.
- Traumatic PPH is due to trauma to the upper or lower genital tract. The lower genital tract should be explored, and the laceration identified and sutured.
- If the tear extends retroperitoneally or intraperitoneally, laparotomy is indicated.
- Secondary PPH is usually due to endometritis or retained placental tissue. Antibiotics are usually administered for all women with secondary PPH.
- Retained placenta can be due to trapped placenta, placenta adherens, or placenta accreta.
- Trapped placenta can be removed by controlled cord traction after administration of glyceryl trinitrate.
- Placenta adherens may be managed with oxytocin. If not successful, manual removal is indicated.
- Adherent placenta is a rare complication associated with life-threatening massive hemorrhage. The placenta invades the myometrium and there is no plane of separation. Adherent placenta is of three types: accreta, increta, and percreta.
- The most common causes of adherent placenta area previous cesarean section and placenta previa.
- If diagnosed antenatally by ultrasonography, planned management is possible and mortality is less.
- If diagnosed during manual removal, bleeding, shock, and mortality are high.
- Uterine inversion is a rare complication associated with profuse bleeding and shock. The shock is hypovolemic and neurogenic.
- Inversion is managed by replacement of the uterus manually, hydrostatically, or surgically.

Self-Assessment

Case-based questions

Case 1

Mrs. GN, 29, third gravida, delivered normally at a local hospital, a baby weighing 2.9 kg. Following delivery of the placenta, there was continuous, profuse bleeding. At admission, she was pale, pulse was 120/min and blood pressure was 90/70 mm of Hg.

1. What is the cause of bleeding likely to be?
2. What is the initial management?
3. What measures should be taken before shifting the patient to a tertiary center?
4. What is the further management?

Case 2

Mrs. PD, 23, second gravida, delivered a live baby girl vaginally. Following this, the placenta was not delivered. She was shifted to a higher center after waiting for 45 minutes. The patient was bleeding, had hypotension, and was looking pale.

1. What is the diagnosis?
2. What is the initial management of retained placenta?
3. What is the management now?
4. What are the complications of hemorrhage and hypotension?

Answers

Case 1

1. Most likely to be atonic postpartum hemorrhage but trauma to the genital tract should be excluded by examination.
2. Catheterize the bladder. Insert a large-bore intravenous line and begin oxytocin infusion with 20 units in 500 mL of normal saline. Obtain blood sample for hematocrit and cross-matching, and continue with volume replacement and blood transfusion. Perform bimanual uterine compression and aortic compression.

3. Condom balloon tamponade, blood transfusion, and fluid replacement.
4. Surgical intervention. Laparotomy and B-Lynch suture. If bleeding is not controlled, uterine artery ligation and stepwise devascularization. Hysterectomy if bleeding continues.

Case 2

1. Retained placenta, probably partially separated.
2. Abdominal examination to look for consistency of the uterus. Vaginal examination to look for trapped placenta. Oxytocin infusion with 20 units in 500 mL of saline. If unsuccessful, intraumbilical oxytocin injection.
3. Volume resuscitation, blood transfusion, and manual removal of the placenta under general anesthesia.
4. Hypotension, shock, renal failure, sepsis, pituitary necrosis and Sheehan's syndrome, anemia, venous thromboembolism, and acute respiratory distress syndrome.

Sample questions

Long-answer questions

1. Describe the causes of postpartum hemorrhage. Discuss in detail the predisposing causes, diagnosis, and management of atonic PPH.
2. Enumerate the important complication of the third stage of labor. Describe the causes and management of retained placenta.

Short-answer questions

1. Traumatic PPH
2. Predisposing factor for atonic PPH
3. Inversion of uterus
4. Internal iliac ligation
5. Manual removal of placenta
6. Vulval hematoma
7. Placenta accreta

44

Obstructed Labor and Uterine Rupture

Case scenario

Mrs. AP, 20, primigravida, was brought from a village with labor pains for the past 28 hours. She had not undergone regular antenatal checkup and after the onset of labor had been at home for 24 hours, under the care of an untrained local dai, who was her neighbor. Since she did not deliver after all attempts by the dai, she was taken to the local primary health center. She was told that the baby was big and could not be delivered vaginally. She was referred to a tertiary center. She looked exhausted and dehydrated, the lower uterine segment was stretched, the bladder edematous, and fetal heart sounds could not be heard.

Introduction

Undiagnosed cephalopelvic disproportion, malpresentations, and fetal anomalies causing obstructed labor are not uncommon in developing countries, particularly in resource-poor rural settings. They are, however, rare in the developed world. Obstructed labor is associated with high perinatal mortality and maternal morbidity and mortality. When left undiagnosed or when access to a health care facility is unavailable, uterine rupture results. This is a preventable obstetric catastrophe and must be avoided.

Obstructed labor

Definition

Obstructed labor results when mechanical causes prevent the fetus from descending through the pelvis, in spite of good uterine contractions. It contributes to approximately 8% of maternal mortality globally. Obstruction may occur at any level in the pelvis.

Etiology

Any condition that interferes with the normal descent of the fetus can give rise to obstruction.

Box 44.1 Causes of obstructed labor

- Cephalopelvic disproportion
 - Abnormal pelvic configuration
 - Small pelvis
 - Fetal macrosomia
- Malpresentations
 - Transverse lie
 - Brow
 - Face
 - Breech
 - Compound
- Soft tissue dystocia
 - Cervical stenosis
 - Fibroid in the lower uterine segment
 - Ovarian tumors
 - Uterine anomalies
- Fetal anomalies
 - Hydrocephalus
 - Fetal ascites/hydrops
 - Fetal tumors

The most common cause is cephalopelvic disproportion (CPD). This could be due to an abnormal pelvic configuration or a large fetus. Malpresentations and fetal anomalies are also important causes (Box 44.1).

Risk factors

Women living in rural areas in developing countries may be managed by untrained personnel, due to poor transport facilities preventing access to better care. Malpresentations and CPD, complicated by prolonged and obstructed labor, may not be diagnosed or may be diagnosed late. This is the most important risk factor for obstructed labor and uterine rupture. Other risk factors

Box 44.2 Risk factors for obstructed labor

- Short stature
- Teenage pregnancy
- Uncontrolled diabetes
- Lack of transport facilities
- Lack of access to health facilities

include short stature that is associated with small pelvis, teenage pregnancies, and uncontrolled diabetes with fetal macrosomia (Box 44.2).

Course in labor

When there is obstruction to the passage of the fetus, the uterus continues to contract in an attempt to overcome the obstruction. As the uterus contracts, the muscle fibers of the upper segment become shorter and thicker with each contraction and those of the lower segment become longer and thinner. Ultimately, a demarcation develops between the contracted upper segment and the stretched lower segment. This is the *physiological retraction ring* (see Chapter 14, *Normal labor: Mechanics, mechanism, and stages*).

When there is obstruction to the passage of the fetus, the process continues; the contracted upper segment pushes the fetus further into the lower segment; the demarcation becomes more distinct and is now known as the **Bandl's ring**. This ring can be palpated abdominally, running transversely or obliquely across the uterus (Fig. 44.1).

The lower uterine segment is stretched and extends higher into the abdomen. The stretched lower segment is friable and thin. This condition is described as **threatened rupture**.

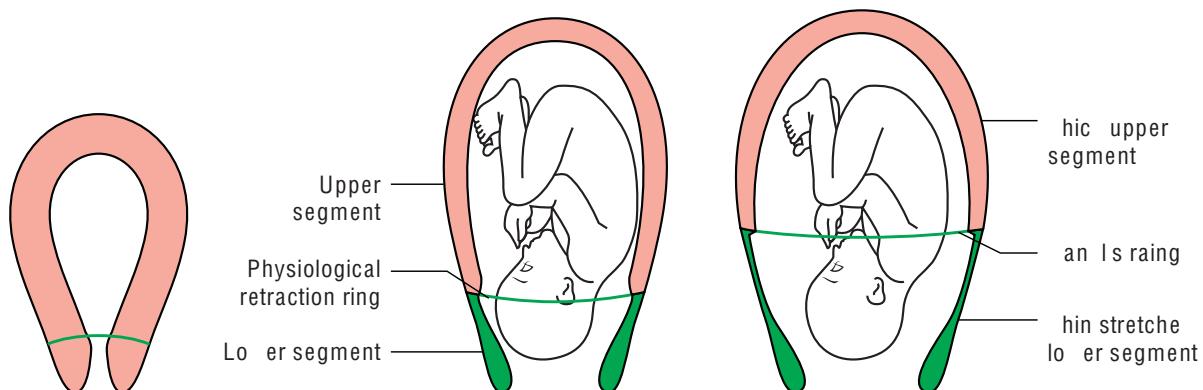


Figure 44.1 Bandl's ring. **a.** Nonpregnant uterus. **b.** Normal labor. **c.** Obstructed labor. Bandl's ring. The demarcation between upper segment and lower segment is not visible in the nonpregnant uterus, becomes obvious in labor and Bandl's ring forms at the demarcation in obstructed labor.

The fetal head is jammed in the pelvis, and the urinary bladder is compressed between the pubic bone and the fetal head. The bladder becomes edematous and is pulled up. Ultimately, this leads to pressure necrosis of the bladder. This area sloughs off after 10–14 days, forming a *vesicovaginal fistula*.

As the process continues unrelentingly, the fetus becomes hypoxic and ultimately intrauterine death results.

With further uterine contractions, the lower segment ruptures (**uterine rupture**), extruding the fetus and placenta into the peritoneal cavity.

A primigravid uterus contracts vigorously initially and may subsequently develop uterine inertia. A multigravid uterus, on the other hand, continues to contract and is more likely to rupture.

Clinical features

The mother has usually gone through prolonged labor before obstructed labor develops. With the rupture of membranes, amniotic fluid volume reduces drastically and the uterus hugs the fetus. Intra-amniotic infection can occur, especially if multiple vaginal examinations are performed. The woman is dehydrated; there may be acidosis. Fetal heart sounds may be irregular or absent.

On pelvic examination, it is usually found that the cervix is not well applied to the presenting part and hangs loose. There is a large caput and irreducible molding. In transverse lie, the arm may have prolapsed (Box 44.3).

Diagnosis

The diagnosis of obstructed labor is by history and clinical examination.

Patients with obstructed labor are usually referred from a smaller facility or have been in labor at home. On arrival at hospital, a detailed history should be obtained as given in Box 44.4.

Physical examination

The clinical findings described earlier should be looked for. The pulse, blood pressure, and temperature should be recorded. The bladder should be catheterized and urine output recorded. Uterine contractions, the presence of Bandl's ring, fetal presentation, station and position, the presence of fetal heart sounds, fetal abnormalities, cervical dilatation, and foul-smelling liquor

Box 44.3 Clinical features of obstructed labor

- History
 - Prolonged labor
 - Prolonged rupture of membranes
- General examination
 - Patient anxious and exhausted
 - Signs of dehydration
 - Tachycardia
 - Tachypnea
 - Fever
 - Evidence of acidosis
- Abdominal examination
 - Uterus tonically contracted
 - Bandl's ring
 - Malpresentation or transverse lie
 - Bladder edematous and pulled up
- Pelvic examination
 - Cervix not well applied to presenting part
 - Large caput
 - Irreducible molding
 - Arm prolapse in transverse lie
 - Meconium-stained/foul-smelling amniotic fluid

Box 44.4 History in obstructed labor

- Maternal age
- Parity
- Antenatal care
- Time of onset of pains
- Time of rupture of membranes
- Multiple vaginal examinations
- Fetal movements
- Fever

are important findings for deciding the mode of delivery (Box 44.5).

Management

Correction of dehydration, prevention of sepsis, and prompt delivery of the fetus are the key steps in management.

- Correct dehydration and acidosis with intravenous dextrose saline and Ringer lactate.
- Send blood for routine investigations such as hematocrit, plasma glucose, creatinine, and electrolytes.
- Catheterize and record urine output.
- If membranes have been ruptured for >18 hours, start an antibiotic. Injection ampicillin 2 g IV stat followed by 1 g IV 6 hourly till delivery is recommended. If the mother has fever or foul-smelling amniotic fluid (suspected chorioamnionitis), in addition, a single daily dose of injection

Box 44.5 Physical examination in obstructed labor

- Maternal height
 - Pulse
 - Blood pressure
 - Temperature
 - Urine output
 - Uterine contractions
 - Presentation/position/station
 - Fetal heart rate/abnormal EFM trace
 - Cervical dilatation
 - Meconium-stained/foul-smelling amniotic fluid
- , electronic fetal monitoring.

gentamicin is recommended. It is administered in a dose of 3–5 mg/kg (180–300 mg for a 60 kg woman) in 100 mL of normal saline over 30 minutes. Discontinue antibiotics when the mother is afebrile for 48 hours.

- Exclude uterine rupture by clinical examination and if necessary, by ultrasonography.
- Immediate cesarean section is recommended for all women in obstructed labor, irrespective of the presentation, cervical dilatation, or condition of the fetus.
- If the cervix is fully dilated, the vertex is at or below the level of the ischial spines, and the fetus is dead, craniotomy followed by vaginal delivery is an option. This must be performed in the operating theatre by an experienced obstetrician.
- During cesarean section, the following precautions should be taken:
 - Incise the uterovesical peritoneum at a higher level to avoid damage to the bladder.
 - Make the uterine incision large enough to avoid lateral extension.
 - Have an assistant ready to disengage the presenting part through the vagina.
 - Anticipate malpresentations and deliver appropriately.
 - Explore the uterine incision for downward or lateral extensions after delivering the fetus.

uterine rupture

Uterine rupture is a life-threatening complication in obstetrics. Rupture of a uterus with a previous cesarean section scar is most common. Rupture of an unscarred uterus is rare in modern obstetrics. Maternal and perinatal mortality and morbidity are high in uterine rupture.

Definitions

Uterine rupture is the nonsurgical, full-thickness tear through all layers of the uterine wall with or without expulsion of the fetus.

In **incomplete rupture** or **dehiscence**, all layers of the uterine wall are not separated and the peritoneum is intact.

Incidence

Uterine rupture, including incomplete rupture or dehiscence, occurs in 1 in 2000 deliveries in developed countries. In India and other developing countries, the incidence is 10-fold higher. The overall incidence varies from 1/100 to 1/1000. Of these, 50%–60% occur in a scarred uterus.

Maternal mortality due to uterine rupture in India is 6%–9%. Perinatal deaths occur in 80% of uterine rupture.

Etiology

Rupture of unscarred uterus

Most ruptures in an unscarred uterus occur due to obstructed labor. Intrauterine manipulations such as internal podalic version, trauma, injudicious use of oxytocin and other uterotonic agents, grandmultiparity, and overdistended uterus are other causes (Box 44.6).

Box 44.6 Causes of rupture of unscarred uterus

- Obstructed labor
 - Cephalopelvic disproportion
 - Malpresentations
 - Soft tissue dystocia
 - Fetal anomalies
- Injudicious use of uterotonic
 - Oxytocin
 - Prostaglandins
- Intrauterine manipulations
 - Internal podalic version
 - Midforceps
 - Destructive operations
- Overdistended uterus
- Grandmultiparity
- Congenital uterine anomalies
 - Bicornuate uterus
- Placenta accreta
- Trauma

Rupture of scarred uterus

The majority of uterine ruptures are scar ruptures. This is usually less catastrophic than the rupture of an unscarred uterus. These may be incomplete ruptures (scar dehiscence) or complete ruptures. Scar rupture can occur in the conditions listed in Box 44.7. The risk is much higher in previous classical cesarean sections and hysterotomies. In previous lower segment cesarean sections, use of prostaglandins and oxytocin increases the risk. Previous vigorous curettage and uterine perforation have also been implicated.

Clinical features

Rupture of unscarred uterus

When the uterus ruptures, the strong and tonic uterine contractions of obstructed labor subside and there is cessation of pain. The mother complains of a feeling of something giving way.

Soon there are signs of intraperitoneal hemorrhage and shock. There is tachycardia, hypotension, and persistent abdominal pain. Free fluid may be present in the abdomen. Hematuria indicates extension of the uterine rupture to the bladder.

The fetal movements may be excessive initially but become less, and the movements may disappear as fetal hypoxia sets in. Fetal bradycardia is followed by disappearance of fetal heart sounds. As the fetus gets extruded into the peritoneal cavity, the uterus contracts and is felt as a globular structure; fetal parts are easily palpable superficially. There is loss of station of the presenting part as the fetus moves up into the peritoneal cavity (Box 44.8).

Rupture of scarred uterus

Antepartum rupture

Rupture during the antenatal period may be silent and present only after fetal compromise occurs.

Box 44.7 Causes of rupture of a scarred uterus

- Previous cesarean section
 - Classical
 - Lower segment
- Previous hysterotomy
- Previous myomectomy
- Previously repaired uterine rupture
- Previous vigorous curettage or perforation of uterus

Box 44.8 Clinical features of uterine rupture

- Rupture of unscarred uterus
 - Cessation of uterine contractions
 - Persistent abdominal pain
 - Feeling of something giving way
 - Tachycardia
 - Hypotension
 - Loss of fetal movements
 - Hematuria
 - Loss of uterine contour
 - Firm, contracted uterus felt separately
 - Loss of fetal station
 - Fetal parts felt easily
 - Fetal heart rate changes
 - Free fluid in the abdomen
 - Vaginal examination
 - Vaginal bleeding
 - Receding of the presenting part
- Rupture of scarred uterus
 - Fetal bradycardia
 - Variable and late decelerations
 - Vaginal bleeding
 - Persistent abdominal pain
 - Hematuria
 - Signs of intra-abdominal hemorrhage
 - All other features as described above

Antepartum rupture occurs in previous classical cesarean section, hysterotomy, and previous upper segment rent repair. The risk is high in the third trimester, after 34 weeks.

Intrapartum rupture

Intrapartum ruptures are the most common. Fetal heart abnormalities such as bradycardia and variable and late decelerations are the earliest sign of lower segment scar rupture in labor. Maternal tachycardia and hypotension indicate rupture and intra-abdominal bleeding. Vaginal bleeding and persistent abdominal pain that is present even between contractions are other clinical features. Other signs are similar to those seen in the rupture of an unscarred uterus.

Occult rupture that occurred intrapartum may present as persistent abdominal pain and vaginal bleeding or hematuria.

Sites of rupture

The site of rupture depends on the etiology.

- Rupture due to obstructed labor is in the lower segment, may be a transverse or oblique tear,

- and may extend upwards to the upper segment or downwards to the cervix and vagina.
- Nonobstructive ruptures are usually in the upper segment, at the fundus (Fig. 44.2).
 - If the uterus is scarred, the rupture happens at the site of the scar.

Timing of rupture

Uterine rupture can occur antenatally or in labor.

- Rupture of an unscarred uterus occurs after prolonged labor or with intrauterine manipulations.
- Rupture of an upper segment scar can occur in the third trimester of pregnancy since the upper segment stretches during pregnancy. This is usually seen in previous classical cesarean section, previous uterine rupture, and myomectomy.
- Scars of previous lower segment cesarean section usually rupture in labor.

Differential diagnosis

Other conditions that present with pain, signs of hemorrhage, and fetal heart rate changes are placental abruption, other causes of intra-abdominal hemorrhage such as rupture of liver in severe pre-eclampsia, and chorioamnionitis.

Complications

Maternal morbidity and mortality and perinatal mortality are high in uterine rupture.

Intra-abdominal bleeding can give rise to hemorrhagic shock with all its associated complications such as renal failure and disseminated intravascular coagulation.

Rents in the lower segment can extend to the vagina, cervix, or bladder. Rupture of the vaginal vault is known as **colporrhesis**. This may be difficult to repair. Rupture close to the broad ligaments can extend to involve uterine vessels and form broad ligament hematomas. Fetal hypoxia leading to hypoxic ischemic encephalopathy and fetal death are common (Box 44.9).

Prediction of scar rupture

Prediction of scar rupture has been discussed in Chapter 20, *Cesarean section and management of pregnancy with previous cesarean*.

Box 44.9 Complications of uterine rupture

- Maternal
 - Hemorrhage
 - Shock
 - Disseminated intravascular coagulation
 - Renal failure
 - Extension to adjacent structures
 - Bladder
 - Uterine vessels
 - Cervix
 - Vagina
 - Maternal mortality
- Fetal
 - Hypoxic ischemic encephalopathy
 - Perinatal mortality

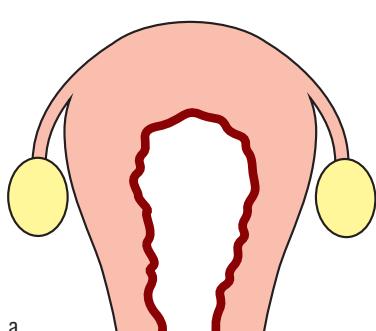


Figure 44.2 Uterine rupture. **a.** Figure shows a vertical uterine rupture extending into the upper segment. **b.** Image shows uterine rupture (as depicted in a.) extending into upper segment. **c.** Fetus is seen in the peritoneal cavity. (Photo courtesy: Dr Rajnish Samal, Bangalore).

Diagnosis

History

Diagnosis of uterine rupture is by history and physical examination. History should focus on risk factors and symptoms suggestive of rupture. Physical examination, including general, abdominal, and pelvic examination, reveals signs described earlier. Intrapartum dehiscence or rupture is suspected when there are changes in fetal heart rate patterns along with maternal hypotension and shock, in a woman with previous uterine surgery. Ultrasonography may be required when diagnosis is in doubt. The fetus is seen lying in the peritoneal cavity with the contracted uterus seen separately. Free fluid is present in the peritoneal cavity.

Management

Immediate laparotomy is indicated in all women with uterine rupture.

- In case of suspected scar dehiscence or rupture, laparotomy should be performed immediately to save the fetus.
- If the woman is admitted with clinical findings of rupture, stabilize her by correction of hypotension and shock. Start intravenous saline or Ringer lactate through a wide-bore cannula or central venous line, pending arrival of blood.
- Begin blood transfusion as soon as possible.

- Catheterize the bladder; document and monitor urine output.
- Perform laparotomy at the earliest. General anesthesia is preferable.
- The abdominal incision may be transverse, but a vertical incision may give better access and may be required in some cases.
- Deliver the fetus that is lying partially or completely in the peritoneal cavity.
- Identify the site of rupture. The surgical options are as follows:
 - *Repair of rent*: This is recommended if the rent is clean and easily repairable and/or the mother is desirous of further childbearing. The mother should be counseled regarding the risk of scar rupture during subsequent pregnancy. Elective cesarean section should be performed in the next pregnancy at or before 36 weeks.
 - *Rent repair with sterilization* is recommended in women who have completed their family.
 - *Total hysterectomy* is recommended when there is fundal rupture, the rent is difficult to repair, and/or there is profuse uncontrollable bleeding.
 - *Subtotal hysterectomy* may be required in rare situations when the woman is bleeding profusely and is hemodynamically unstable. This procedure is associated with decreased operating time, morbidity and mortality, and duration of hospital stay.
- Identify injury to other organs such as bladder and ureter and repair accordingly.

Key points

- Obstructed labor is rare in developed countries but is still encountered in developing countries. It is an important cause of perinatal and maternal mortality.
- The most common cause is cephalopelvic disproportion. Malpresentations, fetal anomalies, and soft tissue dystocia are other causes.
- When there is obstruction to the passage of the fetus, the upper segment contracts and the lower segment stretches. The Bandl's retraction ring forms at the junction of the two segments. This goes on to threatened rupture and ultimately rupture of the uterus.
- The diagnosis of obstructed labor is by history and physical examination.

- Once a woman is admitted with obstructed labor, she should be hydrated, antibiotics should be administered, and she should be taken for an immediate cesarean section.
- Uterine rupture is a life-threatening complication in obstetrics. This can occur in an unscarred or scarred uterus.
- Rupture of an unscarred uterus follows obstructed labor, intrauterine manipulations, or injudicious use of uterotronics or trauma.
- Rupture of a scarred uterus occurs in women with previous cesarean section, myomectomy, hysterotomy, or rent repair.

(Continued)

Key points *Continued*

- The clinical presentation in uterine rupture is with signs of intra-abdominal hemorrhage, the contracted uterus felt separately, and fetal parts easily palpated with loss of station of the presenting part.
- Fetal heart rate abnormalities are the earliest signs of rupture of a scarred uterus.
- Once rupture is diagnosed, laparotomy should be performed immediately, after stabilizing the mother.
- If the woman is desirous of further childbearing and the rent is clean and repairable, rent repair without tubectomy may be an option. Rent repair and sterilization should be performed if it is technically feasible and bleeding is not profuse.
- Hysterectomy is the treatment of choice if there is profuse bleeding and the rent is not repairable.

Self-Assessment

Case-based question

Mrs. AP, 20, primigravida, was brought from a village with labor pains for the past 28 hours. She had been at home for 24 hours, being taken care of by an untrained *dai*. Since she did not deliver after all her attempts, she was taken to the local primary health center. She was told that the baby was big and could not be delivered vaginally. She was referred to a tertiary center. She looked exhausted and dehydrated, the lower segment was stretched, the bladder was edematous, and the vertex two-fifth palpable.

1. What is the diagnosis?
2. What history would you ask for?
3. What will you look for on physical examination?
4. How will you manage this case?
5. What complications do you expect during cesarean section?

Answers

1. Obstructed labor with probably threatened rupture.
2. Duration of ruptured membranes, pelvic examinations performed by *dai*, fever, and fetal movements.
3. General examination—pulse, BP, and temperature
Abdominal examination—uterine tenderness, Bandl's ring, and fetal heart rate and abnormalities
Pelvic examination—foul-smelling or meconium-stained amniotic fluid, caput, molding, and cervical dilatation

4. Rapidly hydrate the patient with normal saline and Ringer lactate, cross-match blood, ask for hematocrit and routine investigations, and start on injection ampicillin 2 g IV stat and then 6 hourly and single daily dose of gentamicin (3–5 mg/kg) in 100 mL of saline as infusion. Take for a cesarean section as soon as she is stabilized.
5. Bladder injury while opening uteroovesical peritoneum, difficulty in delivering the head since it is jammed in the pelvis, extension of uterine incision to the uterine vessels or bladder, and hemorrhage due to friable lower segment.

Sample questions

Long-answer question

What are the causes and clinical features of uterine rupture? How will you manage a multigravida with uterine rupture due to obstructed labor?

Short-answer questions

1. Bandl's ring
2. Threatened rupture of uterus
3. Causes of obstructed labor
4. Complications of ruptured uterus

45

Nonhemorrhagic Shock in Pregnancy

Case scenario

Mrs. AN, 32, was brought to the emergency room with shock, circulatory collapse, and altered sensorium. She had delivered at a local hospital 2 hours earlier after labor induction with vaginal misoprostol supplemented by oxytocin. After delivery, she needed suturing of a cervical tear but did not have significant postpartum hemorrhage. On examination, she had cold and clammy extremities; her pulse was 120/min, BP 90/60 mm Hg, and respiratory rate 40/min. She had been referred to a tertiary care center for management.

Introduction

Hypotension with associated shock during pregnancy and puerperium is an emergency. It is most often due to hemorrhage, but there are other conditions that lead to hypotension as well. *Amniotic fluid embolism* may go undiagnosed since the condition is rare and clinical diagnosis is difficult. *Sepsis* leading to hypotension and septic shock can occur following chorioamnionitis and intrapartum sepsis. This is not uncommon in developing countries. *Disseminated intravascular coagulation* (DIC) is a condition that can occur in women with obstetric complications such as placental abruption, intrauterine fetal death, and massive hemorrhage due to any cause.

Amniotic fluid embolism

Definition

Sudden cardiovascular collapse, altered mental status, and DIC due to the entry of amniotic fluid, fetal debris, and fetal antigens into the maternal circulation through maternal venous channels in the uterus or cervix is known as amniotic fluid embolism syndrome (AFES). This is believed to be an anaphylactoid reaction.

The following four criteria should be present to diagnose a case of AFES:

1. Acute hypotension or cardiac arrest
2. Acute hypoxia

3. Coagulopathy or severe hemorrhage in the absence of other explanations
4. All of these should occur during labor, cesarean delivery, dilation and evacuation, or within 4 hours postpartum with no other explanation of findings

Incidence

Amniotic fluid embolism syndrome is a rare condition, and the incidence is 1–12 cases per 100,000 deliveries.

Risk factors

There are two basic events that result in this complication:

- A breach in the physical barrier between mother and fetus at the endocervical veins, maternal venous sinuses in the placental bed, or other sites of uterine trauma, such as lower segment incision for cesarean section.
- Increase in intrauterine pressure over and above the pressure inside these venous channels. Amniotic fluid enters the maternal venous channels through veins that drain the uterus or cervix.

The risk factors can be classified as follows:

- Conditions that cause opening up of venous channels in the uterus
- Situations that lead to a pressure gradient between the uterus and cervix on the one hand and maternal venous channels on the other hand (Box 45.1)

Box 45.1 Risk factors for amniotic fluid embolism syndrome

- Opening up of venous channels in the uterus
 - Placenta previa
 - Abruptio of placenta
 - Cervical lacerations
 - Uterine atony
 - Cesarean section
 - Instrumental delivery
- Situations causing undue increase in intrauterine pressure
 - Labor induction
 - Precipitate labor
 - Eclampsia

Pathogenesis

Amniotic fluid embolism syndrome is a sudden serious event that occurs usually in the few hours before or after delivery. The exact pathogenesis of this syndrome has not been worked out. Even though amniotic fluid in variable quantities enters the maternal circulation in a good proportion of women during labor, only a small number develop hypoxic shock and circulatory failure. Therefore, it is thought that it is an unpredictable idiosyncratic reaction. The shock is due to an anaphylactoid reaction to fetal antigens in the amniotic fluid. The physical presence of amniotic fluid debris in the pulmonary capillary bed and maternal immunologic and inflammatory reactions to fetal antigens in the amniotic fluid are implicated in the pathogenesis of the syndrome.

Phases of AFES

The following phases are described in mothers who have AFES:

- **Phase 1:** A nondescript prodromal phase of nausea, vomiting, mild tachypnea, mental confusion or agitation, chills, and paresthesiae in the extremities in some women.
- **Phase 2:** A phase of acute hypoxia and acute pulmonary hypertension that lasts for about 15–30 minutes. Several hours may elapse between the entry of amniotic fluid and the occurrence of hypoxia. Vasospasm in the pulmonary vasculature, acute pulmonary hypertension, and features of acute right ventricular failure have been demonstrated by transesophageal echocardiography during this early phase of AFES. A gross–ventilation perfusion mismatch ensues. Large areas of the alveolar surface are ventilated but not perfused. Unoxygenated blood is shunted into the pulmonary veins and into the left heart. This leads to acute hypoxia and the PaO_2 and oxygen saturation decrease.
- **Phase 3:** A phase of acute left ventricular (LV) failure sets in after 3–4 hours. The contributing factors for LV dysfunction are
 - hypoxic injury to the left ventricle;
 - cardiodepressant immunologic and inflammatory mediators released by the mother's immune system;

- direct depressant effect of amniotic fluid on the left ventricle.

Left ventricular failure decreases cardiac output and leads to tachycardia and hypotension. Further, LV failure also causes an increase in the hydrostatic pressure at the venous end of pulmonary capillaries and contributes to pulmonary edema. This in turn worsens hypoxia. With supportive therapy, this acute LV dysfunction is reversible.

- **Phase 4:** A few hours after the early pulmonary edema, leakage of fluid into the alveoli occurs due to damaged alveolar-capillary membrane. This is presumably due to local inflammatory mediators.
- **Phase 5:** Disseminated intravascular coagulation and consumption coagulopathy ensue. The fetal material in maternal circulation probably triggers DIC.

Serum complement is low, serum inflammatory markers are elevated, and serum tryptase

levels are elevated in some women with AFES. These observations support an immunologically mediated inflammatory response leading to damaged alveolocapillary membrane and leakage of fluid into the pulmonary interstitium which damages the alveolar capillary membrane and causes a leak of fluid.

In women who survive the first few hours after the hypoxic hypotensive episode, recovery is usually rapid. This is in sharp contrast to non-cardiogenic pulmonary edema in women with adult respiratory distress syndrome where recovery may take several days.

The sequence of events is depicted in Figure 45.1.

Complications

With the decline in maternal mortality due to sepsis and hemorrhage in developed countries, AFES has emerged as an important cause for

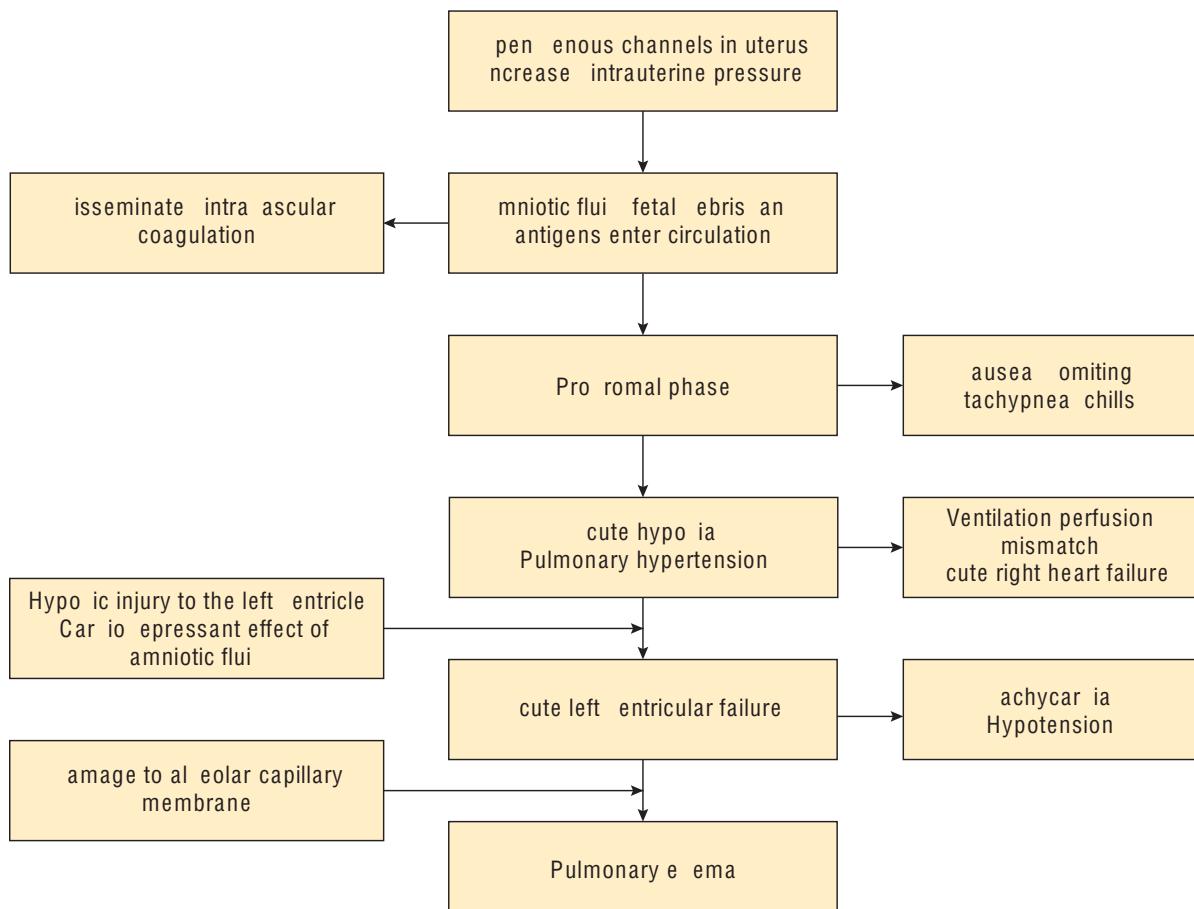


Figure 45.1 Pathogenesis and phases of amniotic fluid embolism syndrome (AFES).

maternal mortality accounting for 10%–20% of maternal deaths. In developing countries, the actual figures for the incidence of AFES and maternal mortality due to this complication are not available.

Maternal mortality in AFES used to be approximately 80% earlier. With current management strategies this has now declined to approximately 20% in developed countries. In underresourced areas, the prognosis continues to be dismal.

There is considerable morbidity in surviving mothers. Of the survivors, 60%–80% suffer significant neurologic damage. Neonatal mortality is 20%–60% and approximately 50% have neurologic sequelae.

The complications of AFES are listed in Box 45.2.

Clinical features

The majority of women with AFES present just before or during labor or in the first 4 hours after delivery. Rarely, they may present with shock up to 48 hours after normal or instrumental delivery or after a cesarean section. Amniotic fluid embolism syndrome has also been reported after first or second trimester abortion, amniocentesis, or abdominal trauma. Clinical features are given in Box 45.3.

Investigations

Since AFES is an emergency, investigations and resuscitative measures must proceed simultaneously. Investigations are aimed at evaluating the woman's condition rather than aid in diagnosis.

- At admission to the emergency room, pulse oximetry shows severe hypoxia (saturation <60%). Blood gas studies show hypoxia, metabolic acidosis, and hypocapnia ($\text{PCO}_2 < 30$).

Box 45.2 Complications of amniotic fluid embolism syndrome

- Maternal mortality
- Neurologic sequelae in mothers
- Neonatal mortality
- Neurologic sequelae in neonates

Box 45.3 Clinical features of amniotic fluid embolism syndrome

- Onset
 - Sudden onset
 - Just before or in labor
 - Within 4 hours of delivery
- Symptoms
 - Tachypnea
 - Restlessness
 - Nausea, vomiting
 - Paresthesia
 - Altered sensorium
 - Convulsions
 - Coma
- Signs
 - Cold extremities
 - Hypotension
 - Crepitations and rhonchi
 - Bleeding from venipuncture sites
 - Vaginal bleeding

- Hematocrit may be low; peripheral smear may show thrombocytopenia and fragmented red blood cells schistocytes if the woman has DIC.
- Serum creatinine may be elevated and serum electrolytes show metabolic acidosis with an anion gap >20, indicating lactic acidosis.
- Chest X-ray shows pulmonary infiltrates and loss of lung volume.
- Electrocardiography (ECG) shows sinus tachycardia, acute right ventricular strain pattern, or ventricular arrhythmia. The cardiac rhythm may be irregular.

Differential diagnosis

As evident from the above description, the clinical features overlap widely with a number of conditions that cause hypotension and acute illness in a woman in labor or postpartum. These include the following:

- Obstetric conditions such as placental abruption, uterine rupture, uterine atony, and eclampsia
- Medical conditions such as septic shock, pulmonary embolism, air embolism, anaphylaxis, massive aspiration, transfusion reaction, and peripartum cardiomyopathy
- Anesthetic problems such as high spinal anesthesia or anaphylactic reaction to local anesthetic agent

Diagnosis

A high index of suspicion, quick diagnosis, and immediate resuscitative measures are the key to successful outcome in AFES.

- **Diagnosis is mainly clinical.** Most often the diagnosis is arrived at by an analysis of the sequence of events and by a process of exclusion of other obstetric emergencies that present in similar fashion. Amniotic fluid embolism must be considered when a woman without significant blood loss during or following delivery presents with respiratory distress, hypotension, and shock (Box 45.4).
- There are no confirmatory laboratory tests.
- If the patient has a pulmonary artery catheter inserted, samples drawn may show amniotic fluid debris, but this is only supportive evidence and not confirmatory evidence.
- Serological tests for TKH2 (a fetal antigen present in maternal lung) and insulin-like growth factor-binding protein 1 (IGF-BP1) are research tools and not available for routine clinical use.

Box 45.4 Diagnosis of amniotic fluid embolism syndrome

- History
 - Risk factors
- Clinical features
 - Sudden onset
 - During or after labor
 - Symptoms and signs
 - Tachycardia, tachypnea
 - Hypotension
 - Acute right ventricular failure
 - Left heart failure
 - Pulmonary edema
 - Hypoxia
 - DIC
 - Investigations
 - Pulse oximetry
 - Blood gas analysis
 - Hypoxia
 - Metabolic acidosis
 - Chest X-ray
 - Pulmonary infiltrates
 - Platelet count
 - DIC workup

D C, disseminated intravascular coagulation.

Management

There is no specific drug or antidote to counter the chain of events that occur in AFES.

The aim of treatment is to correct the physiological abnormalities such as hypoxia, hypotension, and consumption coagulopathy so that maternal cerebral hypoxia, acute renal failure, and fetal hypoxic ischemic encephalopathy are prevented. All women with suspected AFES should be managed in a well-equipped ICU in a tertiary care institution.

- Admit the woman in the ICU.
- Administer oxygen through venturi mask (high-flow oxygen therapy).
- Connect to ECG monitor.
- Insert bladder catheter and record urine output.
- Place a central venous pressure (CVP) line.
- Send blood sample for Hb, peripheral smear blood culture, electrolytes, serum creatinine, liver function tests (LFT), prothrombin time, and partial thromboplastin time. If the woman has oozing from venipuncture sites, send for a full DIC workup. Send a sample for blood grouping and cross-matching.
- Place an intra-arterial line and send for blood gases.
- Monitor ECG, blood pressure, hourly urine output, oxygen saturation, and blood gases.
- Use IV fluids very carefully to maintain an hourly urine output of >30 mL and a CVP of approximately 10 cm.
- If PaO_2 is <65%, intubate and ventilate to maintain optimal oxygen saturation. If hypotension is not corrected, start norepinephrine or dopamine infusion. If woman has DIC and is bleeding, use packed cells, platelet concentrates, and fresh frozen plasma to correct coagulation abnormality and to maintain an Hb of 10 g/dL.

Obstetric management

If AFES occurs intrapartum, a decision must be made regarding immediate delivery and mode of delivery. Urgent delivery is indicated if there is nonreassuring fetal status on electronic fetal monitoring, if there is rapid progressive deterioration of the mother's clinical status, or if delivery would save the mother's life. Vaginal delivery is reasonable if the cervix is fully dilated and the fetal head has descended to at least +2 or +3 station. Otherwise an emergency cesarean section

is indicated. If there is significant coagulopathy, this should be concurrently controlled with blood products. Adequate packed cells, fresh frozen plasma, and cryoprecipitate should be available in the operation room.

Septicemia and Septic shock

The *sepsis syndrome* is a continuum. It consists of an initial phase of bacteremia followed by a systemic inflammatory response syndrome (SIRS) in the host. If treatment is delayed, *septic shock* ensues followed by multiorgan dysfunction and death. Progression of symptoms is rapid and delay in initiating treatment can lead to a fatal outcome.

The systemic inflammatory response syndrome is a constellation of features that represent the host response to different stimuli, including trauma, ischemia, inflammation, and infection. The clinical features are alteration in body temperature (hyperthermia or hypothermia), chills and rigors, tachycardia or bradycardia, hypotension, tachypnea, and metabolic acidosis.

Definitions

The definitions of the terminology used in sepsis syndrome are given below.

- **Bacteremia occurs when bacteria enter the bloodstream from a site of infection.** Blood cultures are usually positive for the concerned pathogen.
- **Sepsis is proven or probable infection with systemic manifestations.**
- **Septic shock refers to sepsis-related hypotension that persists in spite of adequate fluid replacement.**

Clinical criteria for the diagnosis of sepsis

Infection and bacteremia may lead to sepsis, which is diagnosed by the presence of the following signs:

- Fever (temperature $>38.3^{\circ}\text{C}$ or 101°F) or hypothermia (temperature $<36^{\circ}\text{C}$ or 97°F)
- Tachycardia

- Tachypnea
- Leukocytosis (WBC count $>12,000/\mu\text{L}$) or leukopenia (WBC count $<4000/\mu\text{L}$)
- Thrombocytopenia
- Hypoxemia
- Oliguria
- Increased serum creatinine

As the sepsis worsens, severe sepsis is diagnosed by the appearance of the following signs:

- Hypotension
- Worsening oliguria
 - Urine output, 30 mL/hour for 2 hours
- Worsening renal failure
 - Serum creatinine $>2 \text{ mg/dL}$
- Acute lung injury
- Serum bilirubin $>2 \text{ mg/dL}$
- Platelets $<100,000 \text{ mm}^3$
- Prothrombin time $>1.5 \text{ (INR)}$

In the presence of gram-negative organisms and, occasionally, with gram-positive organisms endotoxins are released, leading to septic shock (described in detail later in the chapter).

Incidence

Sepsis in pregnant women is less common (incidence 0.3%) than in the general population (incidence 0.6%). The incidence of septic shock is estimated to be 1 in 8000. However, septic shock is a common cause of maternal and neonatal mortality particularly in developing countries such as India. Maternal mortality can reach 13% in severe sepsis and up to 30% in septic shock. Neonatal mortality can be as high as 40%.

Predisposing factors

Septicemia and septic shock usually occur following maternal infection at one of the following sites:

- Pyelonephritis due to anatomic alterations in the renal tract in pregnancy
- Endometritis in the puerperium due to a large area of denuded maternal tissues exposed to bacteria
- Septic abortion where inadequate evacuation of the products provides a nidus for bacterial proliferation
- Perforation of the uterus with peritonitis

- Infection of surgical wounds (cesarean section, episiotomy) where a breach in the skin is liable for bacterial contamination

Bacteriology

Pelvic infection leading to septicemia is usually caused by gram-negative aerobes and anaerobes. Gram-positive organisms are more common in wound infections. The causative organisms and the toxins involved vary depending on the site and are listed in Table 45.1.

Pathogenesis of septic shock

The pathogenesis of septic shock due to gram-negative infections has been worked out in detail. The concept has been extended to gram-positive infections.

- Gram-negative organisms release a bacterial lipopolysaccharide (LPS) called 'endotoxin.'
- The endotoxin activates an inflammatory cascade in the host resulting in release of inflammatory mediators. This is responsible for the hemodynamic changes.
- Systemic inflammatory response results in release of cytokines. The cytokines cause increased capillary permeability and activate the coagulation system.
- The first event is increased capillary permeability and consequent massive leak of fluid into the interstitium.
- Concurrently, there is vasodilatation leading to tachycardia and hypotension. The extremities feel warm—'warm shock.' If this phase is not aggressively treated with IV fluids and broad-spectrum antibiotics, renal perfusion declines, urine output drops, the coagulation cascade is activated, and DIC and multiorgan failure ensue.

- There is concomitant myocardial depression and this further aggravates the situation.
- The alveolar capillary membrane is damaged and there is exudation of fluid into the lungs leading to adult respiratory distress syndrome (ARDS).
- A similar cascade is initiated by gram-positive organisms and their exotoxins.
- The pathogenesis of septic shock is summarized in Figure 45.2.

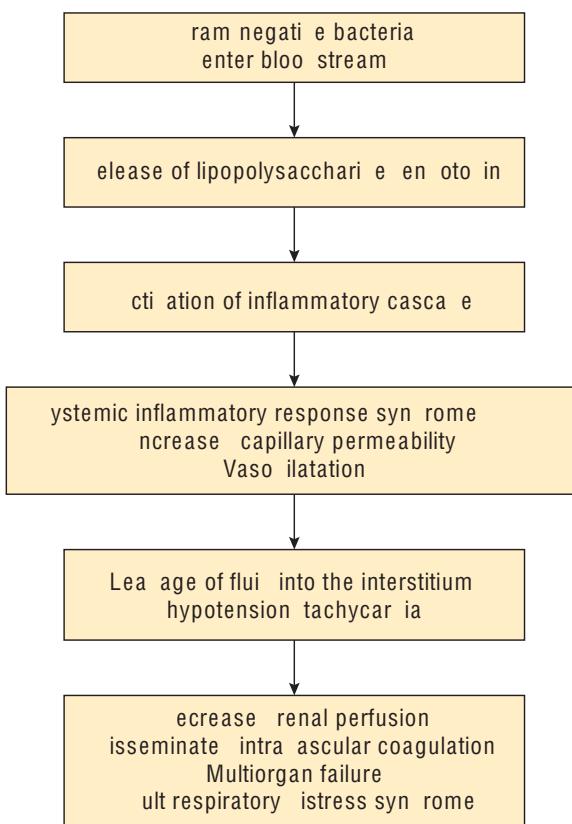


Figure 45.2 Pathogenesis of septic shock.

Table 45.1 Causative organisms and toxins

Location of infection	Causative organism	Toxin
Pyelonephritis	<i>Escherichia coli</i> <i>Enterobacter</i> <i>Leibesiiella</i> <i>Pseudomonas</i>	Endotoxin (LPS)
Endometritis	Same as above	
Pelvic infection	Same as above and anaerobes	Endotoxin (LPS)
Septic abortion	Same as above and anaerobes	Endotoxin (LPS)
Wound infection	Group A hemolytic streptococci <i>Staphylococcus aureus</i> Methicillin-resistant SA <i>Clostridium perfringens</i>	Toxic shock like exotoxin TSST1 Superantigen Exotoxin

PS, lipopolysaccharide; SA, *Staphylococcus aureus*; SS, toxic shock syndrome toxin1.

Clinical features of septic shock

There is abrupt onset of fever, chills, and tachycardia during bacteremia.

Septic shock has the following phases:

- Warm phase—phase of peripheral vasodilatation
 - Tachycardia
 - Hypotension
 - Warm extremities due to vasodilatation
 - Low CVP due to marked decrease in intravascular fluid volume
- Cold phase—phase of peripheral vasoconstriction
 - Elevated CVP due to cardiac failure
 - Poor tissue perfusion and lactic acidosis
 - Tachypnea
 - Adult respiratory distress syndrome
 - Altered sensorium
 - DIC
- Multiorgan failure due to hypotension and DIC
 - Acute renal failure
 - Altered LFT
 - Respiratory failure
 - Cardiac failure

Diagnosis

A high index of suspicion is necessary to recognize sepsis early. Unexplained tachycardia, a spike of fever, and chills with concurrent drop in blood pressure should prompt early intervention. As outcome is critically dependent on early initiation of treatment, early recognition is of paramount importance. Diagnostic features are listed in Box 45.5.

Management

When sepsis is suspected, a three-pronged strategy is instituted. All the steps are undertaken concurrently to

- initiate emergency goal-directed treatment;
- identify the organism and antibiotic therapy; and
- find the source of infection.

Emergency goal-directed treatment

Goal-directed treatment consists of initial resuscitative measures to achieve hemodynamic stability.

Box 45.5 Diagnosis of septic shock

- History
 - Risk factors
 - Septic abortion
 - Puerperal endometritis
 - Pyelonephritis
 - Wound infection
- Symptoms and signs
 - Fever, chills
 - Hypotension
 - Tachycardia
 - Tachypnea
- Evidence of multiorgan failure
 - Oliguria/anuria
 - Respiratory distress
 - Disseminated intravascular coagulation
 - Cardiac failure
 - Altered sensorium

- Treatment is directed toward correcting the hemodynamic derangements caused by the endotoxin.
- The woman is admitted to the ICU.
- IV access is established through a central vein; blood samples are collected for hemogram, culture, creatinine, electrolytes, LFTs, prothrombin time, and aPTT.
- The bladder is catheterized and urine sent for culture.
- Rapid infusion of IV normal saline 2–4 L to get the CVP up to 8–12 cm and to maintain a urine output of 30–50 mL/hour is mandatory.
- Oxygen is administered through venturi mask to achieve a saturation of >95% and PaO_2 of >65%. If this is unsuccessful, the patient may need to be intubated and ventilated.
- In patients in whom hypotension persists even after rapid IV fluid administration, pressor agents (dopamine, norepinephrine, dobutamine) may have to be considered.
- In patients with established acute renal failure, dialysis may be necessary till renal function improves.

Identification of organisms and antibiotic therapy

Appropriate antibiotic therapy is the mainstay of treatment of sepsis.

- Blood, urine, and pus are sent for culture. Pending culture reports, antibiotics are started

Table 45.2 Antibiotic therapy in septic shock

Infection	Antibiotic recommended
Initial therapy	
<i>Secondary level hospital</i>	
Gram negative infections	Ampicillin or augmentin & gentamicin IV
Anaerobes suspected	Add metronidazole or clindamycin
<i>Tertiary level hospital</i>	
ESBL gram-negative infections	Meropenem or aztreonam
Additional therapy	
<i>Surgical wound infections</i>	
Suspected staphylococcal infection	Cloxacillin
Suspected MRSA	Vancomycin/linezolid
Suspected Group A β -hemolytic streptococci	High dose Benzyl penicillin 20,00,000 units 24 hourly
<i>ectrotising fasciitis</i>	Add clindamycin
<i>Suspected clostridial myositis</i>	High dose benzyl penicillin and clindamycin/metronidazole

SB, extended spectrum beta lactamase; SA, methicillin-resistant *Staphylococcus aureus*.

against gram-negative, gram-positive, and anaerobic bacteriae.

- The choice of antibiotics is given in Table 45.2.

Identification of site of infection

Unless the site of infection is identified and the pus or infected tissue removed, it is not possible to eradicate the infection.

- Site of infection is identified by clinical examination, ultrasonography, computerized tomography, and/or magnetic resonance imaging when required.
- If the uterus is found to be gangrenous, an emergency hysterectomy may be lifesaving. Pelvic abscess should be drained by colpotomy. Laparotomy is indicated when there is intra-abdominal collection of pus.

Disseminated intravascular coagulation

Definition

Disseminated intravascular coagulation (DIC) is defined as activation of coagulation in the microcirculation by (a) entry of large amounts of tissue thromboplastin into the circulation or (b) widespread endothelial injury leading to

activation of the intrinsic pathway of coagulation and consumption of coagulation factors with a resultant bleeding diathesis.

Normal coagulation pathway

An outline of the normal coagulation and fibrinolysis cascades is shown in Figure 45.3.

Changes in normal pregnancy

Pregnancy is considered to be a compensated hypercoagulable state due to the changes that occur in the coagulation pathways. This explains the tendency for DIC in the face of additional insults in pregnancy. The physiological changes in pregnancy are as follows:

- Platelet counts marginally decrease, but platelet aggregation increases.
- There is an increase in fibrinogen and factors VII, VIII, IX, and X.
- Thrombin activation is enhanced.
- The fibrinolytic pathway as represented by plasmin activity is partly suppressed.

Causes of DIC in pregnancy

The most serious forms of DIC are still encountered in obstetric practice. It was in fact first recognized in placental abruption. The obstetric

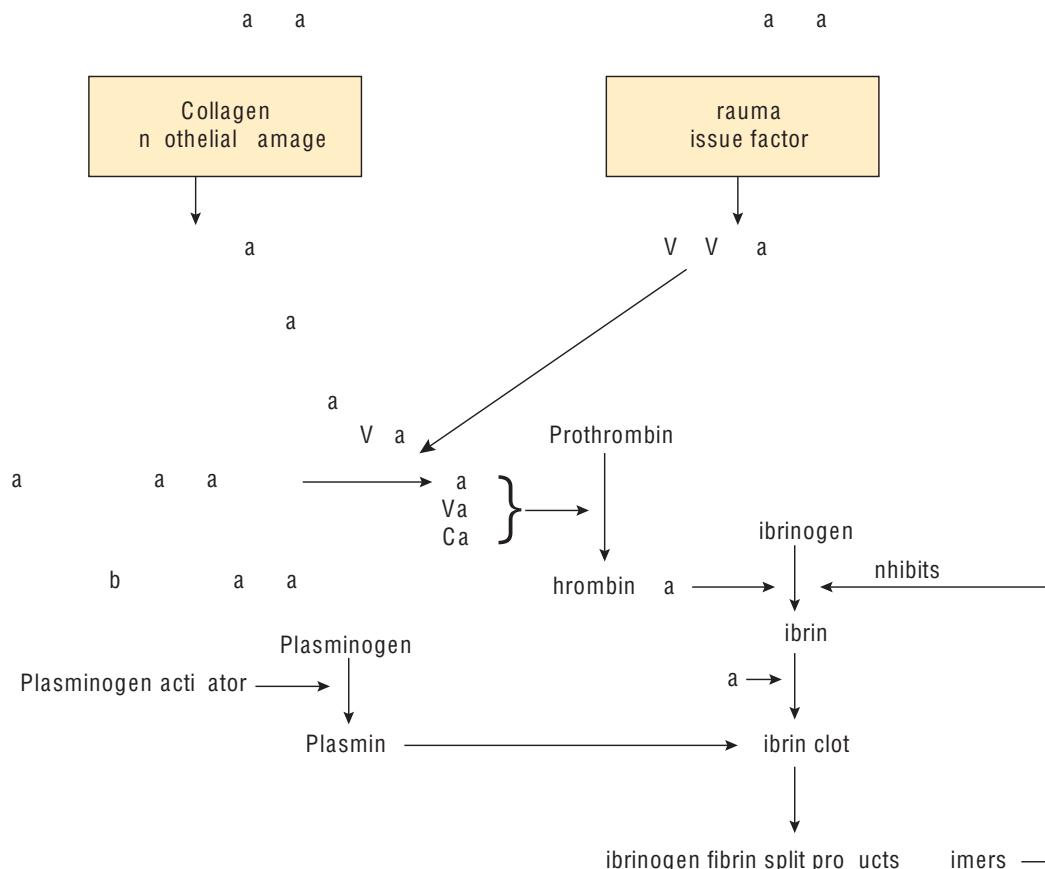


Figure 45.3 Normal coagulation and fibrinolytic pathways.

conditions where DIC is encountered and the pathogenesis are given in Box 45.6.

Complications

Disseminated intravascular coagulation adversely affects maternal and fetal outcome. With severe DIC there is a significant increase in maternal mortality. Perinatal mortality is 30% in the presence of severe DIC.

Clinical features

Clinical features include bleeding from various sites, symptoms due to clotting in microcirculation and end-organ failure, and CNS hypoxia. The clinical features of DIC are listed in Box 45.7.

Diagnosis

A diagnosis of DIC may be suspected clinically but must be confirmed by laboratory tests.

Box 45.6 Causes of disseminated intravascular coagulation and pathogenesis

- Placental abruption
 - Large amounts of thromboplastin at the site of abruption
- Amniotic fluid embolism
 - Fetal squames, fetal antigens
 - Anaphylactoid reaction
- Sepsis syndrome
 - Endotoxins and exotoxins
 - Systemic inflammatory response syndrome
 - Cytokine storm
 - Endothelial injury
- Eclampsia and HELLP syndrome
 - Endothelial injury
- Intrauterine death of the fetus
 - Release of thromboplastin from placenta
- Acute fatty liver of pregnancy
 - Endothelial injury
 - Decreased production of coagulation factors from liver

P, hemolysis, elevated liver enzyme levels, and low platelet levels.

Box 45.7 Clinical features of disseminated intravascular coagulation

- Bleeding from venipuncture sites
- Ecchymoses
- Oozing/bleeding from incisions/lacerations/placental site
 - Episiotomy
 - Cesarean section incisions
 - Profuse vaginal bleeding
- Hypotension and shock
- Symptoms due to clotting in microvasculature
 - Tissue hypoxia and lactic acidosis
 - Decreased urine output
 - Metabolic acidosis
 - Acidotic breathing
 - Hypoxia and tachypnea
 - Altered sensorium

- A history of predisposing obstetric events such as abruption, sepsis, or amniotic fluid embolism is usually present.
- Clinical features of bleeding, ecchymoses, or end-organ failure are sufficient to make a clinical diagnosis.
- Further evaluation by laboratory tests is aimed at confirming the diagnosis and assessing the severity of DIC (Box 45.8).
- Whole blood clotting time is markedly prolonged. A bedside test ('clot retraction test')

Box 45.8 Laboratory tests in disseminated intravascular coagulation

- Negative bedside clotting test
- Prolongation of
 - bleeding time
 - clotting time
 - prothrombin time
 - partial thromboplastin time
- Peripheral smear
 - Thrombocytopenia
 - Fragmented RBCs
- Decrease in
 - fibrinogen
- Increase in
 - fibrin split products (D-dimers)

BCs, red blood cells.

can be performed by collecting a blood sample in a plain tube and observing the time taken for the formation of a clot. In established DIC, the clot may not form for several hours and even if a clot is formed, it is soft and friable and does not retract.

- All bleeding parameters such as bleeding time, clotting time, prothrombin time, partial thromboplastin time, and thrombin time are prolonged.
- The peripheral smear shows thrombocytopenia and schistocytes (fragmented RBCs with abnormal shapes).
- Plasma fibrinogen is markedly decreased (hypofibrinogenemia). High levels of fibrinogen and fibrin split products (D-dimers) are present in the peripheral blood. These are due to secondary hyperfibrinolysis by the plasmin system. The fibrinogen/fibrin split products in turn inhibit formation of fibrin and cause a vicious cycle.

Management

Management of DIC consists of control of hemorrhage, replacement of blood and blood products, and treatment of the underlying cause.

- Supportive treatment with the appropriate blood products is crucial in controlling hemorrhage. Packed cells are used for correction of anemia, platelet concentrates for treating thrombocytopenia, and fresh frozen plasma or cryoprecipitate to replenish deficient factors.
- Recombinant factor VIIa can be used in uncontrollable bleeding, but its use may be associated with increased risk of stroke or pulmonary embolism. Therefore, it should be used with caution.
- Heparin (to prevent clotting) and epsilon-aminocaproic acid (to inhibit fibrinolysis) are not useful in the management of DIC.
- Concurrently, the underlying obstetric condition such as placental abruption, sepsis, or amniotic fluid embolism should be promptly managed.

Key points

- Apart from hemorrhage, the common emergencies in obstetrics that may lead to shock are amniotic fluid embolism, sepsis, and disseminated intravascular coagulation (DIC). These are associated with high maternal mortality.
- Amniotic fluid embolism is a rare condition that occurs in labor or within 4 hours of delivery.
- It occurs in conditions that cause opening up of the venous channels in the uterus and increase in intrauterine pressure. The risk factors are labor induction, precipitate labor, cervical lacerations, cesarean section, and instrumental delivery.
- The exact pathogenesis is not known. It is considered to be an idiosyncratic anaphylactoid reaction to the amniotic fluid that enters the circulation.
- The woman presents with sudden onset of respiratory symptoms, hypotension, hypoxia, pulmonary edema, left heart failure, and DIC.
- The diagnosis is mainly clinical. Chest X-ray may show pulmonary infiltrates.
- The management is supportive. The woman should be admitted to the ICU, hemodynamically stabilized with IV fluids, oxygen administered, intubated and ventilated if necessary, and DIC managed with blood and blood products.
- Septicemia and septic shock can occur following chorioamnionitis, puerperal sepsis and endometritis, post-abortal infection, pyelonephritis, or wound infection.
- The organisms are usually gram-negative bacilli and anaerobes. Infections by gram-positive organisms also occur.
- Following bacteremia, endotoxins are released into the circulation. These activate host cell inflammatory reaction, release of cytokines, and systemic inflammatory response syndrome.
- There is increased capillary permeability, exudation of fluid into lungs causing adult respiratory distress syndrome, hypotension, and hypoxia.
- Clinical diagnosis is by history of predisposing factors, fever, and chills followed by hypotension, tachycardia, tachypnea, oliguria or anuria, respiratory distress, and bleeding tendency due to DIC.
- Emergency supportive treatment should be initiated to correct hypotension, hypoxia, and metabolic problems. Antibiotic therapy should be started pending culture report. Organism causing sepsis must be identified by culture of blood, urine, or pus. The site of infection should be identified and pus /infected tissue removed surgically.
- Pregnancy is considered to be a hypercoagulable state due to the changes that take place in the coagulation system in normal pregnancy. DIC is a pathological disruption of the clotting mechanisms in pregnancy.
- Disseminated intravascular coagulation can occur whenever there is a risk factor such as placental abruption, amniotic fluid embolism syndrome, sepsis, preeclampsia, or acute fatty liver of pregnancy.
- The woman presents with bleeding and ecchymoses. Soon there is hypotension and shock. Reduced urine output, acidosis, and hypoxia ensue.
- The diagnosis of DIC is by a history of bleeding, hypotension, and end-organ failure. Bleeding parameters are deranged, platelet count is low, peripheral smear shows fragmented red blood cells. There is a marked decrease in serum fibrinogen levels and increase in fibrin split products (D-dimers).
- Management is by replacement of blood and blood products and treatment of the cause. Recombinant factor VIIa should be used with caution.

Self-Assessment

Case-based questions

Case 1

Mrs. AN, 32, was brought to the emergency room with shock, circulatory collapse, and altered sensorium. She had delivered 2 hours earlier after labor induction with vaginal misoprostol, supplemented by oxytocin, at a local hospital. After delivery she needed suturing of a cervical tear but did not have significant postpartum hemorrhage. On examination, she had cold and clammy extremities; her pulse was 120/min, BP 90/60 mm Hg, and respiratory rate 40/min.

1. What is the likely diagnosis? Why?
2. What differential diagnosis would you consider?
3. How will you confirm the diagnosis?
4. How will you manage this case?

Case 2

Mrs. PM, 28, who delivered vaginally at a primary center, was brought with high fever and altered sensorium. She was in labor for 26 hours, ruptured membranes 20 hours prior to delivery, and was examined internally by the local *dai* several times. Her pulse was 160/min on admission,

BP was 90/70 mm Hg, temperature was 102°F, and lochia malodorous.

1. What is the diagnosis?
2. What do you think caused this?
3. What is the initial management?
4. If a collection is found in the pouch of Douglas, how will you manage?

Answers

Case 1

1. Amniotic fluid embolism. (a) She had labor induced with misoprostol and augmented with oxytocin, both of which could have caused strong uterine contractions. (b) Shock occurred 2 hours after delivery. (c) There is no hemorrhage.
2. Cardiomyopathy, undiagnosed valvular disease, and uterine inversion.
3. Diagnosis is clinical, by history and clinical examination. Chest X-ray may reveal pulmonary infiltrates. Demonstration of fetal cells, debris, and hair in blood obtained by pulmonary catheterization is diagnostic but seldom performed.
4. Shift the patient to the ICU, start general supportive therapy to correct hypotension, administer oxygen, and intubate and ventilate if required. Correct DIC. Monitor BP, oxygen saturation, urine output, and ECG.

Case 2

1. Septicemia with septic shock.
2. Prolonged labor, prolonged rupture of membranes, multiple pelvic examinations, and failure to start antibiotics after membrane rupture for 18 hours.
3. Shift to ICU. General supportive therapy to correct hypotension; oxygen and intravenous fluids. Antibiotics to cover gram-negative, anaerobic, and gram-positive organisms. Culture blood and urine. Change antibiotics if necessary later. Correct DIC. Identify the site of infection.
4. This should be confirmed by ultrasonography. If there is no collection at any other intra-abdominal site, drainage of pus by colpotomy.

Sample questions

Long-answer question

1. Discuss the etiology, pathogenesis, and management of gram-negative septicemia and septic shock in pregnancy.

Short-answer questions

1. Amniotic fluid embolism
2. Systemic inflammatory response syndrome (SIRS)
3. Causes of DIC in pregnancy

46

Abnormalities of the Placenta, Umbilical Cord, and Fetal Membranes

Case scenario

Mrs. DS, 23, had an uncomplicated vaginal delivery. Six hours later, she started bleeding profusely in the postpartum ward. The bleeding was accompanied by painful uterine cramping. She was rushed back to the operating theater to investigate the cause for bleeding. Exploration of the uterus revealed the presence of a retained cotyledon of placenta.

Introduction

The placental unit is made up of the parenchyma, umbilical cord, and membranes (chorion and amnion). Primary placental abnormalities can have an impact on both maternal and fetal health. Conversely, maternal or fetal disorders may have an effect on the placenta, since this is the crucial maternal-fetal interface.

Examination of the placenta directly after birth can yield invaluable information for the immediate and later management of mother and infant. The examination of normal

placentas and the majority of abnormal placentas can be accomplished within a minute or so. It is essential that the obstetrician performs a thorough, accurate examination of the placenta. Universal examination of the placenta in the delivery room, with documentation of findings, is good clinical practice. In the presence of abnormal appearance or certain clinical conditions, the placenta can be sent for pathological evaluation.

Placental implantation, development, and anatomy are presented in Chapter 5, *Placenta, fetal membranes, and amniotic fluid*.

Advantages of examining the placenta

Examination of the placenta may yield information in several conditions (Box 46.1).

Box 46.1 Conditions in which placental examination is important

- Maternal disorders with an impact on the fetus
- Preterm birth
- Fetal growth restriction
- Stillbirth or neonatal death
- Neonatal neurodevelopmental impairment
- Zygosity and pathology (e.g., twin-to-twin transfusion) in multifetal gestation
- Potentially recurrent disorders

Clinical characteristics of the normal placenta at term

The normal placenta can be rapidly examined and assessed at delivery (Fig. 46.1). The placenta must be kept on a flat surface and examined. The findings to be systematically noted and documented are listed in Box 46.2.

The umbilical cord is examined along with the placenta. The findings should be documented (Box 46.3).

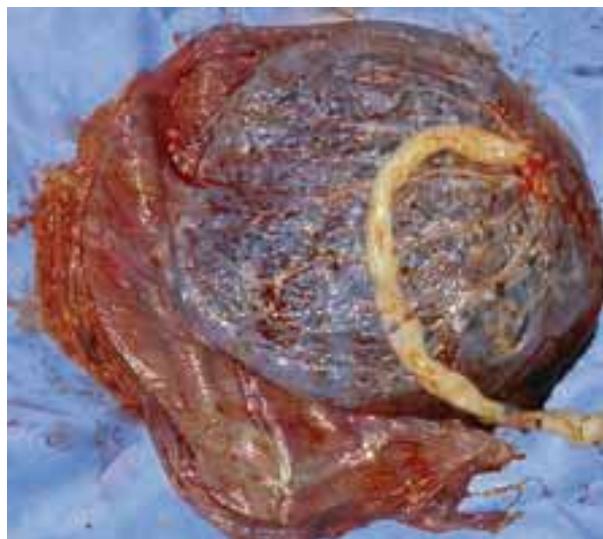


Figure 46.1 The normal placenta. The fetal surface is seen, with the umbilical cord and the shiny fetal membranes.

Box 46.2 Normal findings to be systematically noted and documented in the term placenta

- Shape of the placenta
 - Round or oval
- Size of the term placenta
 - Diameter: 15–25 cm
 - Weight: 500–600 g
 - Thickness: 3 cm
- Maternal surface
 - Color: Dark maroon
 - Appearance: Distinct cotyledons
 - Structure: Complete, with no missing cotyledons
- Fetal surface
 - Shiny and gray
 - Membranes translucent
 - Color of the underlying maroon villous tissue seen

Box 46.3 Umbilical cord: Normal findings

- Length: 55–60 cm
 - Best assessed at delivery
- Diameter: 2.0–2.5 cm
- Wharton's jelly: Abundant
- No true knots or thromboses
- 2 arteries and 1 vein
 - Best assessed in the middle third or the fetal third of the cord

Abnormalities of the placenta

Placental abnormalities may be anatomical or the result of maternal or fetal pathology. Abnormalities of the placenta could include variations in the following:

- Size/weight
- Shape
- Implantation
- Maternal surface and substance
- Mass lesions

Abnormalities of size/weight

The placental weight is usually one-sixth or one-seventh of the infant's weight and is 500–600 g at term. Maternal and fetal conditions have an effect on the placental weight (Box 46.4).

Box 46.4 Effect of maternal and fetal factors on placenta

Large placenta

- High placental weight or >4 cm thick
- Associated with
 - maternal diabetes mellitus
 - fetal or maternal anemia
 - fetal hydrops
 - congenital syphilis

Small placenta

- Low placental weight or <2.5 cm thick
- Associated with
 - preeclampsia
 - fetal growth restriction
 - some aneuploidies (not trisomy 21)
 - infection

Abnormalities of shape

Bilobed or duplex placenta

Bilobed or duplex placenta (Fig. 46.2) refers to complete separation of the placenta into two lobes with separate umbilical arteries and veins that unite in a single umbilical cord.

Bi-lobed and tri-lobed placentas

Other variants are **bidiscoidal** and **tridiscoidal placentas**, which do not have as complete a separation between lobes as the bilobed placenta. The incomplete parenchymal separation typically occurs in the area of the cord insertion site.



Figure 46.2 Bilobed placenta. Complete separation of the placenta into two lobes is seen with separate umbilical arteries and veins that unite in a single umbilical cord (arrow). (Photo courtesy: Mediscan Systems, Chennai.)

Fenestrated placenta

A rare variant is **fenestrated placenta**, which is the absence of the central portion of a discoidal placenta.

Succenturiate placenta

Succenturiate placenta (Fig. 46.3) is a smaller version of the bilobed placenta. An additional lobe (or lobes) of placental tissue is located on the fetal membranes, a few centimeters away from the main disc of the placenta. A placental artery and vein extend from and within the membrane of the main placental mass to each lobe and then divide into smaller vessels supplying individual cotyledons. The ancillary lobes function normally.

The lobe (or lobes) may be expelled in the third stage along with the main placental mass or may be retained. When the succenturiate lobe is retained in the uterus, examination of the placenta may reveal a circular defect in the membranes. Torn ends of the vessels are seen leading up to the defect. Retention of the succenturiate lobe may go unnoticed and leads to secondary postpartum hemorrhage and sepsis.

The complications associated with a succenturiate lobe are listed in Box 46.5.



Figure 46.3 Placenta succenturiata. An additional lobe of placental tissue is located a few centimeters away from the main disc of the placenta (arrow). (Photo courtesy: Mediscan Systems, Chennai.)

Box 46.5 Complications of succenturiate lobe

- Placenta previa or vasa previa
- Retained succenturiate lobe resulting in
 - delayed postpartum hemorrhage
 - delayed infection

lacenta membranacea

Placenta membranacea is a rare type of placenta in which all or part of the fetal membranes is covered by functional placental tissue. These placentas are often deeply implanted and associated with placenta previa or accreta. They may require manual removal. They are associated with a slightly increased risk of

- second trimester miscarriage
- preterm birth
- antepartum and postpartum bleeding

Circumvallate placenta

Circumvallate placenta refers to a placenta where the fetal surface presents a central depression surrounded by a thickened whitish-gray ring. The ring is formed by a double layer of amnion and chorion. This ring may be at a variable distance from the umbilical cord insertion site and the fetal vessels do not extend beyond this ring. These placentas are associated with the complications listed in Box 46.6.

Circummarginate placenta

The ring of membranes is flat and near the edge of the placenta with no central depression. It is not associated with adverse outcomes.

Abnormalities of implantation

lacenta accreta increta an percreta

In these serious abnormalities, trophoblastic tissues invade the myometrium to varying depths. They can cause torrential bleeding. This is discussed in greater detail in Chapter 43, *Complications of the third stage of labor*.

Box 46.6 Complications associated with circumvallate placenta

- Second trimester bleeding
- Abruptio
- Preterm delivery
- Congenital malformations
- Perinatal mortality

Abnormalities of the maternal placental surface and substance

In arcts

Fresh infarcts are dark red, while older infarcts are gray. Infarcts occupying <5% of the placental mass are not clinically important. Larger infarcted areas are associated with the following:

- Fetal growth restriction
- Stillbirth
- Neurological sequelae

fibrin deposition

Firm gray areas may represent fibrin deposition that has no clinical significance unless extensive. Extensive fibrin deposition is seen in pregnancies complicated by antiphospholipid antibody syndrome. It may be associated with placental insufficiency leading to

- fetal growth restriction and
- poor fetal outcome.

A deep yellow band of fibrin deposition along the maternal floor is suspicious for a *maternal floor infarction*, a lesion that carries significant morbidity and recurrence risk.

Calcification

Calcification may be seen as whitish speckling over the maternal surface of the placenta. It can be palpated as diffuse particulate roughness or discrete hard patches over the basal surface of the cotyledons. It is a normal part of placental maturation in the third trimester and is known to occur earlier in smokers. **Placental calcification in the second trimester** is an abnormal finding and is associated with fetal growth restriction or fetal distress.

The significance of placental calcification is listed in Box 46.7.

Box 46.7 Significance of placental calcification

- Normal part of placental maturation
- Occurs earlier in smokers
- Abnormal finding in second trimester
 - Associated with
 - fetal growth restriction
 - fetal distress in labor

Mass lesions

Mass lesions may consist of infarcts, thrombi, cysts, tumors, or abscesses. These are abnormal and should be examined histologically.

Chorioangiomas are focal fleshy, dark red areas in the placental parenchyma. These benign hemangiomas occur in 1% of placentas. Small chorioangiomas are usually of no clinical significance. However, large chorioangiomas are associated with fetal anemia, thrombocytopenia, hydrops, hydramnios, fetal growth restriction, prematurity, and stillbirth.

Pale appearing placenta

Severe fetal anemia may cause the placenta to appear pale. There may be associated hydrops of the placenta.

Abnormalities of the umbilical cord

Abnormalities of the umbilical cord may be benign, with no associated fetal complications. However, when umbilical vessels are involved, adverse fetal effects could result. Abnormalities of the cord could include variations in the following:

- Length
- Coiling
- Edema
- Cord insertion
- Knots
- Vessels

Abnormal length

The length of the umbilical cord reflects the tension placed on the cord by fetal movements. More active the fetus, the longer is the cord. Conversely, an inactive fetus will have a short cord. The normal cord is between 50 cm and 60 cm long.

A **long umbilical cord** is diagnosed when the length is >70 cm.

The complications associated with a long umbilical cord are enumerated in Box 46.8.

A **short umbilical cord** (<40 cm) results from fetal inactivity (Box 46.9).

Coiling

The blood vessels in the umbilical cord characteristically twist or coil around the central axis

Box 46.8 Complications associated with long umbilical cord

- Cord accidents
 - Entanglement
 - Knotting
 - Cord prolapse
- Fetal growth restriction
- Fetal death
- Long-term adverse neurological outcome

Box 46.9 Complications associated with short umbilical cord

- Associated with fetal inactivity related to
 - fetal malformations
 - myopathic and neuropathic diseases
 - oligohydramnios



Figure 46.4 Umbilical cord. The coiling of the blood vessels in the umbilical cord is seen.

(Fig. 46.4). The normal umbilical cord coil index is one coil per 3–5 cm. Coiling of the umbilical cord is thought to protect it from compression, kinking, and torsion, thus preventing disruption of the blood supply to the fetus.

The umbilical coiling index (UCI) is the number of coils divided by the total cord length. Hypocoiling is defined as UCI values less than the 10th percentile. Hypercoiling is defined as UCI values greater than the 90th percentile. Both hypo-coiling and hypercoiling of the umbilical cord are associated with abnormalities (Box 46.10).

Box 46.10 Abnormalities associated with hypocoiling and hypercoiling of the umbilical cord

hypocoiling

- Congenital anomalies
- Growth restriction
- Fetal heart rate abnormalities
- Preterm birth
- Hypertensive disorders
- Abruptio placentae
- Oligohydramnios
- Intrauterine death

hypercoiling

- Diabetes mellitus
- Polyhydramnios
- Cesarean delivery
- Congenital anomalies
- Respiratory distress of the newborn

Edema of the cord

Mild edema of the cord can be present but is of no clinical significance. Massive edema (resulting in regional or diffuse cord diameters of >3 cm) can cause vascular compromise and is often associated with acute changes in the fetal heart rate pattern. Areas of massive edema can be seen in trisomy 18 and omphalocele. Diffuse edema can be associated with hemolytic disease of the newborn, maternal hypertensive disorders, or diabetes.

Stricture

A stricture may be an artifact or the result of torsion or amniotic bands. Strictures have been implicated in the etiology of fetal compromise or demise.

Placental insertion

The umbilical cord normally inserts centrally or slightly eccentrically and directly into the placental disc. Approximately 90% of cord insertions are central or eccentric. Abnormalities of umbilical cord insertion are more common in pregnancies resulting from in vitro fertilization and in multiple gestations.

attle ore placenta

In the battledore placenta, the insertion occurs at the margin of the placenta (Fig. 46.5) (Battledore is an older form of shuttlecock and the battledore



Figure 46.5 Battledore placenta. The umbilical cord is inserted into the margin of the placenta.

placenta resembles the bat used in the game). Marginal insertions are benign.

elamentous cor insertion

A velamentous cord inserts into the membranes rather than the placental disc. Since the velamentous vessels are surrounded only by fetal membranes, with no Wharton's jelly, they are prone to compression or tearing. Velamentous vessels can also occur between lobes of a bilobed placenta. When the vessels lie over the internal os, they are called **vasa previa** and can be associated with torrential bleeding in labor.

Velamentous umbilical cord has been associated with several obstetric complications, including fetal growth restriction, prematurity, congenital anomalies, and low Apgar score.

Cord knots

alse nots

False knots are tortuosity of the umbilical vessels that bulge out from the side of the cord (Fig. 46.6). They are not associated with any adverse outcome.

rue nots

True knots occur in 1% of births (Fig. 46.7). They are associated with a 10% perinatal mortality



Figure 46.6 False knot in cord. Tortuosity of the umbilical vessels are seen bulging from the cord.



Figure 46.7 True knot in cord.

rate. A true cord knot occurs when the fetus passes through a loop of umbilical cord, usually early in pregnancy. In most cases, a knot does not cause fetal compromise. However, when tension is placed on the cord before or during labor and delivery, blood flow may be compromised and result in fetal asphyxia and intrauterine fetal demise.

Cord vessels

As soon as the cord is cut, the blood vessels in the cord must be examined and the number should be documented. The normal cord contains one large, thin-walled umbilical vein and two smaller, thick-walled umbilical arteries (Fig. 46.8).

Significance of single umbilical artery

The presence of a single umbilical artery (SUA) carries significant clinical connotations (Box 46.11).



Figure 46.8 Cut section of the umbilical cord. One large, thin-walled umbilical vein (white arrow) and two smaller, thick-walled umbilical arteries (yellow arrows) are seen.

Box 46.11 Significance of single umbilical artery (SUA)

- May result from one of the following
 - Primary agenesis of one of the umbilical arteries
 - Secondary atresia or atrophy of a previously normal umbilical artery
 - Persistence of the original single allantoic artery of the body stalk
- Associated with anomalies, particularly
 - genitourinary
 - cardiac
 - gastrointestinal
- When not associated with anomalies
 - Good outcome
- The outcome of SUA with associated anomalies or aneuploidy depends on the underlying chromosomal and structural abnormalities
 - Fetal karyotype analysis should be offered when fetal anomalies are detected

Thrombosis

Thrombosis of cord vessels is abnormal and should be investigated. Possible causes include the following:

- Cord compression from a true knot
- Cord prolapse, or head compression
- Marginal or membranous cord insertion
- Fetal hypercoagulable state (e.g., sepsis, hereditary thrombophilia)
- Maternal diabetes mellitus

Umbilical cord cysts

Umbilical cord cysts may occur anywhere along the length of the cord. They arise from embryonic remnants of the vitelline duct and urachus. First trimester umbilical cord cysts noted on ultrasound are often transient and have no clinical significance. Persistent cysts have been associated with a variety of fetal anomalies (particularly patent urachus and omphalocele), but the prevalence rate of these cysts is not documented.



Figure 46.10 Meconium-stained placenta and umbilical cord. This can be seen in postterm babies and after intrauterine fetal hypoxia.

Abnormalities of the fetal membranes

Healthy fetal membranes are translucent (Fig. 46.9), slightly gray, and glistening. They do not contain blood vessels or nerves. The elastic properties and built-in tensile strength of fetal membranes allow them to stretch and accommodate the growing fetus and amniotic fluid.

Meconium staining

The fetus passes meconium in many situations. In postterm fetuses, meconium passage may be normal. However, meconium is also passed in the presence of fetal hypoxia and acidosis. Meconium stains the fetal membranes green (Fig. 46.10).

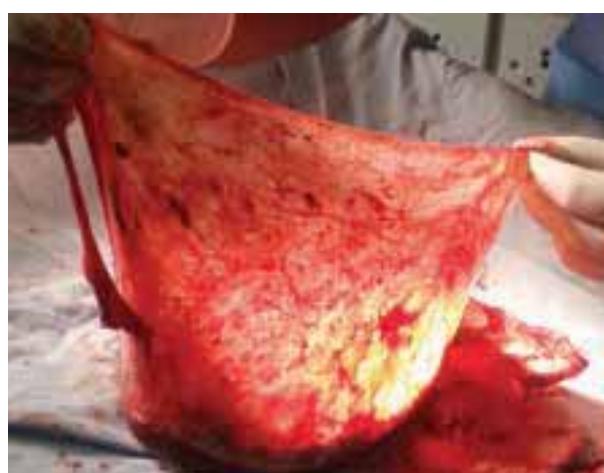


Figure 46.9 A healthy fetal membrane.

Opaque membranes

Mild chorioamnionitis turns the membranes opaque and dull. In more severe infections, there may be a yellow discoloration of the membranes accompanied by a foul odor.

Amnion nodosum

Multiple tiny white, gray, or yellow nodules may be seen on the amnion overlying the placenta. These are called amnion nodosum. They are associated with prolonged oligohydramnios.

Amniotic bands

When there is disruption of the amnion, delicate or robust bands of amnion form between the amnion and the fetus. These may entrap fetal parts and may lead to amputation and deformities.

Ultrasound examination of the placenta

Ultrasound examination of the placenta is just as important as the examination of the fetus. Examining the placenta presents a unique opportunity to detect problems that will significantly affect perinatal outcome. Most of the

abnormalities described above can be identified by ultrasound. 2D imaging provides excellent information about the location and architecture of the placenta. 3D Doppler imaging of the placenta is promising to be a detailed method for examining uteroplacental structure and function.

Pathological examination of the placenta

Pathological examination of the placenta is indicated when any abnormality of potential clinical significance is identified. Indications for pathological examination are listed in Box 46.12.

Box 46.12 Indications for pathological examination of placenta

- Poor pregnancy outcome
 - Prematurity
 - Fetal growth restriction
 - Perinatal death and asphyxia
- Maternal disorders
 - Third trimester bleeding
 - Evidence of fetal or maternal infection
- Multiple pregnancy
 - Zygosity
 - Vascular anastomoses

Key points

- The placental unit is made up of the parenchyma, umbilical cord, and fetal membranes (chorion and amnion).
- Universal examination of the placenta in the delivery room, with documentation of findings, is good clinical practice.
- Placental examination is an essential component of the autopsy in cases of stillbirth or neonatal death.
- The placental weight is usually one-sixth or one-seventh of the infant's weight. Heavier placentas will be thicker and lighter placentas will be thinner due to the effects on placental development.
- Bilobed or duplex placenta refers to complete separation of the placenta into two lobes with separate umbilical arteries and veins that unite in a single umbilical cord.

Storing the fresh placenta

In some clinical situations examination of the fresh placenta will yield valuable information. The indications include the following:

- Evaluation of placental surface changes
- Palpation for solid lesions
- Cultures
- Cytogenetic studies
- Injection of twin placentas to detect anastomoses

Fresh placentas should be refrigerated (not frozen) at 4°C and may be stored this way for 3–7 days.

Fixing the placenta

When the placenta and umbilical cord need to undergo histopathological examination, they should be fixed in 10% formalin. A plastic container with a lid is ideal to hold the placenta. The formalin should completely cover the placenta and cord.

The pathologist should be given a clear picture of the clinical situation for which the placenta is being examined.

In the case of a poor obstetric outcome, having a routine standard gross and histological evaluation of the placenta is extremely helpful to the clinician in counseling the family for a future pregnancy.

- In a succenturiate placenta, an additional lobe (or lobes) of placental tissue is located a few centimeters away. It may be associated with vasa previa or postpartum hemorrhage and infection.
- Circumvallate placenta is associated with second trimester bleeding, abruption, preterm delivery, and perinatal mortality.
- Placenta accreta, increta, and percreta are abnormalities of implantation.
- Examination of the surface of the placenta may reveal fibrin deposition, calcification, and mass lesions.
- The umbilical cord is usually 50–60 cm in length. Both long and short cords are associated with perinatal morbidity and mortality.

(Continued)

Key points *Continued*

- Abnormalities of umbilical cord insertion include battledore placenta and velamentous cord insertion.
- True knots occur in 1% of births and are associated with a 10% perinatal mortality rate.
- A single umbilical artery may be associated with other anomalies and/or aneuploidy.
- Abnormalities of the fetal membranes may include meconium staining, opacity due to infection, amnion nodosum, and amniotic bands.
- Pathological examination of the placenta is indicated when any abnormality of potential clinical significance is identified.

Self-Assessment

Case-based questions

Case

Mrs. DS, 23, had an uncomplicated vaginal delivery. Six hours later, she started bleeding profusely in the post-partum ward. The bleeding was accompanied by painful uterine cramping. She was rushed back to the operating theater to investigate the cause for bleeding. Exploration of the uterus revealed the presence of a retained cotyledon of placenta.

1. What would be the commonest cause for the retained cotyledon of placenta?
2. What other complication can arise in this situation?
3. What is velamentous insertion of the cord? What complication is it associated with?
4. What is the significance of single umbilical artery?

Answers

1. In a succenturiate placenta, an additional lobe (or lobes) of placental tissue is located a few centimeters away from the placental disc. In this case, the succenturiate lobe would have been left behind.

2. A succenturiate cotyledon left behind in the uterus may also be associated with delayed infection.
3. A velamentous cord inserts into the membranes rather than the placental disc. When the vessels lie over the internal os, they are called **vasa previa** and can be associated with torrential bleeding in labor.
4. A single umbilical artery may be associated with gastrointestinal, genitourinary, and cardiac anomalies and/or aneuploidy.

Sample questions

Long-answer question

1. Describe the examination of the placenta at birth. What are the common indications for a pathological examination of the placenta?

Short-answer questions

1. Succenturiate placenta
2. False and true knots of the umbilical cord
3. Velamentous cord insertion
4. Battledore placenta

Section 7

Maternal Diseases Complicating Pregnancy

47

Hypertensive Disorders

Case scenario

Mrs. MN, 23, primigravida, presented at 34 weeks' pregnancy with elevated blood pressure. She had regular antenatal care at the local primary health center from the third month of pregnancy. She was told that her blood pressure was high at 29 weeks' pregnancy and was started on medication; however, during her subsequent checkup at 31 and 33 weeks, her blood pressure continued to be high and the baby was not growing as expected. She was referred for further management to a tertiary center.

Introduction

Hypertensive disorders of pregnancy are commonly encountered and are major causes of perinatal mortality, morbidity, and maternal complications. Preeclampsia/eclampsia is one of the leading causes of maternal death. In the past decade, there have been major advances in the understanding of pathophysiology of these disorders and based on these, new guidelines for management have evolved. A thorough knowledge of the guidelines is essential for early diagnosis and appropriate treatment of the condition.

Definition

Hypertension in pregnancy is defined as a systolic blood pressure (BP) ≥ 140 mm Hg and/or diastolic BP ≥ 90 mm Hg (Korotkoff 5), the measurements confirmed by two or more readings 4–6 hours apart. If Korotkoff 5 is absent, muffling or Korotkoff 4 may be accepted.

A rise in systolic BP of 30 mm Hg or diastolic BP of 15 mm Hg above the midpregnancy BP is no longer used as a criterion for diagnosis of hypertension in pregnancy.

Classification

The American College of Obstetricians and Gynecologists (ACOG) has classified hypertension in pregnancy as given in Box 47.1.

Gestational hypertension

When hypertension (BP: 140/90 mm Hg or more) develops for the first time after 20 weeks' gestation, documented on two occasions at least 4 hours apart in a previously normotensive woman, and there is no proteinuria, it is called gestational hypertension. The clinical course may be any of the following:

- 15%–25% of women develop proteinuria and preeclampsia syndrome.
- 5% of women develop eclampsia even before proteinuria sets in.
- In others, preeclampsia does not develop, and the hypertension resolves within 12 weeks after delivery—reclassified as transient hypertension.
- Hypertension may persist 12 weeks after delivery in a small group of women—reclassified as chronic hypertension.

When gestational hypertension develops late in the third trimester (after 36 weeks), the prognosis is good and progression to preeclampsia is uncommon. When it develops early, progression to preeclampsia is more likely.

Gestational hypertension may be nonsevere (BP 140/90–160/110 mm Hg) or severe (BP \geq 160/110 mm Hg). Severe gestational hypertension is associated with higher perinatal morbidity and mortality (Box 47.2).

Box 47.1 ACOG classification of hypertension in pregnancy

- Gestational hypertension
- Preeclampsia and eclampsia syndrome
- Chronic hypertension
- Preeclampsia superimposed on chronic hypertension

Box 47.2 Gestational hypertension

- Features
 - BP \geq 140/90 mm Hg, checked 4 hours apart
 - Develops after 20 weeks
 - No proteinuria
 - Resolves by 12 weeks postpartum
- Can be
 - Nonsevere (BP: 140/90–160/110 mm Hg)
 - Severe (BP \geq 160/110 mm Hg)
- Clinical course
 - Preeclampsia in 15%–25%
 - Eclampsia in 5%
 - Chronic hypertension in a small number
 - Return to normal by 12 weeks postpartum in the rest
- Prognosis
 - Good
 - When hypertension develops after 36 weeks
 - Nonsevere hypertension

The risk factors, pathogenesis, and pathophysiology of gestational hypertension are not clearly defined and are poorly understood. The pathologic changes in the organ systems that occur with preeclampsia are not seen in gestational hypertension and the maternal and fetal complications are also uncommon.

Preeclampsia syndrome

Preeclampsia syndrome is a new-onset hypertension (\geq 140/90 mm Hg) that develops after 20 weeks' gestation with proteinuria with or without evidence of multiorgan involvement.

Proteinuria is defined as

- 300 mg or more in 24-hour urine sample (or)
- spot urinary protein : creatinine ratio of \geq 0.3 (or)
- 30 mg/dL protein or 1+ dipstick in single random urine sample if the other two are not available.

Estimation of proteinuria by dipstick is not a sensitive method and has high false-positives and false-negatives but is often used when rapid detection is required. A 24-hour urine collection is cumbersome. Urine protein : creatinine ratio

is currently preferred and correlates well with 24-hour urine protein.

Even in the absence of proteinuria, evidence of multiorgan involvement such as headache, visual disturbances, epigastric pain, thrombocytopenia, or elevated liver enzymes along with gestational hypertension is considered preeclampsia (Box 47.3).

Classification of preeclampsia

Preeclampsia is classified into nonsevere and severe based on the criteria listed in Box 47.4 (ACOG Task Force on Hypertension in Pregnancy, 2013).

Nonsevere preeclampsia

The nonsevere category includes what was earlier called mild and moderate. The BP is $>140/90$ mm Hg but $<160/110$ mm Hg, confirmed by repeated examination 4 hours apart. Proteinuria is usually present.

Severe preeclampsia

When BP is $\geq160/110$ mm Hg, it is categorized as severe preeclampsia.

- It is recommended that BP $\geq 160/110$ mm Hg be confirmed by repeat examination 4 hours later but can be confirmed within a shorter interval to facilitate initiation of treatment.

Box 47.3 Preeclampsia syndrome

- New-onset hypertension
- Develops after 20 weeks
- With proteinuria
- In the absence of proteinuria
 - Evidence of multiorgan involvement
- Classified into
 - Nonsevere
 - Severe

- The signs and symptoms of severe preeclampsia are manifestations of multiorgan involvement. These are listed in Table 47.1.
- Serum creatinine of ≥ 1.1 mg/dL or a doubling of serum creatinine in the absence of preexisting renal disease is used as a sign of renal involvement instead of oliguria that was used earlier.
- Nonsevere preeclampsia can progress rapidly to severe preeclampsia.**

Criteria or diagnosis of severe preeclampsia

The clinical and laboratory features listed in Table 47.1 are usually present in most women with severe preeclampsia. However, some features are characteristic of the disease and are considered as criteria for diagnosis of severe preeclampsia (Box 47.4).

- Proteinuria of >5 g/24 hours (3+ or more in random sample) was considered an important indicator in the past but has been excluded now since there is minimal relationship between severity of proteinuria and perinatal outcome.
- Similarly, fetal growth restriction has also been eliminated since management of growth restriction does not depend on the severity of preeclampsia.

Imminent eclampsia

In women with persistent symptoms of severe preeclampsia such as headache, visual disturbances,

Box 47.4 Criteria for severe preeclampsia

- Blood pressure $\geq 160/110$ mm Hg
- Headache and visual disturbances
- Upper abdominal (epigastric) pain
- Thrombocytopenia ($<100,000/\mu\text{L}$)
- Elevated liver enzymes
- Serum creatinine >1.1 mg/dL
- Pulmonary edema

Table 47.1 Causation of clinical/laboratory features of severe preeclampsia

Causation	Clinical/laboratory features
Cerebral edema	Headache
Changes in the optic fundus	Visual disturbances
Liver ischemia	Epigastric pain, elevated liver enzymes
Renal involvement	Proteinuria, elevated serum creatinine
Left ventricular failure	Pulmonary edema
Platelet aggregation and activation; Microangiopathic hemolysis	Thrombocytopenia
Uteroplacental insufficiency	Fetal growth restriction

epigastric pain, and high BP, the term imminent eclampsia was formerly used. However, eclampsia can occur without such symptoms or acute rise in BP; hence, currently it is classified as severe preeclampsia and the term “imminent eclampsia” is not used any more.

Eclampsia

Occurrence of convulsions in a woman with preeclampsia is termed eclampsia. Seizures in the second half of pregnancy and up to 48 hours postpartum, not attributable to any other cause, are always considered to be eclampsia. Seizures may occur antepartum, intrapartum, or within 48 hours after delivery. Rarely, they may occur beyond 48 hours postpartum. Eclampsia is discussed in detail later in this chapter.

Chronic hypertension

Chronic hypertension is defined as hypertension ($\geq 140/90$ mm Hg) detected before 20 weeks' pregnancy or that continues beyond 12 weeks postpartum. Hypertension may be primary or secondary to renal or vascular disease (Box 47.5).

BP usually decreases during the second trimester. A woman with chronic hypertension may have normal BP during this period and the BP may rise to prepregnant levels in the third trimester. This can be misdiagnosed as new-onset hypertension if the woman has not been seen early in pregnancy. Preexisting end-organ damage and other systemic signs may, sometimes, help to differentiate between the two.

Preeclampsia superimposed on chronic hypertension

When there is worsening of preexisting hypertension, new-onset proteinuria, or worsening

Box 47.5 Chronic hypertension

- Hypertension before 20 weeks' pregnancy
- Continues beyond 12 weeks postpartum
- May be
 - Primary
 - Secondary
- Chronic versus gestational hypertension
 - Time of onset
 - Evidence of end-organ damage

of proteinuria in a woman with chronic hypertension, it is termed superimposed preeclampsia. Other signs and symptoms of multiorgan involvement may also be present. Superimposed preeclampsia develops at an earlier gestational age, is more severe, and is associated with higher perinatal loss and fetal growth restriction than preeclampsia that develops in a previously normotensive woman (Box 47.6).

Other hypertensive disorders

Other uncommon types of hypertensive disorders are described in the following subsections.

Atypical preeclampsia

Preeclampsia or eclampsia that develops in a woman in the absence of either hypertension or proteinuria is termed atypical preeclampsia. Gestational hypertension or proteinuria may be present with evidence of multiorgan involvement such as headache, epigastric pain, thrombocytopenia or elevated liver enzymes.

Delta hypertension

Rise in BP in the third trimester but not equal to or beyond the cutoff value of 140/90 mm Hg is called delta hypertension. These women may develop eclampsia or hemolysis, elevated liver enzyme levels, and low platelet levels (HELLP) syndrome and need close monitoring.

Capillary leak syndrome

Gross pedal edema, ascites, pulmonary edema, and proteinuria may develop without associated

Box 47.6 Preeclampsia superimposed on chronic hypertension

- Worsening of hypertension
- New-onset proteinuria
- Worsening of proteinuria
- Features of multiorgan involvement
- Compared with preeclampsia
 - Occurs earlier in gestation (<20 weeks)
 - Hypertension more severe
 - Higher perinatal morbidity and mortality
 - Greater fetal growth restriction

hypertension. This is called capillary leak syndrome. Thrombocytopenia, abnormal liver enzymes, clinical symptoms, and eclampsia may develop later.

Incidence of hypertensive disorders

Incidence of hypertensive disorders varies widely with population and ethnicity. Hypertensive disorders occur in approximately 2%–5% of all pregnancies in the developed world and in approximately 10% of pregnancies in India. Incidence of eclampsia is 1% of all pregnancies in India, but the incidence is much lower in developed countries.

Risk factors for preeclampsia

Risk factors for gestational hypertension are not clearly defined; however, several risk factors have been identified for preeclampsia.

Age is an important risk factor for preeclampsia and is most common in primiparous, young women. Chronic hypertension is seen more often in older women (>35 years). Obesity, diabetes, multiple pregnancy, preexisting medical conditions, and past history of preeclampsia are other risk factors as listed in Box 47.7.

Pathophysiology of preeclampsia

The pathophysiology of gestational hypertension is unknown. Several theories have been proposed for the pathogenesis of preeclampsia syndrome. It involves maternal and fetoplacental factors. The currently accepted plausible mechanisms include the following:

- Abnormal trophoblastic invasion
- Placental underperfusion/hypoxia
- Release of placental factors into maternal circulation
- Maternal vascular endothelial dysfunction and inflammation
- Immunological factors
- Genetic factors

Box 47.7 Risk factors for preeclampsia

- Primiparity
- Age <18 years
- Advanced maternal age (>35 years)
- High body mass index (>35 kg/m²)
- Multiple pregnancy
- Hydatidiform mole
- Rh isoimmunization
- Maternal medical problems
 - Diabetes
 - Hypertension
 - Renal disease
 - Connective tissue disorders
 - Antiphospholipid antibody syndrome
- Past history of preeclampsia
- Family history of preeclampsia
- Race
- Low socioeconomic status
- Environmental factors

Abnormal trophoblastic invasion

Delivery of placenta leads to rapid resolution of all the features of preeclampsia. This observation indicates that placenta plays a critical role in the development of preeclampsia.

In normal pregnancy, the endovascularcytotrophoblasts penetrate the endothelium and muscle layer of the walls of spiral arterioles and convert them into low-resistance vascular channels (see Chapter 5, *Placenta, fetal membranes, and amniotic fluid*). This trophoblastic invasion takes place in the following two stages:

- *Stage 1*: Invasion of the decidual segment of the spiral arterioles at 10–12 weeks
- *Stage 2*: Invasion of the myometrial segment of the spiral arterioles at 16–18 weeks

Although the first stage proceeds normally, the second stage of invasion (penetration of the myometrial segment) does not occur in preeclampsia (Fig. 47.1). This failure of trophoblastic invasion is due to defective differentiation of trophoblast. The arterioles continue to remain as narrow vessels.

Placental hypoperfusion and hypoxia

Failure of trophoblastic invasion and vasodilation result in placental hypoperfusion. Similarly, other medical conditions associated with reduced

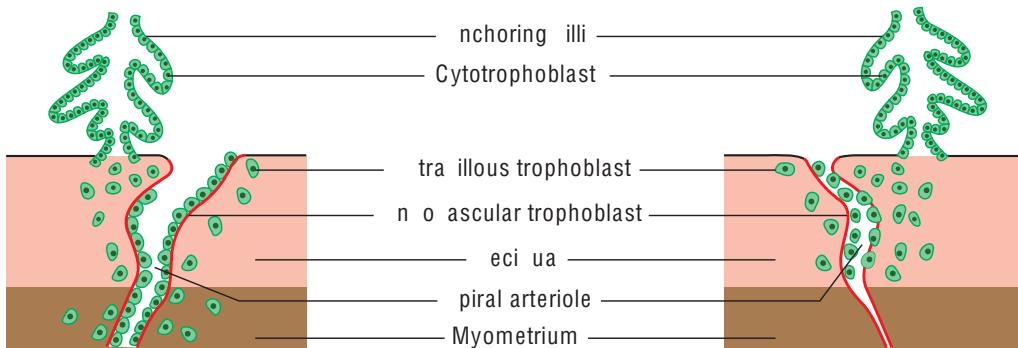


Figure 47.1 Abnormal trophoblastic invasion. **a.** Normal pregnancy. The endovascular cytotrophoblasts penetrate the walls of the spiral arterioles in the decidua and myometrium and convert them into low-resistance channels. **b.** Preeclampsia. The penetration of the wall of the myometrial segment of the spiral arterioles is not seen.

uteroplacental flow such as hypertension, diabetes, and connective tissue disorders also lead to placental hypoperfusion. Placental perfusion declines progressively as pregnancy advances. The resultant is chemia and hypoxia lead to the release of substances into the maternal circulation that cause endothelial dysfunction.

Immunological factors

In normal pregnancy there is an immunological tolerance to paternal and fetal antigens, thus facilitating placental implantation and continuation of pregnancy. The *natural killer cells* (NK cells) in the decidua and the *human leukocyte antigens* (HLAs) of the cytotrophoblasts come in contact but do not react adversely and the fetus is immunologically tolerated. In preeclampsia, this immunological tolerance is believed to be lost leading to abnormal trophoblastic invasion. In nulliparous women who have not previously been exposed to paternal antigens or when paternal antigenic load is high, as in multifetal or molar pregnancies, this **immune maladaptation** is probably more frequent and this may explain the greater predisposition to preeclampsia in these conditions.

Genetic factors

Risk of preeclampsia is higher in a woman with a family history and a history of preeclampsia. There is, therefore, a hereditary predisposition. Several genes have been implicated. Genes for antiangiogenic factors are present on chromosome 13, and genes on chromosome 12q are

linked to HELLP syndrome. Placental changes develop in women with susceptible genes.

Maternal vascular endothelial dysfunction

Several pro-angiogenic and anti-angiogenic factors are produced by the placenta, and the balance between these determines normal endothelial function

The proangiogenic and antiangiogenic factors are listed below.

- Proangiogenic factors: VEGF, PIGF
- Antiangiogenic factor: Soluble fms-like tyrosine kinase-1 (sFlt-1).

In normal pregnancy, there is a balance between production of pro-angiogenic factors and anti-angiogenic factors. In preeclampsia, the placental hypoperfusion and the resultant hypoxia lead to increase in production of anti-angiogenic factors and decrease in pro-angiogenic factors. This results in reduced production of vasodilator prostaglandin [prostaglandin I₂(PGI₂)] and nitric oxide (NO) by the endothelium, endothelial damage and dysfunction.

In addition, placental hypoxia causes release of syncytiotrophoblast debris and microparticles leading to production of cytokines, interleukins, and tumor necrosis factor-alpha (TNF- α), which in turn induce oxidative stress. This oxidative stress leads to increase in free radicals that cause endothelial inflammation, damage, and dysfunction (Fig. 47.2).

The damaged endothelium serves as a nidus for platelet aggregation and microvascular

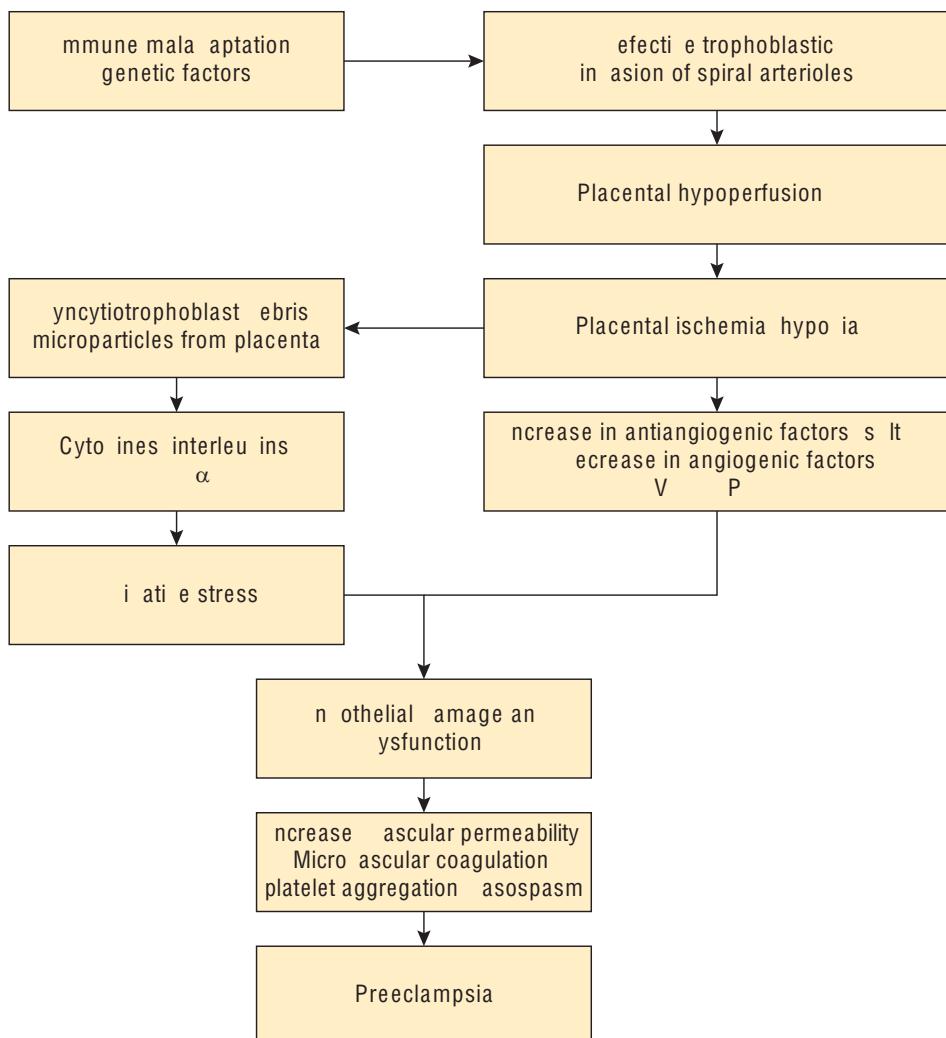


Figure 47.2 Pathophysiology of preeclampsia. PI = placental growth factor; sIL-6 = soluble fms-like tyrosine kinase-1; TNF- α , tumor necrosis factor-alpha; VEGF = vascular endothelial growth factor.

coagulation, and this leads to thrombocytopenia, increased vascular permeability, and vasospasm.

Pathogenesis of preeclampsia

The endothelial damage and dysfunction lead to the following events:

- There is increased response to pressor agents such as angiotensin II and norepinephrine.
- The increased capillary permeability leads to leakage of platelets and fibrinogen through the damaged endothelium and increase in extravascular fluid.

- As already mentioned, there is platelet aggregation and microvascular coagulation.
- Endothelins are released by the endothelium. They are vasoconstrictors.
- The balance between the production of vasodilator prostaglandin (PGI₂) and vasoconstrictor prostaglandin (thromboxane A₂) is altered.
- The endothelins, reduced levels of NO and increase in thromboxane A₂ together lead to vasospasm in the small blood vessels in the end-organs.
- This causes ischemia of the surrounding tissues, necrosis and hemorrhage, which are characteristic changes in preeclampsia (Fig. 47.3).

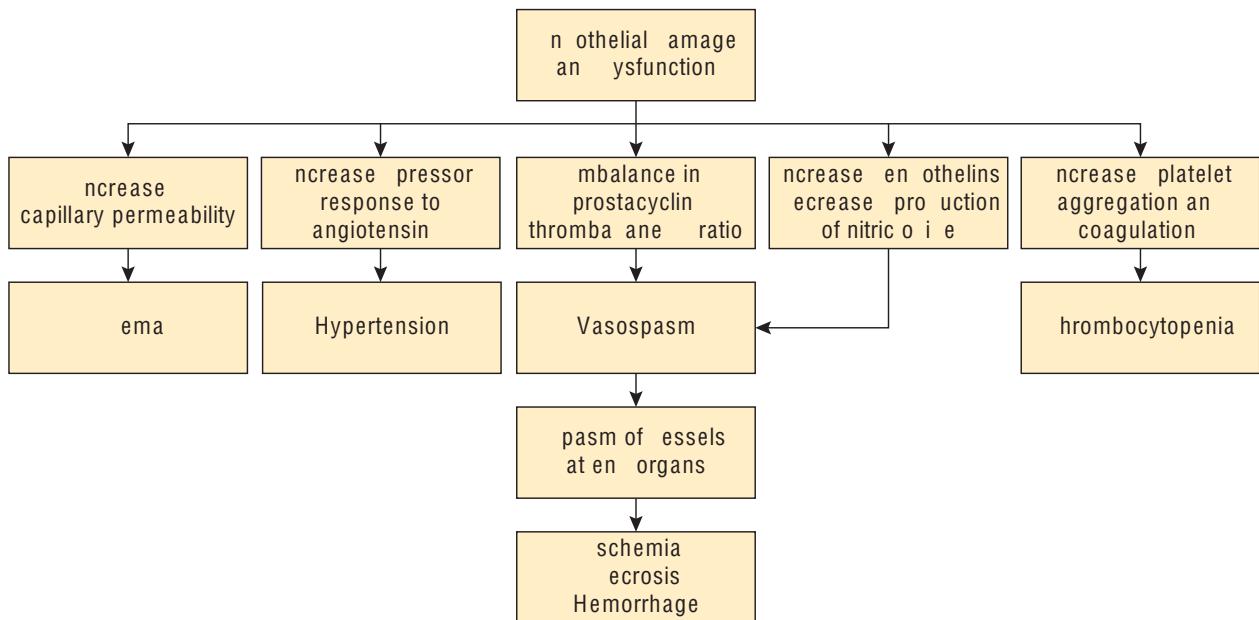


Figure 47.3 Pathogenesis of preeclampsia.

Pathology

The placental changes that predispose to preeclampsia begin early in pregnancy, but the pathological changes progress gradually. Ultimately, the individual end-organs are affected to varying degrees and manifest varying degrees of pathological changes.

Cardiovascular changes

Increased vascular permeability, increased peripheral resistance and hypertension lead to significant changes in the cardiovascular system

- Due to hypertension and increased peripheral resistance, there is increased load on the left ventricle. If hypertension is severe, this can lead to left ventricular dysfunction.
- Increased capillary permeability causes extravasation of fluid into the extravascular space, especially lungs, causing pulmonary edema.
- Due to vasospasm and shrinkage of intravascular compartment, the blood volume expansion that is expected in normal pregnancy does not occur.
- Contracted intravascular compartment and expanded extravascular compartment is an important feature of preeclampsia.
- Extravasation of plasma into interstitial space and vasoconstriction lead to

hemoconcentration. Due to these changes, women with preeclampsia are very sensitive to vigorous fluid therapy and acute blood loss and are at risk for pulmonary edema and hypotension.

- Proteinuria and the resultant hypoalbuminemia lead to reduction in plasma oncotic pressure. This, along with extravasation of fluid, can give rise to edema.

Hematological changes

Significant hematological changes are also observed

- Thrombocytopenia occurs in all the different types of hypertensive disorders in pregnancy. This may become severe in severe preeclampsia and HELLP syndrome.
- Microangiopathic hemolysis occurs due to endothelial damage, platelet adherence, and fibrin deposition. This results in elevated lactic dehydrogenase(LDH) levels and appearance of schistocytes and spherocytes in the peripheral smear.
- Intravascular coagulation leads to reduction in levels of factor VIII, antithrombin III, and proteins C and S and increase in D-dimers.

Cardiovascular and hematological changes in preeclampsia are summarized in Table 47.2.

Table 47.2 Cardiovascular and hematological changes in preeclampsia

Pathogenesis	Clinical manifestations
Vasoconstriction Increase in peripheral resistance	Increased load on left ventricle Left ventricular dysfunction Decrease in capillary volume expansion
Increased capillary permeability Extravasation of fluid into interstitial space	Hemoconcentration Pulmonary edema
Reduced plasma oncotic pressure	Pedal and generalized edema
Microangiopathic hemolysis	<ul style="list-style-type: none"> • Elevated LDH • Schistocytosis, spherocytosis • Elevated D-dimers • Reduced levels of factor VIII, antithrombin III, proteins C and S
Platelet adhesion and aggregation	Thrombocytopenia

D lactic dehydrogenase.

Renal changes

Histological and functional changes occur in the renal system.

- Swelling of the endothelial cells of the renal glomeruli, obstructing the lumen of the capillaries, known as *glomerular capillary endotheliosis*, is a characteristic histological renal lesion in preeclampsia. The glomeruli are enlarged and have markedly reduced blood flow.
- Glomerular filtration is reduced due to (a) reduced plasma volume, (b) reduction in renal blood flow because of high resistance, and (c) glomerular capillary endotheliosis.
- Proteinuria occurs due to increased permeability of the glomeruli to proteins. Most of the protein excreted is albumin.
- Serum creatinine levels increase.
- Uric acid levels are elevated due to decreased clearance of uric acid by the kidney.
- Activation of renin–angiotensin system leads to reduced excretion of sodium and chloride, causing sodium retention.
- Acute tubular necrosis can occur when there is profuse hemorrhage, hypotension, and hypovolemia.
- For the same reasons, acute cortical necrosis, which is rare, can also occur.

Changes in renal function are listed in Box 47.8.

Hepatic changes

The pathological process of preeclampsia leads to changes in the liver as well.

- Liver changes in preeclampsia consist of (a) periportal hemorrhages and (b) vasospasm and infarction around the sinusoids.
- Serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) levels increase, indicating severe disease.
- Hemorrhagic infarctions can form hematoma, which may extend to become subcapsular hematoma. Rarely, this can rupture causing life-threatening hemorrhage.
- Stretching of the liver capsule (Glisson capsule) due to edema and hematoma causes epigastric pain. Liver involvement also causes nausea and vomiting.

Central nervous system changes

Changes in the central nervous system are significant and may lead to convulsions

- Cortical and sub-cortical hemorrhages are the most common lesions in the brain. Softening, necrosis, perivascular infarcts, and hemorrhages are also seen.
- Endothelial damage leads to leakage of fluid into the interstitial tissue, causing perivascular edema and convulsions. Autoregulation of cerebral blood flow is lost, and there is cerebral hyperperfusion, causing headache, papilledema, and scotomata.
- The changes in the brain are termed posterior reversible encephalopathy syndrome (PRES)

Box 47.8 Renal changes in preeclampsia

- Glomerular capillary endotheliosis
 - Reduced glomerular blood flow
 - Reduction in GFR
 - Reduction in plasma volume
 - Reduction in renal blood flow
 - Glomerular endotheliosis
 - Proteinuria
 - Increase in serum creatinine
 - Decreased clearance of uric acid
 - Elevated levels of uric acid
 - Decreased excretion of sodium and chloride
 - Sodium retention
 - Acute tubular necrosis
 - Acute cortical necrosis
- glomerular filtration rate.

when they involve predominantly the occipital lobes. This causes blurred vision, diplopia, and, rarely, blindness.

- Widespread cerebral edema can occur and manifest as confusion and coma.

Retinal changes

Vasospasm is the most common finding in the fundus. Hemorrhages and exudates are seen in severe preeclampsia. Papilledema can also occur. Rarely, retinal detachment can occur, especially following a convulsion. This can cause temporary blindness.

Changes in the liver, central nervous system, and retina are summarized in Table 47.3.

Placental changes

Placental changes play a major role in pathogenesis of preeclampsia.

- Due to the failure of the second stage of trophoblastic invasion, the diameter of the spiral arteries in the myometrium is reduced. The vessel wall undergoes necrosis and the cell wall is replaced by amorphous material. This progresses to obliteration of the vessels and areas of placental infarction (Box 47.9). Fetal growth restriction, placental abruption, and preterm labor are probably due to these changes.

Box 47.9 Placental changes in preeclampsia*Spiral arteries in the myometrium*

- Lack of trophoblastic invasion
 - Narrowing of the arteries
 - Necrosis of vessel wall
 - Obstruction of the lumen
 - Placental infarction
- trophoblast*
- Apoptosis
 - Necrosis
 - Degeneration

Fetal growth restriction
Placental abruption
Preterm labor

Release of syncytiotrophoblast debris
Release of microparticles
Endothelial inflammation

Table 47.3 Hepatic, central nervous system, and retinal changes in preeclampsia

Pathology	Clinical manifestations
Hepatic changes	
Periportal hemorrhages Vasospasm and infarction around sinusoids Hematomas Stretching of liver capsule	} Elevated SGOT, SGPT Nausea, vomiting Spontaneous rupture Epigastric pain
Central nervous system changes	
Cortical and subcortical hemorrhage Softening, infarction, necrosis Focal and generalized edema Posterior reversible encephalopathy	Convulsions, confusion, coma Headache, visual disturbances
Retinal changes	
Vasospasm Hemorrhages and exudates Papilledema Retinal detachment	} Visual disturbances Blindness

- There is increased apoptosis, necrosis, and degeneration of the trophoblast especially syncytiotrophoblast. More syncytiotrophoblast debris and microparticles are released into the maternal circulation, resulting in inflammation of the endothelium and endothelial dysfunction.

Prediction of preeclampsia

Several tests to identify placental hypoperfusion, endothelial dysfunction, and other pathological changes of preeclampsia have been developed. Most tests lack adequate sensitivity and predictive value and are therefore not used. Provocative biophysical tests such as rollover test and angiotensin II challenge test based on increased sensitivity and response to pressor agents were also used in the past. They are also unreliable and time consuming; therefore, they are currently not used.

Uterine artery Doppler velocimetry

Decreased flow in the uterine artery early in gestation is used as predictive test for preeclampsia. Uterine artery Doppler study is more useful in the second trimester. Impaired blood flow is diagnosed by the following:

- Presence of diastolic notching (Fig. 47.4)
- High resistance or pulsatility index or systolic/diastolic ratio

The tests are more useful for prediction of fetal growth restriction than for prediction of preeclampsia and are not recommended for routine screening.

Prevention of preeclampsia

Since the pathogenesis of preeclampsia is complex, preventive strategies have not been very effective. Several approaches and interventions (low-salt diet, fish oil, diuretics, antihypertensives, heparin, and antioxidants) have been studied, but none of them has been proven to be useful in preventing preeclampsia. Calcium

supplementation in high doses (2g/day) was found useful in calcium-deficient and high-risk women.

Identification of pregnancies that are at high risk for preeclampsia, appropriate preconceptional education, close monitoring during pregnancy, and early intervention if BP rises are the most effective methods of prevention of severe disease and eclampsia.

Low-dose aspirin

Platelet aggregation and increase in platelet-derived thromboxane are implicated in the pathogenesis of preeclampsia. Aspirin, administered in low doses (60–80 mg/day), reduces thromboxane synthesis by the platelets without decreasing the production of prostacyclin. ACOG and National Institute for Health and Care Excellence (NICE) guidelines have recommended the use of aspirin in doses of 75 mg/day, started at 12 weeks and continued till delivery. The indications are as follows:

- Women at high risk for preeclampsia
 - Hypertensive disease during a previous pregnancy
 - Chronic kidney disease
 - Autoimmune disease such as systemic lupus erythematosus
 - Antiphospholipid antibody syndrome
 - Type 1 or type 2 diabetes
 - Chronic hypertension
- Women with two or more of the following moderate risk factors for preeclampsia:
 - First pregnancy
 - Age ≥ 40 years
 - Pregnancy interval of >10 years
 - Body mass index (BMI) of 35 kg/m^2 or more at first visit
 - Family history of preeclampsia
 - Multiple pregnancy

Complications of preeclampsia

Maternal and perinatal complications are minimal with gestational hypertension; however,

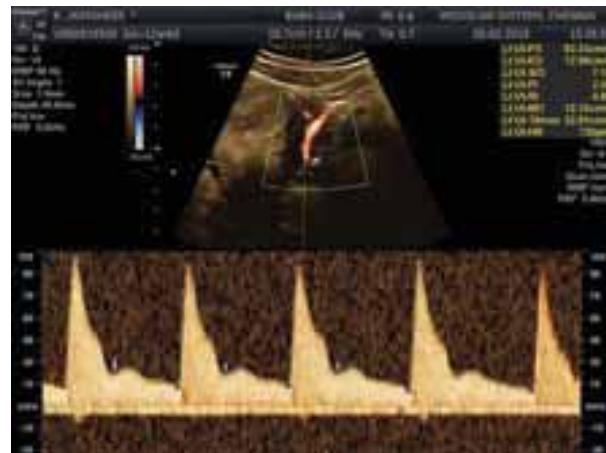
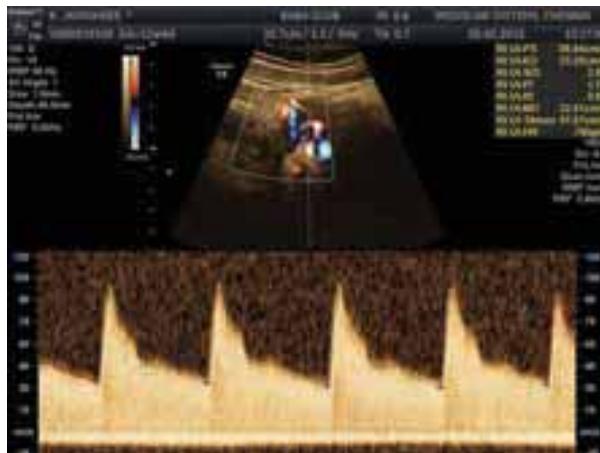


Figure 47.4 Uterine artery Doppler velocimetry. **a.** Normal pregnancy. Normal systolic and diastolic flow in uterine artery. **b.** Diastolic notching and high-resistance flow. The white arrows indicate diastolic notching. Pulsatility index is also high (2.45). (Photo courtesy: Mediscan Systems, Chennai.)

preeclampsia is associated with maternal and perinatal morbidity and mortality.

Maternal complications

Maternal complications include placental abruption, pulmonary edema, rupture of liver due to hematoma, renal failure, HELLP syndrome, disseminated intravascular coagulation (DIC), and convulsions (Box 47.10). There is increased risk of labor induction, operative delivery, and

cesarean section. Long-term maternal complications that are associated with preeclampsia are hypertension, cardiovascular disease, and metabolic syndrome.

Fetal complications

Fetal growth restriction due to placental insufficiency is common in preeclampsia. Increase in perinatal mortality and morbidity in severe preeclampsia is due to fetal growth restriction and prematurity. Prematurity may be due to spontaneous preterm labor or induced labor for severe preeclampsia or fetal compromise. Intrauterine hypoxia and death, intrapartum asphyxia, and hypoxic ischemic encephalopathy are the other complications (Box 47.11).

Box 47.10 Maternal complications in preeclampsia

- Short term
 - Placental abruption
 - Preterm labor
 - Spontaneous
 - Induced
 - Pulmonary edema
 - Rupture of liver due to hematoma
 - HELLP syndrome
 - DIC
 - Acute renal failure
 - Eclampsia
 - Operative vaginal delivery
 - Cesarean section
- Long term
 - Recurrent preeclampsia
 - Chronic hypertension
 - Cardiovascular disease
 - Metabolic syndrome

D C disseminated intravascular coagulation *P* hemolysis, elevated liver enzyme levels, and low platelet levels.

Box 47.11 Fetal complications in preeclampsia

- Short term
 - Fetal growth restriction
 - Prematurity
 - Intrauterine death
 - Intrapartum asphyxia
 - Hypoxic ischemic encephalopathy
 - Perinatal mortality
- Long term
 - Cerebral palsy
 - Other neurological disorders

Clinical features of hypertensive disorders

Most women with gestational hypertension and nonsevere preeclampsia are asymptomatic. An increase in diastolic BP during a routine antenatal visit is the first sign. This usually occurs after 32 weeks. There may be a rapid weight gain of >1kg/week.

Women with severe preeclampsia can present with nausea, vomiting, headache, blurring of vision, and/or epigastric (upper abdominal) pain. Pedal edema extending to legs and vulval edema/ascites can occur with severe proteinuria. Breathlessness may be present when there is pulmonary edema. Decreased fetal movements are indicative of intrauterine hypoxia (Box 47.12).

Box 47.12 Clinical features of hypertensive disorders

- Gestational hypertension and nonsevere preeclampsia
 - Asymptomatic
 - Rise in diastolic BP during antenatal visit
 - Weight gain >1kg/week
- Severe preeclampsia
 - Nausea, vomiting
 - Headache
 - Visual disturbances
 - Epigastric/upper abdominal pain
 - Edema
 - Pedal extending to legs
 - Vulval
 - Ascites
 - Oliguria
 - Reduced fetal movements

Diagnosis of hypertensive disorders

Diagnosis of hypertensive disorders in pregnancy is clinical, by identification of rise in BP. Once hypertension is documented, further evaluation is aimed at

- Making a diagnosis of gestational hypertension, preeclampsia, or chronic hypertension
- Determination of severity of the disease

History

Gestational age at which hypertension is first detected, whether it is before or after 20 weeks, is crucial. BP at the booking visit, especially in the first trimester, should be noted. Past history of gestational hypertension, gestational age at which it occurred, family history of hypertension, history of diabetes, renal disease, autoimmune disorders, or other medical disorders should also be enquired into. Symptoms and signs of severe preeclampsia should be evaluated.

Physical examination

BP readings should be taken in the sitting position with an appropriate cuff. The diastolic BP is recorded when the sound disappears (Korotkoff 5), or muffles (Korotkoff 4) as mentioned earlier. Mild elevations of BP should be reconfirmed by repeat examination after 4 hours. Cardiovascular and respiratory systems and abdomen should be examined. History and physical examination are summarized in Box 47.13.

Investigations

Investigations are ordered for the following reasons (Box 47.14):

- Determine if it is gestational hypertension, preeclampsia, or chronic hypertension.

Urinalysis for proteinuria is the first step in further evaluation. The dipstick method is usually used at initial evaluation. If this is 1+ or more, a spot urine protein : creatinine ratio or 24-hour urinary protein may be performed.

Microscopic examination of a centrifuged urine sediment for red blood cell (RBC) casts, granular casts, or microscopic hematuria may give clues to underlying parenchymal renal disease.

- Assess the severity of the disease.

Tests to assess severity of preeclampsia include serum creatinine to assess renal function, platelet count for thrombocytopenia, LDH, and peripheral smear for schistocytes as evidence of microangiopathic hemolysis and liver enzymes to evaluate liver involvement.

Box 47.13 History and physical examination

- History
 - Gestational age at detection of new-onset hypertension
 - Documented blood pressure at first visit
 - Symptoms of severe preeclampsia
 - Excessive vomiting
 - Past history
 - Hypertension in previous pregnancy
 - Gestational age at which hypertension was detected
 - Family history
 - History of preeclampsia, essential hypertension
 - Medical history
 - Diabetes
 - Hypertension
 - Autoimmune disease
 - Antihypertensive medications
 - Renal disease, connective tissue disorders
 - Antiphospholipid antibody syndrome
- Physical examination
 - General examination
 - Body mass index
 - Blood pressure
 - Sitting position
 - Appropriate cuff
 - Korotkoff 5 or 4
 - Edema
 - Cardiovascular system
 - Respiratory system
 - Pulmonary edema
 - Abdominal examination
 - Abdominal wall edema
 - Ascites
 - Uterine height
 - Signs of multifetal/molar pregnancy
 - Evidence of fetal growth restriction

Evaluate fetal well-being.

Fetal well-being is evaluated by nonstress test (NST). Ultrasound evaluation yields very useful information about the status of the fetus such as estimated fetal weight, fetal growth as assessed by biometric parameters, and fetal well-being as assessed by liquor volume and biophysical profile.

Management of hypertensive disorders

The goals of management are as follows:

- Early identification of worsening of the disease

Box 47.14 Investigations

- To determine nature of hypertensive disease
 - Urine albumin
 - Urine microscopy
 - RBC casts
 - Granular casts
- To determine severity
 - Platelet count
 - Liver enzymes
 - SGOT, SGPT
 - LDH
 - Peripheral smear for schistocytes
 - Serum creatinine
- To assess fetal well-being
 - Nonstress test
 - Ultrasonography
 - Estimated weight
 - Fetal growth
 - Biophysical profile

D lactic dehydrogenase; *BC* red blood cell; *S* serum glutamic oxaloacetic transaminase; *S P* serum glutamic pyruvic transaminase.

- Close monitoring
- Appropriate timing of delivery
- Appropriate mode of delivery

Management of nonsevere gestational hypertension

Nonsevere gestational hypertension is associated with low maternal and perinatal mortality and morbidity.

However, severe hypertension, preeclampsia, or even eclampsia can develop in 15%–25% of these women; therefore, close monitoring is essential.

Maternal monitoring

Worsening of hypertension or development of preeclampsia should be recognised immediately and treatment instituted.

- Women with nonsevere new-onset hypertension can be managed on an outpatient basis.
- They should be seen twice weekly in the outpatient clinic. BP, urine protein, and signs and symptoms of severe disease should be monitored. Platelet count and liver enzymes should be checked once a week.

- Patients should be educated regarding signs and symptoms of severe hypertension/preeclampsia.
- Salt restriction is not recommended.
- Bed rest is not recommended for nonsevere hypertension. Bed rest increases the risk of venous thromboembolism and does not prevent progression to severe preeclampsia. *However, depending on the nature of work and level of BP, restriction of activity and rest for varying periods of time may be required in moderate hypertension (150/100–160/109 mm Hg).*

Fetal surveillance

Serial evaluation of fetal well-being is essential for successful outcome.

- Daily fetal movement count is recommended.
- There are no definite guidelines regarding the necessity for or frequency of performing NSTs, biophysical profile, or fetal growth assessment.
- NSTs and biophysical profile are usually performed once in 2 weeks till 36 weeks and weekly thereafter. Fetal growth assessment should be performed once in 2 weeks after 34 weeks.

Antihypertensive therapy

The purpose of antihypertensive therapy is to reduce the BP to a level that will reduce maternal complications such as severe hypertension, abruption, liver, brain, and renal involvement without reducing placental perfusion.

- According to randomized trials, antihypertensive therapy for nonsevere (mild to moderate) hypertension does not improve maternal or perinatal outcome.
- It reduces the risk of severe hypertension but not the risk of preeclampsia, fetal growth restriction, prematurity, or placental abruption. Antihypertensives are, therefore, not recommended in nonsevere hypertension.
- *However, the guidelines are not very definite for women with moderate hypertension (150/100–160/109 mm Hg). Antihypertensives reduce the risk of development of severe hypertension by 40%–50%. Therefore, in women with moderate hypertension in developing countries (where intensive monitoring may not be available), oral antihypertensives may be used.*

Antenatal glucocorticoids

Gestational hypertension develops after 34 weeks in most women. Glucocorticoids for accelerating pulmonary maturity are recommended only in the rare cases needing delivery before 34 weeks.

Timing of delivery

Women with hypertension should be delivered no later than 40 weeks because there is a potential increase in risk of complications beyond term.

- Women with mild elevation of BP (approximately 140/90 mm Hg) may be delivered by 39–40 weeks' gestation.
- If BP is higher (150/100–160/109 mm Hg), delivery between 37 and 38 weeks is recommended.

Mode of delivery

Ripening of the cervix with prostaglandins and induction of labor with amniotomy followed by oxytocin is safe. A cesarean section is performed only for obstetric indications.

Since hypertension can worsen in the intrapartum period, close monitoring of BP, proteinuria, and other clinical signs and symptoms of severe preeclampsia is mandatory during labor.

Management of severe gestational hypertension

Women who develop severe gestational hypertension ($>160/110$ mm Hg) even in the absence of proteinuria are at a high risk of developing maternal or fetal complications. They should be managed like severe preeclampsia.

Management of gestational hypertension is given in Figure 47.5.

Management of nonsevere preeclampsia

Progression to severe preeclampsia occurs in a higher percentage of women with nonsevere preeclampsia. If progression to severe preeclampsia does not occur, management is similar to

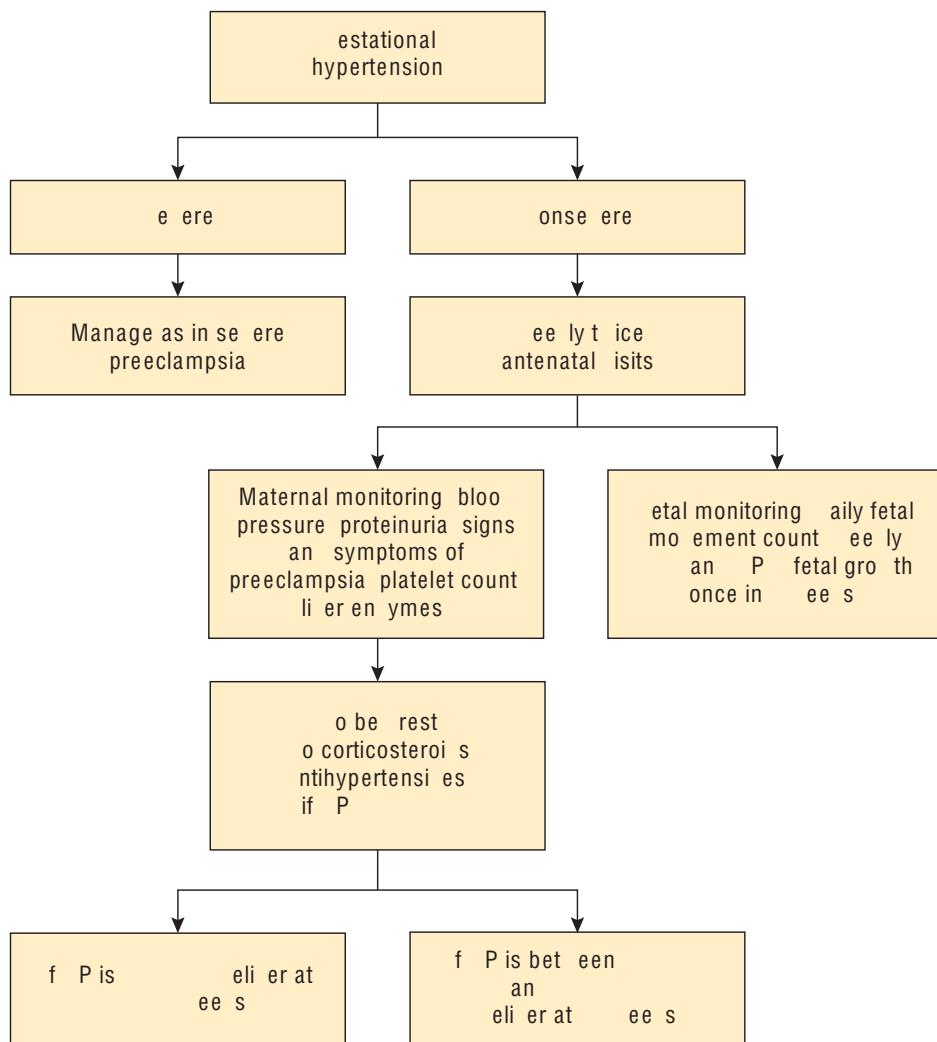


Figure 47.5 Management of gestational hypertension. *BPP* biophysical profile; *S* nonstress test.

nonsevere gestational hypertension with some differences.

- Women with proteinuria should be hospitalized. BP, proteinuria, and signs and symptoms of severe preeclampsia should be monitored daily.
- Fetal surveillance is by daily fetal movement count, NST and biophysical profile (BPP) weekly, and fetal growth monitoring once in 2–3 weeks.
- Complete bed rest is not recommended, but reduced level of physical activity and rest for 4–6 hours/day are usually advised. This reduces risk of progression to severe preeclampsia.
- Recommendations for antihypertensive therapy and corticosteroids are same as for nonsevere gestational hypertension.

Timing of delivery

Waiting beyond gestational age of 37 weeks increases risk of progression to severe preeclampsia and is also associated with other adverse maternal outcomes. Therefore, women with nonsevere preclampsia should be delivered by 37 weeks, in the absence of complications (Fig. 47.6).

Mode of delivery

Mode of delivery is the same as for nonsevere gestational hypertension. Intrapartum electronic fetal monitoring is recommended. Close monitoring of the mother is essential.

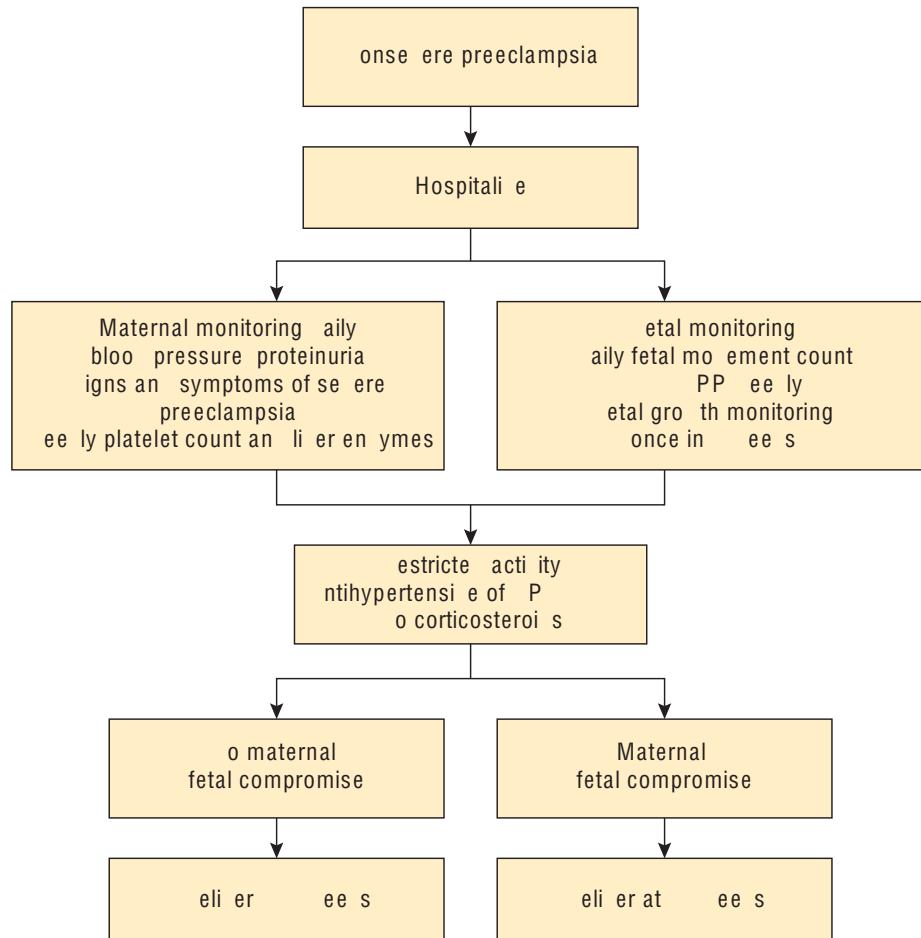


Figure 47.6 Management of nonsevere preeclampsia.

Management of severe preeclampsia

Definitive management of preeclampsia is delivery of the fetus and placenta. Prompt delivery prevents maternal and perinatal complications. However, preterm delivery is not desirable for the fetus. Hence, the benefits (to the mother) of immediate delivery must be weighed against the advantages (to the fetus) of waiting.

- Once severe preeclampsia is diagnosed, the woman should be admitted to the delivery room. Maternal condition should be evaluated (Box 47.15), and the mother should be stabilized before further management is planned.

Immediate management

Antihypertensives, corticosteroids and seizure prophylaxis should be started as soon as possible.

Box 47.15 Maternal evaluation in severe preeclampsia

- Gestational age
- Monitor
 - Blood pressure half-hourly
 - Urine output hourly
 - Urine protein by dipstick 4 hourly
- Evaluate symptoms and signs
 - Headache
 - Visual disturbances
 - Epigastric/upper abdominal pain
 - Altered sensorium, confusion
 - Breathlessness
 - Vaginal bleeding
 - Uterine contractions
- Antihypertensives:** Antihypertensives must be started immediately to reduce the systolic BP to 140–150 mm Hg and diastolic BP to 90–100 mm Hg. Antihypertensives of choice are nifedipine, labetalol, or hydralazine (discussed later in this chapter).

- Seizure prophylaxis:** Magnesium sulfate should be administered for seizure prophylaxis. Dosage and administration are discussed later in this chapter.
- Corticosteroids:** Administer betamethasone to accelerate pulmonary maturity if gestational age is between 26 and 34 weeks.
- Maternal/fetal evaluation** This consists of investigations to look for multiorgan involvement and evaluation of fetal status (Box 47.16).

Box 47.16 Maternal/fetal evaluation in severe preeclampsia

- Investigations
 - Urine protein : Creatinine ratio
 - Peripheral smear for schistocytes
 - SGOT, SGPT
 - Platelet count
 - Serum LDH
 - Serum creatinine
- Fetal evaluation
 - Nonstress test
 - Ultrasonography
 - Gestational age
 - Biophysical profile
 - Estimated weight
 - Umbilical artery Doppler

D lactic dehydrogenase; S serum glutamic oxaloacetic transaminase; S P serum glutamic pyruvic transaminase.

Subsequent management

After observation for 24–48 hours, decision regarding further management is taken. This depends on the following:

- Maternal and fetal condition
- Gestational age

Gestation >34 and <26 weeks are indications for delivery.

Management of severe preeclampsia ≥ 34 weeks' gestation

In severe preeclampsia ≥ 34 weeks' gestation prognosis for fetal survival is good and waiting will jeopardize the mother and the child. Hence, immediate delivery is recommended.

Management of severe preeclampsia ≤ 34 weeks' gestation (preivable preeclampsia)

Both maternal and perinatal outcomes are poor in early onset preeclampsia and waiting will jeopardize the mother.

- In developed countries, the gestational age cutoff for viability is 24 weeks. In under-resourced countries, perinatal survival is low before 26 weeks; hence, 26 weeks or the institutional cutoff (28 weeks) may be used as limit of viability.
- Perinatal complications in the surviving fetuses include respiratory distress syndrome, chronic lung disease, and neurodevelopmental problems and in the mother, HELLP syndrome, renal failure, and pulmonary edema.
- Parents should be counseled regarding these, and pregnancy should be terminated after stabilizing the mother.

Management of severe preeclampsia at ≤ 34 weeks' gestation

Betamethasone should be administered to women at this gestational age, as already mentioned.

Management at 26/28–34 weeks may be any of the following:

- Delivery 24 hours after administration of steroids
- Immediate delivery within 24 hours of administration of steroids
- Expectant management.

Delivery 24 hours after steroids

At gestational age 26–34 weeks, if maternal condition is not satisfactory or there is fetal compromise, delivery is warranted. However, we can wait for 24 hours for the steroids to take effect. Indications for delivery are summarized in Box 47.17.

Box 47.17 Indications for delivery at 26–34 weeks in severe preeclampsia

- Persistent high BP despite antihypertensives
- Cerebral symptoms despite magnesium sulfate
- Maternal renal failure (creatinine >1.5 mg/dL)
- DIC/HELLP syndrome
 - Thrombocytopenia
 - Elevated liver enzymes
 - Elevated LDH
 - Schistocytes in blood smear
- Abnormal umbilical artery Doppler
 - Absent/reversal of diastolic flow
- Amniotic fluid volume (AFI) $<5\text{cm}/\text{MVP} <2\text{cm}$
- Nonreassuring fetal heart tracing
- Severe FGR ($<5\text{th}$ centile for gestation)
- Preterm labor, prelabor rupture of membranes (PROM)

A amniotic fluid index; BP blood pressure; D C disseminated intravascular coagulation; FGR fetal growth restriction; P hemolysis, elevated liver enzyme levels, and low platelet levels; D lactate dehydrogenase; P maximum vertical pocket.

Immediate delivery within 24 hours of steroids

However, delivery should be proceeded with immediately (within 24 hours of steroid administration) if maternal condition is rapidly deteriorating as indicated by rising BP or persistent cerebral symptoms. Immediate delivery is also warranted in placental abruption, intrauterine fetal death, or grossly preterm fetus (<26 weeks; Box 47.18).

Box 47.18 Indications for immediate delivery at 26–34 weeks in severe preeclampsia

- Rising blood pressure despite antihypertensives
 - Cerebral symptoms indicating impending seizures
 - Placental abruption
 - Pulmonary edema
 - Intrauterine death of the fetus

Box 47.19 Maternal and fetal monitoring in severe preeclampsia

- BP 4 hourly/6 hourly
- Intake/output chart
- Urine protein by dipstick daily
- Signs and symptoms evaluated daily
- Test twice weekly
 - Serum creatinine
 - Liver enzymes
 - Platelet count
- Fetal well-being assessed
 - DFMC
 - Twice weekly
 - NST
 - BPP
 - Umbilical artery Doppler

BP blood pressure; *BPP* biophysical profile; *D* daily fetal movement count; *S* nonstress test.

Expectant management

Expectant management is of no benefit to the mother but improves fetal survival and achieves prolongation of pregnancy. Randomized trials and systematic reviews have concluded that expectant management achieves pregnancy prolongation of 7–14 days with maternal complication rate of <5%.

- Expectant management should be undertaken only in a tertiary-level center with neonatal intensive care facilities.
- The mother must be hospitalized till delivery.
- Discontinue magnesium sulfate after 24–48 hours.
- Continue oral antihypertensives.
- Close maternal and fetal monitoring is mandatory (Box 47.19).

Timing of delivery

Women managed expectantly should be delivered at 34 weeks. Any abnormal maternal or fetal test result or maternal complication during expectant management (listed in Box 47.19) is an indication for immediate delivery (after administration of betamethasone).

Mode of delivery

Decision regarding mode of delivery must take into account the gestational age and favourability of the cervix.

- Severe preeclampsia is not an indication for an elective cesarean section. A cesarean section is performed only for obstetric indications.

- Multiparous women with a favorable cervix and normal fetal test results can be delivered by labor induction following cervical ripening.
- When the cervix is unfavorable, gestational age is approximately 34 weeks, if there is associated fetal growth restriction with abnormal fetal testing, a cesarean section is usually the preferred mode of delivery.
- Regional anesthesia is recommended for a cesarean section.
- Worsening of hypertension, convulsions, and pulmonary edema can occur in labor. Close monitoring of BP (half-hourly) and other maternal parameters is mandatory.
- The second stage may be cut short with outlet forceps.
- Injection oxytocin 10 units IM should be given after delivery of placenta since excessive blood loss is tolerated poorly by these women. Methergine should be avoided.

Management of severe preeclampsia is summarized in Figure 47.7.

Antihypertensives in preeclampsia

Severe hypertension can lead to maternal complications such as left ventricular failure, cerebrovascular hemorrhage, and convulsions in severe preeclampsia. Antihypertensives reduce these maternal risks by lowering the BP. They also improve the perinatal survival indirectly,

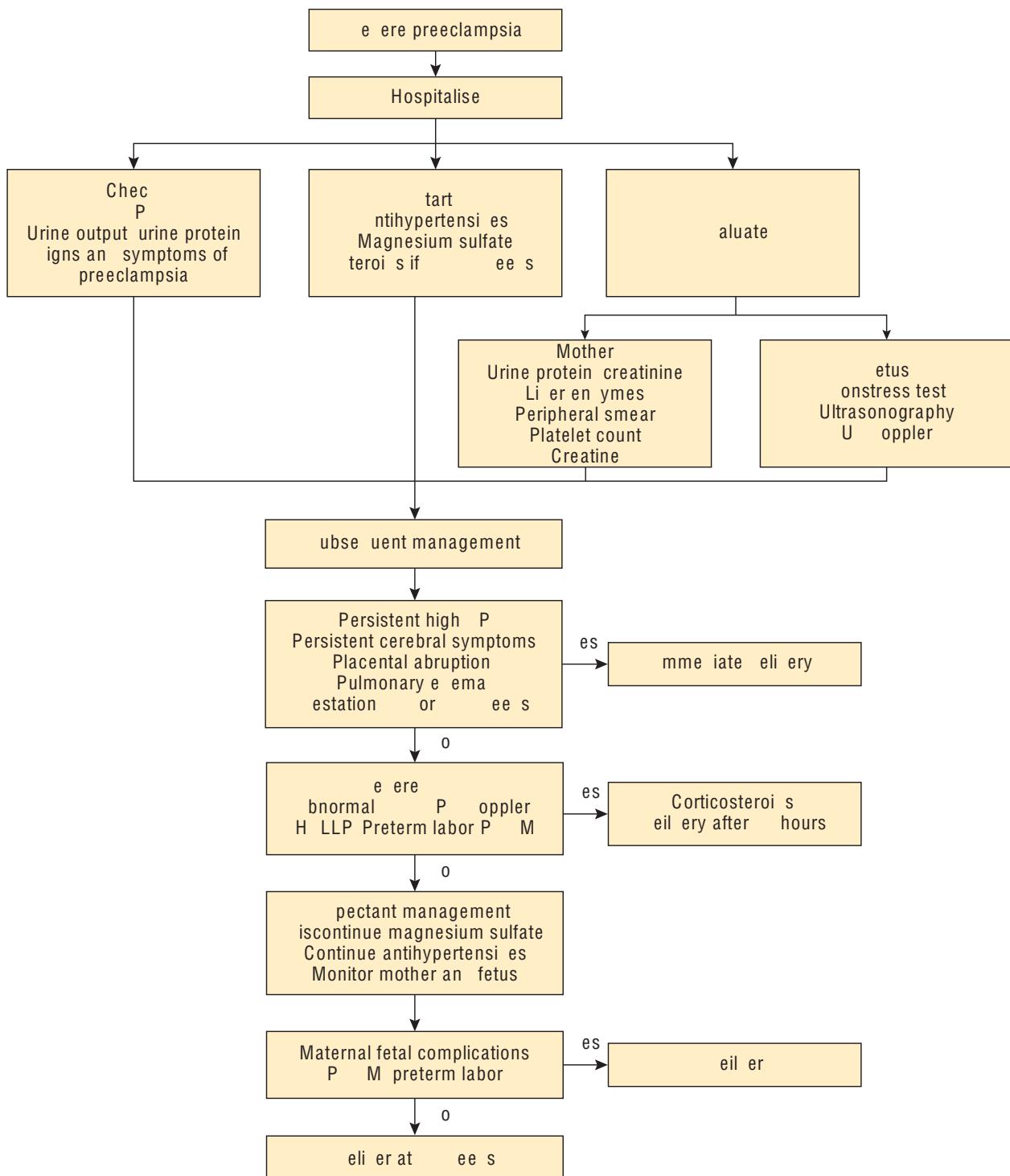


Figure 47.7 Management of severe preeclampsia. BP, blood pressure; BPP, biophysical profile; FGR, fetal growth restriction; HELLP, hemolysis, elevated liver enzyme levels, and low platelet levels; NST, nonstress test; UA, umbilical artery.

by prolongation of pregnancy. Lowering of BP beyond a threshold level can cause decrease in placental perfusion and fetal growth restriction.

Target blood pressure

Target BP in severe hypertension is 140–150 mm Hg systolic and 90–100 mm Hg diastolic. In women with chronic hypertension and end-organ damage, the target BP should be 140/90 mm Hg.

Antihypertensive drugs

The antihypertensive drugs commonly used in preeclampsia and their dosage are listed in Table 47.4.

α -ethyl dopa

α -Methyldopa is not useful in severe preeclampsia for rapid lowering of BP. The drug is safe in pregnancy and has no major side effects. It is useful in chronic hypertension and moderate gestational hypertension. It can be used as outpatient therapy.

abeta₁lalol

Labetalol can be used for rapid reduction of BP. Reduction in placental perfusion is not a concern when used for short periods of time as in severe preeclampsia. Intravenous labetalol is often used as the drug of choice in severe hypertension. Oral labetalol may be used in expectant management of severe preeclampsia or moderate hypertension.

nifedipine

Nifedipine is a calcium channel blocker and is useful for rapid lowering of BP. It is the drug of choice in severe hypertension, as an alternative to labetalol. Side effects include tachycardia, hypotension, and headache. Nifedipine can potentiate the action of magnesium sulfate, but this drug interaction is rare.

hydralazine

Hydralazine is a peripheral vasodilator and lowers the BP rapidly. The side effects may mimic impending eclampsia and include tachycardia, palpitation, headache, nausea, vomiting, and epigastric pain. This drug has been largely replaced by labetalol and nifedipine.

other drugs

Diuretics have been used in management of mild to moderate hypertension but are currently not recommended. Clonidine has unacceptable side effects and rebound hypertension. Sodium nitroprusside may be used as an infusion in refractory hypertension. Diazoxide and α -adrenergic blockers such as prazosin have also been used in refractory hypertension but are not recommended for routine use.

HELLP syndrome

HELLP is a syndrome characterized by hemolysis, elevated liver enzymes, and low platelet count. It is probably a form of severe preeclampsia. However, 15%–20% of women with HELLP

Table 47.4 Antihypertensives used in preeclampsia drugs and dosage

Drug	Mechanism	Dosage
α methyl dopa	Centrally acting Reduces sympathetic outflow Delayed onset of action (3–6 hours)	250–500 mg 6 hourly oral; maximum 2 g/day
Labetalol	Alpha-beta adrenergic blocker Rapid onset of action (1–2 min)	20–40 mg IV Every 10–15 min 200 mg twice daily oral; 220 mg maximum/ cycle
Nifidipine	Calcium channel blocker Rapid onset of action (5–10 min)	10 mg every 30 min oral Followed by 10–20 mg 6–8 hourly
Hydralazine	Peripheral vasodilator Rapid onset of action (10–20 min)	5–10 mg IV Every 15–20 min, maximum 30 mg

syndrome do not have hypertension or proteinuria. HELLP syndrome is also more common in multiparous women.

Pathogenesis and pathology

The hepatic involvement and hemolysis are more severe than in preeclampsia. Infarction and hemorrhage are more pronounced, and rupture of liver hematoma is more common.

Clinical features and diagnosis

HELLP syndrome usually develops between 28 and 36 weeks' gestation. Hypertension and proteinuria are present in 80% of women, but either or both may be absent. The common symptoms are nausea, vomiting, epigastric pain, and occasionally headache. Abruptio placenta, DIC, pulmonary edema, or rupture of liver hematoma may occur.

Diagnosis of HELLP syndrome is made when all of the following criteria are present:

- Microangiopathic hemolysis characterized by
 - Schistocytes/burr cells on blood smear
 - Low serum haptoglobin ($<25 \text{ mg/dL}$)
 - Serum bilirubin $\geq 1.2 \text{ mg/dL}$
- Platelet count $<100,000/\text{mm}^3$
- Serum SGOT/SGPT—twice the upper limit of normal

If all of the criteria are not present, it is referred to as partial HELLP syndrome. Elevated LDH ($>600 \text{ units/L}$) is nonspecific and is not included in the criteria.

Pathogenesis and clinical features of HELLP syndrome are summarized in Box 47.20.

Box 47.20 ELLP syndrome

- Develops between 28 and 36 weeks
- 80% have hypertension and proteinuria
- Symptoms
 - Nausea, vomiting
 - Epigastric pain
 - Headache
- Complications
 - Placental abruption
 - DIC
 - Pulmonary edema
 - Rupture of liver hematoma

D C disseminated intravascular coagulation; *P* hemolysis, elevated liver enzyme levels, and low platelet levels.

Differential diagnosis

HELLP syndrome may be misdiagnosed as AFLP. Idiopathic thrombocytopenia, acute appendicitis and cholecystitis, and thrombotic thrombocytopenic purpura are other differential diagnoses.

Management

Progressive and sudden deterioration of maternal condition can occur with HELLP syndrome. Therefore, expectant management is not recommended irrespective of gestational age. Once HELLP syndrome is diagnosed, patient must be delivered.

- Corticosteroids should be administered for pulmonary maturity if gestational age is <34 weeks.
- Antihypertensives and magnesium sulfate should be used if indicated.
- High-dose dexamethasone has not been found to be beneficial and is not recommended.
- Labor may be induced following cervical ripening with prostaglandins.
- Intramuscular injections, pudendal block, and spinal/epidural anesthesia must be avoided because of risk of bleeding.
- Platelet transfusions are indicated if there is significant bleeding or when platelet count is $<20,000/\text{mm}^3$.

Postpartum management of preeclampsia

After delivery, BP normalizes gradually and dose of antihypertensives should be adjusted accordingly. Patient should be followed up till BP returns to normal. If BP is persistently elevated after 12 weeks, the diagnosis may be changed to chronic hypertension and further evaluation is required.

Chronic hypertension

Pregnancy in women with chronic hypertension is associated with suboptimal maternal and perinatal outcome. Chronic hypertension is usually seen in older women. Even in the absence of superadded preeclampsia, maternal complications and fetal growth restriction are common.

When there is superadded preeclampsia, the maternal and perinatal morbidity and mortality are much higher compared with preeclampsia arising de novo. The maternal and fetal complications are listed in Box 47.21.

Box 47.21 Complications of chronic hypertension

- Superimposed preeclampsia
- Fetal growth restriction
- Preterm birth
- Placental abruption
- Cerebral hemorrhage

Box 47.22 Ultrasoundography in chronic hypertension

- First trimester
 - Gestational age estimated
- Second trimester
 - 18–20 weeks: Morphology
- Third trimester
 - Serial biometry, BPP if uterine height <gestational age
 - Serial umbilical artery Doppler if FGR diagnosed

BPP biophysical profile; FGR fetal growth restriction.

- Ultrasonography must be performed as indicated in Box 47.22.

Diagnosis

Diagnosis of chronic hypertension is by history and BP recording in the first trimester. Since BP falls in the second trimester of pregnancy, if the patient is seen for the first time in the second trimester, the diagnosis may be missed. The subsequent rise in BP may be interpreted as gestational hypertension. Most women have essential hypertension, but renal, endocrine, and other causes of hypertension must be excluded.

Management

- Preconceptional counseling is essential. Patient should be evaluated for causes and complications of hypertension.
- Most antihypertensives are safe in pregnancy except angiotensin receptor blockers and angiotensin-converting enzyme inhibitors. These drugs should be discontinued and substituted with safer drugs (described above).
- Preconceptually or if first seen during pregnancy, investigations should be performed to screen for underlying renal disease, diabetes, and other comorbidities.
- Low-dose aspirin should be started at 12 weeks as prophylaxis against superimposed preeclampsia.
- If the BP rises, dose of antihypertensives must be increased. Alternatively, change over to or addition of nifedipine or labetalol may reduce the BP.
- If superimposed preeclampsia develops, patient must be managed accordingly
- Regular antenatal care, close monitoring of BP and proteinuria, clinical monitoring of fetal growth, and delivery at term is the recommended management.

Eclampsia

Eclampsia is the occurrence of convulsions in a woman with preeclampsia in the absence of other neurological conditions. Hypertension and proteinuria precede the onset of eclampsia in most cases, but occasionally they may be absent.

Incidence

Incidence is variable. In developed countries it is 1.6–10/10,000 births. It occurs in 2%–3% of women with severe preeclampsia, not receiving seizure prophylaxis. In developing countries, the incidence is much higher and occurs in 1%–3.5% of all births.

Risk factors

Risk factors are the same as for preeclampsia (Box 47.7). Young primigravid women from low socioeconomic status are at the highest risk.

Eclampsia is rare before 20 weeks' gestation. It usually occurs in the third trimester, labor, or postpartum. The timing of eclampsia is as follows:

- Antepartum—55%
- Intrapartum—30%
- Postpartum <48 hours after delivery—10%
- Late postpartum >48 hours to <4 weeks after delivery—5%

Pathology

Loss of autoregulation of cerebral circulation causes segmental constriction and dilatation,

ischemia, hemorrhage and necrosis. In addition, there is exudation of fluid causing cerebral edema. Features of hypertensive encephalopathy are also seen.

Clinical features

Typical eclamptic convulsions last for 3–4 minutes and have four stages.

Premonitory stage

The premonitory symptoms occur before the onset of convulsions. These are:

- Headache—frontal or occipital
- Scotomata, blurred vision, diplopia, and photophobia
- Epigastric or right upper quadrant pain
- Mental confusion

Tonic phase

Tonic phase lasts for 15–20 seconds. There is tonic spasm of the muscles and the body is rigid. Twitching of the muscles of the face is seen. There may be frothing in the mouth.

Clonic phase

Clonic phase lasts for 60–70 seconds and the muscles contract and relax. The muscles of the face including the jaw and eyelids are involved initially, but soon the contractions spread to the limbs and the entire body. The contractions are forceful; the woman may bite her tongue or may fall off the bed.

Phase of coma

The convulsions slowly cease and coma usually follows. This lasts for variable length of time. As she wakes up, the woman may be agitated and confused.

Following convulsions, there may be transient metabolic and other changes as listed in Box 47.23. They revert to normal with treatment during the next few hours; urine output improves and fetal heart rate becomes normal. Labor may begin after convulsions.

Another convulsion may follow soon. Repeated convulsions, known as **status**

Box 47.23 Transient changes after eclamptic convulsions

- Hypercapnea
- Hypoxia
- Lactic acidosis
- Proteinuria
- Oliguria
- Hemoglobinemia
- Hemoglobinuria
- Fetal bradycardia

eclampticus, can result in prolonged coma and death.

Complications

Complications of eclampsia occur in 70% of women (Box 47.24). Maternal death occurs in approximately 2% of women and perinatal mortality may be as high as 25%–30% in developing countries.

Box 47.24 Complications of eclampsia

- Maternal
 - Intracranial hemorrhage
 - Aspiration pneumonia
 - Acute pulmonary edema
 - Injuries
 - Placental abruption
 - Renal failure
 - Blindness
 - Hepatocellular damage
 - DIC
 - Psychosis
 - Maternal mortality
- Fetal
 - Fetal heart rate abnormalities
 - Asphyxia
 - Prematurity
 - Intrauterine death

DIC, disseminated intravascular coagulation

Differential diagnosis

When convulsions occur in a pregnant woman in the third trimester or within 48 hours postpartum, in the absence of previous known seizure disorders, the diagnosis is **eclampsia unless proved otherwise**.

The differential diagnosis to be considered is listed in Box 47.25. The most important

Box 47.25 Differential diagnosis in eclampsia

- Epilepsy
- Cerebral venous thrombosis
- Hypertensive encephalopathy
- Posterior reversible encephalopathy syndrome
- Intracranial tumors
- Meningitis/encephalitis

differential diagnosis is epilepsy. If there is significant papilledema, brain tumors must be considered. In women with postpartum eclampsia, cerebral venous thrombosis must be excluded. Hypertensive encephalopathy and infections are other conditions that cause convulsions without focal neurological signs. Posterior reversible encephalopathy syndrome (PRES) closely resembles eclampsia and presents with headache, visual disturbances, confusion, seizures, and, occasionally, hypertension.

Management of eclampsia

Transfer to tertiary center

Patients with eclampsia should be transferred to a tertiary center for management after initiating antihypertensive and anticonvulsant treatment. Intravenous magnesium sulfate 4 g and oral nifedipine 20 mg should be administered. Padded mouth gag should be placed to prevent injury to the tongue. Intravenous line should be in place with infusion of dextrose saline, and patient should be accompanied by a physician during transport.

Management

Management of a woman with eclampsia consists of the following:

- Initial supportive management
- Anticonvulsant therapy
- Antihypertensive therapy
- Obstetric management

Initial management

Patient must be kept comfortable, steps to prevent aspiration and injury and other supportive measures initiated.

- Patient should be kept in left lateral position in a bed with protective side rails to prevent fall. Padded mouth gag should be kept ready for

Box 47.26 Initial management in eclampsia

- Patient in lateral position
- Beds with protective side rails
- Mouth gag kept readily available
- Mouth suction to remove secretions and vomitus
- Vital signs monitored
 - Pulse
 - Blood pressure
 - Respiratory rate
 - Oxygen saturation with pulse oximetry
- Oxygen administered by mask
- IV fluids
- CVP line if required

C P central venous pressure; IV intravenous.

use if convulsions recur. Vomitus and secretions must be aspirated. Initial management should continue as given in Box 47.26.

- Intravenous fluids should be administered with caution. Due to maldistribution of fluid between the extravascular and intravascular compartments, pulmonary edema can occur easily. Ringer lactate 100–125 mL/hour is recommended.
- The bladder should be catheterized after the first dose of magnesium sulfate is administered. Urine output must be monitored hourly.

Anticonvulsant therapy

Magnesium sulfate

Drug of choice for management and prevention of eclamptic convulsions is magnesium sulfate.

- Several randomized trials and meta-analyses have proved the superiority of magnesium sulfate over phenytoin, diazepam, and lytic cocktail for control of convulsions. Further respiratory depression is much less frequent with magnesium sulfate.
- Lytic cocktail, once popular in India, is not used any more. Phenytoin and diazepam may be used when convulsions continue despite adequate dose of magnesium sulfate.
- Pharmacology of magnesium sulfate is given in Box 47.27. It is excreted by the kidney and blood levels increase in renal dysfunction; hence, dosage must be adjusted, if there is renal impairment. Urine output should be monitored and maintained at >100 mL/4 hours for continuation of treatment.

Box 47.27 Pharmacology of magnesium sulfate

- Equally effective by IV and IM routes
- Mechanism of action
 - Central anticonvulsant action
 - Peripheral curare-like action
 - Prevention of calcium influx at myoneural junction
- Excreted by kidney
- Excess dosage causes
 - Respiratory depression
 - Renal failure
- Therapeutic blood levels
 - 5–7 mEq/L
- Effects on fetus
 - Loss of variability of fetal heart rate

- Respiratory depression can occur with high blood levels. Patellar tendon reflexes disappear when levels rise and can be used to monitor toxicity. Respiratory rate and patellar tendon reflexes should be monitored every hour to rule out magnesium toxicity.
- Routine estimation of plasma levels is not recommended.
- Calcium gluconate is the antidote for magnesium. Calcium gluconate 1g should be administered intravenously if respiratory depression occurs.
- Although magnesium is a uterine relaxant, it does not affect uterine contractions at the usual therapeutic levels.
- Fetal heart rate trace may reveal loss of variability when the mother is on magnesium sulfate, but this is clinically insignificant.

Dosage and administration

Magnesium sulfate can be administered intravenously or intramuscularly. Intramuscular administration is painful and has been abandoned in most centers. The dosage is given in Box 47.28. It is the same for prophylaxis and treatment of convulsions. **The loading dose can be given regardless of urine output.** The drug should be discontinued 24 hours after delivery or 24 hours after the last seizure, whichever occurs later.

Box 47.28 Dosage of magnesium sulfate in eclampsia

- Intravenous regimen
 - Loading dose
 - 4 g diluted in 100 mL of IV fluid
 - Administered over 15–20 minutes
 - Maintenance therapy
 - 1 g/hour with infusion pump
- Intramuscular regimen
 - Loading dose
 - 4 g of 20% solution IV over 20 minutes
 - 1 g/min not to be exceeded
 - Followed by 10 g of 50% solution
 - 5g in each buttock, deep IM
 - May be mixed with 1 mL of 2% lidocaine
 - Maintenance therapy
 - 5g of 50% solution 4 hourly, alternate buttocks
 - Monitored before each dose
 - Respiratory rate should be >20/min.
 - Patellar reflex should be present.
 - Urine output should be >100 mL/4hours.
 - If convulsions recur after loading dose
 - Additional 2 g of 20% solution IV over 3–5 minutes

diastolic to 90–100 mm Hg. Antihypertensives used are listed as follows:

- Tab. nifedipine oral
- Injection labetalol IV
- Injection hydralazine IV

The dosage and administration have been discussed earlier in this chapter.

Obstetric management

Once the patient is settled, convulsions are controlled, and antihypertensives are administered, steps must be taken to deliver the fetus.

- The woman may already be in labor. Fetal heart rate changes such as bradycardia, tachycardia, and decelerations can occur during convulsions, but they recover after the seizure. Delivery should be expedited by artificial rupture of membranes and oxytocin augmentation as required.
- If not in labor, decision regarding mode of delivery should take into account the following:
 - Gestational age
 - Cervical Bishop score
 - Estimated fetal weight
 - Fetal compromise
 - Maternal complications
- If the gestational age is closer to term, the cervix is favorable, and there is no fetal

Antihypertensive management

BP must be controlled immediately. The systolic BP should be maintained at 140–160 mm Hg and

compromise or maternal complication, vaginal delivery is the option. Prostaglandins may be used to ripen the cervix further and labor induced with oxytocin.

- Prolonged second stage should be avoided. It is advisable to shorten the second stage with outlet forceps.
- Methergine should not be used. Oxytocin 10 units IM is administered after delivery of placenta to minimize third stage hemorrhage.

Indications for cesarean section

A cesarean section is indicated in situations where labor may be prolonged or for obstetric reasons (Box 47.29).

- Epidural analgesia/anesthesia is recommended during labor and for cesarean section. Spinal anesthesia or combined epidural and spinal techniques may also be used.

Box 47.29 Indications for cesarean section

- Prematurity <32 weeks
- Very unfavorable cervix
- Severe fetal growth restriction
- Abnormal fetal tests
- Maternal complications
 - Pulmonary edema
 - Renal failure
 - Placental abruption
- Obstetric indications
 - Malpresentations
 - Fetal macrosomia
 - Intrapartum nonreassuring fetal status

General anesthesia is associated with risk of difficult intubation and acute rise in BP during intubation.

Management of eclampsia is outlined in Figure 47.8.

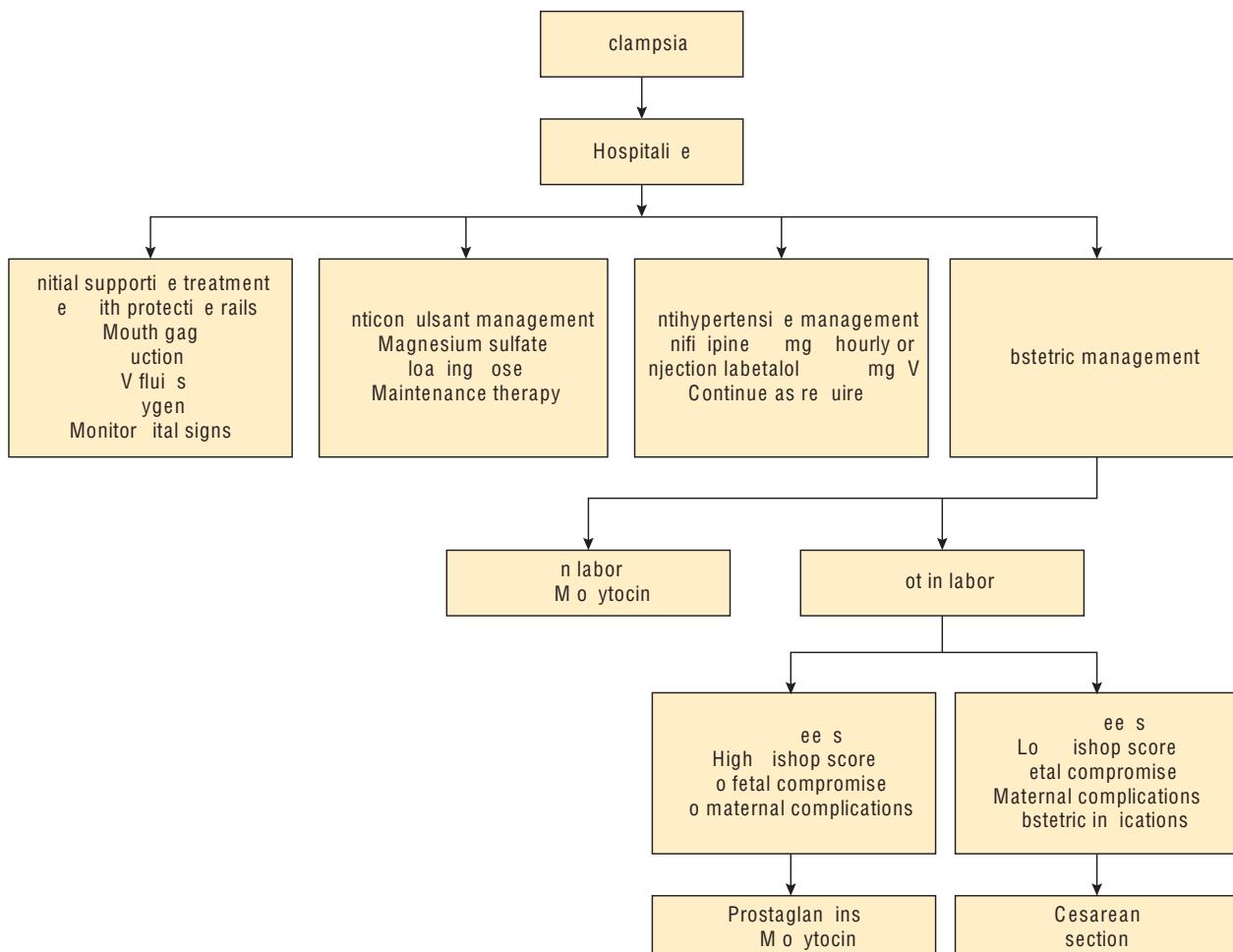


Figure 47.8 Management of eclampsia. A

artificial rupture of membranes.

Postpartum management

BP may remain elevated for a few days postpartum. Oral nifedipine or labetalol can be continued. Close attention should be paid to fluid management and monitoring of BP. Follow-up with BP monitoring should continue till it returns to normal. If BP remains elevated after 6 weeks postpartum, patient should be evaluated for chronic hypertension.

Contraception

Intrauterine devices, progesterone-only pill, and injectable pregestational agents are safe in women with hypertensive disorders. Combined oral contraceptives can be started after BP returns to normal.

Key points

- Hypertension in pregnancy is defined as systolic blood pressure of 140 mm Hg and/or diastolic blood pressure of 90 mmHg, the measurements confirmed by repeated readings 4–6 hours apart.
- The American College of Obstetricians and Gynecologists (ACOG) classifies hypertension in pregnancy into four categories: gestational hypertension, preeclampsia and eclampsia syndrome, chronic hypertension, and preeclampsia superimposed on chronic hypertension.
- Gestational hypertension develops after 20 weeks' gestation and there is no proteinuria.
- Preeclampsia is new-onset hypertension with proteinuria that develops after 20 weeks' gestation. This may be nonsevere or severe based on certain criteria.
- Chronic hypertension is present before 20 weeks' gestation and continues beyond 12 weeks postpartum.
- When there is worsening of hypertension/proteinuria or new-onset proteinuria in a woman with chronic hypertension, it is preeclampsia superimposed on chronic hypertension.
- Risk factors for hypertension are primiparity, younger age group or age >40, multifetal pregnancy, molar pregnancy, maternal medical problems, past and family history of preeclampsia, low socioeconomic status, and environmental factors.
- Pathogenesis of preeclampsia begins with abnormal trophoblastic invasion leading to placental hypoperfusion, ischemia, and hypoxia. Levels of antiangiogenic factors increase and angiogenic factors decrease, causing endothelial damage and dysfunction, leading to increased vascular permeability and microvascular coagulation, vasospasm, and platelet aggregation.
- Endothelial damage and dysfunction is the basic pathology in all organs, causing ischemia, necrosis, and hemorrhage.
- Pathological changes are seen in multiple organ systems in the body such as the heart, kidneys, brain, liver, retina, and placenta.

- There are no reliable, sensitive tests to predict preeclampsia. Uterine artery Doppler is more useful in prediction of fetal growth restriction.
- Low-dose aspirin 75 mg/day is recommended for prevention of preeclampsia in high-risk women.
- Maternal and perinatal complications are minimal with gestational hypertension. Maternal complications of preeclampsia are placental abruption, preterm labor, hemolysis, elevated liver enzyme levels, and low platelet levels (HELLP) syndrome, acute renal failure, and eclampsia.
- Perinatal complications of preeclampsia are growth restriction, prematurity, asphyxia, and risk of perinatal mortality.
- Women with nonsevere gestational hypertension and preeclampsia are asymptomatic.
- Severe preeclampsia is associated with symptoms and signs such as nausea, vomiting, epigastric pain, edema, ascites, and reduced fetal movements.
- Diagnosis of hypertension in pregnancy is clinical. Once high blood pressure is identified, it is important to differentiate among gestational hypertension, preeclampsia, and chronic hypertension.
- This differentiation is by history, physical examination, and investigations. The severity of preeclampsia also has to be determined.
- Nonsevere gestational hypertension can be managed as outpatient by monitoring blood pressure, urine protein, and tests to exclude progression of disease. Fetus is monitored by daily movement count and non-stress test/biophysical profile once in 3 weeks.
- Women with nonsevere hypertension should be delivered by 37–40 weeks' gestation, depending on the blood pressure.
- Women with nonsevere preeclampsia should be hospitalized and monitored more closely and delivered by 37–38 weeks.
- Women with severe gestational hypertension should be hospitalized and started on antihypertensives and

(Continued)

Key points *Continued*

- magnesium sulfate. Corticosteroids should be given if gestational age is 26–34 weeks. Blood pressure, urine output, and proteinuria should be checked hourly.
- Investigations include liver enzymes, platelet count, peripheral smear, and serum creatinine. Fetal well-being should be assessed by biophysical profile and umbilical artery Doppler.
 - Immediate delivery is indicated in women at >34 or <26 weeks' gestation, persistent proteinuria and cerebral symptoms, pulmonary edema, renal failure, HELLP syndrome, abruption, or fetal compromise.
 - Expectant management is an option for women between 26 and 34 weeks' gestation. This consists of close monitoring of maternal and fetal well-being and delivery at 34 weeks or earlier if there is maternal or fetal compromise.

- Expectant management prolongs pregnancy by 7–14 days and improves perinatal survival.
- Antihypertensives used in preeclampsia are α -methyldopa, labetalol, nifedipine, and hydralazine.
- HELLP syndrome consists of hemolysis, elevated liver enzymes, and thrombocytopenia. Women with HELLP syndrome should be delivered as soon as possible after administration of antihypertensives, magnesium sulfate, and betamethasone.
- Eclampsia is the occurrence of convulsions in a woman with severe preeclampsia.
- Eclampsia is associated with maternal and fetal complications, mortality, and morbidity.
- Management of eclampsia is by general supportive therapy, magnesium sulfate for control of seizures, antihypertensives, and immediate delivery.

Self-Assessment

Case-based questions

Case 1

rs primigravida, presented at 32 weeks' pregnancy with elevated blood pressure since 2 weeks, headache, and epigastric pain. Examination revealed blood pressure of 180/110 mm Hg and urine protein on dipstick of 3+. The uterus corresponded to the gestational age, and the fetal heart rate was normal.

- What is the diagnosis?
- How will you evaluate this patient?
- What complications do you anticipate?
- What is the management?

Case 2

Mrs. JC, 24, primigravida, came for regular antenatal checkup at 36 weeks. Her blood pressure was found to be 140/96 mm Hg and urine protein was negative.

- What is the diagnosis?
- How will you differentiate this from chronic hypertension?
- How will you evaluate this woman?
- What is the management?

Case 3

A 30-year-old second gravida was brought to the labor room at 30 weeks' gestation with convulsions on the way to hospital. There was a history of high blood pressure for 3 weeks and headache for 1 day. On examination, patient was not fully conscious, was restless, and had a blood pressure of 200/120 mm Hg.

- What is the diagnosis?
- What is the immediate management?
- What is the obstetric management?
- What complications do you anticipate?

Answers

Case 1

- Severe preeclampsia—blood pressure 160/110 mm Hg and 3+ proteinuria.
- Blood pressure, urine protein, urine output, and signs and symptoms such as headache, visual disturbances, epigastric pain, breathlessness, vaginal bleeding, and fetal movements.

Investigations—urine protein : creatinine ratio, liver function tests, serum creatinine, peripheral smear, platelets, and LDH.

Fetal evaluation—NST, biophysical profile, and umbilical artery Doppler.

- Abruption, pulmonary edema, eclampsia, renal failure, DIC, HELLP, abnormal biophysical profile, and Doppler study.
- Antihypertensive—T. nifedipine 10 mg 6 hourly or IV labetalol 20–40 mg every 15–20 minutes till BP reduces to 160/110 mm Hg. Magnesium sulfate loading dose 4 g IV infusion followed by 1 g hourly.

Betamethasone 12 mg IM Q24 hours.

If blood pressure and other symptoms are under control, no fetal compromise—expectant management till 34 weeks and deliver. If not, immediate delivery.

Case 2

1. Nonsevere gestational hypertension.
2. No family history of preeclampsia, history of high blood pressure prior to pregnancy or in the first trimester, urine microscopy for granular casts, and red cells positive—essential or renal hypertension.

If family history of preeclampsia present, normal blood pressure prior to pregnancy and in the first trimester, and urine microscopy normal, gestational hypertension.

3. Mother: liver function tests, platelet count, and signs and symptoms of preeclampsia—weekly.

Fetal movement count, NST, and biophysical profile—once in 3 weeks.

4. Manage as outpatient. Checkup weekly. Monitor the mother and the fetus. If blood pressure <90 mm Hg, deliver at 39–40 weeks. If blood pressure 90–100 mm Hg, deliver at 37–38 weeks.

Case 3

1. Antepartum eclampsia.
2. General supportive management—left lateral position, bed with side rails, and suction to remove secretions. Check blood pressure, pulse, and respiration.

Magnesium sulfate loading dose.

Injection labetalol 20–40mg IV every 10–15 minutes till blood pressure comes down to 160/110 mm Hg.

Investigations—liver enzymes, platelet count, serum creatinine, NST, biophysical profile, and umbilical artery Doppler.

3. Since gestational age 30 weeks, the cervix likely to be unfavorable. Cesarean section under epidural anesthesia after the mother is stabilized.
4. Pulmonary edema, renal failure, cerebral hemorrhage, recurrence of convulsions, abruption, DIC, blindness, psychosis, and fetal heart rate abnormalities.

Sample questions

Long-answer questions

1. Discuss the clinical features and management of eclampsia.
2. Classify hypertensive disorders of pregnancy. How will you manage nonsevere preeclampsia?
3. What are the signs and symptoms of severe preeclampsia? How will you manage severe preeclampsia at 32 weeks' gestation?

Short-answer questions

1. Complications of preeclampsia
2. Complications of eclampsia
3. HELLP syndrome
4. Pathogenesis of preeclampsia
5. Signs and symptoms of severe preeclampsia
6. Differential diagnosis of eclampsia
7. Magnesium sulfate in eclampsia
8. Antihypertensives in preeclampsia eclampsia syndrome

48

Pregestational and Gestational Diabetes

Case scenario

Mrs. PN, 28, second gravida, was referred to the antenatal clinic by a village midwife at 30 weeks as she felt that the baby was big. Oral glucose tolerance test revealed high fasting and postglucose plasma glucose values. She was admitted to the hospital for control of diabetes and evaluation of fetus.

Introduction

Diabetes is a common medical disorder in India and so it is not uncommon to encounter it in pregnant women. Diabetes in pregnancy is associated with high perinatal mortality and morbidity if hyperglycemia is not well controlled. With better understanding of the pathophysiology of diabetes in pregnancy, and better glycemic control with insulin, perinatal outcome has improved dramatically. Early diagnosis, preconceptional advice, good glycemic control, and appropriate monitoring of fetal well-being are all essential to achieve this.

Incidence

The prevalence and incidence of diabetes are increasing globally. In urban India diabetes prevalence is 9% and in rural India the prevalence is 4%. Further, diabetes mellitus (DM) occurs at a younger age in the Indian population. This is related to lifestyle changes with increasing prevalence of obesity, metabolic syndrome, and polycystic ovary syndrome (PCOS). These conditions predispose to type 2 diabetes occurring at a younger age. This has led to an increase in gestational diabetes mellitus (GDM), a forerunner of type 2 diabetes and pregestational diabetes in Indian women.

Box 48.1 Classification of diabetes in pregnancy

- Pregestational or overt diabetes
 - Type 1
 - Type 2
- Gestational diabetes

Box 48.2 Pregestational (overt) diabetes

- Type 1 diabetes
 - Younger age group
 - Absolute insulin deficiency
 - Immune mediated
 - Idiopathic
 - Nonobese
 - Euglycemia difficult to achieve
 - More prone to
 - ketoacidosis
 - hypoglycemia
- Type 2 diabetes
 - Older age group
 - Increased insulin resistance
 - β -cell dysfunction
 - Usually obese
 - Have associated metabolic syndrome/PCOS
 - May be on oral hypoglycemic agents
 - Less prone to
 - ketoacidosis
 - hypoglycemia

PC S polycystic ovary syndrome.

Classification

Diabetes in pregnancy is classified as in Box 48.1.

A classification by Priscilla White that had been in use since 1978 has been now replaced by the above classification.

Pregestational or overt diabetes mellitus

The two major types of diabetes that can predate pregnancy are type 1 diabetes (formerly known as insulin-dependent diabetes) and type 2 diabetes (formerly known as non-insulin-dependent diabetes).

Type 1 diabetes

Type 1 diabetes may occur at any age but occurs more commonly in younger subjects. It is characterized by absolute insulin deficiency. This is mostly immunologically mediated. Weight loss at presentation, very high and fluctuating plasma glucose levels, high risk for diabetic ketoacidosis (DKA), and difficulty in achieving and maintaining euglycemia are hallmarks of this condition. Further, individuals with type 1 diabetes are prone to hypoglycemic episodes when they are on insulin (Box 48.2).

Type 2 diabetes

Most women with overt diabetes in pregnancy have type 2 diabetes. This disorder usually occurs in the older age group. It is associated with increased peripheral insulin resistance and

pancreatic β -cell dysfunction. Women with type 2 diabetes are usually obese and have a history suggestive of PCOS or other components of the metabolic syndrome. They may be on oral hypoglycemic agents (OHAs) before pregnancy, and this has to be reviewed in the preconceptional period.

Gestational diabetes mellitus

Definition

Gestational diabetes mellitus is defined as any degree of glucose intolerance with onset in or first recognition in pregnancy, irrespective of whether insulin is used for treatment or not.

Because of the increasing number of women who probably have pregestational diabetes that has been first discovered in pregnancy, other terminology has been introduced.

Gestational diabetes: Diabetes diagnosed during the second half of pregnancy.

Box 48.3 Gestational diabetes

- Gestational diabetes is diagnosed for the first time in pregnancy.
- It is due to unmasking of susceptibility to type 2 diabetes.
- It shares common features with type 2 diabetes.
- Most subjects need only lifestyle change for control.
- Occasionally insulin is needed to achieve euglycemia.
- 50% of patients develop overt diabetes later in life.

Box 48.5 Substances causing increase in insulin resistance

- Human placental lactogen
- Estrogen and progesterone
- Cortisol, prolactin
- Tumor necrosis factor- α
- C-reactive protein
- Interleukin-6

Overt diabetes or diabetes mellitus in pregnancy:
Diabetes diagnosed by standard nonpregnant criteria early in pregnancy.

Women with GDM have metabolic characteristics similar to women with type 2 diabetes, and 50% of them develop type 2 diabetes later in life. Gestational diabetes mellitus may therefore be considered to be due to pregnancy induced unmasking of susceptibility to type 2 diabetes (Box 48.3).

Glucose metabolism in pregnancy

To understand the maternal and fetal complications in pregnant diabetics, it is important to be aware of the changes in glucose metabolism in pregnancy. The characteristic changes in glucose homeostasis are listed in Box 48.4.

Fasting hypoglycemia

The fasting hypoglycemia is due to continuous fetal utilization of glucose irrespective of maternal glucose levels, that is, *the fetus continues to be fed even if the mother starves*. The hemodilution of pregnancy and decreased caloric intake in the first trimester due to nausea and vomiting contribute to the hypoglycemia. When blood levels of glucose

Box 48.4 Changes in glucose metabolism in pregnancy

- Tendency for fasting hypoglycemia
- Increase in postprandial glucose
- Increased insulin resistance
- Exaggerated insulin secretion in response to glucose
- Destruction of insulin by placental insulinase
- Increase in hepatic glucose output

are not adequate for the fetus, maternal amino acids and free fatty acids are utilized as substrate for energy. This leads to mild ketosis and is referred to as **accelerated starvation** of pregnancy.

Increased insulin resistance

Peripheral resistance to insulin increases gradually as pregnancy advances. It is due to increasing levels of diabetogenic placental hormones (the most important being human placental lactogen) (Box 48.5) and other diabetogenic substances, in particular, tumor necrosis factor- α (TNF- α).

Postprandial hyperglycemia

Insulin resistance leads to decreased uptake of glucose by cells and consequent postprandial hyperglycemia. Both increase in insulin resistance and placental insulin destruction necessitate increased insulin secretion by β -cells. Despite this increase in insulin, hepatic glucose output continues unabated due to a lack of inhibition of glucagon and an increase in human placental lactogen. Overall, the changes in glucose metabolism in pregnancy lead to a **diabetogenic state**.

The progressive increase in insulin resistance culminates in overt abnormality of glucose tolerance, at approximately 24–28 weeks' gestation. This is the reason for performing the screening test for GDM at this period of gestation, even if first trimester tests are normal.

Screening for diabetes in pregnancy

It is well known that overt diabetes in pregnancy is associated with maternal and fetal complications. However, there was no consensus

regarding need for routine screening since the effect of treating minor abnormalities of blood glucose were not clear. The recently published Hyperglycemia and Adverse Pregnancy Outcome (HAPO) study has clearly established that there is a linear association between rising blood glucose levels and adverse pregnancy outcome, even with minor degrees of glucose intolerance not amounting to diabetes mellitus. A large interventional study showed that diagnosis and appropriate treatment of glucose intolerance significantly reduced these complications, particularly fetal macrosomia and perinatal mortality. The important issues that confront the clinician are (a) whom to screen, (b) how to screen, and (c) when to screen for gestational diabetes.

Whom to screen

Screening for diabetes may be as follows:

- **Universal:** Offered to every pregnant woman.
- **Selective:** Offered only to women with risk factors.

The decision on whether to perform universal or selective screening in a given ethnic group would depend on risk categorization, as shown in Box 48.6. Women with none of the listed risk factors are considered low risk for developing GDM. **Since Indians belong to an ethnic group that is at high risk for developing type 2 DM, all Indian women belong to the high risk category. It is, therefore, recommended that all Indian women be offered screening for GDM.**

The increase in prevalence of obesity in Western countries has resulted in most Western women being placed in the high risk category.

Current recommendation by the International Association of Diabetes and Pregnancy Study Group (IADPSG) is to screen all pregnant women at the first antenatal visit. If the screening is negative at this time, it should be repeated at 24–28 weeks.

Selective screening is practiced in some countries with low prevalence of diabetes.

How to screen

Screening of asymptomatic women with no history of prior glucose abnormality may be by a two-step approach or a one-step approach.

Box 48.6 Women at high risk for developing gestational diabetes

- Personal history of
 - GDM in a previous pregnancy
 - impaired glucose tolerance
 - glucosuria
- Member of an ethnic group with a high prevalence of type 2 diabetes mellitus
- Strong family history of type 2 diabetes
 - First degree relatives
- Maternal age >25 years
- Maternal birthweight >4.0 kg or <2.7 kg
- Medical conditions
 - Metabolic syndrome
 - Polycystic ovary syndrome (PCOS)
 - Current use of glucocorticoids
 - Hypertension
- Obesity
 - Prepregnancy BMI >30 kg/m²
 - Significant weight gain in early adulthood and between pregnancies
 - Excessive gestational weight gain
- Previous poor obstetric outcome suggestive of GDM
 - Delivery of a baby >4.0 kg
 - Unexplained perinatal loss
 - Hypertension/polyhydramnios
 - Birth of a malformed infant
 - Neonatal hypoglycemia
- Glycosuria at the first prenatal visit

B body mass index; D gestational diabetes mellitus; PC S polycystic ovary syndrome.

Two-step approach

The two-step approach consists of screening with glucose challenge test (GCT) followed by glucose tolerance test (GTT) for those who are positive.

Glucose challenge test

Fifty grams of oral glucose is administered irrespective of the time of last meal. Plasma glucose is measured 1 hour later. A value of 130 or 140 mg% is used as a cutoff. Those with values above the cutoff should undergo diagnostic testing with oral GTT (OGTT). A cutoff of 130 mg% has a higher pickup rate, but either cutoff may be used. With the simplification of screening as detailed below, the two-step approach is not commonly used at present.

Box 48.7 One-step approach for diagnosis of GDM and overt DM

- Performed in
 - all pregnant women
- Performed at first prenatal visit
- GDM is diagnosed if
 - fasting plasma glucose >92 mg% but <126 mg%
- Overt diabetes is diagnosed if
 - fasting plasma glucose ≥126 mg%
 - HbA1C ≥6.5% using a standardized assay
 - random plasma glucose ≥200 mg%
- Oral GTT at 24–28 weeks recommended if
 - fasting plasma glucose <92 mg%

D diabetes mellitus; D gestational diabetes mellitus; glucose tolerance test.

ne-step approach

The IADPSG, along with the American Diabetes Association (ADA), has recently recommended the one-step approach. This approach is recommended for all pregnant women. Screening is performed at the first antenatal visit, using fasting plasma glucose (FPG) for the diagnosis of GDM. This also allows for the identification of women with undiagnosed type 2 diabetes. Fasting plasma glucose, random plasma glucose, or HbA1c is used for diagnosis of overt diabetes (Box 48.7).

ral glucose tolerance test

Oral glucose tolerance test has been used as a diagnostic test for diabetes. In pregnancy, there is a delayed absorption of glucose and delayed insulin peak with slow return of blood glucose to normal. Therefore, a modified, prolonged GTT, proposed by Carpenter and Coustan, had been in vogue for several years. A glucose load of 100 g is used and plasma glucose levels are measured hourly for 3 hours. This 3-hour, 100-g glucose OGTT is recommended by the American College of Obstetricians and Gynecologists (ACOG) and has been in use globally until recently. However, this test has been simplified to a 75-g, 2-hour GTT by the IADPSG and is currently recommended for use in pregnancy.

75-g, 2-hour oral glucose tolerance test

The 2-hour test is convenient to perform and the 75-g glucose load is better tolerated. The World

Box 48.8 75-g, 2-hour oral glucose tolerance test

- Overnight fasting
- Fasting plasma glucose
- 75 g glucose mixed in 150 mL of lime juice/water
- Plasma glucose at 1 and 2 hours
- Cutoff values
 - Fasting: 92 mg%
 - 1 hour: 180 mg%
 - 2 hours: 153 mg%
- GDM diagnosed if
 - any one value equal to or more than cutoff value

D gestational diabetes mellitus.

Box 48.9 When to screen for diabetes in pregnancy

- High risk women
 - First visit: Fasting plasma glucose
 - If negative: 75-g, 2-hour GTT at 24–28 weeks
- Low risk
 - 75-g, 2-hour GTT at 24–28 weeks glucose tolerance test.

Health Organization (WHO) also recommends the 75-g, 2-hour GTT, but the cutoff values are marginally different. The IADPSG values are currently accepted (Box 48.8).

When to screen

As already mentioned, all women in the high-risk category must be screened at the first visit by the one-step procedure and if negative, screened again at 24–28 weeks. Oral glucose challenge test for low risk women is performed first **at 24–28 weeks** (Box 48.9).

Diabetes in Pregnancy Study Group India Guidelines

Because of the high prevalence of diabetes in India, the Diabetes in Pregnancy Study Group India (DIPSI) recommends screening of all pregnant Indian women at the first visit. Irrespective of the time of the last meal, 75-g oral glucose should be administered and plasma glucose tested 2 hours later. The advantage of this is that women need not be fasting and the test can be performed at the first visit. The compliance, therefore, is good.

- Plasma glucose ≥ 140 mg%: Gestational diabetes mellitus
- Plasma glucose ≥ 120 mg%: Impaired gestational glucose tolerance

Impact of diabetes on pregnancy

Pregestational and gestational diabetes are associated with several complications in the mother and fetus.

Maternal complications

Pregestational diabetes is associated with a higher rate of maternal complications than gestational diabetes (Box 48.10). Poor glycemic control is the most important factor responsible for maternal complications.

Gestational hypertension occurs in 25%–30% of diabetic pregnancies. *Preeclampsia* is more common in women with diabetic nephropathy and vasculopathy. Hypertension may predate pregnancy in many type 2 diabetics, and this may worsen in pregnancy.

Polyhydramnios is the result of maternal hyperglycemia leading to fetal hyperglycemia and fetal polyuria. Increased amniotic fluid glucose may also be responsible. *Infections* such as vaginal candidiasis, urinary tract infections, and puerperal sepsis are related to poor glycemic control. Polyhydramnios and ascending infection (with resultant chorioamnionitis) are two risk factors for preterm labor. Operative vaginal

Box 48.10 Maternal complications in diabetes

- GDM and overt DM
 - Gestational hypertension and preeclampsia
 - Polyhydramnios
 - Preterm labor
 - Infections
 - Urinary tract infection
 - Vaginal candidiasis
 - Puerperal sepsis
- Increased risk of
 - cesarean section
 - operative vaginal delivery
- In uncontrolled overt DM
 - Ketoacidosis

D diabetes mellitus; D gestational diabetes mellitus.

delivery and cesarean section result from fetal macrosomia.

Fetal complications

Maternal hyperglycemia is the most important cause of fetal and neonatal complications. The three major fetal complications resulting from uncontrolled hyperglycemia are

- spontaneous miscarriage,
- congenital anomalies, and
- macrosomia.

Pregestational diabetes with uncontrolled hyperglycemia is associated with spontaneous miscarriage and congenital anomalies. In gestational diabetes, where the hyperglycemia occurs for the first time in the late second trimester, there is increased risk of macrosomia. Fetal complications are listed in Box 48.11.

Spontaneous miscarriage is associated with pregestational diabetes due to poor control of diabetes in the first trimester.

Congenital anomalies are associated with poor control of diabetes in the first trimester during organogenesis. They occur in 5%–7% of women with overt diabetes and are due to elevated blood sugar before the seventh week of gestation. Ketonemia, hypoglycemia, and an excess of oxygen free radicals also play a role. The common congenital anomalies are listed in Box 48.12. Caudal regression, though specific to diabetes, is not a common anomaly.

Fetal growth restriction occurs in women with pregestational diabetes and associated vasculopathy, hypertension, and preeclampsia.

Macrosomia is defined as birth weight >90 th percentile for gestational age for the population or birth weight >4000 – 4500 g. DIPSI has suggested that a birthweight of >3500 g should be

Box 48.11 Fetal complications

- Overt uncontrolled DM
 - Spontaneous miscarriage
 - Congenital anomalies
 - Fetal growth restriction
- GDM and overt DM
 - Macrosomia
 - Prematurity
 - Late intrauterine death

D diabetes mellitus; D gestational diabetes mellitus.

Box 48.12 Congenital anomalies in diabetic pregnancy

- Central nervous system
 - Anencephaly
 - Spina bifida
 - Holoprosencephaly
- Cardiac
 - Ventricular septal defect
 - Transposition of great vessels
 - Tetralogy of Fallot
- Renal
 - Agenesis
 - Cystic kidney
- Caudal regression syndrome

considered as macrosomic in the Indian context. It is the most common complication of diabetic pregnancy, and occurs in 50% of women with GDM and DM. Maternal hyperglycemia causes fetal hyperglycemia and fetal hyperinsulinemia, leading to fetal macrosomia. Insulin-like growth factors, leptin, and maternal obesity are also contributing factors. Macrosomic infants have relatively broader shoulders, which leads to increased risk of shoulder dystocia and cesarean section (Fig. 48.1). Tight control of glycemia



Figure 48.1 Fetal macrosomia. (Photo courtesy: Dr. Rajnish Samal, Bangalore).

Box 48.13 Neonatal complications

- Respiratory distress syndrome
- Prematurity
- Hypoglycemia
- Hypocalcemia
- Hyperbilirubinemia
- Polycythemia
- Cardiomyopathy

throughout the pregnancy reduces the risk of macrosomia.

Premature labor may be spontaneous, due to polyhydramnios, or induced. Preterm induction of labor is indicated in preeclampsia, fetal growth restriction, macrosomia, or worsening nephropathy. Intrauterine death and stillbirths occur due to poor glycemic control, preeclampsia, or DKA. Hyperglycemia is the most important factor leading to fetal hypoxia.

Neonatal complications

Neonatal mortality and morbidity are increased due to the problems listed in Box 48.13.

Most complications are due to fetal hyperglycemia and hyperinsulinemia and resultant β -cell hyperplasia. Complications such as prematurity and respiratory distress syndrome are now less often seen because strict control of glucose levels allows for delivery at or close to term. Risk of neonatal hypoglycemia increases if glycemic control is not achieved at term and intrapartum. Hyperglycemia stimulates fetal erythropoietin production and results in polycythemia and hyperbilirubinemia.

Late complications in the infant of the diabetic mother

There is a 1%–3% risk of developing diabetes later in life. The risk increases if the father is also a diabetic. There is also increased occurrence of obesity in adult life.

Management

Gestational diabetes

Diagnosis and treatment of GDM reduces maternal and fetal morbidity, especially fetal macrosomia.

Preconceptional management

Women at risk for development of GDM should be given preconceptional advice. Obese women, including those with PCOS, should be advised to lose weight prior to pregnancy and counseled about acceptable weight gain during pregnancy.

Antenatal management

Appropriate antenatal management with repeated counseling, attention to measures to optimise plasma glucose levels, and close monitoring of the mother and fetus are important to ensure optimal outcome.

Medical management

Hyperglycemia is the single most important factor responsible for maternal and fetal complications in GDM, especially fetal macrosomia. The goal of medical management is to reduce blood glucose levels to normal and at the same time avoid hypoglycemia. This is achieved by diet, exercise, and pharmacotherapy with insulin or OHAs.

The target plasma glucose levels in pregnancy are as follows:

- Fasting: ≤95 mg%
- 1-hour postprandial: ≤140 mg%
- 2-hour postprandial: ≤120 mg%

Diet

Diet and lifestyle modification remain the cornerstones of therapy in gestational and pregestational diabetes. With these two modalities of therapy, optimal glycemic control can be achieved in 85% of subjects with GDM. Dietary counseling is referred to as **medical nutritional therapy** (MNT; Box 48.14). Caloric restriction should be recommended for all overweight and obese women regardless of the presence of hyperglycemia. The permitted weight gain during pregnancy in Western women is as follows:

Body mass index (BMI-kg/m ²)	Permitted weight gain (kg)
18–24.9 (normal)	11–16
25–29.9 (overweight)	7–11
≥30 (obese)	5–7 kg

The BMI for the definition of overweight and obesity in Asian women is lower (23 and 25 kg/m² respectively); therefore, the recommended weight gain in pregnancy is also lower.

Box 48.14 Medical nutritional therapy

- Daily requirements
 - Calorie intake
 - Normal weight: 30 kcal/kg
 - Overweight and obese: 22–24 kcal/kg
 - Morbidly obese: 15 kcal/kg
 - Carbohydrates: 40%–50%
 - Fats: 30%–40%
 - Proteins: 20%
- Distribution
 - 3 meals and 3 snacks

Exercise

Moderate exercise, for example, walking briskly for 45–60 min/day, is recommended. This reduces the need for insulin and achieves better glycemic control.

Pharmacotherapy

Treatment with medications is required when optimal plasma glucose levels are not achieved after 1–2 weeks of initiating MNT (3 days, if in the third trimester).

Insulin

Human insulin is recommended in pregnancy since it is least antigenic. Rapid-acting insulin analogs (lispro, aspart) have been found to be safe but are expensive. Long-acting analogs such as glargin have not been studied sufficiently and, therefore, not recommended in pregnancy.

A combination of short-acting and intermediate-acting insulin in the proportion of 30:70, twice daily, before breakfast and before dinner is usually sufficient to achieve good control of glucose in GDM. If fasting glucose and postdinner glucose values are high, the night dose of intermediate-acting insulin should be increased. If postdinner glucose remains elevated, a third dose of short-acting insulin may be given at bedtime. A fourth dose of short-acting insulin may occasionally be required before lunch, if the predinner or postlunch glucose levels are high (Box 48.15).

Glucose monitoring

Women should be educated regarding self-monitoring of glucose. Frequency of monitoring is given in Box 48.16.

Oral hypoglycemic agents

Oral hypoglycemic agents are used as an alternative to insulin. The two drugs used are glyburide

Box 48.15 Insulin therapy in GDM

- Short: Intermediate acting insulin 30:70
- Twice daily doses
- Caloric content of meals adjusted to fine-tune control
- Short-acting insulin added
 - At bedtime, if postdinner glucose high
 - Prelunch, if postlunch glucose high
- Human insulin used
- Insulin analogs
 - Rapid-acting: Safe
 - Long-acting: Not recommended

Box 48.16 Glucose monitoring

- Self-glucose monitoring
- Timing
 - Fasting
 - Postprandial, 1 or 2 hours after meal
- Frequency
 - Daily till euglycemia is achieved and twice weekly thereafter

Box 48.17 Oral hypoglycemic agents

- Glyburide (glibenclamide)
 - Dose: 2.5 mg to initially
 - Can be increased to 20 mg/day
 - Need for additional insulin is less
 - Failure of therapy high if fasting glucose >110 mg%
- Metformin
 - Useful in obese women
 - Dose: 500–2000 mg/day
 - Need for additional insulin is more

(glibenclamide) and metformin. They have been found to be safe in pregnancy. Compliance is better, administration is easier, and maternal/fetal complications are not increased. For these reasons, OHAs are being used as primary treatment in many centers currently (Box 48.17).

Obstetric management

The risk of antepartum and intrapartum complications is increased in gestational and pregestational diabetes. Close monitoring of mother and fetus and early diagnosis of complications are the primary focus of obstetric management.

Antepartum

The diagnosis of GDM is usually made in the first or second trimester. The risk of congenital

anomalies, miscarriages, and ketoacidosis is not increased in these women. Target glucose levels can be achieved and maintained by MNT alone or MNT and pharmacotherapy. If euglycemia is maintained, macrosomia and fetal death are uncommon. Antepartum surveillance is not routinely required in women with uncomplicated GDM with no previous complications. A cesarean section should be performed for obstetric indications only. Women with complicated GDM or those requiring insulin may be delivered at 38 weeks since waiting beyond that can increase the risk of macrosomia and shoulder dystocia. Management is outlined in Figure 48.2.

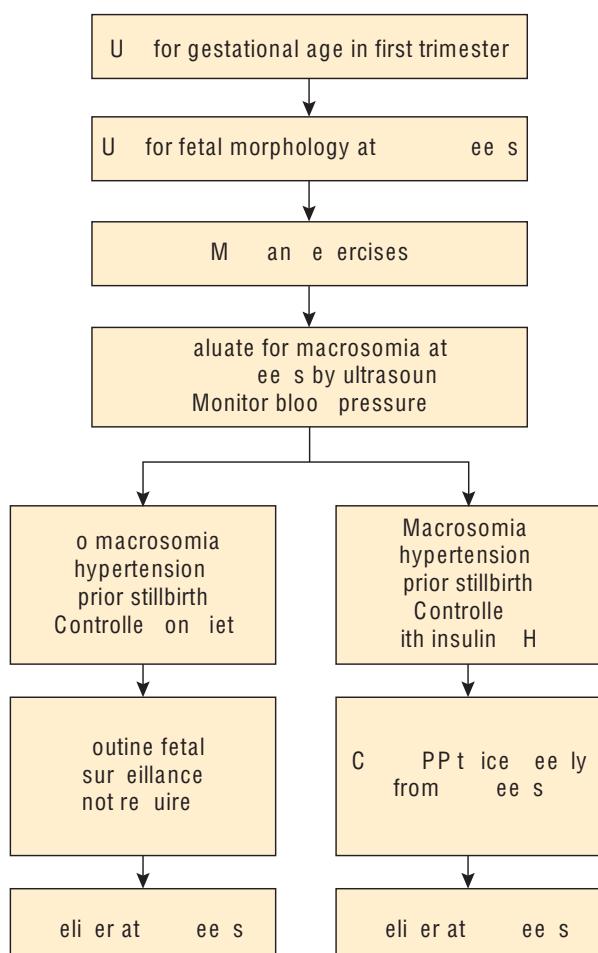


Figure 48.2 Management of gestational diabetes mellitus diagnosed in the first trimester. BPP, biophysical profile; C, cardiotocography; MNT, medical nutritional therapy; OHA, oral hypoglycemic agents; US, ultrasonography.

Box 48.18 Intrapartum management of GDM

- Obstetric management
 - Monitor dilatation and descent
 - Maintain a partogram
 - Watch for arrest of dilatation/descent
 - Monitor fetal heart electronically
 - Anticipate shoulder dystocia
- Glycemic control
 - Target glucose level: <140 mg%
 - GDM on diet
 - Monitor glucose 4–6 hourly
 - Administer insulin only if required
 - GDM on insulin
 - Continue usual bedtime dose of insulin
 - Withhold morning dose of insulin and provide intravenous infusion 5% dextrose in the morning if undergoing
 - induction
 - elective cesarean section
 - Monitor capillary glucose hourly
 - Add soluble insulin to infusion
 - Titrate dose to maintain target glucose level

D gestational diabetic mellitus.

Intrapartum management

Obstetric management consists of electronic fetal heart monitoring, monitoring cervical dilatation and descent, and preparing for management of shoulder dystocia. Uncomplicated GDM on diet will not require insulin during labor but those on insulin in pregnancy will require intrapartum insulin. Plasma glucose may be monitored 4–6 hourly.

The target value for intrapartum glucose level is <140 mg%. Higher values lead to neonatal hypoglycemia. The target levels are achieved by insulin infusion titrated according to capillary glucose levels monitored by glucometer hourly (Box 48.18).

Postpartum management

Insulin requirement falls immediately after delivery. Most women with GDM will not require insulin in the postnatal period. Glucose levels should be tested 24 hours after delivery. Women with GDM should be advised about postpartum diet, exercise, and lifestyle modification.

A 75-g GTT should be performed 6–12 weeks after delivery and repeated 3 yearly since women with GDM are at a high risk for development of type 2 diabetes.

Box 48.19 Maternal complications in pregestational diabetics

- Nephropathy
 - Increased risk of preeclampsia
 - Worsening of proteinuria
 - Worsening of hypertension
- Retinopathy
 - Worsening of proliferative retinopathy
 - Vitreous hemorrhage
 - Treatment: Laser therapy and good glycemic control
- Coronary heart disease
 - Increase in maternal mortality

AC angiotensin-converting enzyme.

Pregestational (overt) diabetes

Pregestational diabetics are prone to fetal complications such as spontaneous miscarriage and congenital anomalies that are not seen in gestational diabetics. In addition, preexisting maternal complications such as nephropathy and retinopathy may worsen during pregnancy (Box 48.19).

ephropathy

Proteinuria worsens during pregnancy in women with diabetic nephropathy. Most women with diabetic nephropathy have associated hypertension and are on antihypertensives. Antihypertensives such as angiotensin-converting enzyme (ACE) inhibitors are contraindicated in pregnancy. These women should be switched to a safer medication preconceptionally. Hypertension may worsen in pregnancy and these women may develop superimposed preeclampsia with its associated fetal and maternal complications. This, in turn, may worsen renal function.

etinopathy

Longstanding pregestational diabetes may be associated with nonproliferative and proliferative retinopathy. Proliferative retinopathy can worsen in pregnancy and vitreous hemorrhage can occur. Laser photocoagulation should be performed before the hemorrhage occurs. Good glycemic control is mandatory to reduce the risk of these complications. Most retinal changes regress after delivery, but a few may persist or progress;

therefore, ophthalmic evaluation, treatment, and follow-up are mandatory during and after pregnancy.

Preconceptional management

Preconceptional management is an important aspect of management of women with pregestational diabetes. The degree of glycemic control should be assessed and complications should be looked for. Medications must be evaluated and changed if required. Oral hypoglycemic agents are not recommended in pregestational diabetes and should be changed to insulin. The patient should be counseled regarding potential complications to the mother and fetus and the need for tight control of blood sugar levels should be emphasized (Box 48.20). The risk of congenital anomalies increases when the HbA1c is >10% at conception and in the first trimester. In order to

avoid complications, plasma glucose and HbA1c should be at optimal levels. Periconceptional folic acid supplementation is recommended to reduce the risk of neural tube defects. Commonly used antihypertensives such as α -methyldopa, nifedipine, and labetalol are safe in pregnancy. If the patient is on ACE inhibitors or angiotensin II receptor blockers (ARB), these should be changed to one of the previously mentioned antihypertensives and control optimized.

Antenatal management

Maternal and perinatal morbidity and mortality are higher in pregestational diabetes. Management should be in consultation with an endocrinologist/diabetologist and neonatologist.

Medical management

Medical management is aimed at maintaining plasma glucose values within target levels. This is the key factor in reducing perinatal mortality and morbidity in diabetic pregnancies. Hypoglycemia should also be avoided. Nocturnal drop in glucose values should be looked for between 2 and 4 am and should be maintained at >60mg%.

Diet (Medical nutritional therapy)

Overall, the dietary requirements are the same as in GDM. It is important to achieve tight glycemic control without causing hypoglycemia and ketosis. Total calories are divided into three meals and three snacks as discussed earlier and distributed as follows:

- Breakfast: 10%–20%
- Lunch: 20%–30%
- Dinner: 30%–40%
- Snacks: 30% (each snack–10%)

Supplementation of folic acid, calcium, magnesium, and zinc is required.

Exercise

Moderate exercise is advisable to assist in glycemic control and to avoid excessive weight gain.

Pharmacotherapy

Oral hypoglycemic agents

Metformin and glyburide (glibenclamide) have not been adequately studied in pregestational diabetes; therefore, they are not recommended routinely. However, metformin is currently

Box 48.20 Preconceptional management of diabetes mellitus

Test	Target value (mg dL)
Fasting glucose	<95
1-hour postprandial glucose	<140
2-hour postprandial glucose	<120
Nocturnal (2–4 am) glucose	>60
HbA1c	<6%
• Evaluate glycemic control	
• Optimize weight to BMI <27 kg/m ²	
• Assess complications	
– Serum creatinine	
– Urine protein and microalbumin	
– Ophthalmic examination	
– ECG/Echocardiogram	
– TSH	
• Review medications	
– Oral hypoglycemic: Change to insulin	
– ACE inhibitors/ARBs: Change to safer drugs	
• Counsel about	
– Maternal complications	
– Fetal complications	
– Need for tight glycemic control	
▪ Diet	
▪ Moderate exercise	
▪ Medications	
• Prescribe folic acid: 5 mg daily	

AC, angiotensin-converting enzyme; A, B, angiotensin receptor blocker; B, body mass index; C, electrocardiography; S, thyroid-stimulating hormone.

recommended as an adjunct to insulin or as primary therapy in obese, mild diabetics.

nsulin

Insulin therapy is started prepregnancy and continued through pregnancy. Intensive insulin therapy is required to achieve euglycemia throughout the day. The requirement of insulin declines in the first trimester due to nausea and vomiting. Ketosis is common at this time and should be watched for and treated early. Insulin requirement increases in the second half of pregnancy and should be adequately replaced.

Short-acting insulin, four times a day, administered before breakfast, lunch, and dinner and at bedtime is usually recommended in pregestational diabetes. Occasionally, a combination of intermediate-acting (NPH) and short-acting insulin, given twice daily, may be sufficient. Rapid-acting insulin analogs (lispro, aspart) may be used, but glargine insulin has not been adequately evaluated. Self-glucose monitoring is convenient and practical. Glucose levels should be monitored fasting and postmeal (breakfast, lunch, and dinner) and dose of insulin adjusted accordingly.

Medical management in pregestational diabetics is outlined in Box 48.21.

bstetric management

The clinician should be aware of the special obstetric issues in a pregnancy complicated by pregestational diabetes and should have expertise to manage them.

Box 48.21 Medical management of pregestational diabetes during pregnancy

- Diet
- Moderate exercise
- Pharmacotherapy
 - Oral hypoglycemic agents: Being evaluated. Metformin in mild, obese diabetics
 - Insulin
 - Human insulin used
 - Short-acting (4 doses per day) or intermediate-acting + short-acting (2 doses per day)
 - Insulin analogs
 - May use rapid-acting analogs
 - Long-acting analog not recommended
- Glucose monitoring
 - Fasting and postmeal
 - Insulin adjusted accordingly

Antepartum management

First trimester

If the woman has not been seen preconceptionally, she should be evaluated for glycemic control, renal functions, and retinopathy at the first visit. Counseling regarding permitted weight gain, diet, exercises, pharmacotherapy, need for tight glycemic control, target glucose values, and potential fetal and maternal complications is mandatory. An ultrasound scan should be performed in the first trimester for accurate estimation of gestational age. This is important since many women may require induction of labor. Measurement of nuchal translucency and first trimester screening for Down syndrome should be done, if available, since second trimester screening cannot be done in diabetics. Folic acid supplementation should be continued.

Second trimester

Maternal serum alpha fetoprotein is estimated at 16–18 weeks' pregnancy to detect neural tube defects. The levels are lower in diabetic pregnancy, and this should be kept in mind when interpreting the results. Detailed assessment of fetal anatomy including a four-chamber view of the heart should be performed at 18–20 weeks. Fetal echocardiography is recommended in all diabetic pregnancies (Box 48.22).

Third trimester

Clinical examination includes close monitoring of blood pressure and obstetric examination to identify polyhydramnios, macrosomia, or growth restriction. Urine examination for proteinuria is mandatory at every visit.

Beginning at 28 weeks, fetal growth should be evaluated. Interval between scans depends on severity of diabetes, glycemic control, and fetal growth abnormality including macrosomia or growth restriction and associated complications such as preeclampsia. Nonstress test (NST) should begin at 32 weeks. Biophysical profile and fetal umbilical and middle cerebral artery Doppler velocimetry are also useful if there is growth restriction. These tests may be performed 2- to 4-weekly if glycemic control is good and fetal growth is normal. In poorly controlled diabetes, preeclampsia, macrosomia, or fetal growth restriction, more frequent testing, such as weekly or twice a week, is required (Box 48.23). Estimation of fetal weight at term

Box 48.22 Antepartum management of pregestational diabetics in the first and second trimesters

- First trimester
 - Evaluation
 - Glycemic status
 - Retinopathy
 - Nephropathy
 - Counseling
 - Diet and exercise
 - Insulin therapy
 - Self-glucose monitoring
 - Target glucose values
 - Complications
 - Maternal
 - Fetal
 - Ultrasonography
 - Accurate estimation of gestational age
 - Nuchal translucency
- Second trimester
 - Maternal serum alpha fetoprotein
 - Ultrasonography
 - Fetal morphology
 - Fetal echocardiogram
 - Close monitoring of blood pressure

Box 48.23 Management of pregestational diabetics in the third trimester

- Clinical examination
 - Blood pressure
 - Symphysiofundal height
 - Fetal macrosomia
 - Fetal growth restriction
 - Polyhydramnios
 - Vulvovaginal candidiasis
- Evaluation of fetal well-being
 - Ultrasonography
 - Started at 28 weeks
 - Once in 1, 2, or 4 weeks or twice a week
 - Look for
 - biophysical profile
 - umbilical and middle cerebral artery Doppler
 - fetal growth and weight
 - Nonstress test
 - Started at 32 weeks
 - Weekly as primary test
 - Twice weekly if indicated

is useful to some extent in deciding on mode of delivery, although it is not a sensitive predictor of shoulder dystocia.

Timing of delivery

The timing of delivery has to be balanced between prematurity and complications arising from delay. Early delivery is associated with an increase in risk of respiratory distress syndrome. Prolonging the pregnancy in the presence of maternal or fetal compromise increases perinatal mortality and morbidity.

In women with good glycemic control and no fetal compromise, preeclampsia, or hypertension, delivery is recommended at 39–40 weeks. Those with poor glycemic control should be delivered by 37 weeks. In women with maternal or fetal compromise, delivery should be planned when the fetal testing becomes abnormal or when preeclampsia worsens (Fig. 48.3).

Vaginal delivery

Vaginal delivery of a macrosomic baby can give rise to shoulder dystocia and brachial plexus injury. Although abdominal circumference and fetal weight have been used to predict shoulder dystocia, they have poor predictive value. The risk of cephalopelvic disproportion and shoulder dystocia increases when fetal weight is >4000 g. A cesarean section is usually performed in this situation. Pregestational diabetes with associated preeclampsia or severe fetal compromise is also an indication for an elective cesarean section (Box 48.24).

Intrapartum management

Maintenance of glucose levels below 140 mg% during labor is essential to avoid neonatal hypoglycemia. This is achieved by infusion of glucose and insulin and hourly monitoring of plasma glucose levels.

Prolonged labor and arrest of dilatation or descent are indicative of cephalopelvic disproportion. Prolonged second stage is a forerunner of shoulder dystocia. Progress of labor should be closely monitored and plotted on a partogram. Electronic fetal monitoring is essential.

Box 48.24 Indications for elective cesarean section

- Estimated weight >4 kg
- Severe preeclampsia
- Severe fetal compromise

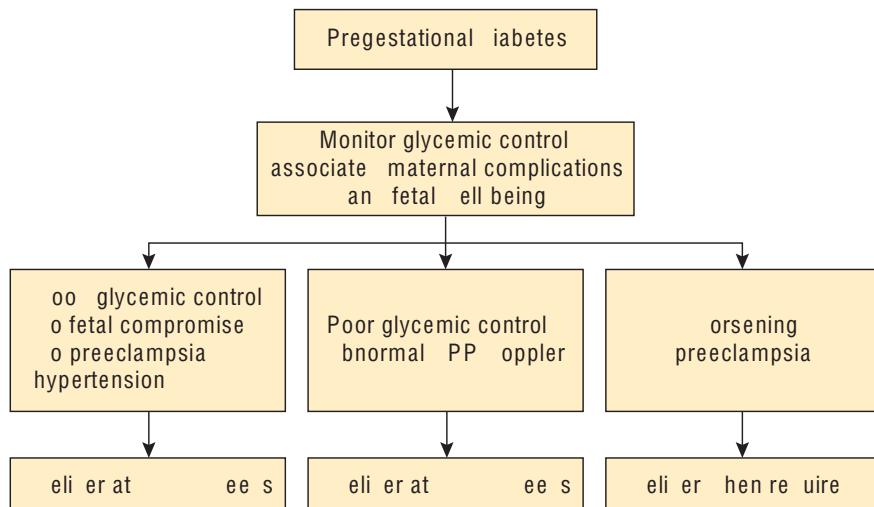


Figure 48.3 Timing and mode of delivery in pregestational diabetics. BPP, biophysical profile.

Intrapartum management is the same as for GDM on insulin, as summarized in Box 48.18.

Postpartum management

Insulin requirement falls immediately after delivery. The dose of insulin should be adjusted accordingly. Breastfeeding should be encouraged as it helps in calorie consumption and glycemic control (Box 48.25).

Contraception

Low-dose oral contraceptive pills, progestrone-only pills, injectable progestogens, and

intrauterine devices are safe in gestational diabetics. In pregestational diabetics with vasculopathy, oral contraceptive pills can increase the risk of thrombosis and worsen insulin resistance. Intrauterine contraceptive devices can be used in these women and, contrary to popular belief, the risk of infection does not increase. Long-acting progestins have not been adequately evaluated (Box 48.26).

Box 48.26 Contraceptive options in diabetes

- Gestational diabetes
 - Low-dose oral contraceptive pills
 - Progestins
 - Intrauterine contraceptive devices
 - Barrier contraception
 - Tubectomy
- Pregestational diabetes
 - Barrier contraception
 - Intrauterine contraceptive devices
 - Tubectomy (if family complete)

Box 48.25 Postpartum management in pregestational diabetics

- Decrease insulin dose to one-third or one-half
- Monitor glucose levels daily
- Change to oral hypoglycemic drugs after 48 hours
- Encourage breastfeeding

Key points

- Diabetes in pregnancy is associated with high perinatal mortality and morbidity if blood glucose levels are not well controlled.
- The prevalence and incidence are increasing globally, due to changes in lifestyle and increase in obesity, metabolic syndrome, and polycystic ovary syndrome.
- Diabetes in pregnancy is classified as gestational and pregestational diabetes. Pregestational diabetes can be type 1 or type 2.
- Type 1 diabetes occurs at a younger age and is due to absolute insulin deficiency. Women with type 1 diabetes are not obese and are prone to ketoacidosis.
- Type 2 diabetes occurs in older women, and is due to peripheral insulin resistance or β -cell dysfunction. These women are obese and ketoacidosis is uncommon.
- Gestational diabetes is defined as glucose intolerance with onset or first recognition in pregnancy irrespective of whether insulin is used for control. It shares many common features with type 2 diabetes.
- Physiological changes in carbohydrate metabolism in pregnancy include fasting hypoglycemia, increase in peripheral resistance to insulin, postprandial hyperglycemia, and an overall diabetogenic state induced by diabetogenic hormones and other diabetogenic substances produced in pregnancy.
- Screening for diabetes can be by a two-step approach that consists of a glucose challenge test followed by diagnostic testing with glucose tolerance test (GTT) or by a one-step approach performed at the first visit that consists of fasting or random plasma glucose or HbA1c.
- Oral glucose tolerance test (OGTT) with 75-g glucose is the diagnostic test currently recommended. Plasma glucose is measured fasting and 1 and 2 hours after glucose administration.
- Risk categorization is used to decide on one-step approach or GTT at 24–28 weeks. Intermediate- and high-risk women undergo the one-step monitoring at the first antenatal visit and if normal, GTT is repeated at 24–28 weeks.
- Diabetes is associated with several maternal and fetal complications. Ketoacidosis, miscarriage, and congenital anomalies occur only in pregestational diabetes.
- Several neonatal problems and late complications can also occur in diabetes.
- Management of pregestational diabetes starts with preconceptional weight reduction and counseling of high risk women.
- Pregestational diabetics should be evaluated for nephropathy and retinopathy prior to pregnancy. Those on oral hypoglycemic agents (OHAs) should be switched to insulin. Antihypertensives such as angiotensin-converting enzyme (ACE) inhibitors and angiotensin II receptor blockers (ARBs) should be changed to α -methyldopa or labetalol.
- Glycemic control is by medical nutritional therapy (MNT), exercises, and insulin in all diabetics. Oral hypoglycemic drugs may be used as an alternative in gestational diabetes.
- Tight glycemic control is the key to prevention of all complications.
- Ultrasonography should be used to estimate gestational age and evaluate nuchal translucency in the first trimester, exclude congenital anomalies at 18–20 weeks, and evaluate fetal well-being and growth in the third trimester.
- In complicated pregnancies, fetal well-being is evaluated by nonstress test (NST), biophysical profile (BPP), umbilical artery and middle cerebral artery Doppler velocimetry. Testing should begin at 28 weeks. Frequency of testing depends on severity of diabetes, glycemic control, associated maternal complications, and fetal well-being.
- Uncomplicated gestational and pregestational diabetes may be delivered at 39–40 weeks. Early delivery is indicated for poor glycemic control, fetal compromise, or preeclampsia.
- An elective cesarean section is recommended if fetal weight is >4 kg.
- Intrapartum glycemic control is by infusion of glucose and insulin and hourly glucose monitoring to titrate insulin dose in order to avoid neonatal hypoglycemia.

Self-Assessment

Case-based questions

Case 1

Mrs. PN, 28, second gravida, at 30 weeks, was referred to the antenatal clinic by a village midwife since she felt that the baby was big. Oral glucose tolerance test with 75 g glucose revealed fasting glucose value of 108 mg/dL, 1-hour

value of 200 mg/dL, and 2-hour value of 160 mg/dL. Her blood sugars were not tested in the previous pregnancy.

1. What is the diagnosis in this case?
2. What maternal complications do you anticipate?
3. What fetal and neonatal complications do you anticipate?
4. How will you control blood sugar?

Case 2

Mrs. JC, 27, second gravida with a previous normal delivery, had come for routine antenatal care at 8 weeks' pregnancy.

1. Will you screen for diabetes? Why?
2. How will you screen?
3. If the screening test reveals a random plasma glucose value of 210 mg%, what complications do you anticipate?
4. What additional evaluation will you do in the first and second trimesters?

Case 3

Mrs. NC, 30, primigravida, pregestational diabetic on 12, 10, 10, and 8 units of soluble insulin with breakfast, lunch, and dinner and at bedtime was admitted for labor induction. Outline the steps of management.

Answers

Case 1

1. Glucose intolerance has been diagnosed for the first time; hence the diagnosis is gestational diabetes.
2. She is in the third trimester—polyhydramnios, gestational hypertension/preeclampsia, and preterm labor should be anticipated. Intrapartum—prolonged labor, instrumental delivery, shoulder dystocia and cesarean section.
3. Macrosomia, neonatal hypoglycemia, hypocalcemia, and hyperbilirubinemia.
4. Start on MNT and moderate exercises, and recheck blood glucose after 3 days. Start on glibenclamide 2.5 mg daily if fasting glucose is >95 mg% but <110 mg%. The dose can be increased by 2.5 mg to a maximum of 10 mg before dinner. If fasting glucose is >110 mg%, start on insulin—combination of intermediate- and short-acting twice daily—and adjust the dose to achieve target glucose values.

Case 2

1. Yes. She is from an ethnic group with high risk for diabetes and is >25 years old.
2. By the one-step approach at the first visit, by a fasting plasma glucose. If >92 mg/dL, she should be

managed as a gestational diabetic. If <92 mg/dL, an oral GTT should be performed at 24 weeks.

3. At 8 weeks' pregnancy, a value of 210 mg/dL indicates pregestational diabetes. Spontaneous miscarriage, congenital malformations, and ketoacidosis are to be anticipated.
4. Maternal serum alpha fetoprotein at 16 weeks, ultrasonography at 18 weeks to exclude congenital anomalies, and fetal echocardiogram for cardiac anomaly.

Case 3

The steps in the management are as follows:

1. Administer the usual dose of insulin the night before induction.
2. Check fasting blood glucose on the day of induction.
3. Start on dextrose infusion.
4. Add soluble insulin to the infusion to maintain glucose level at <140 mg%.
5. Monitor plasma glucose hourly. Monitor progress of labor; maintain a partogram.
6. Monitor the fetal heart electronically.
7. Anticipate shoulder dystocia and be prepared.
8. Perform a cesarean section if there is arrest of descent/dilatation.

Sample questions

Long-answers questions

1. A 32 year old second gravida with pregestational diabetes, comes for antenatal check-up at 8 weeks' gestation. Discuss the management.
2. Discuss the diagnosis and management of gestational diabetes.

Short-answer questions

1. Screening for gestational diabetes
2. Preconceptional management of an overt diabetic
3. Medical nutrition therapy
4. Fetal macrosomia
5. Oral glucose tolerance test in pregnancy
6. Maternal complications in a pregnant diabetic
7. Fetal complications of diabetes in pregnancy

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Hematological Disorders

Case scenario

Mrs. CP, 21, gravida 2, para 1, was in the 16th week of gestation. Her first child was 1 year old. She felt tired and breathless when she climbed stairs. She appeared pale on her routine antenatal checkup.

Introduction

Anemia is the most common hematological disorder in pregnancy. It is a major public health concern in developing countries.

The majority of anemia in pregnancy is due to iron, folate, or vitamin B₁₂ deficiency. Less commonly, it could be a consequence of hemoglobinopathies such as thalassemia and sickle cell anemia. It could also be due to autoimmune hemolytic anemia or aplastic anemia. Sometimes, anemia can be associated with systemic diseases such as chronic infections, rheumatoid arthritis, human immunodeficiency virus (HIV), and renal failure.

Another hematological disorder encountered in pregnancy is thrombocytopenia. It can be gestational thrombocytopenia, immune thrombocytopenia (ITP), or a result of complications of pregnancy.

Anemia in pregnancy

Anemia is one of the most prevalent problems involving nutritional deficiency in pregnant women. Maternal anemia results in significant perinatal morbidity and mortality.

Prevalence

Anemia affects nearly 50% of pregnant women globally. As compared with 25% in developed countries, the prevalence of anemia in Indian mothers is between 80% and 90%.

Definition

Anemia is defined by the World Health Organization (WHO) as hemoglobin levels of $\leq 11 \text{ g/dL}$ or hematocrit of $<33\%$. It can also be

defined as a value less than the fifth percentile of the distribution of hemoglobin or hematocrit in a healthy reference population based on the trimester of pregnancy. The Federation of Obstetric and Gynecological Societies of India (FOGSI) has suggested a cutoff of 10 g/dL for India.

Physiological anemia of pregnancy

In normal pregnancy, there is an increase in blood volume, which results in an associated hemodilution. Although red blood cell (RBC) mass increases during pregnancy, plasma volume increases more, resulting in a relative anemia (see Chapter 3, *Maternal physiology in pregnancy*). This results in a physiologically lowered hemoglobin level, hematocrit value, and RBC count. It has no effect on the mean corpuscular volume (MCV). Since these changes are trimester dependent, anemia is defined as given in Box 49.1.

Categorisation of anemia according to severity

Anemia is categorized by the WHO and the Indian Council of Medical Research (ICMR) as given in Table 49.1.

Box 49.1 Definition of anemia

- ≤ 11 g/dL in the first trimester
- ≤ 10.5 g/dL in the second trimester
- ≤ 11 g/dL in the third trimester
- <11 g/dL at 1 week postpartum
- <12 g/dL at 8 weeks postpartum

Classification of anemia

Anemias can be classified according to their etiology. Nutritional deficiency is the commonest cause. Anemia can also occur due to decreased production of red blood cells, increased destruction of RBCs, or blood loss (Box 49.2)

Box 49.2 Classification of anemia based on etiology

Anemias associated with nutritional deficiency

- Iron deficiency
- Folic acid deficiency
- Vitamin B₁₂ deficiency
- Combined deficiencies

Anemias associated with decreased production of blood cells

- Bone marrow disorders
- Bone marrow suppression
- Chronic renal disorders
 - Low levels of erythropoietin
- Hypothyroidism

Anemias associated with increased red blood cell destruction

- Inherited hemolytic anemias
 - Sickle cell anemia
 - Thalassemia major
 - Hereditary spherocytosis
- Acquired hemolytic anemias
 - Autoimmune hemolytic anemia
 - Hemolytic anemia associated with
 - thrombotic thrombocytopenic purpura
 - hemolytic uremic syndrome
 - malaria

Anemia due to blood loss

- Hemorrhagic anemia
- Heavy menstrual bleeding
- Gastrointestinal bleeding
- Obstetric hemorrhage

Table 49.1 Categorisation of anemia

Category	WHO (hemoglobin in g/dL)	ICMR (hemoglobin in g/dL)
Mild anemia	9–10.9	10–11
Moderate anemia	7–10.9	7–10
Severe anemia	<7	4–7
Very severe	<4, decompensated	<4

C Indian Council of Medical Research;

World Health Organization.

Iron metabolism

Iron requirements vary in the nonpregnant and the pregnant woman. There is an increased demand for iron in pregnancy to supply the fetus and placenta, in addition to supporting the increase in the mother's blood volume. The body's iron stores also have to be supplemented in anticipation of blood loss during delivery and the postpartum period. Pregnancy causes important changes in iron metabolism to meet these demands.

Iron metabolism in the nonpregnant woman

The normal daily diet contains 10–20 mg of iron. Absorption of iron takes place in the duodenum. Ferric iron is converted to ferrous iron before absorption, and only approximately 10%–15% (1–2 mg) of ingested iron is absorbed. Once it enters the blood, it is transported by transferrin. The transferrin–iron complex is stored as follows:

- Bone marrow for formation of hemoglobin (75%)
- Liver and spleen for storage as hemosiderin and ferritin (10%–20%)
- Muscles for formation of myoglobin (10%)
- Other tissues for formation of iron-containing enzymes (5%)

The body draws on these stores during periods of increased iron requirement.

Daily loss of iron is approximately 1–1.5 mg, usually through sweat, urine, and menstrual blood. If the loss exceeds the amount absorbed from the diet, there is iron deficiency anemia. Regulation of iron content of the body is by regulation of absorption. Iron supplementation is not routinely required in the nonpregnant woman who is not anemic, because she can meet the requirements through diet. This is in contrast to a pregnant woman who requires iron supplementation to meet the increased demands of pregnancy.

Iron metabolism in pregnant women

In pregnancy, iron is mobilized from maternal iron stores due to increased demands. However, iron stores are low in women from developing countries. **Therefore, in addition to dietary iron, supplemental iron is mandatory in pregnant women.**

Most of the increased iron requirement occurs in the second half of pregnancy. The requirement becomes 6 mg/day after midpregnancy as compared with 1–2 mg/day in the nonpregnant state. Since only 10% of ingested iron is absorbed, the daily intake should be at least 60 mg, especially after 20 weeks' gestation.

The iron requirement for the entire duration of pregnancy is approximately 1000 mg. Another 200 mg of iron is saved due to pregnancy amenorrhea.

This iron is distributed among various pregnancy demands as described in Box 49.3.

Box 49.3 Distribution of total iron requirement in pregnancy

- Fetus and placenta: 300 mg
- Maternal hemoglobin expansion: 500 mg
- Blood loss at delivery: 200 mg
- Replacement of loss through urine, sweat, and feces: 200 mg

Iron deficiency anemia

Iron deficiency anemia is the commonest nutritional anemia in pregnancy. A pregnant woman often has insufficient iron stores to meet the demands of pregnancy. **All pregnant women should be screened for anemia during pregnancy.** Those with iron deficiency anemia should be treated with supplemental iron, in addition to prenatal vitamins. Indian women are at high risk for iron deficiency anemia, and supplemental iron should be prescribed routinely. Patients with anemia other than iron deficiency anemia should be further evaluated.

Causes of iron deficiency in pregnancy in developing countries

Pregnant women in developing countries are more prone to iron deficiency due to the causes listed in Box 49.4.

Effects of iron deficiency anemia on pregnancy

Iron deficiency anemia during pregnancy can have several adverse effects on the mother. There is increased susceptibility to infection,

Box 49.4 Causes of iron deficiency in developing countries

- Inadequate intake
 - Low bioavailability in diet
 - Diets with low iron content
- Iron loss
 - Hookworm infestation
 - Malaria
- Low iron stores
 - Short interpregnancy interval
 - Multiparity
- Defective absorption
 - Phosphates and phytates in diet
 - Deficiency of vitamin C and vitamin A

thromboembolism, and a high risk of preterm labor. Blood loss during delivery or antepartum hemorrhage is tolerated poorly.

Effects on the fetus are not manifest unless the anemia is moderate to severe. Moderate anemia has been associated with an increased risk of low birth weight, prematurity, and perinatal mortality. Severe anemia with maternal hemoglobin levels <6 g/dL has been associated with abnormal fetal oxygenation resulting in nonreassuring fetal heart rate patterns, reduced amniotic fluid volume, fetal cerebral vasodilatation, and fetal death. Thus, maternal blood transfusion should be considered for fetal indications. Obstetric consequences of iron deficiency anemia in pregnancy are listed in Box 49.5.

Box 49.5 Obstetric consequences of iron deficiency anemia

- maternal*
- Preterm delivery
 - Puerperal sepsis
 - Puerperal thromboembolism
 - Poor tolerance to blood loss
 - Postpartum depression
- fetal and neonatal consequences*
- Prematurity
 - Perinatal mortality
 - Low birth weight
 - Poor mental and psychomotor performance
 - Low iron stores
 - With maternal hemoglobin <6 g/dL
 - Nonreassuring fetal heart rate patterns
 - Reduced amniotic fluid volume
 - Fetal cerebral vasodilatation
 - Fetal death

Clinical features of iron deficiency anemia

The clinical features of iron deficiency anemia are listed in Box 49.6.

Box 49.6 Clinical features of anemia

- Mild-to-moderate anemia
 - Fatigue
 - Headache
 - Exercise intolerance
 - Giddiness
 - Palpitation
 - Edema
- Severe anemia
 - Congestive cardiac failure

Physical examination

The following may be seen in a woman with severe or chronic anemia:

- Pallor of the mucus membranes (nonspecific finding)
- Spoon-shaped nails (koilonychia)
- A glossy tongue, with atrophy of the lingual papillae
- Fissures at the corners of the mouth (angular stomatitis)
- Splenomegaly (in severe, persistent, untreated cases)
- Systolic murmur at the aortic area (hemic murmur)
- Signs of cardiac failure
 - Pedal or generalized edema
 - Tachycardia and hepatomegaly
 - Crepitations at lung bases

Diagnosis

hemoglobin complete blood count and peripheral smear

The diagnosis of iron deficiency anemia is commonly made with a complete blood count (which includes hemoglobin, hematocrit, and the red cell indices) and peripheral smear. In some women, iron studies may be required to establish the etiology. A peripheral smear helps to differentiate between iron deficiency and vitamin B₁₂/folic acid deficiency anemia. **Classically, iron deficiency anemia will exhibit smaller RBCs and is called microcytic anemia.**

With vitamin B₁₂ or folate deficiency, the RBCs are much larger and so it is called *macrocytic anemia*.

Red cell indices should also be determined. Anemias can be differentiated by the MCV. **Iron deficiency anemia will have an MCV of <80 fL, whereas vitamin B₁₂ or folic acid deficiency anemia will have an MCV >100 fL.** Mean corpuscular hemoglobin concentration (MCHC) is a sensitive index of iron deficiency anemia.

Serum ferritin

Measurement of serum ferritin is considered to be a sensitive test for the diagnosis of iron deficiency anemia. The levels do not change with recent iron intake. Ferritin levels <15 µg/L are diagnostic of iron deficiency, but treatment should be initiated when levels are <30 µg/L.

Serum iron and total iron binding capacity

Serum iron (<30 µg/dL) and total iron-binding capacity (TIBC >400 µg/dL) are indicative of iron deficiency but are not as sensitive or specific as ferritin levels.

Diagnostic tests for iron deficiency anemia are enumerated in Box 49.7.

Box 49.7 Diagnostic tests for iron deficiency anemia

- Hemoglobin/hematocrit
 - Low hemoglobin and hematocrit
- Complete blood count
 - Low RBC count
 - Normal or elevated white blood cell count
 - Elevated platelet count
- Red cell indices
 - Low MCV (<80 fL)
 - Low MCHC (<30%)
- Peripheral blood smear
 - RBCs microcytic and hypochromic
 - Anisocytosis and poikilocytosis
- Iron studies
 - Low serum ferritin levels
 - Low serum iron levels
 - Elevated total iron-binding capacity
- Tests to determine etiology
 - Stool examination for hookworm infestation
 - Peripheral smear for malarial parasites
 - Urine microscopy for chronic renal disease

C = mean corpuscular hemoglobin concentration; C = mean corpuscular volume; BC = red blood cell.

Prophylactic measures against iron deficiency anemia in pregnancy

In developing countries, the prevalence of low iron stores and iron deficiency anemia in women of fertile age and in pregnant women is considerable.

Iron supplementation is essential in all pregnant women due to the following reasons:

- During pregnancy maternal requirement for iron increases.
- The demand for absorbed iron increases steadily during pregnancy:
 - 0.8 mg/day in the initial 10 weeks' gestation
 - 6 mg after midpregnancy
 - 7.5 mg/day in the last 10 weeks' gestation
- During the entire gestational period, the average demand for absorbed iron is 4–6 mg/day.
- Only 10% of elemental iron will be absorbed (e.g., 6 mg will be absorbed when 60 mg of elemental iron is taken).
- Dietary iron intake is inadequate to fulfill the body iron demands in the second and third trimesters of pregnancy.

Increase in dietary iron

Pregnant women should be advised to take a diet rich in iron, such as green leafy vegetables, sprouts, jaggery, meats, and liver. Overcooking of food should be avoided. Cooking in iron vessels should be encouraged.

Supplemental iron

WHO guidelines have recommended the following:

- Iron should be provided to pregnant women during antenatal visits.
- Iron should be started with the first antenatal visit.
- For countries such as India, where prevalence of anemia is 80%–90% in pregnancy, WHO recommends **daily supplementation of 60 mg elemental iron, in the form of ferrous salts, along with 400 µg of folic acid for a duration of**
 - At least 6 months during pregnancy
 - 3 months postpartum

The Government of India (Ministry of Health) recommends **100 mg of elemental iron (335 mg of ferrous sulfate) and 500 µg of folic acid for 100 days from 14 weeks' gestation for all pregnant women.** The tablets of ferrous sulfate

and folic acid are supplied free of cost by the Government of India.

arasite control measures

Since the prevalence of hookworm infestation is >20% in India, a single dose of albendazole 400 mg or mebendazole 500 mg in the second trimester is recommended by WHO for all pregnant women in endemic areas.

Prophylactic measures for iron deficiency anemia are summarized in Box 49.8.

Box 49.8 Prophylactic measures against iron deficiency anemia

- Increase in dietary iron
 - Green leafy vegetables
 - Sprouts
 - Meat
 - Liver
- Iron supplementation
 - 60–100 mg elemental iron
 - With 500 µg folic acid
 - For at least 100 days from 14 weeks
- Parasite control measures (to be given in second trimester)
 - Albendazole 400 mg single dose or
 - Mebendazole 500 mg single dose

Treatment of iron deficiency anemia

The treatment of iron deficiency anemia is by iron therapy. Route of iron therapy depends on severity of anemia, gestational age, patient compliance, and other factors.

Oral iron therapy

Oral iron is considered as first-line therapy since it is inexpensive and effective when taken properly.

The recommended oral daily dose for the treatment of iron deficiency anemia in pregnant women is in the range of **120–200 mg/day of elemental iron**, depending on the severity of anemia. This may require iron tablets/capsules to be taken two to three times daily.

Choice of preparation

The most appropriate and effective oral iron therapy is the use of a tablet/capsule containing ferrous salts.

- Ferrous fumarate: 300 mg (100 mg elemental iron) per tablet/capsule

- Ferrous sulfate: 150 mg/200 mg (45 mg/60 mg elemental iron) per tablet/capsule
- Ferrous gluconate: 300 mg (30 mg elemental iron) per tablet/capsule

The tablets supplied by the Government of India can be used two times a day. The efficacy of all iron salts mentioned above is similar, and no one preparation is superior to the other.

A large number of other oral iron-containing preparations and nutritional supplements are available. Some enteric-coated, sustained-release preparations such as carbonyl iron, iron polymaltose complex, and ferrous glycine sulfate are also available. These are more expensive but poorly absorbed because they do not release the drug in the duodenum where iron is best absorbed. These preparations are not superior to the ferrous salts mentioned above and are not recommended.

Recommendations for the administration of oral iron are enumerated in Box 49.9.

Side effects

Approximately 30% or more of women will have gastrointestinal symptoms:

- Nausea
- Constipation or diarrhea
- Epigastric distress and/or vomiting

Women should be reassured that the side effects will usually subside after 10–14 days of continuous usage.

Box 49.9 Recommendations for the administration of oral iron

- Best taken on an empty stomach
 - Early in the morning or
 - 2 hours after food
- Iron salts not to be given with food
 - Absorption impaired with phosphates, phytates, and tannates
- Factors that inhibit the absorption of iron salts
 - Antacids
 - H₂ receptor blockers
 - Proton pump inhibitors
 - Milk and dairy products, eggs, cereal
 - Calcium supplements
 - Certain antibiotics (e.g., quinolones)
- Factors that aid in absorption of iron
 - Orange/lemon juice
 - Vitamin C

response to therapy

An increase in the reticulocyte count is used as an indicator of response to iron therapy.

Reticulocyte count increases 7–10 days after start of therapy. Hemoglobin level increases by 0.3–1 g/dL per week with adequate replacement. If hematological improvement does not occur in 3 weeks, the following steps are recommended:

- Reassess compliance
- Exclude and treat hookworm infestation or bleeding hemorrhoids
- Exclude concomitant folate deficiency
- Exclude thalassemia and chronic illness

parenteral iron therapy

The rise in hemoglobin with parenteral iron therapy is the same as with oral therapy. Ensuring compliance is the most important advantage.

Indications for parenteral iron therapy are listed in Box 49.10.

Box 49.10 Indications for parenteral iron therapy

- Unresponsiveness to oral iron
- Noncompliance
- Intolerance to oral iron
- Need for a quick recovery from anemia
 - Close to delivery
- If hemoglobin is 7–9 g/dL after 20 weeks' gestation (Government of India recommendation)

Calculation of dosage

In calculating the dose of parenteral iron required, the hemoglobin deficit is calculated by subtracting the woman's hemoglobin from the normal level (14 g/dL). The total dose is calculated and 1000 mg is added to replenish the iron stores. The formula for calculating total dose of iron required is given as follows:

$$\text{Total dose of iron} = 2.2 \times \text{pregnant weight(kg)} \\ \times \text{hemoglobin deficit (g/dL)} + 1000 \text{ mg}$$

or

$$\text{Total dose of iron} = 0.3 \times \text{pregnant weight (lb)} \\ \times \text{hemoglobin deficit (\%)} + 1000 \text{ mg}$$

Intramuscular iron therapy

For many years, parenteral iron was given only by the intramuscular route. Iron dextran or iron

sorbitol citrate is given as 100 mg/day, deep intramuscular in the gluteal region, using the 'Z' technique to avoid staining of skin.

However, the intravenous route is now preferred for the following reasons:

- Mobilization of iron from intramuscular sites is slow
- Rise in the hemoglobin concentration is not appreciably faster with intramuscular administration
- Intramuscular iron injection
 - Is poorly absorbed
 - Is painful
 - Stains the buttocks
 - Is associated with the development of gluteal sarcomas

Intravenous iron therapy

There are a number of intravenous iron formulations approved for use. In selecting the dose of parenteral iron required, the iron deficit is calculated based on the fact that 1 g of hemoglobin contains 3.3 mg of elemental iron, along with other variables such as blood volume, desired hemoglobin level, and whether or not one wishes to provide additional iron for body stores.

Iron dextran

- Contains 50 mg of elemental iron/mL
- Approved for intramuscular/intravenous route
- The low-molecular-weight preparation preferred
 - Lesser adverse effects than high-molecular-weight dextran
- May be given as repeated doses of 100 mg IV/day (or)
- As total dose infusion
 - Test dose of 25 mg given as slow intravenous push
 - Observed for 15 minutes for reaction
 - Total dose in 500 mL of normal saline over 4 hours
- Safe in pregnancy

Ferric gluconate compound

- Only for intravenous route
- 125 mg of ferric gluconate complex diluted in 100 mL of isotonic saline
- Infused over 30–60 minutes

Iron sucrose

- Only for intravenous route
- Contains 20 mg iron/mL

- 200 mg infused over 60 minutes
- Total dose administered in divided doses of 200 mg/day as daily infusions

Iron isomaltoside

- 20 mg/kg infused over 15 minutes

Ferric carboxymaltose

- Ferric hydroxide carbohydrate complex
- Less anaphylactic reactions compared with other preparations
- Well tolerated in pregnancy
- 20 mg/kg infused over 15 minutes
- Maximum dose of 1000 mg

The intravenous iron preparations are listed in Table 49.2.

Blood transfusion

Blood transfusion may be required in certain situations in iron deficiency anemia. Severe anemia in any trimester is an indication for transfusion. Blood transfusion is also required in situations where rapid improvement in hemoglobin is essential as in women in labor or close to term. Packed cells are used to avoid fluid overload. Transfusion should be given slowly at the rate of 80–100 mL/hour.

The indications for blood transfusion in pregnant women are given in Box 49.11.

Box 49.11 Indications for blood transfusion

- Hemoglobin <5 g/dL at any gestational age
- Hemoglobin <7 g/dL in late third trimester
- Women with severe anemia in labor

Exchange transfusion

Exchange transfusion is rarely used now. It may be indicated in women with severe anemia in congestive cardiac failure who are prone to fluid overload and worsening of cardiac failure with blood transfusion.

Intrapartum management of iron deficiency anemia

Intrapartum management of iron deficiency anemia consists of the following steps:

- Close monitoring for signs of fluid overload and congestive cardiac failure is mandatory.
- Oxygen by mask should be provided if the anemia is severe.
- Prolonged second stage should be avoided.
- Active management of third stage should be performed to prevent excessive blood loss.
- Oxytocics should be administered to prevent third-stage hemorrhage.

Postnatal hemoglobin should be estimated before discharge in the following situations:

- Women delivered by cesarean section
- Postpartum bleeding >500 mL
- Uncorrected antenatal anemia

If mild anemia is diagnosed in the postpartum period, oral iron therapy is the treatment of choice. If anemia is moderate or severe, intravenous iron is recommended.

Contraception

Contraception is important in women with anemia. Adequate spacing of pregnancies allows

Table 49.2 Intravenous iron preparations

Drug	Maximum approved dose per day (mg of elemental iron)	Test dose	Elemental iron concentration (mg/mL)
Iron dextran (low molecular weight)	100	Required	50
Ferric gluconate	125	Recommended if drug allergies present	12.5
Iron sucrose	200–300	Recommended if drug allergies present	20
Iron isomaltoside	20 mg/kg	No	100
Ferric carboxymaltose	20 mg/kg (maximum 1000 mg)	No	50

time for replenishing iron stores and reduces risk of anemia in subsequent pregnancy. Progesterone-only pill, injection medroxyprogesterone, or combined oral contraceptive pills may be used. Intrauterine devices are not contraindicated, but menorrhagia may be a problem. Multiparous women must be encouraged to undergo tubal ligation.

Megaloblastic anemia in pregnancy

Folic acid deficiency and vitamin B₁₂ deficiency can give rise to anemia with large cells (**megaloblasts**) in blood and the bone marrow. Due to abnormalities in DNA synthesis, nuclear maturation is incomplete and the red cells are large (macrocytes) and neutrophils are hypersegmented.

Folic acid deficiency anemia

Folate deficiency is much less common than iron deficiency. Most iron supplements contain folic acid. Folic acid is anyway recommended to all women contemplating pregnancy to reduce the risk of neural tube defects.

Folic acid deficiency coexists with iron deficiency or vitamin B₁₂ deficiency.

An increased MCV (typically >100 fL) can be suggestive of folic acid and/or vitamin B₁₂ deficiency. Determining serum levels of vitamin B₁₂ and folic acid will differentiate between the two. If the folic acid level is low, the mother is treated with oral folic acid at a dose of 1 mg three times daily.

Etiology

The most common cause of folate deficiency is dietary insufficiency. Causes of folic acid deficiency are listed in Box 49.12.

The diagnosis and treatment of folic acid deficiency anemia are summarized in Box 49.13.

Vitamin B₁₂ deficiency anemia

In severe vitamin B₁₂ (cobalamin) deficiency, the woman presents with profound anemia and macrocytic red cells (MCV >100 fL) with or without varying neurological disturbances.

Box 49.12 Causes of folic acid deficiency

- Dietary insufficiency
- Multifetal pregnancy
- Drugs
 - Dilantin
- Malabsorption syndromes
- Hemolysis
 - Malaria
- Sickle cell disease

Box 49.13 Management of folic acid deficiency anemia

- Diagnosis
 - Macrocytic anemia
 - MCV >100 fL
 - Low serum folic acid level
 - Elevated serum LDH levels
 - Elevated serum homocysteine levels
- Prophylaxis
 - 500 µg of folic acid/day during pregnancy
 - Diet rich in folic acid
 - Fresh leafy vegetables
 - Legumes
 - Animal proteins
- Treatment
 - Oral folic acid tablets 500 µg/day (along with iron)
 - Dietary advice
 - Correct concurrent iron deficiency

D lactate dehydrogenase; C mean corpuscular volume.

Box 49.14 Causes of vitamin B₁₂ deficiency

- Inadequate dietary intake (vegetarians and vegans)
- Pernicious anemia caused by lack of intrinsic factor
- Gastrectomy and gastritis
- Insufficient pancreatic protease (e.g., chronic pancreatitis, Zollinger-Ellison syndrome)
- Malabsorption syndromes
- HIV infection
- Hereditary disorders

human immunodeficiency virus.

The causes for vitamin B₁₂ deficiency are listed in Box 49.14.

Clinical symptoms of vitamin B₁₂ deficiency anemia

Vitamin B₁₂ stores are very large in the body, and it takes years to deplete them. Symptoms therefore take a long time to manifest. If there is iron deficiency anemia concomitantly, vitamin B₁₂

Box 49.15 Signs and symptoms of severe vitamin B₁₂ deficiency

- Smooth beefy red tongue with loss of papillae
- Gastrointestinal symptoms
 - Burning or soreness of tongue
 - Anorexia
 - Nausea and vomiting
 - Heartburn
 - Flatulence
- Neurological symptoms
 - Paresthesias
 - Numbness
 - Weakness
 - Loss of dexterity
 - Impaired memory
 - Personality changes
- Skeletal changes
 - Osteoporosis

deficiency anemia may get masked. The clinical signs and symptoms of severe vitamin B₁₂ deficiency are listed in Box 49.15.

Diagnosis

The diagnosis of vitamin B₁₂ deficiency anemia is commonly made with a complete blood count and peripheral smear. Serum levels of folic acid and vitamin B₁₂ may be required to differentiate the two anemias since both result in megaloblastic (macrocytic) anemia. Diagnostic tests for vitamin B₁₂ deficiency anemia are enumerated in Box 49.16.

Box 49.16 Diagnostic tests for vitamin B₁₂ deficiency anemia

- Complete blood count
 - Low hemoglobin and hematocrit
 - Low RBC count
 - High MCV (>100 fL)
 - Low MCHC
 - Normal or low reticulocyte count
 - Normal or low white blood cell count
 - Low platelet counts
- Peripheral blood smear
 - Macrocytic RBCs
 - Hypersegmented neutrophils
- Serum levels
 - Low vitamin B₁₂ levels
 - High homocysteine levels

C mean corpuscular volume; C C mean corpuscular hemoglobin concentration; BC red blood cell.

Effects of megaloblastic anemia on pregnancy

Association between folic acid/vitamin B₁₂ deficiency anemia and preeclampsia-like syndrome, fetal growth restriction, and placental abruption has been reported but not proven.

Treatment of vitamin B₁₂ deficiency anemia

Parenteral cobalamin

Intramuscular or deep subcutaneous cobalamin is administered:

- 1000 µg (1 mg) every day for 1 week
- Followed by 1 mg every week for 4 weeks

Dimorphic anemia

Dimorphic anemia refers to anemia that has two different causes acting together, for example, iron deficiency as well as a vitamin B₁₂ deficiency, or iron deficiency and folate deficiency. Dimorphic anemia can occur in pregnancy and is not uncommon in women with chronic malnutrition, multifetal pregnancy, or malabsorption. The peripheral smear shows macrocytic and microcytic, hypochromic red cells with anisocytosis. Treatment is by correction of iron and vitamin B₁₂/folic acid deficiency.

Sickle cell disease in pregnancy

Sickle cell disease (SCD) is an inherited disorder due to homozygosity for the abnormal hemoglobin—hemoglobin S (HbS). The two classic features are as follows:

- Hemolysis
 - Results in anemia ('sickle cell anemia')
- Vaso-occlusive phenomena
 - Lead to recurrent painful episodes ('sickle cell crisis')

Most pregnancies complicated by SCD will result in live birth. However, there is an increased risk of obstetric, fetal, and medical complications.

Pathophysiology of sickle cell disease

Anemia occurs as a result of the sickle hemoglobinopathies. Deoxygenation of the abnormal RBCs results in sickling. These permanently damaged RBCs are then removed by the reticuloendothelial system, with the average RBC life span reduced to 17 days. The result is a chronic compensated anemia, with hemoglobin level typically between 6.5 and 9.5 g/dL.

The stiff, inflexible sickle cells obstruct the microvasculature. This can result in vascular stasis, hypoxia, acidosis, and increased 2,3-diphosphoglycerate leading to further deoxygenation, and, thus, more sickling. The microvascular injury can result in ischemic necrosis and end-organ infarction. Organs affected by chronic sickling include the spleen, lungs, kidneys, heart, and brain.

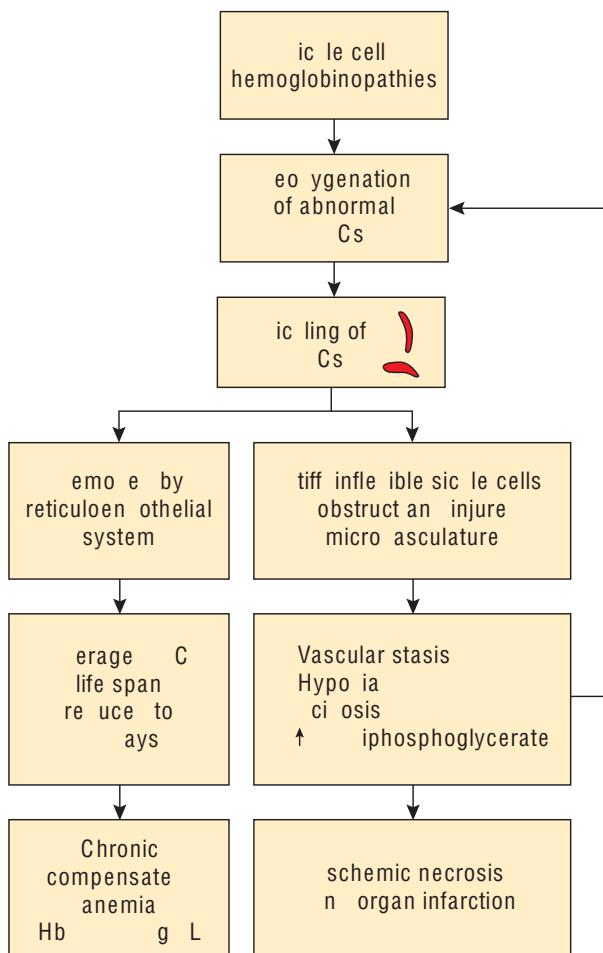


Figure 49.1 Pathophysiology of sickle cell disease. *b*, hemoglobin; *BC*, red blood cell.

The pathophysiology of SCD is encapsulated in Figure 49.1.

Prepregnancy evaluation, counseling, and immunization

A woman with SCD who is contemplating pregnancy should undergo prepregnancy counseling and evaluation (Box 49.17).

Box 49.17 Prepregnancy evaluation, counseling, and immunization in sickle cell disease

- Confirmation of subtype of disease (if not already done)
- Baseline blood pressure
 - Risk factor for
 - superimposed preeclampsia
 - stroke
- Hemoglobin, hematocrit, and ferritin level
 - Women with high iron stores should not receive iron supplements
- Hepatitis B and C screening to assess the risk of perinatal transmission
- Discontinuing the following medications contraindicated in pregnancy:
 - Hydroxyurea
 - Chelating agents
 - Angiotensin-converting enzyme inhibitors
 - Angiotensin II receptor blockers
- Genetic counseling
 - Check husband for hemoglobinopathy
 - Discuss risk of transmitting SCD to fetus
 - Discuss prenatal diagnosis with possible termination of an affected pregnancy
 - Discuss preimplantation genetic diagnosis for selection of embryos without SCD
- Immunization with following vaccines:
 - Pneumococcal
 - *Haemophilus influenzae* type B
 - Meningococcal

SCD sickle cell disease.

Course of SCD during pregnancy

Maternal morbidity from SCD is the same during pregnancy as during the nonpregnant state. The most common maternal SCD complications that occur in over 50% of pregnant women are as follows:

- Anemia

- Acute painful episodes ('sickle cell crisis')
 - Pain involving the abdomen, chest, vertebrae, or extremities
 - More common in later pregnancy and postpartum
 - Associated with thrombophlebitis or preeclampsia
 - More common in sickle cell anemia

Effect of SCD on maternal and fetal outcomes

Pregnancy complicated with SCD has an increased risk of the following:

- Gestational hypertension and preeclampsia
- Eclampsia
- Preterm labor
- Postpartum infection
- Abruptio
- Fetal growth restriction

Women with sickle cell trait do not have an increased risk for pregnancy complications. However, they may have increased risk for anemia and bacteriuria.

In spite of improved maternal and fetal survival, pregnant women with the sickle hemoglobinopathies remain at risk for renal insufficiency, cerebrovascular accident, cardiac dysfunction, leg ulcers, and sepsis, particularly from encapsulated organisms.

Prenatal care in SCD

A pregnant woman who has SCD requires close observation. Other than routine prenatal care, women with SCD also specifically require the following:

- Folic acid supplementation (iron cannot be administered)
- Frequent blood tests for anemia
- Urine culture for bacteriuria every trimester
- Serial ultrasound monitoring for fetal growth
- Fetal surveillance from 34 weeks
- Checking for red blood alloimmunization because of previous frequent blood transfusions

Prophylactic blood transfusions have been recommended for women with previous perinatal mortality, severe anemia, to treat acute complications or in preparation for surgery.

Labor and delivery

There are no medical contraindications to vaginal delivery. Cesarean section can be done when indicated for obstetric reasons. Thromboprophylaxis, adequate hydration, and blood transfusion are recommended in the case of a cesarean delivery.

Cord blood

The cord blood is collected for the following:

- Testing the newborn for hemoglobinopathy
- Storing the stem cells (if negative for hemoglobinopathy) for future transplantation to a family member affected with SCD

Thalassemias in pregnancy

Healthy adults have >95% hemoglobin A (HbA), which consists of two β -globin and two α -globin chains. Thalassemias are characterized by impaired production of one or more of the normal globin chains found in hemoglobin. The clinical consequences can be ineffective erythropoiesis, hemolysis, and anemia of varying degrees.

Types of thalassemias

The characteristics of the different types of thalassemias are listed in Box 49.18.

Box 49.18 Characteristics of different types of thalassemias

- α - or β -thalassemia **minor** or **trait**
 - Majority of affected adults are asymptomatic
 - Microcytic, hypochromic red cells
 - With or without minor degree of anemia
- Thalassemia intermedia
 - Common throughout the world
 - More than one hemoglobin mutation in the same patient
 - For example, sickle cell thalassemia, hemoglobin E (HbE)/ β -thalassemia
- β -Thalassemia **major**
 - Lifelong transfusion-dependent anemia
- α -Thalassemia **major**
 - Incompatible with extrauterine life

Genetics of thalassemias

Inheritance is autosomal recessive. The gene loci for the α -globin chains are located on the short arm of chromosome 16. The β -chain gene is located on the short arm of chromosome 11. Thalassemias are prevalent in many ethnic groups in India.

If both parents have thalassemia minor (or trait), the offspring have a 50% chance of inheriting the trait; 25% will have thalassemia major and 25% will be unaffected (Fig. 49.2).

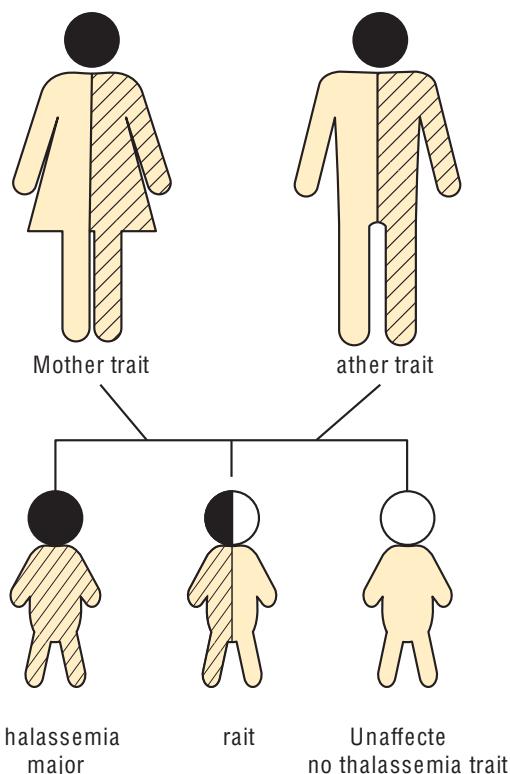


Figure 49.2 Inheritance pattern of thalassemias when both parents have thalassemia trait.

β -Thalassemia

In the β -thalassemias, point mutations cause absence of or reduction in β -chain production. Elevated levels of hemoglobin F (HbF) can often be found and HbA is usually absent in these individuals.

β -Thalassemia major (Cooley anemia)

β -Thalassemia major occurs when both β -genes are missing. The majority of affected women

are infertile. β -Thalassemia is a lifelong transfusion-dependent anemia. It is characterized by the following:

- Erythropoiesis and hemolysis are ineffective.
- During fetal life, high levels of HbF are protective.
- After birth, as HbF levels fall, the infant develops anemia.
- Blood tests
 - Profound hypochromic, microcytic anemia
 - Bizarre red cell morphology
 - Increased indirect bilirubin and lactate dehydrogenase
 - Reduced or absent haptoglobin

β -Thalassemia minor or trait

β -Thalassemia minor occurs in individuals who are heterozygous for the gene mutation and therefore have variable production of the β -globin chain. It has variable clinical effects, depending on the rate of β -chain production. It may be unmasked during pregnancy or uncovered after a mother has delivered a homozygous infant.

Hemoglobin electrophoresis in thalassemia minor characteristically shows the adult hemoglobin, HbA2, to be increased to >3.5%.

Obstetric implications

The following are the obstetric implications:

- Fertility not impaired
- Pregnancy outcomes good
- May become disproportionately anemic
 - Require iron or folate supplementation during pregnancy
- Important to offer prenatal diagnosis to assess fetal hemoglobinopathy (see Chapter 12, *Prenatal screening, prenatal diagnosis, and fetal therapy*)
 - Amniocentesis or chorion villus sampling
 - Noninvasive prenatal testing
 - Polymerase chain reaction (PCR) of fetal DNA

α -Thalassemia

α -Thalassemia disorders involve loss of one of the four α -globin genes. The characteristics of different types of α -thalassemia are summarized in Box 49.19.

Box 49.19 Types of α -thalassemia depending on number of genes deleted

- Deletion of one α -globin gene
 - α -Thalassemia ***minima***
 - Silent carrier
 - Laboratory values in the normal range
- Deletion of two α -chain genes
 - α -Thalassemia ***minor or trait***
 - Mild-to-moderate hypochromic, microcytic anemia
 - Affected woman tolerates pregnancy well
- Deletion of three of the four α -globin genes
 - α -Thalassemia ***intermedia*** or ***b*** ***isease***
 - HbH and Hb Bart's in RBCs
 - Hemolytic anemia soon after birth
 - Anemia of varying severity
 - Worsening of anemia during pregnancy in affected woman
- Deletion of all four α -globin genes
 - α -Thalassemia ***major***
 - RBCs contain HbBart's
 - Fetal hydrops, intrauterine fetal death, or early neonatal death
 - Possibility of development of preeclampsia in woman carrying affected fetus

b hemoglobin H; BC red blood cell.

Obstetric implications

repregnancy

- Prepregnancy counseling should be offered to identify the couple at risk for an affected fetus.
- Partner should be screened for thalassemia.
- Prenatal diagnosis can be discussed.
- Women with hemoglobin H (HbH) disease should be advised to start folic acid 5 mg daily.

antenatal

- Prenatal diagnosis should be offered (chorionic villus sampling or amniocentesis; see Chapter 12, *Prenatal screening, prenatal diagnosis, and fetal therapy*).
- Women with HbH disease will require folate supplementation.
- Blood should be transfused for severe symptomatic anemia.

abor, delivery and postpartum

- These can be managed as in a normal pregnancy with focus on managing anemia.

Thrombocytopenias in pregnancy

Thrombocytopenia or low platelet count is often encountered in pregnancy. It is typically defined as a platelet count lower than 150,000/ μ L. The obstetrician may encounter thrombocytopenia in one of the following three clinical situations:

- Preexisting thrombocytopenia
 - Immune thrombocytopenia
- Decreasing platelet count or newly discovered thrombocytopenia in pregnancy
 - Gestational thrombocytopenia
 - Immune thrombocytopenia
- Acute onset of thrombocytopenia in the setting of
 - severe preeclampsia
 - hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome
 - acute fatty liver of pregnancy (AFLP)
 - disseminated intravascular coagulation

Management of thrombocytopenia in pregnancy depends on its cause.

Normal platelet count in pregnancy

The majority of women have platelet counts within the normal range of 150,000–450,000/ μ L during normal pregnancies. However, the platelet counts may be slightly lower than in healthy, nonpregnant women.

Gestational thrombocytopenia

Diagnosis

The diagnosis of gestational thrombocytopenia is based on the following criteria:

- Mild thrombocytopenia (mostly >100,000/ μ L, rarely <70,000/ μ L)
- No thrombocytopenia outside of pregnancy
- Occurs late in gestation
- No fetal/neonatal thrombocytopenia
- Spontaneous resolution after delivery

It is suggested that gestational thrombocytopenia may be a mild and transient manifestation of immune thrombocytopenia.

anagement

The management of gestational thrombocytopenia involves

- Follow-up of platelet counts during pregnancy and in the postpartum period
- Obstetric management

latelet counts

After the initial diagnosis, platelet counts can be repeated at each antenatal checkup. If the counts drop below 70,000/ μ L, the counts should be repeated weekly.

Obstetric management

Routine obstetric management is appropriate.

- Epidural and spinal analgesia may be given in women with a platelet count between 50,000 and 80,000/ μ L.
- The neonate must be checked for thrombocytopenia, although it is rare following gestational thrombocytopenia.
- Postpartum follow-up of platelet counts is needed to rule out ITP.

Immune thrombocytopenia

Immune thrombocytopenia occurs in approximately 1 in 1000 to 1 in 10,000 pregnant women. The characteristics of ITP are summarized in Box 49.20.

Box 49.20 Characteristics of ITP

- Immunologically mediated platelet destruction
 - Platelet membrane glycoproteins attacked by anti-platelet antibodies (immunoglobulin G)
 - Platelets destroyed rapidly
 - Not compensated by bone marrow
- Persistent thrombocytopenia (<100,000/ μ L)
- Normal or increased megakaryocytes on bone marrow aspirate
- Absence of splenomegaly
- History of
 - easy bruising
 - petechiae
 - epistaxis
 - gingival bleeding

P immune thrombocytopenia.

anagement

The management of ITP involves the following:

- Measures to improve maternal platelet counts
- Appropriate obstetric management
- Management of neonatal thrombocytopenia

Measures to improve maternal platelet counts

- If the counts stay >70,000/ μ L, it is difficult to distinguish the condition from gestational thrombocytopenia. No treatment is required.

In the antenatal period:

- Women with no bleeding manifestations and platelet counts \geq 30,000/ μ L
 - No treatment until 36 weeks' gestation (or sooner if delivery is imminent)
- If platelet counts are <30,000/ μ L or clinically relevant bleeding is present, first-line therapy is
 - Oral corticosteroids (prednisone 1 mg/kg/day) or
 - Intravenous immunoglobulin (IVIg 1 g/kg)
- Medications are adjusted to maintain a safe platelet count

At the time of delivery:

- Although worsening of the disease is not typical during pregnancy, when it occurs, the mother is at risk for bleeding complications at the time of delivery.
- For a woman whose platelet count is <80,000/ μ L but who has not required therapy during pregnancy
 - Oral prednisone can be started 10 days prior to anticipated delivery (10–20 mg/kg/day and titrated as necessary).
- A platelet count of \geq 50,000/ μ L is recommended prior to labor and delivery.
- A combination of platelet transfusion and IVIg may be used to achieve these levels.

Measures to manage ITP in pregnancy are summarized in Figure 49.3.

Obstetric management

Management of labor and delivery is based on obstetric indications. Platelet counts must be monitored and maintained as outlined above. A platelet count >50,000/ μ L is

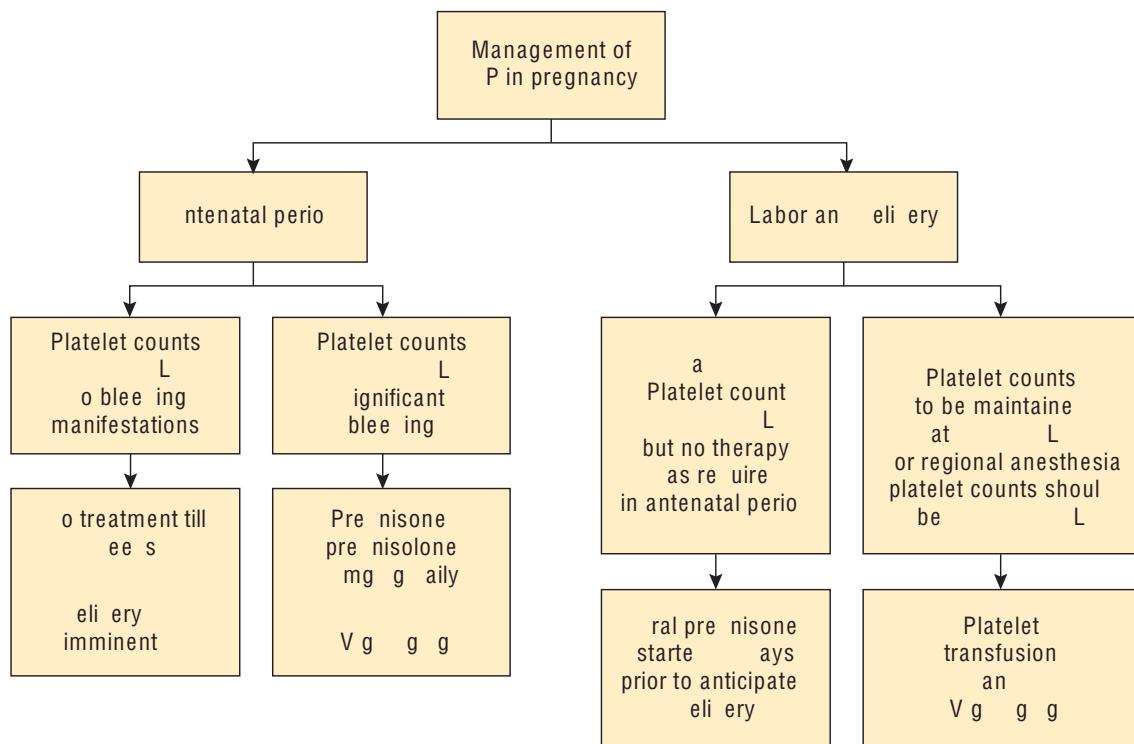


Figure 49.3 Management of ITP in pregnancy. *P* immune thrombocytopenia; *g* intravenous immunoglobulin.

generally considered safe for delivery (vaginal or cesarean).

To protect the fetus, which might have thrombocytopenia, forceps and vacuum-assisted delivery are avoided.

Management of neonatal thrombocytopenia

The risk of severe neonatal thrombocytopenia (e.g., platelet count $< 50,000/\mu\text{L}$) has been

reported to range from 10% to 15% in pregnancies complicated by ITP. Platelet counts $< 20,000/\mu\text{L}$ occur in approximately 5% of patients.

The incidence of neonatal intracerebral hemorrhage is $< 1\%$. There are no differences in the rate of fetal complications with cesarean delivery compared with those with vaginal delivery.

Key points

- Anemia is a major public health concern in developing countries. It is defined by the World Health Organization as hemoglobin levels of $\leq 11 \text{ g/dL}$.
- The majority of anemia in pregnancy is due to iron, folate, or vitamin B_{12} deficiency. Less commonly, it could be a consequence of hemoglobinopathies such as thalassemia and sickle cell anemia.
- Iron deficiency anemia will exhibit smaller red blood cells (RBCs) [mean corpuscular volume (MCV) $< 80 \text{ fL}$] and is called microcytic anemia. With vitamin B_{12} or folic acid deficiency, the RBCs are much larger (MCV $> 100 \text{ fL}$) and so it is called macrocytic anemia.
- Iron deficiency anemia during pregnancy has been associated with an increased risk of low birth weight, preterm delivery, and perinatal mortality.
- The diagnosis of iron deficiency anemia is commonly made with a complete blood count and peripheral smear. In some women, iron studies may be required to establish the etiology.
- Oral iron is considered first-line therapy for iron deficiency anemia since it is inexpensive and effective when taken properly.

(Continued)

Key points *Continued*

- Intravenous iron therapy is indicated in the presence of unresponsiveness to, or intolerance of, oral iron and when there is need for a quick recovery from anemia (e.g., close to delivery).
- Folate deficiency is much less common than iron deficiency. It is a macrocytic anemia.
- In severe vitamin B₁₂ (cobalamin) deficiency, the woman presents with profound anemia and macrocytic red cells (MCV >100 fL) with or without varying neurological disturbances.
- Sickle cell disease (SCD) is an inherited disorder due to homozygosity for the abnormal hemoglobin, hemoglobin S (HbS). The two classic features are hemolysis resulting in anemia ('sickle cell anemia') and vaso-occlusive phenomena.
- Most pregnancies complicated by SCD will result in live birth. However, there is an increased risk of obstetric, fetal, and medical complications, particularly in sickle cell anemia (HbSS).
- Women with sickle cell trait do not have an increased risk for pregnancy complications.
- Thalassemias are characterized by impaired production of one or more of the normal globin chains found in hemoglobin. The clinical consequences can be ineffective erythropoiesis, hemolysis, and anemia of varying degrees.
- In the β-thalassemias, point mutations cause absence of or reduction in β-chain production.
- β-Thalassemia major occurs when both β-genes are missing. The majority of affected women are infertile.
- β-Thalassemia minor occurs in individuals who are heterozygous for the gene mutation and therefore have variable production of the β-globin chain. Pregnancy outcomes are good, although anemia may worsen.
- α-Thalassemia disorders involve a loss of one of the four α-globin genes. Pregnancy in women with α-thalassemia minor is tolerated well. Women with HbH disease may have worsening of anemia in pregnancy.
- Thrombocytopenia or low platelet count is often encountered in pregnancy. It is typically defined as a platelet count lower than 150,000/µL.
- Thrombocytopenia may be encountered in pregnancy as a preexisting condition [immune thrombocytopenia (ITP)], as newly discovered (gestational or ITP), or as part of a pregnancy complication [severe preeclampsia; hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome; acute fatty liver of pregnancy; or disseminated intravascular coagulation (DIC)].
- Treatment of significant thrombocytopenia (<50,000/µL) is with prednisone or intravenous immunoglobulin.

Self-Assessment

Case-based questions

Case 1

Mrs. CP, 21, is a gravida 2, para 1 and is in the 16th week of gestation. Her first child is 1 year old. She feels tired and breathless when she climbs stairs. She appeared pale on her routine antenatal checkup.

1. Define anemia in pregnancy.
2. How will you investigate her?
3. How will you manage iron deficiency anemia?
4. What are the clinical consequences of iron deficiency anemia in pregnancy?

Case 2

Mrs. YH, 32, is a gravida 1, para 0. She is 8 weeks pregnant. She is known to have β-thalassemia trait. She has married a distant relative. She and her husband are anxious to know if the β-thalassemia trait will have any effect on the pregnancy or the baby.

1. What is the inheritance pattern of thalassemias?

2. How can we predict if the baby is affected or not?
3. What are the effects of pregnancy on a woman with β-thalassemia trait?
4. What are the characteristics of β-thalassemia major?

Answers

Case 1

1. Anemia is defined as hemoglobin level of ≤11 g/dL in the first trimester, ≤10.5 g/dL in the second trimester, and ≤11 g/dL in the third trimester.
2. Complete blood count will show low hemoglobin and hematocrit, low RBC count, and MCV <80 fL. Peripheral smear will show microcytic, hypochromic RBCs. There will be low serum iron and ferritin levels and elevated total iron-binding capacity.
3. Oral iron is first-line therapy since she is only 16 weeks pregnant. She should be placed on a ferrous salt preparation containing 100 mg elemental iron twice daily. She should be given appropriate instructions for taking the iron. If she is unable to tolerate iron or is noncompliant, or if the hemoglobin is <7 g/dL after

20 weeks' gestation, intravenous iron therapy may be considered.

4. Moderate to severe iron deficiency anemia during pregnancy has been associated with an increased risk of low birth weight, preterm delivery, and perinatal mortality.

Case 2

1. Inheritance is autosomal recessive. The husband has to be tested for the trait. If both parents have thalassemia minor (or trait), the offspring have a 50% chance of inheriting the trait, 25% will have thalassemia major, and 25% will be unaffected.
2. The parents must be counseled for prenatal diagnosis. A chorionic villus sampling or amniocentesis may be offered so that the fetal status can be defined.
3. Pregnancy outcomes are good. The woman may become disproportionately anemic and will require iron or folate supplementation during pregnancy.
4. β -Thalassemia major is a lifelong transfusion-dependent anemia. There is profound hypochromic, microcytic anemia, bizarre red cell morphology, increased indirect bilirubin and lactate dehydrogenase, and reduced or absent haptoglobin.

Sample questions

Long-answer questions

1. What are the causes of anemia? How will you manage a pregnant woman at term with hemoglobin of 6 g/dL?
2. Discuss the etiology, diagnosis, and management of iron deficiency anemia in pregnancy.

Short-answer questions

1. Prevention of anemia in pregnancy
2. Prophylactic iron therapy
3. Classification of anemia in pregnancy
4. Sickle cell disease complicating pregnancy
5. β -Thalassemia trait in pregnancy

50

Cardiovascular Diseases

Case scenario

Mrs. VN, 22, primigravida, at 26 weeks' pregnancy, was referred from the local primary health center with difficulty in breathing, which was more on lying down. She also had cough with frothy expectoration. She had been told by her local doctor that she had some problem with the heart and had to be managed in a bigger hospital. She had shortness of breath and palpitations on and off prior to pregnancy but had never consulted a doctor.

Introduction

Cardiac disease can be a cause of maternal mortality and morbidity. Rheumatic valvular disease is still seen frequently in developing countries. Congenital heart diseases and pregnancy after valve replacement are also encountered often. The cardiovascular changes in pregnancy may not be well tolerated by women with cardiac disease, and the situation needs specialized care. Management has to be multidisciplinary, involving the obstetrician, cardiologist, neonatologist and intensivist, to optimize outcome.

Incidence

The overall incidence of heart disease in pregnancy is 1%. In developing countries including

India, rheumatic valvular diseases are common and among these, *rheumatic mitral stenosis* accounts for 90% of cases. In developed countries, congenital heart disease, especially atrial septal defect (ASD), is the most common cardiac disease in pregnancy.

Cardiovascular changes in pregnancy

Important anatomical and functional changes occur in the cardiovascular system in pregnancy. These have been discussed in Chapter 3, *Maternal physiology in pregnancy*. These changes begin by 6–8 weeks' pregnancy, reach a peak by 25–30 weeks, and plateau till delivery. The important changes in cardiovascular

Table 50.1 Cardiovascular changes that may cause maternal cardiac decompensation

Changes due to pregnancy	Effect on cardiovascular system
regnancy	
Increase in blood volume Increase in cardiac output Increase in stroke volume }	Increase in preload
Supine hypotension	Poor ventricular filling
Increase in heart rate	Pulmonary congestion/edema
abor	
Tachycardia due to pain/anxiety	• Reduced left ventricular filling • Reduced coronary blood flow
Pumping of blood from uterus Increase in CO/BP with contractions }	Pulmonary congestion/edema
ostpartum	
Shunting of blood from uterus	Pulmonary congestion/edema
uerperium	
Mobilization of extravascular fluid	Pulmonary congestion
Increase in vascular resistance	Increase in afterload

BP blood pressure; C cardiac output.

system that may compromise cardiac function in women with heart disease are as follows:

- Increase in cardiac output
- Decrease in peripheral resistance
- Increase in heart rate
- Increase in blood volume

Changes in the cardiovascular system in pregnancy that may cause maternal decompensation are given in Table 50.1.

Functional classification of cardiac disease

Clinical classification by the New York Heart Association (NYHA) is used for functional classification of the degree of heart failure in pregnancy. This classification is based primarily on symptoms of fatigue, palpitation, dyspnea, and anginal pain (Box 50.1).

Women with NYHA class I and class II disease go through pregnancy uneventfully, but those in class III and class IV disease are prone to complications.

Box 50.1 NYHA classification of cardiac disease in pregnancy

- Class I: ***n*compromise *n*o *l*imitation o *p*hysical *a*ctivity**
 - No symptoms of cardiac insufficiency (on walking, climbing stairs etc.)
- Class II: ***S*light *l*imitation o *p*hysical *a*ctivity**
 - Comfortable at rest
 - Mild symptoms caused by ordinary activity
- Class III: ***a*re *e* *l*imitation o *p*hysical *a*ctivity**
 - Comfortable at rest
 - Symptoms caused by less than ordinary activity (walking a short distance)
- Class IV: ***S*everely *c*ompromise**
 - Symptoms at rest
 - Discomfort increased by any activity

A New York Heart Association.

Predictors of cardiac complications

Certain factors are predictive of maternal decompensation during pregnancy. These are as follows:

- NYHA classification III or IV
- Cyanosis

- Left atrial/ventricular obstruction as indicated by
 - mitral valve area <2 cm²
 - aortic valve area <1.5 cm²
 - peak left ventricular outflow gradient >30 mmHg
- Myocardial dysfunction
 - Ejection fraction <40%
- History of
 - heart failure
 - arrhythmia
 - stroke
 - transient ischemic attack

Box 50.2 Maternal complications of cardiac disease in pregnancy

- Acute pulmonary edema
- Cardiac failure
- Worsening of NYHA class
- Arrhythmias
 - Atrial fibrillation
 - Supraventricular tachycardia
 - Ventricular arrhythmia
- Infective endocarditis
- Maternal death

A New York Heart Association.

Risk categorization of cardiac disease in pregnancy

Maternal mortality in cardiac disease varies with the type of lesion. Risk categorization helps in prepregnancy counseling and management (Table 50.2).

Complications

Although most women with uncomplicated mild cardiac disease have an uneventful pregnancy and labor, complications do occur. The risk is much higher in women with NYHA class

III and IV disease. The complications are listed in Box 50.2.

Acute pulmonary edema

Acute pulmonary edema is common in women with left atrial/ventricular outflow obstruction as seen in moderate-to-severe mitral stenosis and aortic stenosis. It is precipitated by tachycardia and increased venous return that occurs in labor and postpartum. Increase in left atrial pressure leads to pulmonary congestion and pulmonary edema. Risk of pulmonary edema increases during late second trimester, labor, and immediate and late postpartum. Pulmonary edema can also be precipitated by certain intercurrent events as listed in Box 50.3.

Table 50.2 Risk categorization of cardiac disease in pregnancy

Risk category	Cardiac disease
Low risk (maternal mortality <1%)	<ul style="list-style-type: none"> • Septal defects • Mitral stenosis, NYHA class I and class II • Patent ductus arteriosus • Pulmonary/tricuspid lesions
Moderate risk (maternal mortality 5%–15%)	<ul style="list-style-type: none"> • Mitral stenosis, NYHA class III and class IV • Marfan syndrome with normal aorta • Uncomplicated coarctation of aorta • Uncorrected TOF • Prosthetic valves
High risk (maternal mortality 25%–50%)	<ul style="list-style-type: none"> • Eisenmenger syndrome • Pulmonary hypertension • Marfan syndrome with abnormal aorta • Dilated cardiomyopathy

A New York Heart Association; tetralogy of Fallot.

Box 50.3 Factors increasing risk of pulmonary edema

- Normal pregnancy
 - Pregnancy at 28–30 weeks when blood volume peaks
 - Labor
 - Due to pumping of blood from uterus
 - Immediate postpartum
 - Due to shunting of blood from placental bed
 - Puerperium
 - Due to mobilization of extravascular fluid
- Intercurrent events
 - Hypertension
 - Anemia
 - Multifetal pregnancy
 - Thyrotoxicosis
 - Acute febrile illness
 - Atrial fibrillation

Diagnosis and management

The mother usually presents with sudden onset of dyspnea, cough with pink, frothy expectoration, hemoptysis, and orthopnea. Examination reveals tachycardia and coarse crepitations in both lungs. If not treated promptly, the condition can be fatal.

Management consists of oxygen by mask, semirecumbent position, digitalization especially if there is atrial fibrillation, and intravenous diuretic (furosemide). Parenteral morphine is required to reduce the anxiety. Rotating cuff or tourniquet applied to all four limbs and released in succession reduces venous return. Emergency valvotomy or balloon valvuloplasty may be required in women with tight mitral stenosis with intractable or recurrent pulmonary edema.

Cardiac failure

Cardiac failure can occur in the late second trimester with worsening of NYHA class II to III or IV, chronic left heart failure, or right heart failure as in pulmonary stenosis.

Diagnosis and management

Cardiac failure presents with gradually worsening dyspnea, orthopnea, edema, and fatigue. Jugular venous pressure is elevated, and there is tachycardia, pedal edema, and tender hepatomegaly. Basal crepitations are usually present.

Treatment is by salt and fluid restriction, and administration of digoxin and diuretics till symptoms and signs regress.

Worsening of A class

Insidious worsening of NYHA class occurs as pregnancy progresses. It can precipitate pulmonary edema or congestive cardiac failure.

Arrhythmias

Atrial fibrillation is the most common arrhythmia encountered. Inadequate left atrial filling and consequent increase in left atrial pressure can lead to pulmonary edema. Atrial fibrillation can occur anytime in pregnancy.

Diagnosis and management

Atrial fibrillation can be associated with acute pulmonary edema or congestive cardiac failure. The pulse is irregular and the rate is usually $>110/\text{min}$. An ECG showing irregular ventricular rate and absent P waves is diagnostic.

Digoxin reduces the heart rate and controls the fibrillation. β -Blockers such as propranolol or calcium channel blockers such as verapamil can be used. Anticoagulation should be considered to prevent thromboembolism.

Infective endocarditis

Infective endocarditis can occur in valvular and congenital heart disease (except ASD), and in women with prosthetic valves and shunts. Bacteremia occurs during vaginal delivery and cesarean section. Antibiotic prophylaxis was administered in labor to all women with cardiac disease earlier, but it is now known that (a) delivery is associated with very low risk of bacteremia, (b) there is convincing evidence that antibiotic prophylaxis prevents endocarditis, and (c) the risk of adverse reaction to antibiotics outweighs benefits in most situations.

Therefore, the American Heart Association (AHA) and American College of Obstetricians and Gynecologists (ACOG) recommend it only for high-risk patients (Box 50.4). However, several institutions use antibiotics in moderate-risk patients as well (Box 50.5).

Box 50.4 Antibiotic prophylaxis for infective endocarditis (A A and AC G)

- Recommended only for high-risk women
 - Women with prosthetic valves
 - Prior endocarditis
 - Cyanotic heart disease unrepaired/repaired within 6 months
 - Patients with cardiac transplantation
- Antibiotic regimen
 - In active labor
 - Injection ampicillin 2 g IV/IM single dose + injection gentamicin 1.5 mg/kg IV
 - Followed 6 hours later by
 - injection ampicillin 1 g IM/IV
 - *or* amoxicillin 2 g oral
 - If allergic to penicillin
 - Injection vancomycin 1 g IV over 1–2 hours + injection gentamicin 1.5 mg/kg IV
 - *r* cefazoline *or* ceftriaxone 1 g IV
 - *r* clarithromycin/azithromycin 500 mg oral
 - *r* clindamycin 600 mg oral

AC American College of Obstetricians and Gynecologists;
A A American Heart Association.

Box 50.5 Antibiotic prophylaxis in moderate-risk patients

- Moderate-risk patients
 - Congenital heart disease (other than high risk)
 - Mitral and aortic stenosis
 - Mitral valve prolapse with regurgitation
 - Hypertrophic cardiomyopathy
- Antibiotic regimen
 - In active labor
 - Inj. ampicillin 2 g IM/IV *or*
 - Amoxicillin 2 g oral
 - If allergic to penicillin
 - Inj. vancomycin 1 g IV over 1–2 hours

Diagnosis and management

Infective endocarditis presents with fever; petechiae over the skin, conjunctiva, and retina; changing murmurs or appearance of new murmurs; and splenomegaly. Blood cultures usually reveal *Streptococcus faecalis* or α -hemolytic *Streptococcus*. Vegetations are seen on the valves on echocardiography. Treatment is with a high doses of appropriate antibiotics.

Maternal mortality

Maternal deaths can occur in cyanotic congenital heart diseases, rheumatic valvular disease, and cardiomyopathy. Lesions that are associated with pulmonary hypertension have high risk of maternal mortality. Pregnancy is contraindicated in those with high risk conditions (Box 50.1). Women with moderate risk should have corrective surgery before pregnancy. Causes of mortality are listed in Box 50.6.

Fetal risks

In uncomplicated rheumatic valvular disease, fetal complications are uncommon. Spontaneous miscarriage, preterm labor, and fetal growth restriction can occur in tight mitral stenosis, complex cyanotic heart disease, right to left shunt, tetralogy of Fallot (TOF), and Eisenmenger syndrome.

Risk of congenital heart disease is increased in infants of parents with congenital cardiac disease. The risk varies with the type of lesion, but the overall risk is approximately 1%–6% when the mother has a congenital cardiac disease. Marfan syndrome and some hypertrophic cardiomyopathies that are inherited as autosomal dominant carry a 50% risk.

Clinical features

Diagnosis of cardiac disease in pregnancy

Anatomical and physiological changes in pregnancy can mimic cardiac disease, making diagnosis of cardiac disease difficult. These are described in detail in Chapter 3, *Maternal physiology in pregnancy*. The changes that mimic cardiac disease are summarized in Box 50.7.

Box 50.6 Causes of maternal death

- Acute pulmonary edema
- Infective endocarditis
- Congestive cardiac failure
- Pulmonary hypertension
- Aortic dissection
- Arrhythmias

Box 50.7 Cardiovascular changes that mimic heart disease

- Symptoms and signs
 - Breathlessness/palpitation/fatigue
 - Prominent neck veins
 - Pedal edema
- Anatomical changes
 - Displacement of the heart to the left
 - Apex beat shifted upwards and laterally
 - Physiological third heart sound
 - Functional systolic murmurs
 - Internal mammary venous hum
- ECG changes
 - Left-axis deviation
 - ST depression/nonspecific ST-T changes
- Chest X-ray
 - Apparent increase in cardiac size
 - Straightening of left heart border

A diagnosis of cardiac disease should be made only if the symptoms and signs described in Box 50.8 are present. History of rheumatic fever in childhood is significant. Dyspnea, cyanosis, and recurrent respiratory infections from birth or childhood suggest congenital heart disease.

Diagnostic evaluation

As already mentioned, history of rheumatic fever and cardiac symptoms from childhood are

Box 50.8 Symptoms and signs suggestive of cardiac disease

- Symptoms
 - Dyspnea on mild activity
 - Dyspnea at rest/orthopnea
 - Paroxysmal nocturnal dyspnea
 - Hemoptysis
 - Chest pain
 - Pedal edema up to the knees
- Signs
 - Cyanosis
 - Edema not subsiding with overnight rest
 - Grade III or IV systolic murmurs
 - Murmurs associated with thrill
 - Diastolic murmurs
 - Signs of congestive cardiac failure
 - Signs of pulmonary edema
 - Arrhythmia

indicative of valvular and congenital heart disease, respectively. Findings on physical examination as listed above or signs of congestive cardiac failure necessitate further evaluation. Electrocardiography and chest X-ray can be used for diagnosis of cardiac disease in pregnancy. The abdomen must be shielded for chest radiography. However, echocardiography is used extensively for accurate diagnosis of cardiac disease since both anatomical and functional evaluation is feasible. Rarely, cardiac catheterization may be required for diagnosis of the exact valvular or congenital lesion (Box 50.9).

Management

Preconceptional management

Preconceptional counseling and management are important to achieve optimal outcome in women with cardiac disease. This consists of history, accurate identification of cardiac lesion, evaluation of cardiac status by ECG and echocardiography, NYHA classification, and assessment of potential for maternal morbidity and mortality associated with the lesion.

Box 50.9 Diagnostic evaluation of cardiac disease

- History
 - Symptoms of heart disease from childhood
 - History of rheumatic fever
- Symptoms and signs
 - Dyspnea at rest/orthopnea/hemoptysis
 - Murmurs
 - Grade III systolic
 - Associated with thrill
 - Diastolic murmurs
 - Signs of congestive cardiac failure
 - Arrhythmias
- Further evaluation
 - ECG
 - Chest X-ray—after shielding abdomen
 - Echocardiography
 - Valvular disease
 - Congenital heart disease
 - Cardiomyopathy
 - Cardiac catheterization
 - Accurate diagnosis of lesion
 - Acute coronary disease

Surgical correction should be advised for correctable congenital heart diseases and moderate-to-severe mitral and aortic stenosis. If the woman is on anticoagulants, changing over from warfarin to heparin should be discussed. Drugs that are teratogenic should be discontinued and safer drugs should be substituted. If pregnancy is contraindicated (as in Eisenmenger syndrome), the couple should be counseled regarding this and contraception advised (Box 50.10).

Contraindications to pregnancy

Pregnancy is contraindicated in the following conditions where the maternal mortality is >25%.

- Eisenmenger syndrome
- Pulmonary hypertension
- Marfan syndrome with abnormal aorta
- Dilated cardiomyopathy

Pulmonary hypertension is the main cause of mortality. Aortic dissection may occur in Marfan syndrome.

Box 50.10 Preconceptional management of women with cardiac disease

- History
 - Effort tolerance
 - Cardiac surgery
 - Medications
 - Cardiac drugs
 - Anticoagulants
 - Antihypertensives
 - Complications in previous pregnancy
 - Worsening of functional class
 - Pulmonary edema/CCF
 - Infective endocarditis
- Evaluation
 - Type of lesion
 - Severity
 - Functional classification
 - Risk stratification
 - Presence of pulmonary hypertension
- Counseling
 - Maternal risks
 - Fetal complications
 - Risk of congenital heart disease in the fetus
 - Surgical intervention prior to pregnancy
 - Contraindications to pregnancy

CC congestive cardiac failure.

Box 50.11 Conditions in which surgical intervention prior to pregnancy is recommended

- Severe MS/MR
- Severe AS/AR
- Large ASD/VSD
- PDA with moderate pulmonary hypertension
- Severe coarctation of aorta
- Tetralogy of Fallot

A aortic regurgitation; AS aortic stenosis; ASD atrial septal defect; MR mitral regurgitation; MS mitral stenosis; PDA patent ductus arteriosus; SD ventricular septal defect.

Surgical intervention prior to pregnancy should be advised in women with cardiac lesions that carry significant risk in pregnancy (Box 50.11).

Termination of pregnancy

Often, valvular and congenital heart disease in woman present for the first time in pregnancy. If maternal risk is estimated to be high (conditions listed in the section *Contraindications to pregnancy*), termination of pregnancy is advisable. The decision should be individualized and made after discussion with the couple.

Antepartum management

Women with cardiac disease should be managed in a tertiary center by a team consisting of cardiologist, obstetrician, anesthetist, and neonatologist. Thorough clinical evaluation must be performed at the first visit to establish the nature of lesion, functional NYHA class, and maternal and fetal risks. Medication should be reviewed to make sure that they are safe in pregnancy. The mother should be counseled regarding lifestyle and warning signs, depending on the nature of lesion. The need for elective cardiac surgery during pregnancy should be discussed. A close watch should be kept on maternal hemoglobin and blood pressure. Anemia and hypertension should be managed appropriately. Fetal growth should be monitored (Box 50.12).

Management of a class I and II

Women in NYHA class I and II usually have an uncomplicated pregnancy and can be managed on an outpatient basis.

Box 50.12 Antepartum management in women with cardiac disease

- Thorough evaluation at first visit
- Establish
 - Accurate diagnosis
 - NYHA classification
 - Risk stratification
 - Maternal/fetal risks
- Medications reviewed
 - Stop teratogenic drugs
 - Change to safer drugs
- Counsel regarding
 - Termination of pregnancy
 - Cardiac surgery during pregnancy
 - Lifestyle
 - Physical activity as tolerated
 - Avoid stress
 - Prompt reporting of respiratory infections
 - Symptoms of pulmonary edema/CCF
- Monitor
 - Hemoglobin
 - Blood pressure
 - Fetal growth
 - Maternal complications
 - Congestive cardiac failure
 - JVP
 - Hepatomegaly
 - Pulmonary edema
 - Arrhythmias
- Prompt treatment of
 - anemia
 - hypertension
 - respiratory infection
 - asymptomatic bacteriuria

CC congestive cardiac failure; *JVP* jugular venous pressure;
A New York Heart Association.

- The blood volume and cardiac output gradually increase and peak at 28–30 weeks, and the functional classification may worsen. Hence, this must be reevaluated at every visit and at 28–30 weeks.
- If women remain in class I/II, they can be admitted at term for delivery.

anagement o A class III I

Women in class III/IV have to be hospitalized. Once treatment is initiated for cardiac failure or pulmonary edema, the condition may improve and it may be possible to discharge and manage as an outpatient. However, most women who are in class III or IV in early pregnancy continue to

be the same throughout pregnancy and need hospitalization.

In uction o labor

Most women with cardiac disease have spontaneous onset of labor at or near term. Induction of labor is not indicated for cardiac disease. It may be required for other obstetric indications. If induction is required, prostaglandins may be used for cervical ripening. Oxytocin infusion should be given in a higher concentration in lower volume in order to avoid fluid overload. The dosage regimen is as follows:

- Administer 10 units oxytocin in 100 mL of normal saline by infusion pump.
- Start with 0.6–1.2 mL/hour (1–2 mIU/min).
- Increase every 30 minutes by 1.2 mL/hour (2 mIU/min).
- Maximum dose is 20 mL/hour (32 mIU/min).

Intrapartum management

Vaginal delivery is preferred. Cardiac disease is not an indication for a cesarean section. Cesarean section may be performed for obstetric indications.

Labor is considered to be equivalent to moderate exercise. The hemodynamic changes during labor such as tachycardia, increase in cardiac output, and increase in venous return can precipitate acute pulmonary edema or cardiac failure.

Tachycardia is aggravated by the pain of uterine contractions, anxiety, and apprehension. Therefore, adequate analgesia is mandatory. Epidural analgesia is recommended, but hypotension must be avoided. Parenteral morphine or pethidine given in adequate doses may also be sufficient.

The second stage should be cut short with outlet forceps in order to avoid bearing-down efforts and additional strain on the heart.

Ergometrine should be avoided since it results in forceful uterine contraction and shunting of blood into the heart. It can also cause an acute rise in blood pressure. Injection furosemide 40 mg IV after delivery of the placenta reduces the preload and the risk of pulmonary edema.

Management of labor is summarized in Box 50.13.

Box 50.13 Management of labor in cardiac disease

- Semirecumbent position with lateral tilt
- Analgesia
 - Epidural analgesia (*or*)
 - Injection morphine 8 mg hourly (*or*)
 - Injection pethidine 100 mg 6 hourly
- Monitor half hourly
 - Pulse
 - Blood pressure
 - Auscultate lung bases
- Judicious use of intravenous fluids
- Infective endocarditis prophylaxis as required
- Second stage
 - Cut short with forceps/vacuum
- Ergometrine avoided
- Injection furosemide 40 mg IV administered after placental delivery

Box 50.14 Contraception in women with cardiac disease

- Progesterone-only preparations
 - Minipill
 - Depo-medroxyprogesterone acetate
 - LNG-IUS
- Surgical methods
 - Tubectomy
 - Vasectomy

g- S, levonorgestrel intrauterine system.

Cardiac procedures in pregnancy

Cardiac surgery may be required during pregnancy in women with life-threatening complications. The most commonly performed procedure is balloon mitral valvotomy. Indications are as follows:

- Mitral stenosis with
 - recurrent or intractable pulmonary edema;
 - congestive cardiac failure not responding to medical management;
 - NYHA class III or IV in early pregnancy.

The procedure is usually performed in the second trimester, but if pulmonary edema is intractable, the procedure can be undertaken at any gestational age. Following valvotomy, the mitral valve area increases, and functional class improves to class I or II.

Valve replacement in pregnancy is associated with increased maternal morbidity and high fetal mortality especially if cardiopulmonary bypass is used.

Postpartum management

Postpartum monitoring and management of complications are crucial.

- Close monitoring should continue for 24 hours after delivery since cardiac decompensation can occur during this period.
- Complications that can occur in the puerperium are sepsis, thromboembolism, and postpartum hemorrhage. Mobilization of extravascular fluid can lead to cardiac decompensation and pulmonary edema.
- Cardiac status should be reassessed 6 weeks postpartum. Decision regarding cardiac surgery should be made at this time.

Contraception

Contraceptive methods that are safe in women with cardiac disease are listed in Box 50.14.

Estrogen-containing pills increase the risk of thromboembolism and should be avoided. Intrauterine copper-containing devices may give rise to bleeding or infection and should be used with caution. In women with NYHA class III or IV disease, husbands should be advised to undergo vasectomy. Tubal sterilization can be performed in women with class I and II disease, and 6 weeks postpartum in women with class III and IV disease, when the cardiac status has improved.

valvular heart disease

Mitral stenosis

Rheumatic mitral stenosis is the most common valvular heart disease encountered in pregnancy and accounts for 90% of cardiac lesions encountered during pregnancy in the developing world. The stenosis is said to be severe if the valve area is $\leq 1.5 \text{ cm}^2$, moderate if $1.5\text{--}2.5 \text{ cm}^2$, and mild if $2.5\text{--}4 \text{ cm}^2$. Symptoms usually develop when

there is moderate stenosis (Box 50.15). Women with valve area $<1\text{ cm}^2$ are more prone to pulmonary edema and require hemodynamic monitoring in labor.

When the venous return increases in pregnancy, the cardiac output does not increase as expected due to the narrow mitral valve. This results in pulmonary venous congestion, pulmonary edema, and congestive cardiac failure. Tachycardia that occurs in pregnancy reduces left ventricular filling and further compromises cardiac output and increases pulmonary congestion.

Maternal complications in mitral stenosis are pulmonary edema, congestive cardiac failure, atrial fibrillation, and embolization.

Women with moderate or severe mitral stenosis should be advised valvotomy or valve replacement prior to pregnancy. Management of uncorrected mitral stenosis in pregnancy consists of reducing the heart rate with digoxin to reduce ventricular rate (particularly in atrial fibrillation), diuretics to relieve fluid overload and pulmonary congestion, small doses of β -blockers if heart rate is suboptimally controlled with digoxin and penicillin prophylaxis against rheumatic fever. Surgical intervention may be required in intractable or recurrent pulmonary edema. Labor and delivery should be carefully managed as outlined earlier in this chapter.

Box 50.15 Mitral stenosis

- Severity
 - Mild: valve area $2.5\text{--}4\text{ cm}^2$
 - Moderate: valve area $1.5\text{--}2.5\text{ cm}^2$
 - Severe: valve area $<1.5\text{ cm}^2$
- Pathophysiology in pregnancy
 - Inability to increase cardiac output
 - Pulmonary congestion and edema due to
 - increased venous return
 - tachycardia
- Complications
 - Pulmonary edema
 - Congestive cardiac failure
 - Atrial fibrillation
 - Thromboembolism
- Management
 - Digoxin
 - Diuretics
 - β -blockers
 - Penicillin prophylaxis

Mitral regurgitation

Mitral regurgitation may be due to rheumatic fever or mitral valve prolapse. Blood regurgitates into the left atrium, the left atrium dilates, and pulmonary congestion and edema result. Atrial fibrillation is also common. Eventually, the left ventricle dilates and ejection fraction falls.

Mitral regurgitation may be asymptomatic when mild. Severe regurgitation can cause pulmonary edema, right heart failure, atrial fibrillation, pulmonary systolic hypertension, and congestive cardiac failure.

Valve replacement prior to pregnancy is recommended in symptomatic women, with atrial fibrillation, ejection fraction $<50\%$, and pulmonary systolic hypertension. Management of pregnancy is by avoiding fluid overload, use of diuretics, and treatment of atrial fibrillation.

Mitral valve prolapse

Mitral valve prolapse occurs due to myxomatous degeneration of the valve or chordae tendineae. Mitral insufficiency may develop later. Most women are asymptomatic. They withstand pregnancy well. Occasionally chest pain, palpitations, and arrhythmias develop. They are managed with β -blockers. Infective endocarditis prophylaxis is indicated when mitral prolapse is complicated by mitral regurgitation.

Aortic stenosis

Aortic stenosis may be congenital or rheumatic in etiology. Mild-to-moderate stenosis is well tolerated in pregnancy, but severe stenosis with a valve area of $<1\text{ cm}^2$ is associated with high maternal mortality.

Obstruction at the aortic valve leads to left ventricular overload, increase in left ventricular end-diastolic pressure, and fall in ejection fraction. There is reduced cardiac output and decrease in cerebral, cardiac, and uterine perfusion. Pulmonary edema, exertional angina, syncope, arrhythmias, stroke, aortic rupture, and death are known complications.

Severe aortic stenosis should be corrected by surgery before pregnancy. Mild-to-moderate stenosis can be managed with close observation, but severe stenosis requires bed rest and vigilant

Table 50.3 Features of valvular lesions

Lesion	Pathophysiology	Complications
Mitral regurgitation	<ul style="list-style-type: none"> Regurgitation of blood into left atrium Left atrial dilatation Pulmonary congestion Left ventricular dilatation Fall in ejection fraction 	<ul style="list-style-type: none"> Pulmonary edema Atrial fibrillation Pulmonary hypertension Cardiac failure
Mitral valve prolapse	Mitral regurgitation	<ul style="list-style-type: none"> Chest pain, palpitations Arrhythmias
Aortic stenosis	<ul style="list-style-type: none"> Left ventricular overload Increase in end-diastolic pressure Fall in ejection fraction Decreased cardiac output 	<ul style="list-style-type: none"> Pulmonary edema Arrhythmias, stroke Aortic rupture, angina, syncope, death
Aortic insufficiency	No major changes	
Pulmonary stenosis	<ul style="list-style-type: none"> Right ventricular overload Right atrial dilatation 	<ul style="list-style-type: none"> Right heart failure Arrhythmias

management. Hypovolemia, fluid overload, and hypotension should be avoided. Severe stenosis may require balloon valvotomy during pregnancy.

Aortic insufficiency is well tolerated in pregnancy. **Pulmonary stenosis** is usually congenital and should be corrected before pregnancy. In women with uncorrected stenosis, right heart failure and arrhythmias can occur.

The features of various valvular lesions are summarized in Table 50.3. (Features of mitral stenosis are already summarized in Box 50.15.)

Pregnancy in women with prosthetic valves

Pregnancy in women with prosthetic mitral or aortic valves is common now. Most women with prosthetic valves have an uncomplicated pregnancy. There are two types of valves:

- Bioprosthetic
 - Do not require anticoagulants
 - Have higher failure rate
- Mechanical
 - Increased risk of thromboembolism
 - Anticoagulants required
 - Lower failure rate

Complications of pregnancy with prosthetic valves

The complications are listed in Box 50.16.

Box 50.16 Complications of pregnancy in women with prosthetic valves

- Structural failure of the valve
- Infective endocarditis
- Thromboembolism
- Cardiac failure
- Hemorrhage due to anticoagulation
- Miscarriage
- Stillbirth
- Warfarin embryopathy

Anticoagulants in pregnancy

Most young women with valve replacement have mechanical prosthetic valves, and anticoagulation is mandatory. Warfarin is the drug of choice in the nonpregnant state, but choice of anticoagulants in pregnancy is complicated. The effects of warfarin, unfractionated heparin and low-molecular-weight heparin (LMWH) are listed in Table 50.4.

Warfarin

Warfarin has the lowest risk of maternal thromboembolism in pregnancy. However, warfarin crosses the placenta and when used in the first trimester of pregnancy, there is a 5%–10% risk of congenital anomalies. The risk is highest between 6 and 12 weeks' gestation.

Warfarin embryopathy affects cartilage and bone, giving rise to epiphyseal stippling,

Table 50.4 Anticoagulants in pregnancy

	Warfarin	Unfractionated heparin	Low-molecular-weight heparin
Risk of thromboembolism	Least	More	More
Crosses placenta	Yes	No	No
Teratogenic effects	Yes	No	No
Late fetal deaths	Yes	No	No
Loss of bone mineral density	No	Yes	Less
Thrombocytopenia	No	Yes	Less
Monitored with	PT	PTT	Anti-Xa
Secreted in breast milk	Yes	No	No

P prothrombin time; P partial thromboplastin time.

hypoplasia of nasal bone and limbs, and chondromalacia. Exposure in the second trimester can cause central nervous system defects and late fetal loss. The fetal complications are dose dependent and are higher when the dose is >5 mg/day.

If warfarin is administered prior to or during labor, the anticoagulant effect is difficult to reverse and risk of maternal and fetal hemorrhage is high. Therefore, it is prudent to switch to unfractionated heparin before planned delivery.

Unfractionated heparin

The molecule of unfractionated heparin is large and does not cross the placenta; therefore, there are no teratogenic effects. Valve thrombosis is higher with unfractionated heparin compared with that with warfarin. Loss of bone mineral density (10% if used for >6 months) is also associated with the use of heparin. This usually recovers after discontinuation of therapy. Heparin-induced thrombocytopenia (HIT) occurs in 2%–3% of women. Protamine sulfate reverses the effect of heparin. Therefore, heparin is the drug of choice before labor and delivery.

Low-molecular-weight heparin

Low-molecular-weight heparin does not cross the placenta. Thromboembolic events are rare when therapeutic levels are used with monitoring of anti-Xa levels. Risk of thrombocytopenia and osteoporosis is low. Therapeutic dosage requires 12-hourly administration. Protamine

reverses the anticoagulant action only partially; therefore, most clinicians prefer to switch to heparin before labor and delivery.

Recommended anticoagulant regimen

The American College of Cardiology (ACC) and AHA recommend the following:

- Stop warfarin between 6 and 12 weeks and start on dose-adjusted unfractionated heparin/LMWH 12 hourly.
- Switch to warfarin at 12 weeks and continue till 36 weeks.
- Add aspirin 80–100 mg daily.
- Discontinue warfarin and aspirin and restart heparin/LMWH at 36 weeks.
- Switch from LMWH to heparin 36 hours prior to planned delivery.
- Stop heparin 6 hours prior to planned delivery. Resume 6 hours after vaginal delivery or 12 hours after a cesarean section.
- Restart warfarin and overlap with heparin till adequate blood levels are achieved.

Congenital heart disease

Long-term survival after surgery for congenital heart disease has improved dramatically in the past few decades due to improved techniques. Pregnancy in women with corrected congenital heart disease is now commonly encountered. In developed countries, where the incidence of

rheumatic fever has reduced markedly, congenital heart disease is more common than rheumatic valvular disease.

Hemodynamic changes of pregnancy can affect women with congenital heart disease. The maternal cardiovascular complications are listed as follows:

- Fall in systemic vascular resistance increases the magnitude of right to left shunts.
- Increase in cardiac output and blood volume leads to congestive cardiac failure in women with myocardial dysfunction or valvular disease.
- Risk of thromboembolism increases due to hypercoagulability of pregnancy.
- Risk of infective endocarditis is high in women with uncorrected complex cyanotic congenital heart disease and those within 6 months of surgery.
- Arrhythmias worsen in pregnancy and can cause cardiac decompensation.

Risk factors for maternal and fetal complications

The major risk factors that increase maternal and fetal complications in women with congenital heart disease are as follows:

- Pulmonary hypertension
- Maternal cyanosis
- NYHA class III and IV
- Left ventricular outflow obstruction
- Right heart dilatation
- Anticoagulant therapy
- Arrhythmias

Fetal complications

Fetal complications of congenital heart diseases are *spontaneous abortion, preterm birth, fetal growth restriction, and fetal death*. All fetal complications are more common in cyanotic and uncorrected congenital heart diseases.

Septal defects and patent ductus arteriosus

Atrial septal defect and ventricular septal defect (VSD) are the most common congenital cardiac diseases seen in pregnancy. Pregnancy is well tolerated if the defect is small and there is no reversal of shunt. Most women with large VSD become symptomatic early and would have had surgery before pregnancy. Similarly, most cases of patent ductus are identified in childhood and corrected. In women with uncorrected septal defects and patent ductus arteriosus (PDA), fall in systemic resistance in pregnancy can cause reversal of flow through the defect. Pulmonary hypertension, cardiac failure, and arrhythmias are common complications. Ventricular septal defect and PDA are associated with high risk of infective endocarditis. Symptoms and maternal complications of septal defects and PDA are summarized in Table 50.5.

Cyanotic congenital heart diseases

Tetralogy of Fallot (TOF), transposition of great vessels (TGV), and Eisenmenger syndrome may be encountered in pregnancy.

Table 50.5 Symptoms and maternal complications of septal defects and patent ductus arteriosus

	Atrial septal defect	Ventricular septal defect	Patent ductus arteriosus
Symptoms	Mostly asymptomatic	Asymptomatic if $<1.25 \text{ cm}^2$	Symptomatic
Pregnancy	Well tolerated	Tolerated in small defects	Tolerated if no reversal
Complications	<ul style="list-style-type: none"> • Pulmonary hypertension • Cardiac failure • Arrhythmias • Paradoxical embolism 	<ul style="list-style-type: none"> • Pulmonary hypertension • Left ventricular failure • Infective endocarditis • Reversal of shunt (Eisenmenger syndrome) 	<ul style="list-style-type: none"> • Pulmonary hypertension • Cardiac failure • Pulmonary hypertension, cardiac failure • Bacterial endocarditis

Tetralogy of Fallot

Tetralogy of Fallot is the most common cyanotic heart disease. Since patients become symptomatic very early in life, surgical correction is undertaken usually in childhood. Women with corrected TOF tolerate pregnancy well so long as there is no residual lesion. In uncorrected TOF, cyanosis worsens due to increase of shunt. Risk of fetal complications such as fetal growth restriction, spontaneous abortion, and fetal death is high. Postoperative pulmonary insufficiency and right ventricular dysfunction are associated with high risk of complications such as heart failure, arrhythmias, and pulmonary hypertension. Hypotension and epidural analgesia should be avoided.

Transposition of great vessels

Uncorrected TGV is associated with high neonatal mortality. Hence, all women who conceive have surgically corrected TGV. Postsurgical cardiac dysfunction in TGV is also associated with cardiac failure and mortality.

Eisenmenger syndrome

When pulmonary vascular resistance is higher than the systemic resistance, causing right to left shunting of blood, it is called Eisenmenger syndrome. This develops in ASD, VSD, and PDA. Cardiac failure, arrhythmia, cerebrovascular accident, thromboembolism, hyperviscosity syndrome, and sudden death can occur. Risk of maternal death is as high as 40%. **Pregnancy is, therefore, contraindicated and should be terminated in Eisenmenger syndrome.**

Cardiomyopathy

Cardiomyopathy may be associated with ventricular hypertrophy (hypertrophic cardiomyopathy) or dilatation (dilated cardiomyopathy). **Hypertrophic cardiomyopathy** is an autosomal dominant disorder. Women may be asymptomatic but dyspnea, angina pain, and arrhythmias can occur. Pregnancy is well tolerated in a few, but complications are common. **Dilated cardiomyopathy** may be inherited or acquired. Right

and/or left ventricle is dilated and systolic function is reduced.

Peripartum cardiomyopathy

Peripartum cardiomyopathy (PPCM) is a left ventricular dilatation and systolic dysfunction characterized by the following:

- Absence of prior cardiac disease or identifiable cause of cardiac failure
- Development in the last trimester, usually after 34 weeks' gestation or postpartum up to 5 months

The incidence varies from 1/1000 to 1/4000 births. The etiology is unknown although viral infection, autoimmune response, and hypertension have been postulated. Other features are listed in Box 50.17.

Management

Once diagnosed, cardiac failure should be treated with bed rest, diuretics, and digoxin. Prophylactic anticoagulation may be required. Combined oral contraceptive pills must be avoided and subsequent pregnancies strongly discouraged.

Box 50.17 Peripartum cardiomyopathy

- Dilated cardiomyopathy
- Left ventricular systolic dysfunction
- Occurs
 - After 35 weeks' gestation
 - Up to 5 months postpartum
- Incidence: 1/1000–1/4000
- Recurrence in subsequent pregnancy: 85%
- Progresses with subsequent pregnancy
- Diagnosis
 - Sudden onset of cardiac failure after 35 weeks
 - Exclusion of prior cardiac disease
 - No identifiable cause
 - Echocardiography
 - Ejection fraction <45%
 - Left ventricular end-diastolic dimension >2.7 cm/m²
- Complications
 - Thromboembolism
 - Cardiac failure
- Mortality: 5%–10%
- Complete recovery postpartum—50%

Key points

- Cardiac disease is an important cause of maternal mortality and morbidity.
- The hemodynamic changes in pregnancy and labor compromise cardiac function in women with heart disease.
- Functional classification by the New York Heart Association (NYHA) is used for risk stratification and management.
- Factors that predict maternal decompensation are NYHA class III and IV, left ventricular obstruction, myocardial dysfunction, and previous heart failure, arrhythmias, or stroke.
- Maternal complications in heart disease are acute pulmonary edema, cardiac failure, arrhythmias, infective endocarditis, and maternal death.
- Acute pulmonary edema is the most common complication and can occur during pregnancy, labor, or puerperium. The risk is increased by intercurrent events such as anemia, hypertension, or infection. It is managed by parenteral diuretics and digitalization, if required. Intractable and recurrent pulmonary edema is an indication for surgical correction.
- Recommendations for infective endocarditis prophylaxis have changed in recent years. Currently it is recommended only for women with high-risk disease and in some moderate-risk diseases.
- Fetal risks in cardiac disease include spontaneous miscarriage, preterm labor, and fetal growth restriction in tight mitral stenosis and congenital heart disease.
- Many of the symptoms and signs of normal pregnancy can mimic cardiovascular disease. Diagnosis of cardiac disease in pregnancy should be based on specific symptoms and signs and echocardiography.
- Preconceptional management consists of risk stratification and advice regarding avoidance of pregnancy. Surgical correction should be done if possible.
- Risks of maternal and fetal complications including risk of congenital heart disease in the offspring should be discussed with the mother.
- Mothers with cardiac disease should be monitored closely for anemia, hypertension, and infection, and prompt treatment of these conditions is mandatory.
- Antepartum management is based on NYHA classification. Women with class I and II disease usually have an uncomplicated pregnancy.
- Women with class III and IV disease may have to be managed as inpatients.
- Cardiac disease is not an indication for cesarean section. Labor should be managed carefully, second stage cut short, and ergometrine avoided.
- Mitral stenosis is the most common cardiac disease in developing countries. Valve area of $<1.5 \text{ cm}^2$ is considered severe stenosis.
- Pregnancy in women with prosthetic valves must be managed with careful choice of anticoagulants according to current guidelines.
- Congenital heart diseases encountered in pregnancy are septal defects, patent ductus arteriosus (PDA), cyanotic heart diseases, and Eisenmenger syndrome.
- Most women with congenital heart disease would have had corrective surgery before embarking on pregnancy. Fall in systemic resistance, increase in cardiac output, hypercoagulability of pregnancy, and risk of infective endocarditis pose special problems in uncorrected congenital heart disease.
- Peripartum cardiomyopathy is an uncommon problem that recurs in subsequent pregnancies and has a high maternal mortality risk.

Self-Assessment

Case-based questions

Case 1

Mrs. VN, 22, primigravida, at 26 weeks' pregnancy, is referred from the local primary health center with difficulty in breathing, which is more on lying down, and cough with frothy expectoration. She had shortness of breath and palpitations on and off prepregnancy and a history of fever with joint pains in childhood.

1. What is the diagnosis?
2. What could have precipitated this?

3. How will you manage the case?
4. When will you recommend surgical intervention?

Case 2

Mrs. NC, 28, second gravida, presents at 10 weeks' gestation. She was diagnosed as having mitral stenosis during her previous pregnancy.

1. How will you evaluate her?
2. How will you manage her?
3. What contraception will you advise?
4. What should have been advised prior to this pregnancy?

Answers

Case 1

1. Rheumatic valvular disease, probably mitral stenosis with acute pulmonary edema.
2. Hemodynamic changes, especially increase in cardiac output, blood volume, and heart rate in pregnancy. Also anemia, hypertension, or intercurrent infection.
3. Hospitalization, semirecumbent position, oxygen by mask, injection morphine 8 mg IM, intravenous furosemide 120 mg, and digitalis if there is associated atrial fibrillation.
4. If acute pulmonary edema does not respond to treatment or if it is recurrent.

Case 2

1. History—NYHA class and complications during previous pregnancy.

Examination—symptoms and signs indicative of decompensation such as dyspnea, orthopnea, cough hemoptysis, and pedal edema.

Signs of anemia, arrhythmia (pulse rate and rhythm), ECG, and echocardiography to determine the area of mitral valve.

2. Functional classification according to severity of symptoms.

If class I or II, regular follow-up, early recognition and correction of anemia, hypertension, and infections, and monitoring of fetal growth and maternal condition. Watch for worsening of functional class, pulmonary edema, cardiac failure, or arrhythmias.

Allow spontaneous onset of labor. Avoid fluid overload and ergometrine. Monitor pulse, blood pressure, respiration, and lung bases. Cut short second stage with forceps.

Monitor for pulmonary edema after delivery

If class III or IV, hospitalize; consider termination of pregnancy since she is in early pregnancy. Close monitoring for complications throughout pregnancy. Labor and delivery as in class II but with close monitoring.

3. Since this is her second pregnancy, sterilization should be recommended. If unwilling, progestrone-only pill, injection depomedroxyprogesterone acetate, or levonorgestrel intrauterine system (LNG-IUS).
4. Balloon valvotomy before the second pregnancy.

Sample questions

Long-answer questions

1. Discuss the management of labor in a woman with heart disease complicating pregnancy.
2. What is NYHA classification of cardiac disease? How will you manage a woman with mitral stenosis class II who presents at 8 weeks' gestation?

Short-answer questions

1. Acute pulmonary edema in pregnancy
2. Diagnosis of heart disease in pregnancy
3. Management of labor in women with cardiac disease
4. NYHA classification of cardiac disease in pregnancy

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Hepatobiliary and Gastrointestinal Disorders

Case scenario

Mrs. MP, 31, gravida 2, para 1, live 1, presented at 32 weeks with severe pruritus that was worse at night. There were scratch marks over her abdomen and extremities. She was extremely distressed and her family was very concerned.

Introduction

Hepatobiliary disorders that occur during pregnancy can be a clinical challenge. Some hepatic disorders are unique to pregnancy, whereas some new or chronic hepatic diseases unrelated to pregnancy may result in adverse outcomes. Physiological changes in biliary function increase the risk of gallstones, which can be a clinical challenge in the pregnant woman.

Gastrointestinal (GI) disorders are some of the most frequent complaints during pregnancy. Some women have GI disorders that are unique to pregnancy, for example, hyperemesis gravidarum (see Chapter 28, *Hyperemesis gravidarum*). Pregnant women may have chronic GI disorders that evoke special concern during pregnancy. To optimize care for these pregnant women requires understanding of the presentation and prevalence of various GI disorders.

Hepatobiliary disorders

Pregnancy is associated with many normal physiological and anatomical changes that must be taken into consideration when dealing with hepatobiliary diseases and their correct diagnoses.

Some classic signs of chronic liver disease, for example, spider angiomas and palmar erythema, are also common during a normal pregnancy and usually disappear after delivery. The hyperestrogenemia of pregnancy is responsible for these changes, just as it is in nonpregnant women with cirrhosis.

In late pregnancy, the liver is difficult to palpate because of the expanding uterus. A palpable liver is always an abnormal finding in late pregnancy.

In normal pregnancy, most biochemical tests of liver function remain within the normal range,

even if slightly increased or decreased from baseline levels.

hepat ic disorders in pregnancy

If a woman is found to have hepatic disease in pregnancy, it could be a liver disease unique to pregnancy, a new liver disease presenting during pregnancy, or preexisting chronic liver disease.

hepat ic disorders unique to pregnancy

Certain liver diseases are associated exclusively with pregnancy. The liver diseases unique to pregnancy include the following:

- Hyperemesis gravidarum (see Chapter 28, *Hyperemesis gravidarum*)
- Acute fatty liver of pregnancy (AFLP)
- Intrahepatic cholestasis of pregnancy (ICP)
- Hemolysis, elevated liver enzymes, and low platelet count (HELLP) syndrome (see Chapter 47, *Hypertensive disorders*)
- Subcapsular hematoma/hepatic rupture

hepat ic diseases that can occur in pregnancy

Hepatic diseases that can occur both in the nonpregnant and pregnant state include the following:

- Acute viral hepatitis
- Biliary disease

pre existing chronic liver disease in pregnancy

Preexisting chronic liver diseases that can have an impact on pregnancy include the following:

- Chronic viral hepatitis
- Cirrhosis and portal hypertension
- Wilson's disease

hepat ic disorders unique to pregnancy

Acute fatty liver of pregnancy

Although a rare complication of pregnancy, AFLP is an obstetric emergency that can lead to fulminant hepatic failure. It is associated with fatty

infiltration of hepatocytes without inflammation or necrosis. An excessive fetal fatty acid accumulation is released into the maternal circulation. The resulting increased load of long-chain fatty acids is deposited in maternal liver tissue and leads to impaired hepatic function.

The condition often develops in the second half of pregnancy, usually closer to term, with a mean gestational age reported at 36 weeks, but may only be diagnosed after delivery.

Acute fatty liver of pregnancy is caused by an autosomal recessive genetic error. It is associated with a *maternal* genetic predilection or with a *fetal* deficiency of a genetically determined enzyme:

- Maternal genetic mutation that affects mitochondrial fatty acid oxidation pathway
- Fetal deficiency of long-chain 3-hydroxyacyl-coenzyme A dehydrogenase (LCHAD)

Symptoms of AFLP

Symptoms usually develop over several days to weeks and include the following:

- Nausea and vomiting
- Anorexia
- Lethargy
- Abdominal pain
- Ascites
- Progressive jaundice
- Transient polyuria and polydipsia due to transient diabetes insipidus

Acute fatty liver of pregnancy is associated with acute renal failure in up to 60% of cases. There is decreased renal perfusion or acute tubular necrosis. Hepatic encephalopathy occurs in 60% of patients. Approximately 50% of patients also have hypertension, proteinuria, and edema suggestive of preeclampsia. In the early stages, it may be difficult to differentiate AFLP from severe preeclampsia and/or HELLP syndrome. Even the most severely affected women will have complete recovery of liver and kidney function after delivery. However, AFLP is associated with substantial maternal and perinatal morbidity and mortality. Associated maternal complications include postpartum hemorrhage, renal failure, hypoglycemia, disseminated intravascular coagulation (DIC), pancreatitis, and pulmonary edema.

The clinical features of AFLP are summarized in Box 51.1.

Box 51.1 Clinical features of AFLP

- Obstetric emergency with high mortality
- Microvesicular fatty infiltration of hepatocytes
- Occurs closer to term
 - May be diagnosed after delivery
- Risk factors associated with AFLP
 - Older maternal age
 - Primiparity
 - Multiple gestation
 - Preeclampsia
 - Male fetus
 - Being underweight
 - Previous history of AFLP
- Associated with
 - maternal genetic mutation
 - fetal LCHAD deficiency
 - recurrence, though rare
- Symptoms include
 - nausea and vomiting with progressive jaundice
- Complications
 - Acute renal failure 60%
 - Fulminant hepatic failure
 - Hepatic encephalopathy 60%
 - Hypertension, proteinuria, edema 50%
 - Other maternal complications include
 - postpartum hemorrhage
 - hypoglycemia
 - DIC
 - pancreatitis
 - pulmonary edema

A *P*, acute fatty liver of pregnancy; *D C*, disseminated intravascular coagulation; *C AD*, long-chain 3-hydroxyacyl-coenzyme A dehydrogenase.

Diagnosis

The typical clinical presentation is supported by the following laboratory findings:

- Serum aminotransferase moderately elevated (300–500 U/L)
- Bilirubin elevated (5 mg/dL or higher; Table 51.1)
- Leukocytosis
- Hypoglycemia
- Elevated ammonia levels
- Thrombocytopenia
- Neutrophilia
- Coagulopathy
- Renal dysfunction

Management

When AFLP is suspected, it is an indication for hospitalization since the disease is associated with progressive and sudden deterioration.

Management requires a multidisciplinary approach involving hepatologists, nephrologists, anesthetists, and intensivists. Prompt initiation of supportive therapy including correction of hypoglycemia and transfusion of blood products to correct coagulopathy may be life-saving. Delivery is the definitive treatment and should be undertaken as early as possible. The management of AFLP is outlined in Box 51.2.

Prognosis**Maternal mortality**

Maternal mortality is due to hepatic failure leading to hepatic encephalopathy, renal failure, and coagulopathy. Mortality rate can be up to 10% in rural India and centers where facilities for management of complications are not available. The mortality rate can be very low in tertiary centers. Liver function usually returns to normal within a week but may be delayed for months. Complete recovery is generally anticipated.

Perinatal mortality

Perinatal mortality rates can be as high as 85%. The major cause of perinatal mortality is preterm birth due to urgent need for delivery.

Intrahepatic cholestasis of pregnancy

Intrahepatic cholestasis of pregnancy is the most common liver disorder unique to pregnancy. It usually manifests in the third trimester

Box 51.2 Management of AFLP

- Intravenous fluids for correction of
 - hypovolemia
 - hypoglycemia
- Blood products as needed
- Delivery (definitive treatment)
 - Stops overload of fatty acids on mother's liver
 - Induction of labor, although cesarean section is common
 - General anesthesia preferred
 - Regional anesthesia not recommended
 - Risk of hematoma due to coagulopathy
- Recovery within 48–72 hours after delivery
- Severe disease associated with high mortality
 - Management of
 - renal failure
 - hepatic failure

A *P*, acute fatty liver of pregnancy.

(mean onset at 30 weeks' gestation) and is characterized by severe pruritus along with an increase in direct bilirubin. There is little maternal risk, but ICP is associated with an increased risk of preterm delivery and sudden intrauterine fetal death. Symptoms resolve after delivery.

Prevalence

The incidence of ICP in India has been reported to be 0.8%–1.2%.

Etiology and pathogenesis

The etiology of ICP is multifactorial, involving hormonal and genetic factors.

Estrogen and progesterone

The high levels of these two hormones in pregnancy are implicated in the etiology of ICP. This is indicated by the fact that ICP occurs mainly during the third trimester, when serum concentrations of estrogens and progesterone reach their peak. Intrahepatic cholestasis of pregnancy is also more commonly associated with multiple pregnancies, where higher levels of estrogens and progesterone are seen, as compared with singleton pregnancies. These high levels have a cholestatic effect on the hepatic transport system.

Genetic factors

There is evidence that genetic factors have an impact on familial cases and increase the incidence in certain ethnic groups. The combination of genetic factors and high levels of sex hormones produced in pregnancy can predispose to the development of ICP. This may also lead to ICP occurring with the use of estrogen–progesterone combination oral contraceptive pills.

Environmental factors

Although environmental factors have been suspected because of seasonal variation in certain countries, they have not been proven to have an effect on ICP.

Clinical features

The characteristic symptom of ICP is pruritus that starts in the second or third trimester of pregnancy, and disappears after delivery. It is often generalized but is worse on the palms and the soles of the feet. The itching is usually worse

at night and the lack of sleep can cause emotional disturbance. There are no skin lesions, but it is common to see excoriations on the extremities and abdomen due to scratching.

Jaundice is not common but mild jaundice occurs in 10%–15% of cases, typically within 4 weeks of the onset of itching. Abdominal pain is uncommon. Encephalopathy or other features of liver failure do not occur, and their presence should alert one for other causes of liver disease.

Cholestasis reduces the absorption of fat-soluble vitamins that can lead to vitamin K deficiency, possibly resulting in an increased incidence of intrapartum and postpartum hemorrhage. Vitamin K should be administered to the mother.

The risk of recurrence of ICP during subsequent pregnancies is 45%–70%.

Laboratory findings

Urine bile salts are positive. An increase in serum total bile acid (TBA) concentrations to $>10 \mu\text{mol/L}$ may be the first or only laboratory abnormality, but this test is not usually available in most centers.

Serum aminotransferases are normal. Bilirubin levels are elevated but $<5 \text{ mg/dL}$.

The clinical features of ICP are listed in Box 51.3.

Box 51.3 Clinical features of intrahepatic cholestasis of pregnancy

- Physical presentations
 - Pruritus
 - Starts in second or third trimester
 - Generalized
 - Worse on palms and soles
 - Worse at night
 - Sleep disruption
 - Emotional disturbance
 - Scratch marks on extremities and abdomen
 - Jaundice
 - 10%–15% of women
 - Starts 1–4 weeks after itching
 - Vitamin K deficiency
 - Recurrence risk in next pregnancy
 - 45%–70%
- Laboratory values
 - Total bile acids $>10 \mu\text{mol/L}$
 - ALT and AST normal (Table 51.1)
 - Bilirubin elevated but $<5 \text{ mg/dL}$

Management of ICP

Management includes

- symptomatic treatment of the patient
- close monitoring and decision for early delivery of the fetus.

treatment of pruritus

The treatment of pruritus in ICP is summarized in Box 51.4.

Monitoring of fetus

Fetal mortality can be as high as 10%, but the cause of fetal death in ICP is unknown. It seems to be the result of acute anoxic injury rather than chronic placental insufficiency. No test reliably predicts the risk of fetal demise.

Early delivery

The majority of intrauterine fetal deaths in singleton pregnancies complicated by ICP occur after 37 weeks' gestation. Therefore, delivery is recommended no later than 37–38 weeks' gestation.

Since the mother may have vitamin K deficiency, the newborn should receive an injection of vitamin K on delivery (which is a routine part of newborn care).

Maternal outcome

Maternal outcome in ICP is summarized in Box 51.5.

Box 51.5 Maternal outcome in ICP

- Maternal prognosis good
- Following delivery
 - Pruritus disappears rapidly
 - Liver function tests normalize
- No hepatic sequelae
- Increased risk for gallstones
- Estrogen-containing OCPs
 - Can result in cholestatic hepatitis
 - Preferred OCPs
 - Low-dose estrogen OCPs
 - Progesterone-only OCPs

CP, intrahepatic cholestasis of pregnancy; *OCP*, oral contraceptive pill.

Fetal outcome

In contrast to the good prognosis for the mother, fetal morbidity and mortality are high. Intrahepatic cholestasis of pregnancy is associated with the following:

- Prematurity
- Meconium-stained amniotic fluid
- Intrauterine demise
- Increased risk for respiratory distress syndrome (regardless of fetal maturity)

epatic hematoma and rupture

Hepatic hematoma and rupture are rare complications of pregnancy. The incidence of hematoma is 1 in 40,000 deliveries and that of liver capsular rupture is 1 in 250,000 deliveries.

- Subcapsular hematoma formation and liver capsular rupture carry a very high maternal and perinatal mortality.
- They are complications of preeclampsia/eclampsia and HELLP syndrome.
- The exact cause of the hematoma is not known, but hepatic blood flow obstruction due to fibrin deposits in the hepatic sinusoids may occasionally lead to formation of subcapsular liver hematoma.
- When the hematoma continues to grow, it bursts through the Glisson's capsule and results in catastrophic liver rupture.
- Subcapsular hematoma and liver rupture usually present in the second or third trimester. In 30% of cases they occur postpartum, within 48 hours of delivery.

Box 51.4 Treatment of pruritus in intrahepatic cholestasis of pregnancy

- Ursodeoxycholic acid (UDCA)
 - 500 mg twice daily
 - Relieves pruritus
 - Increases bile flow
 - Reduces bilirubin levels
- Cholestyramine
 - 8–16 g/day
 - Decreases ileal absorption of bile salts
 - Much less effective than UDCA
- Dexamethasone
 - Occasionally prescribed
 - When response to UDCA unsatisfactory

Clinical features and management

Women with subcapsular hematoma and rupture present with acute abdominal and shoulder pain, signs of intraperitoneal hemorrhage, and shock. The diagnosis is made by the presence of the following:

- Elevated liver enzymes
- Anemia
- Evidence of DIC
- Intra-abdominal hemorrhage or liver hematoma
 - On ultrasonography/CT scan

Volume resuscitation, transfusion of blood and blood products, and immediate laparotomy are recommended. The fetus is delivered by cesarean section, and the bleeding from the liver is controlled by packing/ligation of the hepatic vessel or partial resection of the necrotic segments of liver.

Hepatic diseases that can occur in pregnancy

Hepatic diseases that occur in pregnancy can run a more severe course in contrast to the nonpregnant state. Maternal mortality and morbidity, and fetal survival may also be affected due to the disease, and, therefore, the need for early delivery.

Viral hepatitis in pregnancy

Viral hepatitis is one of the most commonly occurring infections in pregnant women. It has a potential for serious adverse effects. The incidence of viral hepatitis A, B, and C is the same in pregnancy as it is for the general population, but the incidence of hepatitis E is much higher in pregnancy.

The types of viral hepatitis include the following:

- Hepatitis A
- Hepatitis B
- Hepatitis C
- Hepatitis D
- Hepatitis E

Hepatitis A and B can be prevented effectively through vaccination. However, globally there are a large number of unvaccinated, nonimmune

women who remain at risk for developing viral hepatitis in pregnancy. Governmental and non-governmental programs are under way to achieve universal immunization against hepatitis A and B in India.

Hepatitis A

Hepatitis A virus (HAV) behaves the same way in pregnancy as in nonpregnant women. Hepatitis A virus infection occurs due to person-to-person transmission through fecal-oral contamination.

Clinical features

The clinical features of hepatitis A are enumerated in Box 51.6.

Diagnosis

The diagnosis is made by a combination of clinical features, laboratory investigations, and serological testing.

Laboratory findings

Laboratory findings include the following:

- Serum aminotransferases
 - Elevated >1000–2000 U/L
 - Alanine aminotransferase (ALT) > aspartate aminotransferase (AST)
- Serum total and direct bilirubin
 - Peak after elevation in ALT and AST
 - Usually elevated to >10 mg/dL

Box 51.6 Clinical features of hepatitis A

- Symptoms
 - Malaise
 - Fever
 - Fatigue
 - Anorexia
 - Nausea
 - Right upper quadrant or epigastric pain
- Signs
 - Jaundice of varying degrees
 - Tender hepatomegaly
 - Hepatomegaly
 - High colored urine
 - Stool chalky white or acholic
- Fulminant hepatitis
 - Coagulopathy
 - Encephalopathy

Serology

Serum immunoglobulin M (IgM) for anti-hepatitis A virus (HAV) is the gold standard for detection of acute illness and remains positive for 4–6 months.

Course in pregnancy

The disease tends to be more severe with increasing gestational age. Severe illness during the third trimester may be associated with an increased risk for preterm labor.

Pregnancy complications include the following:

- Preterm labor
- Placental abruption
- Prelabor rupture of the membranes

Perinatal transmission of the virus does not occur. There are no neonatal consequences.

Management in pregnancy

The disease is usually self-limited. Treatment in pregnancy consists of rest and a balanced diet. Patients with fulminant infection require aggressive supportive therapy and should be transferred to a tertiary care center.

Infected women should avoid handling food that will be eaten by others in the family.

Breastfeeding is permissible with appropriate hygienic precautions.

Postexposure prophylaxis

A woman with close personal contact with someone known to have an acute hepatitis A infection should receive

- single 0.02 mL/kg IM dose of immunoglobulin
 - should be given within 2 weeks' exposure
 - provides protection for up to 3 months
 - is 80%–90% effective

If the patient is infected in the third trimester, the newborn should be given passive immunoprophylaxis with hepatitis A immunoglobulin within 48 hours of delivery.

Hepatitis B

The hepatitis B virus (HBV) is acquired through multiple routes, including mucosal, parenteral, sexual, and mother-to-child transmission. Hepatitis B in pregnancy has an impact on both maternal and fetal health.

The hepatitis B virus

Antigen

The hepatitis B virus (HBV) contains three principal antigens:

- Hepatitis B surface antigen (HBsAg)
 - Present on the surface of the virus
 - Circulates freely in the serum
- Hepatitis B core antigen (HBcAg)
 - Present only in hepatocytes
 - Does not circulate in the serum
- Hepatitis B e antigen (HBeAg)
 - Presence indicative of active viral replication
 - Indicative of high infectivity

Chronic hepatitis or carrier state

If the HBsAg persists for more than 6 months after the acute infection, the woman is considered to have a chronic carrier state. Hepatitis B surface IgG antibody (anti-HBs) is absent in the carrier state.

Antibody

Anti-HBs is formed after the HBsAg is cleared from the body after an acute infection. It also forms after vaccination against HBV. Its presence confirms immunity to HBV.

Is actors or hepatitis in action

Although HBsAg has been detected in a variety of body fluids, only serum, semen, and saliva have been proved to be infectious.

All pregnant women should be screened for hepatitis B by testing for HBsAg in the first trimester. Their immunization status for hepatitis B should also be checked.

Clinical features

Clinical presentation is similar to hepatitis A infection.

Diagnosis

As in hepatitis A infection, the transaminase levels are increased and are usually >1000 U/L. The serum bilirubin is raised to >10 mg/dL. It is not possible to differentiate between HAV and HBV infection without a serum test for the presence of HBsAg. Diagnosis of acute hepatitis B infection is made with detection of

- HBsAg and
- IgM antibodies to HBcAg.

ransmission to husband

If a woman is found to be HBsAg positive, her husband/partner should be tested for HBsAg. If he is negative, he should receive the rapid immunization course with hepatitis B vaccine (0, 1, and 2 months). Until the husband's/partner's immunity is confirmed, they should be advised to use a condom since HBV can be sexually transmitted.

ransmission to medical and paramedical staff

A woman infected with HBV is highly infectious to anyone handling her bodily fluids. Standard universal precautions should be taken to prevent contamination.

he effects of infection on pregnancy outcomes

The following are the effects of HBV infection on pregnancy outcomes:

- Acute HBV infection during pregnancy is usually not severe.
- It is not associated with increased mortality or teratogenicity.
- Hepatitis B infection during gestation is not an indication for termination of pregnancy.
- There is an increased risk of
 - low birth weight
 - preterm birth

management in pregnancy

Management of HBV in pregnancy focuses on

- treatment of HBV during pregnancy and
- prevention of perinatal transmission.

Treatment of B during pregnancy

Treatment of acute infection during pregnancy is mainly supportive. Monitoring of liver function tests and prothrombin time (PT) indicates the severity of disease. Antiviral therapy is unnecessary, except in women who have acute liver failure or protracted severe hepatitis.

Prevention of perinatal transmission

Vertical transmission from mother to child accounts for half of the cases of HBV in the world. Maternal-infant transmission can occur in utero, at birth, or after birth. The commonest route of transmission is at birth when maternal secretions in the birth canal come in contact with

the infant's mucosal membranes. Postexposure immunoprophylaxis with hepatitis B immunoglobulin and HBV vaccine can help prevent 85%–95% of cases of perinatal transmission.

The risk of perinatal transmission of HBV to the newborn from mothers who are HbsAg positive is summarized in Box 51.7.

HBeAg should be tested at 34–36 weeks. If positive, the risk of perinatal transmission can be very high if prophylaxis is not given.

Prevention of transmission of HBV from an HBsAg-positive woman during pregnancy and at delivery is outlined in Figure 51.1.

Intrapartum care

The route of delivery depends on obstetric indications. Caregivers must use standard universal precautions to avoid acquiring the infection.

breastfeeding

Breastfeeding is not contraindicated for women who are HBsAg-positive at the time of delivery since the benefits of breastfeeding outweigh the risks.

hepatitis C

The incidence of hepatitis C virus (HCV) in pregnant women is the same as in the general population (0.5%–1.4%). The routes of transmission, clinical features, and management of hepatitis C are summarized in Box 51.8.

hepatitis D

Hepatitis D virus (HDV) is an incomplete viral particle that depends on the presence of HBV for survival. It can occur as a coinfection along with HBV infection or may follow HBV infection (superinfection). It is transmitted through percutaneous or mucosal contact with blood.

Box 51.7 Risk of perinatal transmission of hepatitis B virus

- Infection in the first trimester: 10%
- Infection in the second trimester: 10%
- Infection in the third trimester: 60%
- Without neonatal prophylaxis: 10%–20%
- Presence of HBeAg
 - Without neonatal prophylaxis, risk of infection: 90%

BeAg, hepatitis B e antigen.

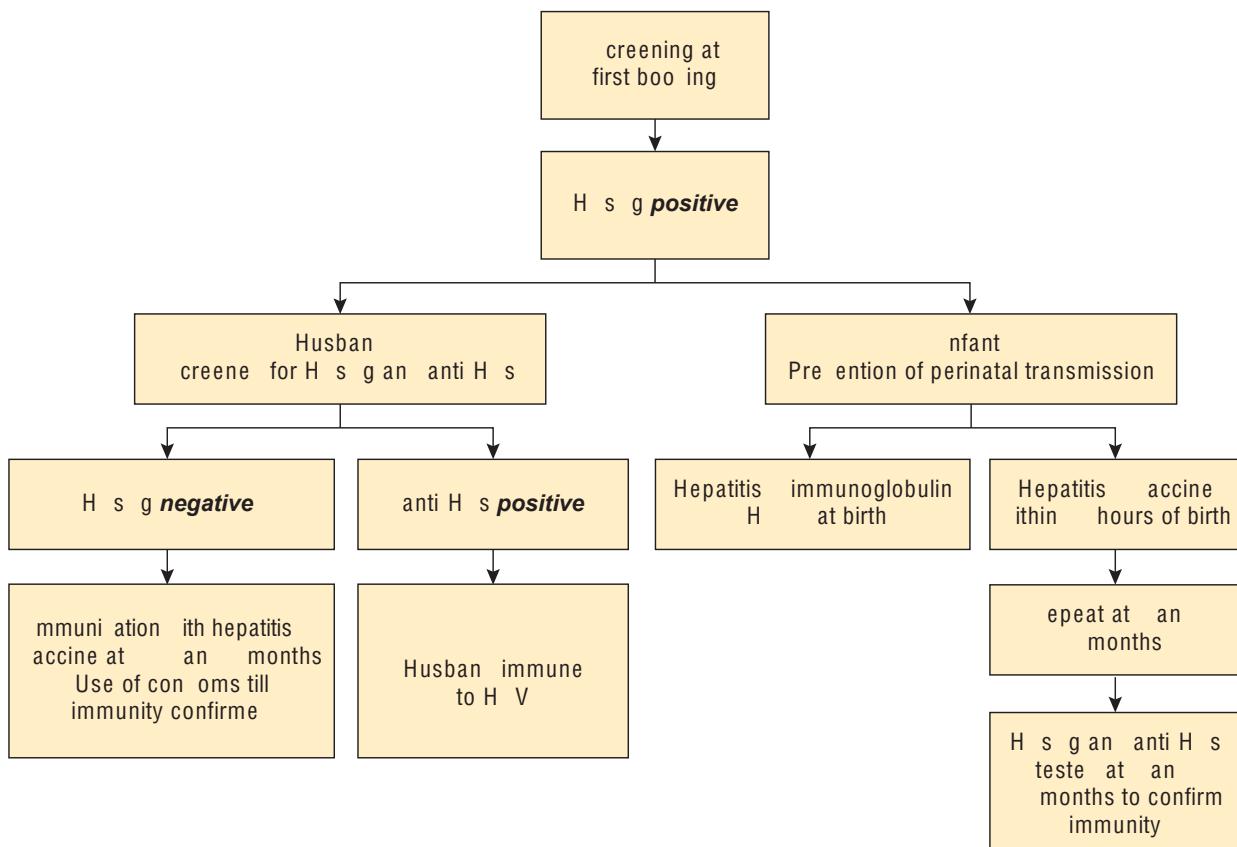


Figure 51.1 Prevention of transmission of hepatitis B virus (HBV) from an HBsAg-positive woman in pregnancy and at delivery. Anti-*Bs* hepatitis B surface immunoglobulin G (IgG) antibody; *BsAg* hepatitis B surface antigen.

Chronic infection with hepatitis D produces more severe disease than the other forms of hepatitis. Approximately 70%–80% of patients with

chronic hepatitis D develop cirrhosis and portal hypertension. The progress of disease can be very rapid and result in cirrhosis within 2 years.

Perinatal transmission can occur at the time of delivery, but neonatal prophylaxis against hepatitis B is effective at decreasing transmission rates.

Box 51.8 Hepatitis C virus: routes of transmission, clinical features, and management

- Routes of transmission
 - Needle stick injuries
 - Intravenous drug use
 - Transfusion of unscreened blood products
 - Sexual contact
 - Perinatal transmission (<5%)
- Clinical features
 - 70% asymptomatic
 - Only 30% symptomatic
 - Present with symptoms similar to hepatitis A or B
- Routine screening of pregnant women
 - Not recommended
- Management
 - General supportive measures
 - Route of delivery does not affect transmission
 - No neonatal vaccination

hepatitis E

Hepatitis E virus (HEV) is more easily acquired and has more adverse effects in pregnancy than in the nonpregnant state. It is also associated with a greater mortality rate in pregnancy. It is not associated with chronic hepatitis or cirrhosis.

It is endemic in developing countries. It is primarily transmitted through

- fecal-oral contamination and
- contaminated water supplies.

Clinical presentation

The clinical presentation of hepatitis E is listed in Box 51.9.

Box 51.9 Clinical presentation of hepatitis E

- Asymptomatic infection (40%)
- Fulminant hepatitis with hepatic encephalopathy (60%)
 - Can be confused with acute fatty liver of pregnancy
 - 25%–100% mortality
- Self-limited disease lasting 1–4 weeks
- Associated with increased rates of
 - abortion
 - stillbirth
 - neonatal deaths

Intrapartum care

In the absence of signs of acute maternal disease, transmission does not depend on the route of delivery. A vaginal delivery or a cesarean section may be undertaken based on obstetric indications.

breast feeding

Breastfeeding is not contraindicated.

Fulminant hepatitis in pregnancy

Fulminant hepatitis in pregnancy can occur following infection with HBV, HAV, or HEV. The disease starts with the usual mild symptoms of hepatitis but progresses rapidly. Clinical features may

mimic AFLP, and the disease is differentiated by the markedly elevated liver enzymes. Maternal mortality is high due to hepatic encephalopathy, renal failure, coagulopathy, metabolic acidosis, and sepsis. Patients with fulminant infection require aggressive supportive therapy and should be transferred to a tertiary care center. Liver transplantation may be required.

Clinical and laboratory findings in acute hepatic diseases in pregnancy

The different presentations and laboratory findings in various acute hepatic diseases in pregnancy are summarized in Table 51.1.

Preexisting chronic liver disease in pregnancy**Chronic autoimmune hepatitis**

Chronic autoimmune hepatitis is a disorder of unknown etiology in which progressive destruction of liver parenchyma ultimately leads to

Table 51.1 Comparison of clinical and laboratory findings in acute hepatic diseases of pregnancy

Disorder	Onset in pregnancy (trimester)	Clinical findings	Liver function tests		Renal function test	ematological and coagulation tests			
			AST (U/L)	ALT (U/L)		Creatinine (mg dL)	Plat	Fib	PT
Hyperemesis	First	Severe N&V	N	N	↑	N	N	N	N
Cholestasis	Third	Pruritus, jaundice	N	1–5	N	N	N	N	N
Acute fatty liver	Third	N&V, ±HTN, hepatic/renal failure	300–500	= or >5	↑↑↑	↓↓	↓↓↓	↑	↑↑↑
HELLP	Second –third	HTN, headache, blurred vision	200–700	2–4	↑	↓↓	↓	N	↑↑↑
Hepatitis	Variable	Jaundice	1000–>2000	5–20	N	↓	N	↑	N

↑, increased levels; ↓, decreased levels; AST, alanine aminotransferase; ALT, aspartate aminotransferase; Creat, creatinine; Fib, fibrinogen; PT, prothrombin time; P, hemolysis, elevated liver enzymes, and low platelet count; HTN, hypertension; N, normal; N&V, nausea and vomiting; Plat, platelets;

cirrhosis. The disease is usually treated with immunosuppressive drugs. The drugs used are corticosteroids and azathioprine. The disease can relapse in pregnancy. Risk of spontaneous miscarriage and fetal demise is high.

Cirrhosis and portal hypertension

Women with decompensated cirrhosis are often anovulatory and rarely conceive. Women who do conceive face increased maternal mortality. Fetal and neonatal outcomes are also poor, with increased rates of preterm deliveries, spontaneous abortions, stillbirths, and neonatal mortality.

Gallstones in pregnancy

Gallstones (cholelithiasis) occur more commonly during pregnancy due to decreased gallbladder motility and increased cholesterol saturation of bile. Up to 10% of pregnant women may develop stones or bile sludge during pregnancy or in the immediate postpartum period. However, only 1% will develop symptoms related to sludge and/or gallstones and the rest will remain asymptomatic.

Increasing age, obesity, and genetic factors contribute to the development of gallstones in pregnancy.

Physiological biliary changes in pregnancy

A variety of physiological changes in the biliary system occur in pregnancy that promote gallstone formation. The two important changes are as follows:

- Facilitation of cholesterol stone formation
 - Estrogen increases cholesterol secretion
 - Progesterone reduces bile acid secretion
 - Concentration of cholesterol increases in bile
 - Ability to dissolve cholesterol reduces.
- Stasis
 - Progesterone slows gallbladder emptying
 - Bile stasis promotes the formation of stones

The above changes lead to formation of sludge and gallstones in pregnant women. These physiological alterations return to normal within 2 months following delivery.

Clinical features

Symptoms related to gallstones develop when the gallbladder contracts in response to a fatty meal.

Gallstones can manifest with the following:

- Right upper quadrant pain
- Nausea and vomiting
- Acute cholecystitis
 - Low-grade fever
 - Mild leukocytosis

Diagnosis

Ultrasound examination is the gold standard for diagnosis of biliary sludge and gallstones.

Presentation

The four presentations of gallstone disease are summarized in Box 51.10.

Differential diagnosis

Gallstone disease presents in pregnancy with the same symptoms as in the nonpregnant patient. However, right upper quadrant pain can occur in other conditions specific to pregnancy. The differential diagnosis for right upper quadrant pain in pregnancy and the differences from gallbladder disease are enumerated in Box 51.11.

Management of gallstone disease in pregnancy

Uncomplicated biliary colic and acute cholecystitis can often be treated with conservative therapy. If surgical intervention is required, it

Box 51.10 Presentations of gallstone disease

- Acute cholecystitis
 - Due to inflammation of mucosal lining
 - Right hypochondrial or epigastric pain
 - Positive Murphy's sign
 - Tenderness in subcostal region on deep palpation during a deep breath
- Biliary colic
 - Due to stone blocking cystic duct opening
 - Pain may be generalized, not always localized
- Gallstone pancreatitis
 - Elevated levels of serum amylase and lipase
- Choledocholithiasis
 - Gallstones in the common bile duct
 - Confirmed by ultrasound or endoscopic retrograde cholangiopancreatography (ERCP)

Box 51.11 Differential diagnosis for right upper quadrant pain in pregnancy

- Severe preeclampsia
 - Differentiated by
 - hypertension
 - thrombocytopenia
- Acute fatty liver of pregnancy
 - Differentiated by
 - higher AST and ALT
 - hypoglycemia
 - acute renal failure
 - DIC

A, alanine aminotransferase; *AS*, aspartate aminotransferase; *DIC*, disseminated intravascular coagulation.

is preferably done laparoscopically in the second trimester since it may be associated with the risk of abortion in the first trimester and the risk of preterm labor in the third trimester. Management is summarized in Figure 51.2.

Gastrointestinal disorders

Pregnant women are susceptible to a host of bowel disturbances at rates similar to those in the nonpregnant state. However, the

pathophysiology of the alteration in bowel pattern may be specific to hormonal and structural changes that occur during pregnancy (see Chapter 3, *Maternal physiology in pregnancy*). Surgical conditions such as appendicitis may also present in pregnancy and may present a diagnostic challenge.

Constipation and diarrhea

After nausea and vomiting, the two common GI problems that occur in pregnancy are constipation and diarrhea.

Constipation

Constipation is more common in the first trimester (due to decreased intake of both solids and liquids) but may occur in any trimester. Constipation is defined as

- straining at defecation at more than 25% of bowel movements;
- hard stool at more than 25% of bowel movements;
- two or fewer movements a week.

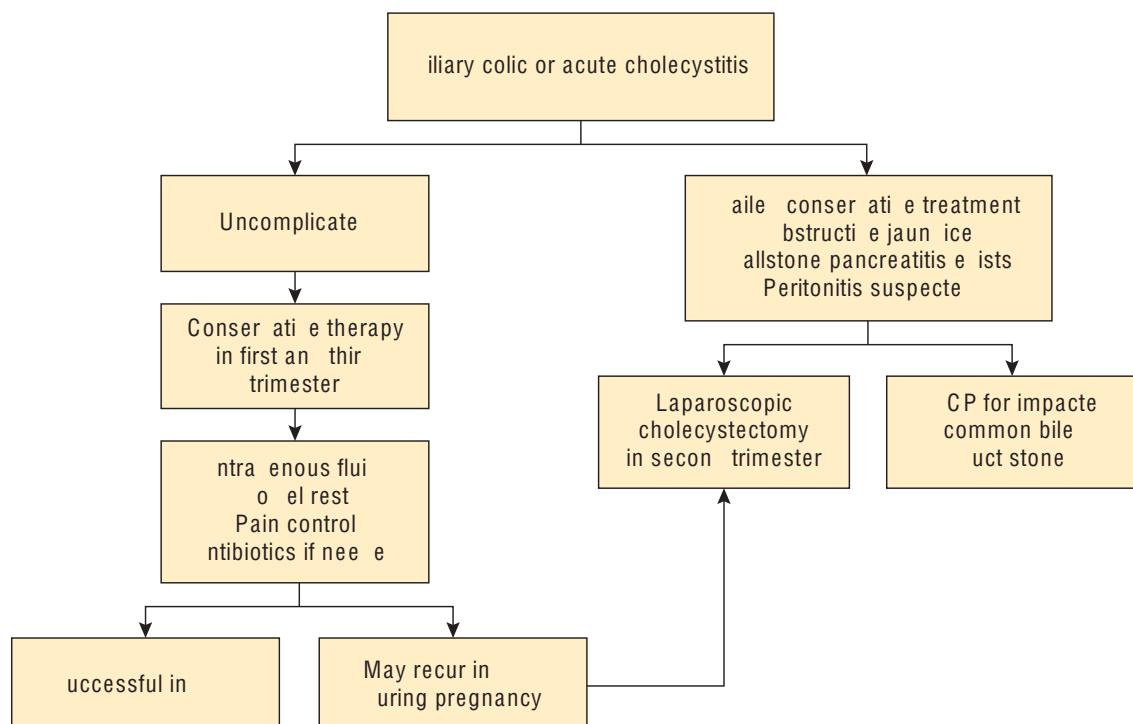


Figure 51.2 Management of gallstone disease in pregnancy.

CP, endoscopic retrograde cholangiopancreatography.

Box 51.12 Management of constipation

- Dietary changes
 - >8 glasses of water/day
 - Fiber intake (20–35 g/day)
- Increasing physical activity
- Using bulking agents
 - Isphaghula husk
 - Methyl cellulose
- Laxatives
 - Liquid paraffin
 - Milk of magnesia
 - Lactulose
 - Castor oil **should not be used**

- Antidiarrheals
 - Loperamide—safe in pregnancy
- Specific treatment for the cause of diarrhea

hemorrhoids

Hemorrhoids are varicosities in the anal canal caused by pressure from the gravid uterus. They are a common complaint during pregnancy in up to 30% of women. They are more frequent in the last trimester of pregnancy and immediately postpartum.

The precipitating causes for hemorrhoids in pregnancy are listed in Box 51.13.

Symptoms and management

Hemorrhoids may present with pruritus, pain, and bleeding. The pregnant woman may feel the hemorrhoids as a bulge at the anal verge.

Management includes the following:

- Relief of symptoms
 - Local antipruritic and anesthetic preparations
 - Sitz baths
 - Treatment of constipation
- Recurrent and severe hemorrhoids
 - Surgical treatment (hemorrhoidectomy)

Gastroesophageal reflux

Gastroesophageal reflux disease (GERD or heartburn) is common during pregnancy. The symptoms worsen from the first to the third trimester and usually disappear after delivery. Gastroesophageal reflux tends to recur in subsequent pregnancies, and can affect both multiparous and nulliparous women.

Pathophysiology of GE D

The causes leading to GERD in pregnancy are enumerated in Box 51.14.

Box 51.13 Precipitating factors for hemorrhoids in pregnancy

- Enlarging gravid uterus
 - Increased abdominal pressure
 - Vascular engorgement and venous stasis
- Constipation
- Postpartum period
 - Pushing efforts during delivery

Causes of constipation

Constipation may occur in 30% of pregnant women. The etiology is multifactorial, and is a combination of the following:

- Decreased small bowel motility
- Decreased colonic motility
- Increased absorption of water
- Mechanical interference by gravid uterus
 - Late in pregnancy
- Iron and calcium supplements

Management

Constipation is managed primarily by dietary and behavioral modification.

The measures for the management of constipation are listed in Box 51.12.

Diarrhea

The causes for diarrhea are the same as for a nonpregnant woman and may have infectious and noninfectious causes.

Diarrhea is evaluated with stool examination for ova, parasites, bacteria, and fecal leukocytes.

Management

The treatment of acute diarrhea includes conservative measures:

- Oral rehydration
 - Fluids containing salt and sugar
- Correction of potential electrolyte abnormalities
 - Bananas (K⁺ replacement)
 - Orange juice

Box 51.14 Pathogenesis of GE D in pregnancy

- Intrinsic factors
 - Abnormal esophageal motility
 - Decreased LES pressure
 - Increased gastric pressure
- Mechanical factors
 - Enlarging gravid uterus
 - Increased intra-abdominal pressure
 - Displacement of the LES

GERD, gastroesophageal reflux disease; LES, lower esophageal sphincter.

Management

Management consists of the following:

- Lifestyle modifications
 - Elevate head end of bed
 - Eat small, frequent meals
 - Avoid eating for 2 hours before bedtime
- Medications
 - Antacids
 - Sucralfate
 - Histamine 2 (H₂) blockers
 - Cimetidine, ranitidine, and famotidine
 - Proton pump inhibitors

Appendicitis

Acute appendicitis is the most common non-obstetric cause of acute abdomen in pregnancy. The diagnosis may be delayed because many of the symptoms such as nausea and vomiting,

anorexia, and raised white blood cell (WBC) count may be considered to be due to pregnancy. The location of the appendix also changes due to displacement of the colon by the enlarging uterus, and the pain is atypical. Therefore, the risk of perforation is higher.

Diagnosis

Physical signs

The physical signs of acute appendicitis in pregnancy depend on the trimester when it occurs.

- Abdominal pain
 - First trimester: Right lower quadrant
 - Second trimester: At the level of the umbilicus
 - Third trimester: Diffuse or in the right upper quadrant
- Nausea, vomiting, and anorexia

Ultrasound

Ultrasound imaging may be useful in locating the appendix and confirming the diagnosis of appendicitis.

Treatment

The treatment of appendicitis is surgical. Laparoscopy or laparotomy is used, depending on the trimester of pregnancy and accessibility of the appendix.

Key points

- Some hepatic disorders are unique to pregnancy, whereas some new or chronic hepatic diseases may result in adverse outcomes.
- Gastrointestinal disorders are some of the most frequent complaints during pregnancy.
- Although a rare complication of pregnancy, acute fatty liver of pregnancy (AFLP) is an obstetric emergency that can lead to fulminant hepatic failure. It is characterized by microvesicular fatty infiltration of hepatocytes.
- Acute fatty liver of pregnancy is associated with acute renal failure or hepatic encephalopathy in up to 60% of cases.
- Acute fatty liver of pregnancy results in substantial maternal and perinatal morbidity and mortality. Associated maternal complications include postpartum hemorrhage, renal failure, hypoglycemia, disseminated intravascular coagulopathy, pancreatitis, and pulmonary edema.
- Aspartate aminotransferase (AST), alanine aminotransferase (ALT), and bilirubin levels may show a modest increase in AFLP.
- Intrahepatic cholestasis of pregnancy (ICP) is the most common liver disorder unique to pregnancy.
- The characteristic symptom of ICP is pruritus that starts in the second or third trimester of pregnancy.

(Continued)

Key points (*Continued*)

- and disappears after delivery. Mild jaundice occurs in 10%–15% of cases. Liver enzymes stay normal in ICP.
- Treatment of pruritus is with ursodeoxycholic acid (UDCA), cholestyramine, or occasionally dexamethasone. Early delivery is the definitive treatment.
 - Subcapsular hematoma formation and liver capsular rupture are rare complications of pregnancy but carry a very high maternal and perinatal mortality.
 - Viral hepatitis is one of the most commonly occurring infections in pregnant women with a potential for serious adverse effects.
 - In viral hepatitis, serum aminotransferases are elevated to 1000–2000 U/L and the serum bilirubin is raised to >10 mg/dL.
 - Hepatitis B virus (HBV) has an impact on both maternal and fetal health. All pregnant women should be screened for hepatitis B by testing for hepatitis B surface antigen (HBsAg) in the first trimester.

- Vertical transmission from mother to child accounts for half of the cases of HBV in the world. The commonest route of transmission is at birth when maternal secretions in the birth canal come in contact with the infant's mucosal membranes.
- Neonates of mothers who are positive for HBsAg should receive passive and active immunization.
- Gallstones (cholelithiasis) occur more commonly during pregnancy due to decreased gallbladder motility and increased cholesterol saturation of bile.
- Gallstone disease can present in pregnancy as acute cholecystitis, biliary colic, gallstone pancreatitis, or choledocholithiasis.
- Pregnant women are susceptible to a host of bowel disturbances at rates similar to that in the nonpregnant state.
- Surgical conditions such as appendicitis may also present in pregnancy and may present a diagnostic challenge.

Self-Assessment

Case-based questions

Case 1

Mrs. MP, 31, gravida 2, para 1, live 1, presented at 24 weeks with severe pruritus that was worse at night. There were scratch marks over her abdomen and extremities. She was extremely distressed and her family was very concerned.

- What is the diagnosis and how will you confirm it?
- What is the etiology?
- How will you manage this condition?
- What is the fetal outcome?

Case 2

Mrs. SP, 30, was a gravida 2, para 1, live 1. On her first prenatal visit she tested positive for HBsAg.

- What is the course of hepatitis B in pregnancy
- How do you assess the risk of transmission to the baby?
- How do you counsel health care workers who are managing the patient?
- How will you prevent mother to child transmission of hepatitis B?

Answers

Case 1

- She has ICP. The diagnosis is confirmed with elevated levels of total bile acids, normal levels of AST and ALT, and mild elevation of bilirubin (<5 mg/dL).
- High levels of estrogen and progesterone in pregnancy are implicated in the etiology of ICP. Genetic factors may also contribute.
- Management includes symptomatic treatment of the patient with ursodeoxycholic acid and close monitoring and decision for early delivery of the fetus.
- Fetal morbidity and mortality are high. ICP is associated with prematurity, meconium-stained amniotic fluid, intrauterine demise, and increased risk for respiratory distress syndrome.

Case 2

- Acute HBV infection during pregnancy is usually not severe. It is not associated with increased mortality

or teratogenicity. It is not an indication for termination of pregnancy.

2. HBeAg should be tested at 34–36 weeks. If positive, the woman is extremely infective. Perinatal transmission can be very high if prophylaxis is not given.
3. A woman infected with HBV is very infectious to anyone handling her bodily fluids. Standard universal precautions such as double gloving should be taken to prevent contamination.
4. Postexposure immunoprophylaxis with hepatitis B immunoglobulin and hepatitis B virus vaccine can help prevent 85%–95% of cases of perinatal transmission.

Sample questions

Long-answer questions

1. What causes intrahepatic cholestasis of pregnancy? Discuss its management.
2. Describe the clinical features, diagnosis, and management of acute fatty liver of pregnancy.

Short-answer questions

1. Gallstone disease in pregnancy
2. Constipation in pregnancy

52

Endocrine Disorders and Obesity

Case scenario

Mrs. LM, 27, had been on thyroxine for hypothyroidism for the past several years. She was planning a pregnancy. She and her husband were concerned about hypothyroidism and its effect on the baby. Her recent blood tests showed a thyroid-stimulating hormone (TSH) value of 6.3 mIU/mL and free T4 of 1.0 ng/dL. They wanted to know whether it was safe to go ahead with a pregnancy.

Introduction

The fetoplacental unit can be likened to a new endocrine organ that is unique to pregnancy. As a result, considerable endocrine changes occur in pregnancy. The pregnant woman and the fetus adapt by alterations in the endocrine metabolism. Manifestations of endocrine diseases can be masked by the physiological changes of pregnancy. More importantly, therapy for the mother has to take into consideration its effects on the fetus.

The growing incidence of obesity is a global problem. The incidence is on the rise in India as well, due to caloric abundance and changing lifestyle in both urban and rural areas. Obesity is

associated with medical problems that increase maternal mortality and morbidity as well as leading to several obstetric complications.

Endocrine disorders

This chapter presents an overview of different endocrine disorders that affect pregnancy and perinatal outcomes. Optimal diagnostic and management strategies are discussed. Major endocrine disorders that women faces during pregnancy include gestational diabetes mellitus, preexisting type 1 diabetes mellitus (see Chapter 48, *Diabetes*), and thyroid, parathyroid, adrenal, and pituitary disorders.

Thyroid disorders in pregnancy

There are several important issues that must be considered when thyroid disorders occur during pregnancy or when women with preexisting treated dysfunction become pregnant. Both hypothyroidism and hyperthyroidism during pregnancy may result in complications for both the mother and the baby. Even subclinical hypothyroidism and thyroid autoimmunity have been linked to adverse maternal and fetal outcomes.

The accurate diagnosis and appropriate treatment of thyroid disease during pregnancy entails a complete understanding of the changes in thyroid physiology and thyroid function tests that accompany normal pregnancy.

Physiological adaptation during pregnancy

The thyroid gland undergoes significant changes in size and function during pregnancy. Several physiological adaptive changes occur.

Effect of human chorionic gonadotropin

Human chorionic gonadotropin (hCG) has the following effects on thyroid function:

- Placental hCG is structurally similar to thyroid-stimulating hormone (TSH).
- It stimulates TSH receptors resulting in
 - increased thyroxine production;
 - suppression of TSH during the first trimester;
 - slight increase in TSH levels by the second trimester.

These changes necessitate the use of trimester-specific cutoffs while interpreting TSH values (Box 52.1).

Box 52.1 Trimester-specific normal ranges for thyroid-stimulating hormone

- First trimester: 0.1–2.5 mIU/mL
- Second trimester: 0.2–3.0 mIU/mL
- Third trimester: 0.3–3.0 mIU/mL

Effect of estrogen on thyroid-binding globulin

Estrogen has the following effects on thyroid-binding globulin:

- Estrogen increases thyroid-binding globulin level.
- Total T3 and T4 levels are elevated.
- Free hormone levels are usually normal or at the upper limits of normal. **Therefore, it is advisable to check free T3 and T4, along with TSH, to evaluate thyroid function during pregnancy.**

See Chapter 3, Maternal physiology in pregnancy for details.

Hypothyroidism in pregnancy

The clinical manifestations, diagnosis, and treatment of hypothyroidism during pregnancy are discussed next.

Overt hypothyroidism

Overt hypothyroidism is hypothyroidism with clinical symptoms, which has been confirmed with blood tests of thyroid function. **Typically the TSH will be elevated to >10 mIU/mL with decreased free T4.**

Overt hypothyroidism complicating pregnancy is uncommon. Its incidence in pregnancy is low because women with untreated hypothyroidism may be anovulatory and have an increased rate of first trimester spontaneous abortion.

Impact on pregnancy

In women with overt hypothyroidism and a continuing pregnancy, there are both maternal and fetal adverse effects as enumerated in Box 52.2.

Subclinical hypothyroidism

Subclinical hypothyroidism has no clinical symptoms but is diagnosed because of abnormalities in thyroid function tests. **The TSH will be elevated with a normal free T4.**

It is more common than overt hypothyroidism, occurring in 2.5% of screened women. The incidence is reported to be as high as 5% in India, which is not an iodine-sufficient country.

Box 52.2 Adverse effects of overt hypothyroidism on pregnancy
Maternal

- Preeclampsia and gestational hypertension
- Anemia
- Preterm delivery
- Placental abruption
- Increased rate of cesarean section

Fetal

- Low birth weight
- Prematurity
- Respiratory distress syndrome
- Perinatal mortality
- Neuropsychological and cognitive impairment

Impact on pregnancy

Although subclinical hypothyroidism has a lower rate of pregnancy complications, it is also implicated in an increased risk for severe preeclampsia, preterm delivery, placental abruption, and/or pregnancy loss. This association seems to be higher in women with elevated thyroid peroxidase (TPO) antibody levels.

Cognitive impairment

There is insufficient evidence to indicate that subclinical hypothyroidism impairs neuropsychological and cognitive development of the fetus or the newborn. However, since there is potential for impairment, treatment of pregnant women with subclinical hypothyroidism is recommended.

Causes of hypothyroidism

The following are the causes of hypothyroidism:

- Iodine deficiency
- Autoimmune thyroiditis (Hashimoto's thyroiditis)
 - Most common cause of hypothyroidism
 - Diagnosed by elevated titers of TPO antibody (also called thyroid microsomal antibody)

Screening for hypothyroidism

Universal screening for hypothyroidism is not recommended in pregnancy. Targeted screening can be offered to women who have one or more of the risk factors listed in Box 52.3.

Box 52.3 Indications for screening for hypothyroidism in pregnancy

- Family or personal history of thyroid disease
- Positive thyroid peroxidase antibodies in the past
- Past thyroid surgery or past radioactive iodine treatment
- History of head and neck radiation
- Type 1 diabetes
- From an area of moderate to severe iodine insufficiency
- Symptoms of hypothyroidism
- Infertility

Diagnosis of hypothyroidism

The classic symptoms of hypothyroidism such as tiredness and lethargy may be difficult to assess in the presence of pregnancy, which itself might give rise to these symptoms.

Thyroid function tests

Tests to evaluate thyroid function include the following:

- **TSH:** This is the test commonly used for diagnosis. Trimester-specific cutoffs should be used.
- **Free T4:** Pregnancy and trimester-specific cutoffs should be used.
- **Total T3 and T4:** values can be elevated in pregnancy due to elevated thyroxine-binding globulin (TBG) levels. If reliable free T3 and T4 assays are not available, total T3 and T4 levels 1.5-fold the nonpregnant cutoff may be used.

Diagnostic criteria for hypothyroidism in pregnancy are summarized in Box 52.4.

Box 52.4 Diagnostic criteria for hypothyroidism in pregnancy

- Overt hypothyroidism
 - Elevated trimester-specific TSH concentration
 - >2.5 mIU/mL in the first trimester
 - >3 mIU/mL in the second and third trimesters
 - Decreased free T4 concentration
 - <0.7 ng/dL in the first trimester
 - <0.5 ng/dL in the second and third trimesters
- Subclinical hypothyroidism
 - Elevated trimester-specific serum TSH concentration
 - Normal free T4 concentration

S = thyroid-stimulating hormone.

Treatment of hypothyroidism in pregnancy

Both overt hypothyroidism and subclinical hypothyroidism should be treated in pregnancy.

Women with hypothyroidism prior to pregnancy

In women who are on treatment prior to pregnancy, it is recommended that TSH levels be brought to below 2.5 mIU/mL prior to conception.

Requirement of thyroxine increases as early as 4 weeks' gestation; therefore, the dose of levothyroxine should be increased by 25% (25–50 µg) as soon as pregnancy is confirmed in a woman with overt hypothyroidism.

Women diagnosed to have hypothyroidism in pregnancy

Levothyroxine (synthetic T4) is the treatment of choice for hypothyroidism in pregnancy. The goal of T4 replacement therapy is to restore normal thyroid function (euthyroidism) as soon as possible. It is recommended that TSH value should be kept at or below 2.5 mIU/L, especially during the first trimester.

TSH levels should be monitored every 4 weeks in the first half of pregnancy and later every 8 weeks.

The treatment and monitoring of hypothyroidism in pregnancy are summarized in Box 52.5.

Postpartum dosage

The criteria for TSH levels differ in nonpregnant women as compared with those in pregnant women.

Box 52.5 Treatment and monitoring of hypothyroidism in pregnancy

- Women on treatment prior to pregnancy
 - TSH should be <2.5 mIU/mL before conception.
 - Dose should be increased by 25% (25–50 µg) on diagnosis of pregnancy.
 - Dose should be titrated with TSH levels.
- Newly diagnosed overt and subclinical hypothyroidism
 - Levothyroxine (synthetic T4)
 - Euthyroid state to be achieved rapidly (TSH ≤2.5 mIU/mL)
- TSH monitored
 - Every 4 weeks in first half of pregnancy
 - Every 8 weeks in latter half of pregnancy

S TSH thyroid-stimulating hormone.

- In women with hypothyroidism predating pregnancy, the dose should be reduced to the prepregnancy dose.
- In women with subclinical hypothyroidism diagnosed in pregnancy:
 - If TPO antibody is negative, treatment can be discontinued.
 - If TPO antibody is positive, treatment may be continued for 6 months.
- TSH and free T4 should be repeated 4–6 weeks after stopping medication and further treatment decided upon.

Hyperthyroidism and pregnancy

The clinical manifestations, diagnosis, and treatment of hyperthyroidism during pregnancy are discussed here.

Overt hyperthyroidism

Overt hyperthyroidism is symptomatic hyperthyroidism that has been confirmed by **low/undetectable TSH and elevated free T4 and/or free T3 levels**. It is a relatively uncommon condition in pregnancy, occurring in only 0.1%–0.4% of all pregnancies.

High serum hCG concentrations during early pregnancy may result in transient subclinical or, rarely, overt hyperthyroidism.

Subclinical hyperthyroidism

Subclinical hyperthyroidism (**low TSH, normal free T4**) may be followed up in pregnancy with no treatment. In these women, TSH, free T4, and/or total T4 or total T3 are monitored every 4–6 weeks.

Clinical presentation

Many of the symptoms of overt hyperthyroidism may be confused with symptoms of pregnancy. These are as follows:

- Tremors
- Sweating
- Heat intolerance
- Palpitation
- Weakness

Signs and symptoms that strongly suggest Graves' disease (autoimmune hyperthyroidism) are as follows:

- Onset of symptoms prior to pregnancy
- Symptoms persisting beyond the first trimester
- Diffuse goiter
- Significant infiltrative ophthalmopathy (exophthalmos) or dermopathy
- Prior history of autoimmune problems

Screening for hyperthyroidism

Although a positive association exists between the presence of thyroid antibodies and pregnancy loss, currently universal screening for antithyroid antibodies and possible treatment is not recommended.

Diagnosis of hyperthyroidism

The diagnosis of hyperthyroidism during pregnancy is based on thyroid function tests and is listed in Box 52.6.

Causes of hyperthyroidism in pregnancy

The following are the causes of hyperthyroidism:

- Autoimmune hyperthyroidism (Graves' disease) is the most common cause of

Box 52.6 Diagnostic criteria for overt and subclinical hyperthyroidism

Overt hyperthyroidism

- TSH
 - Suppressed (<0.1 mIU/L) or
 - Undetectable (<0.01)
- Serum free T4 and/or free T3
 - Elevated
- Serum total T4 and/or total T3
 - Elevated
- TRAb
 - Present only in Graves' disease

Subclinical hyperthyroidism

- TSH
 - Low
- Serum free T4 and/or free T3
 - Normal

Ab TSH receptor antibody; S thyroid-stimulating hormone.

hyperthyroidism in pregnancy and occurs in 0.1%–1% of pregnancies.

- **hCG-mediated hyperthyroidism** occurs in 1%–3% of all pregnancies. It is due to the fact that there is significant similarity between the β -subunits of hCG and TSH. As a result, hCG has weak thyroid-stimulating activity and may cause hyperthyroidism during the period of highest serum hCG concentrations (the first trimester).
- **Conditions that are associated with high hCG levels** may also present with thyrotoxicosis:
 - Hyperemesis gravidarum
 - Multiple pregnancy
 - Gestational trophoblastic neoplasm
- Toxic multinodular goiter and toxic adenoma may present with hyperthyroidism.
- Other uncommon causes include drug-induced thyrotoxicosis, subacute thyroiditis, and thyroid carcinoma.

Impact on pregnancy

Fetal adverse effects

Before planning pregnancy, it is recommended that a woman with thyrotoxicosis undergoes treatment till she is euthyroid.

The effect of thyrotoxicosis on pregnancy might be due to the disease itself or the antithyroid medications used. Inadequately controlled thyrotoxicosis is associated with

- miscarriage
- placental abruption
- preterm labor
- preeclampsia
- increase in perinatal mortality

Fetal adverse effects

Fetal adverse effects include the following:

- Fetal hypothyroidism and goiter may result from over treatment of the mother.
- Transplacental transfer of TSH antibodies may also lead to fetal hyperthyroidism and goiter. This may result in the fetal complications listed as follows:
 - Fetal growth restriction
 - Fetal tachycardia
 - Advanced bone age

- Fetal hydrops
- Fetal death

Treatment of hyperthyroidism in pregnancy

Similar to all autoimmune disorders, Graves' disease may go into remission in pregnancy. Medication may not be required in the second and third trimesters, but the disorder may recur 3 months after delivery.

Therapy for hyperthyroid women in pregnancy is limited by the fact that all available medications have the potential for fetal adverse effects.

Aims of treatment

The following are the aims of treatment:

- Optimize good fetal and maternal outcome.
- Maintain the mother's serum free T4 concentration at or just above the trimester-specific normal range for pregnancy.
- Use the lowest possible dose of antithyroid drugs.

Drug therapy

Thioamides are recommended for treatment of moderate-to-severe hyperthyroidism complicating pregnancy. Available thioamides include propylthiouracil (PTU), methimazole (MMI), and carbimazole (CBZ) that is completely metabolized to MMI.

In the past, PTU was considered the drug of choice throughout pregnancy for women with hyperthyroidism, because of concerns about the possible teratogenic effects of CBZ. However, there have been reports of severe PTU-related liver failure, though rare. This has led to a change in the recommendations. Currently, PTU is used only in the first trimester and CBZ in the second and third trimesters.

Drugs of choice

The following are the drugs of choice:

- Propylthiouracil
- Methimazole
- Carbimazole

The dosage and side effects of antithyroid drugs in pregnancy are summarized in Box 52.7.

Box 52.7 Antithyroid drugs, their side effects, and monitoring of dosage in pregnancy

- Propylthiouracil
 - 50 mg bid or tid
 - Recommended in first trimester
 - Crosses placenta less readily than carbimazole
 - Can cause agranulocytosis and rarely hepatic failure
- Carbimazole
 - 5–15 mg daily
 - Recommended in second and third trimesters
 - Crosses placenta readily
 - Can be teratogenic (choanal atresia and aplasia cutis)
 - Can cause agranulocytosis
- Monitoring of dosage
 - TSH and free T4 concentrations
 - Every 4 weeks
 - More frequently immediately after switching antithyroid drugs
 - Maintained within the trimester-specific range
 - Free T4 concentration
 - Maintained at or just above upper limit of normal
 - Monitoring throughout pregnancy essential
 - Maternal hyperthyroidism in the third trimester may increase risk of low birth weight

TSH, Thyroid-stimulating Hormone.

Management of symptoms of thyrotoxicosis

β -blockers, such as atenolol or propranolol, may be required for the management of tachycardia and tremor. However, β -blockers cannot be used for longer than 2–6 weeks because of concerns regarding fetal growth restriction and hypoglycemia.

Surgery

Surgery is rarely required in pregnancy. If it is required, surgery may be offered in the second trimester. Indications are as follows:

- Patient with a very large goiter
- Poor response to antithyroid medications and significant fetal effects

Radioiodine ablation

Radioiodine for ablating the thyroid gland is used on the nonpregnant woman. However, it may cause ablation of the fetal thyroid tissue that is present by 10–12 weeks. **It is therefore absolutely contraindicated during pregnancy.**

Antithyroid medications and breastfeeding

Antithyroid medications may be used safely during lactation. The recommended drugs and their dosage are as follows:

- Carbimazole
 - Up to a dose of 30 mg/day
- Propylthiouracil
 - Up to a dose of 300 mg/day
- Should be given after a feed

Thyroid nodules and thyroid cancer in pregnancy

It is not uncommon to find thyroid nodules in pregnancy, especially with the routine use of ultrasonogram. Thyroid nodules should be investigated the same way as in a nonpregnant woman.

Management of thyroid nodules in pregnancy

Management of thyroid nodules in pregnancy proceeds as follows:

- Nodules >1 cm should be subjected to fine-needle aspiration cytology (FNAC).
- Nodules <1 cm may also need to be aspirated if they sonologically show suspicious features such as
 - hypoechogenicity,
 - microcalcifications,
 - increased vascularity.

If the nodule is confirmed to be malignant, the management is as discussed below.

Thyroid cancer in pregnancy

Thyroid cancer discovered during pregnancy does not have a negative impact on the prognosis. The management of thyroid cancer in pregnancy is summarized in Box 52.8.

Postpartum thyroid dysfunction

Postpartum thyroiditis

Postpartum thyroiditis is a destructive thyroiditis induced by an autoimmune mechanism within 1

Box 52.8 Management of thyroid cancer in pregnancy

- Well-differentiated thyroid cancers (papillary and follicular carcinoma)
 - Slow growing
 - Surgery may be deferred till the postpartum period if
 - size remains stable
- Monitoring with ultrasound during pregnancy
 - Surgery in second trimester if
 - 50% increase in cancer volume
- Rare cases of aggressive tumors with metastases
 - Surgery in second trimester
- Suppressive thyroxine therapy indicated
 - when surgery postponed
 - after second trimester surgery
- Radioiodine therapy and scans
 - Absolutely contraindicated in pregnancy and lactation

year after pregnancy loss (miscarriage, abortion, ectopic pregnancy) or delivery. The diagnosis of postpartum thyroiditis is based on clinical manifestations and thyroid function tests. The two main types of thyroiditis are as follows:

- Postpartum thyrotoxicosis
- Postpartum exacerbation of chronic lymphocytic (Hashimoto's) thyroiditis

The typical sequence of clinical events is as follows:

- Hyperthyroidism
 - Usually begins 1–4 months after delivery
 - Lasts 2–8 weeks
- Followed by hypothyroidism
 - Lasts from about 2 weeks to 6 months
- Followed by recovery

treatment

The hyperthyroid phase is usually mild and may not require treatment. During the hypothyroid phase of postpartum thyroiditis, symptomatic women require treatment with thyroxine.

Graves' disease

Graves' disease may develop postpartum or there may be an exacerbation. Women whose disease is under control with antithyroid drug therapy may have a relapse in the postpartum period.

Parathyroid dysfunction in pregnancy

Parathyroid glands secrete parathyroid hormone (PTH) that, along with 1,25-dihydroxyvitamin D, is responsible for maintaining calcium and phosphate homeostasis. PTH (also known as parathormone) is a small protein that controls calcium and phosphate homeostasis, as well as bone physiology. PTH has effects antagonistic to those of calcitonin (produced by the thyroid).

Calcium and PTH metabolism in pregnancy is summarized in Box 52.9.

Hyperparathyroidism

Hyperparathyroidism is rare in pregnancy. Causes of hyperparathyroidism in pregnancy are as follows:

- Single parathyroid adenoma—80% of cases
- Primary hyperplasia of the parathyroid glands
- Multiple adenomas
- Parathyroid carcinoma—rare

Hyperparathyroid crisis is a serious complication that may occur in pregnancy or the postpartum period. If not recognized and treated promptly, hyperparathyroid crisis may progress to uremia, coma, and death.

Diagnosis

The diagnosis of hyperparathyroidism is based on persistent hypercalcemia (>9.5 mg/dL) in the presence of increased serum PTH levels. Ultrasound imaging may identify the parathyroid adenoma.

Box 52.9 PT metabolism and calcium in pregnancy

- PTH
 - Slightly decreased in the first half of pregnancy
 - Returns to normal by midgestation
- Calcium
 - 50% protein bound (mostly to albumin)
 - 10% in the form of anion complexes
 - 40% circulates free as ionized calcium
 - Active transfer of maternal calcium to the fetus

P = parathyroid hormone.

Impact of hyperparathyroidism on pregnancy

Hyperparathyroidism is associated with

- preeclampsia
- preterm birth
- high perinatal mortality—25% of cases
- high incidence of neonatal hypocalcemia

Treatment

Surgical excision of the adenoma is the only effective treatment of hyperparathyroidism. Complications due to surgery, particularly in the presence of a single lesion, are low, and the cure rates are high.

Hypoparathyroidism

Damage to or removal of the parathyroid glands during surgery for thyroid gland pathology is the most common etiology of hypoparathyroidism.

Presenting symptoms

Hypoparathyroidism should be suspected in a woman who has a history of thyroid surgery and presents with symptoms of hypocalcemia. The symptoms and signs of hypocalcemia are the same in pregnancy as in the nonpregnant women and include carpopedal spasm and tetany.

Diagnosis of hypocalcemia

The diagnosis of hypoparathyroidism is confirmed by the presence of persistent low serum calcium and high serum phosphate levels in the presence of normal renal function.

Impact on pregnancy

Hypoparathyroidism in pregnancy is associated with the following:

- Perinatal loss
 - Spontaneous abortions
 - Stillbirths
 - Neonatal deaths
- Fetal hyperparathyroidism
 - Generalized skeletal demineralization
 - Subperiosteal bone resorption
 - Bowing of the long bones
 - Osteitis fibrosa cystica
 - Rib and limb deformities

Treatment of hypoparathyroidism

Treatment of hypoparathyroidism in pregnancy does not differ from that in the nonpregnant state.

The woman is prescribed a normal high-calcium diet and vitamin D supplementation.

Vitamin D deficiency

Studies have found an association between low calcium and vitamin D levels and adverse health outcomes in mother and child. However, there is no definite evidence whether the low levels cause the adverse effects or are a marker of poor health, which by itself may result in adverse effects.

- Normal values of vitamin D₃: >20 ng/mL
- Vitamin D insufficiency: 10–20 ng/mL
- Vitamin D deficiency: <10 ng/mL

These values are relevant when they occur despite the availability of adequate sunlight.

There are several observational studies that suggest an association between low maternal vitamin D levels and a higher risk of developing

- Gestational diabetes
- Preeclampsia
- Small for gestational age infants

Effects of vitamin D deficiency on pregnancy

There are several observational studies that suggest an association between low maternal vitamin D levels and adverse pregnancy outcome as outlined in Box 52.10.

Although vitamin D insufficiency and deficiency are common in India, very low levels are not seen frequently. **Routine screening for vitamin D levels is not currently recommended in pregnancy.**

Treatment

There are no studies that conclusively show that administration of vitamin D decreases the risk of

Box 52.10 Effects of low levels of vitamin D on pregnancy

- Low levels of vitamin D are associated with
 - gestational diabetes
 - preeclampsia
 - small for gestational age infants
 - primary cesarean section
 - postpartum depression
- Very low levels of vitamin D in the mother can lead to
 - low vitamin D and calcium levels in the neonate and
 - neonatal convulsions

adverse outcomes. However, current recommendation is to administer 1000 IU of vitamin D daily to all pregnant women. Vitamin D may also be given as 60,000 IU every 2 months.

Adrenal disorders and pregnancy

Adrenal disease, including disorders such as congenital adrenal hyperplasia (CAH), Addison disease, Cushing syndrome, pheochromocytoma, and primary hyperaldosteronism, can cause female subfertility or infertility and have a negative impact on maternal and fetal health during pregnancy.

Congenital adrenal hyperplasia

Congenital adrenal hyperplasia is an inherited endocrine disorder that affects the adrenal gland. It occurs due to the deficiency of 21-hydroxylase enzyme (>90% of all cases of CAH), deficiency of 11-β-hydroxylase enzyme (5%–8% of cases of CAH), or deficiency of 17-α-hydroxylase (very rare). It can be broadly divided into the following:

- Classical forms of CAH
- Late-onset CAH

Adrenal androgens are produced in excess since they are intermediate metabolites that accumulate due to enzyme deficiency. This can give rise to androgenization, anovulation, and infertility. Treatment with glucocorticoids and assisted reproductive techniques has improved successful pregnancy rates.

Effect on pregnancy

Congenital adrenal hyperplasia is an autosomal recessive disorder. If the fetus is affected, the excessive androgens produced can cause virilization of the female fetus.

Management during pregnancy

Management during pregnancy has to take into consideration the glucocorticoid requirements of the mother as well as monitoring of the fetus.

- Glucocorticoids
 - Hydrocortisone, cortisone acetate, prednisolone, and methylprednisolone may be used.

- Clinical status, serum electrolyte levels, and serum androgen levels are checked regularly.
- Fetal sex determination is important since a male fetus will not be affected by maternal androgens.

abor an elivery

Congenital adrenal hyperplasia is managed during labor and delivery as follows:

- Stress-dose glucocorticoid therapy with hydrocortisone ester
 - 50–100 mg IV 8 hourly
 - At the initiation of active labor/or at induction of anesthesia
 - Continued until after delivery
 - Followed by a rapid taper to previous maintenance doses
- Cesarean section for
 - previous surgery for virilization
 - android pelvis

valuation o the in ant

A female infant should be examined for ambiguous genitalia. Virilization of the female genitalia may occur due to

- maternal hyperandrogenism or
- inherited 21-hydroxylase deficiency (if father is a carrier)

If the external genitalia are ambiguous, appropriate laboratory studies should be performed on the infant to exclude 21-hydroxylase deficiency, which can be a life-threatening emergency.

Prenatal diagnosis and treatment of CA

In the past two decades it has become possible to diagnose a fetus with 21-hydroxylase deficiency prenatally. In a pregnant woman with a history of an affected child, oral dexamethasone is started at 4–6 weeks' gestation. Prenatal diagnosis is done using chorionic villus sampling or amniocentesis. Further treatment with dexamethasone depends on the findings. Management of women with a previous history of an affected child or in female fetuses with ambiguous genitalia is summarized in Box 52.11.

Prenatal treatment with dexamethasone is safe for the mother and the fetus. An increase in morbidity or mortality has not been reported in fetuses treated to term and monitored through

Box 52.11 Management of suspected fetal congenital adrenal hyperplasia

- Diagnosis
 - Chorionic villus sampling (12 weeks)
 - To determine genotype or
 - Amniocentesis (16 weeks) to determine
 - 17-hydroxyprogesterone levels in the amniotic fluid
 - High levels confirm presence of 21-hydroxylase deficiency
 - Sex determination
 - Male or female
- Treatment
 - Oral dexamethasone is given to mother
 - 20 µg/kg of maternal body weight/day in divided doses beginning at 4–6 weeks' gestation
 - Crosses the placenta and suppresses the fetal adrenal gland
 - Oral dexamethasone is discontinued in case of
 - male fetus
 - normal genotype on chorionic villus sampling (unaffected female fetus)
 - normal 17-hydroxyprogesterone levels in the amniotic fluid
 - Oral dexamethasone is continued throughout pregnancy in case of
 - affected female

infancy and early childhood. However, dexamethasone therapy can result in weight gain, striae, and glucose intolerance in mothers.

Adrenal insufficiency or Addison disease

Addison disease is a very rare disorder. Adrenocortical insufficiency occurs due to the destruction or dysfunction of the entire adrenal cortex. It affects glucocorticoid and mineralocorticoid function. The onset of disease usually occurs when 90% or more of both adrenal cortices are dysfunctional or destroyed. It is commonly an autoimmune disorder. In developing countries, it could be caused by infections such as tuberculosis.

Maternal exhaustion and low blood pressure may be present. The symptoms of vomiting and hyperpigmentation, which occur in Addison disease, may be mistaken for symptoms of pregnancy. The diagnosis can be confirmed based on results of adrenal function tests.

Addison disease has been associated with fetal growth restriction.

Box 52.12 Management of Addison disease in pregnancy, labor, and delivery

- Glucocorticoid and mineralocorticoid replacement dosages are continued throughout pregnancy
- Increased glucocorticoid dosage may be required in the third trimester
- During labor
 - Adequate saline hydration
 - 25 mg of intravenous hydrocortisone sodium succinate
 - Every 6 hours
- At the time of delivery
 - High-dose parenteral hydrocortisone
 - 100 mg 6 hourly or as a continuous infusion
- After delivery
 - Dosage can be rapidly tapered to maintenance dose in 3 days

Box 52.13 The impact of Cushing syndrome on pregnancy

- Significant risk of maternal morbidity
 - Hypertension and preeclampsia
 - Gestational diabetes
 - Congestive heart failure due to severe hypertension
 - Wound breakdown after surgery
 - Profound proximal myopathy
 - Emotional lability/psychosis
- Fetal morbidity and mortality
 - Premature delivery
 - High perinatal mortality including stillbirths
 - Neonatal cortisol deficiency

Management in pregnancy, labor, and delivery

Management of Addison disease is summarized in Box 52.12.

Cushing syndrome in pregnancy

Cushing syndrome is a collection of signs and symptoms due to prolonged exposure to cortisol. Signs and symptom may include abdominal obesity along with thin arms and legs, a round red face ('moon face'), fat deposition between the shoulders, weak muscles and bones, acne, reddish striae, and fragile skin that heals poorly. Women may have hirsutism and anovulation leading to irregular menstruation. Occasionally there may be changes in mood, headaches, and a chronic feeling of tiredness.

Impact on pregnancy

Cushing syndrome is extremely rare in pregnancy. The impact of Cushing syndrome on pregnancy is summarized in Box 52.13.

Pheochromocytoma in pregnancy

A pheochromocytoma is a rare neuroendocrine tumor of the medulla of the adrenal glands (originating in the chromaffin cells), or extra-adrenal chromaffin tissue that secretes high amounts

of catecholamines, mostly norepinephrine and epinephrine to a lesser extent. The main sign of the disease is severe hypertension.

When associated with pregnancy, it can be catastrophic for the mother and fetus. The mortality rates can be as high as 50% for both mother and fetus. An unrecognized pheochromocytoma can be fatal because an uncontrollable hypertensive crisis may be precipitated by anesthesia or even normal delivery.

Diagnosis in pregnancy

There should be a high index of suspicion in pregnant women who develop severe uncontrollable hypertension in pregnancy associated with unusual features such as the following:

- Headache
- Palpitation
- Excessive sweating
- Family history of pheochromocytoma

Screening of 24-hour urinary catecholamine levels in a sample collected during or immediately after a hypertensive crisis will confirm the diagnosis.

Management in pregnancy

Management in pregnancy includes the following:

- α -Adrenergic blockade with phenoxybenzamine
- β -Blockade with propranolol after successful α -adrenergic blockade
- Surgical removal of tumor before 24 weeks
 - Surgical approach difficult after 24 weeks
- Vaginal delivery associated with higher mortality than cesarean delivery

Primary hyperaldosteronism

Primary hyperaldosteronism is an extremely rare cause of hypertension in pregnancy. A total of 18 cases of pregnancies complicated by hyperaldosteronism have been reported in the literature.

The classic symptoms of hyperaldosteronism are as follows:

- Hypertension
- Hypokalemia
- Elevated urine potassium levels

The commonest cause of hyperaldosteronism is an adrenal adenoma. Excision of the adenoma may be done in the second trimester.

Pituitary disorders in pregnancy

In pregnancy there is a gradual increase in maternal pituitary volume over the course of gestation, with an increased final weight of 660–760 mg, as well as a volume increase of 30% above the pre-gestational volume. Prolactin levels begin to rise at 5–8 weeks' gestation and peak in the third trimester (100–400 ng/mL). For details, see Chapter 3, *Maternal physiology in pregnancy*.

Anterior pituitary disorders

Prolactinoma and pregnancy

Prolactinomas are the most common hormone-secreting pituitary tumors. Based on its size, a prolactinoma can be classified as

- Microprolactinoma (<10 mm diameter)
- Macroprolactinoma (>10 mm diameter)

Lactotrophs in the anterior pituitary undergo neoplastic transformation and result in a tumor. This leads to excess synthesis and secretion of prolactin (hyperprolactinemia). Prolactinomas can cause symptoms due to

- hyperprolactinemia
- space-occupying effects of the tumor itself

Hyperprolactinemia causes symptoms of galactorrhea, amenorrhea, and infertility. Both microprolactinomas and macroprolactinomas are treated with the dopamine agonists bromocriptine

or cabergoline. Currently cabergoline is the drug of choice. Ovulatory cycles are restored in 80%–90% of women and pregnancy is possible.

ect o pregnancy on prolactinoma

Prolactinomas may undergo enlargement in pregnancy, but the majority will not become symptomatic.

ollo up o prolactinoma in pregnancy

Follow-up of prolactinoma in pregnancy is as follows:

- Dopamine agonist is discontinued on diagnosis of pregnancy
- Macroadenomas
 - Monthly screening for symptoms
 - Headache
 - Visual field changes
 - Diabetes insipidus
 - Visual fields tested each trimester

Enlargement requiring intervention is

- rare in microadenomas;
- more common in macroadenomas that have been treated surgically or with radiotherapy earlier;
- 30% in macroadenomas that have not been treated surgically or with radiotherapy earlier.

anagement o symptomatic prolactinoma in pregnancy

Management of symptomatic prolactinoma in pregnancy includes the following:

- Restarting dopamine agonist
- Delivery if pregnancy is sufficiently advanced
- Surgical decompression is rarely required

Sheehan syndrome (pituitary infarction)

Sheehan syndrome is infarction of the pituitary gland after postpartum hemorrhage (PPH) and results in hypopituitarism. The pituitary gland enlarges in pregnancy. Due to the increase in size, the pituitary gland is more susceptible to ischemia when systemic blood pressure falls in PPH (see Chapter 3, *Maternal physiology in pregnancy*).

In developing countries, postpartum pituitary infarction continues to be a common cause of

Box 52.14 Clinical presentation of Sheehan syndrome

- History of postpartum hemorrhage severe enough
 - to cause hypotension
 - to require transfusion of multiple units of blood
- Severe hypopituitarism
 - Significant symptom
 - Failure of lactation during the first days after delivery
 - Development of profound lethargy, anorexia, and weight loss
- Moderate hypopituitarism
 - Failure of postpartum lactation
 - Failure to resume menses in the weeks and months after delivery
 - Gradual loss of sexual hair
 - Milder degrees of fatigue, anorexia, and weight loss
- Mild hypopituitarism
 - Delay in recognition—may take years
- Deficiency of all anterior pituitary hormones
 - GH, prolactin, gonadotropin (FSH and LH), TSH, and adrenocorticotrophic hormone (ACTH) deficiency
- Shrinkage of pituitary size resulting in an 'empty sella' on MRI

S follicle-stimulating hormone; *G* growth hormone; *L*uteinizing hormone; *MRI* magnetic resonance imaging; *TSH* thyroid-stimulating hormone.

hypopituitarism because of the persisting high rate of profound PPH.

Much less commonly, infarction may occur immediately postpartum, even in the absence of obvious hemorrhage. The clinical features of Sheehan syndrome are enumerated in Box 52.14.

treatment

Treatment of hypopituitarism in Sheehan syndrome requires lifelong replacement of all the deficient hormones.

Obesity in pregnancy

Obesity is not the result of a simple imbalance between calorie intake and energy expenditure. It is a complex multifactorial disorder involving genetic, environmental, and endocrine factors.

Overweight and obese women are not only at increased risk of several pregnancy complications, they also face the problem of postpartum weight retention.

Maternal obesity also has an impact on the fetus, resulting in an increased risk of prematurity, stillbirth, congenital anomalies, macrosomia with possible birth injury, and childhood obesity.

WHO classification of obesity

The cutoff BMI for definition of normal and obese women in developed countries is based on mortality outcomes in the Caucasian population. However, Asian women are smaller and complications of obesity occur at a lower BMI. Hence, the World Health Organization (WHO) has developed a classification for the Asian population as given in Box 52.15.

The commonest cause for obesity is overeating and inadequate physical activity, that is, an imbalance between calories consumed and calories spent. Other causes such as hypothyroidism, hypothalamic problems, Cushing syndrome, and drug-induced obesity are rare and should be excluded by history and clinical examination. Polycystic ovarian syndrome is commonly associated with obesity in young women, but the condition is grossly overdiagnosed. Many women with this diagnosis may be just obese with associated menstrual irregularity.

Complications of obesity

Metabolic syndrome is the most common problem associated with obesity (Box 52.16). This consists of increased waist-hip ratio, abdominal obesity, impaired glucose tolerance or diabetes,

Box 52.15 WHO classification of obesity in Asian women

Category	BMI (kg m^2)
Normal weight	18.5–23
Overweight	23–27.5
Obese	>27.5
Class I	27.5–31
Class II	31–35
Class III	≥35

Box 52.16 Metabolic syndrome and its complications

- Increased waist–hip ratio
- Abdominal obesity
- Impaired glucose tolerance or diabetes
- Hypertension
- Dyslipidemia
- Complications
 - Menstrual disorders and infertility
 - Long-term complications
 - Atherosclerosis
 - Coronary heart disease
 - Stroke

hypertension, dyslipidemia, and the complications of these. Menstrual disorders and infertility are quite common. Other long-term complications include atherosclerosis, coronary heart disease, stroke, osteoarthritis of the knees, cholecystitis, and cholelithiasis. The risk of endometrial and breast cancer is also increased in obese women.

Diagnosis of obesity in pregnancy is based on prepregnancy BMI. It is encountered in 6%–10% of pregnancies and so is a very important and common medical disorder complicating pregnancy.

Complications in pregnancy

Pregestational diabetes is present in 15% and hypertension in 30% of obese pregnant women. Many others develop gestational diabetes, hypertension, preeclampsia, or venous thromboembolism. Obstetric palpation and ultrasonographic evaluation are difficult. Labor may be prolonged, and the risk of operative deliveries, cesarean section, and shoulder dystocia is increased. The complications that can occur during pregnancy are listed in Box 52.17.

In addition, the risk of fetal complications is also increased (Box 52.18).

Management

Preconceptional management

Preconceptional counseling regarding weight optimization is mandatory. The complications

Box 52.17 Complications of obesity in pregnancy

- Preconceptional
 - Pregestational diabetes
 - Hypertension
- Antepartum
 - Gestational diabetes
 - Hypertension/preeclampsia
 - Fetal macrosomia
 - Venous thromboembolism
 - Inaccurate ultrasonographic measurements
- Intrapartum
 - Postterm pregnancy
 - Labor induction
 - Prolonged labor
 - Operative vaginal delivery
 - Cesarean section
 - Shoulder dystocia
 - Difficulty in electronic fetal monitoring
- Intraoperative
 - Difficult intubation
 - Aspiration
- Postpartum
 - Postpartum hemorrhage
 - Venous thromboembolism
 - Wound infection

Box 52.18 Fetal complications due to maternal obesity

- Prematurity
- Macrosomia
- Low Apgar scores
- Increase in neonatal intensive care unit admissions
- Perinatal mortality
- Childhood/adolescent/adult obesity
- Metabolic syndrome in adulthood

and risks of obesity should be discussed with the patient. Diabetes and hypertension should be evaluated and controlled, and medications reviewed.

Antepartum management

Pregnant woman with obesity should be counseled regarding recommended weight gain during pregnancy, based on prepregnancy BMI (Table 52.1). Dietary modification and lifestyle changes should be explained and reinforced repeatedly.

Table 52.1 Recommended weight gain based on prepregnancy BMI

Prepregnancy BMI	recommended weight gain (kg)
Normal	11–16
Overweight and class I obese	7–11
Class II and III obese	5–7

B body mass index

Screening for gestational diabetes at the first visit is mandatory. If negative, the test should be repeated at 24 weeks. Ultrasonography should be

performed in the first trimester for dating of pregnancy, in the second trimester for morphology, and in the third trimester to exclude macrosomia. Close monitoring of blood pressure is essential.

Intrapartum management

Consultation with an anesthetist should be sought for women with morbid obesity. Shoulder dystocia should be anticipated. An experienced obstetrician should be present at cesarean section. Thromboprophylaxis is required postpartum.

The infant should be followed up for childhood obesity and other metabolic problems that may occur later.

Key points

- Thyroid dysfunction during pregnancy may result in complications for both the mother and the baby.
- Overt hypothyroidism complicating pregnancy is uncommon. Its incidence in pregnancy is low because untreated hypothyroid women may be anovulatory and have an increased rate of first trimester spontaneous abortion.
- Subclinical hypothyroidism has no clinical symptoms but is diagnosed because of abnormalities in thyroid function tests. The thyroid-stimulating hormone (TSH) will be elevated with a normal free T4.
- Subclinical hypothyroidism has a lower rate of pregnancy complications but is also implicated in an increased risk for severe preeclampsia, preterm delivery, placental abruption, and/or pregnancy loss.
- Universal screening for hypothyroidism is not recommended in pregnancy. Targeted screening can be offered to women who have one or more risk factors.
- Both overt hypothyroidism and subclinical hypothyroidism should be treated in pregnancy.
- In women who are on treatment prior to pregnancy, it is recommended that TSH levels be brought below 2.5 mIU/mL prior to conception.
- Overt hyperthyroidism is symptomatic hyperthyroidism that has been confirmed by low/undetectable TSH and elevated free T4 and/or free T3 levels. It is a relatively uncommon condition in pregnancy, occurring in only 0.1%–0.4% of all pregnancies.
- High serum hCG concentrations during early pregnancy may result in transient subclinical or, rarely, overt hyperthyroidism.
- Graves' disease is the commonest cause of hyperthyroidism in pregnancy. The other cause is hCG-mediated hyperthyroidism.

- Thioamides are recommended for treatment of moderate-to-severe hyperthyroidism complicating pregnancy. Available thioamides include propylthiouracil (recommended in the first trimester) and carbimazole (recommended in the second and third trimesters).
- Thyroid cancer discovered during pregnancy does not have a negative impact on the prognosis.
- Postpartum thyroiditis is a destructive thyroiditis induced by an autoimmune mechanism within 1 year after pregnancy loss (miscarriage, abortion, ectopic pregnancy) or delivery.
- Hyperparathyroidism is rare in pregnancy. The commonest cause of hyperparathyroidism in pregnancy is a single parathyroid adenoma. It is treated by surgical excision.
- Damage to or removal of the parathyroid glands during surgery for thyroid gland pathology is the most common etiology of hypoparathyroidism.
- Hypoparathyroidism may result in perinatal morbidity and mortality. Fetal hyperparathyroidism can be a problem. Treatment is with a normal high-calcium diet and vitamin D supplementation.
- Adrenal disease, including disorders such as congenital adrenal hyperplasia (CAH), Addison disease, Cushing syndrome, pheochromocytoma, and primary hyperaldosteronism, can cause female subfertility or infertility and have a negative impact on maternal and fetal health during pregnancy.
- Although CAH has a low rate of pregnancies, successful births have been reported in a small number of women who became pregnant.
- Management of women with a previous history of an affected child or in female fetuses with ambiguous genitalia includes prenatal diagnosis to rule out CAH in the fetus.

(Continued)

Key points *Continued*

- Addison disease is a very rare disorder. Adrenocortical insufficiency occurs due to the destruction or dysfunction of the entire adrenal cortex. It can result in fetal growth restriction.
- Cushing syndrome is a collection of signs and symptoms due to prolonged exposure to cortisol. It is very rare in pregnancy and has been associated with significant maternal and fetal morbidity and mortality.
- A pheochromocytoma is a rare neuroendocrine tumor of the medulla of the adrenal glands. When associated with pregnancy, it can be catastrophic for the mother and fetus.
- Prolactinomas are the most common hormone-secreting pituitary tumors. They may undergo enlargement in pregnancy, but the majority will not become symptomatic. Symptomatic prolactinomas will require restarting of dopamine agonist.
- Sheehan syndrome is infarction of the pituitary gland after postpartum hemorrhage (PPH) and results in hypopituitarism. Failure of lactation during the first days after delivery is a significant symptom in pregnancies complicated by profound PPH.
- Treatment of hypopituitarism requires replacement of all the deficient hormones.
- Obesity is a common problem encountered in the obstetric population. It is associated with several obstetric complications such as diabetes, hypertension, fetal macrosomia, shoulder dystocia, cesarean delivery, PPH, and deep vein thrombosis (DVT).
- Preconceptional counseling and weight optimization are mandatory in obese women. During pregnancy, close monitoring of blood sugar levels and blood pressure is mandatory.

Self-Assessment

Case-based scenarios

Case 1

Mrs. LM, 27, has been on thyroxine for the past several years for hypothyroidism. She is now planning a pregnancy. She and her husband are concerned about hypothyroidism and its effect on the baby. Her recent blood tests showed a TSH value of 6.3 mIU/mL and free T₄ of 1.0 ng/dL. They want to know whether it is safe to go ahead with a pregnancy.

1. What is the recommended level of TSH preconceptionally?
2. What are the diagnostic criteria for hypothyroidism in pregnancy?
3. What is the impact of hypothyroidism on pregnancy?
4. What are the goals of treatment of hypothyroidism in pregnancy?

Case 2

Mrs. GH, 29, delivered vaginally 7 days ago. She had profuse PPH due to atonic uterus and had hypovolemic shock. She required 6 units of packed cells. She has not been able to establish lactation. She feels tired and exhausted.

1. What is the diagnosis and the pathophysiology?
2. How is the diagnosis confirmed?
3. What are the effects of hypopituitarism?
4. What is the treatment in this case?

Case 3

Mrs. AC, 22, has come for prepregnancy counseling. Her BMI is 31 and her mother is diabetic.

1. What evaluation would you do?
2. What complications are likely if she conceives?
3. How will you counsel her?

Answers

Case 1

1. In women who are on treatment prior to pregnancy, it is recommended that TSH levels be brought below 2.5 mIU/mL prior to conception.
2. Overt hypothyroidism: Elevated trimester-specific TSH with decreased free T₄. Subclinical hypothyroidism: Elevated trimester-specific serum TSH concentration with normal free T₄ concentration.
3. Hypothyroidism is associated with an increased risk for severe preeclampsia, preterm delivery, placental abruption, and/or pregnancy loss. There may also be cognitive impairment in the offspring.
4. The goal of T₄ replacement therapy is to restore normal thyroid function (euthyroidism) as soon as possible. It is recommended that TSH value should be kept at or below 2.5 mIU/L, especially during the first trimester.

Case 2

1. She has Sheehan syndrome. The pituitary gland enlarges in pregnancy. Due to the increase in size, the pituitary gland is more susceptible to ischemia when systemic blood pressure falls in postpartum hemorrhage.
2. Failure to establish lactation is a strong indication of Sheehan syndrome. Tiredness and exhaustion could be a sign of adrenal insufficiency. She needs to be evaluated immediately for adrenal deficiency, and in 4–6 weeks the pituitary hormone levels should be measured.
3. Hypopituitarism may result in failure to establish lactation, profound fatigue, anorexia, and weight loss. There will be loss of sexual hair and failure to resume menses.
4. She will require long-term replacement of pituitary hormones.

Case 3

1. History of irregular cycles and family history of hypertension. Examination to look for acanthosis nigricans, hypertension, and hirsutism. Fasting and postprandial glucose estimation.

2. Antenatal—gestational diabetes, hypertension, preeclampsia, fetal macrosomia, prolonged pregnancy, induction of labor, prolonged labor, instrumental delivery, cesarean section, DVT, shoulder dystocia, and anesthetic complications.
3. Weight optimization before pregnancy by diet and regular exercises. Keep the weight gain in pregnancy appropriate to the prepregnancy BMI. Screening for diabetes during pregnancy, and close watch on the blood pressure and fetal growth.

Sample questions

Long-answer question

1. Discuss thyroid disorders in pregnancy.
2. Sheehan syndrome: Pathophysiology and management.

Short-answer questions

1. Postpartum thyroiditis
2. Prenatal diagnosis of CAH
3. Complications of obesity in pregnancy

53

Respiratory, Dermatological, and Connective Tissue Disorders

Case scenario

Mrs. BN, 24, primigravida, at 32 weeks of pregnancy, presented with skin lesions over the abdomen and thighs that were severely pruritic. She was worried that the condition could be serious and affect the baby as well.

Introduction

Disorders of various organ systems are frequently encountered in pregnancy. Pregnancy predisposes to some of these disorders; some are aggravated by pregnancy and some affect the mother and fetus adversely.

Disorders of the respiratory tract

Changes in the respiratory system in pregnancy are described in Chapter 3, *Maternal physiology in pregnancy*. Hormonal changes affect the mucous membrane producing edema, congestion, and increase in secretions. As the uterus enlarges, the diaphragm is displaced upwards, causing changes in pulmonary function. The vital capacity is maintained, tidal volume and

resting minute ventilation increase, and functional residual capacity is decreased. Oxygen consumption increases by 20%–30%. Dyspnea is, therefore, common in pregnancy and is partly due to the central effect of progesterone.

Diseases of the respiratory tract are very common in pregnancy. Diseases of the cardiovascular system such as valvular and congenital heart diseases, cardiomyopathy, and preeclampsia can cause pulmonary edema and dyspnea. This should be distinguished from primary respiratory conditions. Respiratory infections may be self-limiting but can progress to bronchitis or pneumonia. Preexisting asthma may complicate pregnancy.

rhinitis

Rhinitis is common in pregnancy. The causes are as follows:

- Pregnancy rhinitis
- Allergic rhinitis

- Rhinitis medicamentosa
- Sinusitis

Pregnancy rhinitis is due to the hyperemia and edema of the nasal mucosa. Preexisting allergic rhinitis can worsen during pregnancy. Nasal drops and sprays can give rise to rhinitis medicamentosa. Sinusitis is usually bacterial.

Treatment is symptomatic, usually with saline nasal drops and steam inhalation. Allergic rhinitis responds to cromolyn sodium, nasal sprays, and leukotriene modulators such as montelukast. Bacterial sinusitis requires antibiotics.

Acute bronchitis

Viral upper respiratory infections may progress to bronchitis. The infections are community acquired and caused by influenza virus, adenoviruses, and rhinoviruses. Treatment is symptomatic, and antibiotics are required only if there is secondary bacterial superinfection with purulent sputum. Amoxicillin can be used and is safe in pregnancy.

Pneumonia

Pneumonia is usually community acquired. It may be viral or bacterial. Bacterial pneumonia is caused by *Streptococcus pneumoniae*, *Haemophilus influenzae*, or *Mycoplasma pneumoniae*. Clinical features are the same as in nonpregnant patients. Fever, chills cough, purulent or rusty sputum, and dyspnea are the usual symptoms. Viral pneumonia is often complicated by super added bacterial infection.

Pregnant women with pneumonia should be admitted and symptomatic treatment should be given. Antibiotics are required for treatment of bacterial pneumonia. Amoxicillin with clavulanic acid, azithromycin, cephalosporins, levofloxacin, or ofloxacin may be used (Box 53.1).

Asthma

Asthma is a common medical condition that complicates pregnancy.

Effect of pregnancy on asthma

The symptoms may worsen, improve, or remain stable during pregnancy. Risk of exacerbation

Box 53.1 Respiratory infections in pregnancy

- Acute bronchitis
 - Community acquired
 - Viral infection
 - Influenza/adenovirus/rhinovirus
 - Symptomatic therapy
- Pneumonia
 - Community acquired
 - Present with fever, chills, cough, and dyspnea
 - Bacterial or viral
 - Requires hospitalization
 - Antibiotics if bacterial
 - Amoxicillin with clavulanic acid
 - Azithromycin
 - Cephalosporins
 - Levofloxacin/ofloxacin

depends on the preexisting severity of asthma. Exacerbations are associated with respiratory infections and poor compliance with inhaled steroids. Symptoms can worsen during labor.

Effect of asthma on pregnancy

Women with asthma have a higher risk of developing complications such as preeclampsia and preterm labor, fetal growth restriction, and perinatal mortality. Severe asthma causes respiratory alkalosis, hypoxia, and decreased maternal oxygenation. This leads to decreased placental blood flow and fetal growth restriction. Therefore, good control of asthma with appropriate inhaled steroids used with an inhalation device or nebulizer reduces the risk of complications.

Clinical features

Symptoms of asthma in pregnancy are the same as in nonpregnant patients and include cough, dyspnea, and wheezing on auscultation. The triggers for asthma are also the same. According to the severity of symptoms, asthma in pregnancy is classified into intermittent, mild persistent, moderate persistent, and severe persistent disease. Severity is assessed by measurement of forced expiratory volume (FEV1) and peak expiratory flow rate (PEFR). Arterial blood gas analysis is required during an acute severe attack or in status asthmaticus.

Management of chronic asthma

Management of chronic asthma is by the following:

- Assessment of severity by measurement of FEV and PEFR
- Patient education
- Avoidance of triggers
- Pharmacotherapy

Assessment of severity is essential for planning therapy. It also helps to differentiate asthma from the progesterone-induced dyspnea of pregnancy. **Patient education** should focus on precipitating factors, lifestyle changes, breathing exercises, early recognition of symptoms, and prompt initiation of treatment. **Identification and avoidance of triggers** is mandatory in all asthmatics.

Pharmacotherapy

Pharmacotherapy depends on severity. Drugs used are inhaled corticosteroids such as budesonide and fluticasone; long-acting β -agonists (LABA) such as salmeterol and formoterol; short-acting β -agonists (SABA) such as salbutamol; oral corticosteroids; leukotriene modifiers such as montelukast and zafirlukast; and oral corticosteroids such as prednisolone. A stepwise approach is used as given in Box 53.2.

Box 53.2 Stepwise approach for management of chronic asthma

- Intermittent
 - SABA as required
- Mild persistent
 - SABA as required
 - Low-dose inhaled corticosteroids
- Moderate persistent
 - SABA as required
 - Low-dose inhaled corticosteroids
 - LABA
- Severe persistent
 - SABA as required
 - High-dose inhaled corticosteroids
 - LABA
- Very severe persistent
 - LABA
 - High-dose inhaled corticosteroids using nebulizer
 - Oral/parenteral corticosteroids

ABA long-acting β -agonists; SABA short-acting β -agonists.

β -agonists and inhaled corticosteroids are safe in pregnancy. Oral steroids may be used when indicated, although there are some concerns about their effect on the mother and fetus. Leukotriene modifiers are not as effective as β -agonists or corticosteroids, although they are safe in pregnancy. Theophylline has been used as oral maintenance therapy and has no adverse effects on pregnancy.

Respiratory infection is often the precipitating factor for an acute episode of asthma. This must be treated with appropriate antibiotics.

Management of acute asthma

Early hospitalization is recommended for acute asthma in pregnancy. Management is outlined in Box 53.3.

Intrapartum management

Asthma may worsen during labor. PEFR and FEV1 should be measured and serially monitored in labor in symptomatic women. If the woman has received oral or parenteral steroid therapy in the preceding 4 weeks, hydrocortisone 100 mg should be administered 8 hourly as stress dose and continued for 24 hours after delivery. Oxytocin and prostaglandin E₁ and E₂ may be used, but prostaglandin F_{2a} and methergine are contraindicated. Regional anesthesia is recommended for a cesarean section.

Box 53.3 Management of acute asthma in pregnancy

- Acute asthma
 - Hospitalization
 - Oxygen by mask
 - Pulse oximetry
 - β -adrenergic agonist
 - oral/SC/inhaled
 - Corticosteroids oral/IV
- Status asthmaticus
 - Admission to ICU
 - β -agonists
 - Corticosteroids IV
 - Intubation and mechanical ventilation

Dermatological disorders in pregnancy

Several dermatological changes occur in normal pregnancy. Most of these are self-limiting and resolve after delivery. Treatment is not required unless the symptoms are troublesome.

Dermatological changes in pregnancy

Dermatological changes in pregnancy include pigmentary and vascular changes in the skin, changes in the connective tissue, hair, and nails. These changes are listed in Box 53.4.

Pigmentary changes

Pigmentary changes are common in pregnancy. Most pigmentary changes regress after delivery. Melasma or chloasma typically affects the face and involves the forehead, cheeks, and bridge of the nose. This may worsen with exposure to sunlight. Persistent melasma can be treated with topical retinoic acid, salicylic acid, hydroquinone, or tretinoin.

Box 53.4 Dermatological changes in pregnancy

- Pigmentary changes
 - Hyperpigmentation
 - Areola, genital skin, neck, and axillae
 - Linea nigra
 - Melasma
 - Melanocytic nevi
- Vascular changes
 - Spider nevi
 - Palmar erythema
 - Pyogenic granuloma
 - Vulvar varicosities and hemorrhoids
 - Varicose veins and venous stars in the lower limbs
- Connective tissue changes
 - Striae gravidarum
 - Fibroepithelial polyps
- Hair and nail changes
 - Puerperal hair loss
 - Hirsutism
 - Brittle nails
 - Distal onycholysis

Vascular changes

Vascular changes such as palmar erythema and spider nevi do not require any treatment and resolve spontaneously after delivery. Pyogenic granulomas are red, nodular, and pedunculated lesions. The term pyogenic granuloma is a misnomer because the lesion is neither pyogenic nor is it a granuloma. The lesions often ulcerate and are usually seen on the gums, scalp, trunk, fingers, and toes. Treatment should be delayed until delivery and troublesome persistent lesions can be cauterized.

Connective tissue changes

Striae are seen in most pregnant women but are more severe in obese women. They occur on the abdomen, thighs, buttocks, and breasts. They usually fade after delivery and do not respond to or warrant any treatment.

Fibroepithelial polyps persist after delivery and should be cauterized.

Hair and nail changes

Changes in the hair and nail are due to the hormonal changes of pregnancy. Hirsutism, if obvious, can be treated with waxing or electrolysis.

Pregnancy-specific dermatoses

There are some skin conditions that occur in pregnancy, present with pruritus with or without rashes, and resolve after delivery. Some of these may be associated with fetal complications as well.

Intrahepatic cholestasis

In cholestasis of pregnancy that occurs in the third trimester, the primary symptom is pruritus associated with mild elevation of direct bilirubin and liver enzymes to a lesser extent. Pruritus is generalized, and may be intense and worse at night. There is no skin rash. The condition was formerly termed pruritus of pregnancy. Intrahepatic cholestasis is discussed in greater detail in Chapter 51, *Hepatic and gastrointestinal disorders*.

Pruritic urticarial papules and plaques of pregnancy

Pruritic urticarial papules and plaques of pregnancy (PUPPP) is the most common dermatosis in pregnancy. The condition is characterized by erythematous papules and plaques that occur in the third trimester, associated with itching (Box 53.5). The lesions begin as papules within the abdominal striae and spread to the thighs, buttocks, and arms. Individual lesions coalesce to form plaques. PUPPP is more common with stretching of the abdominal wall as in multiple pregnancy. Lesions resolve after delivery. The disorder does not cause any maternal or fetal complications.

treatment

Initial treatment is with antihistamines. Topical corticosteroids are effective and are used to relieve symptoms. Oral prednisolone may be required with severe itching.

Atopic eruption of pregnancy

Atopic eruption of pregnancy (AEP) includes three types of lesions (Box 53.6):

- *Eczematous patches* that are dry, scaly, and thickened and are usually seen on the flexures, nipples, neck, and face. The lesions appear in the second trimester and are associated with pruritus.
- *Erythematous papules or nodules* usually appear on the trunk or extensor surfaces and are also known as prurigo of pregnancy.
- *Follicular lesions and sterile pustules*, referred to as pruritic folliculitis of pregnancy. All lesions resolve after delivery and do not recur in subsequent pregnancies.

Box 53.5 Pruritic urticarial papules and plaques of pregnancy

- Most common pregnancy dermatosis
- Occurs in third trimester
- Begin as papules within striae
- Coalesce to form plaques
- Associated with pruritus
- Resolve after delivery
- No maternal/fetal complications
- Treatment
 - Antihistamines
 - Topical steroids
 - Occasionally oral prednisolone

Box 53.6 Atopic eruption of pregnancy

- Three types of lesions
 - Eczematous patches (eczema of pregnancy)
 - Erythematous papules (prurigo of pregnancy)
 - Follicular lesions (pruritic folliculitis of pregnancy)
- Associated with pruritus
- Appears in second trimester
- No fetal complications
- Resolves after delivery
- Treatment
 - Antihistamines
 - Topical corticosteroids

Treatment is with antihistamines and topical corticosteroids. Rarely, oral corticosteroids or cyclosporine may be required.

Pemphigoid gestationis

Pemphigoid gestationis is also known as herpes gestationis. This is a rare form of dermatosis and is an autoimmune disorder. The lesions appear in the second trimester and consist of vesicles, bullae, or erythematous plaques (Box 53.7). They are seen over the trunk, buttocks, and limbs. There is associated pruritus. The condition can become worse after delivery and last for several months. The lesions can recur in subsequent pregnancies, during menstruation, and with oral contraceptive use. Risk of fetal mortality is increased due to prematurity and low birth weight.

Treatment of mild-to-moderate cases is with topical corticosteroids, but most women require oral prednisolone 20–40 mg/day. Once new lesions stop appearing, the dose may be

Box 53.7 Pemphigoid gestationis

- Uncommon disorder
- Autoimmune etiology
- Occurs in second trimester
- Vesicles, bullae, and plaques
- Associated with pruritus
- May worsen postpartum
- May persist for several months
- Can recur in subsequent pregnancies
- Fetal complications
 - Prematurity
 - Low birth weight
- Treatment
 - Mild to moderate: Topical steroids
 - Severe: Oral prednisolone

reduced. Long-term treatment may be required. Intravenous immunoglobulin and plasmapheresis have been used in severe cases. Antepartum fetal surveillance is essential.

Pustular psoriasis of pregnancy (impetigo herpetiformis)

Pustular psoriasis of pregnancy (impetigo herpetiformis) manifests as white, sterile pustules on erythematous papules or plaques. The pustules are seen in inframammary areas, axillae, groin, and gluteal areas. The pustules rupture, leaving raw areas. Onset is usually in the third trimester. Associated symptoms are fever, nausea, vomiting, diarrhea, and chills. The condition resolves after delivery but can recur in subsequent pregnancy. Fetal growth restriction and stillbirths can occur.

Treatment is with oral prednisolone 60–80 mg/day. The dose can be tapered when lesions subside.

Connective tissue disorders in pregnancy

Connective tissue disorders are autoimmune and, like other autoimmune disorders, they often tend to go into remission in pregnancy.

- The common connective tissue disorders complicating pregnancy are systemic lupus erythematosus (SLE) and antiphospholipid antibody (APA) syndrome. Rheumatoid arthritis, scleroderma, and vasculitis are uncommon in pregnancy.
- Pregnancy-related changes in autoimmunity can alter the course of these diseases, and amelioration of symptoms or exacerbations can occur. Placental insufficiency and fetal loss can occur in SLE and APA syndrome.
- Pregnancy must be planned when the disease is in remission. Medications must be reviewed. Nonsteroidal anti-inflammatory agents should be discontinued. Prednisolone and azathioprine are safe in pregnancy, but cyclophosphamide, methotrexate, and leflunomide are contraindicated. Evaluation for and treatment of APA syndrome with anticoagulants is mandatory (Chapter 54, *Thromboembolic disorders*).

Systemic lupus erythematosus

Systemic lupus erythematosus occurs predominantly in women. Clinical manifestations include fever, malaise, symmetric small joint polyarthritis, photosensitivity, rash, and anemia. Involvement of renal, vascular, neurological, and musculoskeletal systems may occur. Diagnosis is made using the clinical criteria as laid down by American Rheumatology Association, along with the identification of antinuclear antibodies and other autoantibodies.

During pregnancy, SLE improves in one-third of women, worsens in one-third of women, and remains unchanged in one-third of women. Good outcome can be expected in the following cases:

- Disease has been under remission for 6 months prior to pregnancy.
- There is no lupus nephritis.
- APAs are negative.
- There is no superimposed preeclampsia.

Complications

The multiorgan involvement of the disease with resultant hypertension, thrombophilia, renal failure due to lupus nephritis, and pulmonary hypertension as well as steroid-induced diabetes mellitus can lead to several complications in pregnancy as listed in Box 53.8. Lupus nephritis

Box 53.8 Complications of systemic lupus erythematosus in pregnancy

- Maternal
 - Preeclampsia
 - Preterm labor
 - Eclampsia
 - HELLP syndrome
 - Anemia
 - Thrombocytopenia
 - Deep vein thrombosis
 - Stroke/pulmonary embolism
 - Maternal infections
 - Maternal mortality
- Fetal
 - Prematurity
 - Fetal growth restriction
 - Perinatal mortality
 - Neonatal lupus syndrome
 - Congenital complete heart block

P hemolysis, elevated liver enzymes, low platelets.

significantly worsens the outcome of pregnancy and is associated with a high risk of preeclampsia, eclampsia, and fetal growth restriction.

Management

Disease activity should be monitored by clinical and laboratory parameters. A close watch should be kept on the blood pressure, maternal hemoglobin, platelet count, and proteinuria. Antepartum fetal surveillance is mandatory.

Low-dose aspirin (75 mg/day) should be started as soon as pregnancy is confirmed. Oral prednisolone is the mainstay of treatment; the dose should be adjusted according to disease severity. Azathioprine and hydroxychloroquine may be used if required.

Neonatal lupus syndrome manifests as skin lesions, hematological abnormalities, and hepatic involvement. These are transient and resolve after a few days. Congenital heart block occurs in the fetus of women with high titers of SS-A and SS-B antibodies. Diagnosis can be made by 18–26 weeks. The heart block is permanent and the prognosis is guarded.

Contraception

Combined oral contraceptives should not be used in women with nephritis, APA syndrome, and vascular involvement. Progestin-only pills or injectables and intrauterine devices may be used.

Key points

- Diseases of the respiratory tract such as rhinitis and acute bronchitis are common in pregnancy.
- Rhinitis could be due to mucosal congestion of pregnancy, allergy, or sinusitis. Treatment is symptomatic and with antihistamines.
- Acute bronchitis is usually viral and treated symptomatically. Pneumonia may be viral or bacterial. Antibiotics are required for bacterial infections.
- Asthma may worsen, improve, or remain stable in pregnancy. Severe asthma causes hypoxia and respiratory alkalosis. Assessment of severity is with forced expiratory volume and peak expiratory flow rate.
- Management of asthma consists of assessment of severity, patient education, avoidance of triggers, and pharmacotherapy. Drugs used are inhaled steroids, long-acting β -agonists, short-acting β -agonists, leukotriene modifiers, and oral steroids. Stepwise approach with these drugs is recommended.
- Dermatological disorders are common in pregnancy. Most are self-limiting and resolve after delivery.
- Pregnancy-specific dermatoses present with pruritus with or without rashes and resolve after delivery.
- Intrahepatic cholestasis presents with pruritus and mild elevation of liver enzymes. There is no skin rash. Treatment is with antihistamines. Ursodeoxycholic acid relieves symptoms.
- Pruritic urticarial papules and plaques of pregnancy is the most common dermatosis in pregnancy. Atopic dermatoses are less common. All dermatoses in pregnancy are treated symptomatically with antihistamines and topical steroids.
- Systemic lupus erythematosus improves in one-third of women, worsens in one-third of women, and remains unchanged in one-third of women during pregnancy.
- Systemic lupus erythematosus is associated with complications such as preeclampsia, preterm labor, HELLP syndrome, deep vein thrombosis, maternal mortality, fetal growth restriction, and high perinatal mortality.

Self-Assessment

Case-based questions

Case 1

Mrs. BN, 24, primigravida, at 32 weeks' pregnancy, presented with skin lesions over the abdomen and thighs that were severely pruritic.

1. What are the common conditions that present with pruritus?
2. If the lesions are erythematous papules on the striae over the abdomen and thighs, what is your diagnosis?
3. What is the treatment?

Case 2

Mrs. SM, 28, primigravida, presented at 24 weeks' gestation with acute asthma. She was a known asthmatic from childhood, on inhaled bronchodilators.

1. What complications do you expect in an asthmatic in pregnancy?
2. How will you manage this acute asthmatic attack?
3. How will you manage chronic asthma in pregnancy?
4. How will you manage her in labor?

Answers

Case 1

1. Intrahepatic cholestasis, pruritic urticarial papules and plaques, atopic eruptions, and pemphigoid gestationis are the common conditions associated with pruritus. Pustular psoriasis also occurs in pregnancy.
2. The most likely diagnosis is pruritic urticarial papules and plaques of pregnancy (PUPPP) since it is the most common condition and is seen over the striae.
3. Local emollient creams, antihistamines, and topical steroids.

Case 2

1. Worsening of symptoms can occur. Preeclampsia, preterm labor, fetal growth restriction, and increase in perinatal mortality are other complications.

2. Acute asthma should be managed with hospitalization; administration of oxygen; oral or intravenous corticosteroids; and oral, subcutaneous, or inhaled short-acting β -agonists. Oxygen saturation should be monitored by pulse oximetry.
3. Chronic asthma is managed by assessment of severity by measurement of forced expiratory volume (FEV1) and peak expiratory flow rate (PEFR), patient education, and avoidance of triggers. Medications include inhaled corticosteroids, long-acting β agonists and short-acting β -agonists. Pharmacotherapy depends on the severity of symptoms.
4. FEV1 and PEFR should be monitored. If she had received oral or parenteral steroids in the past 4 weeks, hydrocortisone 100 mg is administered IV 8^t hourly for 24 hours or till delivery. Methergine and prostaglandin F_{2 α} should be avoided. Cesarean section should be under regional anaesthesia.

Sample questions

Long-answer question

1. Discuss the management of asthma in pregnancy.

Short-answer questions

1. Pruritic urticarial papules and plaques of pregnancy
2. Pregnancy specific dermatoses
3. Pregnancy in a woman with systemic lupus erythematosus

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Thromboembolic Disorders

Case scenario

Mrs. GN, 26, came with her husband for a consultation to the clinic. She had been married for 6 years, had three miscarriages—two in the first trimester and one in the second—and one stillbirth in a pregnancy complicated by high blood pressure. She had been investigated elsewhere and was told that she had an abnormal blood test that predisposes to clot formation. She did not understand the significance of this and wanted to know what should be done during her next pregnancy and whether any treatment was necessary before she attempted pregnancy.

Introduction

Pregnancy is a hypercoagulable state. Any additional risk factor that predisposes to coagulation can give rise to thromboembolism. Some of these risk factors, such as thrombophilias, are associated with poor obstetric outcome due to the involvement of placental vessels. Deep vein thrombosis (DVT) and pulmonary embolism are also common in pregnancy and the puerperium. Diagnosis and management of these conditions require a thorough understanding of the pathophysiology, clinical judgment, and expertise.

Thrombophilias

Normal coagulation is inhibited by several regulatory proteins. Deficiency of these proteins can lead to a hypercoagulable state, resulting in venous or arterial thrombosis and embolism. This condition is known as thrombophilia, which may be *acquired* or *inherited*. The commonest presenting manifestation in thrombophilia is venous thromboembolism. However, the process may involve the placental vasculature and therefore may also cause obstetric problems.

Acquired thrombophilias in pregnancy

The most common acquired thrombophilia in pregnancy is antiphospholipid antibody (APA) syndrome. Others are heparin-induced thrombocytopenia and thrombophilias associated with cancers, which are not of obstetric significance.

Antiphospholipid antibody syndrome

Antiphospholipid antibody syndrome is defined as the presence of antiphospholipid antibodies along with thrombotic or obstetric events. It is of two types:

- Primary APA syndrome: There is no underlying connective tissue disorder.
- Secondary APA syndrome: Occurs in association with a connective tissue disorder such as systemic lupus erythematosus (SLE).

Antiphospholipid antibodies

Antiphospholipid antibodies are antibodies against the cell membrane phospholipids or their binding proteins. These phospholipids are expressed on the cell membrane of the endothelial cells and have antithrombotic and anticoagulant action, serving to prevent coagulation within blood vessels. Antibodies against these cause slow and progressive thrombosis. These antibodies are present most often in women with SLE or other connective tissue disorders but can also be present in 2%–5% of normal women. The antibodies may be immunoglobulin G (IgG), immunoglobulin M (IgM), or immunoglobulin A (IgA).

The antiphospholipid antibodies are as follows:

- Anti- β -2 glycoprotein1 antibody
- Lupus anticoagulant (LA)
- Anti-cardiolipin antibody (ACA)
- Antibodies to phosphatidyl serine and phosphatidyl inositol
- Antibody to prothrombin
- Antibody to annexin V

All antiphospholipid antibodies are not incriminated in the causation of APA syndrome.

These antibodies are present in a small proportion of normal women, but all women with such circulating antibodies do not develop APA

syndrome. This requires a ***second hit*** or a precipitating factor in the form of pregnancy, oral contraceptive pills, smoking, malignancy, hypertension, dyslipidemia, or prolonged immobilization. **Therefore, the mere presence of antibodies is only a predisposing factor and not the same as having APA syndrome.**

Criteria for diagnosis of APA syndrome

The international consensus revised (Sapporo) criteria, 2006, for the diagnosis of APA syndrome are given in Box 54.1.

- **One clinical criterion and one lab criterion must be present for the diagnosis of APA syndrome**
- The significance of the presence of antibodies to prothrombin, annexin V, phosphatidyl serine, and phosphatidyl inositol is unclear, hence these antibodies are not included in the definition.

Box 54.1 Antiphospholipid antibodies syndrome Sapporo criteria (2006)

- Clinical criteria
 - Occurrence of arterial/venous/small vessel thrombosis, with unequivocal imaging or histologic evidence of thrombosis
 - In any tissue or organ, excluding superficial venous thrombosis
 - Pregnancy morbidity
 - One or more unexplained fetal deaths ≥ 10 weeks' gestation with normal fetal morphology by prenatal ultrasound examination or direct postnatal examination
 - ≥ 3 unexplained, consecutive, spontaneous pregnancy losses of <10 weeks' gestation, after exclusion of maternal anatomic and hormonal abnormalities and paternal and maternal chromosomal abnormalities
 - ≥ 1 preterm deliveries of a morphologically normal infant before 34 weeks' gestation due to severe preeclampsia, eclampsia, or features consistent with placental insufficiency
 - Laboratory criteria – should be present on 2 occasions at least 12 weeks apart
 - Lupus anticoagulant
 - Anticardiolipin antibody IgG or IgM, medium or high titer
 - Anti- β -2 glycoprotein1 antibody IgG or IgM, medium or high titer

- Generally accepted features of placental insufficiency include
 - abnormal or nonreassuring fetal surveillance test
 - abnormal umbilical Doppler flow velocimetry waveform analysis
 - oligohydramnios
 - birth weight less than the 10th percentile for the gestational age

Box 54.2 Obstetric complications of antiphospholipid antibody syndrome

- Recurrent pregnancy loss (3 or more) <10 weeks
- Pregnancy loss >10 weeks
- Pregnancy loss before 34 weeks due to
 - early onset preeclampsia
 - placental abruption
 - fetal growth restriction
 - intrauterine fetal death

Pathogenesis

The antiphospholipid antibodies act by

- procoagulant action on protein C, annexin V, platelets, proteases, tissue factor, and impaired fibrinolysis, increasing the risk of vascular thrombosis;
- increasing vascular tone with resultant increased risk of atherosclerosis, fetal neurological damage, and fetal loss due to involvement of placental vessels; and
- increasing trophoblastic apoptosis and decreasing trophoblastic fusion and invasion, leading to poor placentation.

Pathology

The pathological changes include thrombosis of placental vessels with perivascular inflammation, placental infarcts, and hypovascular villi. These changes lead to poor placental perfusion, resulting in preeclampsia, pregnancy loss and placental abruption.

Obstetric complications in APA syndrome

Obstetric complications in antiphospholipid APA syndrome are listed in Box 54.2. In addition, women with APA syndrome are also prone to development of thromboembolism during pregnancy and puerperium.

Diagnosis

Antiphospholipid antibody syndrome is suspected when there is a history of thromboembolism, known obstetric complications of APA syndrome, a history of systemic lupus erythematosus (SLE), or other connective tissue disorders. In women with a suggestive history, laboratory tests are indicated. A positive test should

be repeated 12 weeks later. If the second test is positive, the diagnosis is confirmed. When the second test is negative and the index of suspicion is high, a third test may be done after a few weeks.

In women with APA syndrome, both anti-cardiolipin antibody (ACA) and lupus anticoagulant (LA) may be positive in 85%; only one antibody may be present in 15%. In 11% of women, only anti- β -2 glycoprotein antibody is positive. Hence, all three antibodies should be tested. The tests are listed in Box 54.3.

Anticardiolipin antibodies are detected using enzyme-linked immunosorbent assay (ELISA) and reported as GPL or MPL units for IgG and IgM, respectively.

Box 54.3 Diagnostic tests for antiphospholipid antibody syndrome

- Anticardiolipin antibody
 - Tested using ELISA
 - Positive if
 - IgM and IgG antibodies >40 units MPL or GPL
- Lupus anticoagulant
 - More specific but less sensitive
 - Coagulation tests used
 - aPTT
 - dRVVT
 - Kaolin clotting time
- Anti- β -2 glycoprotein 1
 - Most common antiphospholipid antibody
 - Tested using ELISA
 - Positive if
 - IgM and IgG antibodies
 - >99th percentile for the lab
- If any test is positive, the test should be repeated 12 weeks later

Lupus anticoagulant is a misnomer; it is a pro-coagulant and not an anticoagulant. It is measured indirectly using activated partial thromboplastin time (aPTT). Dilute Russell viper venom time (dRVVT) and kaolin clotting time (KCT) can also be used, but aPTT is the primary test. A significantly prolonged aPTT that is not corrected by the addition of normal plasma indicates the presence of LA.

Anti-β-2 glycoprotein I is also detected using ELISA and reported as SGU and SMU for IgG and IgM antibodies, respectively.

Management

Goals of management

The goals of management are as follows:

- To minimize maternal and perinatal risks and improve pregnancy outcome
- To prevent another thrombotic episode in a woman with a history of thrombosis

Preconceptional counseling is essential. Low-dose aspirin should be started in the preconceptional period along with folic acid.

Medical management

Medical management includes

- low-dose aspirin
- heparin
 - unfractionated heparin (UFH)
 - low-molecular-weight heparin (LMWH)

Low-dose aspirin

Low-dose aspirin has an antiplatelet effect and stimulates normal growth of trophoblasts. It is usually started as soon as pregnancy is confirmed. Currently, most investigators recommend starting it preconceptionally since it has beneficial effects on implantation as well. Low-dose aspirin alone, at the dose of 75 mg daily, improves pregnancy outcome in 42%–80% of women. Aspirin should be discontinued at 36 weeks.

Heparin

A combination of heparin and aspirin improves pregnancy outcome by 80%. The medications should be started as soon as fetal cardiac activity is confirmed on ultrasound scan. Heparin is

administered in prophylactic dose, as UFH or LMWH. The advantages of LMWH are discussed later in the section *Therapeutic anticoagulation*.

Unfractionated heparin

Unfractionated heparin is administered as subcutaneous injection, 5000 units twice daily, to prevent thrombosis. It does not cross the placenta. Monitoring of aPTT and platelet count is not required when administered in this prophylactic dose.

Low-molecular-weight heparin

Low-molecular-weight heparin is given as a once-daily dose (dalteparin 5000 units or enoxaparin 40 mg). It is more expensive but more convenient.

In women who have had a history of venous thromboembolism, heparin or warfarin must be continued till 6 weeks postpartum. In women who have received anticoagulation for miscarriage or pregnancy loss, the anticoagulation may be stopped after delivery.

Obstetric management

Obstetric management consists of monitoring the mother and fetus for complications and deciding the appropriate timing of delivery.

- Early ultrasonography is performed to establish gestational age.
- Blood pressure and urine protein are closely monitored.
- Ultrasonography should be performed at 18–20 weeks for morphology. Serial scans are repeated once in 2–4 weeks from 28 gestational weeks to monitor fetal growth.
- Biophysical profile and Doppler flow velocimetry of the umbilical artery and middle cerebral artery are performed in the presence of fetal growth restriction.
- Planned delivery is recommended. In pregnancies with fetal or maternal compromise, delivery is planned at or after 34 weeks, ensuring fetal maturity. If there is no maternal or fetal compromise, delivery is usually at 38 weeks.
- Heparin should be stopped 12 hours prior to planned delivery and restarted 6 hours after delivery. Low dose aspirin is stopped at 36 weeks or 1 week prior to planned delivery.

- Postpartum, if anticoagulation is indicated, changeover to warfarin is more convenient because of the oral route of administration. This should be continued for 6 weeks in women with a history of thrombosis in the present pregnancy, and for 6 months in women with past and family history of thrombosis.

Inherited thrombophilias in pregnancy

Inherited thrombophilias are a group of disorders that are genetically inherited and associated with a risk of arterial or venous thrombosis. In addition, they have been implicated in adverse pregnancy outcomes. They are uncommon in the Asian population.

Classification

Inherited thrombophilias are broadly classified into two groups as given in Box 54.4.

The mere presence of a carrier state of thrombophilia does not increase the risk of thrombosis. Thrombosis generally occurs when other associated risk factors (*second hit*) such as immobilization, obesity, and infection are present.

Based on the risk of thromboembolism, inherited thrombophilias are also classified into high risk and low risk groups as given in Box 54.5.

Adverse pregnancy outcomes

Inherited thrombophilias have been implicated in the poor pregnancy outcomes outlined in Box 54.6.

However, the association between adverse pregnancy outcomes and inherited thrombophilias is not consistent. Since there is no clear

Box 54.5 Risk grouping of inherited thrombophilias

- High risk group
 - FVL/PGM homozygous
 - Antithrombin III deficiency
 - Compound heterozygous
- Low risk group
 - FVL/PGM heterozygous
 - Protein C/protein S deficiency
 - Hyper-homocysteinemia

factor V Leiden; P prothrombin gene (G20210A) mutation.

Box 54.6 Adverse pregnancy outcomes in inherited thrombophilias

- Recurrent miscarriage
- Stillbirth
- Preeclampsia
- Fetal growth restriction
- Placental abruption

evidence, testing for thrombophilias is not recommended in women with these outcomes.

Screening for thrombophilias

The recommendations regarding screening for thrombophilias include the following:

- Routine screening for all pregnant women is not indicated due to the low prevalence of the condition.
- There is insufficient evidence to support screening for thrombophilias in women with recurrent pregnancy loss, preeclampsia, or any other adverse pregnancy outcome.
- Indication for screening includes women with a first-degree relative with high risk thrombophilia or women with a history of venous thromboembolism in the nonpregnant state.

Diagnosis

The tests recommended for diagnosis are as follows:

- Genotyping for factor V Leiden
- Antithrombin-heparin cofactor assay
- Functional assay for protein C and protein S
- Polymerase chain reaction (PCR) for prothrombin gene mutation
- Fasting plasma homocysteine levels

Box 54.4 Inherited thrombophilias

- Deficiency of anticoagulants
 - Antithrombin deficiency
 - Protein C and protein S deficiency
 - Hyperhomocysteinemia
- Gene mutations of procoagulant factors
 - Factor V Leiden (FVL) mutations
 - Prothrombin gene (G20210A) mutation (PGM)

Management

Women with a diagnosis of thrombophilia should have preconception counseling regarding the risk of thrombosis. If there is a history of thromboembolism in association with high-risk thrombophilia, antepartum and intrapartum prophylactic anticoagulation is required. The presence of additional risk factors for thromboembolism (given later in this chapter) and the severity of thrombophilia should be taken into account before anticoagulation is decided upon. Dosage of prophylactic UFH and LMWH is as described earlier for APA syndrome.

Thromboembolic disorders in pregnancy

Deep vein thrombosis

Venous thrombosis and pulmonary embolism occur in 1/1000 pregnancies. Venous thrombosis is more common antepartum, and pulmonary embolism is more frequent in the postpartum period.

Risk factors

Risk factors specific to pregnancy

Risk factors specific to pregnancy (Box 54.7) are as follows:

- Hypercoagulability or prothrombotic state of pregnancy which is due to
 - increase in fibrinogen and factors VI, VIII, IX, X, and XII
 - decrease in anticoagulant factors protein C and protein S
 - increase in plasminogen activator inhibitors
- Venous stasis in the lower limbs due to the pressure on the pelvic vessels and vena cava by gravid uterus
- Endothelial injury

Risk factors not specific to pregnancy

Risk factors not specific to pregnancy are listed in Box 54.7.

Box 54.7 Risk factors for thromboembolism in pregnancy

- Specific to pregnancy
 - Hypercoagulable state
 - Venous stasis
 - Endothelial injury
 - Multifetal pregnancy
 - Cesarean delivery
- Not specific to pregnancy
 - Obesity ($BMI >30 \text{ kg/m}^2$)
 - Maternal age >35 years
 - Severe proteinuria
 - Prolonged bed rest
 - Antiphospholipid syndrome
 - Inherited thrombophilias
 - Anemia
 - Hemorrhage
 - Genetic factors

B body mass index.

Clinical features

Deep vein thrombosis usually occurs in the lower limbs and iliofemoral veins. **It involves the left leg in 90% of cases.** The woman usually presents with a sudden onset of unilateral painful pale swelling of the entire lower limb (*phlegmasia alba dolens*). Reflex arterial spasm leads to a cold lower limb with reduced arterial pulsations. Calf muscle tenderness and Homan's sign (patient winces due to calf muscle pain when the foot is dorsiflexed) can be elicited.

The major complication of DVT is the occurrence of pulmonary embolism, which may be a life-threatening event.

Diagnosis

Clinical diagnosis is difficult; therefore, further evaluation is essential. The tests used for the diagnosis of DVT are listed in Box 54.8.

Duplex ultrasound is considered to be the primary noninvasive diagnostic method for DVT. It combines compression ultrasonography with

Box 54.8 Tests used for the diagnosis of deep vein thrombosis

- Duplex ultrasonography/compression ultrasonography
- Magnetic resonance venography
- Ascending contrast venography
- D-dimer assay

Doppler waveform analysis. It is most often used for calf and iliac veins.

Compression ultrasonography (CUS) is a good screening test for DVT. It is highly sensitive and specific for femoral vein thrombosis. The ultrasound transducer is placed over the femoral vein, beginning at the inguinal ligament and moving down the leg to the superficial and deep veins. Noncompressibility of the venous lumen and echogenic material in the lumen are diagnostic of thrombus.

MR venography is not used during pregnancy but is useful in the puerperium. Pelvic veins can be assessed better with this.

D-dimer assays are useful in nonpregnant women, but during pregnancy, the test is not

sensitive since D-dimer levels are elevated in normal pregnancy, preeclampsia, multifetal pregnancy, and placental abruption. High levels of >500 ng/mL may be indicative of thrombosis.

The algorithm used for the diagnosis of DVT is given in Figure 54.1.

Management

Management consists of bed rest and therapeutic anticoagulation, which is discussed later in this chapter. Once the symptoms are better, the patient may be ambulated. Elastic compression stockings should be used and continued for 1–2 years. Edema of the affected leg, venous ulcers, and persistent pain are common postthrombotic complications.

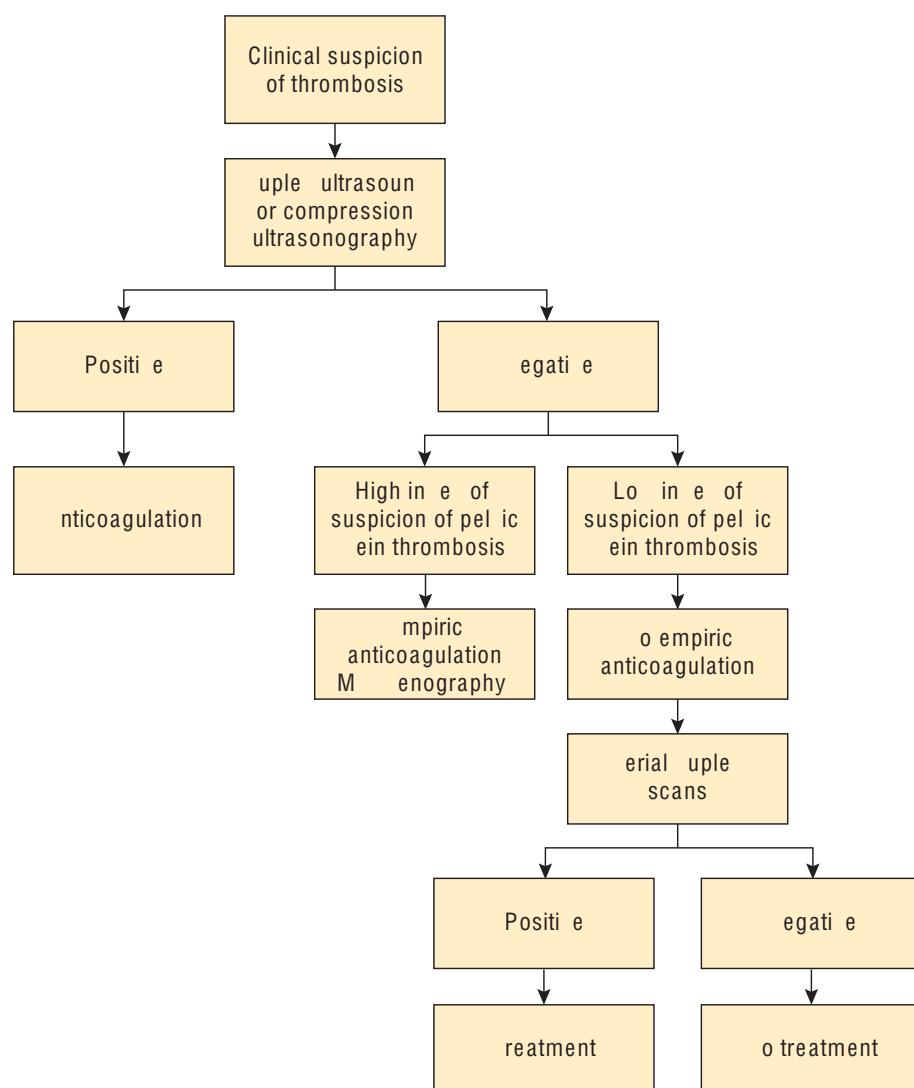


Figure 54.1 Diagnosis of deep vein thrombosis in pregnancy.

Pulmonary embolism

Pulmonary embolism can occur during pregnancy or the puerperium but is uncommon in the absence of DVT. However, 30%–60% of women with DVT can have silent pulmonary embolism.

Clinical features

The usual presentation is unexplained tachycardia, dyspnea, and hypoxemia. Pleuritic pain and hemoptysis may ensue, and when pulmonary embolism is massive, there is sudden severe hypotension.

Diagnosis

Readily available tests such as chest X-ray and ECG are not sensitive tests for the diagnosis of pulmonary embolism. There are no radiographic findings specific for this condition, although wedge-shaped pleural-base opacities, blunting of the costophrenic angle due to pleural reaction, and elevated hemidiaphragm due to the loss of lung volume may be suggestive. Similarly, ECG changes characteristic of acute cor pulmonale are seen in only 25% of patients. Moreover, pregnancy-associated changes in ECG may increase false-positive results. *However, these tests can be used to exclude other conditions that can present with similar symptoms such as acute pulmonary edema.* Furthermore, they may aid decision making regarding the need and urgency of other more sensitive and specific secondary diagnostic tests to diagnose pulmonary embolism (Box 54.9).

Ventilation–perfusion scan and computerized tomographic pulmonary angiography are the specific tests used for the diagnosis of pulmonary embolism. The evaluation of the lower limbs by Duplex scan/ CUS for evidence of DVT is mandatory whenever pulmonary embolism is suspected.

Management

Therapeutic anticoagulation should be started immediately when the diagnosis is confirmed. Venacaval filters are used in cases of recurrent pulmonary embolism arising from the pelvis or lower limbs. Thrombolytic therapy with tissue

Box 54.9 Diagnosis of pulmonary embolism

- Nonspecific tests
 - Chest X-ray
 - ECG
 - Arterial blood gases
 - Echocardiography
- Specific diagnostic tests
 - Ventilation–perfusion scans
 - Computerized tomographic pulmonary angiography
 - Magnetic resonance pulmonary angiography
 - Pulmonary angiography
- Evaluation of lower limbs for deep vein thrombosis
 - Duplex/Compression ultrasonography

plasminogen activators has been used in severe massive pulmonary embolism but not recommended as a routine.

Anticoagulation in pregnancy

Anticoagulation in pregnancy may be (a) prophylactic, to prevent thromboembolism in high-risk women and those on prosthetic valves and also for the management of APA or (b) therapeutic, for treatment of DVT or pulmonary embolism.

Therapeutic anticoagulation

Therapeutic anticoagulation is required in women with established DVT or pulmonary embolism. Unfractionated heparin or LMWH may be used in weight-adjusted doses.

Low-molecular-weight heparin

Low-molecular-weight heparin is preferred to UFH because it has several advantages as listed in Box 54.10. However, the cost of therapy is higher with LMWH and so UFH is still used in resource-poor settings. Low-molecular-weight heparin is administered without laboratory monitoring, since no laboratory assessment of the anticoagulant effect is consistent with clinical endpoints. Anti-factor Xa levels must be maintained at 0.5–1 IU/mL. However, routine monitoring of Anti Xa levels is not recommended.

Box 54.10 Therapeutic use of low-molecular-weight heparin

- Indications
 - Established DVT/pulmonary embolism
- Drug of choice because of
 - better bioavailability
 - longer plasma half-life
 - predictable dose response
 - more reduction in thrombus size
 - lower risk of major bleeding
 - lower incidence of recurrent thromboembolism
 - low risk of osteoporosis
 - low risk of thrombocytopenia
 - less frequent dosing
- No laboratory monitoring
- Must be switched to UFH at 36 weeks

D deep vein thrombosis; , unfractionated heparin.

The effect of LMWH cannot be completely reversed with protamine sulfate; hence, it is prudent to switch to UFH at 36 weeks.

Unfractionated heparin

Unfractionated heparin is indicated for immediate treatment of pulmonary embolism or when anticoagulation is required when immediate delivery or a cesarean section is anticipated. Initial administration is by intravenous route, monitored by aPTT levels. aPTT should be maintained at 1.5–2.5 times the control values. After 7–10 days, subcutaneous 12-hourly doses should be used. The effects of UFH can be reversed with protamine sulfate when required (Box 54.11).

Dosage of LMW and F

Therapeutic, weight-adjusted doses of LMWH and UFH are given in Box 54.12.

Box 54.11 Therapeutic use of unfractionated heparin

- Indications
 - Immediate treatment of pulmonary embolism
 - When delivery/cesarean section anticipated
 - After 36 weeks in all women on therapeutic anticoagulation
- Initially administered as IV
- Switch to subcutaneous 12 hourly after 7–10 days
- Monitored with aPTT
 - 1.5–2.5 times control values
- Can be reversed with protamine sulfate

Intrapartum management

Delivery should be a planned event in a woman on therapeutic anticoagulation. Anticoagulants should be stopped 24–36 hours before planned delivery or cesarean section. This reduces the risk of maternal bleeding and hematoma formation with epidural or spinal anesthesia. Regional anesthesia should not be administered within 24 hours of the last therapeutic dose of either UFH or LMWH.

Postpartum anticoagulation

Therapeutic anticoagulation should be continued for 6 months postpartum. Low-molecular-weight heparin is started 6 hours after vaginal delivery or 12 hours after a cesarean section along with warfarin 5 mg daily. Dosage of LMWH is gradually reduced and replaced by warfarin to maintain international normalized ratio (INR) at 2–3.

Thromboprophylaxis in pregnancy and the postpartum period

Thromboembolism in pregnancy and the puerperium can be minimized by prophylactic anticoagulation and nonpharmacological methods like compression stocking. However, use of anticoagulants has complications. Hence, it should be administered only when there are indications and adherence to guidelines is

Box 54.12 Therapeutic doses of LMW and F

Drug	Dosage	route
• Enoxaparin	1 mg/kg, 12 hourly	SC
• Dalteparin	200 units/kg once daily (or) 100 units/kg 12 hourly	SC
• Tinzaparin	175 units/kg once daily 70–100 units/kg (5000–10,000 units)	SC
	15–20 units/kg (1000 units)/hour	IV bolus Infusion
	Followed 7–10 days later by 10,000 units 12 hourly	SC

low-molecular-weight heparin; , unfractionated heparin.

essential. Women are categorized into high, intermediate, and low risk based on factors listed in Box 54.13.

- All pregnant women should undergo risk assessment prepregnancy or early in pregnancy, when they are hospitalized and postpartum.

Box 54.13 Risk categorization for thromboembolism in pregnancy

High risk	<ul style="list-style-type: none"> Any previous VTE except a single event related to major surgery High risk thrombophilia + VTE
Intermediate risk	<ul style="list-style-type: none"> Hospital admission Single previous VTE related to major surgery High risk thrombophilia + no VTE Medical comorbidities like sickle cell disease, nephrotic syndrome, SLE or heart failure
Low risk	<ul style="list-style-type: none"> Obesity (BMI >30 kg/m²) Age >35 Parity ≥3 Gross varicose veins Immobilization Family history of unprovoked or estrogen-provoked VTE in first-degree relative Low risk thrombophilia Multiple pregnancy Preeclampsia
Transient risk factors	<ul style="list-style-type: none"> Dehydration/hyperemesis Current systemic infection Long-distance travel

BMI, body mass index; VTE, venous thromboembolism.

- Antenatal anticoagulation, continued postnatally for 6 weeks to 6 months, is recommended for all high risk, intermediate risk, and low risk women with ≥4 risk factors. Those with 3 or less risk factors may be given postnatal thromboprophylaxis.
- Cesarean section alone in the absence of associated risk factors is not an indication for thromboprophylaxis. It should be given only if an associated risk factor is present.

Dosage of anticoagulants for thromboprophylaxis

Low-molecular-weight heparin is preferred to UFH. The dosage has been described earlier.

Cerebral venous thrombosis

Cerebral venous thrombosis sometimes occurs in the puerperium. There is thrombosis of the superior sagittal sinus due to thrombophilia. The patient complains of severe headache and may have seizures. The condition must be differentiated from postpartum eclampsia. Fundus examination shows papilledema due to raised intracranial pressure, and physical examination may reveal mild weakness of the lower limbs (paraparesis) or weakness of one half of the body (hemiparesis). There may be urinary retention. The diagnosis is confirmed by MR venography, and treatment is with anticonvulsants and anticoagulation.

Key points

- Deficiency of the proteins that inhibit coagulation is known as thrombophilia. This may be acquired or congenital.
- The most common acquired thrombophilia is antiphospholipid antibody (APA) syndrome. This is associated with several obstetric complications, including miscarriage, placental abruption, preeclampsia, and fetal growth restriction.
- The three important antiphospholipid antibodies are lupus anticoagulant, anticardiolipin antibody, and anti-β-2 glycoprotein antibodies. Antiphospholipid antibody syndrome is the presence of these antibodies along with thrombotic events or pregnancy morbidity.
- Diagnosis of APA is by history of thromboembolism or a characteristic obstetric event and presence of one of the antibodies on two occasions, 12 weeks apart.

(Continued)

Key points *Continued*

- Medical management is with low-dose aspirin and heparin, either unfractionated or low-molecular-weight heparin. Aspirin should be discontinued at 36 weeks and heparin 12 hours before delivery.
- Obstetric management consists of close monitoring of blood pressure, fetal growth, and fetal well-being by serial ultrasonography and planned delivery at 38 weeks. Maternal or fetal complications may indicate earlier delivery.
- Women on prophylactic anticoagulation for recurrent pregnancy loss or pregnancy loss do not require postpartum anticoagulation.
- Postpartum anticoagulation with warfarin should be continued for 6 weeks in those without thrombotic event and for 6 months in those with thrombotic event.
- Inherited thrombophilias are classified as high risk group and low risk group, based on the risk of thromboembolism.
- Pregnancy complications in inherited thrombophilias are recurrent miscarriage, stillbirth, preeclampsia, fetal growth restriction, and placental abruption.
- Routine screening for inherited thrombophilia or screening in women with obstetric problems is not recommended except in those with a positive family history of high risk thrombophilia or a thrombotic event in the nonpregnant state.
- Management is with anticoagulation during the antepartum and postpartum periods depending on the history of thromboembolism and associated risk factors.
- Deep vein thrombosis (DVT) occurs in pregnancy due to the hypercoagulability of blood, venous stasis, endothelial injury, and other risk factors such as obesity, prolonged bed rest, APA syndrome, cesarean section, and genetic factors.
- Deep vein thrombosis in pregnancy involves the left leg in 90% of cases. Pain, tenderness in calf muscles, and positive Homan's sign are the typical clinical features. Screening is by compression ultrasonography (CUS) and confirmation is by Duplex ultrasonography although other tests are available.
- Management is with bed rest, therapeutic anticoagulation, and gradual ambulation.
- Pulmonary embolism usually occurs following DVT. Clinical symptoms are dyspnea, hypoxemia, and tachycardia.
- Diagnosis is by computerized tomographic pulmonary angiography, although other tests are available. Treatment is by therapeutic anticoagulation.
- Low-molecular-weight heparin is the drug of choice for therapeutic and prophylactic anticoagulation in pregnancy. It has the advantages that it does not cross the placenta and has a longer half-life, better bioavailability, low risk of thrombocytopenia and osteoporosis, and predictable dose response.
- Unfractionated heparin is used only for immediate treatment of pulmonary embolism and when delivery or a cesarean section is imminent.
- Thromboprophylaxis is indicated in women with prolonged immobilization, APA syndrome, and inherited thrombophilias. It is also indicated in women undergoing a cesarean section when additional risk factors are present.

Self-Assessment

Case-based questions

Case 1

Mrs. GN, 26, came for a consultation with her husband to the clinic. She had been married for 6 years, had three miscarriages—two in the first trimester and one in the second—and one stillbirth in a pregnancy complicated by high blood pressure.

1. What conditions can give rise to the obstetric complications in this woman?
2. What important details would you like to know in history?
3. What investigations will you do?
4. How will you manage her next pregnancy?

Case 2

Mrs. KT, 30, was 24 weeks' pregnant. Her body mass index was 38 and her hemoglobin was 8 g/dL. She complained of acute pain in the left lower limb with swelling over the calf muscles. She was brought to the hospital.

1. What is the diagnosis likely to be?
2. What are the risk factors for this condition?
3. How will you confirm the diagnosis?
4. How will you manage the complication?

Answers

Case 1

1. Acquired and inherited thrombophilias.
2. Past and family history of thromboembolism, fetal weight, history of the live abortus or dead fetus, severity of hypertension, and proteinuria.
3. If there is no past or family history of thromboembolism, LA, ACA, and anti-β-2 glycoprotein 1. If a family history of thrombophilia, or past history or family history of thromboembolism is present, thrombophilia workup should be done.
4. If she is positive for APA, aspirin 75 mg when pregnancy is confirmed, UFH or LMWH (enoxaparin 40 mg SC) daily when cardiac activity is confirmed. The following is recommended:
 - Close monitoring of blood pressure and fetal growth.
 - Serial ultrasound scans for fetal growth and well-being.
 If pregnancy progresses with no complications, deliver at 38 weeks. Stop aspirin at 36 weeks and LMWH 12 hours prior to delivery.

Case 2

1. Deep vein thrombosis.
2. Pregnancy, obesity, prolonged immobilization, anemia, multifetal pregnancy, antiphospholipid positive,

inherited thrombophilias, cesarean section, and maternal age >35 years.

3. History of calf muscle pain, tenderness, edema, and Homan's sign. Compression ultrasonography and Duplex scan.
4. Bed rest till swelling subsides and therapeutic anticoagulation with LMWH (enoxaparin) 1 mg/kg 12-hourly SC throughout pregnancy. Ambulation after symptoms subside and elastic bandage or pressure stockings. Planned delivery at 38 weeks, and discontinue LMWH 24 hours prior to induction. Restart warfarin and LMWH postpartum and gradually switch to warfarin.

Sample questions

Long-answer question

1. What is antiphospholipid antibody syndrome? Discuss the clinical presentation, diagnosis, and management of pregnancy in a third gravida with two previous miscarriages and antiphospholipid syndrome.

Short-answer questions

1. Inherited thrombophilias
2. Prophylactic anticoagulation
3. Pulmonary embolism in pregnancy
4. Deep vein thrombosis in pregnancy

55

Urinary Tract and Renal Disorders

Case scenarios

Mrs. JP, 29, was in her sixth month of pregnancy. She gave a history of dysuria for 2 days. She presented with fever, chills, and severe flank pain.

Mrs. BN, 24, was pregnant with her first pregnancy. She developed hypertension at 32 weeks, and this progressed rapidly to preeclampsia. She had abruption at 35 weeks. She developed severe hypovolemic shock. In spite of adequate volume replacement, she developed oliguria. She was transferred to a tertiary center for further care.

Introduction

Pregnant women commonly face renal and urinary tract disorders. Anatomical and physiological changes that occur in pregnancy predispose women to development of these problems and sometimes to rapid worsening of disease. Some conditions (e.g., nephrolithiasis) may be preexisting and may be uncovered in pregnancy. Some renal conditions (e.g., preeclampsia) are unique to pregnancy.

Understanding the physiological changes that occur in a normal pregnancy helps in the proper interpretation of common laboratory and diagnostic studies when evaluating renal disease in women during pregnancy.

In the presence of preexisting kidney disease, the effect of the kidney disease on the pregnancy as well as the effect of pregnancy on the kidney disease has to be taken into consideration to properly manage the pregnancy.

Certain complications of pregnancy can result in acute renal injury and lead to renal failure. Being aware of these complications and taking early preventive steps can help avert acute renal injury.

Urinary tract changes due to pregnancy

Pregnancy affects both the kidney and the rest of the urinary tract. Increase in renal blood flow

and glomerular filtration rate (GFR) and dilatation of the renal pelvis and ureters are the most significant changes. These changes have been discussed in greater detail in Chapter 3, *Maternal physiology in pregnancy*. These changes have an impact on renal and urinary tract disorders.

Urinary tract disorders

The most common urinary tract disorder in pregnancy is urinary tract infection (UTI).

Urinary tract infection in pregnancy

Urinary tract infections are among the most common bacterial infections occurring in pregnancy.

Hormonal and mechanical changes of pregnancy increase urinary stasis and vesicoureteral reflux, thus predisposing to the occurrence of UTI. The other important contributing factor is the short urethra in women, making it easier for bacteria to gain access (Box 55.1).

Vaginal infections can cause or mimic UTIs. Differentiating between the two depends on a good history, physical examination, and the results of vaginal and urinary cultures.

UTIs in pregnancy may be one of the following:

- Asymptomatic bacteriuria (ASB)
- Symptomatic lower UTI (cystitis)
- Pyelonephritis

Box 55.1 Risk factors for TI in pregnancy

- Changes in pregnancy
 - Hormonal changes
 - Mechanical changes
- Lead to
 - increased urinary stasis
 - increased vesicoureteral reflux
- Other factors
 - Short urethra in women

urinary tract infection.

Definitions

Asymptomatic bacteriuria

Asymptomatic bacteriuria is commonly defined as the presence of more than 100,000 organisms/mL in two consecutive urine samples in an asymptomatic woman. Untreated ASB is a risk factor for acute cystitis (40%) and pyelonephritis (25%–30%) in pregnancy (Box 55.2). Its association with maternal complications such as preterm birth or low birth weight is unproven.

Acute cystitis

Acute cystitis is symptomatic infection of the lower urinary tract. There is inflammation of the bladder mucosa as a result of bacterial infection. Acute cystitis develops in approximately 1% of pregnant patients. It may progress to pyelonephritis in 15%–50% of cases.

Acute pyelonephritis

Acute pyelonephritis is an infection of the upper urinary tract and kidneys. Pyelonephritis is the most common serious medical complication in pregnant women, occurring in approximately 2% of all pregnancies. Acute pyelonephritis is characterized by fever, flank pain, and tenderness in addition to significant bacteriuria. It occurs most often in the second trimester and is more common in young primigravidae (Box 55.3).

Box 55.2 Asymptomatic bacteriuria

- >100,000 colonies/mL in two consecutive samples
- Implies persistent actively multiplying bacteria in the urinary tract
- Usually single organism
- Found in 2%–7% of pregnancies
- Often develops in first trimester
- Risk of progression
 - Cystitis: 40%
 - Pyelonephritis: 25%–30%

Box 55.3 Characteristics of pyelonephritis

- Significant bacteriuria
- Fever
- Flank pain
- Flank tenderness
- More common in
 - second trimester
 - young primigravidas

Pathophysiology of UTIs

Infections result from ascending colonization of the urinary tract, mainly by existing vaginal, perineal, and fecal flora.

Maternal physiological and anatomical factors predisposing to ascending infection are summarized in Box 55.4.

Natural course of UTI

Untreated asymptomatic bacteriuria may lead to UTI and pyelonephritis. In developed countries, all women are screened for asymptomatic bacteriuria with a urine culture at the first antenatal visit. Urine culture may not be cost-effective in underresourced areas. Therefore, testing for nitrites in urine with a dipstick is an alternative (discussed later in this chapter). All pregnant women should be screened by one of the methods.

In most cases of UTI in pregnancy, the prognosis is good and most women will recover with appropriate antibiotic coverage. Untreated UTIs are associated with risks to both the fetus and the mother, as listed in Box 55.5.

Microbiology of UTI

Escherichia coli is the predominant organism implicated in 80% of both asymptomatic bacteriuria and UTI in pregnant women.

Box 55.4 Physiological and anatomical factors predisposing to ascending infection

- Urinary retention caused by
 - weight of the enlarging uterus
 - urinary stasis due to
 - progesterone-induced ureteral smooth muscle relaxation
- Vesicoureteral reflux
- Glycosuria

Box 55.5 Complications of untreated UTI in pregnancy

- Pyelonephritis
- Preterm birth
- Fetal growth restriction and low birth weight
- Increased perinatal mortality

urinary tract infection.

Box 55.6 Organisms causing UTI in pregnancy

- *Escherichia coli*
- *Lebsiella pneumoniae*
- *Proteus mirabilis*
- *Enterobacter species*
- *Staphylococcus saprophyticus*
- Group B β-hemolytic *Streptococcus*
- *Proteus* species

urinary tract infection.

Other organisms may also be responsible for infection, as listed in Box 55.6.

Drug resistance is an alarming problem globally. Infections caused by extended-spectrum β-lactamase (ESBL)-producing strains are increasingly implicated even in uncomplicated UTIs. In India, ESBL-producing bacteria are a growing problem, even in pregnant women.

Clinical manifestations of UTI

Cystitis

The symptoms of cystitis (Box 55.7) may be misleading in pregnant women who may experience frequency, urgency, and suprapubic pressure as a result of pregnancy itself.

Pyelonephritis

In addition to symptoms of cystitis, women with pyelonephritis also present with the symptoms listed in Box 55.8.

Box 55.7 Symptoms of cystitis

- Burning with urination (dysuria)
 - Most significant symptom
- Hematuria
- Frequency
- Urgency
- Suprapubic pain

Box 55.8 Symptoms of pyelonephritis

- Symptoms of cystitis
- Fever ($>38^{\circ}\text{C}$)
- Rigors
- Costovertebral angle/flank tenderness (on affected side)
 - Right-side flank pain more common than left-side flank pain
- Anorexia
- Nausea and vomiting

Of the women with severe pyelonephritis, 20% will develop complications that include septic shock syndrome or acute respiratory distress syndrome (ARDS). It is therefore very important to recognize this condition and institute immediate treatment. Complications of acute pyelonephritis are listed in Box 55.9.

Diagnosis of UTI

Urinalysis and urine culture (with antibiotic sensitivity) are important in confirming the diagnosis of UTI and pyelonephritis. Although a first morning specimen of urine is preferred because there is a greater concentration of bacteria, the urine sample can be collected at any time of the day.

Collecting the urine specimen

An optimal clean-catch, midstream urine is collected by instructing the woman to follow the following steps (to minimize the degree of contamination with bacteria from the urethra and surrounding area):

- With one hand, spread the labia.
- With the other hand, wash the urethral meatus with water.
- Void the initial portion of the bladder contents into the toilet.
- Catch the middle portion of the bladder contents in the sterile collection container, while keeping the labia spread with the first hand.

A catheterized specimen is collected only if the patient is

- unable to void,
- too ill or bedridden,
- extremely obese.

Diagnostic tests for UTI in pregnancy are listed in Box 55.10.

Box 55.9 Complications of acute pyelonephritis

- Bacteremia
- Septic shock syndrome
- Endotoxic shock
- Adult respiratory distress syndrome
- Hemolytic anemia
- Thrombocytopenia
- Uterine contractions
 - Preterm labor

Box 55.10 Diagnostic tests for UTI in pregnancy

- Urinalysis
 - Macroscopic appearance
 - Microscopic analysis
 - Leukocytes
 - Red blood cells
 - Bacteria
- Urine protein
- Dipstick test
 - Leukocyte esterase
 - Nitrates
- Urine culture and sensitivity

urinary tract infection.

Urinalysis

Appearance

The urine may appear turbid because of pyuria (presence of leukocytes/pus cells in the urine).

Pyuria or leukocyturia

The centrifuged specimen is examined for the presence of leukocytes (pus cells) and the pus cells are counted per high-power field (hpf).

True UTI is unusual without pyuria. However, pyuria can occur without UTI in the following conditions:

- Patients who have already taken antibiotics
- Contamination from vaginal secretions
- Other causes of urinary tract inflammation

Dipstick test or nitrates

Biochemical reagent strips are available to test for leukocyte esterase and nitrates in urine. Griess reagent may also be used for testing for nitrates. The presence of leukocytes does not always indicate bacteriuria; hence, nitrite dipstick test is more reliable and is used as a rapid test for the diagnosis of urinary infection. All uropathogens do not reduce nitrates to nitrite. The sensitivity is 30%–40%, but the test has high specificity.

Findings that raise suspicion for the presence of UTI are summarized in Table 55.1.

Urine culture and antibiotic sensitivity

It is mandatory to send the urine for culture and antibiotic sensitivity prior to starting antibiotic therapy.

Table 55.1 Findings on urinalysis that may indicate the presence of UTI

Test	Finding suggestive of UTI
Clarity	Turbid in the presence of pyuria
Odor	Ammonia odor in infections with urea-splitting organism (<i>Proteus</i> , <i>lebsiella</i>)
Leukocytes (pus cells)/hpf	>10/hpf indicates possible UTI
Leukocyte esterase (dipstick test for enzyme present in WBCs)	Positive results indicate presence of neutrophils; >4 WBCs/hpf, an indicator of UTI
Nitrites (dipstick test—surrogate marker for bacteriuria)	Positive test indicates that bacteria may be present in significant numbers
Red blood cells	Microscopic hematuria (>5/hpf) common with urinary tract infection but not in urethritis or vaginitis
Protein/albumin (dipstick test)	In UTI, usually trace to 1+
Bacteria	Microscopic bacteriuria may be seen. Five bacteria per hpf correspond to a colony count of 10^5 /mL

hpf high-power field; UTI urinary tract infection; BCs white blood cells.

Urine culture is essential in the evaluation of suspected UTI to

- confirm the presence of bacteriuria,
- identify the organism, and
- detect the antibiotic sensitivity pattern.

Since most symptomatic women receive empirical antibiotic treatment while awaiting the urine culture reports, the sensitivity pattern helps in deciding whether to continue the same antibiotic or switch to another one.

Definition of significant bacterial count on culture

The colony count of the bacteria is important to differentiate an actual infection from nonsignificant contamination of the urine sample.

Asymptomatic women

10^5 colony-forming units per milliliter of urine (cfu/mL) grown from a clean midstream specimen is a sign of a clinically significant UTI.

Symptomatic women with pyuria

$\geq 10^5$ (100,000) cfu/mL is considered significant and indicative of an infection. Some clinically symptomatic women with significant pyuria show a lower colony count on urine culture. In these women, $\geq 10^4$ cfu/mL may also be taken as significant infection.

Antibiotic sensitivity

The determination of antibiotic sensitivity and resistance is very important. The effect of an antibiotic against bacterial growth can be measured with broth dilution tests or agar diffusion tests. The final result of the test is the minimum inhibitory concentration (MIC) of commonly used antibiotics. This indicates which antibiotic may be used to treat the UTI successfully.

Management

Asymptomatic bacteria and cystitis can be treated as outpatient, while pyelonephritis requires hospitalization.

Management of asymptomatic bacteriuria and acute cystitis

Women with UTI are advised to drink plenty of oral fluids.

Asymptomatic bacteriuria

Women who have been diagnosed as having asymptomatic bacteriuria can be treated with nitrofurantoin 100 mg at bedtime for 10 days.

Antibiotic therapy for cystitis

The following points should be noted about antibiotic therapy for cystitis:

- The majority of infections are by *E. coli*. Hence, empirical antibiotic therapy is started to treat this organism since the culture results take 48 hours to be reported. A rapid dipstick test may be performed before starting treatment. If required, antibiotics may be changed after culture results.
- Oral antibiotics are the treatment of choice for asymptomatic bacteriuria and cystitis.
- Treatment with a single dose of antibiotic is not recommended in pregnancy.

The common antibiotics used in cystitis are listed in Box 55.11.

Box 55.11 Antibiotics used in the treatment of cystitis in pregnancy

One of the following antibiotics, depending on sensitivity

- Nitrofurantoin monohydrate/macrocystals
 - 100 mg orally twice daily for 5–7 days
- Amoxicillin
 - 500 mg orally twice daily for 5–7 days
- Amoxicillin-clavulanate
 - 500/125 mg orally twice daily for 3–7 days
- Cephalexin
 - 500 mg orally twice daily for 3–7 days
- Cefuroxime
 - 250 mg orally twice daily for 3–7 days

Norfloxacin, ciprofloxacin, and co-trimoxazole should be avoided for the treatment of UTI in pregnancy.

- A follow-up culture is done to confirm sterilization of the urine. A change of antibiotic or a longer course is warranted if the culture is positive.
- For women with persistent or recurrent bacteriuria, prophylactic or suppressive antibiotics may be warranted in addition to retreatment.

Treatment of dysuria in cystitis

Dysuria can be very distressing. For symptomatic relief, the woman can be treated with flavoxate or phenazopyridine for 48 hours.

- Flavoxate hydrochloride counteracts smooth muscle spasm of the urinary tract and exerts its effect directly on the muscle.
- Phenazopyridine exerts local analgesic and anesthetic effects on the urinary tract. Phenazopyridine causes the passage of orange colored urine, and the woman should be warned about it.

Management of pyelonephritis

Management of pyelonephritis consists of the following:

- Pyelonephritis should be treated with hospitalization and intravenous fluids.
- Pregnant women should be evaluated with further tests.
- Blood should be drawn for
 - blood culture and sensitivity for bacteremia
 - hemogram to monitor anemia

- serum creatinine to monitor for acute renal injury
 - serum electrolytes.
- Antibiotics should be administered.

Parenteral, broad-spectrum β -lactams are the preferred antibiotics for initial empirical therapy of pyelonephritis. The commonly used antibiotics are third-generation cephalosporins such as cefoxitin or ceftriaxone, penicillins, extended-spectrum penicillins, carbapenems, and aminoglycosides.

Most women will show definite improvement within 24–48 hours of appropriate antibiotic therapy. Once afebrile for 48 hours, pregnant women can be switched to oral therapy depending on the culture and sensitivity results. They can then be treated on an outpatient basis for 10–14 days. Culture should be repeated after 1 week.

Supportive therapy

Fever should be managed with antipyretics (preferably acetaminophen) and nausea and vomiting with antiemetics.

The management of pyelonephritis is summarized in Box 55.12.

Box 55.12 Management of pyelonephritis

- Hospitalization
- Urine culture and antibiotic sensitivity
- Blood tests
 - Blood culture
 - Hemogram, serum creatinine, electrolytes
- Vital signs monitored
 - Urine output
 - Tachypnea (early sign of respiratory distress)
 - Chest X-ray to rule out ARDS
 - Temperature
 - Antipyretics
- IV fluids
 - Maintain urine output of ≥ 50 mL/hour.
- IV antibiotics
 - Third-generation cephalosporins
 - Cefoxitin or ceftriaxone
 - Penicillins
 - Extended-spectrum penicillins
 - Carbapenems
 - Aminoglycosides
- Change to oral antibiotics when afebrile for 48 hours
 - Continue for 10 days
- Repeat urine culture after 1 week to confirm cure

A DS acute respiratory distress syndrome.

enal disorders

Acute renal failure (acute renal injury) in pregnancy

Acute renal failure (ARF) or acute kidney injury (AKI) in pregnancy is characterized by a rapid decrease in the glomerular filtration rate (GFR) over a matter of minutes or days. It may result from many of the same causes that occur in nonpregnant women. However, there are specific conditions in pregnancy that may precipitate ARF.

ARF is suspected in the following conditions:

- Oliguria (urine output of <30 mL/hour or <400 mL/24 hours)
- Anuria (absent urination)
- Deteriorating renal function as demonstrated by rising serum creatinine

Causes of A F unique to pregnancy

Acute renal failure is associated with two distinct periods in pregnancy: the first trimester and the third trimester. Postpartum ARF resulting from hemorrhage and sepsis are additional important causes. Common causes are listed in Box 55.13.

Box 55.13 Causes of A F in pregnancy

Causes in the first trimester

- Prerenal causes
 - Hyperemesis gravidarum
 - Hemorrhage
 - Abortion
 - Ruptured ectopic pregnancy
 - Sepsis
 - Septic abortion

Causes in the third trimester and postpartum period

- Prerenal causes
 - Antepartum hemorrhage (placental abruption)
 - Postpartum hemorrhage
- Intrarenal causes
 - Severe preeclampsia
 - HELLP syndrome
 - Acute fatty liver of pregnancy
 - Thrombotic microangiopathies

A = acute renal failure; P = hemolysis, elevated liver enzymes, and low platelet count.

The precipitating factor for ARF is renal ischemia. The degree of renal failure depends on the severity of ischemia.

- Mild ischemia causes reversible ARF
- More prolonged ischemia leads to acute tubular necrosis (ATN)
- Severe ischemia gives rise to bilateral cortical necrosis.

The four most common causes of intrarenal ARF in late pregnancy and the postpartum period are discussed here.

Severe preeclampsia

Pregnancy complications superimposed on severe preeclampsia may precipitate ARF. These complications are as follows:

- Significant bleeding with hemodynamic instability
- Marked disseminated intravascular coagulation (DIC)
- HELLP syndrome (*hemolysis, elevated liver enzymes, and low platelets*)
- Placental abruption that may occur with severe preeclampsia

synrome

HELLP is a syndrome characterized by hemolysis, elevated liver enzymes, and low platelet count. Although it is associated with severe preeclampsia, 15%–20% of women with HELLP syndrome do not have hypertension or proteinuria.

Acute renal failure may occur in up to 40% of women with the HELLP syndrome. As in severe preeclampsia, ARF may be a result of direct renal injury or as a consequence of abruption. Although the maternal mortality following ARF in the HELLP syndrome is low (1%), perinatal mortality rate is high.

Acute fatty liver of pregnancy

Acute fatty liver of pregnancy (AFLP) is associated with fatty infiltration of hepatocytes without inflammation or necrosis. It is associated with ARF in up to 60% of cases. There is decreased renal perfusion or ATN. In the early stages, it may be difficult to differentiate AFLP from severe preeclampsia and/or HELLP syndrome.

Thrombotic microangiopathies

Thrombotic microangiopathies are a combination of thrombocytopenia and microangiopathic anemia. They are rare and affect 1 in 25,000 pregnancies. They are characterized by the presence of fibrin and/or platelet thrombi in the microcirculation of multiple organs. It may be difficult to differentiate severe preeclampsia from thrombotic microangiopathies because of the similar clinical and histological characteristics. A history of preceding hypertension and proteinuria favors a diagnosis of preeclampsia.

Thrombotic microangiopathies can be divided into two distinct entities depending on which target organ is more affected and the timing of onset, as given in Box 55.14.

In actual practice, the distinction may be difficult since the clinical manifestations of these two conditions may overlap.

Thrombotic thrombocytopenic purpura (TTP) is identified by the presence of fever,

Box 55.14 Thrombotic microangiopathies in pregnancy

- *Thrombotic thrombocytopenic purpura* P
 - Neurological abnormalities dominant
 - Kidney injury minimal
 - Diagnosed predominantly in the second and third trimesters
- *hemolytic uremic syndrome* S
 - Renal failure profound
 - Diagnosed primarily in the postpartum period.

thrombocytopenia (usually severe), microangiopathic hemolytic anemia, mild renal failure (creatinine <1.4 mg/dL), and neurological symptoms such as disorientation, ataxia, headache, focal neurological deficit, seizures, or aphasia. The etiology of TTP has been linked to abnormalities in von Willebrand factor protease, otherwise known as ADAMTS-13.

Pregnancy-associated hemolytic uremic syndrome (HUS) occasionally develops as a complication of preeclampsia. The clinical features of HUS are similar, but neurological involvement is rare while renal involvement is profound. Postpartum HUS has a high mortality rate.

The differentiating features of severe preeclampsia, HELLP syndrome, AFLP, TTP, and HUS are listed in Table 55.2.

uterine hemorrhage and A F

Acute renal failure is especially common in pregnancy complicated by massive hemorrhage and hypotension/hypovolemia. The causes of massive hemorrhage leading to ARF are listed in Box 55.15.

Box 55.15 Obstetric conditions causing hemorrhage and acute renal failure

- Placental abruption
- Disseminated intravascular coagulation
- Postpartum hemorrhage
 - Atonic/traumatic hemorrhage
 - Adherent placenta
 - Uterine rupture

Table 55.2 Differentiating features of severe preeclampsia, HELLP syndrome, AFLP, TTP, and S

	Severe preeclampsia	HELLP	AFLP	TTP	S
Onset of symptoms	Third trimester	Third trimester	Third trimester	Second or third trimester	Postpartum
Hypertension	100%	80%	25%–50%	Occasionally	+
Acute renal failure	Mild	Mild/moderate	Moderate	Mild/moderate	Severe
Thrombocytopenia	±	+	–	++	++
Hemolytic anemia	–	–	±	++	+
Increased PTT	±	±	+	–	–
Increased liver transaminase	±	+	++	–	–
ADAMTS-13 activity <10%	–	–	–	++	+
Renal outcome	Good	Good	Good	Poor	Poor

A P acute fatty liver of pregnancy; P hemolysis, elevated liver enzymes, and low platelet count; S hemolytic uremic syndrome; P partial thromboplastin time; P thrombotic thrombocytopenic purpura; +, positive; –, negative.

If there is associated severe preeclampsia or HELLP syndrome, the renal consequences of hemorrhage are worsened. Hemorrhage will exacerbate the hypovolemic state already associated with severe preeclampsia and precipitate the development and progression of ATN.

ATN is potentially reversible, and with supportive therapy, the damage can be minimal. If the renal ischemia is mild and the renal failure is reversible, the oliguric phase is followed by the diuretic phase. Electrolyte disturbances are common during this phase.

Without immediate intervention, the ATN can progress rapidly to bilateral renal cortical necrosis (BRCN). This almost always leads to permanent and irreversible renal damage. Of the cases of ARF, 20% will progress to BRCN.

Diagnostic criteria for ATN and BRCN are listed in Box 55.16.

Management of A F in pregnancy

Treatment of ARF in pregnancy poses special challenges, as there are risks to both the mother and the fetus. Management is best provided by a multidisciplinary team that involves obstetricians, nephrologists, neonatologists, and other specialists, as needed.

Prevention of A

Prevention of ARF is summarized in Box 55.17.

Box 55.16 Diagnostic criteria for AT and B C

Diagnosis of A

- Urinary sodium >25 mEq/L
- Urine examination
 - Tubular cell debris
 - Brown granular (pigmented) casts
 - Oliguria (50% of cases)

Diagnosis of B C

- Anuria persisting for >1 week
- CT with contrast or selective renal angiography (imaging not essential)
 - Delayed filling
 - Poor arborization of the interlobar arteries
 - Absent or nonhomogeneous filling at the level of the cortex
- Renal biopsy

A acute tubular necrosis; B C bilateral renal cortical necrosis; C computed tomography.

Box 55.17 Measures to prevent A F

- Prompt management of hypotension
- Early identification of obstetric hemorrhage
 - Adequate volume replacement
 - Adequate blood component replacement
- Appropriate management of severe preeclampsia
- Anticipation of and close monitoring for sepsis syndrome in
 - septic abortion
 - pyelonephritis
 - chorioamnionitis

The key issues in the management of ARF in pregnancy include the following:

- Correction of hypovolemia when present
- Prevention of further injury
- Initiation of renal replacement therapy (RRT or dialysis) when indicated
- Treatment of underlying cause
- The delivery of baby and the placenta as promptly as possible

enal dialysis

The indications for dialysis are similar to other patients with ARF and are listed in Box 55.18.

Options or dialysis

The options for RRT in ARF include the following:

- Intermittent hemodialysis
- Peritoneal dialysis (PD)
- Continuous hemofiltration [continuous renal replacement therapy (CRRT)]
- Slow low-efficiency dialysis (SLED)

Peritoneal dialysis and intermittent hemodialysis still continue to be the more cost-effective and affordable RRT modalities in developing countries.

The diagnostic and management algorithms for ARF occurring at different times during pregnancy are outlined in Figures 55.1 and 55.2.

Box 55.18 Indications for T (dialysis)

- Electrolyte imbalance, especially hyperkalemia
- Metabolic acidosis
- Volume overload
- Symptomatic uremia
 - Pericarditis
 - Neuropathy
 - Mental status changes

renal replacement therapy.

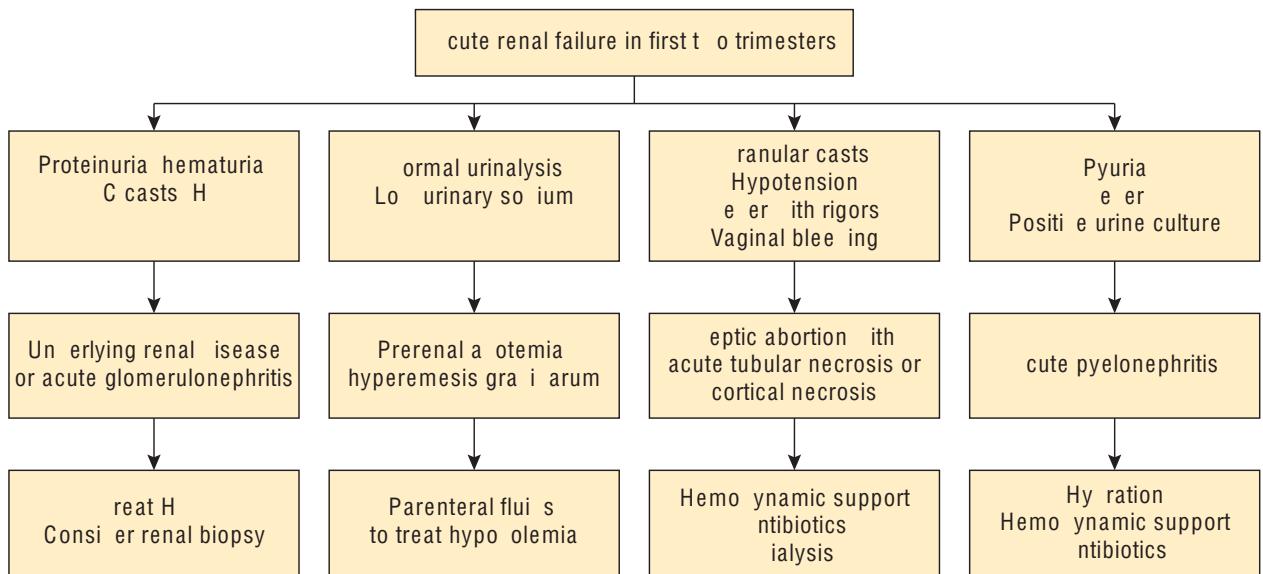


Figure 55.1 Diagnostic and management algorithm for acute renal failure in the second trimester. A, acute renal failure; H, hypertension; a, sodium.

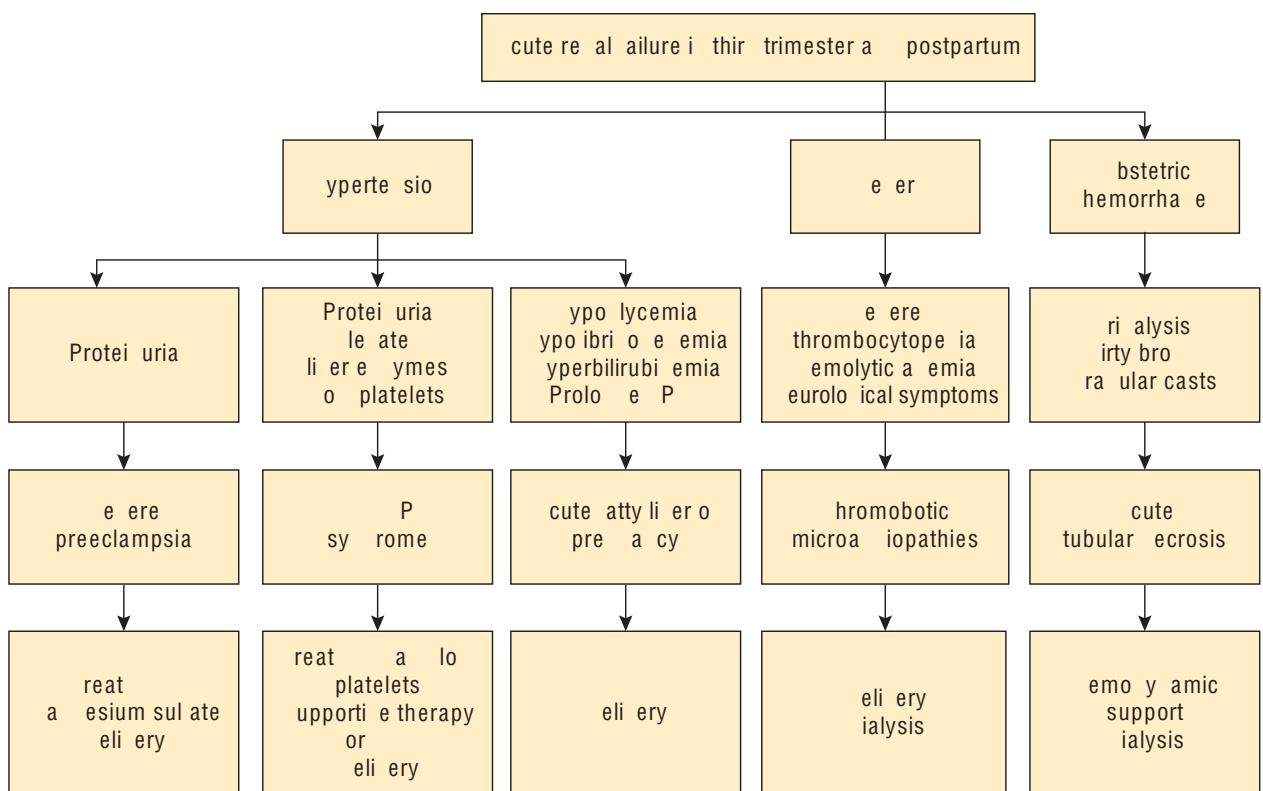


Figure 55.2 Diagnostic and management algorithm for acute renal failure occurring in the third trimester and postpartum period. A, acute renal failure; P, hemolysis, elevated liver enzymes, and low platelet count; H, hypertension; a, sodium; P, partial thromboplastin time.

Chronic renal diseases in pregnancy

Chronic renal disorders can have adverse effects on pregnancy and the disease itself may worsen due to pregnancy.

The common chronic renal disorders encountered in pregnancy are listed in Box 55.19.

Effect of pregnancy on kidney disease

Pregnancy can affect women with renal disease. Women who have hypertension and/or a pre-pregnancy creatinine level of >1.5 mg/day are at risk for permanent exacerbation of the underlying kidney disease. It is prudent for such women to avoid a pregnancy till these parameters are improved.

The effects of pregnancy on kidney disease are listed in Box 55.20.

Box 55.19 Common chronic renal disorders in pregnancy

- Chronic glomerulonephritis
- Nephrotic syndrome
- Renal failure due to nephrolithiasis
- Lupus nephritis
- Diabetic nephropathy
- Renal artery stenosis

Box 55.20 Effects of pregnancy on kidney disease

- Proteinuria increases in 50% of cases
- Hypertension develops in 25% of cases
 - Severe hypertension
 - Maternal adverse effects
 - Premature delivery
 - Poor fetal outcome
- Worsening of edema
- Effect on renal function
 - Risk of permanent exacerbation of renal disease in women with
 - prepregnancy creatinine level >1.5 mg/dL and or
 - preexisting hypertension
- Increased incidence of pyelonephritis

Box 55.21 Effect of chronic renal disease on pregnancy

- Higher rates of adverse maternal outcomes
- Higher risk of poor fetal outcomes
- Preeclampsia more difficult to diagnose in the presence of preexisting hypertension and proteinuria
- Greater risk of early onset preeclampsia

Effect of kidney disease on pregnancy

Although the rate of live births is $>90\%$ in women with normal renal function, women with chronic kidney disease are at higher risk for adverse maternal and fetal outcomes as indicated in Box 55.21.

A few common chronic renal disorders are discussed in the following sections.

ephrotic syndrome

Nephrotic syndrome is a nonspecific kidney disorder due to glomerular injury. It is characterized by increased capillary wall permeability to serum proteins. The following clinical findings are present:

- Proteinuria (>3.5 g/24 hours)
- Hypoalbuminemia (low levels of protein in the blood)
- Edema
- Hyperlipidemia

Causes of nephrotic syndrome in pregnancy

The causes of nephrotic syndrome in pregnancy are enumerated in Box 55.22.

Box 55.22 Causes of nephrotic syndrome in pregnancy

- Severe preeclampsia
 - Most common cause
- Preexisting renal disease with a marked increase in proteinuria during pregnancy
 - Lupus nephritis
 - Diabetic nephropathy
 - Proliferative glomerulonephropathy
 - Other chronic renal disorders

Management of nephrotic syndrome in pregnancy

Management involves the control of edema and the prevention of deep vein thrombosis (DVT).

Edema

The following points should be noted about edema:

- Managed by limiting dietary sodium to 1.5 g (approximately 60 mEq) of sodium per day
- Bed rest and leg elevation
- Diuretics occasionally indicated for severe, intractable edema
 - Contraindicated in preeclampsia
- Record of daily weight to monitor edema

Prevention of deep venous thrombosis

Nephrotic syndrome is associated with an increased risk of DVT. Prophylactic anticoagulation should be considered in pregnant women with nephrotic syndrome and severe hypoalbuminemia.

Natural course in pregnancy

Prognosis depends on the cause of nephrotic syndrome. It is generally good if renal function is adequate and there is no associated hypertension. When the syndrome is associated with high levels of creatinine (azotemia), a successful pregnancy is unlikely.

Glomerulonephritis

Glomerulonephritis may be acute or chronic.

Acute glomerulonephritis is uncommon in pregnancy. Streptococcal infections usually occur at a younger age. Acute glomerulonephritis may be a presentation of the following renal conditions:

- Poststreptococcal glomerulonephritis
- Lupus glomerulonephritis
- Membranoproliferative glomerulonephritis

Acute glomerulonephritis is characterized by the following:

- Hematuria: Sudden appearance of red blood cells and red blood cell casts in the urine
- Impaired renal function
- Sodium and water retention leading to
 - edema
 - hypertension

Box 55.23 Management of acute glomerulonephritis

- Control of hypertension
- Electrolyte balance
- Management of edema
- Management of underlying cause
- Management of uremia
 - Conservative measures
 - Possible renal dialysis

- proteinuria, which is common but normally less than 3.5 g/24 hours

The condition may be difficult to differentiate from preeclampsia.

Management

Management of acute glomerulonephritis is summarized in Box 55.23.

Chronic glomerulonephritis indicates progressive loss of renal function, proteinuria, and diminishing renal size caused by primary or secondary glomerular disease that has failed to resolve or respond to treatment. End-stage renal failure eventually ensues, requiring hemodialysis.

Pregnancy does not adversely affect the course of renal disease in patients who have normal renal function before pregnancy.

Diabetic nephropathy

Diabetic nephropathy may complicate up to 10% of pregnancies in women with pregestational diabetes. The characteristic pathology of diabetic nephropathy is diffuse or nodular glomerulosclerosis. The cause of diabetic nephropathy is attributed to poor glycemic control, hypertension, an increase in GFR, or an increase in protein intake and excretion, all of which are affected by pregnancy. Pregnancy has an adverse effect on diabetic nephropathy, increasing proteinuria and creatinine clearance.

Presenting signs

Diabetic nephropathy usually presents with the following:

- Significant proteinuria
- Azotemia
- Hypertension

Prognosis

Women with diabetic nephropathy are at increased risk for adverse maternal and fetal outcome:

- Preterm delivery
- Fetal growth restriction
- Preeclampsia
- Hypertensive complications

Approximately 20% of women with diabetic nephropathy during pregnancy will progress to renal failure by 5 years postpartum.

ephrolithiasis

Nephrolithiasis is often a chronic renal disorder, but symptoms may occur for the first time in pregnancy.

Nephrolithiasis (renal and ureteric calculi) is the most common cause of nonobstetric abdominal pain needing hospitalization in pregnant women.

The incidence and rate of recurrent calculi are similar in both pregnant and nonpregnant patients. Nearly 80%–90% of patients are diagnosed after the first trimester. Symptomatic stones are found in the ureter twice as often as in the renal pelvis and affect both ureters with similar frequency.

The pregnant woman presents with abrupt onset of intense pain, which radiates from the flank to the groin or labia (typical *ureteric colic*). The pain is usually intermittent and spasmodic, each episode an hour or longer. The pain of ureteric colic results from dilation, stretching, and spasm of the ureter because of the acute ureteral obstruction. The pain is often accompanied by nausea and vomiting.

Clinical presentation of nephrolithiasis is given in Box 55.24.

Investigations

The investigations for the confirmation of nephrolithiasis are listed in Box 55.25.

Management

Management of urolithiasis is summarized in Box 55.26. The first line of management is conservative. The goals are to facilitate the spontaneous passage of the stone and pain relief. This will result in relief for 80% of patients. Surgical intervention is resorted to only when there are

Box 55.24 Clinical features of nephrolithiasis

Symptoms

- Intense pain, abrupt in onset
- Flank pain
- Pain radiating to the groin or labia
- Nausea and vomiting
- Dysuria
- Gross or microscopic hematuria

Signs

- Costovertebral angle tenderness
- Generalized flank tenderness
- Guarding
- Rigidity

Box 55.25 Investigations for the confirmation of nephrolithiasis

- Urinalysis
 - Presence of RBCs may suggest a calculus
- Renal ultrasonography
 - First-line screening tool for urolithiasis in pregnant women
 - Ultrasound signs of ureteric calculus
 - Hydronephrosis greater than expected in pregnancy
 - Identification of calculus
 - Dilated ureter extending below the level of the iliac arteries
 - Asymmetry of ureteral jets suggesting obstruction of one of the ureters

BCs red blood cells.

Box 55.26 Management of urolithiasis

- Conservative management
 - Bed rest
 - Intravenous fluids for hydration
 - Straining urine through a filter to check for passage of calculus
 - Analgesics
 - Antiemetics
 - Antibiotics indicated in the presence of a UTI
- Surgical interventions
 - Ureteroscopy
 - Removal of stone with basket
 - Contact lithotripsy (crushing of stone)
 - Ureteral stent
 - Placed after ureteroscopy
 - Facilitates drainage of urine

urinary tract infection.

indications that include intractable pain, ureteral obstruction, and sepsis.

Surgical management

A total of 20% of pregnant women with nephrolithiasis will require surgical intervention. Indications for surgical intervention are listed in Box 55.27.

Box 55.27 Indications for surgical intervention in nephrolithiasis

- Ureteral obstruction associated with worsening renal function
- Intractable pain despite maximal conservative measures
- Obstruction in a solitary kidney
- Associated sepsis

Key points

- Anatomical and physiological changes that occur in pregnancy predispose women to development of urinary tract and renal problems and sometimes to rapid worsening of disease.
- Women with chronic renal failure who have hypertension and/or a prepregnancy creatinine level of >1.5 mg/day are at risk for permanent exacerbation of the underlying kidney disease. It is prudent for such women to avoid a pregnancy till these parameters are improved.
- Although the rate of live births is >90% in women with normal renal function, women with chronic kidney disease are at higher risk for adverse maternal and fetal outcomes.
- Urinary tract infections (UTIs) are among the most common bacterial infections occurring in pregnancy.
- Vaginal infections can cause or mimic UTIs. Differentiating between the two depends on a good history, physical examination, and the results of vaginal and urinary cultures.
- Untreated asymptomatic bacteriuria is a risk factor for acute cystitis (40%) and pyelonephritis (25%–30%) in pregnancy.
- Acute cystitis is due to the inflammation of the bladder mucosa as a result of bacterial infection.
- Acute pyelonephritis is an infection of the upper urinary tract and kidneys. It is characterized by fever, flank pain, and tenderness in addition to significant bacteriuria.
- Urinary tract infection is investigated with urinalysis and culture and antibiotic sensitivity of a clean-catch midstream urine specimen.
- Pyelonephritis warrants hospitalization and treatment with parenteral antibiotics.
- Acute renal failure [ARF or acute kidney injury (AKI)] in pregnancy is characterized by a rapid decrease in the glomerular filtration rate over a matter of minutes or days.

- In the first trimester, ARF usually results from hydremesis gravidarum or septic abortion.
- The four most common causes of ARF in late pregnancy and the postpartum period are severe preeclampsia, HELLP syndrome, acute fatty liver of pregnancy, and thrombotic microangiopathies.
- Massive hemorrhage is also implicated as a cause of ARF in pregnancy.
- Hemorrhage will exacerbate the hypovolemic state already associated with severe preeclampsia and precipitate the development and progression of acute tubular necrosis.
- Pregnancy in women with chronic renal failure is associated with an increase in the risk of complications. The renal functions, proteinuria, and hypertension also worsen in pregnancy.
- Nephrotic syndrome is a nonspecific kidney disorder due to glomerular injury. It is characterized by increased capillary wall permeability to serum proteins.
- Acute glomerulonephritis may be a presentation of post streptococcal glomerulonephritis, lupus glomerulonephritis, and membranoproliferative glomerulonephritis.
- Chronic glomerulonephritis indicates progressive loss of renal function, proteinuria, and diminishing renal size caused by primary or secondary glomerular disease that has failed to resolve or respond to treatment.
- Diabetic nephropathy may complicate up to 10% of pregnancies in women with pregestational diabetes. The characteristic pathology of diabetic nephropathy is diffuse or nodular glomerulosclerosis.
- Nephrolithiasis (renal and ureteric calculi) is the most common cause of nonobstetric abdominal pain needing hospitalization in pregnant women.

Self-Assessment

Case-based questions

Case 1

Mrs. JP, 29, was in her sixth month of pregnancy. She gave a history of dysuria for 2 days. She presented with fever, chills, and severe flank pain.

1. What is the diagnosis?
2. How will you manage this patient?
3. What are the adverse effects of this condition?
4. Define significant bacterial count on urine culture.

Case 2

Mrs. BN, 24, was pregnant with her first pregnancy. She developed hypertension at 32 weeks, and this progressed rapidly to preeclampsia. She had abruption at 35 weeks. She developed severe hypovolemic shock. In spite of adequate volume replacement, she developed oliguria. She was transferred to a tertiary center for further care.

1. What does oliguria signify?
2. What is HELLP syndrome?
3. How will you manage this patient?
4. How will you differentiate acute fatty liver of pregnancy?

Answers

Case 1

1. Symptoms of lower urinary tract infection associated with fever and flank pain are suggestive of acute pyelonephritis.
2. She needs to be hospitalized; urinalysis and urine culture with antibiotic sensitivity have to be done on a clean-catch midstream urine specimen, and she has to be started on parenteral antibiotics. After she has

been afebrile for 48 hours, she can be switched to oral antibiotics.

3. Adverse effects can be preterm labor, and in severe cases, septic shock and acute respiratory distress syndrome.
4. $\geq 10^5$ (100,000) cfu/mL is considered significant and indicative of a urinary infection.

Case 2

1. Oliguria in spite of adequate volume replacement indicates acute renal failure. Renal function tests will confirm increasing levels of creatinine.
2. HELLP is a syndrome characterized by hemolysis, elevated liver enzymes, and low platelet count. Although it is associated with severe preeclampsia, 15%–20% of women with HELLP syndrome do not have hypertension or proteinuria.
3. Along with the management of hypertension, magnesium sulfate, and delivery, she might require dialysis.
4. The diagnosis of acute fatty liver should be suspected when preeclampsia is associated with hypoglycemia, hypofibrinogenemia, hyperbilirubinemia, and prolonged partial thromboplastin time in the absence of abruptio placentae.

Sample questions

Long-answer question

1. What are the causes and management of acute renal failure in pregnancy?

Short-answer questions

1. UTI in pregnancy
2. Asymptomatic bacteriuria
3. Pregnancy in chronic renal disease

56

Infections

Case scenario

Mrs. BG, 36, pregnant for the first time, presented at the antenatal clinic with a few clear vesicles on her face and abdomen. Her 6-year-old nephew was just recovering from chicken pox.

Introduction

Pregnant women are susceptible to infections just like other women. However, infections in pregnancy are a complex issue because the embryo and fetus are vulnerable, right from the time of the implantation of the fertilized ovum through the time of delivery. Therapy is also restricted because of the concern about teratogenicity. In the peripartum period, the newborn is susceptible to transmission of infection from the mother.

Generally, infections that occur in the first trimester (during the period of organogenesis) give rise to congenital anomalies. However, some infections are transmitted transplacentally even at later periods of gestation.

Many of the infections in pregnancy may be asymptomatic and therefore obstetricians have

to have a high index of suspicion even for the mildest symptom. Screening for some infections is mandatory. Treatment for intrauterine infections is aimed at treating both the mother and the fetus.

Transmission of maternal infection

Transmission of maternal infection to the fetus and newborn can occur

- through the transplacental route
- as an ascending infection from the lower genital tract
- through contact with genital lesions or secretions during delivery
- through breastfeeding

Immune response to infection

Two types of antibodies may be produced in response to an infection: immunoglobulin M (IgM) and immunoglobulin G (IgG; Box 56.1). They are specific for each different infection, for example, rubella antibodies are different from the antibodies for herpes.

Fetal status

When fetal infection is suspected, the presence of IgM antibodies in amniotic fluid/fetal blood

Box 56.1 Antibodies produced in response to infection

g antibodies

- **Indicate acute phase of infection**

- First to be produced by the body in response to an infection
- Present within 1–2 weeks after the initial exposure
- Rise for a short time period and then decline
- Eventually fall below detectable levels
- Do not cross the placenta

g antibodies

- **Indicate lifelong immunity**

- Produced a few weeks after the initial infection
- Provide long-term protection
- Rise in levels during active infection, stabilize later
- Persist lifelong
- Cross the placenta

Antibody testing

- Performed to determine immunity in pregnant women
 - Who have been exposed to someone with an infection or
 - Who have symptoms suggestive of infection
- Distinction between current, recent, and old infections possible by comparing the absence or presence of both IgG and IgM in the same sample
 - IgM negative, IgG negative
 - No recent infection
 - Susceptible to future infection
 - Only IgM positive
 - Current infection
 - IgM positive and IgG positive
 - Recent infection
 - Only IgG positive
 - Old infection (immune)

g immunoglobulin G; *g* immunoglobulin M.

will confirm active fetal infection since maternal IgM antibodies cannot cross the placenta. The presence of IgG antibodies in the amniotic fluid or fetal blood is inconclusive since maternal IgG antibodies can cross the placenta.

Types of infections

The infections in pregnancy that have an impact on maternal/fetal health and discussed in this chapter are as follows:

- Viral
 - Parvovirus B19
 - Herpes simplex virus (HSV)
 - Cytomegalovirus (CMV)
 - Rubella
 - Varicella
 - Human immunodeficiency virus (HIV)
- Protozoal
 - Toxoplasmosis
 - Malaria
- Bacterial
 - Tuberculosis (TB)

viral infections

Parvovirus B19 in pregnancy

Parvoviral B19 infection is a respiratory illness that may be associated with a febrile illness, rash, and arthralgia. Approximately 30%–50% of pregnant women are immune to the infection due to prior exposure to the infection. The rate of parvoviral infection is highest in pregnant school teachers who come in close contact with toddlers.

Signs and symptoms

Parvoviral infection may vary from a mild asymptomatic illness to erythema infectiosum—a febrile illness associated with a rash ('slapped cheek' appearance, which is more common in children than in adults), arthropathy, viral myocarditis, or rarely an aplastic crisis.

By the time the rash develops at the end of the incubation period of 2 weeks, the woman is no longer infective.

Box 56.2 Effect of parvovirus B19 on pregnancy

- Risk of fetal loss if infection occurs
 - in first trimester: 15%
 - between 13 and 20 weeks' gestation: 10%
 - after 20 weeks: 1%
- Transient effusions
 - Isolated fetal pleural or pericardial effusions
 - Due to pleural or myocardial inflammation
 - Resolve spontaneously
- Fetal hydrops
 - Severe anemia and nonimmune hydrops fetalis
 - Higher incidence in women infected before 20 weeks
 - Clinical course
 - Rapid fetal death (within a few days to weeks) or
 - Resolves spontaneously with normal infant at delivery

- If fetal anemia is diagnosed
 - Intrauterine transfusion or
 - Delivery if fetus is term or near term

The long-term prognosis is good after intrauterine transfusion.

Genital herpes simplex infection in pregnancy

Genital HSV infection is common among women of childbearing age. During pregnancy, the major concern is transmission of maternal HSV infection to the fetus, as neonatal infection can result in serious morbidity and mortality.

Genital herpes is due to HSV-2 and HSV-1, although HSV-2 infections are more common. It is spread by sexual contact.

Effect on pregnancy

The effect of parvovirus B19 is summarized in Box 56.2.

Diagnosis

If there is clinical suspicion or recent known exposure, a serum parvoviral test for IgM and IgG is essential.

Fetal infection is confirmed or ruled out by obtaining amniotic fluid (amniocentesis) or fetal blood (fetal blood sampling). Polymerase chain reaction (PCR) is used to detect B19 DNA.

Treatment

There is no known antiviral treatment for this condition. The clinical course is self-limiting. Fetal surveillance should be instituted to diagnose fetal anemia and nonimmune hydrops, which may occur up to 12 weeks following a confirmed acute infection.

Diagnosis and management of fetal anemia by hydrops

Parvovirus B19 infection is usually suspected in pregnancy in the presence of nonimmune fetal hydrops. If fetal infection has been diagnosed by PCR on amniotic fluid or fetal blood, the following steps are followed:

- Periodic middle cerebral artery (MCA) Doppler to assess for the presence of fetal anemia

Signs and symptoms

The signs and symptoms of genital herpes simplex infection depend on whether it is a **primary** or **recurrent** infection. The clinical presentation is summarized in Box 56.3.

Implications in pregnancy

Transmission to fetus

The risk of transmission to the fetus depends on the timing of infection and whether it is primary or recurrent.

Primary infection in early pregnancy

- Rarely associated with miscarriage or congenital anomalies
- Risk of transplacental infection of fetus low

Box 56.3 Clinical presentation of genital herpes simplex

• Primary infection

- First occurrence of HSV infection
- Symptoms
 - Severe painful genital ulcers
 - Severe dysuria due to ulcerated vesicles
 - Tender inguinal lymphadenopathy

• Recurrent infection

- Preexisting antibodies to HSV-1 or HSV-2
- Disease milder
- Low risk of maternal-fetal transmission at vaginal delivery

Primary infection in the third trimester

- High risk of maternal-fetal transmission at vaginal delivery (40%–50%)

Recurrent infection

- Risk of transmission at delivery much lower than with primary genital infection (3%–5%)

Diagnosis of genital herpes simplex

The diagnosis of HSV infection is summarized in Box 56.4.

Treatment of herpes simplex in pregnancy

Primary infection

Symptom control

For symptom control, analgesia with paracetamol or nonsteroidal anti-inflammatory drugs (NSAIDs) can be considered along with sitz baths.

An indwelling Foley catheter may be required in women with severe dysuria.

Antiviral therapy

Antiviral therapy can decrease the symptoms and consequences of primary infection in the

Box 56.4 Diagnosis of herpes simplex virus infection

- Clinical examination
 - Painful vesicles (in primary infection)
- Viral cultures of fluid from deroofed vesicles
 - Sensitivity
 - 80% in primary infection
 - 35% in recurrent infection
- PCR
 - More sensitive test than culture
 - Preferred test in symptomatic patients
- Serology for IgG antibodies not used routinely

g immunoglobulin G; PC polymerase chain reaction.

mother. Acyclovir, valacyclovir, and famciclovir are used for treatment of maternal herpes. Acyclovir is safe in pregnancy and commonly used. Antiviral therapy may be used for treatment of primary infection or recurrent infection, or as suppressive therapy in women with history of recurrent infections. The dosage is given in Table 56.1.

Management of pregnancy

Maternal HSV infection transmitted to the infant during delivery can result in major neonatal morbidity and mortality. Neonatal infection results from fetal contact with virus shed from infected sites in the cervix, vagina, and the vulva.

Infections or suppressive therapy

Suppressive therapy given from 36 weeks' gestation reduces the risk of HSV lesions at term and the need for cesarean section. It is used in women with

- primary active infection in the first or second trimester;
- recurrent infections in any trimester.

Cesarean section

Cesarean section is indicated in women with active genital lesions in the 6 weeks leading up to delivery.

With spontaneous rupture of membranes in women with active lesions, a cesarean section must be performed within 4 hours. However, there is some benefit of doing cesarean section even when the duration of rupture of membrane is >4 hours.

Vaginal delivery

Vaginal delivery is undertaken in women with no active genital lesions.

Table 56.1 Recommended dosage of antiviral therapy in herpes simplex virus infection

Drug	Primary infection	Recurrent infection	Suppressive therapy
Acyclovir	400 mg tid for 7–10 days	800 mg bid for 5 days	400 mg tid
Valacyclovir	1 g bid for 7–10 days	500 mg bid for 3 days	500–1000 mg od

- To prevent neonatal transmission in asymptomatic women with a previous history of HSV infection, avoid
 - fetal scalp electrode
 - vacuum or forceps delivery
- If vaginal delivery is undertaken in the presence of active lesions, the mother and the neonate should be given intravenous acyclovir.

Neonatal S

Neonatal HSV is a serious condition. It can be due to the following:

- Direct contact with virus during vaginal delivery
- Postpartum HSV transmission to the neonate by not following proper hand washing
- Very rarely, vertical transmission by transplacental or ascending transmembranous infection

The clinical features of neonatal HSV are summarized in Box 56.5.

Postpartum management

Thorough hand washing is recommended if the mother or anyone who handles the newborn has HSV lesions.

Breastfeeding is encouraged since it is quite rare to have lesions on the chest.

Cytomegalovirus infection in pregnancy

Cytomegalovirus (CMV) is a commonly occurring DNA herpes virus that presents with a wide

variety of clinical manifestations. It is the most common congenital viral infection, with a prevalence of approximately 0.5% in the newborn. Congenital human CMV infection is the leading infectious cause of mental disability and sensorineural deafness.

In adults, CMV is transmitted by contact with infected nasopharyngeal secretions, urine, saliva, semen, cervical and vaginal secretions, breast milk, tissue, or blood. After primary infection, the virus remains dormant and periodic reactivation occurs during which there is virus shedding.

Primary infection during pregnancy is associated with 40% risk of fetal infection.

Recurrent infection/reactivation is associated with a much lower risk of fetal infection (<1%).

Maternal transmission to the fetus/infant is through the following:

- Transplacental infection
- Contact with maternal genital secretions during delivery
- Ascending infection from the maternal genital tract (not very common)
- Breast milk

Diagnosis of maternal infection

Routine maternal testing for CMV is not recommended. Indications for diagnostic testing in pregnancy are as follows:

- Mononucleosis-like illness in the mother
- A fetal anomaly suggestive of congenital CMV infection detected on prenatal ultrasound examination (see Box 56.7)

Diagnostic tests

Maternal IgG, IgM, and the IgG avidity testing should be done.

Diagnosis of recent infection

Recent infection is diagnosed as follows:

- Detection of CMV IgM antibodies
- Four-fold increase in CMV IgG antibodies

The anti-CM IgG avidity test

The anti-CMV IgG avidity test is currently the most reliable procedure to identify primary

Box 56.5 Clinical features of neonatal S

- Mucocutaneous infection
 - Skin, eye, and mouth (SEM) disease: 40% of cases
- HSV encephalitis with or without SEM
 - In 30% of neonatal HSV disease
 - Presents with
 - seizures (focal or generalized)
 - lethargy
 - irritability
 - tremors
- Disseminated form
 - Multiorgan dysfunction
 - 90% fatal

S herpes simplex virus.

infection in pregnant women. The IgG avidity test is highly specific (100%) and sensitive (94.3%). The avidity index helps to decide whether the infection is recent or old. This is based on the fact that antibodies bind less avidly to antigens during the early stages (low avidity) than in chronic stages of infection (high avidity).

Congenital CM infection

Congenital human CMV infection is the leading infectious cause of mental disability and sensorineural deafness.

The majority of women with primary CMV diagnosed before 20 weeks' gestation will deliver an unaffected infant.

The clinical manifestations of congenital CMV are listed in Box 56.6.

Box 56.6 The clinical manifestations of congenital CM

- 90% of infants
 - No manifestations at birth
- 10% of affected infants
 - Long-term neurological sequelae associated with
 - ventriculomegaly
 - periventricular leukomalacia
 - microcephaly
- Other clinical manifestations include
 - chorioretinitis
 - sensorineural hearing loss
 - hepatosplenomegaly
 - purpuric skin eruption, petechiae
 - jaundice
 - fetal growth restriction
- Blood tests reveal
 - hemolytic anemia
 - thrombocytopenia
 - hyperbilirubinemia

C = cytomegalovirus.

Diagnosis of congenital CM infection

The steps to be followed for the diagnosis of congenital CMV infection are delineated in Figure 56.1.

The first step in the prenatal diagnosis of congenital CMV infection is determination of maternal primary and secondary infection by serological testing. Following a diagnosis of maternal infection, serial ultrasonography should be performed every 2 weeks to detect fetal abnormalities. Abnormal findings on ultrasound should prompt further testing with amniocentesis.

Ultrasound findings suggestive of fetal CMV infection are enumerated in Box 56.7.

renal iagnosis o congenital C in ection

Amniocentesis is done to obtain amniotic fluid. Fetal blood sampling for fetal IgM is not a reliable test.

- Amniocentesis
 - To obtain a sample of amniotic fluid
 - Done after 21 weeks' gestation
 - Time interval of 6 weeks between first diagnosis of maternal infection and prenatal diagnosis

Box 56.7 Ultrasound findings suggestive of fetal cytomegalovirus infection

- Symmetric fetal growth restriction
- Cerebral ventriculomegaly
- Intracranial calcifications
- Microcephaly
- Oligohydramnios/polyhydramnios
- Hyperechogenic bowel
- Hepatic calcifications
- Hydrops fetalis/ascites
- Pleural effusion
- Placental enlargement

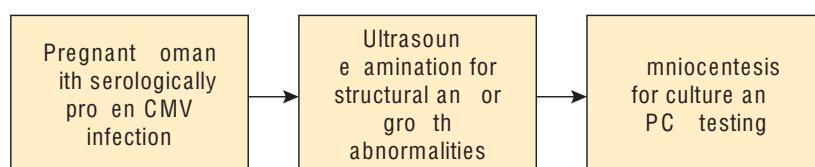


Figure 56.1 The steps for the diagnosis of congenital CMV infection. C = cytomegalovirus; PC = polymerase chain reaction.

- Diagnosis made by
 - PCR for CMV DNA

Although infection before 20 weeks' gestation is associated with minimal risk of the fetus being infected, women may choose to terminate the pregnancy if they find that the fetus is infected, because of the concern about long-term sequelae.

Treatment of CMV infection in pregnancy

Use of antiviral drugs for treatment of CMV infections is rarely indicated in pregnant women since they do not decrease perinatal transmission. Pregnant women must be counseled in depth about the extent of CMV infection and risk of neurological sequelae.

Management of congenital CMV infection in neonates

All neonates at risk of congenital CMV infection should be assessed and investigated by a pediatrician after delivery.

Investigations to be done before 3 weeks of age are as follows:

- CMV culture or PCR: Urine or saliva and blood for CMV IgM
- Complete blood examination and liver function tests
- Central nervous system imaging
- Ocular examination and newborn hearing screen

Neonatal treatment with ganciclovir for 6 weeks has been proven to prevent late-onset hearing loss.

Rubella in pregnancy

Rubella (German measles) is a childhood disease that has been eliminated to a large extent by routine childhood rubella vaccination. Rubella is an RNA virus, transmitted through respiratory droplets. Infection usually occurs in school-going children living in crowded areas. The incubation period is 12–19 days. Although rubella is a mild infection in older children and adults, it can have potentially devastating effects on the developing fetus.

Maternal infection

Maternal rubella is a mild, self-limiting disease, which may go unnoticed. It is asymptomatic in 25%–50% of cases.

The clinical manifestations in symptomatic patients include mild fever, malaise, rashes that spread from face to extremities, and lymphadenopathy.

Fetal effects of rubella infection congenital rubella syndrome

Rubella infection can have catastrophic effects on the developing fetus, resulting in spontaneous abortion, fetal infection, stillbirth, or fetal growth restriction.

Congenital infection can affect almost all organs of the fetus (Box 56.8). Severity of congenital rubella syndrome (CRS) is related to the period of pregnancy at which infection occurs. Earlier the gestational age of infection, more severe are the effects (Table 56.2).

Diagnosis of rubella infection

maternal infection

Acute rubella syndrome is best diagnosed by the following:

- Presence of rubella-specific IgM

Box 56.8 Clinical features of congenital rubella syndrome

- Sensorineural hearing loss
 - Most common defect
- Eye defects
 - Cataract
 - Glaucoma
 - Retinitis
- Cardiac lesions
 - Most common
 - Patent ductus arteriosus
 - Branch pulmonary artery stenosis
 - Other lesions
 - Pulmonary valvular stenosis
 - Aortic valve stenosis
 - Ventricular septal defect
 - Tetralogy of Fallot
 - Coarctation of the aorta
- Microphthalmia
- Microcephaly
- Cerebral palsy
- Hepatosplenomegaly and jaundice
- Fetal growth restriction
- Mental disability

Table 56.2 Risk of fetal infection and fetal defects based on gestational age

Gestational age (weeks)	Risk of infection (%)	Risk of defect (%)
<11	80	100
13–16	50	35 (deafness alone)
After 16	25	0–1
>36	100	Fetal growth restriction only

- IgG titer
 - A four-fold rise in serum obtained 7–10 days after onset of rash and repeated 2–3 weeks later
- Positive rubella culture in specimen from
 - nasal swab, throat swab, blood, urine

Interpretation of maternal rubella IgM and IgG antibodies is summarized in Table 56.3.

etal in ection

Fetal infection is diagnosed by the following:

- Rubella-specific PCR in
 - chorionic villus sampling (CVS)
 - fetal blood
- Ultrasound diagnosis difficult

Counseling regarding risk of fetal defects

The possibility of severe defects in the infant can make the parents anxious. Counseling should include risk of maternal–fetal transmission

Table 56.3 Interpretation of maternal rubella IgM and IgG antibodies

IgM negative and IgG positive	<ul style="list-style-type: none"> • Mother immune to rubella • No recent infection • No risk of fetal infection
IgM negative and IgG negative	<ul style="list-style-type: none"> • No recent infection • No immunity to rubella • Recommend rubella vaccine postpartum
IgM positive and IgG negative	<ul style="list-style-type: none"> • Indicates current infection
IgM positive and four-fold increase in IgG 2–3 weeks later	<ul style="list-style-type: none"> • Indicates recent infection

g immunoglobulin G; g immunoglobulin M.

depending on gestational age. A good rule of thumb to follow would be as follows:

- Infection at <11 weeks' gestation
 - Risk of multiple major defects high
 - Termination offered
- Infection at 13–16 weeks' gestation
 - Risk of sensorineural deafness high
 - Counseling and termination of pregnancy offered
- Infection after 16 weeks' gestation
 - Risk of defects very low
 - May continue pregnancy

Varicella- zoster infection in pregnancy

Varicella-zoster virus (VZV) infection causes two clinically distinct forms of disease: varicella (chicken pox) and herpes zoster (shingles). VZV is a DNA virus from the herpes virus family.

Primary varicella infection (chicken pox)

Varicella infection is not common in pregnancy. Primary VZV infection results in the diffuse vesicular rash of chicken pox. Primary infection with VZV during pregnancy has significant implications for maternal and fetal health. The severity of disease and complications are much more in adults. Varicella pneumonia is estimated to complicate up to 10% of maternal infections and contributes to morbidity and mortality.

The characteristics of chicken pox are listed in Box 56.9.

Box 56.9 Characteristics of chicken pox

- Transmitted as
 - droplet infection
 - direct personal contact
- Incubation period: 10–21 days
- Patient infectious
 - 48 hours before rash appears
 - Until vesicles crust over
- Primary varicella infection
 - Provides immunity for life
- VZV stays dormant in sensory nerve ganglia
 - Herpes zoster (shingles) caused by reactivation

varicella-zoster virus.

herpes zoster

Herpes zoster results from reactivation of VZV virus that has been dormant in sensory nerve ganglia. It presents as localized painful vesicles along a sensory nerve dermatome. Maternal herpes zoster infection is not associated with a significant risk of adverse effects on the fetus.

Maternal varicella

Diagnosis

The diagnosis is clinical and is based on the classical appearance of the lesions. In cases of doubt, varicella virus can be isolated from scrapings from the lesions by culture or by fluorescent antibody testing. Serological testing for varicella IgM is not necessary for the diagnosis of maternal varicella.

Fetal and neonatal risks

The risk of spontaneous miscarriage does not appear to be increased if chicken pox occurs in the first trimester.

Congenital varicella syndrome

Congenital varicella syndrome is an extremely rare disorder in which affected infants have distinctive abnormalities at birth due to maternal infection up to 20 weeks' gestation.

- Affected newborns may have a low birth weight and characteristic abnormalities. The range and severity of associated symptoms and physical findings may vary greatly from case to case depending on when maternal varicella-zoster infection occurred during fetal development.
- Rates of congenital varicella syndrome
 - Before 13 weeks: 0.4%
 - Between 13 and 20 weeks: 2%
- Since the risk of congenital varicella syndrome is very low, termination of pregnancy is not warranted and need not be advised for women who develop chicken pox in pregnancy.

The clinical features of congenital varicella syndrome are listed in Box 56.10.

Neonatal infection

Neonatal varicella infection that is seen in the infant immediately after birth carries a mortality

Box 56.10 Clinical features of congenital varicella syndrome

- Dermatomal skin scarring
- Eye defects
 - Microphthalmia
 - Chorioretinitis
 - Cataracts
- Limb hypoplasia
- Neurological abnormalities
 - Microcephaly
 - Cortical atrophy
 - Mental disability
- Dysfunction of bowel and bladder sphincters

rate as high as 25%. Neonatal infection results from maternal infection that occurs

- Near or during the time of delivery
 - Transplacental transmission
 - Ascending vaginal infection
- Immediately postpartum
 - Direct contact

The infant will develop passive immunity when the maternal IgG antibodies cross the placenta. Severe chicken pox is most likely to occur if the infant is born within 7 days of onset of the mother's rash or if the mother develops the rash up to 7 days after delivery when the infant has not had the time to develop immunity.

It is advised to avoid elective delivery until 5–7 days after the onset of maternal rash to allow for the passive transfer of antibodies from mother to child.

Management of varicella in pregnancy

Antenatal treatment

Postexposure prophylaxis

A pregnant woman who has never had chicken pox but is exposed to an active case should be offered postexposure prophylaxis.

- Passive immunization with **varicella-zoster immune globulin (VZIG)** reduces the risk of varicella infection and also reduces the severity of infection in those who develop chicken pox.
- VZIG is effective when given up to 10 days after contact.

Uncomplicated varicella

All pregnant women with uncomplicated varicella should be treated with oral acyclovir

- 800 mg five times a day for 5–7 days
- Within 24 hours of the onset of the rash

Symptomatic treatment is essential for itching and secondary infections.

Varicella pneumonia

Varicella pneumonia during pregnancy is a medical emergency with a high mortality rate.

It is treated with intravenous acyclovir (10 mg/kg every 8 hours).

Fetal surveillance and prenatal diagnosis

Fetal surveillance and prenatal diagnosis consists of the following:

- Detailed ultrasound can detect limb deformity, microcephaly, hydrocephalus, soft-tissue calcification, and fetal growth restriction.
- Fetal sampling for the presence of varicella IgM is not a useful test to confirm fetal infection.

Neonatal varicella infection

Neonatal varicella infection is managed as follows:

- If delivery occurs within 7 days of onset of maternal rash or if the mother develops a rash within 7 days of delivery, the neonate should be given VZIG.
- Acyclovir should be administered to treat neonatal infection.
- Neonatal blood should be sent for VZV IgM antibody and later a follow-up sample should be tested for IgG antibody.

Human immunodeficiency virus and pregnancy

The human immunodeficiency virus (HIV) is a lentivirus (a subgroup of retrovirus) that causes the **acquired immunodeficiency syndrome** (AIDS). In AIDS, there is a progressive failure of the immune system. Life-threatening opportunistic infections and cancers flourish in this immunosuppressed state. Without treatment, life expectancy after infection with HIV is estimated to be 9–11 years. Infection with HIV

occurs by the transfer of blood, semen, vaginal fluid, or breast milk. HIV is present both as free virus particles and virus within infected immune cells in these bodily fluids.

India is home to the world's third largest population suffering from HIV/AIDS. Women with heterosexually acquired HIV infection represent the most rapidly increasing group of HIV-infected individuals in the world. They account for 1 in 4 new HIV diagnoses and deaths caused by AIDS.

Screening for HIV in pregnant women

Screening for HIV in pregnant women consists of the following:

- All pregnant women should be given pretest counseling regarding screening for HIV.
- All pregnant women (except those who opt out) should undergo HIV screening early in each pregnancy.
- Repeat testing in the third trimester is recommended for those who are at high risk of infection.
- Women who present in labor without prior HIV testing should undergo rapid HIV testing.
- Rapid tests can be performed anywhere and do not require laboratory facilities or highly trained staff. Results come as fast as in 20 minutes.
- A pregnant woman with a positive rapid HIV test should be managed as if HIV-infected to prevent perinatal HIV transmission.
- If no rapid testing is available, the untested woman should also be managed as if HIV-infected to prevent perinatal HIV transmission.

Effect of pregnancy on HIV infection

An HIV-positive woman may become pregnant or a pregnant woman may be found to be HIV positive when she is tested during the routine antenatal checkup.

The disease does not worsen during pregnancy and the rate of progression is not altered.

Sequelae of maternal HIV infection

An HIV-infected pregnancy is associated with fetal sequelae. Sequelae can be minimized by the

appropriate use of antiretroviral therapy (ART). The most important and worrisome sequela is the vertical transmission of disease to the fetus and infant. Mother-to-child transmission (MTCT) is responsible for 90% of HIV in children worldwide.

Fetal sequelae of maternal HIV are summarized in Box 56.11.

Diagnosis

Tests used for screening and diagnosis of HIV include antibody tests, antigen test, and nucleic acid tests.

I antibody tests

HIV antibody tests are used most commonly for screening and diagnosis. Antibody tests may be as follows:

- Enzyme-linked immunosorbent assay (ELISA)
- Western blot
- Rapid tests
- Nucleic acid tests

ELISA test

Enzyme-linked immunosorbent assay (ELISA) is a sensitive test and is used as the primary screening test. False positives can occur with ELISA. Hence, if the ELISA test is positive, Western blot test should be performed before the patient is declared to be HIV positive.

Western blot tests

Western blot tests are more specific and are used as confirmatory tests.

Box 56.11 Fetal sequelae of I in pregnancy

- Spontaneous abortion, low birth weight, and stillbirth
- Increased risk of preterm delivery
- MTCT
 - Responsible for
 - 90% of HIV infection in children worldwide
 - Route of transmission
 - Intrauterine transmission 5%–10%
 - During delivery 10%–20%
 - Postdelivery transmission 5%–20%
 - Without antiretroviral therapy, rates of MTCT
 - 15%–30% without breastfeeding
 - 30%–45% with prolonged breastfeeding
 - With appropriate ART, rate of MTCT
 - <2%

A antiretroviral therapy; I human immunodeficiency virus;
C mother-to-child transmission.

Rapid tests

Rapid tests are point-of-care tests, used when results are required within a short period of time, like a woman in labor. Positive tests should be confirmed by Western blot tests.

Nucleic acid tests

Nucleic acid tests are used when the initial tests are inconclusive, especially for determination of HIV-1/HIV-2. They are expensive and not offered routinely.

Factors that increase risk of mother-to-child transmission

There are certain maternal and obstetric factors that increase the risk of MTCT (Box 56.12). These should be kept in mind during management of HIV-positive women.

Management of the pregnant woman with I

The management of the pregnant woman with HIV infection has advanced significantly over the past three decades due to ART and a better understanding of the prevention of perinatal HIV transmission.

Management of HIV successfully in pregnancy hinges on four main factors:

1. Universal testing of pregnant women for HIV infection
2. Use of ART to prevent vertical transmission

Box 56.12 Factors that increase risk of MTCT

- Virus-related factors
 - Maternal viral load
 - Low CD4 count
- Maternal disease-related factors
 - Seroconversion during pregnancy
 - Advanced stage
- Obstetric factors
 - Vaginal delivery
 - Prelabor rupture of membranes
 - Preterm labor
 - Chorioamnionitis
 - Ventouse delivery
 - Antepartum invasive procedures
 - Fetal scalp blood sampling
 - Use of fetal scalp electrode
- Breastfeeding

C mother-to-child transmission.

3. Use of cesarean section, when appropriate
4. Avoidance of breastfeeding, when feasible

A thorough history and physical examination should be performed in the HIV-infected pregnant woman. The history should include details of opportunistic infections, sexually transmitted infections (STIs), medication use, immunization status, and substance abuse. Physical examination should specifically look for signs of advanced HIV infection and concomitant STIs.

Counseling should be provided to modify risk behavior regarding HIV transmission, smoking, and illicit drug use. In addition to routine immunization, pregnant women with HIV should receive hepatitis B, influenza, and pneumococcal vaccines. Inactivated influenza vaccine is also strongly advised.

Clinical screening for TB should be performed at each antenatal visit by asking for history of cough, blood-stained sputum, fever, weight loss, and pleuritic pain. CD4 count should be performed.

Because of the increased risk of pneumocystis pneumonia, chemoprophylaxis with trimethoprim-sulfamethoxazole (one double-strength tablet daily) is recommended for all pregnant women with a CD4 count of <250 cells/mm³.

It is recommended that all pregnant HIV-infected women receive a combination antiretroviral drug regimen, regardless of CD4 T-lymphocyte count or plasma HIV RNA copy number, to prevent perinatal transmission. ART should be initiated by 14 weeks' gestation.

The management of pregnant women with HIV is summarized in Box 56.13.

Monitoring of I

HIV disease progression and response to antiretroviral treatment are monitored using two surrogate markers:

- CD4 T-lymphocyte (CD4) cell count
 - Defines overall immune function of an HIV-infected patient
 - Determines the urgency to initiate ART
 - Progression to AIDS signified by a count of <200 cell/mm³
- HIV RNA (viral load)
 - Marker of response to ART
 - Helps monitor effectiveness of therapy

Box 56.13 Management of pregnant women with I

- History
 - On antiretroviral therapy or not
 - Opportunistic infections
 - Candidiasis
 - TORCH infections
 - Tuberculosis
 - Medications used
 - Immunization status
 - Substance abuse
- Physical examination
 - Signs of advanced HIV infection
 - Concomitant sexually transmitted infections
- Immunizations
 - DPT and other routine vaccines in pregnancy
 - Hepatitis B, influenza, and pneumococcal vaccines
- Chemoprophylaxis for pneumocystis pneumonia
- Antiretroviral therapy to be initiated by 14 weeks' gestation

DP, diphtheria, pertussis, and tetanus; *C*, human immunodeficiency virus; *C*, Toxoplasmosis, Other (syphilis, varicella-zoster, parvovirus B19), Rubella, Cytomegalovirus (CMV), and Herpes.

ther laboratory evaluation in the pregnant patient with I

The pregnant patient with HIV should also be evaluated with the following tests:

- Hemoglobin and hematocrit (anemia is associated with increased risk of adverse pregnancy outcomes as well as increased MTCT)
- Viral load measurement (especially at 34–36 weeks to decide on mode of delivery)
- Viral hepatitis markers [hepatitis B surface antigen (HBsAg) and hepatitis C virus (HCV) antibodies]
- Screening for gestational diabetes
- Screening for sexually transmitted infections (STIs)
- Testing for tuberculosis
- Screening for genital infections

General principles of antiretroviral therapy use during pregnancy

The goals of ART are as follows:

- Treatment of maternal HIV disease
- Reduction of perinatal transmission

Antiretroviral therapy in pregnancy

The 2013 World Health Organization (WHO) recommendations for ART in pregnancy have

changed from the previous 2010 regimens. The new recommendations are given in the next subsections.

Pregnant and breastfeeding women with HIV

Two options are available (Fig. 56.2):

Option 1. Pregnant and breastfeeding women with HIV should be placed on lifelong ART regardless of CD4 count or WHO clinical stage.

Option 2. Pregnant and breastfeeding women with HIV

- With CD4 counts <500 or at clinical stage 3 or 4
 - Lifelong therapy
- With CD4 counts >500
 - ART should be initiated but stopped after delivery and completion of breastfeeding

Antiretroviral therapy regimen

The recommended ART regimen for all pregnant women including those in the first trimester and women of childbearing age is given in Box 56.14.

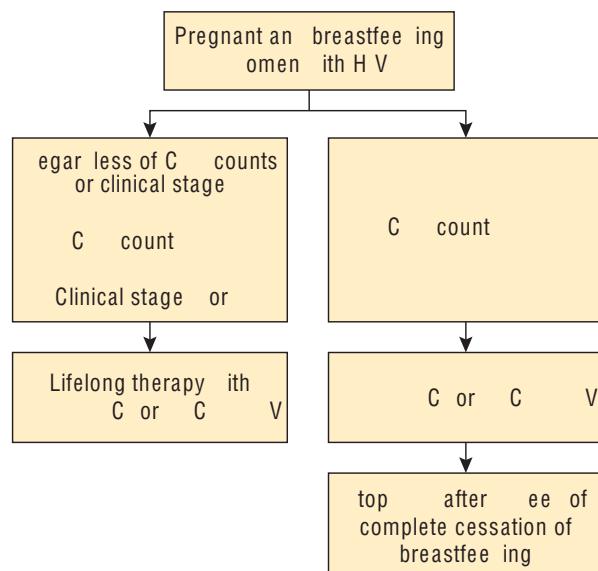


Figure 56.2 ART for pregnant and breastfeeding women with HIV. A = antiretroviral therapy; C = emtricitabine; D = tenofovir; E = efavirenz; H = human immunodeficiency virus; V = lamivudine.

Box 56.14 Antiretroviral therapy regimen in pregnant and breastfeeding women

- Once-daily combination of
 - Tenofovir (TDF) 300 mg
 - Lamivudine (3TC) 300 mg (or)
 - Emtricitabine (FTC) 200 mg
 - Efavirenz (EFV) 600 mg

- Women should be started on this regimen as soon as the diagnosis of HIV infection is made.
- ART should be initiated even if the woman presents after 36 weeks' gestation.
- Women who are HIV-infected, already receiving ART and who become pregnant should continue the same regimen throughout pregnancy, labor, and breastfeeding and lifelong thereafter.
- If the woman is diagnosed for the first time to be HIV positive during labor, the same ART should be initiated immediately. Evaluation and CD4 assessment must be performed the next day or as early as possible.

In infants

Infant prophylaxis should begin at birth or when HIV exposure is recognized postpartum (Fig. 56.3).

- Infants of mothers who are receiving ART and are breastfeeding
 - Should receive 6 weeks of infant prophylaxis with daily **nevirapine** (NVP)
- Infants receiving replacement feeding
 - Should receive 4–6 weeks of prophylaxis with daily NVP or twice-daily **zidovudine** (AZT)

Delivery in infected women

Although cesarean section should be the preferred mode of delivery in HIV-infected women, this is not practical in resource-limited regions.

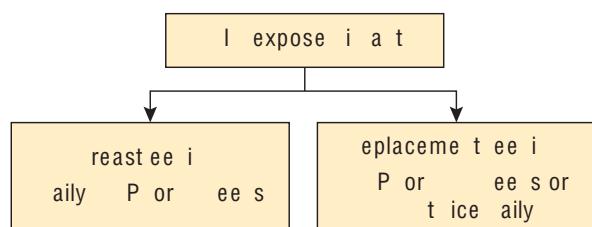


Figure 56.3 Antiretroviral therapy for HIV-exposed infants. A = zidovudine; C = human immunodeficiency virus; E = nevirapine.

- Elective cesarean section is associated with reduced rates of MTCT among women
 - Who have not received antiretroviral drugs
 - Who have received AZT alone
 - Who have not achieved viral suppression (HIV viral load >1000 copies/mL)
- In resource-limited regions
 - Vaginal delivery accepted
 - Obstetric indications for cesarean
 - Fetal scalp electrodes contraindicated
 - Amniotomy avoided unless delivery is imminent

To prevent transmission, it is mandatory that universal precautions be used by all the staff dealing with the delivery of an HIV-infected woman.

Universal or standard precautions

Universal (now referred to as standard) precautions ensure a high level of protection against transmission of infection including blood-borne viruses in the healthcare setting and are recommended for the care and treatment of all patients and in the handling of the following:

- Blood, including dried blood
- All other body substances, secretions, and excretions (excluding sweat) regardless of whether they contain visible blood
- Nonintact skin
- Mucous membranes

Universal or standard precautions are aimed at preventing transmission of blood-borne viruses (Box 56.15).

Box 56.15 Universal or standard precautions for preventing transmission of blood-borne viruses

- Personal hygiene practices
 - Particularly hand washing
- Use of personal protective equipment
 - Double gloving
 - Gowns
 - Protective eyewear
- Aseptic technique
- Safe disposal systems for
 - sharps
 - contaminated matter
- Adequate sterilization of reusable equipment
- Environmental controls

Standard precautions should be implemented universally. Although they are very important in known cases of HIV or hepatitis B, they should be implemented in all cases, to avoid transmission from a patient whose infectious status is unknown.

Breastfeeding

Avoidance of breastfeeding is a definite way to prevent HIV transmission via breast milk during the postnatal period. However, the 2010 WHO guidelines recommend exclusive breastfeeding for 6 months, in combination with maternal or infant antiretroviral prophylaxis, to minimize HIV transmission from the mother and, at the same time, optimize the benefits of breastfeeding for the infant.

Replacement feeding is recommended for infants born to HIV-infected mothers in developed countries. However, in developing countries, replacement feeding is associated with greater infant morbidity and mortality from diarrheal disease, pneumonia, and other infectious diseases.

Feeding should be either exclusive breastfeeding or exclusive replacement feeding for the first 6 months. Mixed feeding is not recommended for infants of HIV-positive mothers.

The National AIDS Control Organization guidelines and PPTCT program

The National AIDS Control Organization (NACO), under the Ministry of Health, Government of India, launched the Prevention of Parent to Child Transmission (PPTCT) of HIV program in 2001–2002. In 2012, the policy of multidrug regimen, as recommended by the WHO, has also been adopted by the PPTCT program (Box 56.16).

The PPTCT services are provided through the integrated counseling and testing centers (ICTCs). The ICTCs may be of the following types:

- *Stand-alone ICTCs*: These are located in medical colleges, district hospitals, Taluk hospitals, and community health centers.
- *Facility integrated ICTCs (F-ICTCs)*: These are located in primary health centers. The staff is trained in counseling and testing for HIV with kits provided. If a woman tests positive, she is referred to ICTCs.

Box 56.16 Goals of the PPTCT program

- Antenatal care
 - Pretest and posttest counseling
 - Offering termination of pregnancy to HIV-positive women
 - Counseling regarding safe delivery, birth planning, and infant feeding
 - Providing ART
 - Psychosocial support
 - Routine antenatal care
- Intrapartum care
- Postnatal care
 - Counseling regarding breastfeeding
 - ART for mother and infant
 - Family planning services

- *Screening centers:* Health facilities where auxiliary nurse midwives are trained in counseling and performing finger prick test. If a woman tests positive, she is referred to ICTCs.

With effect from January 1, 2014, pregnant women who are found to be HIV positive are initiated on lifelong ART, irrespective of CD4 count and WHO clinical staging. Their newborn (HIV-exposed) babies are initiated on 6 weeks of syrup NVP immediately after birth so as to prevent transmission of HIV from mother to child and this is extended to 12 weeks of syrup NVP if the duration of the ART of mother is <24 weeks.

Proto oal infections

Toxoplasmosis in pregnancy

Toxoplasma gondii is a common protozoan parasite that infects humans and is mainly acquired in childhood and adolescence. *T. gondii* infection is acquired through

- ingestion of cysts in infected, undercooked meat;
- ingestion of oocysts that may contaminate cat litter, soil, water, and food.

Raising awareness of this infection is important. Pregnant women are advised to

- avoid handling cat litter;
- wash hands after handling uncooked meats; and
- wash fruits and vegetables if consumed raw.

When the initial toxoplasmic infection occurs in pregnancy, transmission to the fetus results in congenital toxoplasmosis and associated neurological and ocular manifestations.

Presentation in pregnancy

The clinical presentation of toxoplasmosis in pregnancy is summarized in Box 56.17.

Effects on fetus

Most infected neonates have no clinical manifestations. The characteristics of congenital infection are summarized in Box 56.18.

Box 56.17 Clinical presentation of toxoplasmosis in pregnancy

- Brief febrile illness
- Usually asymptomatic
- Preconceptional disease not transmitted to fetus
 - Except in women with AIDS
- Fetus affected with primary infection in pregnancy
- Termination of pregnancy indicated with
 - Ultrasonographic evidence of fetal abnormalities
 - Intracranial calcification
 - Hydrocephalus
 - Intrahepatic calcifications
 - Hyperechoic bowel
- Risk of fetal infection increases with advancing gestational age
 - Infected at 13 weeks: Fetal infection in 15%
 - Infected at 26 weeks: Fetal infection in 45%
 - Infected at 36 weeks: Fetal infection in 70%

A DS = acquired immunodeficiency syndrome.

Box 56.18 Characteristics of congenital *T. oplasma* infection

- Classic tetrad of congenital *T. oplasma* infection includes
 - chorioretinitis
 - hydrocephalus
 - intracranial calcification
 - convulsions
- Infected infants may also exhibit
 - jaundice
 - hepatosplenomegaly
 - anemia

Diagnosis

Due to the low prevalence of the disease, routine screening of all pregnant women for toxoplasmosis is not recommended.

The diagnosis of toxoplasmosis is usually made by detection of *Toxoplasma*-specific IgG, IgM, or immunoglobulin A (IgA) antibodies. **IgM antibodies for *Toxoplasma* may persist for many years.** Therefore, IgM positivity alone may not indicate a recent infection. All three antibodies should be tested for.

Repeat testing should be performed 2–3 weeks later if acute infection is suspected.

There are several tests available that detect these immunoglobulin antibodies within several weeks of infection.

Prenatal diagnosis

When toxoplasmosis is suspected in pregnancy, due to either maternal disease or ultrasound features suggestive of toxoplasmosis, prenatal diagnostic techniques may be utilized for confirming or ruling out fetal disease. Prenatal confirmation allows decision making for drug therapy. It also allows women to decide whether they want to continue or terminate the pregnancy.

Amniotic fluid or fetal blood sampling is done after 18 weeks' gestation. PCR/DNA amplification techniques are required for confirmation of diagnosis of congenital infection.

Treatment

Spiramycin

If a woman is diagnosed as having a primary toxoplasmosis infection in pregnancy, treatment with spiramycin reduces the risk of fetal infection. It is not effective if the fetus is already infected.

Spiramycin is given as 1 g orally every 8 hours on an empty stomach. Treatment is continued till delivery.

Pyrimethamine sulfa ine and folic acid

If prenatal diagnosis confirms the presence of fetal infection, treatment with pyrimethamine, sulfadiazine, and folic acid is recommended. The treatment is continued till delivery.

Pyrimethamine (25 mg once per day orally) and sulfadiazine (4 g/day orally divided into two to four doses) are administered. Folic acid (10–25 mg/day orally) is added during pyrimethamine and sulfadiazine administration to prevent bone marrow suppression.

Malaria in pregnancy

Malaria is a major parasitic illness that has a deleterious impact on maternal health. Pregnancy reduces a woman's immunity to malaria. Pregnant women therefore

- are more likely to get malaria than men or nonpregnant women;
- have more frequent episodes of malaria;
- suffer more serious forms of malaria; and
- have a higher risk of complications.

Lack of immunity to malaria

In India, the transmission of malaria follows a pattern of unstable transmission. Transmission is seasonal and the risk of getting malaria is highest before the monsoon. This means that the majority of Indians do not develop acquired immunity and are susceptible to infection with malaria. Pregnant women with no previous immunity to malaria have a two-fold to three-fold likelihood of developing severe malarial infection as compared with nonpregnant adults living in the same area. Primigravidae are more susceptible than multigravidae.

Microbiology

Most infections are due to either *Plasmodium falciparum* or *Plasmodium vivax*, but mixed infections with more than one malarial species also occur. The main burden of malarial infection during pregnancy results from infection with *P. falciparum*. **The majority of malaria-related deaths are due to *P. falciparum*.**

Clinical features

In endemic areas, where partial immunity is common, most malarial infections in pregnant women are asymptomatic, but the mother remains at risk for anemia and the fetus is at risk for low birth weight. Nearly 60% of pregnant women presenting with malaria are anemic.

Box 56.19 Signs and symptoms of malaria in pregnancy

- Fever associated with
 - headache
 - myalgia
 - sweats and rigors
 - nausea and vomiting
 - diarrhea
- Examination may reveal
 - pyrexia
 - perspiration
 - pallor/jaundice
 - splenomegaly
 - respiratory distress
- Falciparum malaria may be associated with
 - confusion
 - coma
 - neurological focal signs
 - severe anemia
 - respiratory difficulties

If a pregnant woman presents with a flu-like illness, a high index of suspicion for malaria is important in an endemic area or with history of recent travel to an endemic area. The signs and symptoms of malaria are summarized in Box 56.19.

Effects of malaria on pregnancy

The effects of malaria on pregnancy are listed in Box 56.20.

Diagnosis

Microscopic diagnosis allows species identification and estimation of parasitemia, so that appropriate antimalarials can be prescribed.

Box 56.20 Adverse effects of severe malarial infection

- Systemic infection may result in
 - miscarriage
 - premature birth
 - stillbirth
 - maternal and fetal mortality
- Parasitemia may result in
 - severe maternal and fetal anemia
 - fetal growth restriction and low birth weight
 - susceptibility of infant to malaria
- Placental malaria
 - Occurs with *P. falciparum*
 - Poor pregnancy outcome due to damage to villi

- Rapid detection tests may miss low parasitemia, which is more likely in pregnant women, and rapid detection tests are relatively insensitive in *P. vivax* malaria.
- In a febrile patient, three negative malaria smears 12–24 hours apart rule out the diagnosis of malaria.

Prevention and management of malaria in pregnancy

A simple approach to malaria prevention and treatment should follow four steps which are mentioned in Box 56.21.

treatment

Malaria in pregnancy is an emergency and treatment should be initiated immediately.

- Pregnant women with uncomplicated malaria should be hospitalized.
- Pregnant women with severe and complicated malaria may require admission to an intensive care unit.
- *P. vivax*, *P. ovale*, or *P. malariae*
 - Chloroquine
- Uncomplicated *P. falciparum* (or mixed, e.g., *P. falciparum* and *P. vivax*)
 - First trimester
 - Quinine
 - Second and third trimesters
 - Artemisinin combination therapy
- Severe falciparum malaria
 - Intravenous artesunate treatment of choice
 - Intravenous quinine if artesunate not available
- **Primaquine should not be used in pregnancy.**
- Fever
 - Treated with antipyretics
- Screen women with malaria for anemia and treat appropriately.

The recommendations of the Government of India for the treatment of malaria in pregnancy are listed in Table 56.4.

Box 56.21 The ABCD approach to malaria in pregnancy

- Awareness of risk
- Insect prevention using insecticide-treated nets (ITNs)
- Chemoprophylaxis
- Diagnosis and treatment that must be prompt

Table 56.4 Recommendations of Government of India for treatment of malaria in pregnancy

Type of infection	Trimester	Drug	Day 1	Day 2	Day 3
<i>Plasmodium vivax</i>	All	10 mg/kg chloroquine	4 tablets	4 tablets	2 tablets
<i>Plasmodium falciparum</i>	First	10 mg/kg quinine	3 times/day × 7 days		
	Second and third	50 mg artesunate orally or 500 mg sulfadoxine + 25 mg pyrimethamine	4 tablets 3 tablets	4 tablets 0	4 tablets
Severe <i>P. falciparum</i>	All	2.4 mg/kg artesunate IV or 20 mg/kg quinine Maintenance dose: 10 mg/kg	0, 12, and 24 hours, and then daily thereafter	On admission	
				8-Hourly	

Primaquine should not be prescribed in pregnancy.

Congenital malaria

Vertical transmission to the fetus can occur particularly when there is infection at the time of birth and the placenta and cord are blood film positive for malaria. Infection of the newborn can occur despite appropriate treatment in the mother during pregnancy. If the placenta is positive for parasites, weekly screening of the newborn for 28 days is useful to allow early detection and treatment of congenital malaria.

likelihood of progression from latent infection to active disease. Fortunately pregnancy does not impact the response to treatment.

Pulmonary TB with respiratory symptoms is more common in pregnancy. Pregnant patients with pulmonary TB

- have the same clinical manifestations as non-pregnant patients and
- may have delay in diagnosis because
 - malaise and fatigue may be attributed to pregnancy and
 - weight loss may be difficult to recognize.

Extrapulmonary TB may have vague symptoms and diagnosis may be delayed in pregnancy.

Bacterial infections

Tuberculosis in pregnancy

In India tuberculosis (TB) continues to be a major public health issue despite a global fall in the incidence of TB. India accounts for one-fifth of the global TB burden. Each year nearly 2 million people in India develop TB, of which approximately 0.87 million are infectious cases. It is estimated that approximately 330,000 Indians die due to TB every year.

Tuberculosis is a significant contributor to maternal mortality, with the disease being among the three leading causes of death among women aged 15–45 years.

Signs and symptoms

Pregnancy does not negatively influence the pathogenesis of TB nor does it increase the

Diagnosis

The diagnosis and confirmation of infection may require a combination of diagnostic tests.

- The tuberculin skin test (Mantoux) is considered both valid and safe to use throughout pregnancy but may not be useful in countries like India where prior exposure rate is high.
- X-rays are useful in making a diagnosis and should not be avoided due to pregnancy.
- Sputum examination for acid-fast bacilli (AFB) is useful.
- Although a culture may take 4–6 weeks to obtain a result, it is still useful in the management of multidrug-resistant TB.
- Lymph node biopsy may be required in women with extrapulmonary TB.

Effect of tuberculosis on pregnancy

Maternal TB has been shown to have an increased association with the risk of the following:

- Spontaneous abortion
- Perinatal mortality
- Small for gestational age and low birth weight

Tuberculosis and the newborn

Congenital TB is a rare complication of in utero TB infection. It occurs by placental hematogenous transmission or by ingestion and aspiration of infected amniotic fluid.

The newborn infant is at a higher risk of postnatal infection due to exposure to the mother's aerosolized respiratory secretions.

Treatment

Antituberculous drugs should not be withheld from a woman because of pregnancy. Untreated TB disease is a greater threat to a pregnant woman and the fetus than its treatment.

Pregnant women should be started on treatment as soon as TB is suspected. The preferred treatment regimen is summarized in Box 56.22.

Multidrug-resistant TB poses a special problem since the safety of the second line of drugs is not established in pregnancy. Elective abortion

Box 56.22 Treatment regimen for tuberculosis in pregnancy

- | | | |
|---|--|--|
| <ul style="list-style-type: none"> • Isoniazid (INH) • Rifampicin (RIF) • Ethambutol (EMB) • Pyrazinamide (PZA) | <div style="border-left: 1px solid black; padding-left: 5px; margin-right: 10px;">Followed by</div> <ul style="list-style-type: none"> • INH and RIF daily (or twice weekly) for 4 months | <div style="border-left: 1px solid black; padding-left: 5px; margin-right: 10px;">For 2 months</div> |
|---|--|--|

has been suggested in women undergoing treatment for multidrug-resistant TB.

Prophylactic pyridoxine in the dose of 10 mg/day is recommended along with antituberculosis treatment (ATT).

Treatment of tuberculosis in lactating women

Breastfeeding can be continued in women receiving first-line ATT drugs. The drugs should be taken preferably after breastfeeding and the next feed could be a bottlefeed.

Supplemental pyridoxine should be administered to an infant on isoniazid (INH) or if the breastfeeding mother is taking INH because pyridoxine deficiency may cause seizures in the newborn.

Follow-up of the newborn infant

The follow-up of the newborn infant is summarized in Box 56.23.

Box 56.23 Follow-up of the newborn infant of a mother with tuberculosis

- Mother sputum positive
 - Infant evaluated for active tuberculosis
 - Chest X-ray
 - Examination of gastric aspirate
 - Sputum for AFB
 - Infant shows no evidence of active tuberculosis
 - INH prophylaxis for 3 months till
 - mother's sputum becomes negative for AFB
 - infant is tuberculin negative
 - Infant tuberculin positive
 - INH prophylaxis for 6 months
 - Active tuberculosis ruled out
 - infant does not have active or latent infection
 - Routine BCG vaccination

A *B* acid-fast bacilli; *BC*, *Bacillus Calmette-Guérin*; INH, isoniazid.

Key points

- Infections in pregnancy are a complex issue because the embryo and fetus are vulnerable, right from conception through the time of delivery.
- Transmission of maternal infection to the fetus or newborn can occur by hematogenous spread, through the transplacental route, as an ascending infection from the lower genital tract or through breastfeeding.

- Two types of antibodies may be produced in response to an infection—immunoglobulin M (IgM) antibodies indicate acute phase of infection. Immunoglobulin G (IgG) antibodies indicate lifelong immunity.
- Parvovirus B19 infection is a respiratory illness that may be associated with a febrile illness, rash, and arthralgia in the mother. It can cause nonimmune hydrops in the fetus.

(Continued)

Key points *Continued*

- Genital herpes simplex virus (HSV) infection is common among women of childbearing age. During pregnancy, the major concern is transmission of maternal HSV infection to the fetus, as neonatal infection can result in serious morbidity and mortality.
- Neonatal HSV is a serious condition. It can be due to direct contact with virus during vaginal delivery, postpartum HSV transmission to the neonate by not following proper hand washing, and very rarely due to vertical transmission by transplacental or ascending transmembranous infection.
- Cytomegalovirus is a commonly occurring DNA herpes virus that presents with a wide variety of clinical manifestations. Infection of the fetus is a common cause of sensorineural hearing loss and mental disability.
- Rubella is an RNA virus, transmitted through respiratory droplets. Although rubella is a mild infection in older children and adults, it can have potentially devastating effects on the developing fetus.
- Congenital infection with rubella can affect almost all organs of the fetus. Sensorineural hearing loss and cataracts are the most common defects. Maternal infection after 16 weeks is associated with the least number of congenital defects.
- Varicella-zoster virus (VZV) infection causes two clinically distinct forms of disease: varicella (chicken pox) and herpes zoster (shingles).
- Primary VZV infection results in the diffuse vesicular rash of chicken pox. Primary infection with VZV during pregnancy has significant implications for maternal and fetal health.
- Congenital varicella syndrome is an extremely rare disorder in which affected infants have distinctive abnormalities at birth due to maternal infection up to 20 weeks' gestation.
- The human immunodeficiency virus (HIV) is a lentivirus (a subgroup of retrovirus) that causes the acquired immunodeficiency syndrome (AIDS).
- All pregnant women should undergo HIV screening early in each pregnancy.
- Repeat testing in the third trimester is recommended for those who are at high risk of infection.
- Women who present in labor without prior HIV testing should undergo rapid HIV testing.
- Management of HIV successfully in pregnancy hinges on universal testing of pregnant women for HIV infection; use of antiretroviral therapy to prevent vertical transmission; use of cesarean section, when appropriate; and avoidance of breastfeeding, when feasible.
- The goals of antiretroviral therapy in pregnancy are treatment of maternal HIV disease and reduction of perinatal transmission.
- *o oplasma gondii* is a common protozoan parasite that infects humans.
- When the initial toxoplasmodic infection occurs in pregnancy, transmission to the fetus results in congenital toxoplasmosis and associated neurological and ocular manifestations.
- Malaria is a major parasitic illness that has a deleterious impact on maternal health. Pregnancy reduces a woman's immunity to malaria.
- Malaria in pregnancy is an emergency. Pregnant women with uncomplicated malaria should be hospitalized. Pregnant women with severe and complicated malaria may require admission to an intensive care unit.
- In India, tuberculosis continues to be a major public health issue despite a global fall in the incidence of tuberculosis.
- Tuberculosis is a significant contributor to maternal mortality, with the disease being among the three leading causes of death among women aged 15–45 years.

Self-Assessment

Case-based questions

Case 1

Mrs. BG, 36, pregnant for the first time, presents at the antenatal clinic with a few clear vesicles on her face and abdomen. Her 6-year-old nephew is just recovering from chicken pox.

1. What is the treatment for chicken pox in pregnancy?
2. What is the major maternal complication of chicken pox?
3. What is the congenital varicella syndrome?
4. What is postexposure prophylaxis?

Case 2

Mrs. EL, 31, gravida 3, para 2, live 2, is in her 12th week of pregnancy and has come for her first booking visit. One week later her HIV test is reported as positive. She is devastated.

1. How will you treat her to prevent MTCT?
2. What infant prophylaxis should be administered at birth?
3. What would be the optimal route of delivery?
4. What is the recommendation for breastfeeding?

Answers

Case 1

1. All pregnant women with uncomplicated varicella should be treated with oral acyclovir 800 mg five times a day for 5–7 days, and treatment should be started within 24 hours of the onset of the rash.
2. Varicella pneumonia during pregnancy is a medical emergency with a high mortality rate. It is treated with intravenous acyclovir 10 mg/kg every 8 hours.
3. Congenital varicella syndrome is an extremely rare disorder in which affected infants have distinctive abnormalities at birth. Affected newborns may have a low birth weight and limb deformity, microcephaly, hydrocephalus, and soft-tissue calcification.
4. A pregnant woman who has never had chicken pox but is exposed to an active case should be offered postexposure prophylaxis with VZIG. This reduces the risk of varicella infection and also reduces the severity of infection in those who develop chicken pox.

Case 2

1. Blood tests for baseline CD4 and viral load and start on once-daily fixed-dose combination of TDF + 3TC (or FTC) + EFV.
2. Infant prophylaxis should begin at birth. Infants of mothers who are receiving ART and are breastfeeding should receive 6 weeks of infant prophylaxis with daily NVP. Infants receiving replacement feeding

should receive 4–6 weeks of prophylaxis with daily NVP (or twice-daily AZT).

3. Elective cesarean section is associated with reduced rates of MTCT.
4. Avoidance of breastfeeding is a definite way to prevent HIV transmission via breast milk during the postnatal period. However, the 2010 WHO guidelines recommend exclusive breastfeeding for 6 months, in combination with maternal or infant antiretroviral prophylaxis, to minimize HIV transmission from the mother and, at the same time, optimize the benefits of breastfeeding for the infant.

Sample questions

Long-answer questions

1. Describe the effects of HIV on the fetus. How is MTCT prevented?
2. Discuss the management of a pregnant woman who has a positive screening test for HIV.

Short-answer questions

1. Universal precaution to be observed for HIV patient at delivery
2. Management of malaria in pregnancy
3. Fetal effects of maternal rubella
4. PPTCT services
5. Varicella infection in pregnancy
6. Tuberculosis in pregnancy

57

Benign and Malignant Tumors of the Reproductive Tract

Case scenario

Mrs. HN, 32, third gravida, wife of a construction worker, was referred to the hospital at 11 weeks of gestation with a history of blood-stained vaginal discharge and a friable growth on the cervix. She was suspected to have cervical cancer and was referred for further management. She had two living children aged 7 and 4 years, and the woman and her husband were very worried and upset by the diagnosis of 'cancer'

Introduction

Benign and malignant tumors of the genital tract and also other malignancies can occur in pregnancy. Diagnosis of malignancy at any time in life is terrifying, more so during pregnancy. Pregnant women are usually young and may have other small children to take care of. Diagnosis and management of any neoplasm and particularly cancer at this time should take into account the mother and the unborn child. Management decisions should be discussed with the woman and her family and taken in consultation with a neonatologist, oncologist, and psychologist.

Benign neoplasms in pregnancy

The benign neoplasms of the genital tract that may be encountered in pregnancy are listed in Box 57.1.

Benign neoplasms of the cervix

Cervical polyp

Cervical polyps arise from the endocervix and may be asymptomatic but usually present with irregular bleeding or spotting. They can be

Box 57.1 Benign neoplasms of the genital tract in pregnancy

- Cervix
 - Polyp
- Uterus
 - Leiomyoma
 - Adenomyoma/adenomyosis
- Ovary
 - Functional cysts
- Corpus luteum cysts
- Theca lutein cysts
 - Luteomas
 - Dermoid cyst
 - Epithelial tumors

twisted off if the pedicle is slender. Thick pedicles must be ligated and the polyp excised. The procedure should be done cautiously because of the increased risk of bleeding due to the vascularity of pregnancy.

Benign neoplasm of the uterus uterine leiomyoma

The incidence of leiomyoma in pregnancy is approximately 2%. Myomas may be intramural, subserous, submucous, cervical, or located in the broad ligament. They can increase in size in pregnancy due to high levels of estrogens. They may outgrow their blood supply and undergo red degeneration, which is unique to pregnancy.

Symptoms

Small myomas are asymptomatic. The woman may complain of a sensation of pelvic pressure or may present with acute or chronic pain.

Red degeneration

Red degeneration of myoma presents with acute pain, low-grade fever, tenderness, and leucocytosis. The condition must be differentiated from appendicitis, pyelonephritis, and ureteric colic. The uterus is tender. The pain may last for 1 week or more. Treatment is with analgesics. Surgery is not indicated. Red degeneration is also known to occur with the use of combined oral contraceptive pills.

Complications

Myomas in pregnancy can be associated with the complications listed in Box 57.2. The size of the myoma, location, and implantation of the placenta over the myoma are important contributing factors. Large myomas that occupy the lower segment cause malpresentations and may also impede engagement of the fetal head. Placental implantation over the myoma can lead to miscarriage, placental abruption, adherent placenta, and postpartum hemorrhage. Submucous myomas may get infected postpartum.

Diagnosis and management

Most myomas are diagnosed on routine ultrasonography. If the uterus appears larger than gestational age or irregular, ultrasonography should be performed (Fig. 57.1).

Management is conservative. Even when myomas are encountered at a cesarean section, myomectomy is not indicated since troublesome bleeding can occur. Exceptions to this rule are pedunculated subserous myomas and myomas located in the lower segment, in the line of or close to the incision.

Adenomyoma adenomyosis

Although adenomyosis is usually seen in perimenopausal, multiparous women, adenomyomas can occur in young women. They are asymptomatic during pregnancy. Rarely, placenta previa, atonic hemorrhage, and uterine rupture have been reported. Adenomyosis and adenomyoma are managed conservatively.

Box 57.2 Complications of myomas in pregnancy

- Spontaneous miscarriage
- Preterm labor
- Malpresentations
- Placental abruption
- Obstructed labor
- Cesarean section
- Adherent placenta
- Postpartum hemorrhage
- Puerperal sepsis

Benign neoplasms of the ovary

In the preultrasonography era, the incidence of ovarian neoplasms in pregnancy was 1 in 2000. With routine ultrasonography and an increase in early detection, the incidence has increased to 2.2%. The majority are benign tumors.

Functional cysts

Functional cysts are usually due to hormonal changes that occur with normal pregnancy or the high hCG levels in hydatidiform mole.

Corpus luteum cysts

Corpus luteum cysts are multiloculated cysts that arise from the corpus luteum and often go unnoticed. They are <10 cm in size, pink or hemorrhagic in appearance. They resolve spontaneously but may occasionally rupture. The features of corpus luteum cysts are given in Box 57.3.

Theca lutein cysts

Theca lutein cysts are the result of stimulation by human chorionic gonadotropin (hCG) and occur in conditions with high levels of hCG. They are most common in molar pregnancy but may be seen in multiple pregnancy, Rh isoimmunization, and gestational diabetes. The characteristics of theca lutein cysts are given in Box 57.4.

Box 57.3 Corpus luteum cysts

- <10 cm in size
- Pink/hemorrhagic
- Asymptomatic
- Regress spontaneously

Box 57.4 Theca lutein cysts

- Bilateral
- Grayish, filled with straw-colored fluid
- Occur with elevated hCG
 - Molar pregnancy
 - Multiple pregnancy
 - Rh isoimmunization
 - Gestational diabetes
- Asymptomatic
- Occasionally undergo torsion/rupture
- Regress spontaneously
- Managed conservatively

Luteoma of pregnancy

Luteomas of pregnancy are bilateral solid tumors that occur rarely in pregnancy and secrete progesterone and testosterone. The tumors are 6–10 cm in size. They are usually asymptomatic, but 25% of tumors present with maternal virilization and virilization of the female fetus. If diagnosed antenatally and the fetus is female, removal of the tumor is recommended. Large tumors may also necessitate removal. Smaller luteomas normally regress spontaneously after delivery (Box 57.5).

Cystic teratoma

Cystic teratomas are the most common tumors that present in pregnancy. They are cystic, contain elements from all three germ cell layers, and are filled with fat. They are often found in the pouch of Douglas. They can undergo torsion or rupture, or, rarely, obstruct labor.

Epithelial tumors

The common epithelial tumors such as serous and mucinous cystadenomas, endometrioid tumor, and Brenner tumor can occur in pregnancy. The size may vary from small to very large tumors. Small tumors are asymptomatic, but large tumors present with mass or abdominal pain. They can undergo torsion or rupture and occasionally obstruct labor. Malignancy has to be excluded before conservative management is decided upon. Tumors of low malignant potential may also occur.

Complications of benign ovarian tumors in pregnancy

Most benign tumors are asymptomatic and regress spontaneously. When the ovarian tumor is persistent, the enlarging uterus pushes it into

Box 57.5 Luteoma of pregnancy

- Bilateral, solid tumors
- Secrete progesterone/testosterone
- Regress spontaneously postpartum
- Usually asymptomatic
- Can cause virilization of mother/female fetus
- Managed conservatively
- Surgical removal if large/complicated

the abdomen after 12–14 weeks. They may occasionally be wedged posteriorly and obstruct labor (Box 57.6). Rarely, malpresentations occur. If there is torsion, it usually occurs in the second trimester or in the puerperium, when the tumors are freely mobile in the abdomen.

Diagnosis and management

Most benign tumors are diagnosed on routine ultrasonography in the first or second trimester. Sonographic features of malignancy such as solid areas, complex nature of the cyst, papillary excrescences, and increased septal and cyst wall thickness should be looked for (Fig. 57.2).

Management is usually conservative since most functional cysts regress by the second trimester. When masses are larger than 5–6 cm or persistent after 18 weeks, the risk of complications is higher. When there is suspicion of malignancy or a complication such as torsion, hemorrhage or rupture, immediate surgery is indicated irrespective of gestational age.

- All other ovarian tumors should be followed up till 18–20 weeks. Most cysts regress by this gestational age, and if surgery is indicated, it is best performed in the second trimester.
- Persistent cysts with benign features and <8 cm in size may be followed up or aspirated under ultrasound guidance.
- Dermoid cysts can be left alone and removed postpartum.
- Complex masses, large tumors >8 cm, and tumors that continue to increase in size should be removed laparoscopically or by laparotomy.

Management of benign ovarian tumors in pregnancy is shown in Figure 57.1.

Box 57.6 Complications of benign ovarian tumors

- Torsion
 - Second trimester
 - Puerperium
- Hemorrhage
- Rupture
- Malpresentations
- Obstruction to descent of fetal head

Malignancies in pregnancy

Malignancy occurs in 1/1000 pregnancies. Delay in diagnosis is common since many of the symptoms of malignancy overlap with symptoms of normal pregnancy and the large size of the uterus makes physical examination difficult.

Cancers in pregnancy may be cancers of the genital tract or other cancers. The common nongenital tract cancers that occur in the reproductive age are thyroid cancer, leukemia, and lymphoma.

Special considerations

Diagnosis and management of cancer in pregnancy has to take into account certain special considerations which are as follows:

- Clinical assessment is difficult.
- Staging is affected by the uterine size.
- Evaluation modalities such as computed tomography (CT) scan and X-rays with contrast studies can affect the fetus.
- Surgery and anesthesia may carry increased risk to the mother.
- Pregnancy can affect the course of hormone-sensitive cancers.
- Treatment modalities such as chemotherapy and radiotherapy can affect the fetus.
- Termination of pregnancy has to be given due consideration.
- Deferring therapy till delivery may adversely affect the prognosis.

Gynecologic malignancies

Cervical and breast cancers are the most common gynecologic cancers in pregnancy. Ovarian cancers are less frequent (Box 57.7). Cancers of the vulva and fallopian tube are rare.

Diagnosis of cancers in pregnancy

Imaging

Ultrasonography is safe and is the preferred mode of evaluation. Most radiological procedures such as chest or abdominal radiograph result in exposure of <0.05 Gy, which is safe in pregnancy. Magnetic resonance imaging is

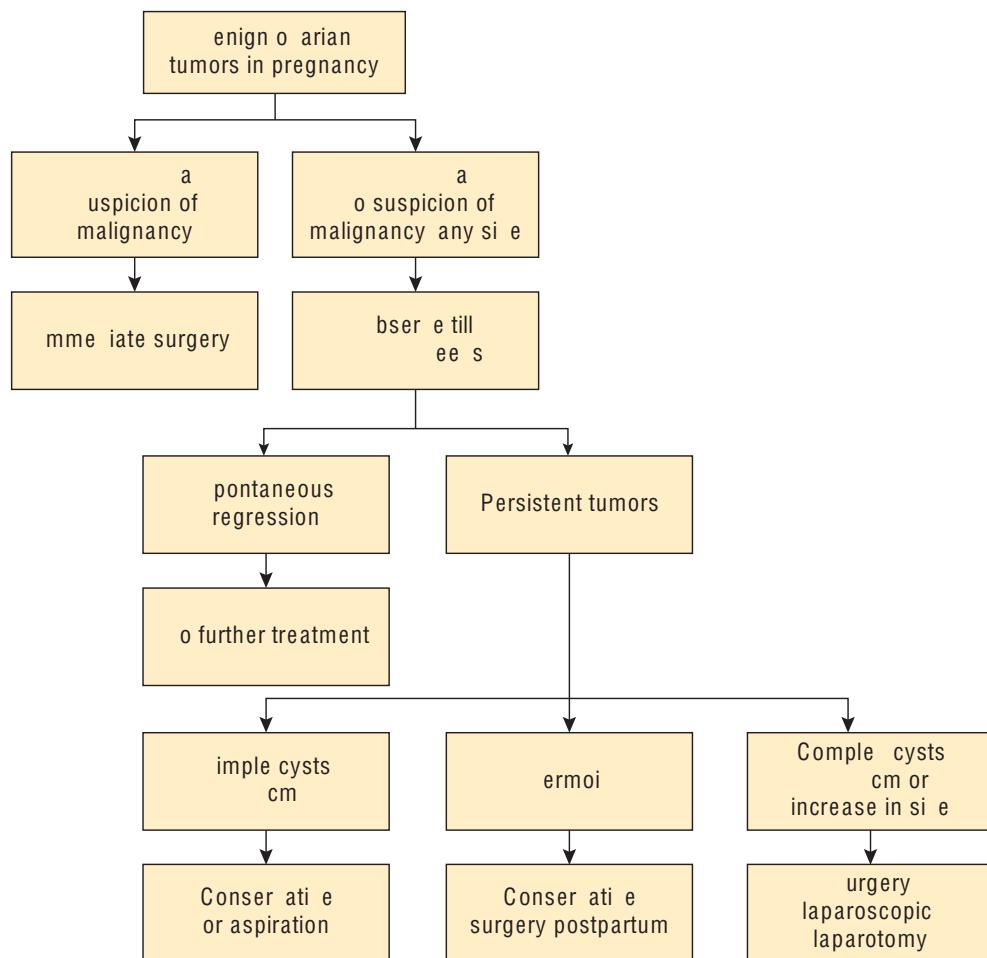


Figure 57.1 Management of benign ovarian tumors in pregnancy.

Box 57.7 Incidence of gynecologic malignancies in pregnancy

Cervical intraepithelial neoplasia	1.3/1000
Invasive cervical cancer	1/1000
Ovarian cancer	0.1/1000
Breast cancer	0.33/1000

found in higher than normal levels during fetal development, differentiation, and maturation. Their levels vary with gestational age. They cannot, therefore, be used for the diagnosis of ovarian tumors in pregnancy (Box 57.8).

Box 57.8 Diagnostic tests for cancers in pregnancy

- Ultrasonography: Safe, recommended mode of imaging
- CT scan: Benefits outweigh the risks
- MRI: Considered safe
- Radiography: Limited radiation, safe
- Tumor markers
 - Levels elevated in pregnancy
 - Vary with gestation
 - Cannot be used

preferred over CT scan, though CT scan may be used if the benefits outweigh the risks in this situation.

Tumor markers

Levels of tumor markers such as CA 125, serum alpha fetoprotein, b hCG, and inhibin A are

Management of cancers in pregnancy

Management of malignancies in pregnancy has to take into account the fetus as well. Termination of pregnancy may be desirable in some situations to safeguard the mother. Treatment may have to be modified and some treatments deferred till delivery. All these issues have to be discussed with the woman and her partner and decisions must be made with their concurrence.

Surgery

The best time to perform surgery is the second trimester. The risk of miscarriage and preterm labor is less. Lateral tilt is required to relieve the pressure of the gravid uterus on the vena cava. Anesthesia is safe in pregnancy.

Radiotherapy

Exposure to radiotherapy has several adverse effects on the fetus. Exposure in early pregnancy may result in fetal death or congenital malformations. Later in gestation, the effects include carcinogenesis, neurodevelopmental abnormalities, mental retardation, growth restriction, and skeletal and ophthalmic abnormalities. Leukemia and other childhood tumors may also occur later. The effects are dose related. Radiotherapy is, therefore, contraindicated in pregnancy. If considered mandatory, pregnancy should be terminated.

Chemotherapy

All chemotherapeutic drugs are theoretically teratogenic and mutagenic, especially in the first trimester. Congenital malformations, spontaneous miscarriage, mental retardation, and fetal growth restriction result from exposure to chemotherapy. Hence, chemotherapy is contraindicated in the first trimester of pregnancy. After the period of organogenesis, there may be no adverse effects; therefore, exposure to chemotherapy in the second and third trimesters is considered safe (Box 57.9). Administration within 3 weeks of expected delivery or after 35 weeks' gestation can cause neonatal myelosuppression. Moreover, suppression of the maternal bone marrow during labor and delivery

Box 57.9 Radiotherapy and chemotherapy in pregnancy

- Radiotherapy
 - First trimester—fetal death/congenital malformations
 - Second and third trimesters
 - Neurodevelopmental abnormalities
 - Carcinogenesis
 - Fetal growth disorders
 - Contraindicated in pregnancy
- Chemotherapeutic drugs
 - Teratogenic and mutagenic
 - First trimester
 - Spontaneous miscarriage
 - Congenital malformations
 - Mental retardation
 - Second and third trimesters
 - No adverse effects
 - Considered safe
 - After 35 weeks or within 3 weeks of expected delivery
 - Neonatal myelosuppression
 - Maternal myelosuppression during delivery
 - Sepsis
 - Hemorrhage
 - Death

increases the risk of fatal sepsis, hemorrhage, and death.

Cervical intraepithelial neoplasia

Cervical intraepithelial neoplasia (CIN) is often encountered in pregnancy. When abnormal cytological findings are reported, further evaluation is necessary for making a final diagnosis.

Abnormal cytology in pregnancy

Cervical cytology if done during pregnancy may reveal an abnormality. The abnormality may involve squamous or glandular cells. HPV testing must be performed, if available, in all women with atypical squamous cells of undetermined significance (ASC-US). Further evaluation of ASC-US and low-grade squamous intraepithelial lesion (LSIL) is by a repeat smear after delivery or immediate colposcopy and biopsy depends on the severity of abnormality and HPV positivity (Box 57.10).

Box 57.10 Evaluation of abnormal cytology in pregnancy

- ASC-US: HPV negative/unknown—repeat cytology 6 weeks postpartum
 - ASC-US: } HPV positive—colposcopy 6 weeks postpartum
 - LSIL }
 - ASC-H/AGC
 - HSIL
 - Squamous cell carcinoma
 - Adenocarcinoma in situ
 - Adenocarcinoma }
- Immediate colposcopy and biopsy

A C, atypical glandular cells; ASC- atypical squamous cells that cannot exclude HSIL; ASC- S atypical squamous cells of undetermined significance; P human papilloma virus; S high-grade squamous intraepithelial lesion; S low-grade squamous epithelial lesion.

Colposcopy and biopsy

Colposcopy and biopsy are indicated when high-grade squamous intraepithelial lesions (HSIL) or glandular lesions are reported on cytology.

- Colposcopy is made easier in pregnancy due to eversion of the cervix and visibility of the transformation zone. The eversion increases further as pregnancy advances. Directed biopsy can be taken to confirm the diagnosis, from areas suspected to have cervical intraepithelial neoplasia(CIN) II/III or invasive cancer.

Colposcopic interpretation in pregnancy is difficult due to increased vascularity and pregnancy-related changes in the cervix.

- Endocervical curettage should not be performed during pregnancy.
- Cervical biopsy may be associated with bleeding but can be controlled with packing.

Histological diagnosis of CI

Cervical biopsy may confirm CIN. When histological diagnosis of CIN has been made, most cases can be reevaluated after delivery and treated.

- Many CIN lesions regress after delivery; therefore, it is acceptable to defer treatment of CIN till 6 weeks postpartum.

- A repeat colposcopy should be performed 6 weeks postpartum before proceeding with treatment since 70% of CIN may resolve.
- Cone biopsy and loop electrosurgical excision procedure (LEEP) should be avoided unless microinvasive or invasive cancer is suspected. These procedures are associated with the risk of hemorrhage, infection, preterm labor, and preterm prelabor rupture of membranes. If considered mandatory, they should be performed at 14–20 weeks. For a cone biopsy, the cone should be shallow, away from the internal os.
- Women with CIN can be delivered vaginally.
- Microinvasive carcinoma diagnosed by cone biopsy, with cone margins free should be delivered vaginally and definitive surgery performed 6 weeks postpartum.
- Invasive cancer diagnosed on biopsy or conization should be managed according to stage and gestational age.

Management of CIN in pregnancy is summarized in Figure 57.2.

Invasive cervical cancer

Cervical cancer is the most common malignancy in pregnancy. Most cervical cancers in pregnancy are early stage disease probably because advanced disease is symptomatic before pregnancy and also interferes with conception.

Clinical features and diagnosis

Most women with stage IA disease are asymptomatic. When an obvious growth is present as in stage IB or greater, irregular bleeding or blood-stained vaginal discharge can occur. Diagnosis is by clinical examination. Clinical features and diagnosis are listed in Box 57.11.

Management

Microinvasive cancer (stage IA1) with free cone margins can be delivered vaginally at term and total hysterectomy performed 6 weeks postpartum.

- Management of invasive cancer depends on gestational age and stage of the disease.

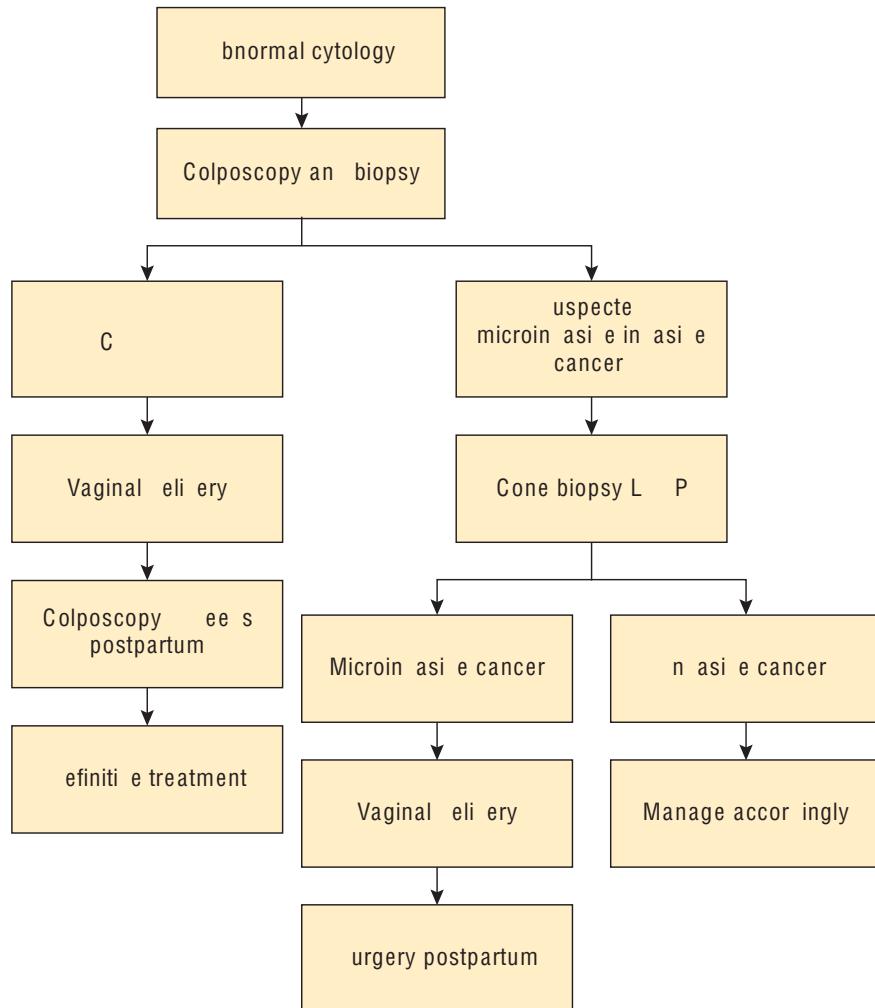


Figure 57.2 Management of cervical intraepithelial neoplasia in pregnancy. CIN, cervical intraepithelial neoplasia; L.P., loop electrosurgical excision procedure.

Early stage disease (stages IA1 and IIA)

Management of early stage disease (stages IA2, IB, and IIA) depends on gestational age as discussed below (Fig. 57.3a).

- If gestational age is <20 weeks, radical hysterectomy and pelvic lymphadenectomy should be performed. This may be performed with the fetus in utero.
- If gestational age is 20–34 weeks, the options are as follows:
 - Wait until 34 weeks, deliver by a cesarean section, and proceed with radical surgery.
 - Administer two to three cycles of neoadjuvant chemotherapy with cisplatin and

paclitaxel, deliver by cesarean section at 34 weeks, and proceed with radical surgery.

- If gestational age is >34 weeks, delivery by classical cesarean section and radical surgery are recommended.

Locally advanced disease (stages II and III)

Management of locally advanced disease (stages IIB and III) also depends on gestational age, as discussed below (Fig. 57.3b).

- If gestational age is <20 weeks, external radiation should be administered first. Spontaneous abortion occurs within 2–5 weeks in most women in the first trimester. Women in the

Box 57.11 Clinical features and diagnosis of invasive cervical cancer

- Symptoms
 - Asymptomatic
 - Irregular bleeding
 - Vaginal discharge
- Diagnosis and staging
 - Speculum examination
 - Bimanual pelvic examination
 - Rectal examination
- Further evaluation
 - Chest X-ray
 - Ultrasonography
 - Liver
 - Urinary tract
 - MRI
 - In advanced disease
 - Size of the tumor
 - Parametrial involvement
 - Liver metastasis
 - Hydronephrosis

late first or second trimesters may need evacuation of the uterus. This is followed by brachytherapy.

- If gestational age is 20–34 weeks, the options are
 - Perform immediate hysterotomy/cesarean section followed by a combination of radiation and chemotherapy (chemoradiation).
 - Administer neoadjuvant chemotherapy with cisplatin and paclitaxel, and deliver by a cesarean section at 34 weeks followed by radiotherapy.
- If gestational age is >34 weeks, classical cesarean section followed by chemoradiation as per protocol is recommended.

Metastatic disease

Women with metastatic disease should be treated as would the nonpregnant woman, since waiting is not an option. Delivery of the fetus by hysterotomy or cesarean section, chemotherapy for metastatic disease, and palliative radiation for local disease control are the usual modalities of management.

Treatment of invasive cervical cancer in pregnancy is summarized in Figure 57.3.

Mode of delivery

Vaginal delivery does not worsen the prognosis in stage IA1 or IA2 disease. However, prognosis may be altered in larger tumors of stage IB or more. In labor, cervical tears and spread of tumor and hemorrhage may occur. Episiotomy must be avoided since tumor recurrence at this site has been reported.

Classical cesarean is recommended since an incision on the lower segment may cut through tumor and cause excessive bleeding.

varian cancer

Ovarian cancers that occur in pregnancy are usually early stage tumors. Germ cell tumors are more common than epithelial tumors.

Clinical features and diagnosis

Most ovarian tumors are asymptomatic and diagnosed on routine ultrasound scan. Occasionally they may present with torsion. Ultrasonographic features may suggest the diagnosis of malignancy. Tumor markers may not be of use as discussed earlier.

Management

Immediate laparotomy is recommended in all women suspected to have malignant ovarian tumors, irrespective of gestational age.

Germ cell tumors

Most germ cell tumors in pregnancy are limited to one ovary. At laparotomy, unilateral or bilateral oophorectomy should be performed. Surgical exploration, lymphadenectomy, omentectomy, and staging should be performed as in the nonpregnant woman. In women with advanced disease in early pregnancy, termination should be considered since chemotherapy cannot be delayed till the second trimester.

Adjuvant chemotherapy is required for all except stage IA dysgerminoma. A combination of bleomycin, etoposide, and cisplatin is used. Chemotherapy can be administered in the second and third trimester and the pregnancy may be continued till term.

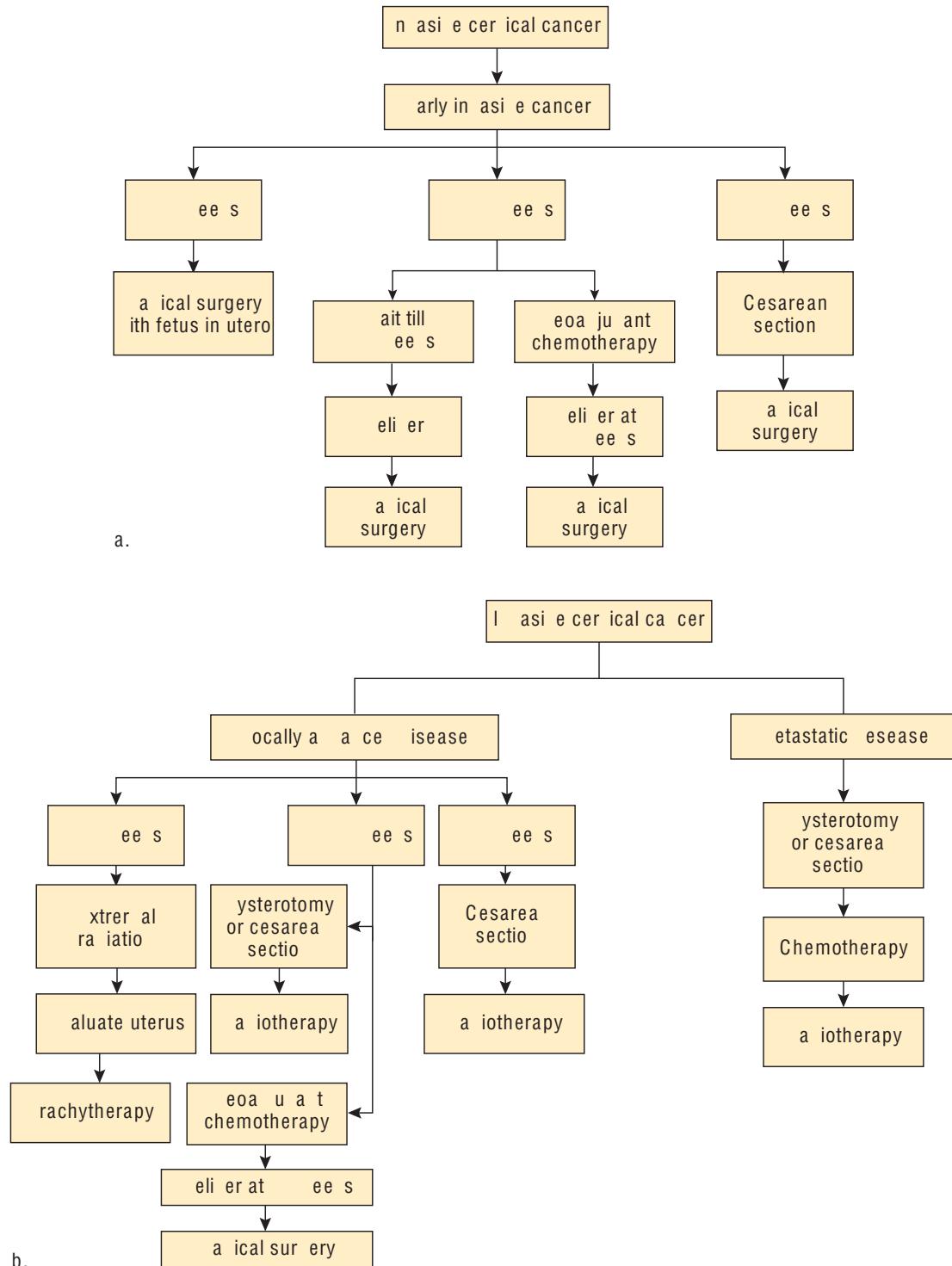


Figure 57.3 Treatment of invasive cervical cancer in pregnancy. **a.** Early **b.** Locally advanced and metastatic.

Epithelial tumors

Management of malignant epithelial ovarian tumors in pregnancy depends on the stage of the disease.

- Tumors of low malignant potential and early stage cancers predominate in pregnancy. A staging laparotomy should be performed as in the nonpregnant woman. Peritoneal washing, bilateral oophorectomy, omentectomy, lymphadenectomy, and exploration of the abdomen are essential for staging. If the pregnancy continues, the woman may be delivered at term.
- In women with early stage high risk disease, three cycles of chemotherapy should be administered after the first trimester.
- Management of advanced epithelial tumors depends on the gestational age.
 - First trimester: Hysterectomy and cytoreductive surgery followed by adjuvant chemotherapy as in the nonpregnant woman.
 - Second and third trimester: Removal of the bulky tumor, oophorectomy, and limited surgery followed by 3 cycles of chemotherapy with cisplatin and paclitaxel is an acceptable option. Completion of surgery should be performed after delivery and further courses of chemotherapy should be administered.

Breast cancer

Gestational or pregnancy-associated breast cancer is one that is diagnosed in pregnancy, during lactation or anytime in the first year after delivery. The majority of breast cancers associated with pregnancy are infiltrating duct carcinoma. Breast cancers in pregnancy may be poorly differentiated and in more advanced stages. Estrogen and progesterone receptor positivity is lower than in nonpregnant women with breast cancer. Pregnancy does not worsen the prognosis of the disease.

Clinical features and diagnosis

Most women with breast cancer present with a lump that can be identified despite pregnancy-related breast changes. Blood-stained nipple discharge may be present occasionally.

Mammography is difficult to interpret in pregnancy but is not contraindicated. Ultrasonography and core/incisional or excisional biopsy are used for diagnosis. MRI may be useful in special situations.

Once the diagnosis is made, staging is mandatory. Suspicious lymph nodes should be evaluated by fine-needle aspiration biopsy. Further evaluation is given in Box 57.12.

Management

Treatment of breast cancer in pregnancy is along the same lines as in nonpregnant women with a few modifications.

- Termination of pregnancy is not required.
- Surgery may be mastectomy or breast-conserving surgery. Axillary node dissection is mandatory.
- Breast-conserving surgery should be followed by radiotherapy, which is contraindicated in pregnancy. Hence, mastectomy may be an option even in early stage disease.
- Breast-conserving surgery followed by chemotherapy during pregnancy and delayed radiotherapy is also an option.
- Chemotherapy should be administered without delay following surgery. However, it should not be administered in the first trimester.

Box 57.12 Clinical features, diagnosis, and evaluation of breast cancer in pregnancy

- Symptoms
 - Breast lump
 - Blood-stained nipple discharge
- Diagnosis
 - Clinical examination
 - Ultrasonography
 - Core/incisional/excisional biopsy
 - Mammography
 - Interpretation difficult
 - MRI
 - Liver and brain metastasis
 - Chest X-ray
 - Bone scan
 - Only if bone metastasis suspected
- Assessment of cardiac function and liver function tests
 - for chemotherapy

- The combination used for chemotherapy is doxorubicin and cyclophosphamide with or without 5-fluorouracil.
- Immunotherapy with monoclonal antibodies such as trastuzumab is not recommended in

pregnancy because of the associated risk of miscarriage, preterm birth, fetal renal failure, and oligohydramnios.

Key points

- Uterine leiomyomas, functional ovarian cysts, dermoid cysts, and epithelial ovarian cysts are common benign neoplasms that occur in pregnancy.
- Uterine leiomyomas are usually diagnosed on ultrasound scan.
- Myomas can give rise to complications in pregnancy. They also undergo red degeneration, which is associated with pain, mild fever, and leucocytosis.
- Management of myomas is conservative. Even when encountered at cesarean section, myomectomy should be avoided.
- Functional cysts of the ovary and luteoma regress spontaneously and can be observed without intervention. Luteoma can give rise to maternal and fetal virilization.
- Cystic teratoma (dermoid cyst) and epithelial ovarian tumors can undergo torsion, especially in the second trimester and the puerperium. Rupture and hemorrhage are other complications.
- When malignancy is suspected, the tumor should be removed. All other tumors can be followed up till 18 weeks. If they do not regress, simple cysts may be aspirated. Dermoid cysts and large cysts must be removed.
- Cervical and breast cancers are the most common cancers in pregnancy.
- Ultrasonography is safe. CT scan and MRI can also be used in pregnancy.
- Radiotherapy is contraindicated. Chemotherapy should not be used in the first trimester. It is safe in the second and third trimesters.
- Abnormal cytology other than atypical squamous cells of undetermined significance (ASC-US) and low-grade squamous intraepithelial lesions should be evaluated by colposcopy. Biopsy must be performed if high-grade squamous intraepithelial lesion or invasive cancer is suspected.
- Conization and loop electrosurgical excision procedure (LEEP) should be performed only if microinvasive/invasive cancer is suspected.
- Treatment of cervical intraepithelial neoplasia (CIN) should be deferred till the postpartum period.
- Treatment of invasive cervical cancer depends on stage of the disease and gestational age.
- Germ cell tumors are more common than epithelial ovarian cancers.
- All ovarian cancers should be subjected to staging laparotomy. Adjuvant chemotherapy can be administered after the first trimester.
- Gestational breast cancer is usually infiltrating duct carcinoma. It tends to be more advanced and poorly differentiated in pregnancy.
- After confirmation of diagnosis of breast cancer, staging and metastatic workup should be done.
- Mastectomy followed by chemotherapy or breast-conserving surgery followed by chemotherapy and delayed radiotherapy are treatment options.

Self-Assessment

Case-based questions

Case 1

Mrs. HN, 32, third gravida, wife of a construction worker, was referred to the hospital at 11 weeks' gestation with a history of blood-stained vaginal discharge and a friable growth on the cervix. She was suspected to have cervical cancer and was referred for further management.

- What is the most likely diagnosis?
- How will you evaluate her?

- What factors will determine the treatment?
- If the disease is in stage IB, what is the treatment?

Case 2

Mrs. NT, 28, primigravida, was found to have an ovarian cyst of 6 cm in size at 8 weeks' gestation during routine ultrasonography.

- How will you evaluate this patient?
- What complications can occur?

3. How will you manage?
4. If the cyst shows features of malignancy, what is the management?

Answers

Case 1

1. Invasive cervical cancer.
2. Speculum examination and bimanual pelvic and rectal examination to stage the disease. Biopsy to confirm diagnosis. Chest X-ray and ultrasonography of the liver and urinary tract. MRI only if required and the disease is in advanced stage.
3. Stage of the disease and gestational age.
4. Radical surgery with the fetus in utero is the treatment of choice. This should be undertaken after discussion with the patient.

Case 2

1. Ultrasonographic features of malignancy should be looked for—presence of solid areas, septal thickness, thickness of cyst wall, and papillary excrescences. Features of cystic teratoma also should be noted.
2. Torsion, hemorrhage, and rupture.

3. If no features of malignancy, observe till 18–20 weeks. If it does not regress and is a simple cyst, aspirate. If dermoid cyst, perform laparoscopic surgery at 18–20 weeks. If size increases or features suggestive of malignancy are present, perform laparoscopic surgery or laparotomy.
4. Laparotomy should be performed, irrespective of gestational age. Unilateral or bilateral oophorectomy (depending on type of tumor) and staging should be done. Omentectomy, lymphadenectomy, and peritoneal washing are essential. This should be followed by chemotherapy after 12 weeks' pregnancy.

Sample questions

Long-answer question

1. Discuss the clinical features and management of cervical cancer in pregnancy.

Short-answer questions

1. Cervical intraepithelial neoplasia in pregnancy
2. Evaluation and management of ovarian mass in pregnancy
3. Management of gestational breast cancer

Section 8

Social Obstetrics

58

Maternal Mortality

Case scenario

Mrs. VN, 28, a fourth gravida, was brought to the labor room in shock. She had delivered normally 2 hours ago at a local hospital and had started bleeding profusely after delivery of the placenta. She had been given intravenous fluids and 1 unit of blood; some medications had been administered, but the bleeding continued. Since there was no facility for further management at the local center, she was referred to a tertiary-level hospital. On the way, she lost consciousness. On examination, she had acidotic breathing; peripheral pulse and blood pressure were not recordable. She died 10 minutes after arrival at the tertiary center, while resuscitative measures were underway.

Introduction

Maternal mortality is one of the indices of health care in every country. Maternal death is always a tragic event and most often avoidable. It is estimated that globally, every minute a mother dies due to complications of pregnancy or labor. Most maternal deaths occur in developing countries; 86% occur in sub-Saharan Africa and south Asia. Preventing maternal death begins with preconceptional management; good antenatal, intrapartum, and postpartum care; early identification and management of anemia, hypertension, and hemorrhage and health education.

Definitions

Maternal death is defined by the World Health Organization (WHO) as death of a woman occurring during pregnancy, childbirth, or within 42 days of delivery, irrespective of the duration and site of pregnancy, from any cause related to or aggravated by pregnancy or its management, but not from accidental or incidental causes.

Late maternal death is maternal death occurring after 42 days but within 1 year of termination of pregnancy.

Maternal mortality rate (MMR) is the number of maternal deaths in a given period per 100,000

women of reproductive age during the same period.

Maternal mortality ratio (MMR) is defined as the number of maternal deaths in a given period per 100,000 live births during the same period. It is obtained by dividing the number of maternal deaths in a population during some time interval by the number of live births occurring in the same period. The MMR, therefore, depicts the risk of maternal death relative to the frequency of childbearing.

Direct maternal death is the death of a mother due to obstetric complications of pregnancy, labor, and puerperium or from interventions, omissions, incorrect treatment, or a chain of events resulting from any of these factors, for example, deaths due to eclampsia, postpartum hemorrhage, or abortion.

Indirect maternal death is the death of a mother resulting from previous existing diseases or diseases that developed during pregnancy, which were not due to obstetric causes but aggravated by physiological adaptation to pregnancy, for example, deaths due to mitral valve disease or renal failure.

Pregnancy-associated death is death of a woman, from any cause, while pregnant or within one calendar year of termination of pregnancy, regardless of the duration or site of pregnancy.

Pregnancy-related death is a pregnancy-associated death that results from (a) complications of pregnancy itself, (b) the chain of events initiated by pregnancy that led to death, or (c) aggravation of an unrelated condition by the physiological or pharmacological effects of pregnancy and that subsequently caused death.

Maternal mortality Global and Indian scenario

Maternal mortality in developing countries differs from that in developed countries. Even within India maternal mortality varies from state to state.

- The global number of maternal deaths has declined from 523,000 in 1990 to 293,000 in 2013, as per data from UNICEF. The MMR declined by 45% with an annual reduction rate of 2.6%.
- At least 99% of maternal deaths occur in developing countries; 800 women still die each day due to direct or indirect causes.

- Sub-Saharan Africa has the highest MMR (510/100,000 live births), followed by South Asia (190/100,000 live births). In contrast, the MMR in the United States of America is 21/100,000 live births.
- Approximately 17% of maternal deaths occur in India. The MMR was 230/100,000 live births in 2008 and has decreased to 200/100,000 live births in 2010. Every 5 minutes, one woman in India dies from complications of childbirth and 15% of women develop life-threatening complications.
- The mortality ratio in India is not uniform but varies with the region and state (Fig. 58.1). The Empowered Action Group (EAG) states (Bihar, Jharkhand, Madhya Pradesh, Chattisgarh, Orissa, Rajasthan, Uttar Pradesh, and Uttarakhand) have a much higher mortality ratio, and the southern states (Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu) have a lower ratio. The mortality ratios for 2010–2012 are as follows:
 - EAG states and Assam: 257/100,000
 - Southern states: 105/100,000
 - Other states: 208/100,000

This difference in mortality ratios is due to several factors, including availability of government health programs, accessibility, socio-economic status, culture and customs, literacy, and awareness.

- The majority (80%) of maternal deaths are preventable.

Causes of maternal mortality

The causes of maternal mortality are shown in Figure 58.2.

Direct causes

Direct causes are responsible for 75% of maternal deaths. The major causes of maternal death are hemorrhage, sepsis, obstructed labor and uterine rupture, and hypertensive disorders. The other direct causes are abortion, ectopic pregnancy, anesthetic accidents, and embolism.

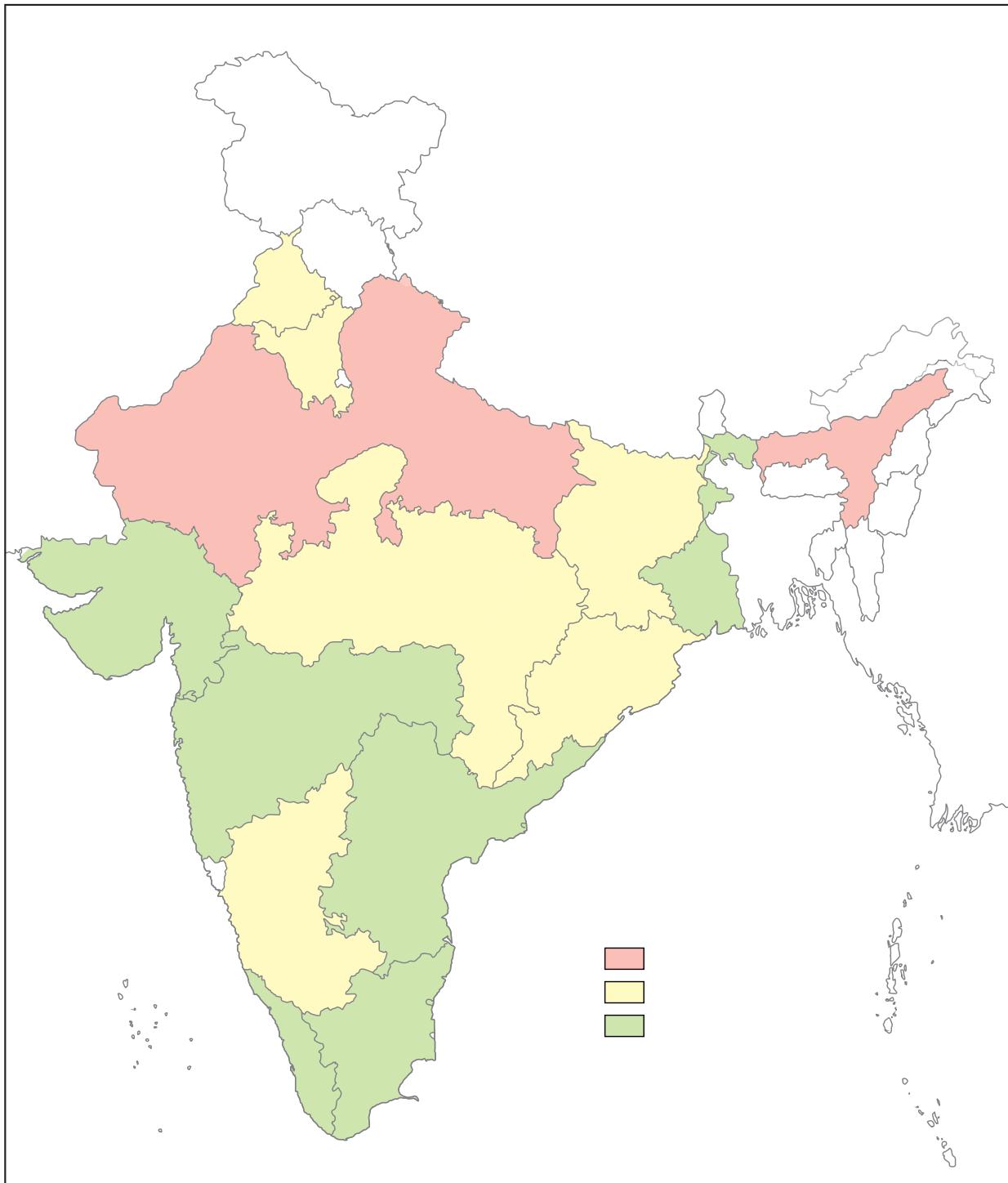


Figure 58.1 Maternal mortality in various states of India, 2007–2009. (Source: Special Bulletin, 2011, Office of Registrar General, India.)

Hemorrhage is the leading cause and accounts for almost 30% of deaths. This includes antepartum and postpartum hemorrhage, ectopic pregnancy, and other causes of hemorrhage.

Sepsis—puerperal and postoperative—is the next leading direct cause, accounting for 19% of deaths.

Obstructed labor and resultant uterine rupture and other complications occur in 10% of

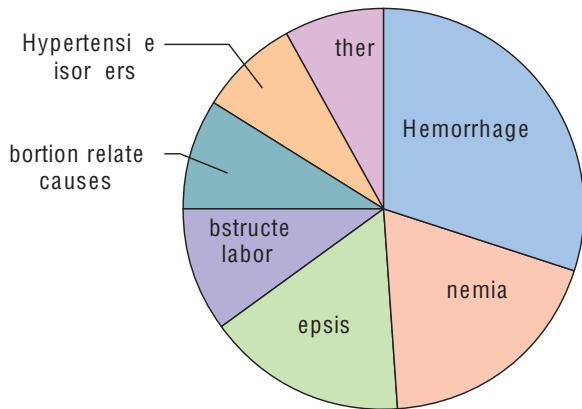


Figure 58.2 Causes of maternal deaths, 2005.

deaths. Complications due to spontaneous and induced abortions such as bleeding and infection account for 9% of deaths. Severe preeclampsia, eclampsia, HELLP syndrome, and other hypertensive disorders are the cause in 8% of deaths (Box 58.1). Amniotic fluid embolism is now being recognized as one of the causes, although the actual incidence is difficult to determine.

Indirect causes

The indirect causes of maternal death are **anemia, cardiovascular diseases, hepatitis, malaria, and other medical disorders of pregnancy**.

Box 58.1 Causes of maternal deaths

- Direct causes
 - Hemorrhage: 30%
 - Antepartum hemorrhage
 - Postpartum hemorrhage
 - Ectopic pregnancy
 - Adherent placenta
 - Injuries to the birth canal
 - Sepsis: 19%
 - Puerperal endometritis
 - Postoperative infection
 - Obstructed labor/uterine rupture: 10%
 - Abortion: 9%
 - Spontaneous
 - Induced
 - Hemorrhage
 - Sepsis
 - Hypertensive disorders: 8%
- Indirect causes
 - Anemia: 19%
 - Others: 8%
 - Coincidental causes
 - Accidents
 - Suicides

and other medical disorders of pregnancy. Anemia is the second most common cause and accounts for 19% of deaths. Malaria is common in endemic areas. HIV infection is now emerging as an important cause since it can worsen during pregnancy and also increase the risk of infection.

Cardiac diseases account for 5%–6% of maternal deaths. Rheumatic valvular disease and congenital heart diseases are worsened by the physiological changes of pregnancy, anemia, and hemorrhage. Hepatitis, transmitted by poor sanitary conditions, is also an indirect cause of death.

Co-incidental causes unrelated to pregnancy account for a small, variable percentage of all maternal mortalities. These are mainly due to accidents or suicides.

Timing of maternal deaths

Most maternal deaths occur after delivery, in the immediate postpartum period. Postpartum hemorrhage causes death in 2–3 hours. The time to death in ruptured uterus, obstructed labor, and eclampsia may vary from hours to 1–2 days. Approximately one-fourth of the maternal deaths occur in the antepartum period and are due to antepartum hemorrhage, abortion, and ectopic pregnancy. Intrapartum deaths are the least frequent. The proportion of deaths that occur in antepartum, intrapartum, and postpartum periods are as follows:

- Antepartum: 25%
- Intrapartum: 15%
- Postpartum: 65%

Factors associated with high maternal mortality

Several factors are associated with higher maternal mortality rates. These are listed in Box 58.2.

Age

The mortality is higher in teenage pregnancies due to illegitimate pregnancies, induced abortions, lack of antenatal care, higher risk of pre-eclampsia, and obstructed labor. Similarly, mortality is higher in older women (age >35 years) due to multiparity, anemia, induced abortions,

Box 58.2 Factors associated with high maternal mortality

- Age
 - 13–19 years
 - Age >35 years
- Parity
 - Primigravida
 - Parity >4
- Low socioeconomic status
- Lack of antenatal care
- Place of delivery
- Geographic location
- Rural areas

hypertensive disorders, and antepartum and postpartum hemorrhage.

Parity

The second to the fourth pregnancies are considered the safest. Complications are higher in primigravidas but several times higher in multiparous women with four or more previous deliveries. Age-related and parity-related complications account for the mortality.

Socioeconomic status

Health-seeking behavior, education, awareness, and nutrition are related to socioeconomic status. Maternal mortality is higher in women of low socioeconomic strata. There is increased prevalence of anemia, malnutrition, unsafe abortion, and lack of antenatal care and immunization in this group.

Antenatal care

Women who do not have regular antenatal care are at a higher risk of anemia, infections, eclampsia and severe preeclampsia, preterm labor obstructed, and abnormal labor due to malpresentations and cephalopelvic disproportion.

Place of delivery

Home deliveries and those conducted by untrained personnel are associated with higher risk. Approximately 65% of all deliveries in India still occur at home.

Geographic location

The EAG states have a higher MMR. As already mentioned, these states have low literacy rates, lower per capita income, early marriage, very little spacing between pregnancies, other customs that place the mother at risk, poor utilization of facilities, and higher prevalence of diseases such as malaria.

Urban and rural areas

The mortality is more in rural areas due to lack of availability or easy access to facilities, poverty, illiteracy, and socioeconomic factors.

The three delays

Following are the three delays associated with a high risk of mortality:

- Delay in deciding to seek care
- Delay in reaching the facility on time
- Delay in receiving treatment

Delay in deciding to seek care is on the part of the family and community. The reasons may be financial, cultural, or social. Home care by unskilled personnel and failure to recognize the seriousness of the situation are also important factors.

Delay in reaching the facility is due to lack of transportation, lack of good roads, and poor accessibility.

Delay in receiving treatment is a problem faced at the healthcare facility. Lack of trained personnel, lack of supplies, and incorrect treatment are the usual reasons.

Reasons for decline in maternal mortality

The MMR has shown a slow but steady decline globally. Even in developing countries such as India, the mortality has decreased. The reasons for this are listed in Box 58.3.

Box 58.3 Reasons for decline in maternal mortality

- Increase in deliveries by skilled attendants
- Increase in institutional deliveries
- Country-led health plans
- Better antenatal care
- Increase in awareness
- Better availability of
 - blood banks
 - antibiotics
 - cesarean section
 - safe abortions
- Training in emergency obstetric care

Strategies to reduce maternal mortality

Although the mortality ratio has reduced, it has not reached the expected goals. Several strategies have been planned and implemented in developing countries toward further reduction of maternal mortality.

Safe motherhood initiatives

The safe motherhood initiative was launched in 1987 to reduce maternal mortality by half by the year 2000 in developing countries. It was later extended to 2010. Family planning, antenatal, intrapartum, postpartum care, post-abortion care, and control of sexually transmitted infections and HIV infection are the goals of the program. This is discussed further in Chapter 60, *National health programs in obstetrics*.

Maternal and Child health services

Several national and international Maternal and Child Health (MCH) services were introduced to reduce maternal and child mortality, and to promote reproductive health along with physical and psychological development of the child. The Child Survival and Safe Motherhood (CSSM) program, Reproductive and Child Health (RCH)

program, and National Rural Health Mission (NRHM) are some of the important MCH programs.

Child Survival and Safe Motherhood program

The CSSM program was launched in 1992 and continued till 1997. It consisted of a safe motherhood and child survival components. Provision of aseptic delivery kits and strengthening of first referral units for management of high-risk pregnancies and obstetric emergencies resulted in a modest reduction in maternal mortality.

This was subsequently incorporated in RCH programs. CSSM program is discussed further in Chapter 60, *National health programs in obstetrics*.

Reproductive and Child health program

The RCH programs, launched by the Ministry of Health and Family Welfare, followed the CSSM program. The first phase of the program was launched in 1997.

Reproductive and Child health-I

Phase 1 of the RCH program was between 1997 and 2004. The RCH-I interventions for reducing maternal mortality are listed in Box 58.4.

RCH-I is discussed further in Chapter 60, *National health programs in obstetrics*.

Box 58.4 Reproductive and child health interventions

- Antenatal care
- Intrapartal care
- Postnatal care
- Emergency obstetric care
- Institutional deliveries
- Family planning
- Safe abortion services
- Immunization against tetanus
- Training TBAs and ANMs
- Providing transportation
- Upgrading old PHCs and setting up of FRUs

A auxiliary nurse midwife; C first referral unit; P primary health center; BA traditional birth attendant.

reproductive and Child Health II

The functions of RCH-I were enhanced and strengthened by the RCH-II program launched in 2005. The objectives are as follows:

- To establish healthcare services with improved access and quality to respond to the needs of the disadvantaged people
- To ensure that no one is denied services because of inability to pay
- To ensure better and equitable utilization of services
- To further reduce MMR, infant mortality rate, and total fertility rate

The major strategies are as follows:

- Essential obstetric care, which includes institutional delivery and delivery in the presence of skilled birth attendant (SBA)
- Emergency obstetric care (EmOC) round the clock at primary health centers (PHCs) and community health centers
- Strengthening referral systems
- Safe abortion services
- Newborn and child health services
- New initiatives such as training of doctors, Janani Suraksha Yojana, and the Vande Mataram scheme

RCH-II is discussed in detail in Chapter 60, *National health programs in obstetrics*.

National Rural Health Mission

The NRHM was initiated in India in 2005 to provide affordable and quality health care to the poorest households in the remotest regions of the country. Reduction in infant and maternal mortality is one of the goals of NRHM. Under NRHM, the key strategies are as follows:

- Creation of a cadre of accredited social health activists (ASHA), who counsel women on antenatal care, delivery, breastfeeding, nutrition, and sanitation and accompany the woman to the health facility
- Strengthening of subcenters, PHCs, and community health centers (CHCs) to provide 24-hour obstetric services
- Provision of guidelines for management of obstetric emergencies, referrals, skills lab,

abortion care, SBA training, and maternal death review

- District health plan integrating village health plans and state and national plans for health, sanitation, and nutrition
- Indira Gandhi Matritva Sahyog Yojana (IGMSY) to promote appropriate utilization of services by providing cash incentives to mothers
- Pradhan Mantri Gram Sadak Yojana (PMGSY) to provide connectivity and improve transport
- Improving sanitation and hygiene
- Promoting private-public partnership in health services

The goals, objectives, and strategies of NRHM are discussed in detail in Chapter 60, *National health programs in obstetrics*.

Millennium Development Goals

The Millennium Development Goals (MDGs) were established by the United Nations in the year 2000 and consist of eight international development goals. Improving maternal health is one of the goals (goal 5):

- Target 5A: To reduce the MMR by 75% between 1990 and 2015
- Target 5B: To achieve universal access to reproductive health by 2015

The targeted annual reduction in MMR is 5.5%. Implementation of this is by the steps and strategies given in the following subsections.

Skilled birth attendants

Although deliveries in the presence of SBAs is an important strategy in MDGs, randomized trials and meta-analysis have not shown a significant benefit. Moreover, in addition to SBAs being made available, their utilization by women must be ensured.

Emergency obstetric care

The seven basic services for provision of EmOC as outlined by the WHO are listed in Box 58.5.

In addition, if ability to perform a cesarean section and facility for blood transfusion are available, it is considered *comprehensive* emergency care. Blood transfusion is an important component of obstetric care since hemorrhage

Box 58.5 Basic services for emergency obstetric care

- Administration of
 - parenteral antibiotics
 - uterotronics
 - magnesium sulfate in severe preeclampsia/eclampsia
- Assisted vaginal delivery
 - Forceps
 - Vacuum
- Manual removal of placenta
- Removal of retained products
 - Manually
 - Vacuum aspiration
 - Dilatation and curettage
- Neonatal resuscitation with bag and mask

is the most common cause of maternal death. The time from onset of bleeding to death can be 1–2 hours in antepartum and postpartum hemorrhage, and this is due to hypovolemic shock. Blood transfusion will help in buying time while the patient is being shifted to a higher center.

Availability of transport and communication

Availability of transport and communication reduces perinatal mortality significantly and maternal mortality to some extent.

Availability of ultrasonography

Availability of ultrasonography helps in the early diagnosis of ectopic pregnancy, molar pregnancy, and in the localization of placenta. Early referral for institutional care is made possible.

Family planning

Family planning reduces mortality in multiple ways:

- Reduces the number of unwanted pregnancies
- Delays the first pregnancy
- Reduces multiparity
- Increases spacing between pregnancies
- Reduces unsafe abortion

Policies and infrastructure

Policies and protocols for management of various clinical situations and complications are an essential and integral part of strategies to reduce mortality. These include the following:

- Protocols for antenatal and postnatal care
- Management of complications
- Timely referral systems
- Community services linked to a healthcare facility to provide continuity of care
- Steps to ensure that guidelines and protocols are available, accessible, and acceptable to the population
- Empowerment of women and eradication of gender inequality
- Practice of evidence-based medicine
- Regular monitoring and audit of outcomes
- Proper documentation
- Utilization of the data to further improve quality of services

nongovernmental organizations

Several nongovernmental organizations (NGOs) also share the same goal and work toward reducing maternal deaths. A coordinated effort by the government, NGOs, and the private sector working together is a major strategy.

Maternal and Perinatal Death Inquiry and Response

Maternal and Perinatal Death Inquiry and Response (MAPEDIR) is an initiative by UNICEF, introduced in 2005. It is a collaborative initiative including the Government of India, state governments, district administrations, Panchayati Raj, NGOs, medical colleges, WHO, and UNICEF. It consists of an inquiry to establish the cause of maternal deaths, sensitize the health officials to the issues, and galvanize the community, organizations, and government into taking action. If successful, this initiative could be extended to more states and could contribute significantly toward achieving MDG 5.

Confidential inquiry into maternal deaths

Confidential inquiry into maternal deaths has been initiated by a few state governments, and awareness is being created among the caregivers regarding the common causes of maternal death and appropriate action plans are being drawn up and implemented.

Box 58.6 Interventions in specific clinical situations

- Hemorrhage
 - Active management of third stage of labor
 - Use of misoprostol when skilled attendant is not available
 - Condom balloon tamponade
 - Use of ultrasonography in antepartum hemorrhage and first trimester bleeding
- Infection
 - Better sanitation and safe drinking water
 - Distribution of clean delivery kits
 - Promotion of *si cleans* at delivery—clean hands, clean perineum, clean delivery surface, clean cord, clean tying instruments, and clean cutting surfaces
 - Use of antibiotics
 - Antenatal immunization against tetanus
 - Anti-retroviral therapy for HIV-positive women
 - Chemoprophylaxis against and prompt treatment of malaria
- Hypertensive disorders
 - Monitoring of blood pressure during pregnancy
 - Low-dose aspirin in women at high risk of preeclampsia
 - Administration of prophylactic magnesium sulfate
 - Administration of antihypertensives
- Obstructed labor
 - Use of partogram
 - Early identification of abnormality and referral
 - Availability of facilities for cesarean section
- Anemia
 - Iron and folic acid supplementation
 - Treatment of worm infestations
 - Dietary advice
- Abortion
 - Family planning services
 - Safe abortion services
 - Utilization of medical methods of abortion
 - Use of antibiotics

Interventions in specific clinical situations

The major causes of maternal mortality have been identified. Approaches for prevention and treatment of these conditions have been developed (Box 58.6). Educating both the skilled and unskilled birth attendants about the application of these is a major step in the reduction of maternal mortality.

Key points

- Maternal mortality is one of the indices of health. Most maternal deaths occur in developing countries.
- Maternal death is defined as death of a woman occurring during pregnancy, during childbirth, or within 42 days of delivery, irrespective of duration or site of pregnancy, from any cause related to or aggravated by pregnancy or its management but not from accidental or incidental causes.
- **maternal mortality rate (MMR)** is the number of maternal deaths in a given period per 100,000 women of reproductive age during the same period.
- Maternal mortality ratio (MMR) is the number of maternal deaths per 100,000 live births, a measure of the risk of death once a woman has become pregnant.
- Global MMR has declined by 45%. However, 99% of maternal deaths occur in developing countries; 17% of maternal deaths occur in India.
- Maternal mortality in India varies with the region and state. The Empowered Action Group states have a higher mortality ratio.
- A total of 80% of maternal deaths are preventable.
- Causes of maternal mortality are divided into direct, indirect, and other causes.
- Direct causes account for 75% of deaths and include hemorrhage, sepsis, obstructed labor, hypertensive disorders, ectopic pregnancy, anesthetic accidents, and embolism. Hemorrhage is the leading cause of maternal mortality.
- Anemia is the most important indirect cause. Cardiovascular disease, hepatitis, malaria, and other medical disorders are the other indirect causes.
- Majority of deaths (65%) occur in the postpartum period.

(Continued)

Key points *Continued*

- Age, parity, low socioeconomic status, lack of antenatal care, place of delivery, and geographic location are factors that influence maternal mortality.
- Maternal mortality has declined slowly and steadily in the past few years. The reasons include increase in delivery by skilled attendants and hospital deliveries, country-led health plans, better antenatal and intrapartum care, better facilities for blood transfusion, cesarean section, safe abortion, use of antibiotics, and training in emergency obstetric care.
- There are several nationwide strategies and programs for reduction of maternal mortality. These include safe motherhood initiatives, Maternal and Child Health (MCH) services, including Child Survival and Safe Motherhood (CSSM), Reproductive and Child Health (RCH)-I and -II, and National Rural Health Mission (NRHM).
- Improvement in maternal health is one of the goals of Millennium Development Goals (MDGs). Implementation of this is by delivery by skilled birth attendants, training in emergency obstetric care (EmOC), improved transport and communication facilities, availability of ultrasonography, family planning, and development of policies and infrastructure.
- Several nongovernmental organizations (NGOs) also work toward reduction of maternal deaths.
- Confidential inquiry into maternal deaths and Maternal and Perinatal Death Inquiry and Response (MAPE-DIR) are other important strategies.
- Interventions have also been developed to manage specific clinical situations that are associated with high maternal mortality.

Self-Assessment

Case-based questions

Case

Mrs. VN, 28, fourth gravida, was brought to the labor room in shock. She had delivered normally 2 hours ago at a local hospital and had started bleeding profusely after delivery of placenta. She had been given intravenous fluids and 1 unit of blood; some medications had been administered, but the bleeding continued. Since there was no facility for further management at the local center, she was referred to a tertiary-level hospital. On the way, she had lost consciousness. On examination, she had acidotic breathing; the pulse and blood pressure were not recordable. She died 10 minutes after arrival, while resuscitative measures were underway.

1. What are the direct causes of maternal mortality? What percentage of maternal mortality occurs due to hemorrhage?
2. How would you prevent this?
3. What could have been done at the local center by way of treatment?

Answers

1. Direct causes are hemorrhage, sepsis, obstructed labor, hypertensive disorders, and abortion. Approximately 30% of deaths occur due to hemorrhage.

2. Active management of the third stage of labor. Oxytocin immediately after placental delivery, and if not available or if there is no skilled birth attendant, oral or rectal misoprostol.
3. Administration of oxytocin, adequate blood transfusion, intravenous crystalloids, and condom balloon tamponade before and during transfer. Early identification and immediate transfer to a higher center.

Sample questions

Long-answer question

1. Define maternal death and maternal mortality ratio. What are the causes and what are the steps taken to reduce maternal mortality ratio in India?

Short-answer questions

1. Maternal mortality
2. Causes of maternal mortality
3. RCH intervention
4. Strategies to reduce maternal mortality

59

Perinatal Mortality

Case scenario

Mrs. SG, 32, primigravida, at 38 weeks of gestation, was brought to the hospital from a primary health center. She had been in labor for 18 hours. On examination, she was dehydrated and exhausted. The uterus was term size, contracting every 5–6 minutes for 30–40 seconds. The lower segment was stretched and there was a Bandl's constriction ring. On pelvic examination, the cervix was fully dilated, vertex at -2 station, and molding was 3+; there was a large caput, membranes were absent, and thick meconium stained fluid was draining. Fetal heart rate was 160–180/min; the electronic monitoring trace showed late decelerations. A deeply asphyxiated baby weighing 3.8 kg was delivered by a cesarean section. The baby died on the second neonatal day.

Introduction

Perinatal mortality is an index of antenatal and intrapartum care and also of the socio-economic condition of the community. Like maternal mortality, the perinatal mortality is four to five times higher in developing countries than in the developed world. Although institutional deliveries have increased under the national programs, this has not resulted in the expected reduction in perinatal mortality.

Definitions

Live birth

Live birth is defined as one in which the newborn at or after birth shows any sign of life such as breathing, presence of a heart-beat, movement of voluntary muscles or cord pulsations.

Stillbirth (fetal death)

Stillbirth is one where the fetus shows no signs of life at or after birth. Stillbirths or fetal deaths are divided into **early** (20–27 weeks' gestation or fetus weighing >500 g) and **late** (>28 weeks' gestation or fetus weighing >1000 g). Developing countries include under stillbirth only deaths after 28 weeks, a fetus weighing ≥ 1000 g, or with a crown–heel length of ≥ 35 cm.

Stillbirth rate is the number of stillbirths per 1000 births, including live births and stillbirths.

Neonatal death

Neonatal death is the death of an infant before 28 days of age. **Early neonatal death** is one that occurs in the first 7 days after birth and **late neonatal death** is one that occurs from 8 to 28 days after birth.

Early neonatal mortality rate is the number of neonatal deaths before 7 days after birth per 1000 live births.

Neonatal mortality rate is the number of neonatal deaths before 28 days after birth per 1000 live births.

Perinatal mortality

Perinatal mortality or deaths, according to the World Health Organization (WHO), include fetal deaths after 28 weeks' gestation and neonatal deaths within 7 days of birth. Where gestational age is not known, fetal weight of 1000 g or crown–heel length of 35 cm may be used. In developed countries, deaths from 20 weeks' gestation are included under perinatal mortality.

Perinatal mortality rate (PNMR) is the number of stillbirths plus neonatal deaths before 7 days per 1000 births, live and stillborn.

Perinatal mortality global and Indian scenario

Perinatal mortality rates vary in developing and developed countries. Even within India, the rates differ between the states.

- PNMR has been declining steadily globally.

- The decline in mortality of fetuses after 28 weeks' gestation has been steady, but the decline between 20 and 27 weeks has remained static. The PNMR declined by 25% between 1990 and 2003 in the United States (from 9/1000 to 6.7/1000). Since then, the PNMR has remained steady.
- There are 5.9 million perinatal deaths worldwide annually and most of them are in developing countries.
- In the year 2010, the rates in India were as follows:
 - Neonatal mortality rate: 33/1000 live births
 - Early neonatal mortality rate: 25/1000 live births
 - Stillbirth rate: 7/1000 births
 - PNMR: 32/1000 births
- The stillbirth rates are unreliable since they are grossly underreported.
- The majority (75%) of neonatal deaths occur in the first week of life and 36% occur in the first 24 hours. Reducing early neonatal mortality has been a major challenge.
- Neonatal deaths account for 40% of mortality occurring in the under-5 age group in India. Neonatal mortality rate dropped by 25% from 1980 to 1990, another 15% from 1990 to 2000, and again by 15% from 2000 to 2009. It was 33 per 1000 live births in 2010.
- The perinatal mortality varies in different states of India (Table 59.1).
- The mortality rates also vary between rural and urban areas (2010):

	Rural	Urban	Total
Overall PNMR/ 1000 births	35	22	32
Neonatal mortality rate	36	19	33
Early neonatal mortality rate	28	15	25

Causes of perinatal mortality

Perinatal deaths, be they late fetal deaths or early neonatal deaths, are due to causes listed in Box 59.1.

Table 59.1 Perinatal mortality rates (P M) in different states of India (2010)

State	P M (1000 births)	Stillbirth rate (1000 births)	neonatal mortality rate (1000 live births)
Madhya Pradesh	42	8	44
Orissa	41	8	42
Uttar Pradesh	35	5	42
Gujarat	32	8	31
Andhra Pradesh	31	7	30
Maharashtra	24	7	22
Tamil Nadu	23	10	16
Kerala	12	7	7
India	32	7	33

Box 59.1 Causes of perinatal mortality

- Asphyxia
 - Antepartum
 - Intrapartum
- Infections
 - Antepartum
 - Intrapartum
 - Neonatal
- Prematurity
- Low birth weight
- Pulmonary complications
 - Respiratory distress syndrome
 - Meconium aspiration
 - Aspiration pneumonia
 - Pulmonary hemorrhage
- Congenital malformations
- Chromosomal anomalies
- Birth injuries
- Neonatal jaundice
- Metabolic and other causes

Sepsis

An infection may be acquired antepartum through transplacental transmission or intrapartum in prolonged labor, obstructed labor, and prelabor rupture of membranes. Neonatal infections can occur in prematurity or through infection of the umbilical cord due to the lack of aseptic precautions at delivery. This can progress to septicemia and death.

Prematurity

Prematurity can be due to spontaneous preterm birth or induced preterm delivery for maternal or fetal compromise.

Spontaneous preterm labor can occur in multifetal pregnancy, cervical incompetence, prelabor rupture of membranes, placental abruption, or placenta previa.

Labor is induced preterm in conditions such as severe preeclampsia/eclampsia, diabetes, antiphospholipid antibody (APA) syndrome, and rupture of membranes with maternal complications or nonreassuring fetal status.

The preterm neonate may develop respiratory distress syndrome, necrotizing enterocolitis, jaundice, pulmonary hemorrhage, or sepsis, and all these conditions may contribute to perinatal mortality.

Low birth weight

Low birth weight occurs due to chronic placental insufficiency in maternal conditions such as

Asphyxia

Asphyxia is the result of placental insufficiency and can be due to maternal or fetal causes. It may be *acute* as in placental abruption, cord prolapse, obstructed labor, or uterine rupture.

Chronic asphyxia occurs in maternal medical disorders and preeclampsia.

Intrapartum asphyxia occurs in prolonged and difficult labors, instrumental delivery, obstructed labor, and uterine rupture. Asphyxia can cause a stillbirth or neonatal death.

preeclampsia, pregestational diabetes, chronic hypertension, APA syndrome, multifetal pregnancy, and intrauterine infections. Fetal chromosomal or congenital anomalies may also be the cause.

Low-birth-weight neonates are prone to complications such as necrotizing enterocolitis, hypoxic ischemic encephalopathy (HIE), intracranial hemorrhage, sepsis, and jaundice.

Pulmonary complications

Respiratory distress syndrome is usually associated with prematurity and the resultant lack of surfactant. Meconium aspiration occurs in postmaturity or in conditions in which intrauterine hypoxic episode has led to meconium passage. This is aspirated when there is antepartum or intrapartum hypoxia. Pulmonary hemorrhage occurs in prematurity, sepsis, and low-birth-weight neonates. Aspiration of the infected amniotic fluid in chorioamnionitis leads to aspiration pneumonia.

Congenital malformations and chromosomal anomalies

Congenital malformations that are incompatible with life such as anencephaly, renal agenesis, large diaphragmatic hernia, omphalocele, tracheoesophageal fistula, and Potter's syndrome can cause perinatal deaths. Some anomalies can be corrected by immediate surgery, but this depends on the accuracy of antenatal diagnosis and neonatal surgical facilities available at the center where delivery takes place. Chromosomal anomalies can also cause late fetal death or neonatal death.

Birth injuries

Birth injuries result from difficult or instrumental deliveries. Intracranial injuries can occur in assisted breech delivery and forceps delivery. Obstructed labor, malpresentations, and prematurity are the contributing factors.

Neonatal jaundice

Most cases of neonatal jaundice are mild and self-limiting. However, high indirect bilirubin

levels lead to kernicterus, brain damage, and death. Prematurity, Rh isoimmunization, ABO and other incompatibilities, and septicemia are the common causes of neonatal jaundice.

Metabolic and other causes

Hypoglycemia, hypokalemia, hypocalcemia, and hypomagnesemia are metabolic abnormalities encountered in maternal diabetes, sepsis, and prematurity. When severe and not treated promptly, they can cause neonatal death. Polycythemia, which is common in infants born to diabetic mothers, can also lead to cardiac failure and death.

Predisposing factors

Several epidemiological factors and maternal and fetal conditions predispose to perinatal mortality.

Epidemiological factors

The epidemiological factors are listed in Box 59.2.

Maternal and fetal conditions

Maternal and fetal conditions that predispose to stillbirth or neonatal death have been already discussed. These are listed in Box 59.3.

Box 59.2 Epidemiological factors for perinatal mortality

- Maternal age
 - 13–19 years
 - Age >35 years
- Parity
 - Parity ≥ 5
- Low socioeconomic status
- Poor maternal nutrition
- Rural areas
- Geographic location
- Female illiteracy

Box 59.3 Maternal and fetal conditions predisposing to perinatal mortality

- Maternal conditions
 - Hypertensive disorders
 - Diabetes mellitus
 - Antepartum hemorrhage
 - Maternal infections
 - Multifetal pregnancy
 - Prelabor rupture of membranes
 - Preterm labor
 - Antiphospholipid antibody syndrome
 - Uterine anomalies
 - Obstructed labor/uterine rupture
 - Instrumental delivery
- Fetal conditions
 - Congenital anomalies
 - Chromosomal anomalies
 - Fetal growth restriction
 - Malpresentations

Timing of perinatal deaths

The majority of perinatal deaths occur in the neonatal period. One-third of stillbirths occur in labor; two-thirds are late fetal deaths. Neonatal deaths account for 40% of under-5 mortality.

Reasons for high neonatal mortality in India

Low socioeconomic status

Low socioeconomic status predisposes to poor nutrition, anemia, fetal growth restriction, preterm labor, and more home deliveries by unskilled birth attendants.

Rural health infrastructure

A large percentage of the Indian population is rural. Inadequate intrapartum and neonatal care facilities in rural health centres is an important contributing factor for high neonatal mortality.

- Less than 20% of the rural community health centers provide essential newborn care services. Facilities for the care of low-birth-weight babies are available in even fewer centers.
- Statistics in 2010 show that there is a 55% shortfall of obstetricians and 69% shortfall of

pediatricians in community health centers. This leads to inadequate antenatal, intrapartum, and neonatal care.

Female illiteracy

Female illiteracy is associated with poor utilization of antenatal care, home deliveries, and unsafe practices during delivery and in newborn care with an increase in the risk of maternal, antenatal, intrapartum, and neonatal complications.

Lack of communication and transportation services

Early referral and transfer to community or district healthcare services is made difficult due to poor communication and transport facilities. This increases intrapartum asphyxia, stillbirths, sepsis, and neonatal deaths.

Strategies to reduce perinatal mortality

A large percentage of perinatal deaths are preventable. Several general and focused preventive strategies have been initiated by the government to reduce late fetal, intrapartum, and neonatal deaths.

General measures

Prenatal nutrition

Nutritional advice to pregnant mothers regarding the requirement for additional calories, carbohydrates, proteins, and minerals and supplementation of folic acid and iron prevents malnutrition and anemia in the mother and decreases the risk of low birth weight.

Improving antenatal care

Availability and utilization of antenatal care in rural and semiurban areas helps in screening and early identification of maternal complications such as preeclampsia and diabetes. Ultrasonography aids the diagnosis of congenital malformations. Supplementation of folic acid and iron reduces chances of anemia and helps prevent neural tube defects.

Delivery by skilled birth attendants

Delivery by skilled birth attendants will ensure early referrals when there are complications, reduce the risk of obstructed labor, help in appropriate management of malpresentations and labor abnormalities, promote aseptic techniques, and ensure early breastfeeding.

Training of midwives and traditional birth attendants in newborn care

In areas where transportation to a good health care facility is difficult, deliveries are conducted by traditional birth attendants (TBAs) and midwives. Training the midwives and TBAs in newborn care is a strategy that has been successful in many developing countries.

Socioeconomic development and education

Improving female literacy, socioeconomic conditions, nutrition, sanitation, and supply of safe water are essential basic steps to reduce perinatal mortality.

National initiatives to improve perinatal mortality

Maternal and child care services

With an aim to reducing maternal and infant mortality, several programs have been introduced under Maternal and Child Health (MCH) services.

Child Survival and Safe Motherhood Program

Child Survival and Safe Motherhood Program is one of the MCH programs introduced in 1992 (refer to Chapter 60, *National health programs in obstetrics*). The program has undertaken steps to reduce perinatal mortality by antenatal care, identification of high risk pregnancies and referral, provision of aseptic delivery kits, and promotion of institutional deliveries. This program has been subsequently incorporated

into Reproductive and Child Health (RCH) programs.

Reproductive and Child Health Programs I and II

RCH-I and II also focus on the following:

- Immunization
- Essential newborn care
 - Resuscitation of the newborn
 - Prevention of hypothermia
 - Prevention of infection
 - Exclusive breastfeeding
 - Referral of sick newborn

Janani Suraksha Yojana (JSY), under RCH-II, encourages institutional delivery, thereby improving newborn care. This is given in detail in *Chapter 60, National health programs in Obstetrics*.

National Rural Health Mission

National Rural Health Mission (NRHM) has been discussed in Chapter 60, *National health programs in obstetrics*. Reducing perinatal and infant mortality rates is one of the major objectives of NRHM.

Under NRHM, accredited social health activists (ASHAs) are selected for every 1000 population. The gaps in rural health care are bridged by the ASHA. She counsels the mother regarding the place of delivery, breastfeeding, neonatal immunization, and prevention of infections.

Integrated Management of Neonatal and Childhood Illness

Integrated Management of Neonatal and Childhood Illness (IMNCI) is one of the main interventions under NRHM. This is being set up in subcenters and primary health centers. The strategy encompasses a range of interventions to prevent and manage neonatal and childhood illnesses such as asphyxia, sepsis, pneumonia, low birth weight, and other childhood illnesses.

Special Care Newborn Units

Special care newborn units (SCNUs) have been established at district hospitals to educate medical officers and equip the facilities to care for

newborns referred with problems. Newborn stabilization units (NBSUs) are set up at the first referral units and community health centers to stabilize the neonate and offer initial care before transferring to district hospitals.

Promotion of home-based newborn care

Promotion of home-based newborn care (HBNC) initiative consists of empowering and training village health workers and ASHAs in basic neonatal resuscitation, identification and management of conditions such as neonatal infection and hypothermia, and early referral. Easily comprehensible standard management guidelines are formulated and made available.

Janani Shishu Suraksha Karyakram (JSSK) is aimed at eliminating out-of-pocket expenses for the pregnant woman and sick neonate, which are major deterrents to institutional care. All expenses related to delivery in a public

institution including transport to a facility, transport between health facilities, cost of drugs and consumables, 3-day stay in hospital and 7-day stay in case of a cesarean section, and care of sick neonate up to 30 days of age are taken care of by the government. This program is discussed further in Chapter 60, *National health programs in obstetrics*.

Comprehensive Emergency Obstetric and Newborn Care

Comprehensive Emergency Obstetric and Newborn Care (CEmONC) program has also been introduced at facilities at various levels. Round-the-clock emergency obstetric services; infrastructure to manage emergencies such as eclampsia, antepartum/postpartum hemorrhage, and other emergencies; blood bank facilities; availability of anesthetists; and newborn intensive care units are ensured under this program.

Key points

- Perinatal mortality is an index of antenatal and intrapartum care and the socioeconomic conditions of the community. It is four to five times higher in developing countries than in developed countries.
- Perinatal mortality or deaths, according to the WHO, include fetal deaths after 28 weeks' gestation and neonatal deaths within 7 days of birth. Where gestational age is not known, fetal weight of 1000 g or crown-heel length of 35 cm may be used. In the developed countries, deaths from 20 weeks are included under perinatal mortality.
- Perinatal mortality rate (PNMR) is the number of stillbirths plus neonatal deaths before 7 days per 1000 births, live and stillborn.
- Perinatal mortality rate has been decreasing globally. Most deaths occur in the developing countries. The PNMR in India in 2010 was 32/1000 births.
- A total of 75% of neonatal deaths occur in the first week of life.
- The PNMR varies in different states of India.
- Causes of perinatal deaths are asphyxia, infections, prematurity, low birth weight, pulmonary complications, congenital malformations, birth injuries, neonatal jaundice, and metabolic causes.
- Predisposing factors are environmental factors, maternal age, parity, low socioeconomic status, poor maternal nutrition, geographic location, and female literacy.
- Maternal conditions that cause perinatal deaths are hypertensive disorders, antepartum hemorrhage, diabetes, preterm labor, maternal infections, multifetal pregnancy, and operative vaginal delivery.
- Fetal conditions are congenital and chromosomal anomalies, fetal growth restriction, and malpresentations.
- Strategies to reduce perinatal mortality consist of prenatal nutrition, improving antenatal care, delivery by skilled birth attendants, training of TBAs in newborn care, and socioeconomic development and education.
- National programs under Maternal and Child Health services have also incorporated strategies to reduce perinatal deaths. The programs include Child Survival and Safe Motherhood Program, Reproductive and Child Health Programs I and II, and National Rural Health Mission (NRHM).
- Under NRHM, Integrated Management of Neonatal and Childhood Illness, special newborn care units, home-based newborn care, and Comprehensive Emergency Obstetric and Newborn Care are initiatives to reduce perinatal mortality.

Self-Assessment

Case-based question

Mrs. SG, 32, primigravida, at 38 weeks' gestation, was brought to the hospital from a primary health center. She had been in labor for 18 hours. On examination, she was dehydrated and exhausted. The uterus was term size, contracting every 5–6 minutes for 30–40 seconds. The lower segment was stretched and there was Bandl's constriction ring. On pelvic examination, the cervix was fully dilated, vertex at –2 station, and molding was 3+ at occipitoparietal and 2+ at parietoparietal sutures. A large caput was present, membranes were absent, and thick meconium was draining. Fetal heart rate was 160–180/min; electronic monitoring trace showed late decelerations. A deeply asphyxiated baby weighing 3.8 kg was delivered by cesarean section. The baby died on the second neonatal day.

1. What is the cause of death? Was it avoidable?
2. What are the predisposing factors?
3. What could have been done to prevent this?

Answers

1. The cause of death is asphyxia. It is avoidable.
2. The predisposing factors are given as follows:
 - a. Lack of appropriate antenatal care and screening for diabetes, and proper estimation of fetal weight
 - b. Lack of awareness and education due to which delivery for a 32-year-old primigravida with a fetus

weighing 3.8 kg was undertaken at a primary health center

- c. Inappropriate intrapartum management and failure to identify delay in the progress of labor
- d. Late referral from primary health center to a higher health care facility
3. The following could have been done to prevent this:
 - a. Antenatal care, screening for diabetes, and clinical/ultrasonographic estimation of fetal weight
 - b. Early identification of abnormal labor and early referral
 - c. Referral to a hospital with facilities for cesarean section for intrapartum care

Sample questions

Long-answer question

1. Define perinatal mortality rate. What are the causes of perinatal mortality? How will you prevent perinatal deaths?

Short-answer questions

1. Causes of perinatal deaths
2. Strategies to reduce perinatal mortality

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National Health Programs in Obstetrics

Case scenario

Mrs. NT, 20, primigravida, from a village nearby, was brought to a private hospital for delivery. She had antenatal care at a primary health center elsewhere and was visiting her relatives when she started labor pains. Her husband was a manual laborer and earned daily wages of Rs. 250/day. The couple had saved only Rs. 2000 for anticipated expenses during delivery. On arrival at the hospital, she was told that the delivery would cost her Rs. 10,000. The couple was distraught and did not know where to go.

Introduction

Preventive medicine is an essential component of obstetrics. The aim of obstetric care is to achieve optimal outcomes for the mother and child. This is achieved through appropriate attention to social and environmental factors in addition to obstetric and neonatal care. There are several difficulties experienced by women in utilizing health care facilities and this is one of the reasons for the high maternal and perinatal mortality in developing countries. To overcome these difficulties, which may be financial, social, cultural, or physical, the Government of India, the World Health Organization (WHO), and other organizations have introduced several health programs.

Health care providers and the public must be aware of these programs and utilize them appropriately to achieve the goals of these programs.

Safe Motherhood Initiative

The Safe Motherhood Initiative (SMI) was launched by the WHO in 1987, following a conference in Nairobi, to reduce maternal mortality ratio in developing countries by half by the year 2000; later it was extended to 2010. It is a worldwide effort that aims to increase attention to and reduce the devastating numbers of women who die during pregnancy or labor, or suffer life-threatening illness during pregnancy or

Box 60.1 Pillars of safe motherhood

- Family planning
- Antenatal care
- Obstetric (intrapartum) care
- Postnatal care
- Postabortion care
- STI/HIV control

human immunodeficiency virus; S sexually transmitted infection.

labor every year. The strategies and interventions outlined by the WHO, referred to as the '*pillars of safe motherhood*', are given in Box 60.1.

- Family planning services provide access to contraception. Efforts are made to reduce maternal problems related to frequent pregnancies at short intervals and offer safe medical termination of pregnancy.
- Antenatal, intrapartum, and postnatal care are made available at primary health centers (PHCs), first referral units (FRUs), and community health centers (CHCs). Round-the-clock availability of doctors and midwives is ensured. Through the emergency obstetric care (EmOC) program, health care providers are trained in antenatal and intrapartum care.
- Institutional deliveries are encouraged and utilization of skilled birth attendants promoted.
- Referral system and transport facilities have been strengthened.
- Programs have been introduced to control sexually transmitted infections (STIs). Prevention, early diagnosis, and treatment of STIs and human immunodeficiency virus (HIV) are addressed.
- Overall improvement of the status of women has been achieved through education, empowerment, vocational training, and employment opportunities.

Maternal and Child health services

Women in the reproductive age group and children younger than 5 years are considered a vulnerable group with high mortality and morbidity. They constitute one-third of the total population of India.

The aims of Maternal and Child Health (MCH) services have been to reduce the maternal and childhood mortality and to promote reproductive health and optimize physical and psychological development of the child. Several national and international programs have been instituted for this purpose. The current concepts include the following:

- Integration of services by obstetricians, pediatricians, community health workers, and social workers to promote continuity of care
- Risk-based approach—identification of women and children at high risk, for better utilization of resources
- Introduction and training of field workers such as multipurpose workers, *dais*, traditional birth attendants (TBAs), anganwadi workers, and accredited social health activists (ASHAs)
- Utilizing primary health care to provide MCH care; provide education regarding nutrition, sanitation, and prevention of infections; and provide family-oriented care and support

The MCH programs in India are discussed in the subsequent sections.

Child Survival and Safe Motherhood program

The Child Survival and Safe Motherhood (CSSM) program was introduced in 1992, assisted by the World Bank. The program integrated the services of the Family Welfare Program, tetanus toxoid immunization of pregnant women, and training program for *dais*. The components of the CSSM program are given in Box 60.2.

The program made a significant impact in many parts of the country. CSSM has been subsequently incorporated into the Reproductive and Child Health (RCH) program in 1996.

Reproductive and Child health Program I

Definition

Reproductive health is defined as a state in which people have the ability to reproduce and regulate

Box 60.2 The components of CSSM program

- Safe motherhood
 - Early registration of pregnancy
 - Provide minimum of three antenatal checkups
 - Tetanus immunization
 - Identification of high risk pregnancies and referral
 - Provision of aseptic delivery kits
 - Strengthening FRUs for dealing with obstetric emergencies
 - Training of TBAs
 - Control of anemia in pregnant women
 - Promotion of institutional deliveries
- Child survival component
 - Augmentation of oral rehydration therapy program
 - Prevention of blindness
 - Prevention of acute respiratory infections
 - Universal immunization

first referral unit; BA traditional birth attendant.

their fertility, women are able to go through pregnancy and childbirth safely, the outcome of pregnancies is successful in terms of maternal and infant survival and well-being and couples are able to have sexual relations free of the fear of pregnancies and of contracting diseases.

Based on this concept, the first phase of the program, RCH-I, was launched by the Ministry of Health and Family Welfare in the year 1997. The main aim was to reduce infant, child, and maternal mortality rates. RCH-I incorporated the programs listed in Box 60.3.

The program includes the following:

- Family planning: Improved methods of contraception, condom distribution, safe abortion services, and intrauterine contraceptive device (IUD) insertion services
- Child health programs: Essential newborn care, intensification of immunization, micronutrient supply, exclusive breastfeeding, special care for

Box 60.3 Components of eproductive and Child health Program I

- Family planning program
- Child Survival and Safe Motherhood program
- Prevention and management of RTIs/STIs/HIV
- Adolescent health care and family life education
- Client approach to health care

human immunodeficiency virus; RTI reproductive tract infection; S sexually transmitted infections.

preterm and low-birth-weight babies, vitamin A prophylaxis, and treatment of anemia

- Safe motherhood programs: Antenatal care, institutional deliveries, delivery in the presence of skilled birth attendants, EmOC, and safe abortion services
- Prevention and management of STIs/RTIs/HIV: Specialist facilities for the diagnosis and treatment of STIs/reproductive tract infections (RTIs) in district hospitals and some subcenters
- Adolescent health care: Prevention and treatment of anemia and awareness regarding reproductive health issues
- Integration of services for maternal and child care
- Demand-driven services and programs through decentralized participatory process with a paradigm shift in programs
 - From camp oriented to client oriented: Sterilization camps, IUD camps, and immunization camps were replaced by a full range of RCH services that were need based.
 - From target oriented to goal oriented: Targets for various programs and camps were replaced by goals that were demand driven and involved community participation.
 - From quantity oriented to quality oriented: The stress on quantity or numbers was replaced by well-planned health services of high quality.
- Upgradation of facilities in PHCs and setting up of FRUs to provide comprehensive obstetric and newborn care
- Improvement of outreach services for vulnerable groups such as urban slums, tribal population, and adolescents

eproductive and Child health Program II

Phase II of RCH was launched on April 1, 2005. The aim was to make a change in major critical health indicators, that is, reduce maternal and infant mortality rate and total fertility rate. The program is a means to achieve outcomes envisioned in the Millennium Development Goals, National Population Policy 2000, the Tenth Plan, and National Health Policy 2002. RCH-I had

several lacunae, and attempts have been made to rectify these in RCH-II.

Objectives

The overall objectives of RCH-II are as follows:

- To establish health care services with improved access and quality to respond to the needs of the disadvantaged people
- To ensure that no one is denied services because of the inability to pay
- To ensure better and equitable utilization of services

Components of C-II

Components of RCH-II are listed in Box 60.4.

Strategies of C-II

The essential strategies of RCH-II are listed in Box 60.5.

Essential obstetric care

Round-the-clock obstetric and newborn care services are made available at PHCs and CHCs to ensure institutional delivery. Presence of a skilled attendant at delivery has been identified as an important strategy to reduce maternal mortality, and this has been implemented in RCH-II. Auxiliary nurse midwives (ANMs) and nurses are now permitted to use drugs in emergency situations to reduce maternal mortality.

Emergency obstetric care

EmOC and newborn care is made available at FRUs. The FRUs have been equipped with labor

Box 60.5 Major strategies of reproductive and child health program II

- Essential obstetric care
 - Institutional delivery
 - Skilled birth attendants at delivery
 - Empower health workers by training them to use emergency drugs
- Emergency obstetric care
 - Operationalizing FRUs
 - Round-the-clock services at PHCs and CHCs
 - Blood storage facility
 - Emergency obstetric and newborn care
- Strengthening referral system
 - Communication facilities
 - Transport services
 - Linkage with self-help groups and NGOs
- Newborn and child health
 - IMNCI services
 - Skilled care at birth
 - SNCUs
 - Home-based newborn care
- Safe abortion services
 - Medical methods of abortion
 - Manual vacuum aspiration
- New initiatives
 - Training doctors in emergency obstetric care
 - Janani Suraksha Yojana
 - Vande Mataram scheme

C Cs, community health centers; C integrated management of neonatal and childhood illness; P Cs primary health centers; S C sick newborn care unit.

room, operation theater, laboratory services, and blood storage facility so that they can perform cesarean sections.

Strengthening of referral system

First referral units are provided ambulances for referral and quick transport of women and newborn babies. Local self-help groups, nongovernmental organizations (NGOs), and women groups have been involved in providing communication and transport facilities.

Safe abortion services

Medical termination of early pregnancy with mifepristone and misoprostol and manual vacuum aspiration are safe methods of termination. Under RCH-II, facilities for these methods of termination are provided.

Box 60.4 Components of reproductive and child health program II

- Population stabilization
- Maternal health
- Newborn care and child health
- Adolescent health
- Control of RTIs/STDs
- Urban and tribal health
- New initiatives

RTI reproductive tract infection; S D sexually transmitted disease.

Newborn and child health components

Integrate management of neonatal and childhood illness

Care of the newborn child and young children is a continuum. Therefore, it is desirable to have an integrated approach to this vulnerable section. The Government has therefore introduced integrated management of neonatal and childhood illnesses (IMNCI).

- IMNCI is one of the main strategies under RCH-II. It is an integrated approach to prevention of diseases, promotion of child health and development, and provision of standard care for management of childhood illnesses.
- Skilled personnel are trained to provide care from birth up to 2 months of age.
- Preservice IMNCI training is included in the medical curriculum.
- Facility-based IMNCI integrates IMNCI care with facility-based care and focuses on in-patient management of neonatal childhood illnesses such as asphyxia, pneumonia, diarrhea, malaria, respiratory infections, measles, and malnutrition.

Stabilization care facilities for sick newborns are provided at CHCs, FRUs, and district hospitals, and sick newborn care units (SNCUs) have been set up at district hospitals. Home-based newborn care by the ASHAs has been developed in some states.

New initiatives

Training of doctors

Training in EmOC for doctors working in FRUs, PHCs, and CHCs is one of the important new initiatives of RCH-II. Training is also provided in lifesaving anesthetic skills and performing a cesarean section.

Janani Suraksha Yojana

The Janani Suraksha Yojana (JSY) is a safe motherhood intervention introduced by the Government of India under RCH-II and National Rural Health Mission (NRHM) to encourage institutional delivery. It was launched on April 12, 2005.

- The program is 100% centrally sponsored.
- The objective of the initiative is to reduce maternal and infant mortality and promote institutional deliveries.
- It integrates cash assistance with delivery and postdelivery care.
- The benefit is available to
 - Low-performing states: All pregnant women, delivering in government health centers such as subcenters, PHC/CHC/FRU/general wards of district and state hospitals, or accredited private institutions
 - High-performing states: Below-poverty-line pregnant women, aged 19 years and above
 - Low- and high-performing states: All women belonging to scheduled castes (SC) and scheduled tribes (ST), delivering in a government health center such as subcenters, PHC/CHC/FRU/general ward of district and state hospitals, or accredited private institutions
 - In 2013, the age cutoff of 19 years has been removed for below-poverty-line women in all states.
- ASHAs serve as a link between the woman and the health care facility.
- The scale of cash assistance is different for rural and urban areas. Cash assistance consists of a mother's package and an ASHA's package.
- The entitlements include drugs, consumables, transport from home to institution and back, free food, free diagnostic tests, and treatment of the newborn.
- Assistance covers normal delivery and cesarean section at government hospitals or accredited private institutions.
- The scheme has resulted in a significant rise in institutional deliveries. The increase has been more in low-performing states.

Vande Mataram Scheme

Under the Vande Mataram scheme, any obstetric or gynecology specialist can volunteer to provide safe motherhood services. The enrolled doctors have a Vande Mataram logo, and patients are provided cards with the logo. Antenatal and intrapartum care are provided by the doctor, and difficult cases may be referred to government hospitals.

National Rural Health Mission

The NRHM program was launched by the Government of India on April 12, 2005, for a period of 7 years (2005–2012) to improve rural health care throughout the country. The objective of the program was to provide accessible, affordable, accountable, effective, and reliable primary health care, especially to the poor and vulnerable sections of population. The program included components of RCH-II, National Disease Control Program, and strategies of NRHM.

Goals of M

The goals of the NRHM are listed in Box 60.6.

Core strategies of M

Enhancing public health services at the village level, PHCs, CHCs, and district level; integrating health and family welfare programs at the national, state, block, and district levels; and collection, assessment, and review are the important strategies of NRHM. To achieve these, the action plan consists of several components as listed in Box 60.7.

Accredited social health activists

One accredited social health activist (ASHA) is selected for every 1000 population.

- Every village has a female ASHA chosen by the panchayat, to act as a link between the community and public health system. She is a

Box 60.7 Strategies of M

- Accredited social health activists (ASHAs)
- Strengthening of subcenters, PHCs, and CHCs
- District health plan
- Sanitation and hygiene
- Strengthening of disease control programs
- Public–private partnership
- Janani Shishu Suraksha Karyakram (JSSK)
- New health financing mechanisms
- Reorienting medical/health education

C Cs community health centers; P Cs primary health centers.

volunteer, educated up to class 8, and receives performance-based compensation for various activities.

- She is trained in public health with training material developed at the national level.
- She performs the following functions:
 - She facilitates preparation and implementation of village health plan along with anganwadi workers, ANMs, and self-help groups.
 - She is given a drug kit containing essential allopathic drugs and Ayurveda, yoga and naturopathy, Unani, Siddha, and Homeopathy (AYUSH) drugs and provides primary medical care for minor ailments.
 - She promotes immunization and provides referral and escort services to pregnant women and children.
 - She serves as a link between pregnant women and the government or private institutions for facilitating assistance under JSY.
 - She creates awareness in the community regarding health, sanitation, and nutrition.
 - She counsels women regarding safe delivery, breastfeeding, contraception, immunization, and STDs.
 - She helps in the construction of household toilets.
 - She works closely with a Anganwadi workers and ANMs.

Strengthening of subcenters, P Cs, and C Cs

A variety of measures can be undertaken for strengthening of subcenters, PHCs, and CHCs, such as follows:

- Strengthening of subcenters by (a) supplying essential drugs, both allopathic and AYUSH,

Box 60.6 Goals of M

- Reduction in
 - infant mortality rate to 60/1000 live births
 - maternal mortality ratio to 220/100,000 live births
- Universal access to public health services
- Prevention and control of
 - communicable diseases
 - noncommunicable diseases
- Population stabilization
- Promotion of healthy life style
- Revitalization of local health traditions and AYUSH

A S Ayurveda, yoga and naturopathy, Unani, Siddha, and homeopathy.

- (b) commissioning of new subcenters and upgrading existing ones, and (c) providing multipurpose health workers and additional ANMs whenever necessary
- Strengthening of PHCs by (a) providing round-the-clock service at PHCs, (b) supplying essential drugs, and (c) upgrading existing PHCs and initiating new programs for the control of noncommunicable diseases
- Strengthening of CHCs for first referral care by (a) providing 24-hour service at CHCs, (b) setting up standards for infrastructure, staffing, and functioning of CHCs, and (c) hospital management by the *Rogi Kalyan Samiti* or the hospital management committee

Janani Shishu Suraksha Karyakram

Under JSY, institutional deliveries increased but out-of-pocket expenditure for women and their families was high. The Janani Shishu Suraksha Karyakram (JSSK) was launched in June 2011 to assure free services to all pregnant women and sick neonates accessing public health institutions.

Expenses incurred are toward admission charges, diagnostic tests, charges for a cesarean section, diet, and transport. These factors are the cause for 25% of women not seeking institutional delivery.

The scheme entitles pregnant women and sick newborn to a number of services listed in the following subsections.

Pregnant women

Pregnant women are provided

- free drugs, consumables, blood transfusion, diagnostic tests, and diet;
- free transport from home to health care facility and back and between facilities in case of referral;
- free stay at the facility for >48 hours if required (3 days after normal delivery, 7 days after cesarean section);
- free cesarean section.

Sick newborn

A sick newborn is provided

- free treatment, drugs, consumables, and blood;
- free transport;
- free stay at hospital up to 30 days.

Other strategies

Other strategies include the following:

- District Health Plan is an amalgamation of village health plans and state and national plans for health, water supply, sanitation, and nutrition. All health and family welfare programs at district levels merged together are called the District Health Mission, and all state-level plans are together called the State Health Mission.
- Sanitation and hygiene are guided by the District Health Mission and implemented through village health and sanitation committee. ASHAs are involved in promoting construction of household toilets.
- Disease control programs for malaria, TB, filaria, blindness, and iodine deficiency are integrated. New initiatives have been launched for control of noncommunicable diseases.
- Nearly 75% of health services are by the private sector; therefore, guidelines for private-public partnership have been developed.
- Mobile medical units and ambulance services have been provided to remote areas.

Outcomes of NRHM at national level

Outcomes of NRHM at the national level are as follows:

- Reduction in infant mortality rate, maternal mortality ratio, and fertility rate
- Reduction in mortality rate of communicable diseases such as kala-azar, dengue, and Japanese encephalitis
- Reduction in the prevalence of leprosy
- Increase in the utilization of directly observed therapy services (DOTS) for TB
- Increase in the utilization of FRUs

Community level

Outcomes of NRHM at the community level are as follows:

- Availability of generic drugs for common ailments at subcenters, PHCs, and CHCs
- Good services at PHCs and CHCs
- Improved transport, referral, escort system, and subsidized hospital care through JSY resulting in improved institutional delivery
- Improved outreach services

Key points

- The Government of India, the World Health Organization (WHO), and other organizations have launched several health programs for women from time to time.
- The Safe Motherhood Initiative was launched by the WHO in 1987 to reduce the maternal mortality ratio in developing countries.
- The pillars of the program were family planning, antenatal care, intrapartum and postnatal care, postabortion care, and control of sexually transmitted infection (STI)/human immunodeficiency virus (HIV). Maternal and Child Health (MCH) services were introduced to reduce maternal and childhood mortality. Several programs have been introduced under MCH services.
- The Child Survival and Safe Motherhood (CSSM) program was introduced in 1992 and integrated Family Welfare Program, TT immunization of pregnant women, and Dais Training Program. The program had safe motherhood and child survival components. The CSSM was incorporated into the Reproductive and Child Health (RCH) program later.
- Reproductive Health Program I was started in 1997 to reduce infant, child, and maternal mortality rates. The program includes family planning, child health programs, safe motherhood programs, prevention and management of STIs/reproductive tract infections and HIV, adolescent health care, and integration of various services for maternal and child care.
- Setting up of first referral units and upgradation of primary health centers (PHCs) to provide comprehensive obstetric and newborn care were important strategies of RCH-I.
- Reproductive Health Program II was launched in 2005 to reduce maternal and infant mortality rates and total fertility rate.
- The core strategies were essential obstetric care, emergency obstetric care, strengthening referral systems, newborn and child care, safe abortion services, and new initiatives.
- Providing round-the-clock services at PHCs and community health centers (CHCs), improving transport facilities, blood storage facility, and Integrated Management of Neonatal and Childhood Illness services were important components.
- New initiatives included Janani Suraksha Yojana, Vande Mataram scheme, and training of doctors in emergency obstetric care.
- The National Rural Health Mission (NRHM) was launched in 2005, for a period of 7 years. The objective of NRHM is to provide affordable, accessible, and reliable health care to the poor and vulnerable.
- The goals of NRHM were reduction in infant and maternal mortality rates, prevention and control of communicable and noncommunicable diseases, population stabilization, and revitalization of local health traditions and Ayurveda, yoga and naturopathy, Unani, Siddha, and homeopathy (AYUSH).
- An accredited social health activist (ASHA) is an integral and important part of NRHM. She is a volunteer who is trained in public health and serves several functions.
- Strengthening of subcenters, PHCs, and CHCs, District Health Plan, sanitation and hygiene, and private-public partnership are core strategies.
- The NRHM has achieved several positive outcomes at national and community levels.

Self-Assessment

Case-based question

Mrs. BN, 20, primigravida, from a village in Tamil Nadu, was brought to an accredited private hospital for delivery. She had antenatal care at a primary health center elsewhere and was visiting her relatives when she started labor pains. Her husband was a manual laborer and earned daily wages of Rs. 200/day. The couple had saved only Rs. 2000 for anticipated expenses during delivery. On arrival at the hospital, she was told that the delivery would cost her Rs. 10,000. The couple was distraught and did not know where to go.

1. What help is available to Mrs. BN?
2. What are the criteria for eligibility?
3. Who normally accompanies pregnant women to the hospital and advises them regarding the scheme?
4. What are the other functions of ASHA?

Answers

1. Mrs. BN can make use of the Janani Suraksha Yojana, which is a new initiative under RCH-II/NRHM.
2. In high-performing states, women below the poverty line or belonging to SC/ST are eligible for the scheme for delivery at PHC/CHC/district hospital or accredited private hospitals.
3. An accredited social health activist creates awareness regarding safe delivery, breastfeeding, and immunization and escorts pregnant women to PHCs and to institutions to which they are referred.
4. An ASHA facilitates preparation and implementation of the village health plan along with anganwadi workers, ANMs, and self-help groups; provides primary medical care for minor ailments; promotes immunization; creates awareness in the community regarding

health, sanitation, and nutrition; counsels women regarding safe delivery, breastfeeding, contraception, immunization, and STDs; helps in construction of household toilets and works closely with anganwadi workers and ANMs.

Sample questions

Long-answer questions

1. Discuss the various health programs at the national level to reduce maternal and infant mortality.

2. What is NRHM? Discuss the goal, objectives, strategies, and outcomes of NRHM.

Short-answer questions

1. Safe Motherhood Initiative
2. Child Survival and Safe Motherhood Program
3. Reproductive and Child Health Programs
4. Janani Suraksha Yojana