Chapter 1 Anatomy

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The anatomical knowledge of the female genital organs (Figure 1.1) and their relation to the neighbouring structures help in the diagnosis of various gynaecological diseases and in interpreting the findings of ultrasound, computed tomography (CT) and magnetic resonance imaging (MRI) scanning. During gynaecological surgery, distortions of the pelvic organs are better appreciated and dealt with and a grave injury to the structures such as bladder, ureter and rectum is avoided. The understanding of the lymphatic drainage of the pelvic organs is necessary in staging various genital tract malignancies and in their surgical dissection.

The Vulva

The vulva is an ill-defined area which in gynaecological practice comprises the whole of the external genitalia and conveniently includes the perineum. It is, therefore, bounded anteriorly by the mons veneris (pubis), laterally by the labia majora and posteriorly by the perineum.

Labia Majora

The labia majora pass from the mons veneris to end posteriorly in the skin over the perineal body. They consist of folds of skin which enclose a variable amount of fat and are best developed in the childbearing period of life. In children before the age of puberty and in postmenopausal women, the amount of subcutaneous fat in the labia majora is relatively scanty, and the cleft between the labia is therefore conspicuous. At puberty, pudendal hair appear on the mons veneris, the outer surface of the labia majora and in some cases on the skin of the perineum as well. The inner surfaces of the labia majora are hairless and the skin of this area is softer, moister and pinker than over the outer surfaces (Figure 1.2). The labia majora are covered with squamous epithelium and contain sebaceous glands, sweat glands and hair follicles. There are also certain specialized sweat glands called apocrine glands, which produce a characteristic aroma and from which the rare tumour of hidradenoma of the vulva is derived. The secretion increases during sexual excitement.

The presence of all these structures in the labia majora renders them liable to common skin lesions such as folliculitis, boils and sebaceous cysts (Figure 1.3). Its masculine counterpart is the scrotum.

Bartholin's Gland

Bartholin's gland lies posterolaterally in relation to the vaginal orifice, deep to the bulbospongiosus muscle and superficial to the outer layer of the triangular ligament. It is embedded in the erectile tissue of the vestibular bulb at its posterior extremity. It is normally impalpable when healthy, but can be readily palpated between the finger and the

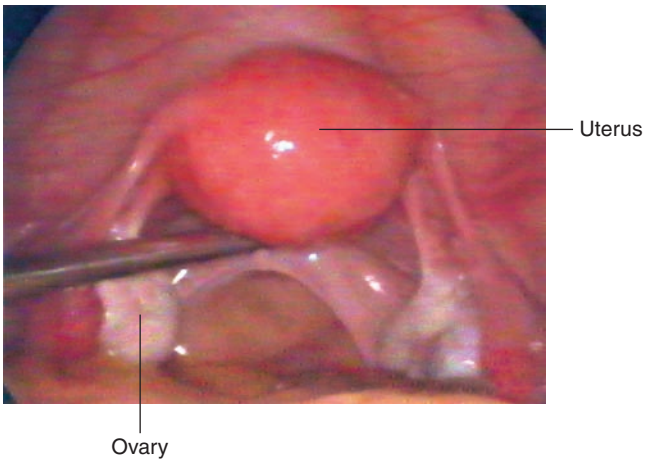


Figure 1.1 General view of internal genital organs showing the normal uterus and ovaries.

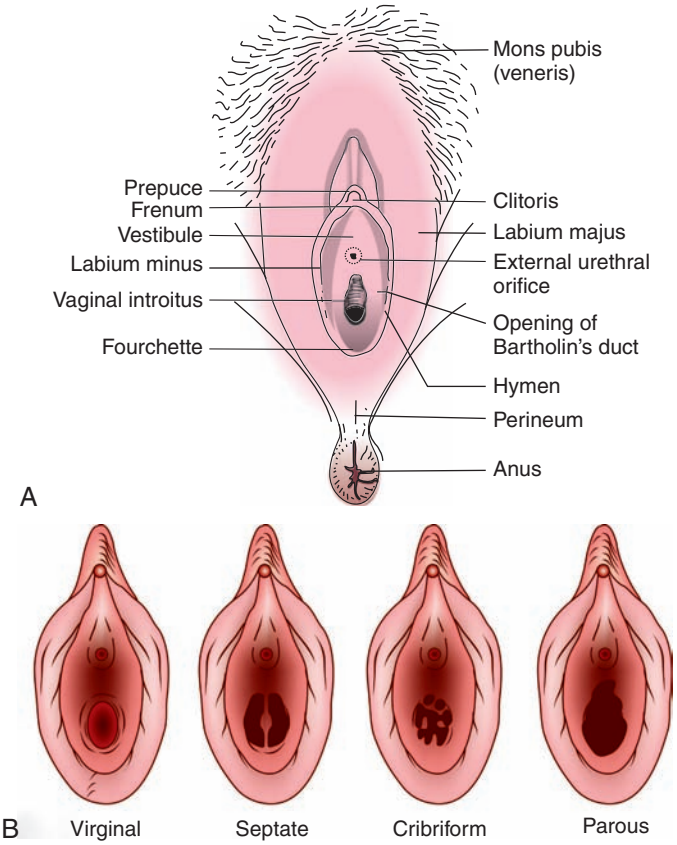


Figure 1.2 **(A)** Anatomy of the vulva. **(B)** Variations of the hymen.

thumb when enlarged by inflammation. Its vascular bed accounts for the brisk bleeding, which always accompanies its removal. Its duct passes forwards and inwards to open, external to the hymen, on the inner side of the labium minus. The gland measures about 10 mm in diameter and lies near the junction of the middle and posterior thirds of the labium majus. The duct of the gland is about 25 mm long and a thin mucous secretion can be expressed from it by pressure upon the gland. Bartholin's gland and its duct are infected in acute gonorrhoea, when the reddened mouth of

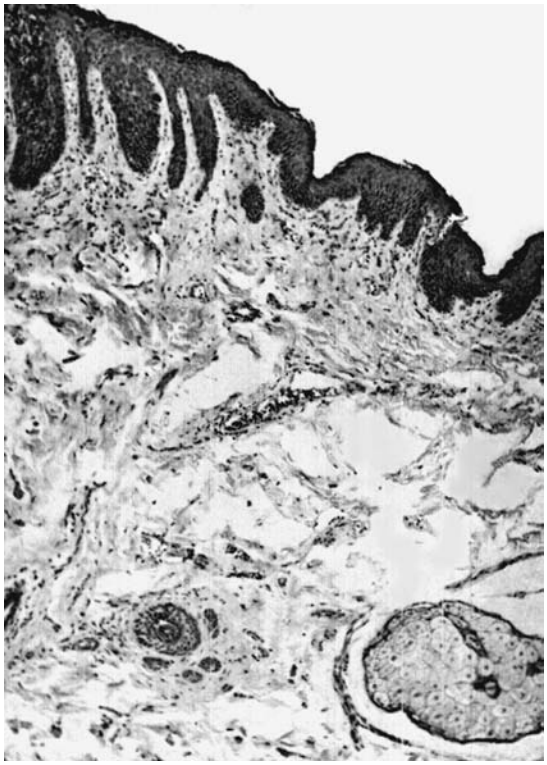


Figure 1.3 Histological section of the labium majus showing squamous epithelium with hair follicle and sebaceous gland (×55).

the duct can easily be distinguished on the inner surface of the labium minus to one side of the vaginal orifice below the level of the hymen. Bartholin's gland is a compound racemose gland and its acini are lined by low columnar epithelium (Figure 1.4). The epithelium of the duct is cubical near the acini, but becomes transitional and finally squamous near the mouth of the duct. The function of the gland is to secrete lubricating mucous during coitus. The labia majora join at the posterior commissure and merge imperceptibly into the perineum.

Labia Minora

The labia minora are thin folds of skin which enclose veins and elastic tissue and lie on the inner aspect of the labia majora. The vascular labia minora are erectile during sexual activity; they do not contain any sebaceous glands or hair follicles (Figure 1.5). Anteriorly, they enclose the clitoris to form the prepuce on the upper surface and the frenulum on its undersurface. Posteriorly, they join to form the fourchette. The fourchette is a thin fold of skin, identified when the labia are separated, and it is often torn during parturition. The fossa navicularis is the small hollow between the hymen and the fourchette. Labia minora is homologous with the ventral aspect of the penis.

The **clitoris** is an erectile organ and consists of a glans, covered by the frenulum and prepuce, and a body which is subcutaneous; it corresponds to the penis and is attached to the undersurface of the symphysis pubis by the suspensory ligament. Normally, the clitoris is 1–1½ cm long and 5 mm

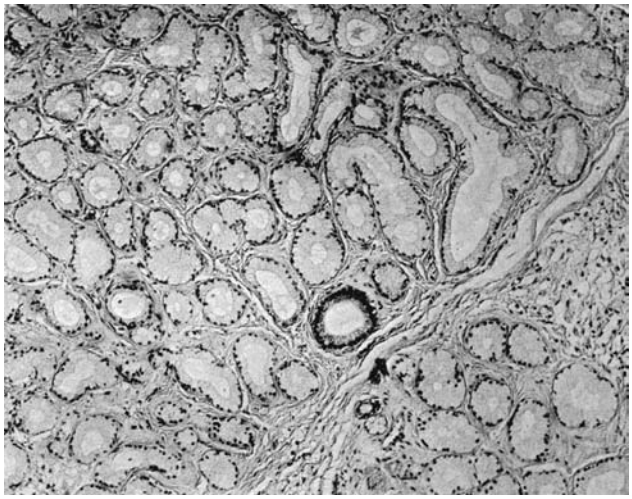


Figure 1.4 Bartholin's gland. Low-power view showing the structure of a compound racemose gland with acini lined by low columnar epithelium (×92).

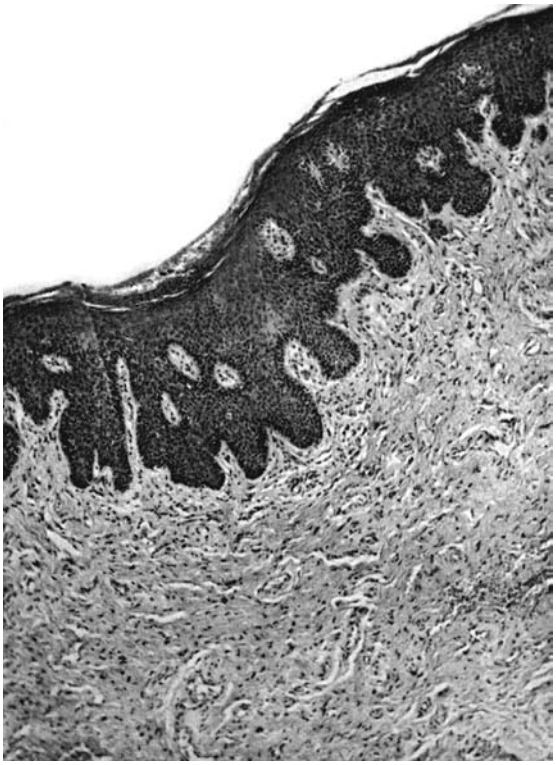


Figure 1.5 Histological section of the labium minus showing squamous epithelium. Note complete absence of hair follicles and sebaceous and sweat glands.

in width. Clitoris of more than 3.5 cm in length and 1 cm in width is called clitoromegaly, and occurs in virilism due to excess of androgen hormone. The clitoris is well supplied with nerve endings and is extremely sensitive. During coitus it becomes erect and plays a considerable part in inducing orgasm in the female. The clitoris is highly vascular. An injury to the clitoris causes profuse bleeding and can be very painful.

The **vestibule** is the space lying between the anterior and the inner aspects of the labia minora and is bounded posteriorly by the vaginal introitus. The *external urinary meatus lies* immediately posterior to the clitoris. The vaginal orifice lies posterior to the meatus and is surrounded by the hymen. In virgins, the hymen is represented by a thin membrane covered on each surface by squamous epithelium. It generally has a small eccentric opening, which is usually not wide enough to admit the fingertip. Coitus results in the rupture of the hymen; the resulting lacerations are radially arranged and are multiple. Occasionally, coital rupture can cause a brisk haemorrhage. During childbirth, further lacerations occur: the hymen is widely stretched and subsequently is represented by the tags of skin known as the carunculae myrtiformes. With the popularity of the use of internal sanitary tampons, the loss of integrity of the hymen is no longer an evidence of loss of virginity.

The vulval tissues respond to hormones, especially oestrogen, during the childbearing years. After menopause, atrophy due to oestrogen deficiency makes the vulval skin thinner and drier, and this may lead to atrophic vulvitis and itching. *Mons pubis* is an area which overlaps the symphysis pubis and contains fat. At puberty, abundant hair grow over it.

The Vagina

The vagina is a fibromuscular passage that connects the uterus to the introitus. The lower end of the vagina lies at the level of the hymen and of the introitus vaginae. It is surrounded at this point by the erectile tissue of the *bulb*, which corresponds to the corpus spongiosum of the male. The direction of the vagina is approximately parallel to the plane of the brim of the true pelvis; the vagina is slightly curved forwards from above downwards, and its anterior and posterior walls lie in close contact. It is not of uniform calibre, being nearly twice as capacious in its upper part and somewhat flask shaped. The vaginal portion of the cervix projects into its upper end and leads to the formation of the anterior, posterior and lateral fornices. The depth of the fornices depends upon the development of the portio vaginalis of the cervix. In girls before puberty and in elderly women in whom the uterus has undergone postmenopausal atrophy, the fornices are shallow while in women with congenital elongation of the portio vaginalis of the cervix, the fornices are deep. The vagina is attached to the cervix at a higher level posteriorly than elsewhere, and this makes the posterior fornix the deepest of the fornices and the posterior vaginal wall longer than the anterior. The posterior wall is 4.5 inch (11.5 cm) long, whereas the anterior wall measures 3.5 inch (9 cm). Transverse folds which are present in the vaginal walls of nulliparae allow the vagina to stretch and dilate during coitus and parturition. These folds are partly obliterated in women who have borne many children. In the anterior vaginal wall, three sulci can be distinguished. One lies immediately above the meatus and is called *submeatal sulcus* (Figure 1.6). About 35 mm above this sulcus in the anterior vaginal wall is a second sulcus, known as the *transverse vaginal sulcus,* which corresponds approximately

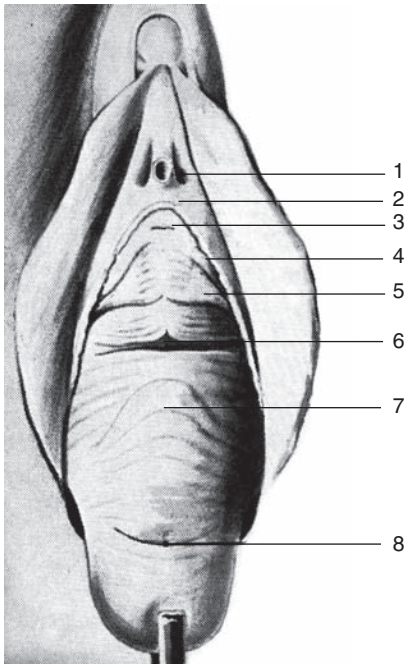
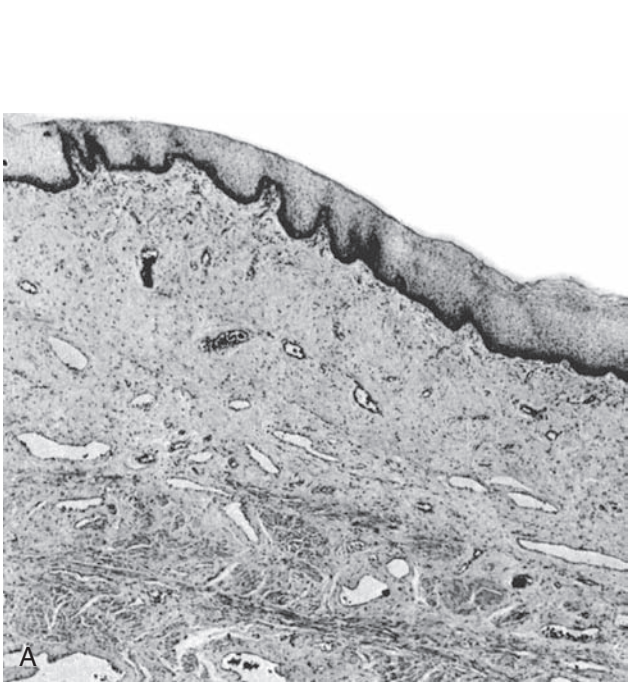


Figure 1.6 A case of prolapse in which the cervix has been drawn down. (1) Parameatal recess, (2) hymen, (3) submeatal sulcus, (4) paraurethral recess, (5) oblique vaginal fold, (6) transverse sulcus of the anterior vaginal wall, (7) arched rugae of the vaginal wall and (8) bladder sulcus.

to the junction of the urethra and the bladder. Further upwards is the *bladder sulcus*, indicating the junction of the bladder to the anterior vaginal wall.

The vaginal mucosa is lined by nonkeratized squamous epithelium which consists of a basal layer of cuboidal cells, a middle layer of prickle cells and a superficial layer of cornified cells (Figure 1.7). In the newborn, the epithelium is almost transitional in type and cornified cells are scanty until puberty is reached. No glands open into the vagina, and the vaginal secretion is derived partly from the mucous discharge of the cervix and partly from transudation through the vaginal epithelium. The subepithelial layer is vascular and contains much erectile tissue. A muscle layer consisting of a complex interlacing lattice of plain muscle lies external to the subepithelial layer while the large vessels lie in the connective tissues surrounding the vagina. If the female fetus is exposed to diethylstilboestrol (DES) taken by the mother during pregnancy, columnar epithelium appears in the upper two-thirds of vaginal mucosa, which can develop vaginal adenosis and vaginal cancer during adolescence. The keratinization of vaginal mucosa occurs in prolapse due to the exposure of vagina to the outside and ulcer may form over the vaginal mucosa (decubitus ulcer). The keratized mucosa appears skin-like and brown. Menopause causes atrophy of the vagina.

The *vaginal secretion* is small in amount in healthy women and consists of white coagulated material. When it is examined under the microscope, squamous cells which have been shed from the vaginal epithelium and Döderlein's bacilli alone are found. *Döderlein's bacillus* is a large Gram-positive rod-shaped organism, which grows anaerobically on acid media. The vaginal secretion is acidic due to the presence of lactic acid, and this acidity inhibits the growth of pathogenic organisms. The pH of the vagina averages about 4.5 during reproductive life. The acidity, which is undoubtedly oestrogen dependent, falls after menopause to neutral or even alkaline. Before puberty, the pH is about 7. This high pH before puberty and after menopause explains



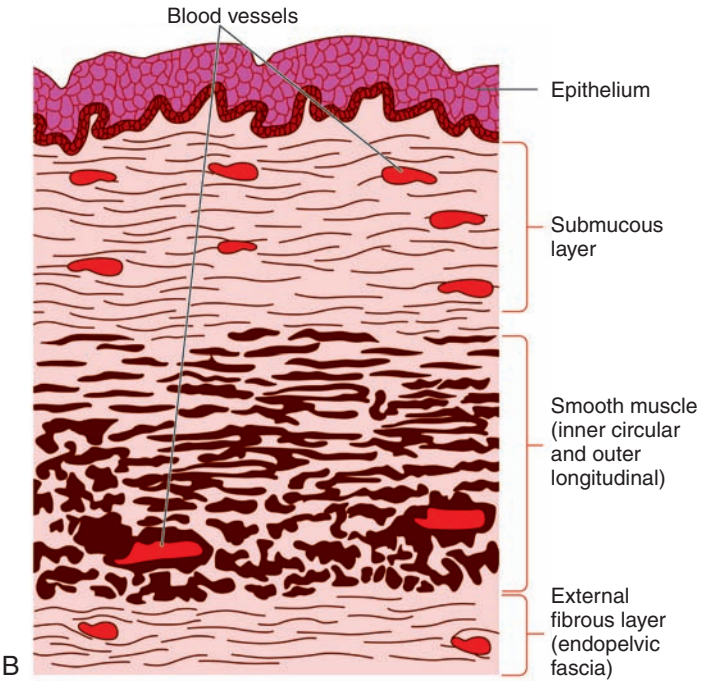


Figure 1.7 **(A)** Low-power (×36) microscopic appearance of the vaginal wall showing the corrugated squamous epithelium and bundles of plain muscle cells subjacent to the vascular subepithelial layer. **(B)** Structure of the vaginal wall.

the tendency for the development of mixed organism infections in these age groups.

The synthesis of lactic acid is probably influenced by either enzyme or bacterial activity (Döderlein's) on the glycogen of the epithelial cells, which itself is dependent on the presence of oestrogen, so that its deficient activity can be boosted by the administration of oral or local oestrogen. During the puerperium and also in cases of leucorrhoea, the acidity of the vagina is reduced and pathogenic organisms are then able to survive. The squamous cells of the vagina and cervix stain a deep brown colour after being painted with iodine solution, owing to the presence of glycogen in healthy cells (positive Schiller's test). In a postmenopausal woman, because of the absence of or low glycogen-containing superficial cells, Schiller's test becomes negative.

The vaginal epithelium is under the ovarian hormonal influences of oestrogen and progesterone. Oestrogen proliferates the glycogen-containing superficial cells and progesterone causes proliferation of intermediate cells. Lack of these hormones in a menopausal woman leaves only the basal cells with a thin vaginal mucosa.

The abnormal and malignant cells also do not contain glycogen and do not take up the stain. Similarly, these abnormal cells turn white with acetic acid due to coagulation of protein. These areas are selected for biopsy in the detection of cancer.

Relations of Vagina

Anterior Relation

In its lower half the vagina is closely related to the urethra and the paraurethral glands (Skene's tubules), so closely in fact that the urethrovaginal fascia is a fused structure and only separable by a sharp dissection. In its upper half the vagina is related to the bladder in the region of the trigone, and here the vesical and vaginal fasciae are easily separable by blunt dissection via the vesicovaginal space. There is a considerable vascular and lymphatic intercommunication between the vesical and the vaginal vessels, a sinister relationship having a bearing on the surgery of malignant disease of this area.

Posterior Relations

The lower third of the vagina is related to the perineal body, the middle third to the ampulla of the rectum and the upper third to the anterior wall of the pouch of Douglas, which contains large and small bowel loops. This partition dividing the vagina from the peritoneal cavity is the thinnest area in the whole peritoneal surface and, therefore, a site of election for pointing and opening of pelvic abscess or the production of a hernia or enterocele. This is also an ideal site for colpocentesis in the diagnosis of ectopic pregnancy.

Pouch of Douglas (Figure 1.8) is a peritoneal cul-de-sac in the rectovaginal space in the pelvis. It is bounded anteriorly by the peritoneum covering the posterior vaginal wall and posteriorly by the peritoneum covering the sigmoid colon and the rectum. Laterally, the uterosacral ligaments limit its boundary whereas the floor is the reflection of the peritoneum of the peritoneal cavity.

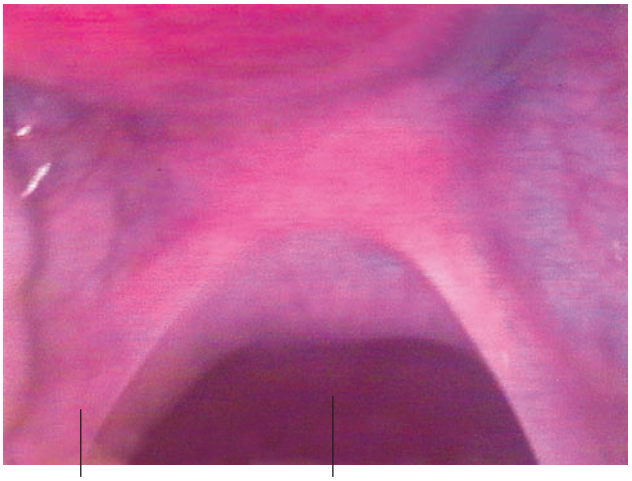


Figure 1.8 Pouch of Douglas showing uterosacral ligaments as upper border.

The endometriotic nodules and metastatic growth of an ovarian cancer are felt in the pouch of Douglas, so also pelvic inflammatory mass. The uterosacral ligaments are thickened and become nodular in advanced cancer cervix.

Lateral Relations

The lateral relations from below upwards are the cavernous tissue of the vestibule; the superficial muscles of the perineum; the triangular ligament and at about 2.5 cm from the introitus the levator ani, lateral to which is the ischiorectal fossa. Above the levator lies the endopelvic cellular tissue, and its condensation, called Mackenrodt's ligament, on either side. The ureter traverses this tissue in the ureteric canal and is about 12 mm anterolateral to the lateral fornix.

Superior Relations

The cervix with its four fornices—anterior, posterior and two lateral—are related to the uterine vessels, Mackenrodt's ligament and the ureter. Posteriorly, surrounding the pouch of Douglas lie the uterosacral ligaments which can be identified on vaginal examination, especially if thickened by disease such as endometriosis and cancer cervix.

Squamocolumnar junction, also known as transitional zone, is clinically a very important junction where the squamous epithelium lining the vagina merges with the columnar epithelium of the endocervix and is 1–10 mm (Figure 1.9). Here, the constant cellular activity of the cells takes place, and the cells are highly sensitive to irritants, mutagens and viral agents such as papilloma virus 16, 18. These cause nuclear changes that can eventually lead to dysplasia and carcinoma cervix, which is the most common malignancy of the female genital tract in India. Squamocolumnar junction is of two types: first one is embryonic when columnar epithelium spreads over the external os. After

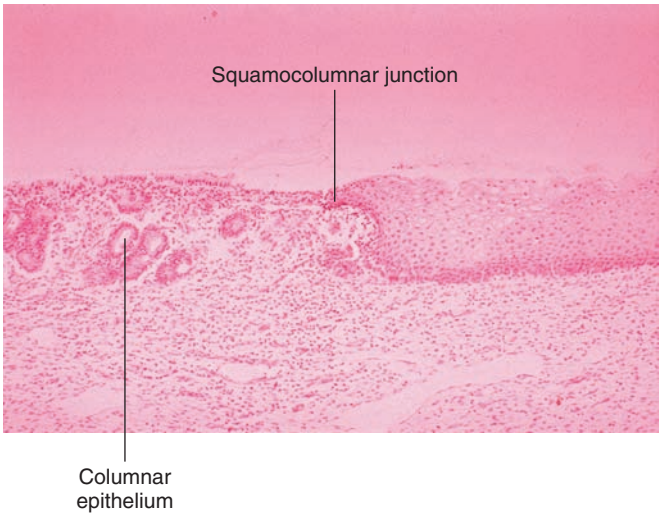


Figure 1.9 Squamocolumnar junction. In the 'ideal' cervix, the original squamous epithelium abuts the columnar epithelium. (Source: Hacker NF, Gambone JC, Hobel CJ, Hacker and Moore's Essentials of Obstetrics and Gynecology, 5th ed. Philadelphia: Elsevier, 2010.)

puberty, metaplasia of columnar epithelium under the influence of oestrogen brings squamous epithelium close to the external os, thus creating transitional zone between the two junctions. In women exposed to DES in utero, this zone is well outside the os, spreading over the vaginal vault. In a menopausal woman, it gets indrawn inside the os. During pregnancy and with oral contraceptives, it pouts out of os.

The squamocolumnar junction is well outside the external os during the reproductive period, and in Pap smear this area is scraped and the cytology of its cells studied for the nuclear changes, in the screening programme for cancer cervix.

During pregnancy, the external os becomes patulous and the squamocolumnar junction is well exposed all round. Pap smear yields the most accurate cytological findings.

In menopausal women, the cervix shrinks and the squamocolumnar junction gets indrawn into the cervical canal. It is therefore not easily accessible, and ill exposed to the vagina, for visual inspection. This explains high false-negative findings in Pap smear in older women. Giving oestrogen locally or orally or prostaglandin E (misoprostol) pessary allows this junction to pout out and improves the efficacy of the Pap smear cytology.

The squamocolumnar junction is studied colposcopically when the Pap smear shows abnormal cells, and the abnormal areas are biopsied for cancer detection.

The Uterus

The uterus is pyriform in shape and measures approximately 9 cm in length, 6.5 cm in width and 3.5 cm in thickness. It is divided anatomically and functionally into body and cervix. It weighs 1 ounce (60 g). The line of division corresponds to the level of the internal os, and here the

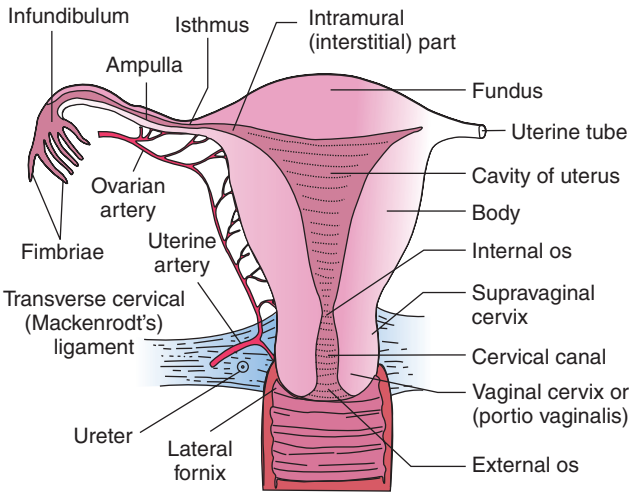


Figure 1.10 A nulliparous uterus showing the anatomical structures.

mucous membrane lining the cavity of the uterus becomes continuous with that of the cervical canal (Figure 1.10). At this level the peritoneum of the front of the uterus is reflected on to the bladder, and the uterine artery, after passing almost transversely across the pelvis, reaches the uterus, turns at right angle and passes vertically upwards along the lateral wall of the uterus. The cervix is divided into vaginal and supravaginal portions. The fundus of the uterus is that part of the corpus uteri which lies above the insertion of the fallopian tubes. The cavity of the uterus communicates above with the openings of the fallopian tubes, and by way of their abdominal ostia is in direct continuity with the peritoneal cavity. The uterine cavity is triangular in shape with a capacity of 3 mL. The lower angle is formed by the internal os. The lateral angle connecting to the fallopian tube is called the cornual end. The wall of the uterus consists of three layers, the peritoneal covering called perimetrium, the muscle layer or myometrium and the mucous membrane or endometrium.

The uterus is capable of distension during pregnancy, as well as with distended media during hysteroscopic examination. Otherwise the two walls are in opposition.

Perimetrium

The peritoneal covering of the uterus is incomplete. Anteriorly, the whole of the body of the uterus is covered with peritoneum. The peritoneum is reflected on to the bladder at the level of the internal os. The cervix of the uterus has therefore no peritoneal covering anteriorly. Posteriorly, the whole of the body of the uterus is covered by peritoneum, as is the supravaginal portion of the cervix. The peritoneum is reflected from the supravaginal portion of the cervix on to the posterior vaginal wall in the region of the posterior fornix. The peritoneal layer is incomplete laterally because of the insertion of the fallopian tubes, the round and ovarian ligaments into the uterus, and below this level the two sheets of peritoneum, which constitute the broad ligament, leave a thin bare area laterally on each side.

Myometrium

The myometrium is the thickest of the three layers of the wall of the uterus. In the cervix the myometrium consists of plain muscle tissue together with a large amount of fibrous tissue, which gives it a hard consistency. The muscle fibres and fibrous tissues are mixed together without orderly arrangement. In the body of the uterus the myometrium measures about 10–20 mm in thickness, and three layers can be distinguished which are best marked in the pregnant and puerperal uterus. The external layer lies immediately beneath the peritoneum and is longitudinal, the fibres passing from the cervix anteriorly over the fundus to reach the posterior surface of the cervix. This layer is thin and cannot easily be identified in the nulliparous uterus. The main function of this layer is a detrusor action during the expulsion of the fetus. The middle layer is the thickest of the three and consists of bundles of muscle separated by connective tissue, the exact amount of which varies with age; plain muscle tissue is best marked in the childbearing period, especially during pregnancy while before puberty and after menopause it is much less plentiful. There is a tendency for the muscle bundles to interlace, and as the blood vessels which supply the uterus are distributed in the connective tissues, the calibre of the vessels is in part controlled by the contraction of the muscle cells. The purpose of this layer is therefore in part haemostatic, though its expulsive role is equally important. This layer is described as *living ligatures of the uterus*, and is responsible for control of bleeding in the third stage of labour. Inefficient contraction and retraction of these muscle fibres cause prolonged labour and atonic postpartum haemorrhage (PPH).

The inner muscle layer consists of circular fibres. The layer is never well marked and is best represented by the circular muscle fibres around the internal os and the openings of the fallopian tubes. It can be regarded as sphincteric in action. The myometrium is thickest at the fundus (1–2 cm) and thinnest at the cornual end (3–4 mm), one should therefore be careful during curettage and endometrial ablation not to perforate the cornual end.

Endometrium

The endometrium or mucous membrane lining the cavity of the uterus has a different structure from that of the endocervix. It is described in Chapter 2, 'Normal Histology'.

The cervix is spindle shaped and measures 2.5 cm or a little more. It is bounded above by the internal os and below by the external os (Figure 1.10). The mucosal lining of the cervix differs from that of the body of the uterus by the absence of a submucosa. The endocervix is lined by a single layer of high columnar ciliated epithelium with spindle-shaped nuclei lying adjacent to the basement membrane with abundant cytoplasm and mucin. The direction of the cilia is downwards towards the external os. The glands are racemose in type (Figure 1.11A and B) and secrete mucus with a high content of fructose glycoprotein, mucopolysaccharide and sodium chloride. The secretion is alkaline and has a pH of 7.8 and its fructose content renders it attractive to ascending spermatozoa. This secretion collects as a plug in the cervical canal and possibly hinders ascending infections. In gonococcal and chlamydial infections of the cervix, the organisms collect amongst the crypts of the cervical glands. In nulliparous women, the external os is circular but vaginal delivery results in the transverse slit which characterizes the parous cervix. The cervix contains more of fibrous tissue and collagen than the muscle fibres, which are dispersed scarcely amongst the fibrous tissue. Cervix contains mainly collagen and only 10% of muscle fibres. Light microscopic examination reveals 29% muscle fibres in its upper one-third, 18% in the middle one-third and only 6% in the lower one-third, whereas the body of the uterus contains 70% muscle fibres. The change from fibrous tissue of cervix to the muscle tissue of the body is quite abrupt. In late pregnancy and at term, under the influence of

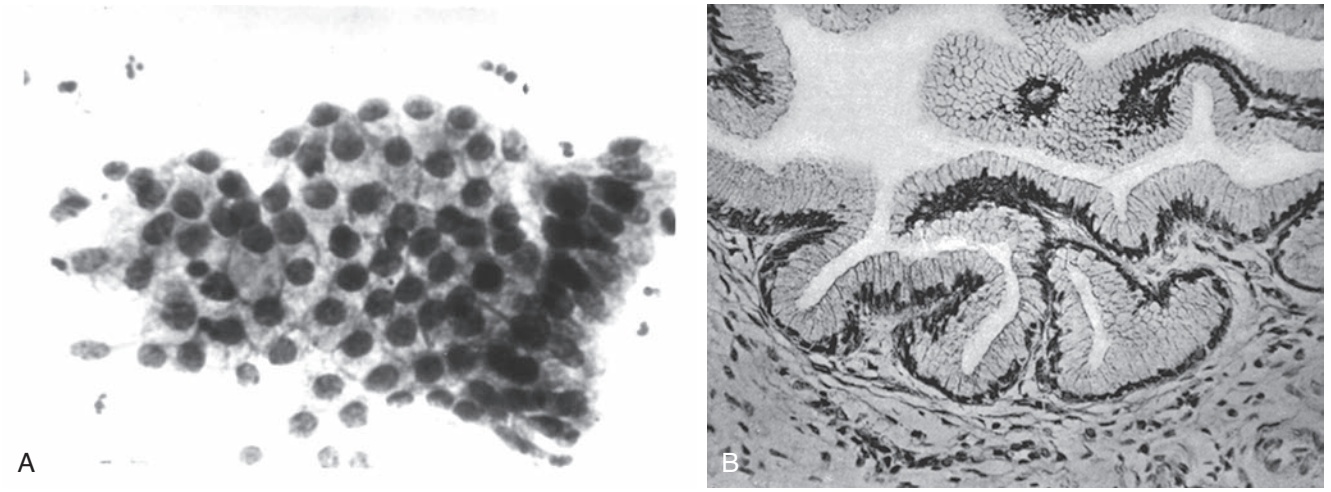


Figure 1.11 (**A**) Normal endocervical cells. (**B**) Normal cervical glands. These are of the racemose type and are lined by high columnar epithelium which secretes mucous (×250).

prostaglandin, collagenase dissolves collagen into fluid form and renders the cervix soft and stretchable during labour.

Functions of the endocervical cell lining are as follows:

- The cilia are directed downwards and prevent ascending infection.
- The cells sieve out abnormal sperms and allow healthy sperms to enter the uterus.
- It provides nutrition to the sperms.
- It allows capacitation of sperms.

Structurally and functionally, the body of the uterus and that of the cervix are in marked contrast. The cervical epithelium shows no periodic alteration during the menstrual cycle, and the decidual reaction of pregnancy is seen only rarely in the cervix. Similarly, the malignant disease of the uterus is an adenocarcinoma of the endometrium while carcinoma of the cervix is usually a squamous cell growth of high malignancy.

An intermediate zone, *the isthmus,* 6 mm in length, lies between the endometrium of the body and the mucous membrane of the cervical canal. Its epithelial lining resembles and behaves like the endometrium of the body. The isthmic portion stretches during pregnancy and forms the lower uterine segment in late pregnancy. This isthmic portion is less contractile during pregnancy and labour but further stretches under uterine contractions. It is identified during caesarean delivery by the loose fold of peritoneal lining covering its anterior surface.

The relationship between the length of the cervix and that of the body of the uterus varies with age. Before puberty, the cervix to corpus ratio is 2:1. At puberty, this ratio is reversed to 1:2, and during the reproductive years, cervix to corpus ratio may be 1:3 or even 1:4. After menopause, the whole organ atrophies and the portio vaginalis may eventually disappear.

Whereas the endometrial secretion is scanty and fluid in nature, the cervical secretion is abundant and its quality and quantity change in the different phases of the menstrual cycle, under different hormonal effects. The cervical mucous is rich in fructose, glycoprotein and mucopolysaccharides. Fructose is nutritive to sperms during their passage in the cervical canal. Under oestrogenic influence in the preovulatory phase, the glycoprotein network is arranged parallel to each other and facilitates sperm penetration, whereas under the progesterone secretion, the network forms interlacing bridges and prevents their entry into the cervical canal. This property of progesterone is used in contraceptive pill and progesterone-impregnated intrauterine contraceptive device. Sodium chloride content in the mucous increases at ovulation and forms a fern-like pattern when a drop of mucous is dried on a slide and studied under microscope.

Position of the Uterus

The uterus normally lies in a position of anteversion and anteflexion. The body of the uterus is bent forwards on the cervix approximately at the level of the internal os, and this forward inclination of the body of the uterus on the cervix constitutes anteflexion. The direction of the axis of the cervix depends upon the position of the uterus. In anteversion (Figure 1.12B), the external os is directed downwards and backwards so that on vaginal examination the examining fingers find that the lowest part of the cervix is the anterior lip. When the uterus is retroverted the cervix is directed downwards and forwards, and the lowest part of the cervix is either the external os or the posterior lip. As a result of its normal position of anteflexion, the body of the uterus lies against the bladder. The pouch of peritoneum that separates the bladder from the uterus is the uterovesical pouch. The peritoneum is reflected from the front of the uterus on to the bladder at the level of the internal os.

Posteriorly, a large peritoneal pouch lies between the uterus and the rectosigmoid colon. If the uterus is pulled forwards, two folds of peritoneum can be seen to pass backwards from the uterus to reach the parietal peritoneum lateral to the rectum. These folds, the uterosacral folds, lie at the level of the internal os and pass backwards and upwards. The uterosacral ligaments are condensation of the pelvic cellular tissues and lie at a lower level and within the uterosacral folds. The pouch of peritoneum below the level of the uterosacral folds, which is bounded in front by the peritoneum covering the upper part of the posterior vaginal wall and posteriorly by the peritoneum covering the sigmoid colon and the upper end of the rectum, is the pouch of Douglas. The posterior fornix of the vagina is in close relation to the peritoneal cavity, as only the posterior vaginal wall and a single layer of peritoneum separate the vagina from the peritoneal cavity. Collection of pus in the pouch of Douglas can therefore be evacuated without difficulty by incising the vagina in the region of the posterior fornix. On the other hand, the uterovesical pouch is approached with difficulty from the vagina; first the vagina must be incised and then the bladder separated from the cervix and the vesicocervical space traversed before the uterovesical fold of the peritoneum is reached (Figure 1.12A).

The Uterine Appendages

The uterus projects upwards from the pelvic floor into the peritoneal cavity and carries on each side of it two folds of peritoneum, which pass laterally to the pelvic wall and form the *broad ligaments.* The fallopian tubes pass outwards from the uterine cornua and lie in the upper border of the broad ligaments. The ovarian ligaments posteriorly, and the round ligaments anteriorly, also pass into the uterine cornua, but at a slightly lower level than the fallopian tubes. Both these ligaments and the fallopian tubes are covered with peritoneum.

The *round ligament* passes from the uterine cornua beneath the anterior peritoneal fold of the broad ligament to reach the internal abdominal ring. In this part of its course it is curved and lies immediately beneath the peritoneum, and is easily distinguished. The round ligament passes down the inguinal canal and finally ends by becoming adherent to the skin of the labia majora. The ligaments consist

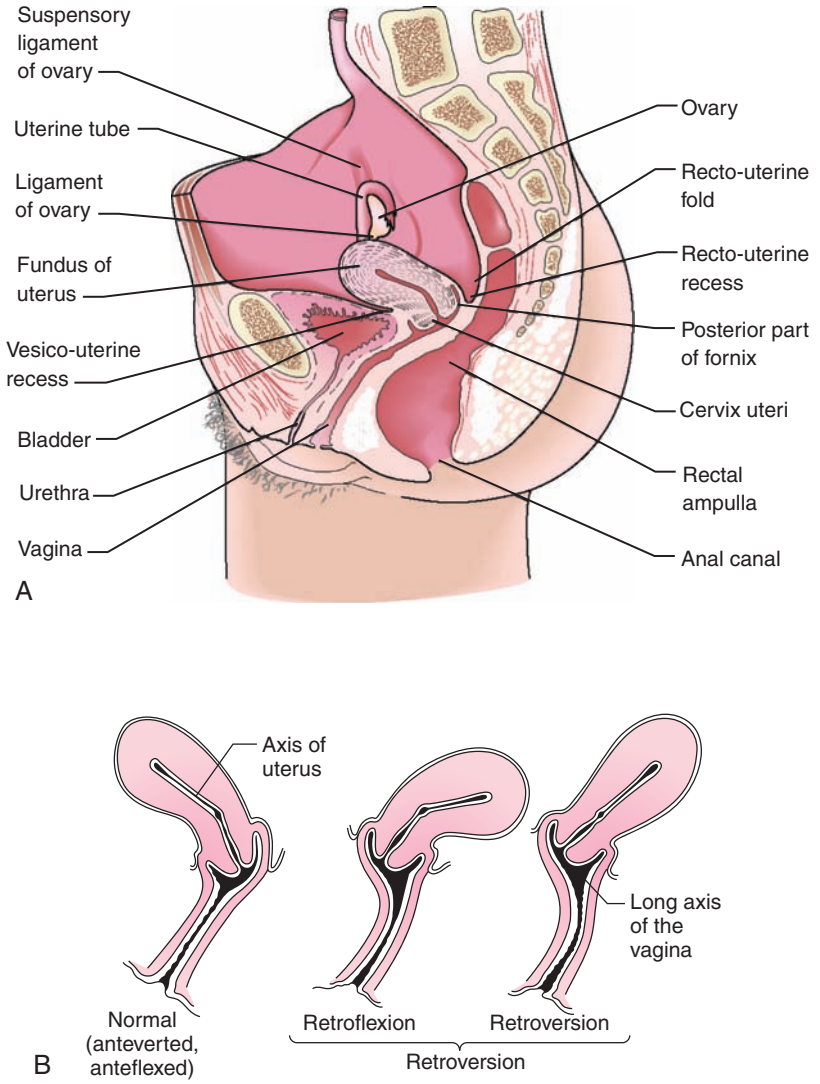


Figure 1.12 **(A)** The relationship of the female reproductive organs: sagittal section. (From Figure 7-1. Chris Brooker: Alexander's Nursing Practice, 4th Ed. Churchill Livingstone: Elsevier, 2011.) **(B)** Anteverted, anteflexed and retroverted uterus.

of plain muscle and connective tissue and vary considerably in thickness. They hypertrophy during pregnancy. The round ligaments are much better developed in multiparae than in nulliparae. They are most remarkably hypertrophied in the presence of large fibroids when they may attain a diameter of 1 cm. They correspond developmentally to the gubernaculum testis and are morphologically continuous with the ovarian ligaments, as during intrauterine life the ovarian and round ligaments are continuous and connect the lower pole of the primitive ovary to the inguinal canal. The round ligaments are lax and, except during labour, are free of tension. There is no evidence that the normal position of anteflexion and anteversion of the uterus is produced by contraction of the round ligaments. The ligaments, however, may be shortened by operation or they may be attached to the anterior abdominal wall, both procedures being used to cause anteversion in a uterus which is pathologically retroverted. The round ligaments are supplied by a branch of the ovarian artery derived from its anastomosis with the uterine artery, hence the necessity for ligation of the round ligament during hysterectomy. Along it lymphatic vessels pass from the fundus, which connect with those draining the labium majus into the inguinal glands. This explains the possibility of metastases in these glands in late cases of cancer of the endometrium of the fundus.

The *ovarian ligaments* pass upwards and inwards from the inner poles of the ovaries to reach the cornua of the uterus (Figure 1.13) below the level of the attachment of the fallopian tubes. They lie beneath the posterior peritoneal fold of the broad ligament and measure about 2.5 cm in length. Like the round ligaments, they consist of plain muscle fibres and connective tissue, but they are not so prominent because they contain less plain muscle tissue. They are morphologically a continuation of the round ligament (contents of broad ligaments are listed in Table 1.1).

Infundibulopelvic ligament is that portion of the broad ligament that extends from the infundibulum of the fallopian tube to the lateral pelvic wall. It encloses the ovarian vessels, lymphatics and nerves of the ovary. The ureter

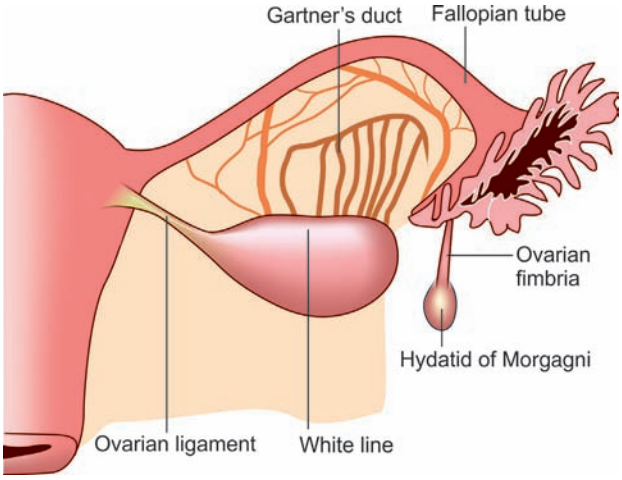


Figure 1.13 The right uterine appendages viewed from behind.

TABLE 1.1 Contents of broad ligament

- Fallopian tube—upper portion
- Round ligament—anteriorly
- Ovarian ligament—posterior fold
- Vestigial structures of Wolffian body—epoophoron and paroophoron
- Vestigial structure of Wolffian duct—Gartner's duct
- Ureter
- Uterine vessels
- Pelvic nerves
- Parametrial lymph node
- Pelvic cellular tissue condensed to form Mackenrodt's ligament
- Infundibulopelvic ligament

is also in close contact and can be damaged during clamping of this ligament.

Mesovarium attaches the ovary to the posterior fold of peritoneum of the broad ligament and contains vessels, lymphatics and nerves of the ovary. Mesosalpinx lies between the fallopian tube and the ovary and contains the anastomotic vessels between the ovary and uterus and the vestigial structures of the Wolffian body and the duct (see section on The Ovaries).

Fallopian Tubes

Each fallopian tube (Figures 1.13 and 1.14) is attached to the uterine cornu and passes outwards and backwards in the upper part of the broad ligament. The fallopian tube measures 4 inch (10 cm) or more in length and approximately 8 mm in diameter, but the diameter diminishes near the cornu of the uterus to 1 mm. The fallopian tube is divided anatomically into four parts:

1. **The interstitial portion** is the innermost part of the tube which traverses the myometrium to open into the endometrial cavity. It is the shortest part of the tube, its length being the thickness of the uterine muscle, about 18 mm. It is also the narrowest part, its internal diameter being 1 mm or less so that only the finest cannula can be passed into it during falloscopy examination. There are no longitudinal muscle fibres here but the circular fibres are well developed (Figure 1.15).
2. **The isthmus** comprises the next and inner part of the tube and represents about one-third of the total length, i.e. 35 mm. It is narrow but a little wider than the interstitial part and its lumen has a diameter of 2 mm. Its muscle wall contains both longitudinal and circular fibres, and it is covered by peritoneum except for a small inferior bare area related to the broad ligament. It is relatively straight.
3. **The ampulla** is the lateral, widest and longest part of the tube and comprises roughly two-thirds of the tube, measuring 2.5–3 inch (60–75 mm) in length. Here the mucosa is arborescent with many complex folds (Figure 1.16). Fertilization occurs in the ampullary portion of the fallopian tube.
4. **The fimbriated extremity or infundibulum** is where the abdominal ostium opens into the peritoneal cavity. The fimbriae are motile and almost prehensile, and enjoy a considerable range of movement and action. One fimbria—the ovarian fimbria—is larger and longer than

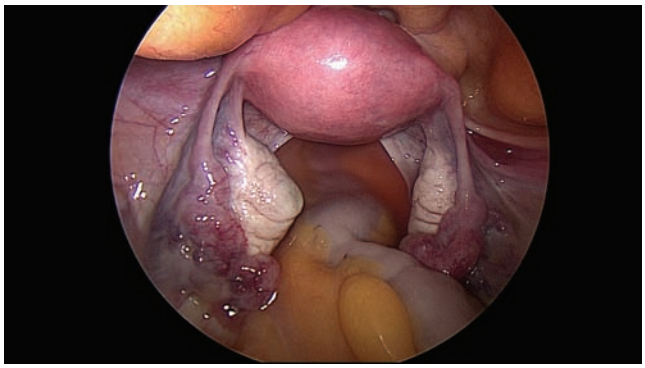


Figure 1.14 Laparoscopic view of the pelvis showing normal uterus and bilateral adnexa. (Courtesy: Dr Marwah.)

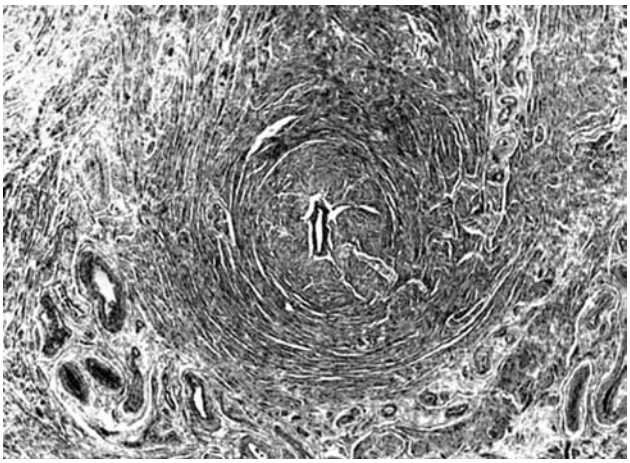


Figure 1.15 Interstitial part of fallopian tube. Note complete absence of plicae and the narrow calibre of the canal (×22).

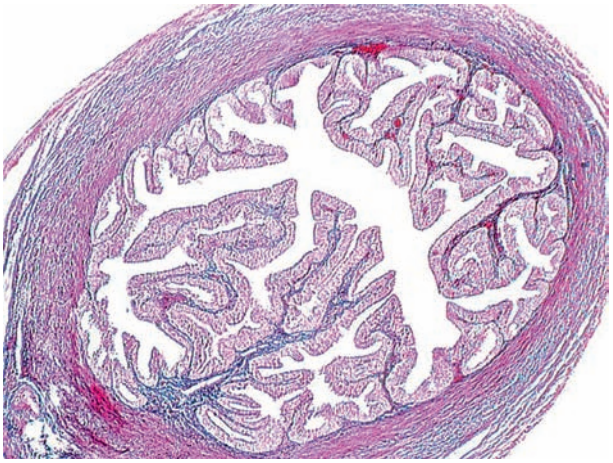


Figure 1.16 Ampullary portion of fallopian tube to show arrangement of plicae (×18). (Source: Gwen V Childs, PhD, Professor and Chair, Department of Neurobiology and Developmental Sciences, University of Arkansas for Medical Sciences, Little Rock.)

the others and is attached to the region of the ovary. This fimbria embraces the ovary at ovulation, picks up the ovum and carries it to the ampullary portion.

The fallopian tube represents the cranial end of the Müllerian duct, and its lumen is continuous with the cavity of the uterus. Consequently, spermatozoa and the fertilized ovum can pass along the tube. Fluids such as dyes and gases such as carbon dioxide may be injected through the uterus and by way of the fallopian tubes into the peritoneal cavity, and by these means the patency of the fallopian tubes can be investigated clinically by dye test (Figure 1.17). The fallopian tubes lie in the upper part of the broad ligaments and are covered with peritoneum except along a thin area inferiorly, which is left bare by the reflection of the peritoneum to form the two layers of the broad ligament. The blood supply of the fallopian tube is mainly derived from the tubal branches of the ovarian artery, but the anastomosing branch of the uterine artery supplies its inner part. Unlike the vermiform appendix, the fallopian tube does not become gangrenous when acutely inflamed, as it has two sources of blood supply which reach it at opposite ends. The lymphatics of the fallopian tube communicate with the lymphatics of the fundus of the uterus and with those of the ovary, and they drain along the infundibulopelvic ligament to the para-aortic glands near the origin of the ovarian artery from the aorta. Some drain into the pelvic glands.

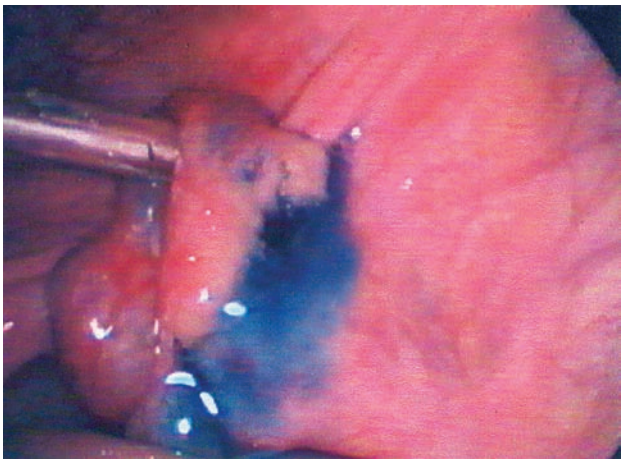


Figure 1.17 Fimbrial end of a patent fallopian tube. Dye test shows spill.

The fallopian tubes have three layers: serous, muscular and mucous. The serous layer consists of the mesothelium of the peritoneum. Intervening between the mesothelium and the muscle layer is a well-defined subserous layer in which numerous small blood vessels and lymphatics can be demonstrated. The muscular layer consists of outer longitudinal and inner circular fibres. The circular fibres are best developed in the isthmus and are thinned out near the fimbriated extremity. The mucous membrane is thrown into folds or plicae. Near the isthmus three folds can be recognized, but when traced laterally they divide and subdivide so that in the ampullary region they become highly complex. Each plica consists of stroma which is covered by epithelium. The stroma is cellular and its cells are in some ways similar to those of the endometrium. The blood vessels of the stroma are plentiful and are particularly well marked in the ampullary region. The epithelium of the mucous membrane consists of three types of cells: the most common is ciliated, and is either columnar or cubical in type. Its function is to propel a fluid current towards the uterus and plays some part in the transport of the inert ovum which, unlike the sperm, has no motile power of its own. Next in order of frequency is a goblet-shaped cell, not ciliated, which does not give the histochemical reactions for mucin. Its function is lubricant and possibly nutritive to the ovum. A cell intermediate in type to the two already mentioned can be distinguished, and small rod-shaped cells are also present. These are the so-called peg cells whose purpose is not known. It has been possible to demonstrate differences in the histological appearances of the epithelium of the fallopian tubes during the menstrual cycle. *The hysterosalpingogram, sonosalpingogram and laparoscopic chromotubation are the clinical methods of testing the patency of the fallopian tubes*. Laparoscopy also identifies external tubal adhesions.

The Ovaries

Each ovary weighs 4–8 g and measures about 35 mm in length, 25 mm in width and 18 mm in thickness. The ovary (Figures 1.14 and 1.18) is almond shaped, pearly grey due to a compact tunica albuginea, and the surface is slightly corrugated. Before puberty, the ovaries are small and located near the pelvic brim. After menopause they atrophy and become shrunken and the grooves and furrows on the surface become well marked. The menopausal ovary measures 20 mm × 10 mm × 15 mm with a volume of 8 mL or less. An ovary larger than this as measured ultrasonically

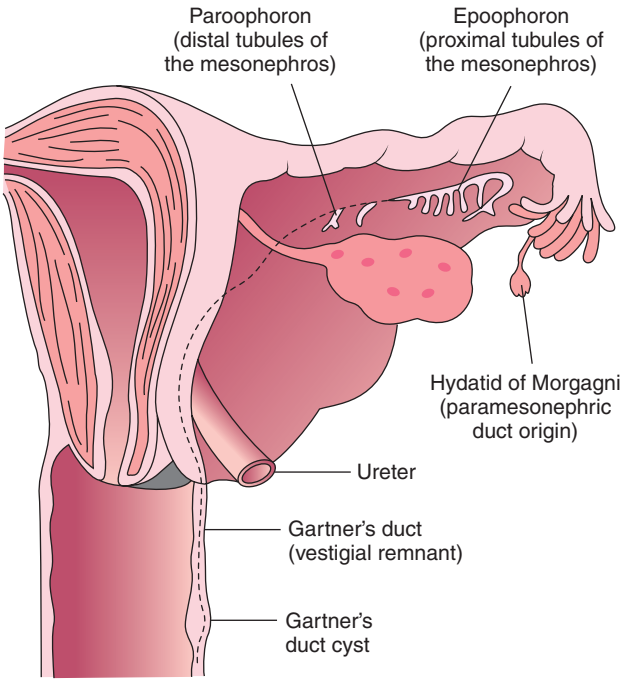


Figure 1.18 Remnants of the mesonephric (Wolffian) ducts that may persist in the anterolateral vagina or adjacent to the uterus within the broad ligament or mesosalpinx.

is of great concern in menopausal women. The ovary is attached to the back of the broad ligament by a thin mesentery, the *mesovarium*. Laterally, the ovary is related to the fossa below the bifurcation of the common iliac artery and the ureter. Medially, it is close to the fimbria of the fallopian tube, which stretches over it around ovulation. It is attached to the cornu of the uterus by the ovarian ligament. The infundibulopelvic ligament is the outer border of the broad ligament and contains the ovarian vessels, nerves and lymphatics. The ovaries are not normally palpable during bimanual examination, but cause pain on touch. The *epoophoron,* also known as the organ of Rosenmüller, represents the cranial end of the Wolffian body. It consists of a series of vertical tubules in the mesovarium and mesosalpinx between the fallopian tube above and the ovary below. Each tubule is surrounded by plain muscle and is lined by cubical cells.

The paroophoron represents the caudal end of the Wolffian body and similarly contains vertical tubules. It sometimes forms paraovarian cyst.

The Wolffian duct (Gartner's duct) is an imperfect duct which runs parallel to, but below, the fallopian tube in the mesosalpinx. The duct passes downwards by the side of the uterus to the level of the internal os where it passes into the tissues of the cervix. It then runs forwards to reach the anterolateral aspect of the vaginal wall and may reach as far down as the hymen. The duct sometimes forms a cyst, called Gartner's cyst, in the broad ligament or in the vagina, and may need surgical enucleation (Figure 1.18). Histology of the ovary is described in Chapter 2.

The Urethra

The urethra measures 35 mm in length and 5–6 mm in diameter. It passes downwards and forwards from the base of the bladder behind the symphysis pubis to end in the external meatus. Its epithelial lining consists of squamous epithelium at the external meatus, but becomes transitional in the canal. Deep to the epithelium is a layer rich in small vessels and connective tissue. The urethral wall comprises inner longitudinal and outer circular involuntary muscle fibres, which are arranged as crisscross spirals. The longitudinal fibres contract and shorten the urethra during micturition. The outer circular fibres keep the internal sphincter closed.

The neck of the bladder (internal urethral sphincter) lies above the levator ani muscles and thus maintains the continence of urine by receiving the same abdominal pressure as the bladder. The bladder base forms an angle of 100° with the posterior urethral wall (posterior urethrovesical angle), which is also responsible for maintaining urinary continence.

Relations

Posteriorly, upper portion of the urethra is loosely connected to the vagina by vesicovaginal fascia and can be dissected easily. In its lower one-third, it is firmly attached to the vagina by pubourethral ligament and requires a sharp dissection. Laterally, it is surrounded by the areolar tissue, the compressor urethra and the superficial perineal muscles. Pubourethral ligament fixes the mid-urethra to the pubic bone and the lateral pelvic wall and maintains continence of urine. Anteriorly, the urethra is separated from the pubic bone by the areolar tissue.

The external urinary meatus lies in the vestibule, 2 cm below the clitoris and is partly concealed by the upper end of the labia minora. Numerous periurethral glands surround the urethra and open by tiny ducts into its lumen. These are analogues of the prostate in males. The paraurethral glands of Skene are important paired glands which lie alongside the floor of the urethra and open by tiny ducts close to the external meatus. The glands when infected form periurethral abscess and cysts.

The proximal urethra derives blood supply from the inferior vesical artery and distal urethra from internal pudendal artery. The veins drain into the vesical plexus and internal pudendal vein. The urethra is innervated by the internal pudendal nerve. The urethra is developed from the cloaca.

The proximity of the urethra to the vagina makes it susceptible to infection spreading from the lower genital tract. The commonest infective organisms are gonorrhoea, chlamydia and trichomonads. The urethral swab, culture and urine culture can identify the organisms.

The Bladder

The bladder is a smooth muscle organ with a body and a trigone. It lies between the symphysis pubis in front and the uterus behind, being separated from the uterus by the

uterovesical peritoneum. It is a pelvic organ with a capacity to hold 500–600 mL of urine. The bladder distends upwards with a fixed base at the trigone, and then becomes palpable abdominally.

The bladder has an apex, a base, a superior and two inferolateral surfaces. The neck of the bladder (internal urinary sphincter) lies above the levator ani muscles, so that the raised abdominal pressure transmits the pressure equally to the bladder and its neck, hence maintaining urinary continence during coughing and sneezing. Anteriorly, lies the cave of Retzius (retropubic space). Posteriorly, it is in proximity to the uterus and supravaginal portion of the cervix, separated from them by the uterovesical pouch of peritoneum.

The ureters enter the bladder obliquely, and the area between the ureteric openings and the internal urinary sphincter forms a fixed triangular area called trigone. The apex is continuous with the urachus.

The bladder receives blood supply from the superior and inferior vesical arteries, and the pubic branch of the inferior epigastric artery. The venous plexus drains into internal iliac vein. The lymphatics drain into internal and external iliac glands.

Nerve Supply

The sympathetic outflow is from first and second lumbar segments of the spinal cord which inhibits contractions of the detrusor (bladder) muscle and maintains internal sphincteric contraction. The parasympathetic outflow from S2, S3 and S4 stimulates the detrusor muscle and relaxes the internal sphincter, thus initiating micturition. The sensory nerve fibres reach the central nervous system via the splanchnic nerves (parasympathetic S2–S4). The somatic afferent fibres travel with sympathetic nerves via hypogastric plexus and enter the first and second lumbar segments of the spinal cord. The bladder wall is lined by transitional epithelium, which gets folded when empty but allows bladder distension. The lining membrane of the trigone is fixed to the muscle wall. The muscular coat of the bladder is composed of smooth muscle known as detrusor. The neck of the bladder (internal urinary sphincter) is surrounded by circular muscle fibres.

The Ureter

Every gynaecologist should be familiar with the anatomy of the pelvic portion of the ureter, as injury can occur during pelvic surgery. The ureter needs to be dissected during Wertheim's hysterectomy for cancer of the cervix. The ureter may run in close relation to the broad ligament cyst and myoma.

The pelvic portion of the ureter is 13 cm long and 5 mm in diameter. It passes over the bifurcation of the common iliac artery and runs downwards and forwards in the ovarian fossa deep to the peritoneum. Where it enters the true pelvis at the brim it is crossed by the ovarian vessels, and on the left side the mesosigmoid is an anterior relation. In this situation, the obturator vessels and nerve lie laterally, and the hypogastric lymph nodes are closely related. The course of the ureter is then downwards and forwards immediately beneath the peritoneum to which it is always closely attached.

On the pelvic floor, the ureter pierces Mackenrodt's ligament where a canal, the ureteric canal, is developed. It is necessary that the ureter must have room for normal peristalsis without any pressure from the surrounding structures, and the ureteric canal protects the ureter from the outside pressure. In its passage through the ureteric canal, the ureter is crossed by the uterine artery above and the uterine plexus of veins below, thus being forked between the uterine vessels. After leaving the ureteric canal, the ureter passes forwards and medially to reach the bladder, being separated from the cervix by a distance of 1–2 cm (Figure 1.19). The course of the ureter through the pelvis is

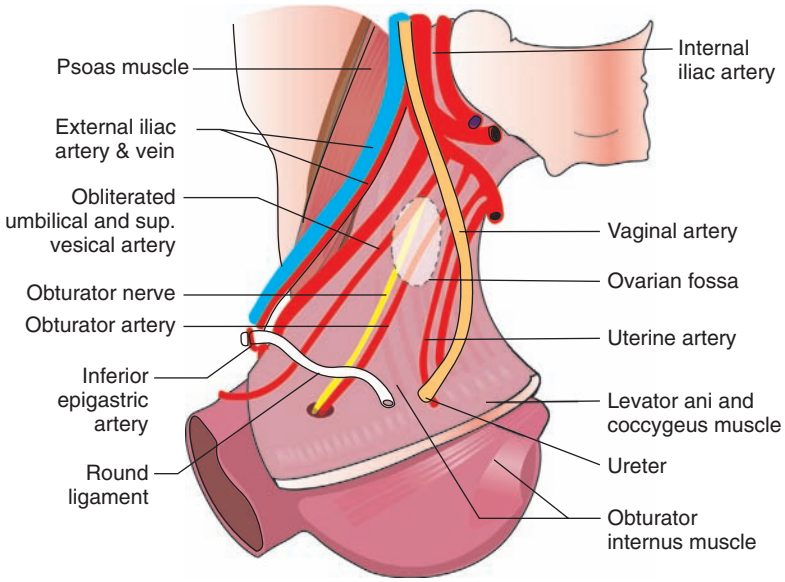


Figure 1.19 Relation of the ureter to the pelvic vessels in the ovarian fossa.

not always constant. At operation, the ureter is recognized by its pale glistening appearance and by a fine longitudinal plexus of vessels on its surface, but more particularly by its peristaltic movements. It can also be recognized by palpation between the finger and the thumb as a firm cord, which, as it escapes, gives a characteristic snap. The ureter is rarely duplicated. In advanced stage of cancer of the cervix with extensive involvement of the parametrium, stricture of the ureter causes hydronephrosis and uraemia.

The ureter derives its blood supply from the common, external and internal iliac arteries in addition to a constant vessel from the uterine and inferior vesical artery. The vessels form a longitudinal anastomosis up and down the ureter which protects the ureter from ischaemia if one vessel is ligated or injured. However, damage of several small vessels can cause avascular necrosis and ureteric fistula. The small branches of the renal artery also supply blood to the ureter above the pelvic brim.

The blood supply to the pelvic ureter is principally from the lateral side, and the ureteric dissection should be done along its medial side.

The injury to the ureter occurs at the infundibulopelvic ligament on the lateral pelvic wall, in the ureteric canal when the uterine vessels are ligated, near the internal cervical os and near the uterosacral ligament. It is important to identify the ureter during Wertheim hysterectomy, broad ligament tumour dissection and while ligating the internal iliac artery.

The lymphatics drain into internal and external iliac glands. The sympathetic nerve supply comes from hypogastric and pelvic plexus; para sympathetic from sacral plexus.

The Rectum and Anal Canal

The rectum is the continuation of the pelvic colon and lies in the pelvis at the level of third sacral vertebrae. It measures 12–15 cm and continues as anal canal. It is covered anteriorly and laterally by pelvic peritoneum which forms the posterior surface of the pouch of Douglas. Lower down, it is in close contact with the posterior vaginal wall, separated by rectovaginal septum. The anal canal is separated from the lower one-third of posterior vaginal wall by the perineal body. Posteriorly, it lies close to the sacrum and coccyx with loose articular tissue, middle sacral artery and pelvic nerve plexus. Laterally lie the two uterosacral ligaments above and levator ani muscles below and ischiorectal fossa. The rectum is surrounded by rectal fascia. The anal canal measures 2.5 cm. Anteriorly, it is related to the perineal body and posteriorly to the anococcygeal body. It has two sphincters: (i) involuntary internal sphincter in the upper two-thirds and (ii) voluntary external sphincter surrounded by puborectalis muscle of the levator ani muscle below.

The rectum and anal canal receive the blood supply from (i) superior rectal branch of interior mesenteric artery and (ii) middle and inferior rectal branches of internal iliac artery. The rectum and upper one-third of anal canal drain via superior rectal veins into portal circulation. Lower one-third portion of anal canal drains into inferior rectal vein (systemic circulation).

The Lymphatics

The rectum and upper one-third of anus drain into internal iliac and preaortic lymphatic nodes. Lower one-third drains into superficial inguinal lymph nodes.

Autonomic pelvic plexus innervate the rectum and upper portion of the anal canal. The lower portion of the anal canal is innervated by the inferior haemorrhoidal nerve. The rectum and upper two-thirds of the anal canal develop from the dorsal portion of the cloaca. The lower anal canal is derived from ectoderm.

Breasts

The breasts are bilateral modified sweat glands extending from second to sixth intercostal spaces in the midclavicular line (Figure 1.20). Each breast contains 15–20 lobes and each lobe is made up of acini, ducts and fat. All the ducts open into the nipple. Each breast receives blood supply from lateral thoracic branches of axillary artery and intercostal arteries. The veins accompany the arteries. The lymphatics drain into axillary, transpectoral and internal mammary nodes, hence the need to remove them in breast cancer. The nerves come from fourth, fifth and sixth intercostal nerves.

During pregnancy, the oestrogen and progesterone hormones cause increased vascularity and size in the breasts, and also skin pigmentation. The raised prolactin level starts watery and milk secretion from early weeks onwards. The parenchyma of the breast develops from ectoderm, but stroma is derived from mesoderm.

The Pelvic Musculature

The pelvic muscles of importance in gynaecology are those of the pelvic floor. These muscles are grouped into three layers: (i) those of the pelvic diaphragm; (ii) those of the

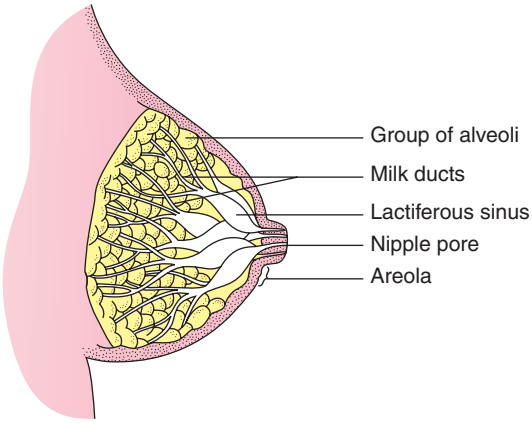


Figure 1.20 Anatomy of the female breast.

urogenital diaphragm and (iii) the superficial muscles of the pelvic floor.

Pelvic Diaphragm

The pelvic diaphragm consists of two levator ani muscles. Each levator ani muscle consists of three main divisions: the pubococcygeus, the iliococcygeus and the ischiococcygeus. The pubococcygeus muscle arises from the posterior surface of the body of the pubic bone and passes backwards, lateral to the vagina and the rectum, to be inserted into the anococcygeal raphe and into the coccyx. The inner fibres which come together posterior to the rectum are known as the puborectalis portion of the muscle: they sling up and support the rectum. Some of the inner fibres of the puborectalis fuse with the outer wall of the vagina as they pass lateral to it. Other fibres decussate between the vagina and the rectum in the situation of the perineal body. These decussating fibres divide the space between the two levator ani muscles into an anterior portion, the hiatus urogenitalis, through which passes the urethra and vagina, and a posterior portion, the hiatus rectalis, through which passes the rectum. The dimensions of the hiatus urogenitalis depend upon two main factors: the tone of the levator muscles and the existence of the decussating fibres of the puborectalis muscle.

Perineal tears occurring during parturition divide these decussating fibres, causing the hiatus urogenitalis to become patulous and lead to prolapse. In visceroptosis and asthenic states, the levator muscles become lax, the dimensions of the hiatus urogenitalis are increased and there is a tendency for the pelvic viscera to prolapse. The iliococcygeus is a fan-shaped muscle arising from a broad origin along the white line of the pelvic fascia and passing backwards and inwards to be inserted into the coccyx. The ischiococcygeus or coccygeus muscle has a narrow origin from the ischial spine and spreads out posteriorly to be inserted into the front of the coccyx (Figures 1.21 and 1.22).

The levator muscles together constitute the pelvic diaphragm and support the pelvic viscera: contraction of the levator muscle pulls the rectum and vagina towards the symphysis pubis; the rectum is thereby kinked and closed, and the vagina narrowed anteroposteriorly. The origin of the levator muscle is fixed because the muscle arises anteriorly either from bone or from fascia which is attached to the bone; posteriorly the insertion is either into the anococcygeal raphe or into the coccyx, both of which are moveable. It follows that the contraction of the levator muscles leads to the posterior attachments being pulled towards the symphysis pubis. The movement of the internal rotation of the presenting part during parturition is assisted by this property of the levator muscles. Uterine contractions push the presenting part down upon the levator ani (pelvic floor) and cause the muscles to contract as a result of the direct pressure of the presenting part. The lowest part of the fetus is carried forwards during the contractions of the levator muscles, and as the anterior fibres of the muscles are directed inwards as well as forwards, the presenting part rotates forwards and inwards.

The superior and inferior surfaces of the levator muscles are covered by the pelvic fascia, which separates the muscles from the cellular tissues of the parametrium above and from the fibrous and fatty tissues of the ischiorectal fossa below.

Urogenital Diaphragm

The urogenital diaphragm is also called the triangular ligament. It is not so well developed in the female as in the male. It extends from the pubic arch anteriorly to the central point of the perineum posteriorly and consists of two layers of fascia through which pass the vagina and the urethra. The central point of the female perineum lies between the vagina and the rectum. Within the two fascial layers of the urogenital diaphragm lies the deep transverse perineal muscle, which extends laterally on each side to reach the

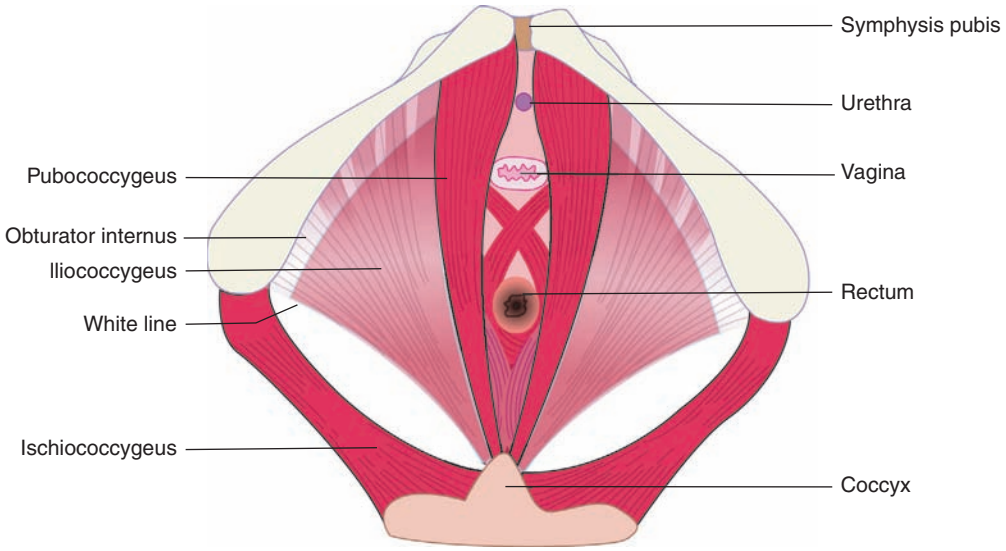


Figure 1.21 The muscular pelvic floor seen from above after the removal of the pelvic viscera and pelvic fascia.

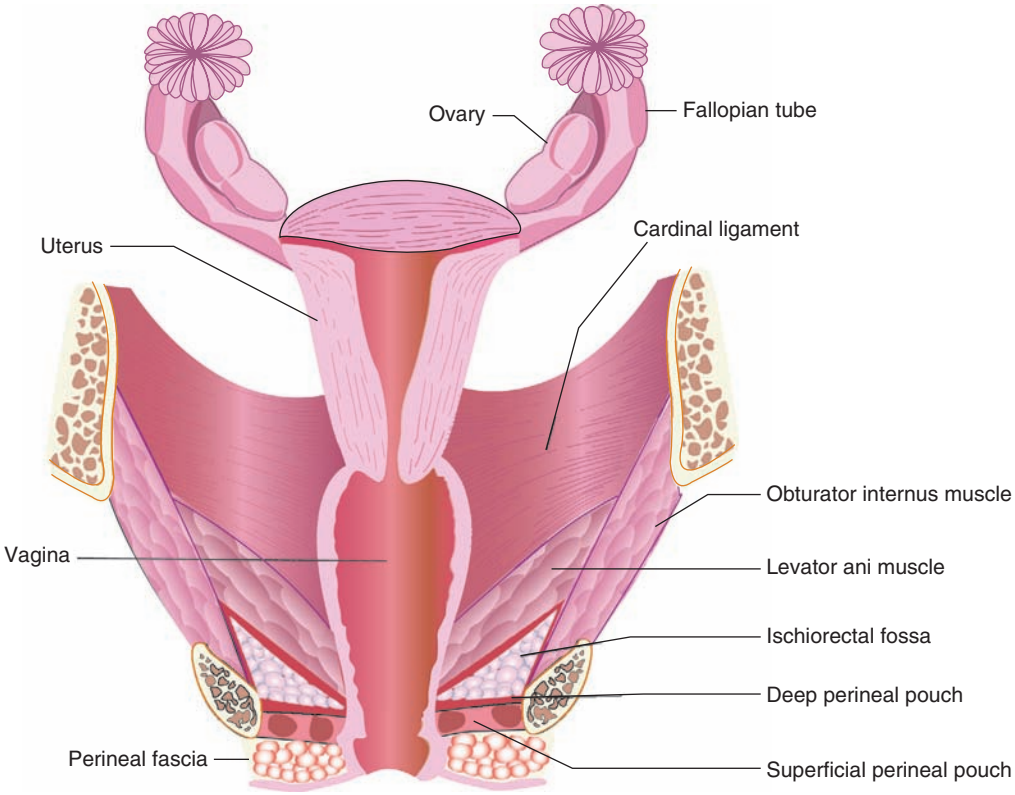


Figure 1.22 Anatomy of the pelvic floor in coronal section.

ramus of the pubic bone. This muscle is so poorly developed that it is difficult to dissect in anatomical specimens and needs a special histological technique for its demonstration. Its functional significance is dubious. The striped muscle or voluntary sphincter of the urethra also lies between the two layers of the triangular ligament.

Superficial Muscles

Four muscles are identified in this layer. The external sphincter muscle of the anus is attached anteriorly to the central point of the perineum and surrounds the anus. The bulbospongiosus muscle, or as it is sometimes called the sphincter vaginae, extends from the central point of the perineum along each side of the vagina to be attached anteriorly to the symphysis pubis. It lies around and lateral to the urethral bulb. The ischiocavernous muscle extends on each side of the ischial tuberosity in relation to the crura of the clitoris to reach it in the midline. The superficial transverse muscle of the perineum passes laterally on each side from the central point of the perineum to the pubic ramus (Figure 1.23). Deep to these superficial muscles and between them and the inferior layer of the triangular ligament lie the vestibular bulb and the greater vestibular glands of *Bartholin*.

The *perineal body* intervenes between the posterior vaginal wall and the anal canal. It is pyramidal in shape with its apex on a level with the junction of the middle and lower thirds of the posterior vaginal wall. The three layers of the muscles of the pelvic floor are represented in the perineal body, and the intervening tissue consisting of fat and fibrous tissue. Superficially, passing from the central point of the perineum are the external sphincter of the anus, the bulbospongiosus and the superficial transverse muscle of the perineum. Deep to this layer lies the fascial layer of the urogenital diaphragm (triangular ligament) enclosing the deep transverse muscle of the perineum. Deeper still, the pelvic diaphragm is represented by the fibres of the levator ani muscles which decussate between the vagina and the rectum. The perineal body is examined by inspection and by palpation. Two fingers are placed in the vagina and flexed laterally; the thumb being applied externally over the labium majus, the levator muscles can be palpated with remarkable ease and the size of the hiatus urogenitalis can be assessed. On asking the patient to contract her pelvic floor muscles, the tone of these muscles can be estimated.

Prolapse of the genital tract, stress incontinence of urine and faecal incontinence are all related to laxity and atonicity of the muscles of the pelvic floor as well as denervation of pelvic nerves during childbirth. Lately, perineal ultrasound and MRI have greatly improved our knowledge of these supportive structures in maintaining the uterine position and continence of urine and faeces.

The Pelvic Cellular Tissue

The pelvic cellular tissue consists of loose areolar tissue which intervenes between the pelvic peritoneum above and the pelvic fascia below. It is continuous with the subperitoneal connective tissue and with the loose tissue of the

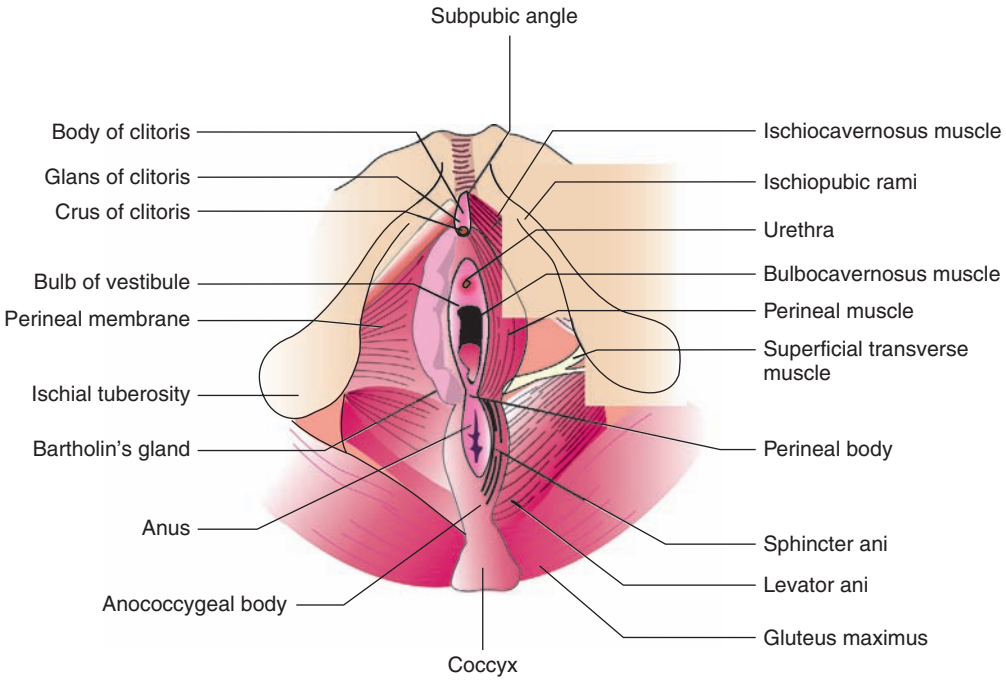


Figure 1.23 The perineum.

perinephric region. The areolar tissue is loose, and when inflamed in the condition of pelvic cellulitis it may lead to the formation of a palpable swelling. As there is a direct continuation between the perinephric and pelvic cellular tissues, effusions arising in either of these situations may track to point as an abscess in the other. In the pelvis, the pelvic cellular tissue is bounded above by the peritoneum and below by the fascia which covers the upper surface of the levator ani muscles. Laterally it is bounded by the pelvic wall, mainly by the fascia which covers the inner surface of the obturator internus while medially it comes into contact with the uterus and the upper part of the vagina.

The **parametrium** is that part of the pelvic cellular tissue which surrounds the uterus. It is by definition extraperitoneal and is most plentiful on each side of the uterus below the level of the internal os. The endopelvic fascia in this region thickens to form ligamentous supports called *Mackenrodt's or cardinal ligaments*. Above this level, the presence of the broad ligaments reduces the amount of parametrium to a minimum. It should be remembered that the level of the levator ani muscle is well below the level of the cervix, being more than halfway down the vagina. The pelvic cellular tissue is usually very plentiful on each side of the vagina, where it is called paravaginal cellular tissue or paracolpos.

A distinction is drawn between the pelvic fascia and the endopelvic fascia. The pelvic fascia consists of the dense connective tissue which covers the surfaces above and below the levator ani and the obturator internus muscles. On the other hand, the endopelvic fascia forms the connective tissue coverings for the vagina, the supravaginal portion of the cervix, the uterus, the bladder, the urethra and the rectum. In addition, condensed bands of endopelvic fascia pass from these moveable organs to the back of the pubic bones, to the lateral walls of the pelvis and to the front of the sacrum. The function of the endopelvic fascia is partly to convey blood vessels to the pelvic organs and partly to support them. Between the different layers of the endopelvic fascia are bloodless spaces which are important to identify in vaginal plastic operations. The term pelvic cellular tissue should be restricted to cellular tissue which intervenes between the different layers of the endopelvic fascia and which lies between the peritoneum above and the true pelvic fascia below.

Anteriorly, the bladder is covered by an endopelvic fascial layer called the vesical fascia while behind it lie the vagina and the supravaginal portion of the cervix covered by their own endopelvic fascial layers.

Immediately behind the uterus and the vagina, the peritoneum which covers the back of the uterus and the posterior vaginal fornix reduces the pelvic cellular tissue to a minimum in these situations. Deep to the uterosacral folds of peritoneum the endopelvic fascia is plentiful, and here it is condensed to form the uterosacral ligaments which pass backwards and upwards from the uterus in the front to reach the sacrum lateral to the rectosigmoid. The uterosacral ligaments help to support the uterus and prevent it from being forced down by intra-abdominal pressure. By their tone they also tend to pull back the cervix and thereby antevert the uterus. Plain muscle fibres can be demonstrated in them. They contain sympathetic and parasympathetic nerves. Mackenrodt ligaments, similar to uterosacral ligaments, help to support the uterus and prevent it from being forced down when the intra-abdominal pressure is raised. They are composed almost entirely of connective tissue and contain very little plain muscle (Figure 1.24).

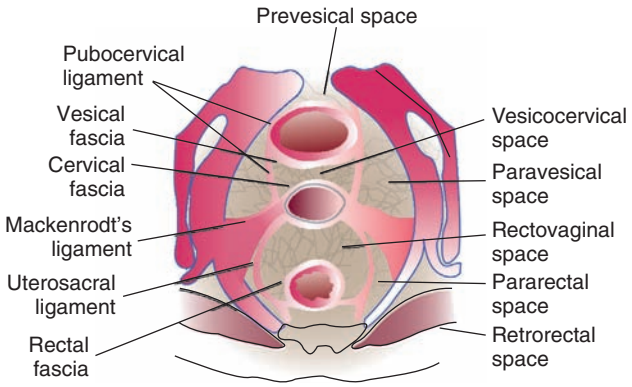


Figure 1.24 The pelvic cellular tissue shown in the cross-section of the pelvis.

A third and equally important part of the supporting mechanism of the pelvic viscera is the pubovesicocervical fascia or the pubocervical fascia. This is a condensation of the endopelvic fascia which passes from the anterolateral aspect of the cervix to be attached to the back of the pubic bone lateral to the symphysis. Some of its cervical attachment fans out laterally and imperceptibly into the transverse cervical or Mackenrodt's ligament. It can, therefore, be regarded morphologically and functionally as a part of this structure.

If Figure 1.24 is studied, the supports of the uterus and the bladder are seen to be triradiate condensation of endopelvic fascia:

1. The anterior spoke is the pubocervical fascia or so-called pubocervical ligament.
2. The lateral spoke is Mackenrodt's ligament.
3. The posterior spoke is the uterosacral ligament.

All these three embrace and insert into the cervix and, when intact, operate on it such as the strings of a hammock, preventing descent. If one or two strings are torn, the contents of the hammock prolapse with resulting descent of the bladder and the uterus.

The endopelvic fascial tissue contains the uterine arteries and veins, together with the venous plexus around the cervix and the lateral fornices of the vagina. The lymphatics from the upper two-thirds of the vagina and from the uterus, the ovaries and the fallopian tubes also pass through the pelvic cellular tissue. On each side of the uterus there is sometimes a small inconstant lymphatic gland known as the gland of the parametrium, about the size of the pin's head, near the ureteric canal. The ureter passes through the parametrium via the ureteric canal in an anteroposterior direction, about 1 cm lateral to the cervix to reach the bladder. It passes below the level of the uterine vessels, which cross it as they run transversely through the pelvis to reach the uterus. Sympathetic nerve ganglia and nerve fibres are plentiful in the parametrium (Frankenhauser's plexus).

In the condition of parametritis, the parametrium is inflamed and thickened. Rarely a large swelling forms which extends as far down as the fascia covering the levator ani muscles, and medially it comes directly into contact with the uterus and the upper part of the vagina. Laterally it extends as far out as the pelvic wall. Posteriorly it extends along the uterosacral ligaments in close relation to the rectosigmoid. Such a swelling may track upwards out of the pelvis to reach the subperitoneal tissues of the iliac region when the effusions may point above Poupart's ligament lateral to the great vessels. In other cases, the swelling may track upwards to the perinephric region. In advanced cases of carcinoma of the cervix, the cancer cells infiltrate the parametrium when they spread either laterally along Mackenrodt's ligaments or posteriorly along the uterosacral ligaments. Clinically, infiltration of the parametrium is detected by determining the mobility of the cervix and the body of the uterus, by palpating in the situation of Mackenrodt's ligament through the lateral fornix of the vagina and by examining the uterosacral ligaments by rectal examination. The fibrosis resulting from chronic parametritis causes chronic pelvic pain and ureteric obstruction (Table 1.2).

TABLE 1.2 Supports of the genital organs

Level I	Uterosacral ligaments and cardinal ligaments support the uterus and vaginal vault
Level II	Pelvic facias and paracolpos which connects the vagina to the white line on the lateral pelvic wall through arcus tendinous
Level III	Levator ani muscles support the lower one third of vagina

The Pelvic Blood Vessels

The ovarian arteries arise from the aorta, just below the level of the renal arteries. They pass downwards to cross first the ureter and then the external iliac artery, and then they pass into the infundibulopelvic fold. The ovarian artery sends branches to the ovaries and to the outer part of the fallopian tubes; it ends by anastomosing with the terminal part of the uterine artery after giving off a branch to the cornu and one to the round ligament.

Internal iliac artery is one of the bifurcations of the common iliac artery. It is 2 cm in length. The ureter lies anterior and the internal iliac vein posterior to it. It divides into an anterior and a posterior branch. The anterior branch supplies the pelvic organs. In obstetric and gynaecological surgery, profuse haemorrhage is controlled by ligating the internal iliac artery on either side. During this procedure, the anterior relation of the ureter to the artery should be remembered and injury to the ureter avoided.

The *uterine artery* arises from the anterior trunk of the internal iliac (or hypogastric artery). Its course is at first downwards and forwards until it reaches the parametrium when it turns medially towards the uterus. It reaches the uterus at the level of the internal os, where it turns upwards, at right angles, and follows a spiral course along the lateral border of the uterus to the region of the uterine

cornu; here it sends a branch to supply the fallopian tube and ends by anastomosing with the ovarian artery. The tortuosity is lost when the uterus enlarges during pregnancy. During the vertical part of its course, it sends branches which run transversely and pass into the myometrium (Figure 1.25). These are called the arcuate arteries and from them arises a series of radial arteries almost at right angles. These radial arteries reach the basal layers of the endometrium where they are termed as the basal arteries. From these the terminal spiral and straight arterioles of the endometrium are derived. The least vascular part of the uterus is in the midline. The vaginal branch of the uterine artery arises before the uterine artery passes vertically upwards at the level of the internal os. It passes downwards through the parametrium to reach the vagina in the region of the lateral fornix. This descending vaginal artery is of great importance during the operation of total hysterectomy since, if not separately clamped and tied, it may lead to dangerous operative haemorrhage. The arcuate arteries that supply the cervix are sometimes called the circular artery of the cervix. From these or the descending vaginal branches the anterior and posterior azygos arteries of the vagina are derived.

The following are the branches of the uterine artery:

- Ureteric
- Descending vaginal—these unite to form the anterior and posterior azygos artery of the vagina
- Circular cervical
- Arcuate → radial → basal → spiral and straight arterioles of the functional layer of the endometrium
- Anastomotic with the ovarian artery

The relation of the uterine artery to the ureter is of great importance. The uterine artery crosses above the ureter in the parametrium where it gives off an important ureteric branch to that structure. The artery runs transversely while the ureter runs approximately anteroposteriorly through the ureteric canal of the parametrium.

Middle sacral artery is a single artery which arises from the terminal aorta. It descends in the middle of the lumbar vertebra and the sacrum to the tip of the coccyx.

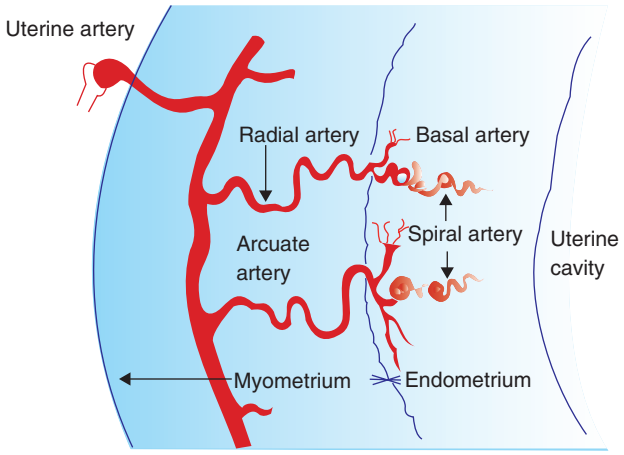


Figure 1.25 The uterine artery and its branches in the uterus.

There is an extensive network of collateral connections in the pelvic arterial vasculature that provides a rich anastomotic communication between major vessel systems. This degree of communication is important to ensure adequate supply of oxygen and nutrients in the event of major trauma or other vascular compromise. Hypogastric (internal iliac) artery ligation continues to be used as a strategy for the management of massive pelvic haemorrhage when other measures have failed. Bilateral hypogastric artery ligation effectively reduces pulse pressure in the pelvis, converting flow characteristics from that of an arterial to a venous system and allowing collateral channels of circulation to provide with adequate blood supply to the pelvic structures. This function is best illustrated by the example of preservation of reproductive functions, followed by successful pregnancies occurring after undertaking the lifesaving operation of bilateral ligation, of both hypogastric and ovarian arteries for uncontrolled atonic PPH after delivery. Details of collateral circulation are given in Table 1.3.

The Vaginal Arteries

Usually the blood supply of the upper part of the vagina is derived from the vaginal branch of the uterine artery. This vessel reaches the lateral fornix of the vagina and then passes downwards along the lateral vaginal wall. It sends branches transversely across the vagina, which anastomoses with branches on the opposite side to form the azygos arteries of the vagina, which run down longitudinally, one in front of the vagina and one behind. These small vessels are encountered in the operations of anterior and posterior colporrhaphy. In some cases, the vaginal artery does not arise direct from the uterine artery but arises from the anterior division of the hypogastric artery, when it corresponds to the inferior vesical artery in the male.

TABLE 1.3 Collateral arterial circulation of the pelvis

Primary Arteries	Collateral Arteries
Aorta	
Ovarian artery	Uterine artery
Superior rectal artery (inferior mesenteric artery)	Middle rectal artery Inferior rectal artery (internal pudendal)
Lumbar arteries	Iliolumbar artery
Vertebral arteries	Iliolumbar artery
Middle sacral artery	Lateral sacral artery
External iliac	
Deep iliac circumflex artery	Iliolumbar artery Superior gluteal artery
Inferior epigastric artery	Obturator artery
Femoral	
Medial femoral circumflex artery	Obturator artery Inferior gluteal artery
Lateral femoral circumflex artery	Superior gluteal Iliolumbar artery

The Arteries of the Vulva and Perineum

The blood vessels of the perineum and external genitalia are derived from the internal pudendal artery, a terminal branch of the anterior division of the internal iliac artery. The artery leaves the pelvis through greater sciatic foramen, winds round the ischial spine and enters the ischiorectal fossa. The main vessel passes forwards in the ischiorectal fossa adjacent to the obturator internus muscle in Alcock's canal. It gives off the inferior haemorrhoidal artery and the transverse perineal artery which supplies the perineum and the region of the external sphincter. It then pierces the urogenital diaphragm and sends another transverse branch to supply the posterior part of the labia and to supply the erectile tissue which surrounds the vaginal orifice. The internal pudendal artery ends as the dorsal artery of the clitoris, supplying the clitoris and vestibule. The tissues around the vaginal orifice, the clitoris and the crura of the clitoris contain a large amount of erectile tissue. Lacerations of the anterior part of the vulva during childbirth may be accompanied by severe bleeding. The terminal branches of the internal pudendal artery anastomose with superficial and deep pudendal arteries which are branches of the femoral artery. This anastomosis is important as it provides an alternative blood supply to the bladder in extended pelvic surgery when the vesical branches of the hypogastric are tied off or even the main trunk of the hypogastric itself may have been ligated at its source.

The Pelvic Veins

The left ovarian vein ends by passing into the left renal vein. The right ovarian vein terminates in the inferior vena cava. The most important feature of the pelvic veins is that they form plexuses. These are well marked in the case of the ovarian veins in the infundibulopelvic fold where they form a pampiniform plexus and cause chronic pelvic pain. Occasionally, this plexus becomes varicose and the large dilated veins form a varicocele similar to the condition seen in the male. The uterine plexus is found around the uterine artery near the uterus and the vaginal plexus around the lateral fornix of the vagina. These venous plexuses are well developed in the presence of large myomas and also during pregnancy when a venous plexus can be distinguished between the base of the bladder and the uterus. The uterine plexus of vein drains into the internal iliac vein. There are two additional channels of venous drainage which are of interest in explaining unexpected sites of metastases in malignant disease of the genital tract:

- A portal systemic anastomosis exists between the hypogastric vein and the portal system via the middle and inferior haemorrhoidal veins of the systemic and the superior haemorrhoidal veins of the portal system. This accounts for some liver metastases of the genital tract malignancies.
- A combination between the middle and lateral sacral and lateral lumbar venous system and the vertebral plexus, which may explain some vertebral and even intracranial metastases, rarely seen in genital tract cancers. In such patients the lungs may escape metastases as they are bypassed by the malignant emboli.
- Uterine veins communicate with the vaginal veins. This explains vaginal metastasis in uterine cancer and endometriosis. The middle sacral veins are two in number on either side of the artery and drain into the left common iliac vein. These veins are encountered during presacral neurectomy, vaginal vault sacropexy and exenteration operation.

The Lymphatic System

The lymphatics and lymphatic glands which drain the female genital organs are of special importance in malignant disease. The surgical removal or radiation should include all the regional glands for curative effect.

The Lymphatic Glands or Nodes

The lymphatic glands which drain the female genital organs are as follows (Figure 1.26).

The Inguinal Glands

This group of glands consists of a horizontal and a vertical group. The horizontal group lies superficially, parallel to Poupart's ligament while the vertical group, otherwise known as the deep femoral glands, follows the saphenous and femoral veins. The uppermost of the deep femoral glands, called the gland of Cloquet or the gland of Rosenmüller, lies beneath Poupart's ligament in the femoral canal between Gimbernat's ligament and the femoral vein. Inconstant deep inguinal nodes are found in the inguinal canal, along the course of the round ligament, and in the tissues of the mons veneris. In such conditions, as primary sore and Bartholin's abscess, the horizontal inguinal group becomes inflamed. There is some evidence that lymphatics from the fundus of the uterus pass along the round ligament and drain into the horizontal inguinal group. It is more likely that these glands will become involved after the appearance of the late suburethral metastasis seen in advanced carcinoma corporis uteri, where the growth has spread down the vagina by retrograde lymphatic spread. The inguinal glands drain the vulva and lower third of the vagina, the lymphatics of the medial portion of the vulva communicate with lymphatics of the opposite side. It is therefore necessary to perform bilateral inguinal lymphadenectomy when cancer occurs in the medial portion of the vulva.

The Glands of the Parametrium

The hypogastric group (internal iliac glands) contains all the regional glands for the cervix, the bladder, the upper third of the vagina and also the greater part of the body of the uterus. This group of glands may be extensively involved in carcinoma of the uterus, cervix and vagina. The glands are most numerous immediately below the bifurcation of the

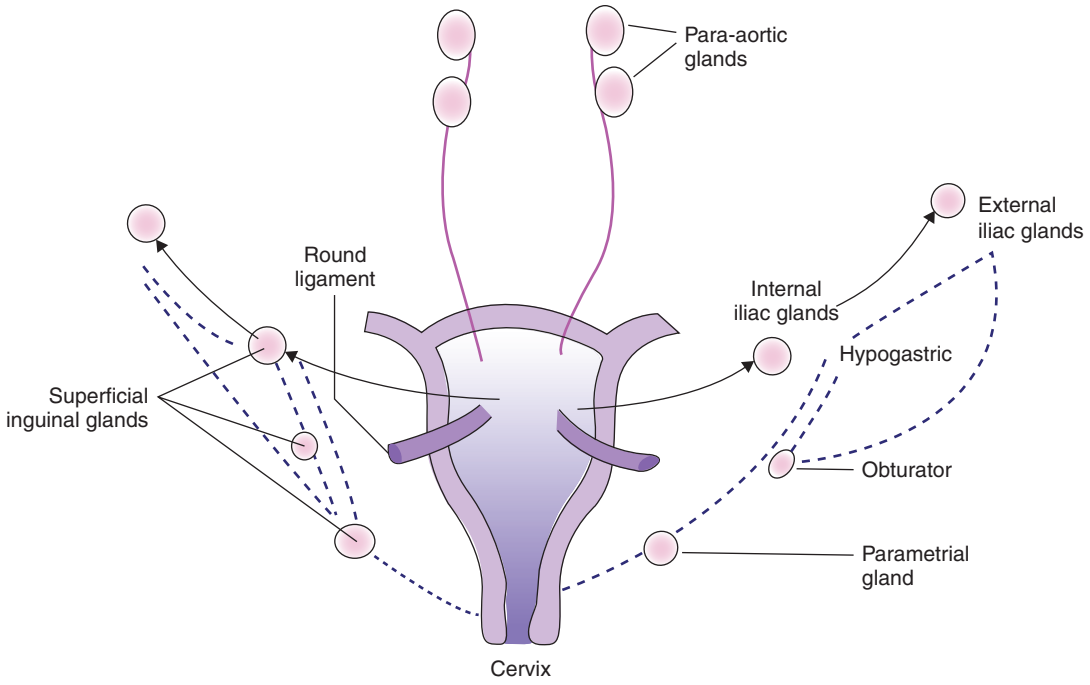


Figure 1.26 Pelvic lymphatic drainage of the cervix.

common iliac group. A further group of these glands situated in the obturator fossa is often called the obturator glands and is frequently the most obviously involved in carcinoma of the cervix. These drain into external and common iliac glands.

External Iliac Glands

This group of glands, several in number, is situated in relation to the external iliac artery and vein. A clean dissection of the external iliac glands can only be made if both vessels are completely mobilized as some of the glands lie lateral to the vessels between them and the lateral pelvic wall. These glands receive drainage from the obturator and hypogastric glands and are involved in late cervical cancer.

Common Iliac Glands

This group is the upward continuation of the external and hypogastric group and, therefore, involved next in genital tract cancer.

The Sacral Group

These glands lie on each side of the rectum and receive lymphatics from the cervix of the uterus and from the upper third of the vagina which have passed backwards along the uterosacral ligaments. Two groups of glands can be recognized, a lateral group lying lateral to the rectum and a medial group lying in front of the promontory of the sacrum. The lymphatics from these glands pass directly either to the inferior lumbar group or to the common iliac group.

The Lumbar Group of Glands

These lymphatic glands are divided into an inferior group that lies in front of the aorta below the origin of the inferior mesenteric artery and a superior lumbar group which lies near the origin of the ovarian arteries. The superior group of lumbar glands receives lymphatics from the ovaries and fallopian tubes as well as from the inferior lumbar glands. The lymphatics from the fundus of the uterus join the ovarian lymphatics to pass to the same group.

The lymphatic glands already mentioned, namely, the glands of the parametrium, the superficial inguinal, the hypogastric, external and common iliac, the sacral and the lumbar receive lymphatics 'direct' from the female generative organs and are known as the 'regional lymphatic glands' of the female genitalia.

These regional lymph nodes are not palpable clinically, but can be identified on CT and MRI scan if they are enlarged to 1 cm or more. At surgery, these glands should be palpated, removed or biopsied. This helps in staging the cancer and in the postoperative radiotherapy.

The Nerve Supply

Both sympathetic and parasympathetic systems supply the female genital organs as well as the bladder (Figure 1.27).

The sympathetic system consists of the presacral nerve which lies in front of the sacral promontory. This nerve plexus divides into two hypogastric nerves which pass downwards and laterally along the pelvic wall to terminate in the inferior hypogastric plexus. This plexus is diffuse and lies in the situation of the uterosacral ligaments. It also receives fibres from the parasympathetic system consisting of sacral fibres 2, 3 and 4. From here, the nerve fibres pass to all the pelvic organs.

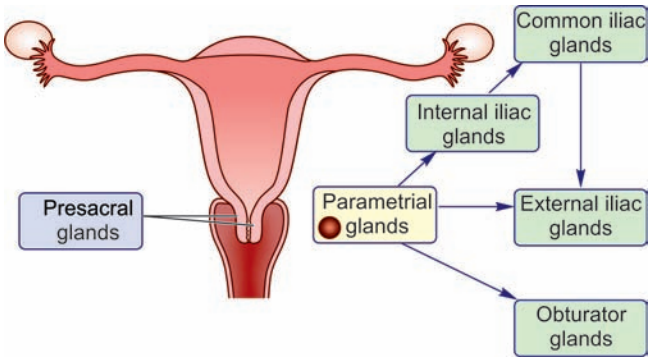


Figure 1.27 Lymphatic drainage of the pelvic lymph nodes.

The cervix is well surrounded by a rich plexus of nerves called Frankenhauser's plexus. The lower vagina is innervated by pudendal nerve.

The ovaries derive their nerve supply from the coeliac and renal ganglia which follow the course of the ovarian vessels.

The ilioinguinal nerve, derived from L1, and the genital branch of the genitofemoral nerve (L1 and L2) supply the mons, the upper and outer aspect of the labia majora and the perineum.

The pudendal nerve derived from sacral second, third and fourth segments supplies the lower vagina, clitoris, posterior part of the labia majora and the perineum. Presacral neurectomy is rarely performed to relieve chronic pelvic pain, and pain due to endometriosis. Pudendal block is needed in operative vaginal deliveries (Table 1.4).

Applied Anatomy and Its Clinical Significance

1. **Vulva.** The skin of the external genitalia is prone to local and general dermatitis. The moist intertriginous parts of the vulva are susceptible to chronic infection. Mucous glands in the vestibular location may become cystic. A cyst of the canal of Nuck may be mistaken for an indirect inguinal hernia. The loose areolar tissue of the vulva and its rich vascularity account for the large haematomas that are formed as a consequence of vascular injury during childbirth or accidental injuries. Vulval cancer is rare and occurs in old age. Lymphatic drainage of vulva is relevant in radical vulvectomy for cancer. Pudendal nerve block is required in episiotomy and forceps delivery. The internal pudendal block is performed by injecting local anaesthetic drug into the nerve at the level of ischial spine, as the nerve winds round this spine.
2. **Vagina.** The posterior vaginal fornix lies in proximity to the peritoneal pouch of Douglas. It is a convenient site for access to the peritoneal cavity, colpopuncture, colpocentesis and diagnostic culdoscopy in the diagnosis of pelvic abscess, ectopic pregnancy and pelvic endometriosis. The ureters have a close relation to the lateral vaginal fornices, particularly in patients with uterine prolapse. Ureteric injury should be guarded against during vaginal surgery on the uterus, as also when attempting to suture vaginal lacerations (colporrhexis) high in the vaginal vault. The anatomic proximity of the bladder base, urethra and vagina and the interrelationship between their vascular and lymphatic networks result in inflammation of the vagina (vaginitis) causing urinary tract symptoms such as frequency and dysuria. Gartner's duct cysts represent a cystic dilatation of the remnants of the embryonic mesonephros. They are present in the lateral walls of the vagina. These are generally asymptomatic, but they may cause dyspareunia or vaginal discomfort. In the lower third of the vagina, Gartner's duct cysts are located anteriorly and may mimic a large urethral diverticulum. Squamous cell carcinoma of vagina is very rare and occurs usually over the decubitus ulcer in a woman with vaginal prolapse.

TABLE 1.4 Nerve supply in the pelvis

Organ	Spinal Segments	Nerves
Perineum, vulva, lower vagina	S2–4	Pudendal, inguinal, genitofemoral, posterofemoral cutaneous
Upper vagina, cervix, lower uterine segment, posterior urethra, bladder trigone, uterosacral and cardinal ligaments, rectosigmoid, lower ureter	S2–4	Pelvic parasympathetics
Uterine fundus, proximal fallopian tubes, broad ligament, upper bladder, caecum, appendix, terminal large bowel	T11–12, L1	Sympathetics via hypogastric plexus
Outer two-thirds of fallopian tubes, upper ureter	T9–10	Sympathetics via aortic and superior mesenteric plexus
Ovaries	T9–10	Sympathetics via renal and aortic plexus and celiac and mesenteric ganglia
Abdominal wall	T12–L1	Iliohypogastric
	T12–L1	Ilioinguinal
	L1–2	Genitofemoral

Adenocarcinoma of vagina has been reported in young girls who were exposed to DES in utero and can occur in the upper part of the vagina. Lymphatic drainage of vulva is relevant in radical vulvectomy for cancer. Pudendal nerve block is required in episiotomy and forceps delivery. The internal pudendal block is performed by injecting local anaesthetist drug into the nerve at the level of ischial spine as the nerve winds round this spine.

3. **Cervix.** The major vascular supply of the cervix is located laterally. Deep lateral sutures placed laterally to include the vaginal mucosa and the substance of the cervix would help to control bleeding during surgical procedures on the cervix such as conization or the surgical evacuation of the cervical canal in cervical ectopic pregnancy. The stroma of the endocervix unlike the ectocervix is rich in nerve endings; hence, manipulation of the cervical canal can cause an unexpected vasovagal attack and severe bradycardia or even cardiac arrest. The lymphatics of the cervix are very complex involving multiple chains of nodes. The principal regional nodes are the obturator, common iliac, internal iliac and visceral nodes of the parametria; others may also be occasionally involved, hence the need for wide nodal dissection during the treatment of cancer cervix employing radical surgery. Squamocolumnar junction is the site of cancer of the cervix. Precancerous lesion of the cervix needs ablation or excision depending upon the age of the woman and its grade (Figure 1.28).

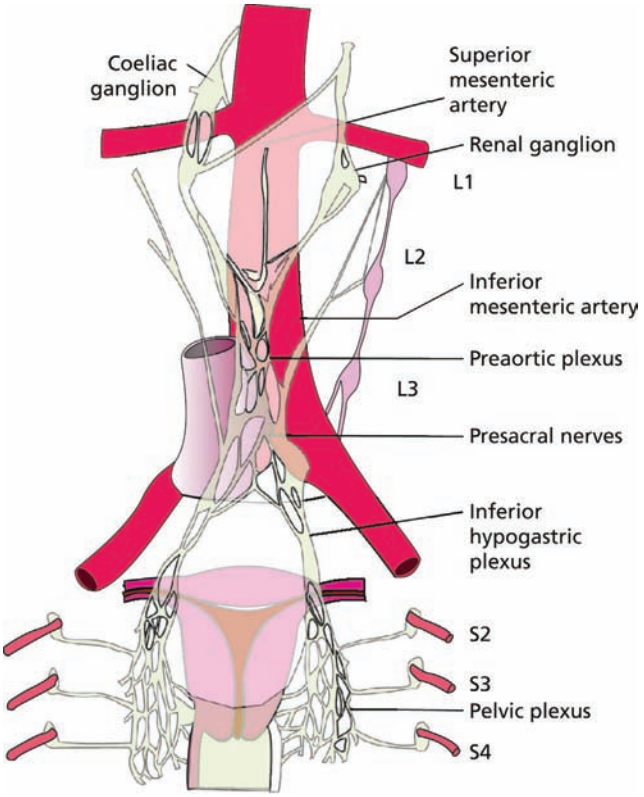


Figure 1.28 Pelvic innervation.

4. **Uterus.** Dysmenorrhoea is not an uncommon symptom, necessitating treatment in day-to-day practice. Whereas, most cases of primary dysmenorrhoea are treated successfully by prostaglandin synthetase inhibitors, there are occasional cases where oral medications may not suffice. In these women, the division of the sensory nerves that accompany the sympathetic nerves can lead to relief. The operations of presacral neurectomy and the endoscopic division of the uterosacral ligaments near the uterine attachment (laparoscopic uterosacral nerve ablation) have been designed to meet this end. The surgeon must be careful to avoid injury to the ureters. Since the uterus receives its main blood supply from the laterally placed uterine arteries, the operation of myomectomy of anterior wall uterine fibroids through a midline incision is attended with the least amount of blood loss. Earlier, it has been discussed that the uterus has a rich blood supply from the branches of the vascular anastomotic arcade between the uterine arteries and the ovarian arteries. There is also presence of an extensive pelvic collateral circulation to ensure enough blood supply in emergency situations wherein bilateral surgical ligation of the hypogastric vessels becomes necessary as a life-saving procedure.
5. **Fallopian tubes.** The right fallopian tube lies in proximity to the appendix. Therefore, it is often difficult to differentiate between acute appendicitis and acute salpingitis. The wide mesosalpinx of the ampullary portion of the tube permits this part to undergo torsion. Mesonephric remnants in the broad ligament may be the cause of formation of parovarian cysts. These often mimic ovarian neoplasms. They have been reported to undergo torsion. Falloscopy visualizes the tubal mucosa and patency of the medial end and salpingoscopy studies the mucosa and patency of the ampullary end of the fallopian tube, and enables us to decide between tubal surgery and in vitro fertilization in tubal infertility.
6. **Ovaries.** There is a wide variation in the size of the ovaries during the childbearing years and after menopause. Atrophic menopausal ovaries are not palpable on vaginal examination. Therefore, any palpable adnexal mass in a postmenopausal woman should be viewed with suspicion and investigated thoroughly to exclude a neoplasm. The location of the ovary in the ovarian fossa lies in proximity to the ureters. Hence, during pelvic surgical procedures for severe endometriosis or pelvic inflammatory disease that involve the ovaries, great caution must be exercised to avoid ureteric injury. Ultrasound scanning for any adnexal mass, polycystic ovarian disease and ovulation monitoring is possible and is easy, cost effective, accurate and noninvasive. Additional hormonal monitoring is, however, required in in vitro fertilization programme.
7. **Surgical precautions during gynaecological operations.** The anatomic proximity of female reproductive organs with the ureters, urinary bladder and rectum in

the pelvis is a major consideration during gynaecologic surgery. Surgical compromise of the ureter may occur during clamping or ligation of the infundibulopelvic folds, clamping and ligation of the cardinal ligaments, reperitonealization of the lateral wall following hysterectomy or during wide approximation of endopelvic fascia during anterior colporrhaphy repair.

At the base of the broad ligaments, the uterine artery crosses the ureter. During Wertheim's operation, when in doubt whether the structure under view is a blood vessel or the ureter, the feel of the structure is helpful; also, mild stroking lengthwise invokes a wave of peristalsis in the ureter. During abdominal hysterectomy for benign uterine disease, the practice of intrafascial clamping of the parametrium also helps to prevent ureteric injury. Subtotal hysterectomy in younger women in whom the cervix is healthy (Pap test normal) has the advantage of retaining the cervix for sexual reasons and for reducing the risk of future vault prolapse. The urinary bladder if well drained during pelvic surgery will be less vulnerable to inadvertent trauma. During colposuspension operations for stress urinary incontinence, there may be significant venous bleeding in the cave of Retzius. If proper drainage is not provided, there is a possibility of occurrence of a large subfascial haematoma that may extend up to the umbilicus. Rectal injuries occur most frequently during vaginal hysterectomy associated with high posterior colporrhaphy and enterocele repair. The rectum is also vulnerable to injury in the presence of wide adhesions, obliterating the pouch of Douglas in cases of extensive pelvic endometriosis, chronic pelvic inflammatory disease or advanced pelvic malignancy.

The genital prolapse is caused by atonicity, relaxation or damage to the nerve of the pelvic floor muscles and the supporting ligaments. The knowledge of these anatomical structures is necessary in the repair of various types of prolapse and in enhancement and buttressing these structures.

Stress incontinence of urine can be cured by elevating the neck of the bladder and mid-urethral ligamentary suspension.

Key Points

- Anatomical knowledge of the pelvic organs is essential to interpret the clinical findings as well as those of ultrasound, CT and MRI to make an accurate gynaecological diagnosis.
- Normal vaginal secretion is small in amount and varies with the phase of the menstrual cycle. Döderlein's bacilli predominate. They are Gram-positive and grow anaerobically in an acid medium of 4.5 pH. Low acidity does not allow other organisms to grow and cause vaginitis.
- Normal cervix has several physiological functions. The alkaline secretion attracts sperms at ovulation and sieves out the abnormal sperms in their ascent. The plug of mucous prevents entry of sperms as well as bacteria, and prevents pregnancy and pelvic inflammatory disease. The internal os remains competent during pregnancy, but effaces as its collagen dissolves near term. Capacitation of sperms occurs in the cervical canal.
- Fallopian tube. The nutritive secretion of endosalpinx, peristaltic movements of the musculature and ovarian fimbria play important roles in fertility.
- Knowledge of lymphatic drainage of the pelvic organs is important in staging, removal or radiation of lymphatic metastasis in genital organ malignancies. CT and MRI are used in mapping the lymph nodes involved in genital tract cancers.
- Remnants of the Wolffian body and its duct can cause parovarian cyst and Gartner's duct cyst.
- The pelvic portion of the ureter lies close to the genital organs. It is recognized by its pale glistening appearance and peristalsis. It needs to be dissected and protected against injury during gynaecological surgery.
- Pelvic floor muscles and fasciae hold the pelvic organs in place. Prolapse, stress incontinence of urine and faeces are related to the laxity and atonicity of these structures. Denervation of the pelvic nerves during childbirth is also responsible.
- The bladder, rectum and anal canal share the same muscular and ligamentary supports. Laxity of these supportive structures causes genital prolapse as well as urinary, faecal incontinence.
- Breast examination now falls in the domain of the gynaecologists. It is therefore important to know the structure of the breasts and changes that occur at different age groups.

Self-Assessment

Q.1 Describe the anatomy of Bartholin's gland and its clinical significance.
Q.2 Describe the pelvic diaphragm and its importance in preventing genital prolapse.
Q.3 Describe the course of the ureter in the pelvis. Where is it vulnerable to injury during pelvic surgery?
Q.4 Describe the pelvic cellular tissue supports of the uterus.

Suggested Reading

Cunningham FG, Leveno KL, Bloom SL et al. (eds). William's Obstetrics. 23rd Ed. New York, McGraw Hill, 2010; 14–35.
Schorge JO, Schaffer JI, Halvorson LM et al. (eds). William's Gynaecology. 1st Ed. New York, McGraw Hill, 2008; 798.