

# **1. ANATOMY AND PHYSIOLOGY**

## **ANATOMY OF THE OVARIES AND FALLOPIAN TUBES**

### **Ovarian Anatomy:**

- Only structure in the abdominopelvic cavity that is not covered by peritoneum
- Only truly INTRAPERITONEAL structure
- Located posterior and lateral to the uterus in the adnexa
- Connected medially to the uterine cornua by the ovarian ligament
- Anterior surface connected to the posterior surface of the broad ligament by the mesovarium
- Infundibulopelvic ligament contains vessels and extends from lateral pelvic wall to lateral ovary
- Ureter, internal Iliac artery and vein are posterior and lateral to the ovary
- Internal iliac vessels are the best landmark for locating the ovaries Sonographically; ovaries are anterior and medial to the internal iliac vessels
- The iliopsoas muscle is also a landmark for the lateral aspect of the adnexa
- The ovary should be identified medial to the iliopsoas muscles
- Hilum of the ovary is located on the superoanterior surface
- Premenopausal size 3 x 2 x 1cm
- Volume 6-13cc, ( $L \times W \times AP \times 0.523 = \text{volume}$ )
- Normal follicle size: Immature 10mm or less, Dominant 15-25mm
- A dominant follicle forms each month on one ovary and that follicle releases the ovum with ovulation
- Graafian follicle is another term for dominant follicle
- Postmenopausal ovaries normally do not exceed 2cm in any dimension or 8cc volume

### **Fossa of Waldeyer (Ovarian Fossa):**

- Shallow peritoneal fossa on lateral pelvic wall
- Bordered by ureter and iliac vessels

### **Codex:**

- Functional tissue of the ovary
- Composed of 1000s of oocytes embedded in connective tissue
- Follicles form in the cortex layer

- Each cycle, 4-5 eggs mature and release
- Varies in thickness according to the age of the individual

#### *Medulla:*

- Connective tissue and vessels that supply and drain cortex
- There is no sonographic distinction between the cortex and medulla

#### **Ovarian Vasculature:**

- Dual blood supply from branches of the uterine artery and the ovarian arteries
- Uterine arteries branch from the internal iliac arteries
- Ovarian arteries branch from the anterior aorta below the renal arteries
- Small branches of the uterine artery merge with branches of the ovarian artery near the uterine cornua
- Right ovarian vein empties into IVC
- Left ovarian vein empties into left renal vein

#### **Fallopian Tube Anatomy:**

- AKA Oviducts or Salpinges or Uterine Tubes
- Trumpet shaped, muscular canals
- 8-14cm in length
- Usually tortuous
- Extend from cornua to medial ovary
- Supplied with blood from the vascular arch

#### **Tube Segments:**

1. Interstitial - AKA intramural; short section that passes thru uterine wall; Most Dangerous Place for Ectopic!!!!
2. Isthmus - middle portion
3. Ampulla - widest and longest portion; egg fertilization normally occurs here; most ectopics occur in this segment
4. Infundibulum - contains fimbriae; trumpet shaped end opens into pelvic peritoneal cavity

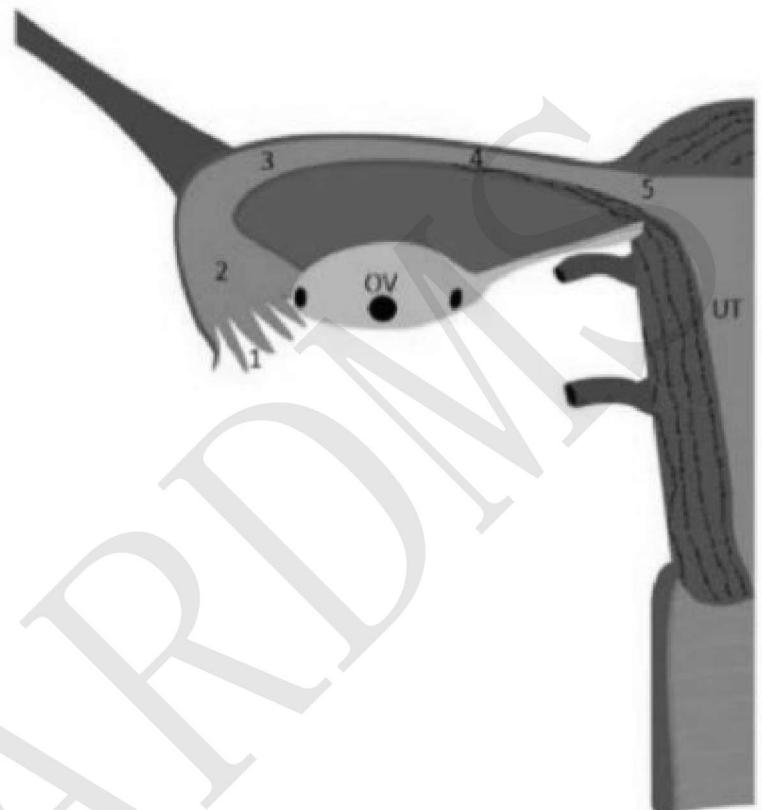
#### **Wall Layers:**

- Mucosal lining - contains cilia to help propel the egg thru the tube
- Muscle

- Serosal coating

## Fallopian Tube Anatomy

1. Fimbriae
2. Infundibulum
3. Ampulla
4. Isthmus
5. Interstitial



## ANATOMY OF THE FEMALE PELVIS

*Commonly Used Quadrant Terminology:*  
RUQ - Right Upper Quadrant

RLQ - Right Lower Quadrant

LUQ - Left Upper Quadrant

LLQ - Left Lower Quadrant

\*\*\*Abdomen divided by sagittal plane crossing through midline at umbilicus and a transverse plane crossing through the abdomen at the level of the umbilicus

*Addison's Nine Regions:*

Right Hypochondrium - liver, GB, hepatic flexure of colon

Epigastric - pancreas, stomach, transverse colon

Left Hypochondrium - spleen, stomach, left kidney (upper pole)

Right Lumbar - right kidney, ascending colon

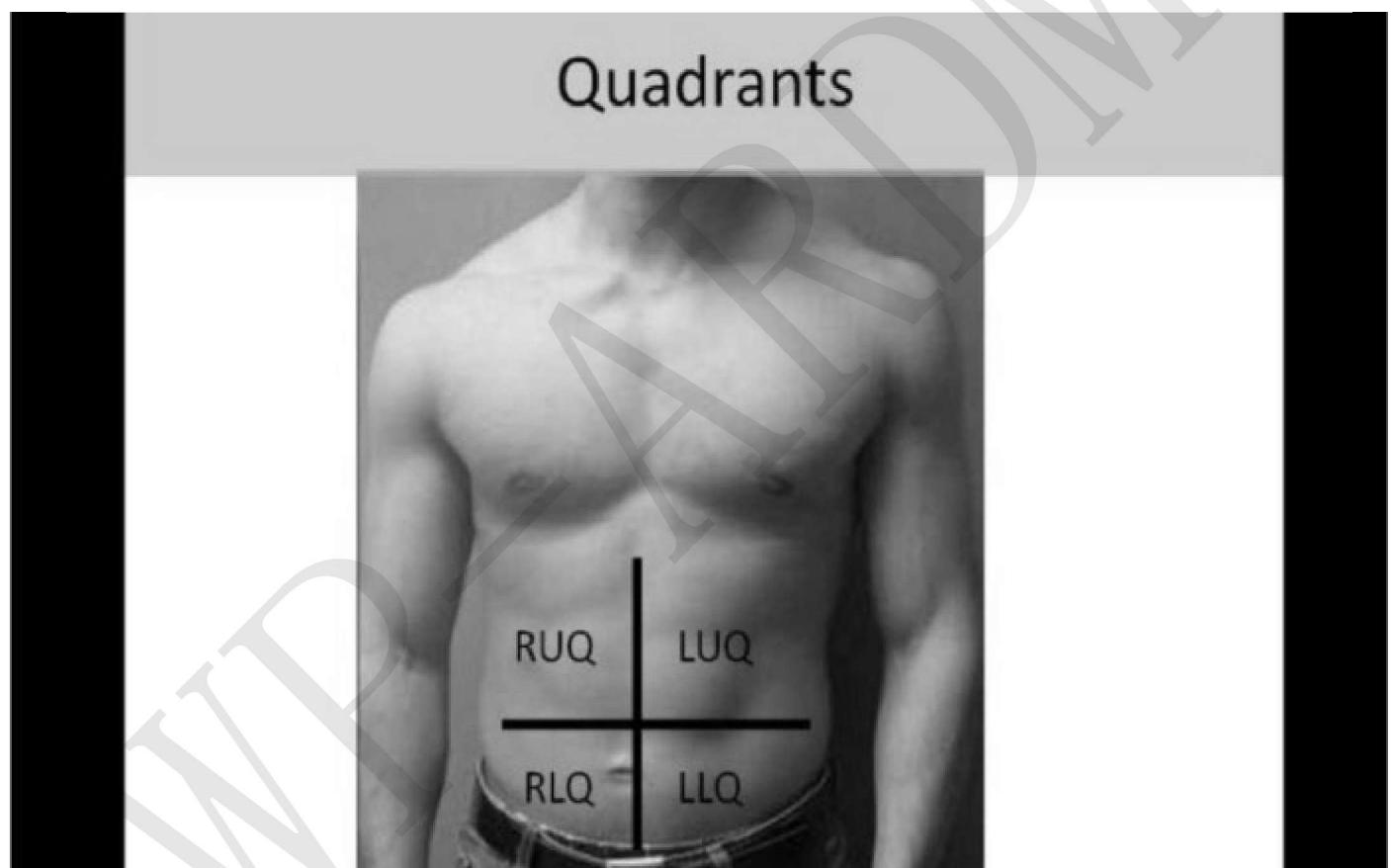
Umbilical - Transverse colon, small bowel

Left Lumbar - left kidney (mid/lower poles), descending colon

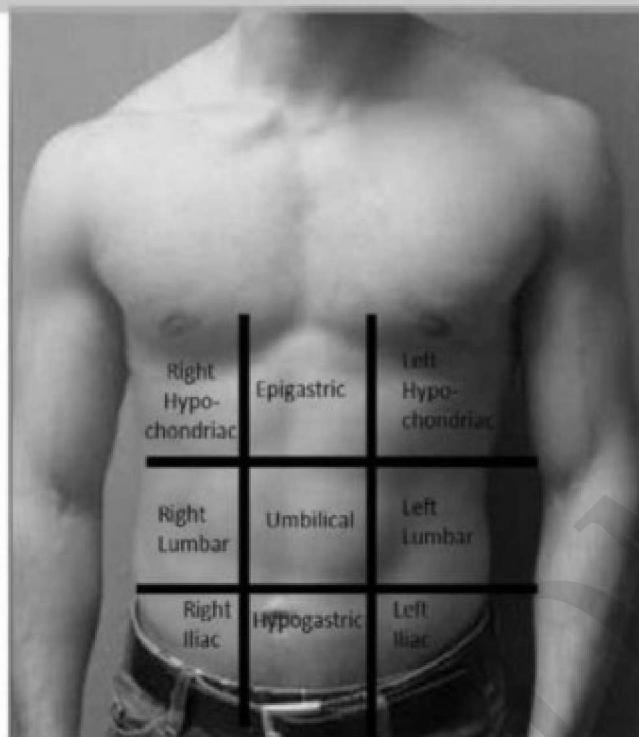
*Right Iliac - ovary, seminal vesicle*

*Hypogastric - bladder, uterus, prostate, rectum, sigmoid*

*Left Iliac - ovary, seminal vesicle*



# Addison's Nine Regions



## ANATOMY

### *Internal Organs:*

- Uterus
- Fallopian Tubes
- Ovaries
- Vagina
- Accessory Glands
- Skene glands-paraurethral gland
- Bartholin glands-on either side of vagina
- Mammary glands-within the breasts

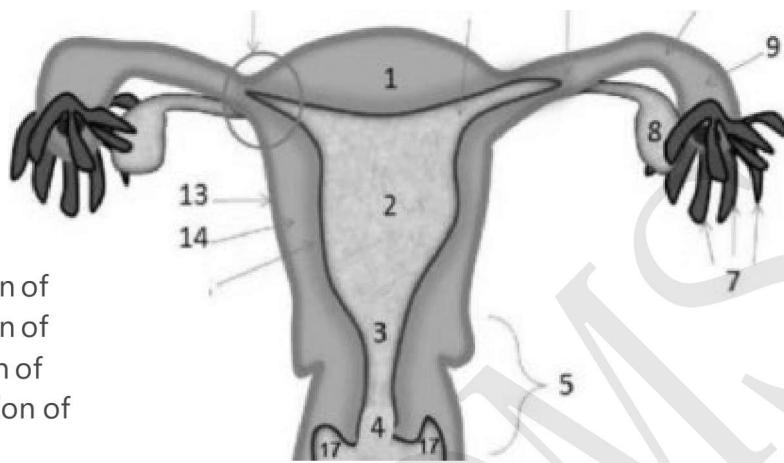
### *External Structures:*

- Mons Pubis- fatty prominence covering the symphysis pubis
- Labia Majora- outer lips covering vaginal opening
- Labia Minora- inner lips, smaller
- Clitoris- lies below the junction of the labia majora

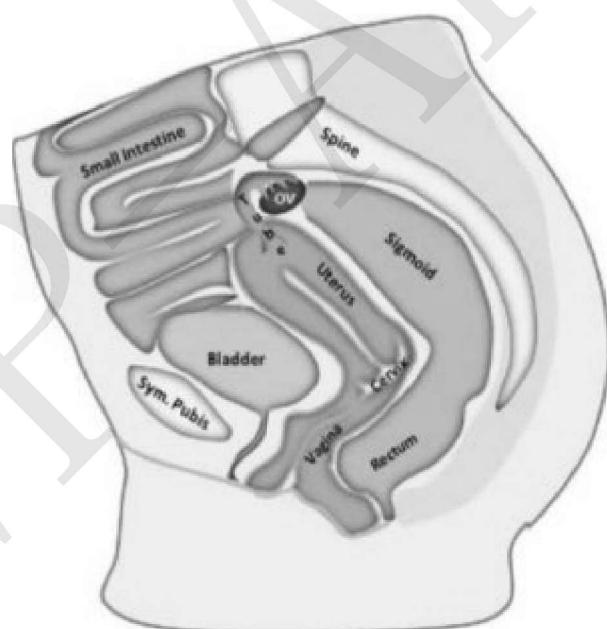
- Linea Terminalis- imaginary line connecting superior sacrum to symphysis pubis, separates true and false pelvis

# FEMALE REPRODUCTIVE ANATOMY

1. Uterine
2. Fundus
3. Uterine Cavity
4. Internal os
5. External os
6. Cervix Vagina
7. Fimbriae
8. Ovary
9. Infundibulum portion of tube
10. Ampulla portion of tube
11. Isthmus portion of tube
12. Interstitial portion of tube
13. Perimetrium
14. Myometrium
15. Endometrium
16. Uterine Cornua
17. Vaginal Fornices



# PELVIC ANATOMY



### *Greater/False Pelvis:*

- Above the pelvic brim
- Communicates with the abdominal cavity
- Contains sigmoid colon and ileum
- Muscles
  - Rectus Abdominis - forms anterior wall of abdominopelvic cavity, from xiphoid to symphysis pubis
  - Transverse Abdominis - form the anterolateral borders of the abdominopelvic cavity
  - Psoas Major - 2 muscles (left and right) originate in lumbar vertebral region and extend to the iliac crests;
  - Iliopsoas - psoas muscle connects with iliacus muscle to form iliopsoas muscle

### *Lesser/True Pelvis:*

- Below the pelvic brim
- Formed by the bony bowl of the pelvic bones
- Enclosed inferiorly by membranes and muscles
- Contains uterus, vagina, fallopian tubes, ovaries, rectum and bladder

### *Pelvic Muscles in True Pelvis:*

- All muscles should be hypoechoic to the surrounding pelvic organs, some have visible striations
- Levator Ani
  - Most inferior structure
  - Pubococcygeus and Iliococcygeus muscles together are referred to as the levator ani muscles
  - Connects the coccyx and the pubis bone
  - Forms the floor of the pelvis
  - Has 3 openings for urethra, vagina and rectum
  - Can be identified on ultrasound as the flat muscle extending laterally on both sides of the vaginal cuff
  - Pelvic diaphragm formed by the levator ani and coccygeus muscles
  - Weakness in the levator ani muscles can lead to uterine or rectal prolapse
- Obturator Internus
  - Located laterally at the acetabulum
  - Triangular sheet
    - Covers anterior and lateral walls of the pelvis
- Piriformis
  - Superior and lateral to levator ani muscles
  - Originates from sacrum and connects to the greater trochanter
  - Covers posterior wall
  - Most commonly mistaken for ovaries on ultrasound

- Coccygeus
  - Forms the posterior portion of the pelvic wall
  - Originates from the coccyx
- Psoas
  - Originates in lumbar vertebral region
  - Connects with the iliacus muscle to form the iliopsoas muscle
- Rectus Abdominis
  - Forms the anterior abdominal wall
  - Extends from the xiphoid process to the symphysis pubis
  - Linea alba separates the muscles in the midline of the abdomen, extends from xiphoid to pubis

***Functions of the Pelvic Skeleton:***

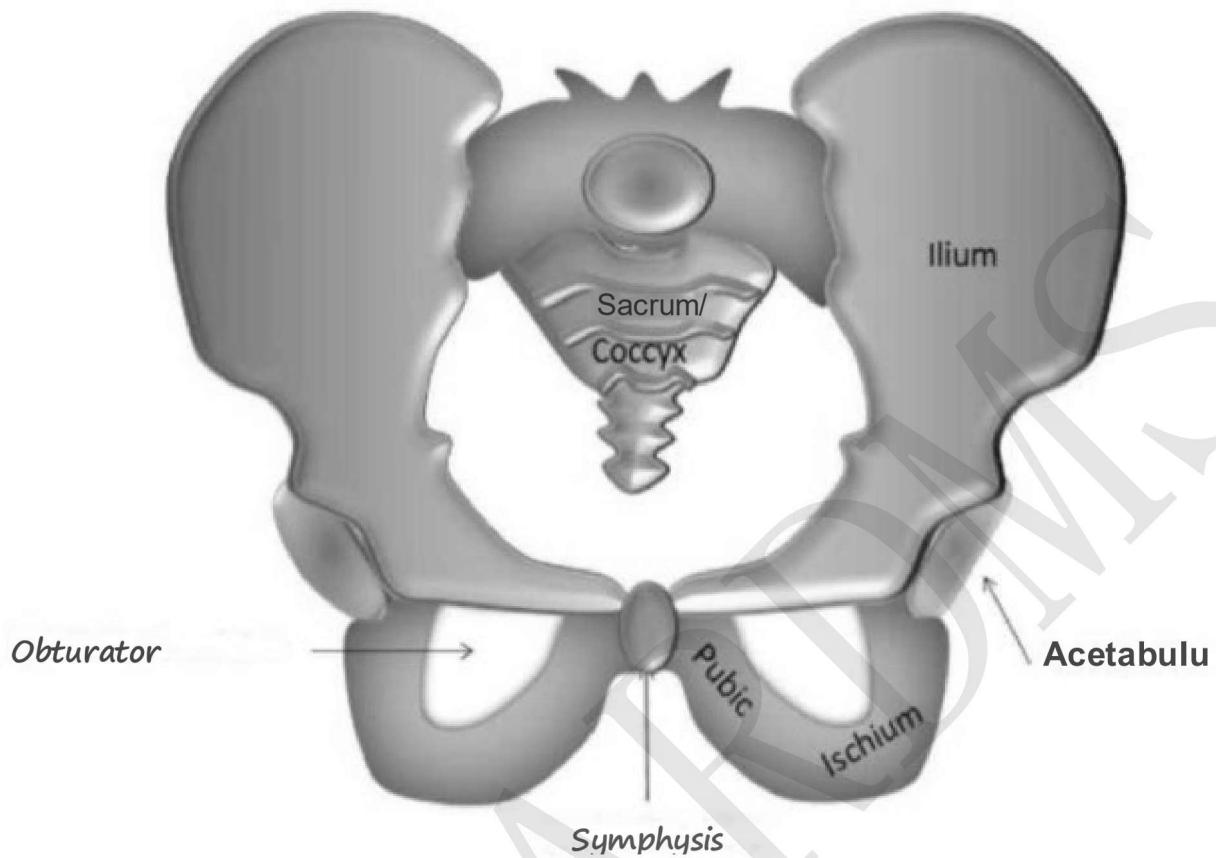
- Provides a weight bearing bridge between spine and ribs
- Directs the pathway of the fetal head during childbirth
- Protects reproductive organs
- Innominate bones
  - AKA hip bones
  - Ischium
  - Ilium (the ileum is in the GI tract, the ilium is a pelvic bone)
  - Pubis
- Sacrum
- Coccyx
- *Bones are echogenic with posterior shadowing*

***Pelvic Spaces:***

1. *Anterior Cul-de-Sac:*
  - Fold in the peritoneum between anterior uterus and posterior bladder
  - AKA vesicouterine pouch
2. *Posterior Cul-de-Sac:*
  - Fold in the peritoneum between posterior uterus and anterior rectum
  - AKA rectouterine pouch or pouch of Douglas
  - Most dependent portion of the pelvis
  - Most likely location for pooling of free fluid
3. *Space of Retzius:*

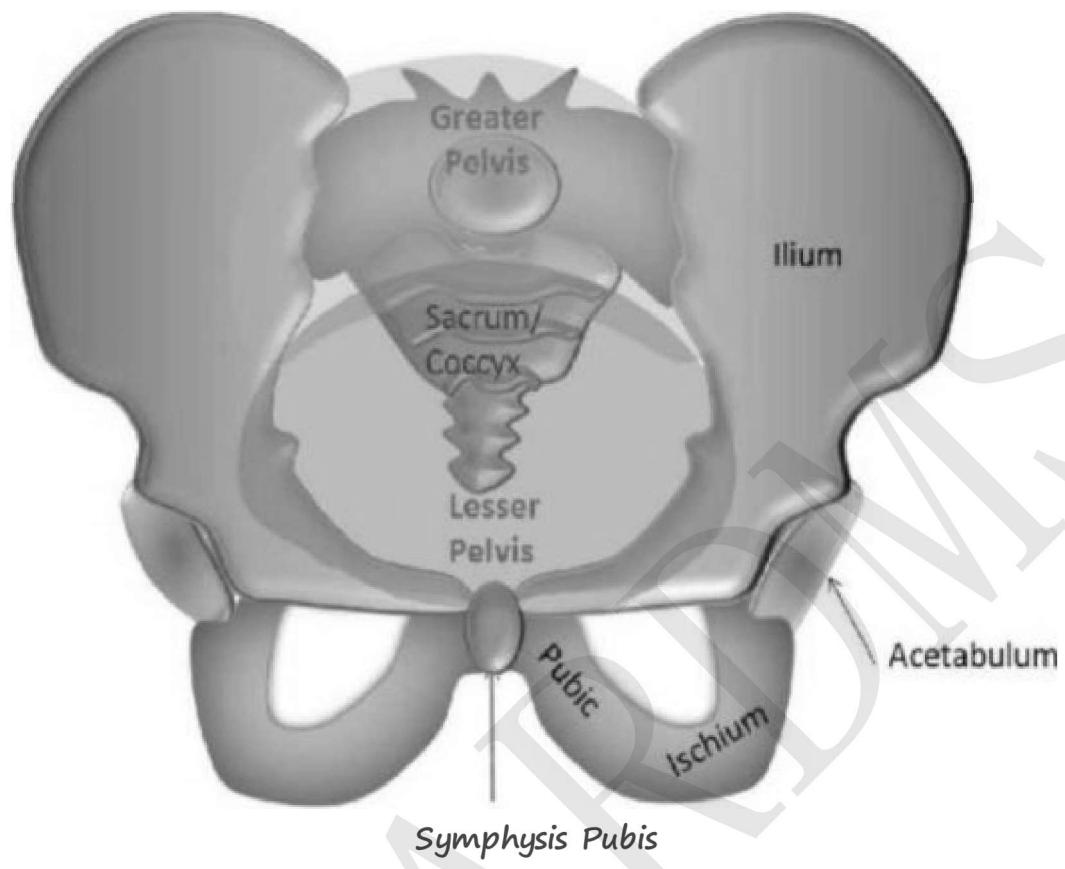
- o Anterior to bladder, posterior to symphysis pubis
- o Space between the transversalis layer and outer fascia of the peritoneum
- o AKA retroperitoneal space
- o Not contiguous with abdominopelvic cavity
- o Very unusual for fluid collection
- o Usually contains fat

# Pelvic Bones

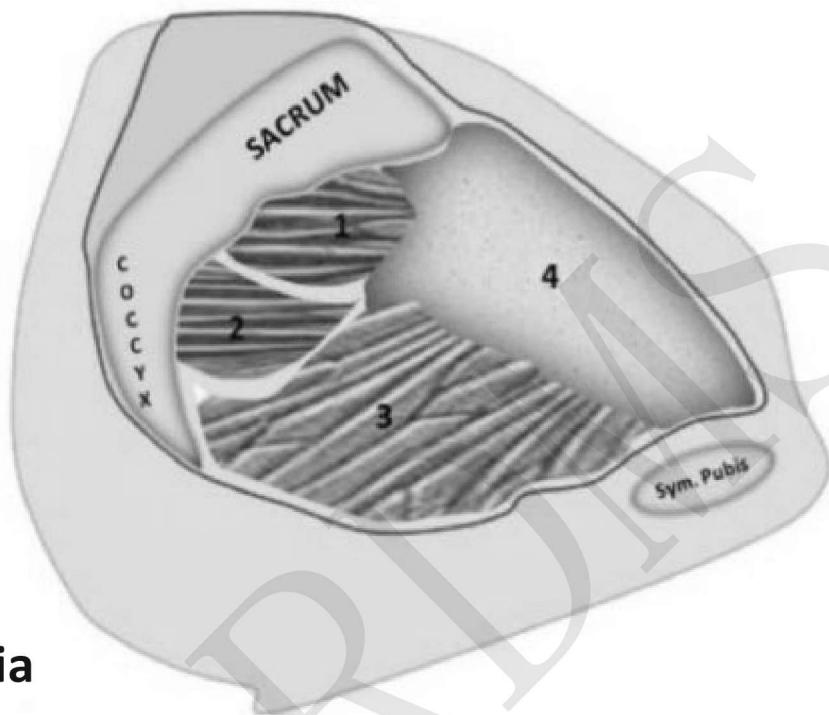


# Greater and Lesser Pelvis

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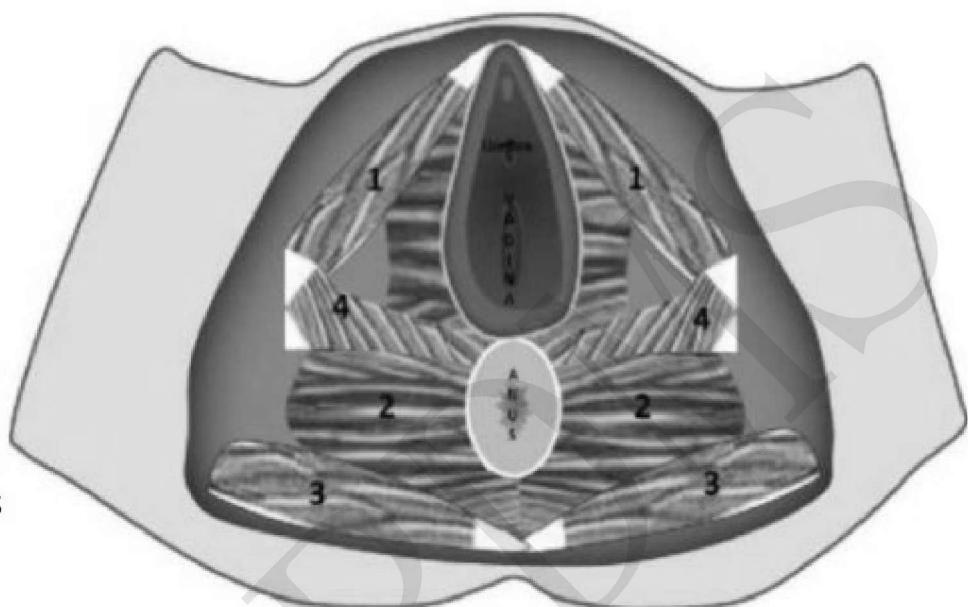


# Lateral Pelvic Wall Muscles



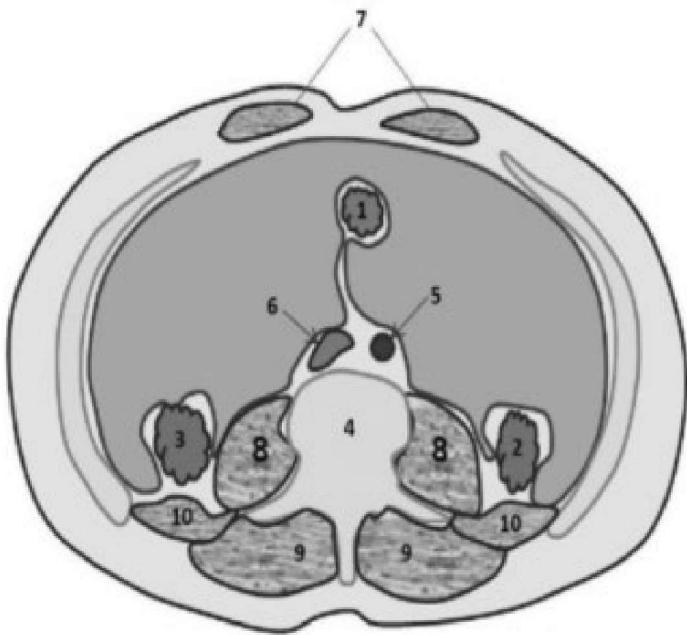
- 1. Piriformis**
- 2. Coccygeous**
- 3. Levator Ani**
- 4. Obturator Fascia**

# Pelvic Muscles



1. Obturator Internus
2. **Levator Ani**
3. Gluteus Maximus
4. Transversus Perinei

# Pelvic Anatomy



1. Small Bowel
2. Descending colon
3. Ascending colon
4. Lumber spine
5. Aorta
6. IVC
7. Rectus Abdominis muscles
8. Psoas major muscles
9. Supraspinatus muscles
10. Quadratus Lumborum muscles

# Free Fluid in Posterior Cul-de-sac



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# Pelvic Pelvic



## Ligaments:

### Broad Ligaments:

- NOT true ligaments
- Wing like folds of the peritoneum extending from the uterine cornua to the lateral pelvic walls
- Separates pelvic cavity into anterior and posterior portions
- Covers anterior and posterior surfaces of the uterus
- Encases most of fallopian tubes and round ligament, ovarian ligament and vessels
- Loosely positions uterus in pelvic cavity and supports tubes and ovaries
- Mesovarium - portion of the peritoneum connecting anterior ovary to posterior broad ligament; contains vessels
- Mesosalpinx - free margin of the broad ligament where the fallopian tube travels; contains vessels
- Spaces within the peritoneal cavity that are posterior to the broad ligaments = Adnexa
- Fluid in the pelvis (ascites) will cause the broad ligament to become visible

Sonographically

### Round Ligaments:

- Fibromuscular bands extending from uterine horns to labia majora
- Maintains normal uterine fundal position and provides structural support

- Assists in birth

*Cardinal Ligaments:*

- AKA Transverse Cervical Ligament of Mackenrodt
- Band of fibrous tissue and muscle
- Extends from upper lateral cervix to lateral pelvic wall
- Contains the uterine and vaginal vessels
- Determines the cervix position/orientation in the pelvis with the uterosacral ligaments

*Uterosacral! Ligaments:*

- Extend from upper cervix to lateral sacrum
- Determines the cervix position/orientation in the pelvis with the cardinal ligaments

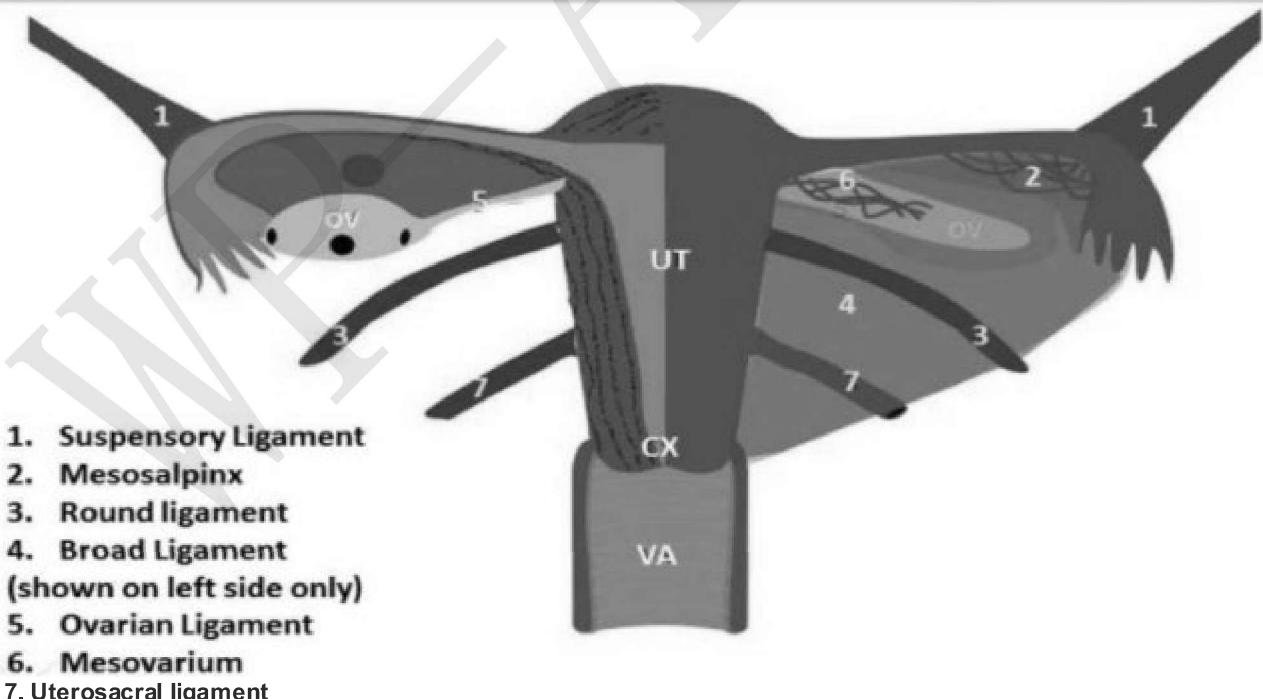
*Suspensory Ligaments:*

- AKA infundibulopelvic ligament
- Folds of peritoneum that contain the ovarian vessels
- Supports fallopian tubes and ovaries within pelvis

*Ovarian Ligaments:*

- Lies within the folds of the broad ligament
- Supports the medial aspect of the ovary and its position relative to the uterine cornua
- Connects the medial ovary to the lateral uterine wall

## Pelvic Ligaments

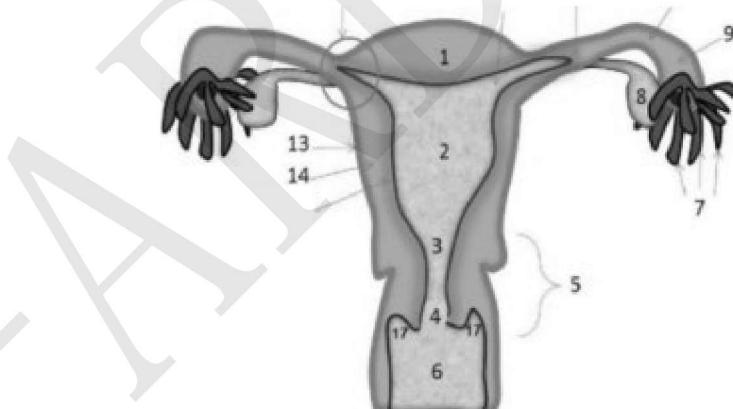


### Vagina Anatomy:

- Anterior to rectum, posterior to bladder and urethra
- Between the right and left levator ani muscles
- Collapsible, fibromuscular tube
- Outlet covered by the hymen
- Connects to cervix
- The lower segment of the cervix extends slightly in to the vaginal canal which forms the vaginal fornices
- Vaginal fornices - superior recesses of the vagina caused by the extension of the cervix into the vaginal canal
- Vaginal walls should not exceed 1cm thickness, both measured together no greater than 2cm
- Average cuff measurement 1.4cm

### FEMALE REPRODUCTIVE ANATOMY

- 1.Uterine Fundus
- 2.Uterine Cavity
- 3.Internal os
- 4.External os
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- 6.Vagina
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- 9.Infundibulum portion of tube
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- 12.Interstitial portion of tube
- 13.Perimetrium
14. Myometrium
15. Endometrium
16. Uterine Cornua



### Uterine Anatomy:

- Hollow, thick-walled muscular organ
- Inner mucous layer = endometrium
- Muscle layer = myometrium
- Outer serous layer = perimetrium or serosa
- Internal os - opening from uterus into cervix
- External os - opening from cervix to vagina
- Fundus - most superior portion of the uterus above where the cornua extend into the ovaries

## *fallopian tubes*

- Body - AKA *corpus*; mid-section of the uterus that has great flexibility to expand with pregnancy
- *Isthmus* - lower portion of the corpus connected to the cervix
- Lower uterine segment - short segment between the body and the cervix in the *PREGNANT* patient
- Cervix connects uterine cavity with vagina

## *Three Wall Layers:*

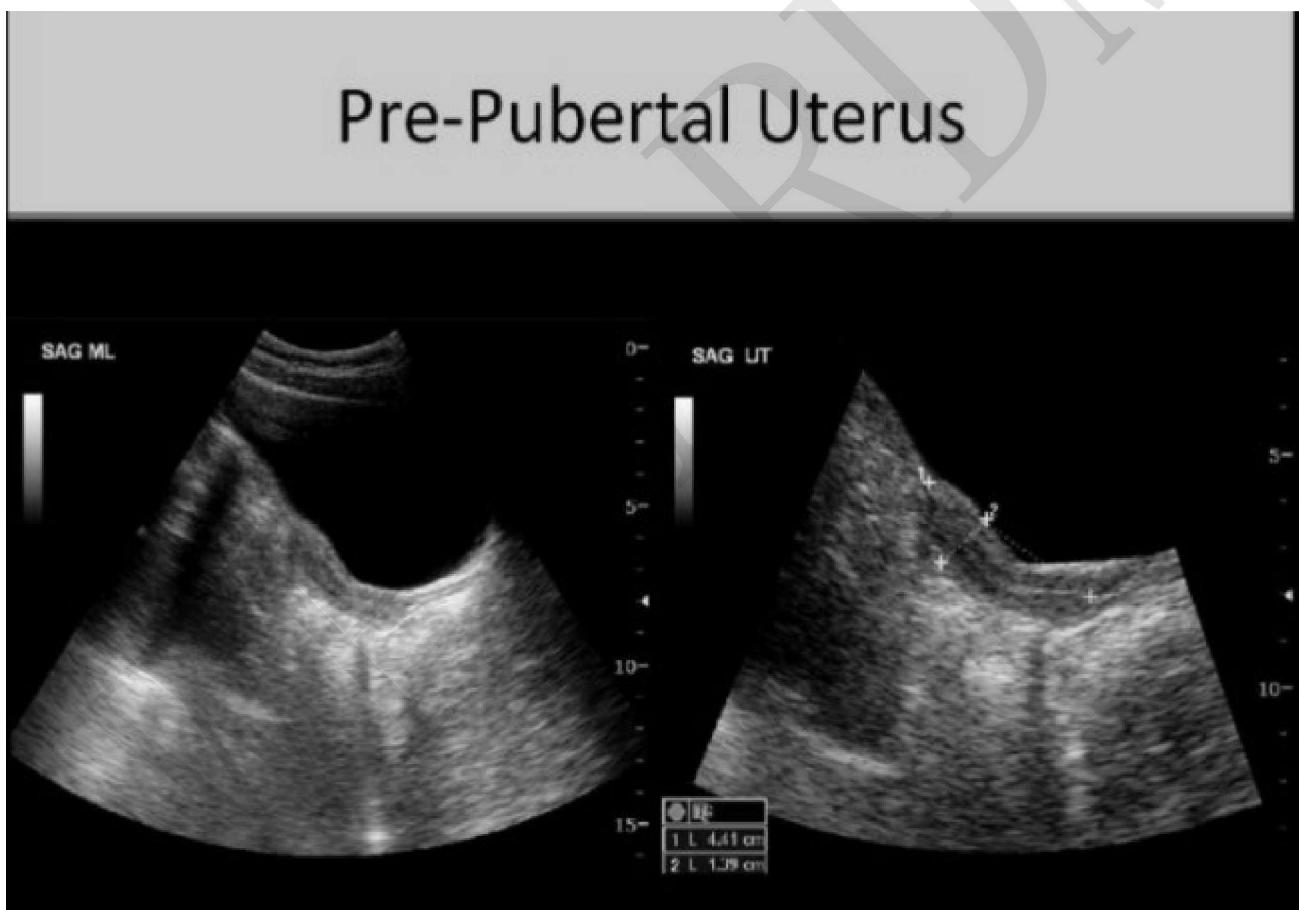
- Endometrium
  - Innermost layer
  - Composed of 2 layers
    5. superficial or functional layer - thickens and is sloughed off with menses
    6. deep or basal layer - not influenced by the menstrual cycle
  - Varies in thickness during the menstrual cycle due to proliferation and sloughing
- Myometrium
  - Middle layer
  - Thickest layer
  - Involved in birth
- Perimetrium
  - Outermost layer
  - Serosa
  - Composed of fibrous connective tissue

## *Location/Landmarks:*

- Round, cardinal and uterosacral ligaments suspend the uterus in the pelvic cavity
- Uterus sits between two layers of the broad ligament
- Posterior to bladder
- Anterior to rectosigmoid colon
- Segmented into the fundus, corpus and cervix

**Size:**

- Nulliparous
  - 6 to 8.5 cm length
  - 2 to 4cm AP
  - 3 to 5cm width
- Multiparous
  - 8 to 10.5 cm length
  - 3 to 5 cm AP
  - 4 to 6cm width
- Measure the length in the sagittal plane, from uterine fundus to the level of the external os
- Neonatal - Cervix more than 2X longer than the body/fundus
- Prepubertal - body half the size of the cervix
- Adult - (nulliparous) 1:1 ratio of cervix and body/fundus length
- Adult - (multiparous) body/fundus at least 2 x longer than cervix
- Postmenopausal - segment ratio remains same, overall organ atrophy

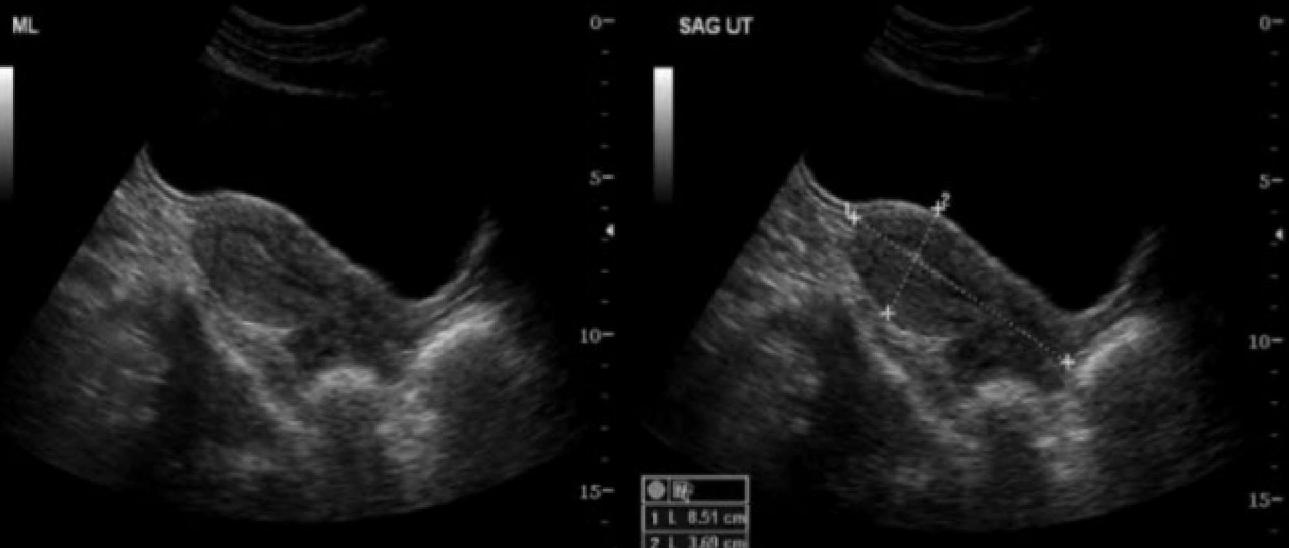


# Postmenopausal Uterus



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## Premenopausal, Nulligravida Uterus



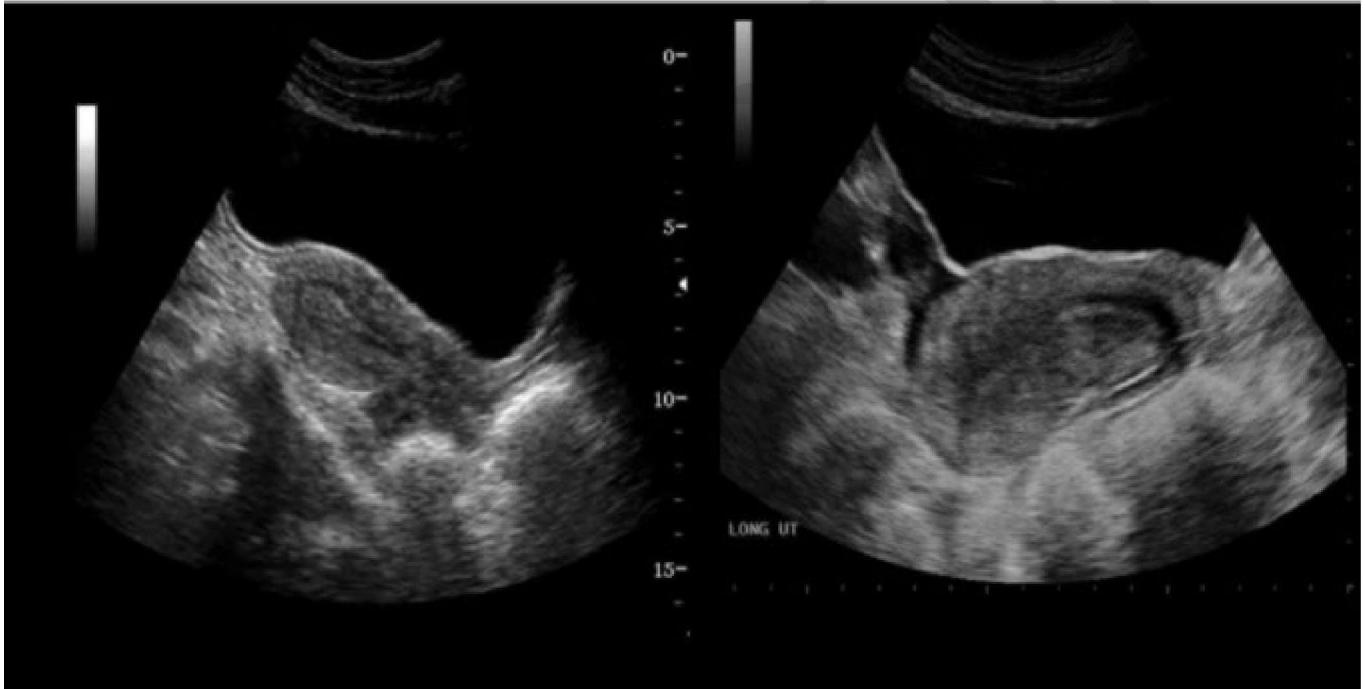
## Pre-Menopausal, Multigravida Uterus



### **Uterine/Cervix Position:**

- Anteverted - uterus forms a <90 degree angle with the cervix, cervix angles anterior from its origin at the vaginal cuff
- Anteflexed - uterine body forms a sharp angle with the cervix, folds over sharply on the cervix
- Retroverted - uterine body tips posteriorly with a small angle between the corpus and the cervix, cervix angles posterior from its origin at the vaginal cuff
- Retroflexed - uterine body folds posteriorly at a very sharp angle to the cervix
- Dextroflexed - uterine body flexed to the right
- Dextroposition - entire uterus is displaced to the right
- Levoflexed - uterine body flexed to the left
- Levoposition - entire uterus is displaced to the left

### **Anteverted vs. Retroverted Cervix**

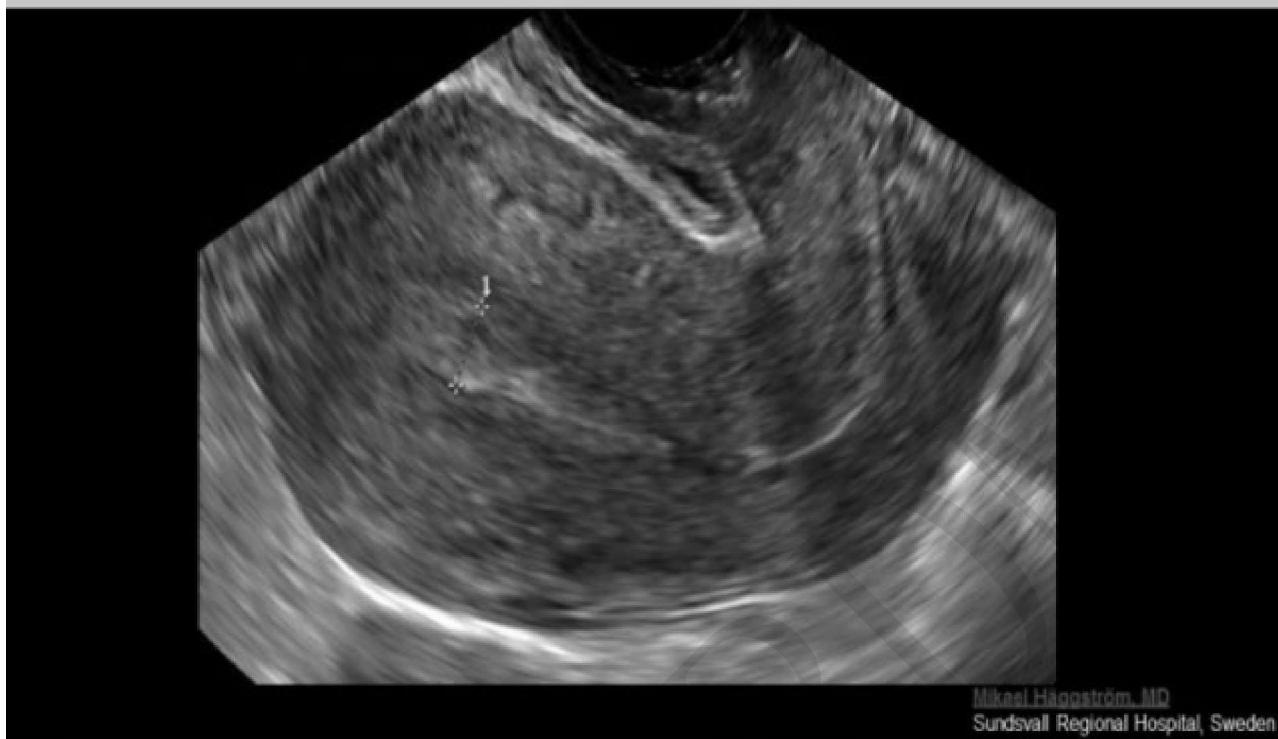


## Retroflexed Uterine Fundus



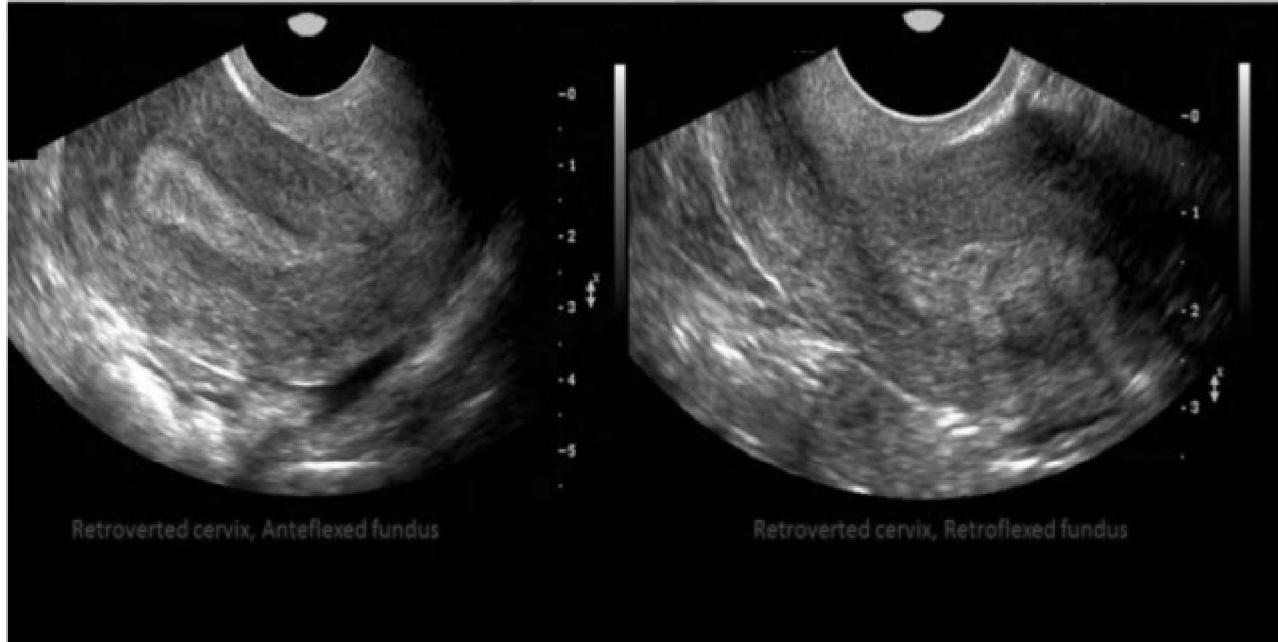
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# Anteflexed Uterine Fundus



Mikael Hagström, MD  
Sundsvall Regional Hospital, Sweden

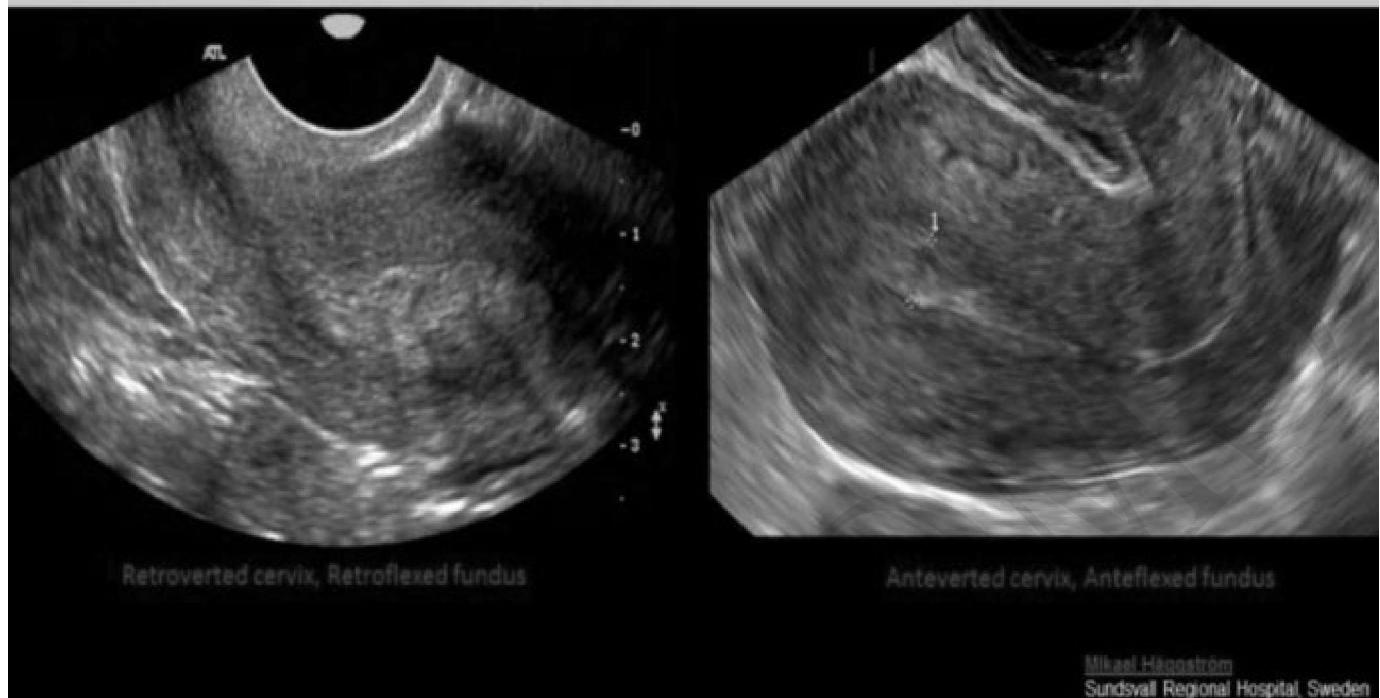
## Uterine and Cervical Position



Retroverted cervix, Anteflexed fundus

Retroverted cervix, Retroflexed fundus

# Uterine and Cervical Position



## Uterine Arterial Supply:

- Uterine artery flow is of moderate velocity and high resistance
- Resistance increases with age until diastolic flow is absent or nearly absent (RI 1.0)

## Internal Iliac Artery AKA Hypogastric Artery

- In a non-pregnant patient, the internal iliac artery is smaller in caliber than the external iliac artery
- Courses anterior to the internal iliac vein
- Divides into anterior and posterior segments
- Branches include the umbilical artery, inferior vesicle artery, and middle rectal artery
- The uterine artery is an anterior segment branch

## Uterine Artery:

- Branch of the anterior interior iliac artery
- Right and left uterine arteries
- Extend to the cervix to then course superiorly along the outside of the uterus
- The vaginal artery branches from the uterine artery and supplies vagina with blood
- Small branches merge with branches of the ovarian artery near the uterine cornua
- Blood is supplied to the ovaries and tubes by the uterine artery and ovarian artery
- Gives rise to many small arcuate arteries

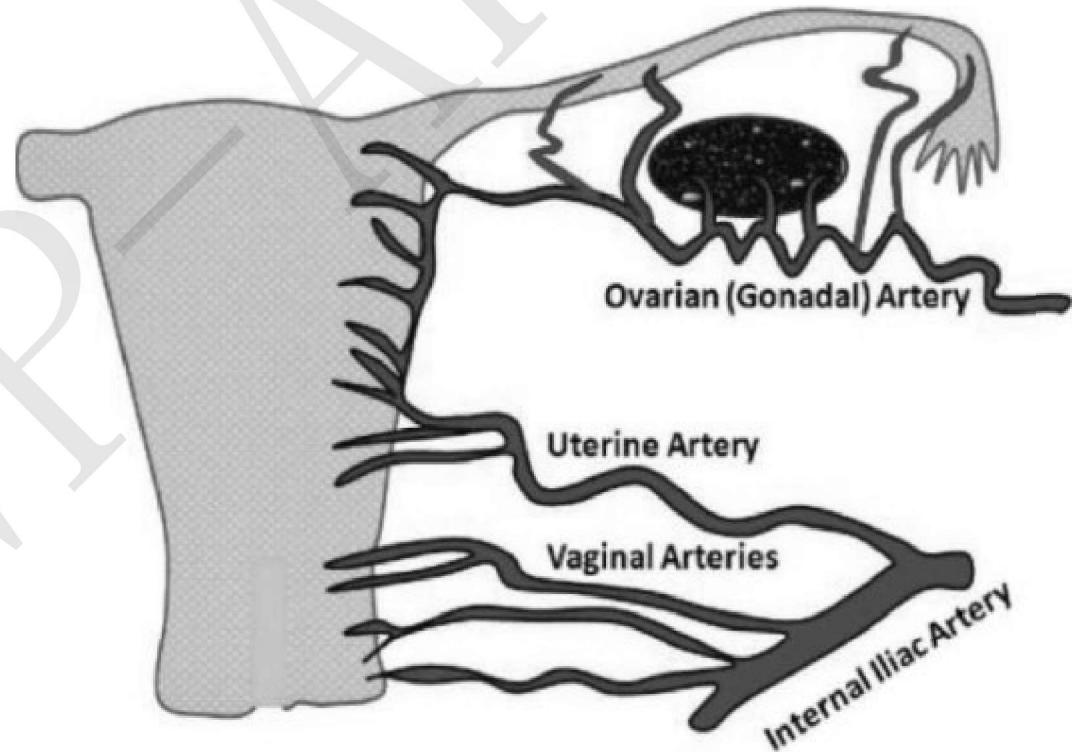
### *Arcuate Arteries:*

- Encircle the periphery of the uterus
- Course parallel to the long axis of the uterus
- Gives rise to smaller branches called radial arteries that penetrate the serosa and myometrium
- The radial arteries penetrate the myometrium and branch into the spiral and straight arteries
- Straight arteries supply the basal layer of the endometrium
- Spiral arteries supply the functional layer of the endometrium and are stimulated by the menstrual cycle

### *Uterine Venous Drainage:*

- Uterine veins empty into the internal iliac veins
- Internal iliac veins are posterior and medial to the internal iliac arteries
- Iliac vessels are located lateral and posterior to the ovaries
- In a non-pregnant patient, the internal iliac vein is smaller in caliber than the external iliac vein
- Merges with the external iliac vein to form the common iliac vein
- Drains pelvic organs

## **ARTERIAL SUPPLY**



*Contraception and Hormone Replacement  
Therapy*

**Contraceptive Medications:**

- Limits formation of dominant follicles and prevents ovulation by suppressing FSH
- If no follicle matures, estrogen levels do not rise, then LH levels do not rise because there is no ovum ready to be released
- Endometrial proliferation will also be suppressed and the layer will not go through cyclical changes/remains thin
- Many come in pill form or can be an injection such as Depo-provera
- Used to treat irregular or absent menstrual cycles, menstrual cramps, premenstrual symptoms, endometriosis, Primary Ovarian Insufficiency (POI) and Polycystic Ovary Syndrome (PCOS)
- Some forms of contraception significantly reduce or prevent menses
- Chronic use of oral contraceptives has been related to the formation of hepatic adenoma

**Reversible Contraception Devices:**

- Devices that are put in place to temporarily prevent pregnancy
- Diaphragm
- Intrauterine devices:
  - Made of polyethylene, metal or combination
  - Some are designed to release progestin to prevent the embryo from implanting in the uterine wall
    - Impregnated with barium sulfate to allow for visualization on x-rays
    - Most IUDs demonstrate an entrance-exit reflection sonographically
    - 3D US is the gold standard method of evaluation of IUD position in the endometrial cavity
- Retired IUDs - no longer widely used in the US, but may still be seen on ultrasound exams
  - Lippes Loop
  - Saf-T-Coil
  - Daikon Shield (retired)
  - Zipper Ring
  - Copper 7/Copper T (retired)
  - Progestasert
- Mirena IUD
  - Releases progestin and lasts for 5 years
  - Causes the endometrium to be hostile to implantation of an embryo
  - Increases thickness of cervical mucus to prevent sperm from reaching the endometrial cavity
    - T-shaped
    - Highly reflective on ultrasound exams
    - 3D/4D coronal view of the uterus is preferred for documenting IUD position
- ParaGard IUD

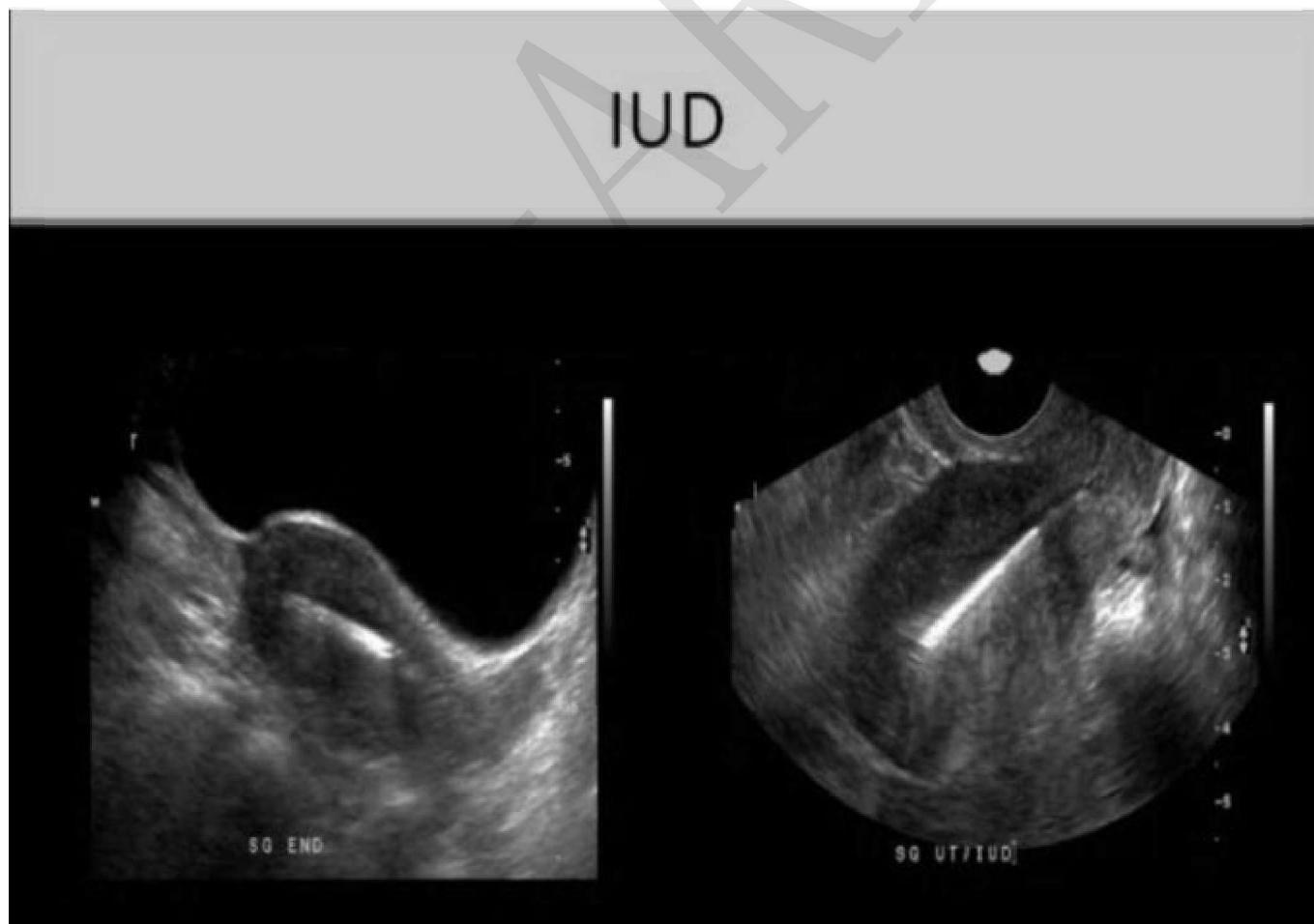
- Coated in copper and lasts for 10 years
- Copper acts as an irritant to the endometrium to prevent fertilization
- T-shaped
- Highly reflective on ultrasound exams
- 3D/4D coronal view of the uterus is preferred for documenting IUD position

***Irreversible Contraception Devices:***

- Ensure devices are coils that are placed in the fallopian tubes
- 3-6 months after insertion, scar tissue will have formed around the devices and obstruct the fallopian tubes
- Hysterosalpingogram is performed at 3 months to assess the tubal patency

***IUD Complications:***

- Low position
- Expulsion
- Ectopic
- PID
- Perforation of the myometrium
- Migration
- Pain
- Cramping and bleeding after the placement procedure



# IUD Abnormal

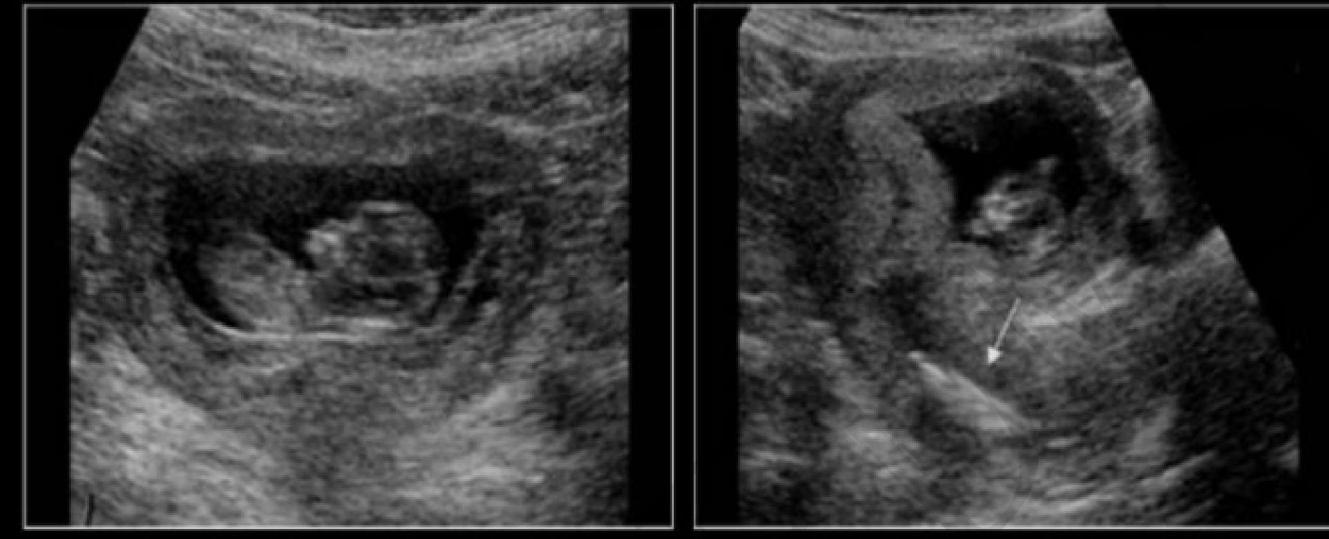


# IUD and Pregnancy



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# Abnormal IUD with Normal IUP



## **Menopause:**

- Ovarian follicles no longer mature and ovulation ceases
- Ovaries no longer produce estrogen and progesterone which stops menses
- Uterine atrophy occurs
- Symptoms include:
  - Amenorrhea
  - Hot flashes, sweating
  - Fatigue
  - Moodiness, irritability
  - Loss of sex drive
- Functional breast tissue is replaced by fatty tissue

## **Hormone Replacement Therapy:**

- Menopause usually occurs between age 44 and 55 years
- Estrogen therapy used to reduce menopause symptoms, help prevent osteoporosis, raises good cholesterol levels
- Can prevent osteoporosis and reduce risk of coronary artery disease
- Can lead to increased endometrial thickness/hyperplasia
- Increases risk of developing thrombosis and subsequent embolization
- Unopposed estrogen therapy used in women who have had a hysterectomy
  - Leads to increased risk of endometrial carcinoma
- Estrogen and Progestin used in women who still have the uterus

- o Combination therapy has reduced risk of carcinoma when compared to unopposed estrogen
- o Normal endometrial thickness <12mm
- o When a patient is on HRT, their uterus still can go through the menstrual cycle due to the hormonal stimulation
- o Cycles may be shorter and lighter than in premenopause
- o The endometrium in these patients should appear similar to a premenopausal patient at the same point in the menstrual cycle

***Tamoxifen Therapy:***

- Anti-estrogen drug given to some breast cancer patients
  - Associated with endometrial hyperplasia and endometrial carcinoma
  - Commonly leads to hyperplasia with cystic changes in the endometrium
- Changes with Tamoxifen

## **PHYSIOLOGY OF THE UTERUS AND OVARIES**

***Physiology of the Vagina:***

1. To receive seminal fluid
2. Excretory duct for menstruation
3. Lowest portion of birth canal

***Physiology of the Uterus:***

- Menstruation - menarche usually occurs age 11-14 years
  - o Menarche refers to the onset of menses
  - o Thelarche refers to the development of the breasts
  - o Menopause usually occurs age 44 - 55 yrs
  - o Premature menopause <40yrs
- Pregnancy
- Labor and expulsion of fetus at birth

***Precocious Puberty:***

- Uterus enlarges and ovulation occurs prior to age 8
- Commonly caused by pituitary or hypothalamic tumor with abnormal pituitary gland function stimulating the production of hormones
- Can also be caused by ovarian tumors that secrete estrogen
- Can be idiopathic

***Endometrial Anatomy:***

- Two layers
  - o Functionalis - sloughed off in menstruation, most superficial layer within uterus
  - o Basalis - "permanent" layer of tissue that is not sloughed off in menstruation, serves as

a source of cell regrowth for functionalis layer

*Endometrial Blood Supply:*

- Internal Iliac Artery - Uterine Artery - Arcuate Artery - Radial Artery - Straight and Spiral Arteries
- Uterine - courses along lateral margin between layers of broad ligament
- Arcuate - circle the uterus within the myometrium
- Radial - penetrates the serosa and myometrium
- Straight - supply deeper 1/3 of endometrium(basal layer), does NOT slough off with menstruation
- Spiral - supply functionalis or decidua layer of endometrium and the vessels are sloughed off and reformed after menses; respond to ovarian hormones

*Hormones of the Menstrual Cycle:*

*Gonadotropin Releasing Hormone (GnRH):*

- Secreted by the hypothalamus when estrogen levels are low
- Stimulates pituitary gland to produce and release luteinizing hormone and follicle stimulating hormone

*Follicle Stimulating Hormone:*

- Secreted by the anterior pituitary gland
- Stimulates estrogen production
- Responsible for follicle and ova maturation

### **Luteinizing Hormone:**

- Secreted by the anterior pituitary gland
- Stimulates theca cells to produce androgens that are converted into estrogen
- Responsible for ovulation and corpus luteal development

### **Estrogen:**

- Naturally produced steroid hormone
- Responsible for the development of reproductive organs and maintains their function during reproductive years
- Causes development of secondary sex characteristics such as axillary and pubic hair, breast development, fat deposits on breasts, thighs and buttocks
- Stimulates endometrium to thicken prior to ovulation
- Stimulates the contraction of the fallopian tubes
- Responsible for cervical mucus production and changes in viscosity of the mucus throughout the menstrual cycle
- Stimulates cervix to produce viscous mucus just prior to ovulation to assist the sperm in reaching the ovum

### **Estradiol:**

- The principle component of estrogen formed by ovarian follicles, adrenal cortex and the placenta
- Responsible for reproductive development and maintenance
- Levels monitored to predict ovulation in patients undergoing fertility treatments
- Linked to endometriosis, fibroids and carcinoma

### **Estriol:**

- Component of estrogen
- Only produced in the placenta (pregnancy)

### **Estrone:**

- Component of estrogen
- Only type of estrogen found in the postmenopausal woman

### **Progesterone:**

- Produced by the corpus luteal cells post-ovulation
- Responsible for premenstrual symptoms and symptoms of pregnancy (nausea, vomiting)
- Responsible for endometrial proliferation AFTER ovulation to prepare for implantation
- Blocks the development of new follicles
- Stimulates uterine blood supply for pregnancy
- Causes breasts to prepare for lactation but inhibits lactation during pregnancy
- Causes formation of cervical mucus plug in pregnancy
- Causes cervical mucus to dry up, the cervix tightens and a mucus plug forms in pregnancy

### **Prolactin:**

- Produced by the pituitary gland
- Stimulates milk production with pregnancy

- Milk production usually begins within 2-3 days post partum

### ***Oxytocin:***

- Produced by the pituitary gland
- Causes ductal contraction with lactation

### ***Testosterone:***

- Produced by the ovary and adrenal glands
- Overproduction causes virilization

### ***Endometrial Cycle:***

#### **Day 1-5 Menstrual Phase:**

- At the onset and during menstruation, estrogen and progesterone levels are very low causing the uterus to shed the lining
- <4mm endometrial thickness at the end of menstruation

#### **Day 6-10: Early Proliferative Phase:**

- Increasing estrogen levels cause endometrial proliferation
- 4-8mm endometrial thickness
- Early phase - endometrium appears as a thin hyperechoic line

#### **Day 11-14: Late Proliferative Phase:**

- Increasing estrogen levels continue to cause endometrial proliferation
- <16mm endometrial thickness at the end of the late phase
- Late phase - appears to have three layers
- The outer layer will be hyperechoic, the middle layer hypoechoic and the inner layer will appear as an echogenic line
- May be referred to as the periovulatory phase

#### **Day 15 -28: Secretory Phase:**

- Increased estrogen and progesterone levels cause a decrease in FSH and LH levels
- Mucous is produced in the cervix with ovulation
- Endometrium continues to thicken
- If no fertilization occurs the corpus luteal cyst involutes causing decreased progesterone levels until menstruation begins on Day 1
- <18mm endometrial thickness; thickened hyperechoic appearance

## Normal Endometrium



Courtesy of: [www.ObGYN.net](http://www.ObGYN.net)

## Early Proliferative Phase



## Late Proliferative Phase



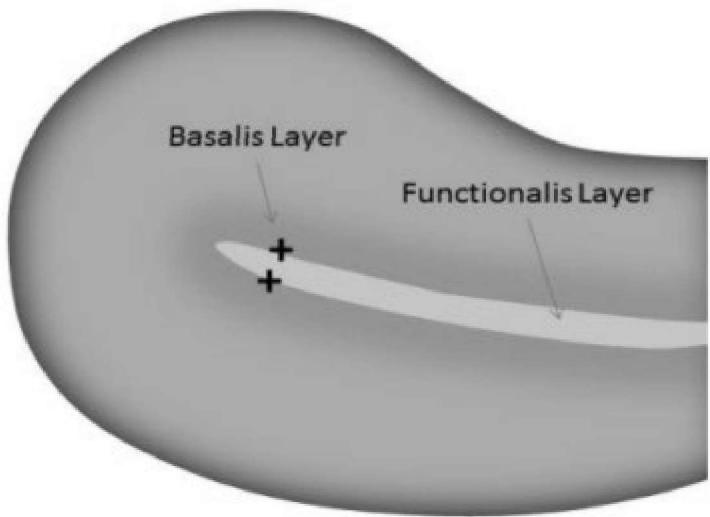
# Secretory Phase



## *Measuring the Endometrium:*

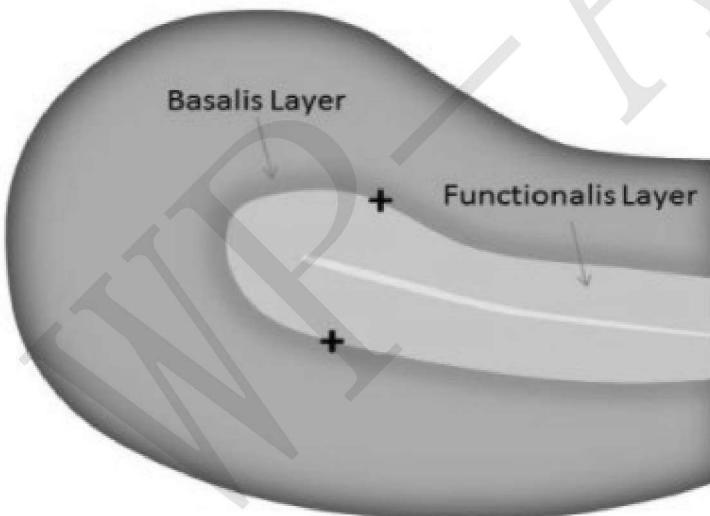
- o Best evaluated by transvaginal approach
- o Requires a true midsagittal view (oblique view close to cornua can cause overestimate thickness)
- o Place the calipers from the border of the functionalis layer and basalis layer to the opposite border of the functionalis layer with the basalis layer
- o If fluid is present, measure the thickness of the two functionalis layers and add them together
- o Fluid is NOT included in the endometrial thickness measurement

# Endometrial Assessment



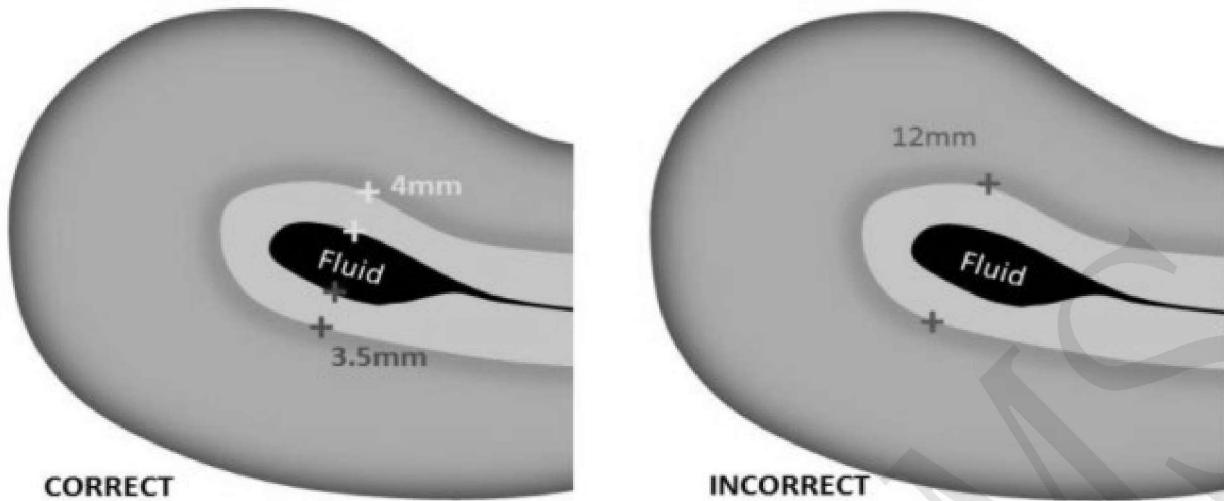
Measure from the outer edge of the functionalis layer to the outer edge of the functionalis layer. Do not include the basalis layer.

# Endometrial Assessment



Measure from the outer edge of the functionalis layer to the outer edge of the functionalis layer. Do not include the basalis layer.

# Endometrial Assessment



When fluid is present in the canal, measure the two functionalis layers separately then add the numbers together.

Endometrial thickness =  $4\text{mm} + 3.5\text{mm} = 7.5\text{mm}$  reported on exam NOT 12mm

- Endometrial thickness varies with age, menstrual phase and hormone replacement therapy (HRT)
- Premenopausal demonstrates normal thickness <18mm
- Postmenopausal with estrogen HRT demonstrates normal thickness <8mm
- Postmenopausal with combined estrogen and progesterone HRT demonstrates normal thickness 10-12mm
- Postmenopausal symptomatic with no HRT demonstrates normal thickness <5mm
- Postmenopausal asymptomatic with no HRT demonstrates normal thickness <8mm

## Ovarian Cycle:

### Day 1-5 Early Ovarian Follicular Phase:

- At the onset and during menstruation, estrogen and progesterone levels are very low
- These low levels are detected in the blood stream by the hypothalamus, which releases Gonadotropin Releasing Hormone (GnRH)
- Pituitary gland senses the increased levels of GnRH and releases Follicle Stimulating Hormone (FSH) and Luteinizing Hormone (LH) into the blood stream
- Rising FSH levels cause the ovaries to increase the estrogen production in the body and cause follicle growth
- FSH and LH stimulate the production of estrogen by the follicles
- Multiple follicles develop by day 5-7 and the dominant follicle will grow 2-3mm a day until ovulation occurs

### Day 6-14 Late Ovarian Follicular Phase

- Estrogen and FSH levels continue to rise

- A dominant follicle will emerge and move toward outer wall of ovary
- Two dominant follicles form with dizygotic twins
- Dominant follicle is visible Sonographically during day 8-12 of the cycle
- Non-dominant follicles are typically 10mm or less in size
- Any follicle >15mm will usually release an egg
- Most dominant follicles reach a size of 15 - 25mm before ovulation
- LH levels surge 24-36hrs before ovulation

#### Day 15-28 Luteal Phase

- LH surge causes ovulation usually on day 14
- Corpus luteal cyst forms to secrete progesterone and estrogen and suppress LH production/release
- If there is no fertilization (no bhCG), the corpus luteum involutes 12-14 days after ovulation and progesterone/estrogen levels decrease
- When the corpus luteum involutes it becomes a corpus albicans

#### *Summary of the Ovarian Hormone Cycle:*

- Estrogen decreases - Hypothalamus releases GRH which causes pituitary gland to release FSH/LH which causes ovaries to increase estrogen production and form a dominant follicle to prepare for ovulation
- Mid cycle, there is a sudden surge in the production of LH from the pituitary gland; this surge in LH triggers ovulation
- After ovulation occurs, the LH levels cause the follicle to develop into a corpus luteum
- The corpus luteum secretes a steadily increasing amount of progesterone which continues the preparation of the endometrium for a possible implantation
- Progesterone also inhibits the development of a new dominant follicle

#### *If Fertilization DOES NOT Occur:*

- Increasing progesterone levels will actually cause a decrease in the progesterone levels
- Progesterone production is stimulated by luteinizing hormone (LH), which is also stimulated by GRH
- The rising level of progesterone inhibits the release of GRH which limits LH production and then decreases progesterone production
- As the progesterone level drops, the corpus luteum begins to degenerate and becomes a corpus albicans 4-5 days postovulation
- The endometrium begins to break down and menstruation begins

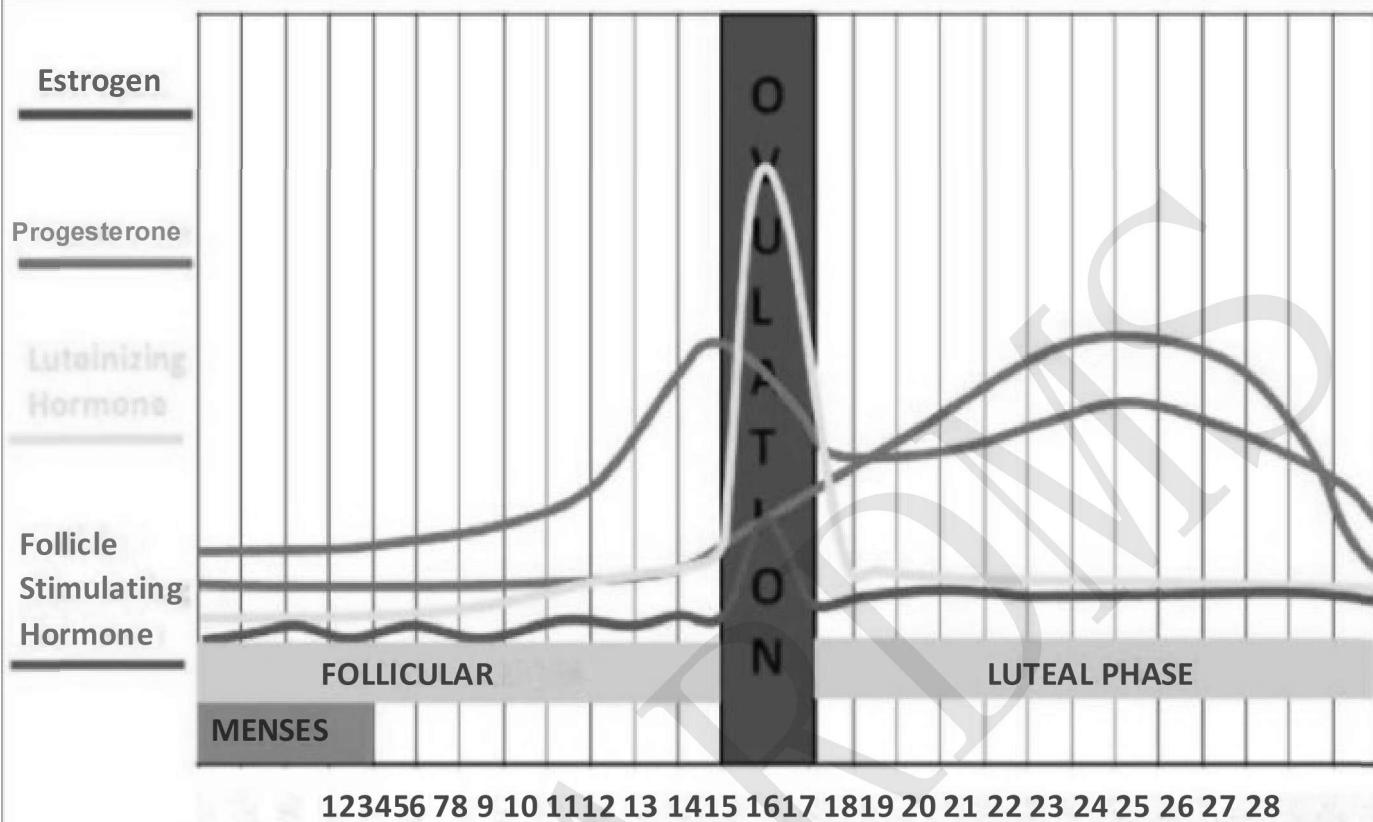
Progesterone decreases — Hypothalamus releases GRH — causes pituitary gland to release a surge of LH — ovulation occurs w/ corpus luteum formation

#### *If Fertilization DOES Occur:*

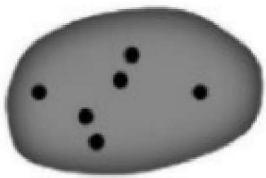
- It normally happens within 24-36hrs after ovulation
- The first mitotic divisions occur as the egg travels through the segments of the fallopian tube
- By the end of the week 1, the developing embryo has become a blastocyst

- At this time, the blastocyst reaches the uterus and embeds itself in the endometrium, a process called implantation
- With implantation, pregnancy is established
- Implantation occurs day 20 - 23 gestational age
- When the blastocyst implants into the uterus, it consists of two parts; the inner cell mass will become the fetus and the trophoblast will develop into the placenta
- The trophoblast secretes human chorionic gonadotropin (hCG) which is detected in maternal urine
  - The trophoblast must be implanted in order to produce hCG
  - Increasing hCG prevents the deterioration of the corpus luteum at the end of week 4
  - The CL cyst remains until around week 14 when the placenta takes over progesterone production
  - The placenta also maintains necessary progesterone levels to maintain the pregnancy
  - Synthetic progesterone may be given to mothers with low levels to prevent early birth

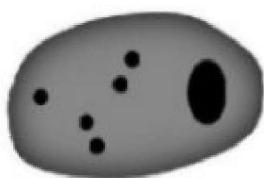
# Menstrual Cycle Hormone Levels



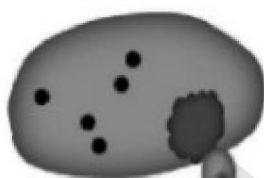
# Ovulation



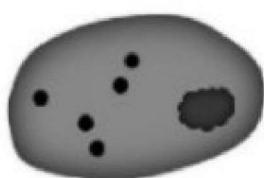
Primary Follicles



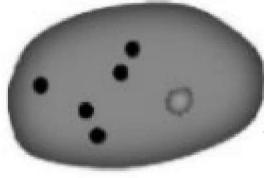
Mature, Dominant Follicle



Follicle Rupture: Egg released

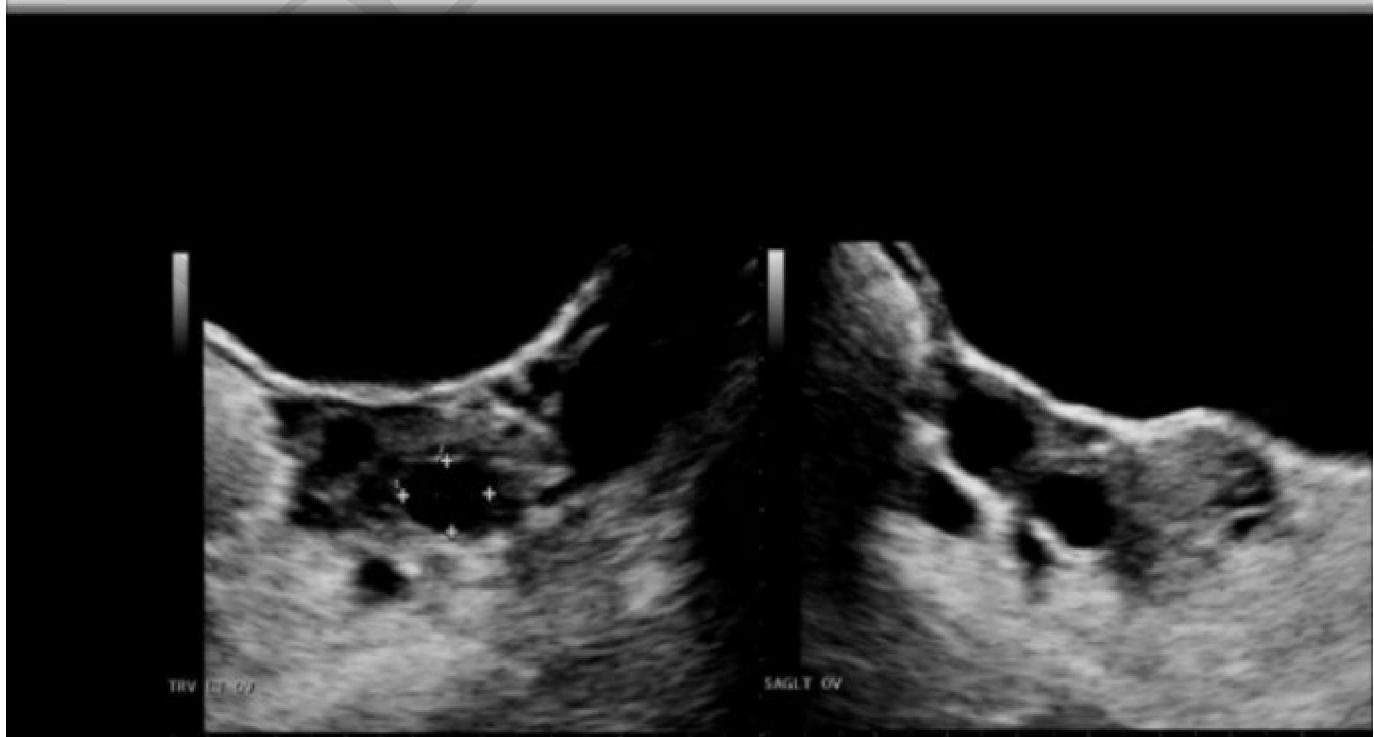


Corpus Luteum

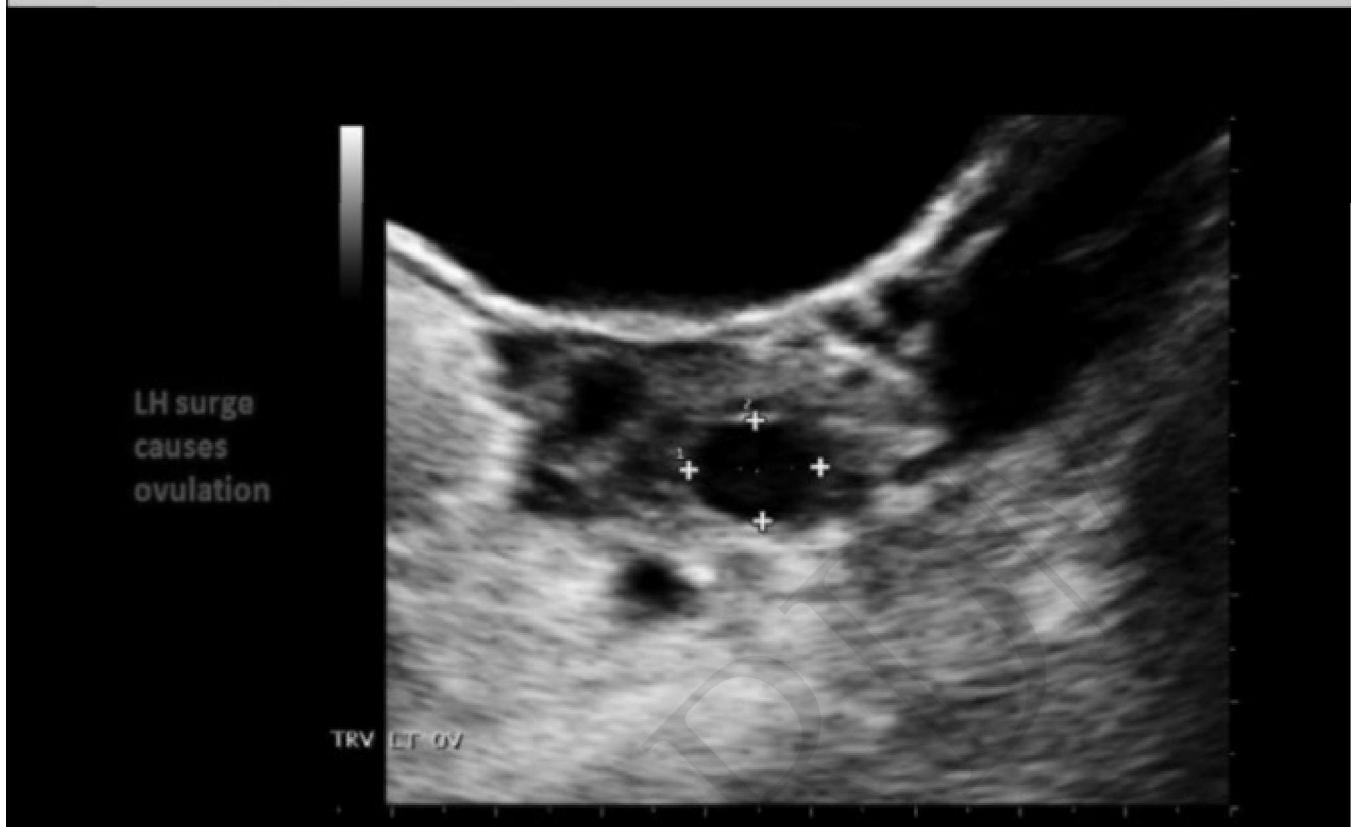


Corpus Albicans

## Follicle Production



# Dominant Follicle



# Corpus Luteal Cyst



# Corpus Luteal Cyst



## 2. Techniques, Protocols and Procedures General Information

### **Considerations For ALL Exams:**

- Universal Precautions guidelines, hand washing, isolation techniques, AKA Standard Precautions
- Personal protective equipment (gowns, goggles, masks)
- CPR guidelines - 30 compressions/ 2 breaths adult and child single rescuer protocol;

- double rescuer technique requires 15 compressions/ 2 breaths; 100 compressions per minute for child/infant
- Choking - abdominal thrusts
- Pregnant or Obese patient - use chest thrusts
- Syncope - if no risk of spinal injury, move patient to the supine position and elevate legs
- Be careful of other medical equipment connected to patient; oxygen, IV therapy, monitors; NEVER alter settings or alter other equipment in use

***Exam Preparation:***

- Verify correct patient using birth date or wristband
  - If a patient cannot be verified, do NOT perform the exam and reschedule the exam until verification can be accomplished
  - If a patient is unconscious and without a wristband, you must confirm the patient identity by contacting their nurse
- Confirm script matches exam scheduled
  - The exam can always be rescheduled, but it is not the Sonographers role to CANCEL an exam
- Review any prior pertinent diagnostic exams and reports
- Take detailed patient history
- Explain exam to patient and time frame for results
- Present pertinent history and prior reports/cases to radiologist
- Accurately record measurements and comments on tech worksheet
- Indicate any necessary info regarding patient follow up
- NEVER provide clinical findings directly to the patient, this information must come from the physician

***Informed Consent:***

- Required for all invasive procedures
- Lists the procedure and potential associated risks and complications
- Must be signed PRIOR to the procedure AFTER physician answers any questions/concerns
- By signing the form, the patient indicates that they have an understanding of the procedure, complications and expected outcomes
- The patient must be of sound mind and have a full understanding of the information presented when giving permission for a procedure by signing the form
- Patients under the age of 18, those not of sound mind and those that do not speak English well should not be allowed to sign the consent form; a guardian or HIPAA "approved" family member must give the consent
- Consent can be revoked by the patient at any time for any reason
  - If consent is revoked during an exam/procedure, the exam/procedure should be discontinued at a point that maintains patient health and safety

***Health Insurance Portability and Accountability Act (HIPAA):***

- Sets national standards for the security of protected health information (PHI)
- PHI refers to individually identifiable health information
- Cannot communicate health information about a specific patient to anyone but that patient
- With proper documentation, PHI can be shared with those parties specified in writing by

the patient

- Patients can give permission to others to receive PHI by signing the appropriate permission form
- Patients under 18

### ***Communication:***

#### **1. Sonographer and Patient**

- Explain any preparation required for the upcoming exam or procedure
  - Optimal images on any type of transabdominal pelvic US exam require the patient to drink 24-32oz of water prior to the exam and maintain a full bladder
  - Transvaginal exams offer more optimal images when the patient has an empty bladder
- 1st trimester OB exams also need to fill their bladder and hold it until the exam is complete
- 2nd trimester OB exams must fill their bladder, but will be able to void after the cervix and fetal structures in the lower uterine segment are evaluated
- Explain the exam or procedure and answer questions related to how the exam is performed
- Obtain pertinent history related to indication for current exam
- Discuss when the patient can expect the results and that as a Sonographer you cannot provide any results for the exam

#### **2. Sonographer and Radiologist**

- Discuss findings on the exam and any related exam difficulties
- Indicate any critical findings that require immediate attention
- Coordinate current study with any prior exams for review by the Radiologist

### ***Examples of Critical Findings:***

- Placenta] abruption
- Premature rupture of membranes
- Ectopic pregnancy
- Cord prolapse into interna] os
- Cervical shortening with funneling
- Umbilical cord knot
- Fetal distress

### ***Patient Infection Control and Isolation:***

#### ***Standard Precautions:***

- Used for all patients
- Includes personal protective equipment
- Hand hygiene - hands should be washed
  - Before touching a patient, even if gloves will be used
  - Before exiting the patient's room after touching the patient or something in their room
  - After contact with blood, body fluids or excretions, or wound dressings
  - After glove removal
- Gloves
  - Wear gloves when there is potential contact with blood (e.g., during phlebotomy), body

- fluids, mucous membranes, nonintact skin or contaminated equipment
- o NEVER wear the same pair of gloves for the care of more than one patient
- o Discard used gloves and never wash gloves for the purpose of reuse
- o Perform hand hygiene before and immediately after removing gloves
- o To remove gloves - the first glove, pull the wrist section of the glove toward the fingers, turning the glove inside out as it is removed; place the removed glove in the hand still wearing a glove; pull the second glove off like the first and you should have both gloves inside out and rolled together for disposal

- Gowns
  - Wear a gown to protect skin and clothing during times where contact with blood or body fluids is possible
  - Never wear the same gown for the care of more than one patient
  - Remove gown - pull sides together in the front to fold the exposed sides together, slide off the arms, roll gown up with exposed areas all facing inward and discard
  - Perform hand hygiene before leaving the exam room
- Facemasks
  - Wear a facemask to protect nose and mouth during times where contact with respiratory secretions and sprays of blood or body fluids is possible
  - Remove mask - untie the bottom and then the top, discard without touching the front of the mask
- Goggles or Face Shields
  - Wear eye protection during times where contact with respiratory secretions and sprays of blood or body fluids is possible
  - Personal eyeglasses and contact lenses are NOT considered adequate eye protection
  - Remove the goggles - touch the sides of the goggles to remove and discard, do not touch the front of the goggles

★★★*Standard precautions should also be applied in all of the situations below*

#### *Isolation Precautions:*

- Contact Precautions
  - Used to protect others from germs in patients that have stool incontinence, draining wounds and/or skin lesions that cannot be covered, or uncontrolled secretions
  - Enteric - difficile, rotavirus, or norovirus
  - Wound and Skin - MRSA, VRE, Scabies, Impetigo
  - Wear gloves when touching the patient and items in the patient' s immediate environment
  - Wear a gown if substantial contact with the patient or their environment is expected
  - Perform hand hygiene after removal of PPE
- Droplet Precautions
  - Used to protect others from germs in the patient's nose, mouth, throat, and lungs
  - Patient's with suspected infection and that exhibits sneezing, coughing or spitting
  - Includes patients with pneumonia, influenza, adenovirus, mumps, rubella, meningitis, bordetella pertusis
  - Wear a facemask (surgical mask) for close contact with the patient
  - Wear gloves when touching the patient and items in the patient' s immediate environment
  - Wear a gown and/or goggles if excessive spraying of respiratory fluids is anticipated
  - Perform hand hygiene after removal of PPE
  - Patient should wear a facemask when exiting the exam room
- Airborne Precautions
  - Strict isolation

- Separation from others to prevent the spread, by contact or airborne transmission, of highly contagious diseases
- Patients suspected to be infected with a pathogen that can be transmitted by airborne route
  - Tuberculosis, measles, chickenpox (varicella), shingles
  - Wear a fit-tested N-95 or higher level disposable respirator when in the patient's room
  - Put the respirator on before entering the room and remove it after exiting
  - Wear a gown and/or goggles if excessive spraying of respiratory fluids is anticipated
  - Perform hand hygiene after removal of PPE
  - Patient should wear a facemask when exiting the exam room
- Protective Environment Precautions
  - Reverse protective isolation
  - Protects patients from the germs of others
  - It is used with patients who have extremely impaired immune systems or recent organ transplant
  - Wear gloves and mask
  - Equipment should be cleaned and disinfected before and after leaving the patient room
  - Perform hand hygiene after removal of PPE

### **Transducer Disinfection:**

- Medical devices are categorized for disinfection based on their use
  - Non-Critical devices come in contact with intact skin
  - Semi-Critical devices come in contact with high risk patients, non-intact skin or mucous membranes
  - Critical devices are used in a sterile field or within a blood vessel
- Low or Intermediate disinfection performed for transducers used for standard exams over intact skin
- High Level Disinfection refers to the use of a chemical solution on a transducer to reduce or eliminate of all microorganisms except bacterial spores
- A high level disinfectant (HLD) refers to the chemical used to remove all viable microorganisms from a surface
  - Examples include Glutaraldehyde, Hydrogen peroxide (used in Trophon system), Metricide, Cidex
    - The type of HLD used relates to differences in soak time, rinse time, temperature maintenance, required ventilation and duration of use of solution
    - Always wear the recommended personal protective equipment when disinfecting the transducer
- Certain chemicals are unsafe to use on the transducer due to the potential for deterioration of the matching layer and glues used to assemble the transducer
- Never immerse the electrical component of the transducer in the disinfectant
- Sprays and wipes are NOT acceptable for high level disinfection
- Sterilization refers to the complete destruction of all living organisms on an object using exposure to heat, chemicals, or radiation
  - Needle guides on transducers are CRITICAL devices that require sterilization after each patient
- Transducers cannot be thermally sterilized because heating the PE element above the Curie point can cause it to lose its piezoelectric properties; PZT has a Curie point of 300 -

# Spaulding Classification of Transducers

	Type of use	Examples of transducers	Type of disinfection	Examples of disinfectants
Non-Critical	Transducer used on intact skin	Curved, vector, linear probes used for standard exams	Low or intermediate disinfection	Saniwipes, T-spray
Semi-Critical	Transducer used on high risk patients, non-intact skin or mucous membranes	Endovaginal, Endorectal and Transesophageal probes	High-level Disinfection (in addition to protective sheath)	Ortho-phthalaldehyde (OPA), Glutaraldehyde, Hydrogen Peroxide
Critical	Transducer used in sterile field or within blood vessel	Intravascular probes and standard probes used in invasive procedures and operating room	Sterilization	Thermal* or chemicals

\* Keep in mind that transducers cannot be thermally sterilized due risk of loss of the piezoelectric effect when heated above the Curie temperature

## High Level Disinfection

1. Cleaning – removing foreign material using water and soap or enzymatic cleansers
2. Check the temperature of the HLD and use a test strip (once per day) to assess proper concentration
3. Soak – be sure the entire probe is immersed up to the end of the handle
4. Rinse – refer to manufacturer guidelines for amount of rinse cycles
5. Dry the probe with soft towel

# PROCEDURES, PROTOCOLS & TECHNIQUES

## ***Exam Indications:***

- Evaluate congenital anomalies
- Abnormal menses
- Pain
- IUD placement
- Palpable mass
- Abnormal labs
- Infertility
- Follicle monitoring
- Ovum retrieval
- Invasive procedures
- PID
- Ectopic pregnancy
- Anomalies
- Carcinoma
- Postmenopausal bleeding

## ***Symptom Terminology:***

4. Anovulation - absence of ovulation
5. Amenorrhea - absence of menstruation
6. Dysmenorrhea - difficult and painful menstruation
7. Hypermenorrhea - increased flow during cycle
8. Hypomenorrhea - abnormally decreased flow during cycle
9. Oligomenorrhea - menstruation that occurs in >35 day intervals
10. Polymenorrhea - menstruation that occurs in <21 day intervals
11. Menorrhagia - regular cycles that are heavy and longer than normal
12. Metrorrhagia - irregular cycle, intermenstrual bleeding, breakthrough bleeding, spotting
13. Menometrorrhagia - irregular cycles with heavy bleeding
14. Mittelschmerz - pain associated with ovulation
15. Dyspareunia - pain associated with sexual intercourse

### **Patient History:**

- Age
- Pregnancy history
- LMP
- Menses description
  - Abnormal uterine bleeding refers to menstrual changes caused by uterine lesions
  - Dysfunctional uterine bleeding refers to menstrual changes caused by abnormalities of the endocrine system
- IUD?
- Oral contraceptives?
- Hormone replacement therapy?
- Surgery?

### **Pelvic Surgeries:**

- Total Hysterectomy - uterus and ovaries removed, only vaginal cuff remains
- Partial Hysterectomy - uterus removed and only one ovary or no ovaries are removed with it
- Salpingo-oophorectomy - ovaries and fallopian tubes removed
- Salpingectomy - fallopian tube removed
- Oophorectomy - ovary removed
- Tubal Ligation - fallopian tubes are clamped or severed to prevent the ovum from entering the uterus for potential fertilization
- Polypectomy - removal of an endometrial polyp
- Myomectomy - removal of a leiomyoma

### **Pregnancy History Notation:**

- GPMAL
  - Gravida - number of pregnancies
  - Parity - number of fetuses carried to term
  - Miscarriage - number of spontaneous abortions, blighted ovum
  - Abortion - number of abortions
  - Living Children
  - Example: G3P2012 - patient had 3 pregnancies, 2 full term pregnancies, 0 miscarriages, 1 abortion, 2 living children
- GTPAL
  - G = number of pregnancies
  - T = number of term fetuses
  - P = number of pre-term births
  - A = number of abortions or miscarriages
  - L = number of living children
  - GTPAL: Current pregnant female with G4T2P0A2L2 = 4 pregnancies, 2 term births, 0 pre-term, 2 miscarriage/abortion, 2 live children

### **Exam Techniques:**

*Transabdominal*

- 3.5 - 5MHz average probe frequency
- Patient drinks 32oz water and does not void to keep bladder full
- The bladder should be filled to a level that extends superior to the fundus of the uterus
- Obtain longitudinal and transverse images of the uterus, ovaries and adnexa
- Uterine length: longitudinal view, fundus to the cervix
- Uterine AP: longitudinal view, anterior to posterior, perpendicular to the length measurement
- Uterine width: axial or coronal view
- Document changes in uterine contour and echogenicity
- Endometrium: mid-sagittal plane, measure from edges of the basal endometrium; do not include hypoechoic myometrium
- Iliopsoas muscles and internal iliac vessels are used as landmarks to identify the ovaries
- Graded compression - slowly and steadily compress the bowel
  - Used to displace bowel gas obscuring the image
  - Can improve the visualization of a bowel segment in suspected appendicitis

#### *Transvaginal*

- 5-10 MHz average probe frequency
- NOT performed on patients that cannot consent and those that have never been sexually active
- Transperineal and translabial scanning can be used in patients who are not able to be evaluated with TV approach
- Empty bladder
- The patient is placed in the lithotomy position on a table set to Trendelenburg position (Head tilted slightly lower than legs)
- The transducer is placed in a latex cover with gel
- The cover should be manipulated to remove air bubbles from the gel near the tip
- Sterile gel should be used on the outside of the cover before the probe is inserted
- Obtain longitudinal and transverse images of the uterus, ovaries and adnexa
- When attempting to image the fundus of an anteverted uterus with transvaginal US, the transducer should be angled so the handle is closer to the bed
- When attempting to image the fundus of an retroverted uterus with transvaginal US, the transducer should be angled so the handle is farther from the bed
- The cervix, myometrium and endometrium should be evaluated and documented
- The uterine myometrium should be homogeneous throughout
- Small rounded anechoic areas may be visualized along the periphery (vessels)
- Measure the endometrial thickness in the longitudinal midline uterine view
- Measure the thickness of the functionalis tissue from the anterior basal layer to the posterior basal layer
- Patient with normal menses are best evaluated during the first 7-10 days of their cycle; endometrium is at its thinnest and no dominant follicles should be present
- Patients with suspected congenital uterine anomalies are best evaluated in the secretory phase because the endometrium is most prominent; helps to identify defects such as uterine didelphys or bicornis much more easily
- Evaluate the posteror cul-de-sac for the presence of fluid or a mass
- An ultrasound water enema or cleansing enema may be necessary to differentiate a mass from feces

- Iliopsoas muscles and internal iliac vessels are used as landmarks to identify the ovaries
- Applying manual compression on the anterior abdomen, increasing image sector size, changing patient position and an empty urinary bladder can all aid in visualizing an ovary that is high in the adnexa
- Document the ovarian size by measuring the length, width and AP dimensions
- Apply color Doppler to ovaries and obtain PW Doppler waveform
  - Doppler evaluation of the ovaries preferred during day 9 through 28 of ovarian cycle
  - Low velocity, low resistance flow with increased diastolic flow
  - Resistance is lower in the ovary that contains the dominant follicle
  - Doppler of the perimeter of the dominant follicle will demonstrate high velocity flow with increased diastolic flow

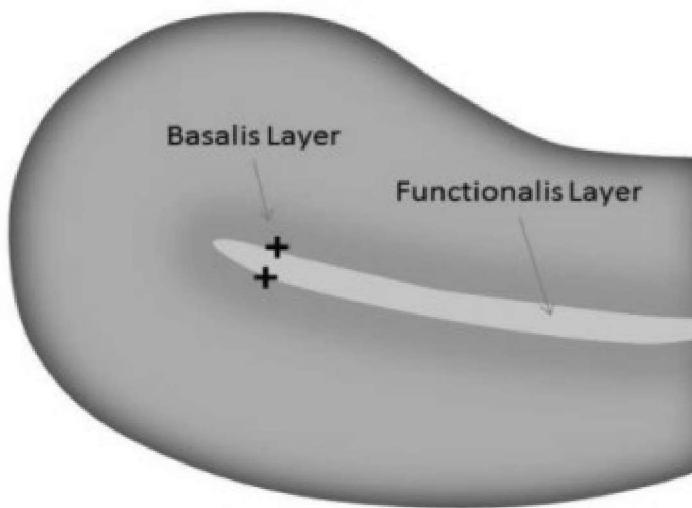
## Transvaginal Sagittal



## Transvaginal Coronal

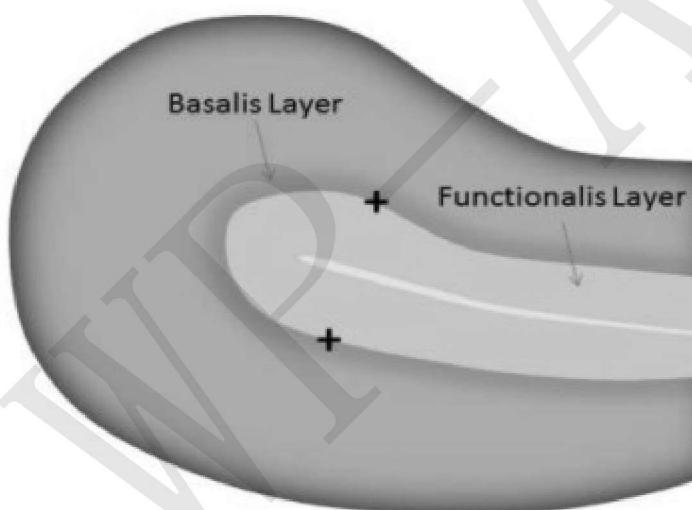


# Endometrial Assessment



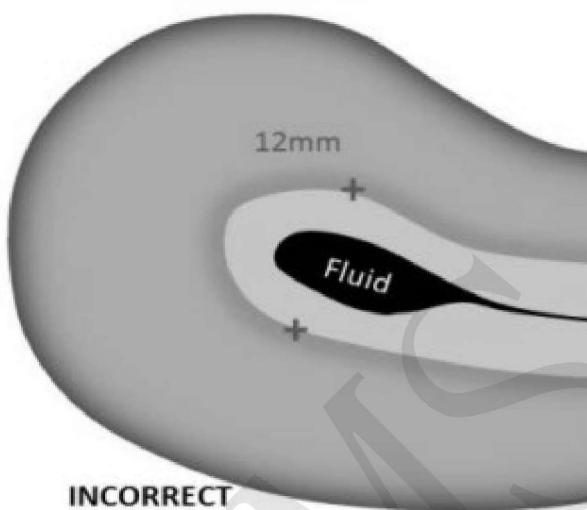
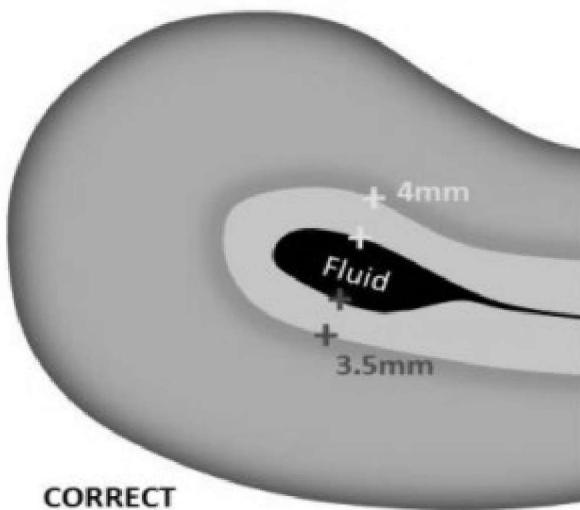
Measure from the outer edge of the functionalis layer to the outer edge of the functionalis layer. Do not include the basalis layer.

# Endometrial Assessment



Measure from the outer edge of the functionalis layer to the outer edge of the functionalis layer. Do not include the basalis layer.

# Endometrial Assessment



When fluid is present in the canal, measure the two functionalis layers separately then add the numbers together.

Endometrial thickness =  $4\text{mm} + 3.5\text{mm} = 7.5\text{mm}$  reported on exam NOT 12mm

## Pediatric/Adolescent Pelvic Sonography:

- Common indications: ambiguous genitalia, prepubertal vaginal bleeding, primary amenorrhea, pelvic pain, or pelvic mass
  - Primary amenorrhea refers to the absence of menarche after age 15
  - Common causes include gonadal dysgenesis, hypothalamic hypogonadism, agenesis of the vagina, cervix, or uterus, imperforate hymen or transverse vaginal septum, pituitary disease, PCOD or adrenal hyperplasia
- Sonography is preferred for the evaluation of the pediatric/adolescent pelvis
  - Used to determine the presence of a uterus and ovaries
  - Evaluate the cause for vaginal bleeding; precocious puberty, estrogen secreting ovarian tumor, obstruction of the cervix or vagina
  - Evaluate the cause for primary amenorrhea; PCOD, hydrocolpos, hydrometrocolpos, uterine agenesis
  - Evaluate the cause of pelvic pain; cyst, teratoma, torsion, appendicitis, PID
- Transabdominal technique is used for the exam; TV only performed in sexually active patients

## Premenopausal and Postmenopausal Exam Objectives:

- Confirm the presence or absence of a mass
- Determine single or multiple masses
- Determine anatomic relationship of pathology
- Evaluate size, contour, acoustic properties and internal consistency
- Identify pathology

- Demonstrate the involvement of other organs
- Provide guidance for procedures

WP - APPENDIX

### ***Exam Optimization Techniques:***

- 1.** Always use multiple planes to evaluate each organ/structure
  - Transverse, Sagittal, Coronal and Oblique
- 2.** Choose the best frequency transducer for the evaluation
  - Higher frequency = better resolution, less penetration
  - Lower frequency = lower resolution, better penetration
- 3.** For the best axial resolution of the transducer, perpendicular beam incidence is recommended
  - Reflection improves when the beam is perpendicular to the structure being evaluated
- 4.** Document related artifacts
  - Fluid filled structures - edge shadowing and anterior reverberation artifacts
  - Solid structures - sound attenuation, posterior shadowing
- 5.** Decubitus, semi-erect and other positions are useful in evaluating the fetal anatomy and multiple pregnancies
- 6.** Administration of water can be used to create a transabdominal window to view fetal anatomy, uterus and ovaries
- 7.** When pathology is identified, the exam should be modified accordingly  
Examples:
  - When free fluid is identified in the pelvis, the flanks areas should also be evaluated for potential fluid
  - If an ectopic pregnancy is suspected, the subhepatic space should also be evaluated for free fluid
  - When a malignancy is suspected, evaluate the bladder wall for invasion, cul-de-sac and Morrison pouch for fluid, liver for metastasis, enlarged lymph lymphnodes in the pelvis
  - IUGR suspected on biometry, perform Doppler assessment of MCA and umbilical artery
  - Suspected Trisomy 21, evaluate the orbital distance, fifth digit middle phalanx, nasal bone, presence of AVSD

### ***Tips for Transvaginal Sonography:***

- Remove all air bubbles from between protective probe sheath and probe
- Reduce the sector width to increase frame rate, improve temporal and lateral resolution
- Scan the organ of interest in the center of the field of view
- Position the tip of the probe as close as possible to the area of interest
- Use external manual compression of the anterior abdomen to bring the organ of interest closer to the probe tip
- Change patient position to improve visualization of the area of interest
- Use color Doppler to differentiate cystic structures from vascular structures

### ***Advantages of Transvaginal Sonography:***

- Assists with interventional procedures

- Decreased artifact
- Empty bladder
- Obesity can greatly limit trans-abdominal exams
- Improved resolution
- Most accurate for follicle studies
- Early pregnancy diagnosis; can identify embryologic changes about 1 week earlier than transabdominal exam
- Best 2nd/3rd Trimester cervix evaluation

*Disadvantages of Transvaginal Sonography:*

- *Orientation of images*
- *Limited depth of field of view*
- *Obesity can limit probe mobility*
- *Non-sexually active patients cannot be scanned*
- *Discomfort in elderly patients*
- *Unable to evaluate pregnancies in 3rd trimester*
- *Unable to evaluate a large fibroid uterus*

Alternative Testing Techniques

***Related Diagnostic Testing:***

5. Pap smear - sample taken to assess for suspicious cells in the cervix
6. Culdoscopy
  - o Visual examination of the female pelvic cavity through an endoscope
7. Laparoscopy
  - o Requires local or general anesthesia
  - o Small incision is made, usually in the umbilicus, through which a laparoscope is inserted
  - o Used for treatment of ectopic pregnancy and biopsy procedures
8. Hysteroscopy
  - o Endoscope placed through the vagina into the uterus
  - o Used to evaluate interior uterine walls
9. Salpingoscopy
  - o Endoscope placed through the vagina into the uterus
  - o Used to evaluate fallopian tubes

## 10. Biopsy

- o A needle is used obtain a sample of tissue for histologic evaluation

## 11. Dilatation and Curettage (D&C)

- o The lining of the uterus (endometrium) is scraped away to diagnose and treat heavy menstrual bleeding, endometrial polyps and uterine fibroids
- o Can be used to obtain a specimen for suspected carcinoma
- o May cause infertility due to the formation of endometrial adhesions
- o Increases risk of cervical ectopic due to reduced ability for blastocyst implantation in the endometrial canal

## 12. Dilatation and Evacuation (D&E)

- o Used to evacuate retained products of conception (RPOC), missed abortion, pregnancy termination
- o May cause infertility due to the formation of endometrial adhesions

## 13. Sonoelastography:

- o Provides measurement of tissue stiffness
- o Measures changes in the tissue when stress applied (compression or system generated)
  - o Aids in the evaluation of fibroids, polyps and cervical malignancies because these tissues have reduced changes in response to stress
- o The tissue strain is assessed by comparing the change in normal tissues to the area of interest

- Sonohysterogram

- Administration of saline into the endometrial canal via catheter
- The patient should take a nonsteroidal anti-inflammatory drug (NSAID) approximately 30 minutes prior to the procedure
- The bladder should be emptied immediately prior to the procedure
- The patient is placed in the lithotomy position with elevation of the pelvis
- The catheter is passed into the uterine cavity past the internal os
- Catheter usually has a balloon at the tip that is inflated to seal the cervix and keep the fluid in the canal
- The vaginal transducer is inserted and positioned to obtain a longitudinal imaging of the uterus
- Sterile saline is administered while the uterus is under direct visualization
- Slower rates of saline infusion will reduce cramping and patient discomfort
- Used to assess focal lesions of the endometrium
- Commonly used for polyp evaluation, submucosal fibroid evaluation and to assess suspected adenomyosis
- Helpful in differentiating an endometrial polyp from a submucosal fibroid, but not always conclusive
  - The polyp will be composed of the endometrial tissue
  - The fibroid will appear as a solid mass covered by a layer of endometrium as it protrudes into the cavity
- Preliminary exam performed to evaluate endometrial thickness and identify any suspected focal findings
- Preliminary exam also necessary to confirm the patient has no signs of adnexal tenderness, infection or pregnancy
- During the procedure, color Doppler is helpful to identify stalk for a polyp
- If an abnormal area of focal endometrial thickening is identified, an endometrial biopsy should be performed at that time
- Complications:
  - During and after the procedure the patient may experience cramping, bleeding, bloating
  - Infection can be a complication post-procedure
  - In some cases the patient may have a vasovagal response during or just after the procedure
  - Active bleeding at the time of exam may reduce accuracy because a clot may be present, but it is not a contraindication
- Absolute contraindications for the procedure - pregnancy or PID
- Reasons to terminate the exam without completing it:
  - Inability to cannulate the cervix
  - Improper cervical seal around balloon allowing fluid to leak
  - Adhesions or fibroids that inhibit the distension of the canal (includes Asherman)

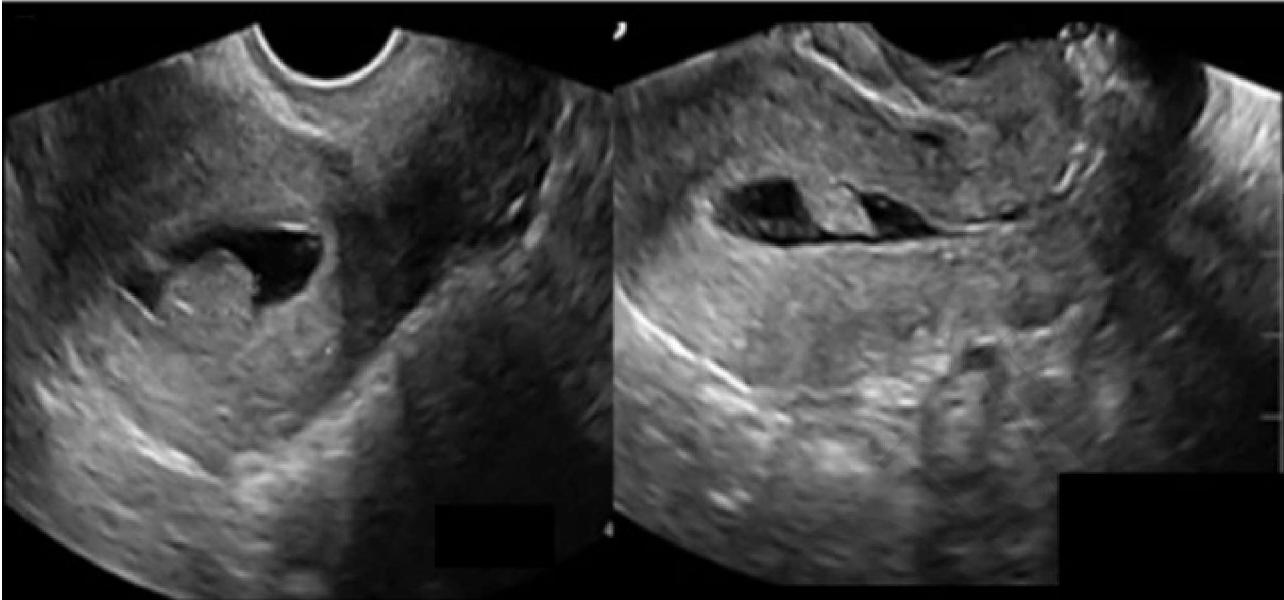
syndrome)

## Sonohysterogram – Normal Endometrium



Adapted from: Hysterosalpingocontrast sonography (HyCoSy): evaluation of the pain perception, side effects and complications.  
Marci R, Marcucci I, Marcucci AA, Pacini N, Salacone P, Sebastianelli A, Caponecchia L, Lo Monte G, Rago R - BMC Med Imaging (2013)

## Sonohysterography - Polyp



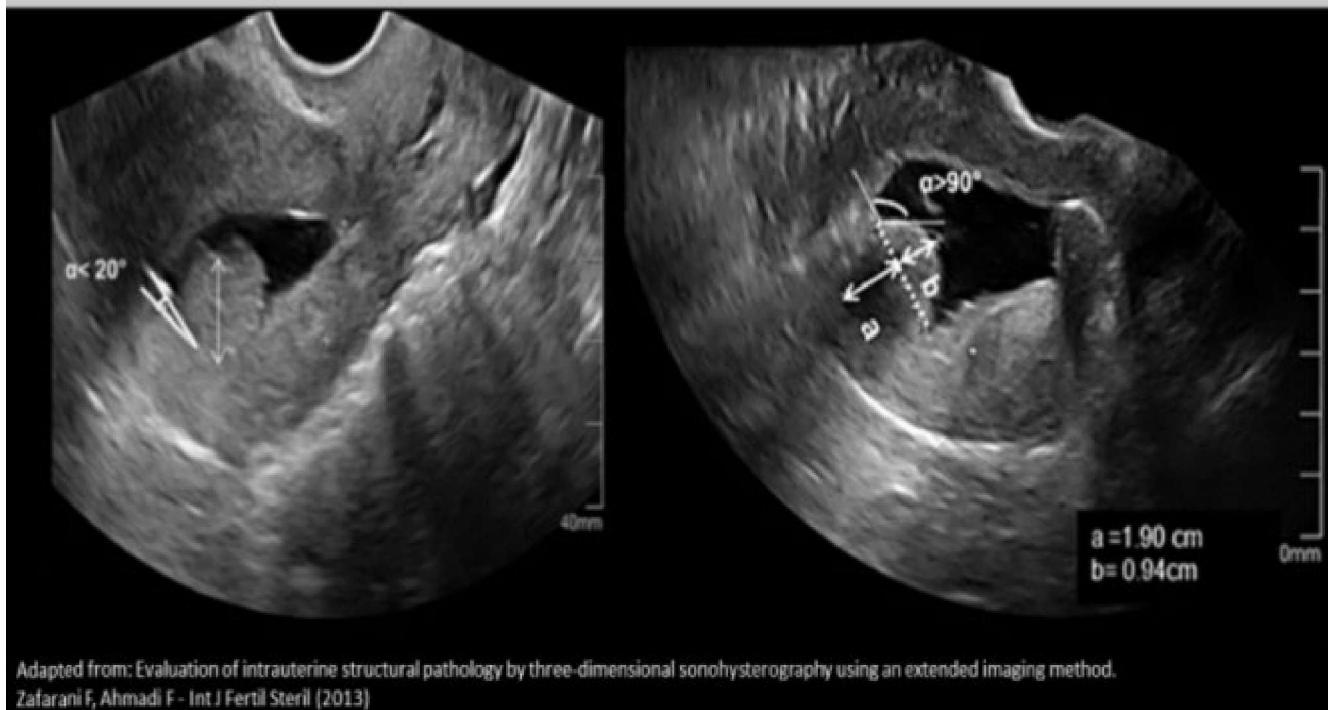
Adapted from: Evaluation of intrauterine structural pathology by three-dimensional sonohysterography using an extended imaging method.  
Zafarani F, Ahmadi F - Int J Fertil Steril (2013)

## Sonohysterography – Endometrial Hyperplasia



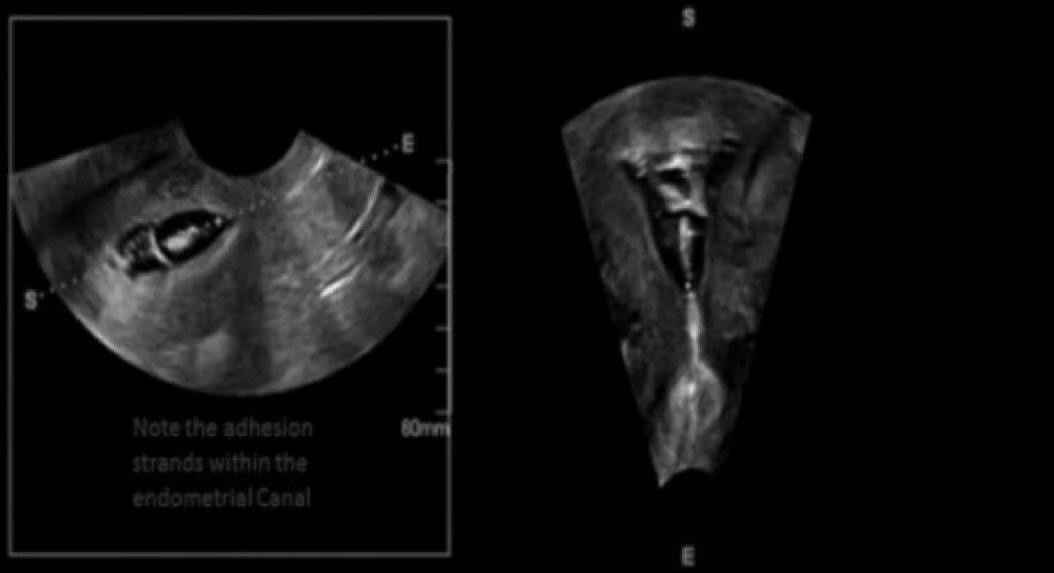
Adapted from: Evaluation of intrauterine structural pathology by three-dimensional sonohysterography using an extended imaging method.  
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## Sonohysterography – Fibroid



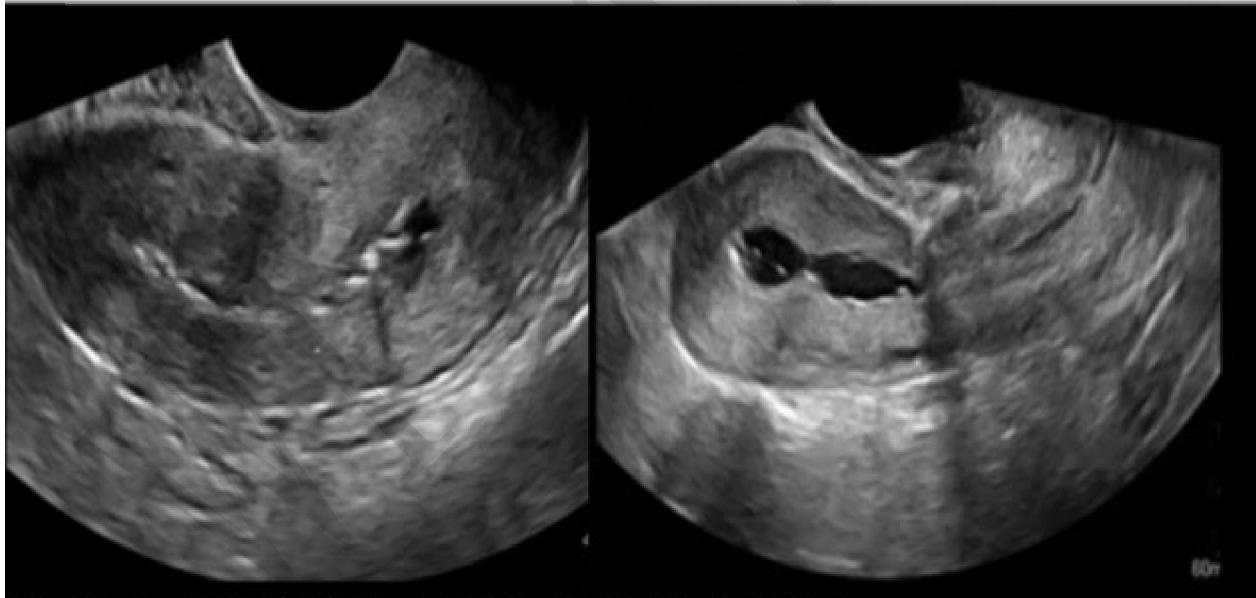
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# Asherman Syndrome



Adapted from: Hysterosalpingography finding in intra uterine adhesion (asherman's syndrome): a pictorial essay.  
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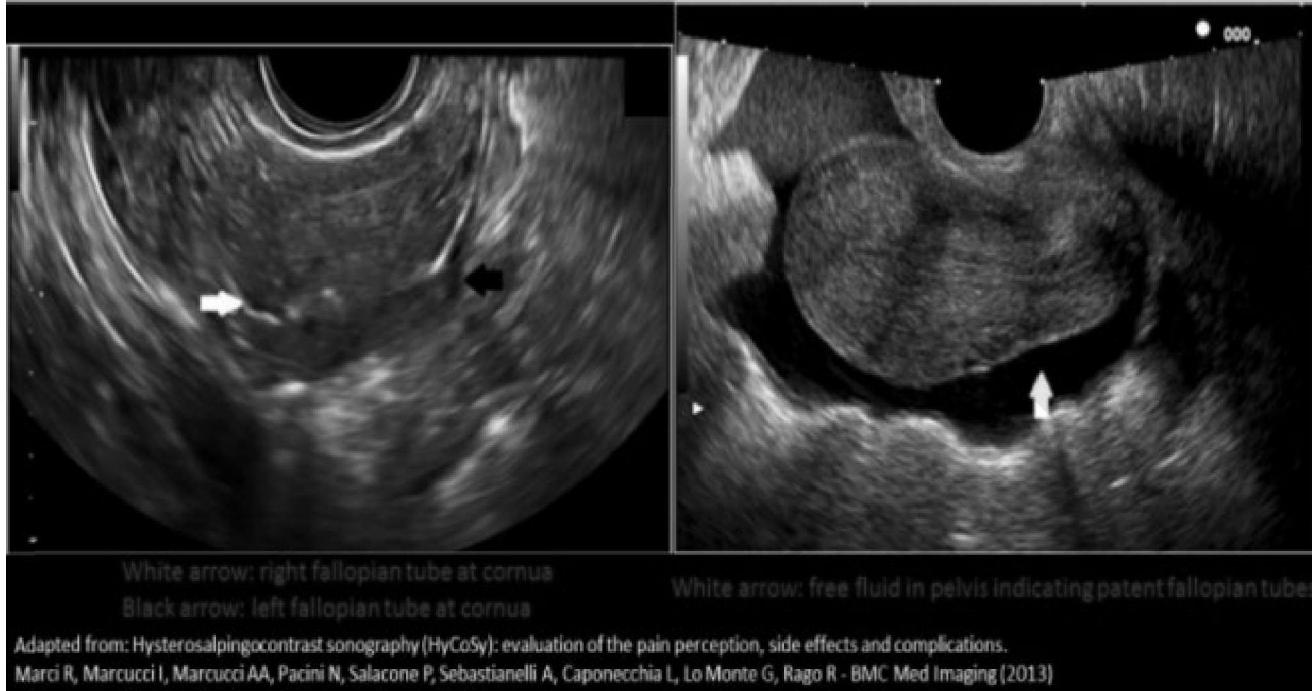


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- **Hysterosalpingogram**
  - Administration of iodinated dye or air into the fallopian tubes
  - Used for fallopian tube evaluation for infertility patients
  - Allergy to seafood (iodine) is a contraindication for this procedure
  - TV US can be used to assess for correct position of Essure devices placed in the proximal fallopian tube, BUT hysterosalpingography still remains the gold standard method of evaluation
  - Essure devices are used to obstruct the fallopian tubes to prevent pregnancy
  - Hysterosalpingography performed 3 months after the procedure should demonstrate NON-patent tubes with no fluid filling tubes and entering pelvis

## Hysterosalpingogram - Normal Fallopian Tubes



- **Culdocentesis**

- Transvaginal puncture of the pouch of Douglas (posterior cul-de-sac) for aspiration of fluid
- \* Lab Testing
  - Beta hCG levels
  - AFP levels
  - CA 125 levels
- White blood cell count
- Testosterone/estrogen levels

# Laboratory Values

	<b>Increased With:</b>
Alpha-fetoprotein (AFP)	Endodermal Sinus Tumor (Yolk Sac Tumor)
Human Chorionic Gonadotropin (hCG)	Dysgerminoma
Estrogen	Granulosa Cell Tumor Thecoma
Testosterone	Androblastoma (Sertoli Leydig Tumor)
Lactate Dehydrogenase (LDH)	Dysgerminoma
White Blood Cell Count	Endometritis Pelvic Inflammatory Disease
CA 125	Pelvic Inflammatory Disease Endometriosis Ovarian Cystadenocarcinoma Ovarian Germ Cell Tumors Endometrial Carcinoma Fallopian Tube Carcinoma Fibroids (some cases)

### **3.Uterine Pathology**

#### **Congenital Uterine Abnormalities**

##### **Embryology**

###### *Mesonephric Duct*

- AKA Wolffian duct
- Degenerates in females, forms male sex anatomy

###### *Paramesonephric Duct*

- AKA Mullerian duct
- Forms the fallopian tubes, uterus and upper vagina

###### *Germ Cells*

- Migration of these cells from the genital ridge to form ovaries
- Follow gubernaculum as they descend into the pelvis from the level of T10-12 in the spine

##### **Congenital Anomalies:**

- Abnormalities of the evolution of the Mullerian duct
- Failure of structures to:
  1. Form
  2. Fuse
  3. Separate
  4. Disappear (dissolution)
- Associated with urinary system defects
- Gonads and the urinary system form at the same time in the pelvic cavity
- This is important because if one system has a congenital defect the other system might have a defect too
- When a uterine defect is identified, the kidneys and bladder should also be evaluated

##### **Evaluation of Congenital Uterine Anomalies:**

- MRI is the gold standard method of diagnosis and classification of congenital uterine anomalies
- 3D US can provide useful information
  - Abnormalities of fusion (bicornuate and didelphys) result in a convex or flat uterine fundus with >1cm cleft in the tissue between the two endometrial cavities
  - Abnormalities of resorption result in a normal, convex or flat fundus with <1cm cleft in the myometrial tissue

##### **Uterine Fluid Accumulations:**

- -colpos = Accumulation of fluid, blood and/or pus in the vagina due to obstruction of genital tract
- -metra = Accumulation of fluid, blood and/or pus in the uterine cavity due to obstruction of genital tract

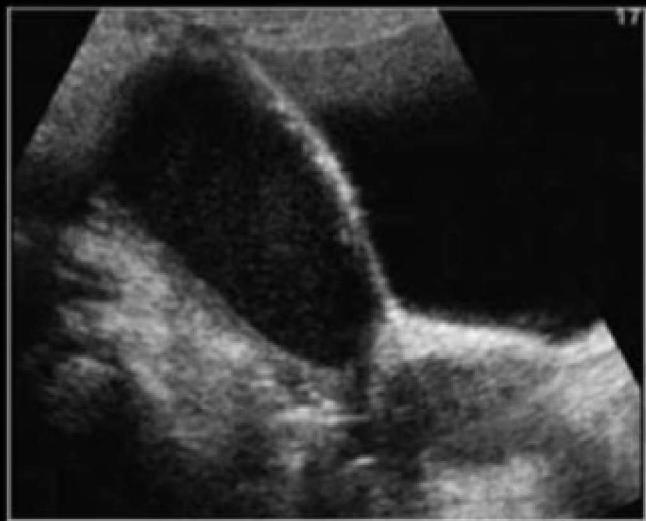
- -metrocolpos = Accumulation of fluid, blood and/or pus in the vagina, cervix and uterine cavity due to obstruction of genital tract
- Hydro- = fluid
- Hemato- = blood
- Pyo - = pus
- Hematometrocolpos (blood fills the uterine cavity, cervix and vagina) is commonly caused by imperforate hymen; primary symptoms are pain and amenorrhea
- Hematometra - demonstrates enlarged uterus, fluid filled uterine cavity with low level echoes, normal vagina/cervix; primary symptoms are pain and amenorrhea
- Pyometra and pyometrocolpos are related to fever, leukocytosis, PID
- If the uterus is enlarged, it can compress the ureter(s) causing hydronephrosis

## Hematometra

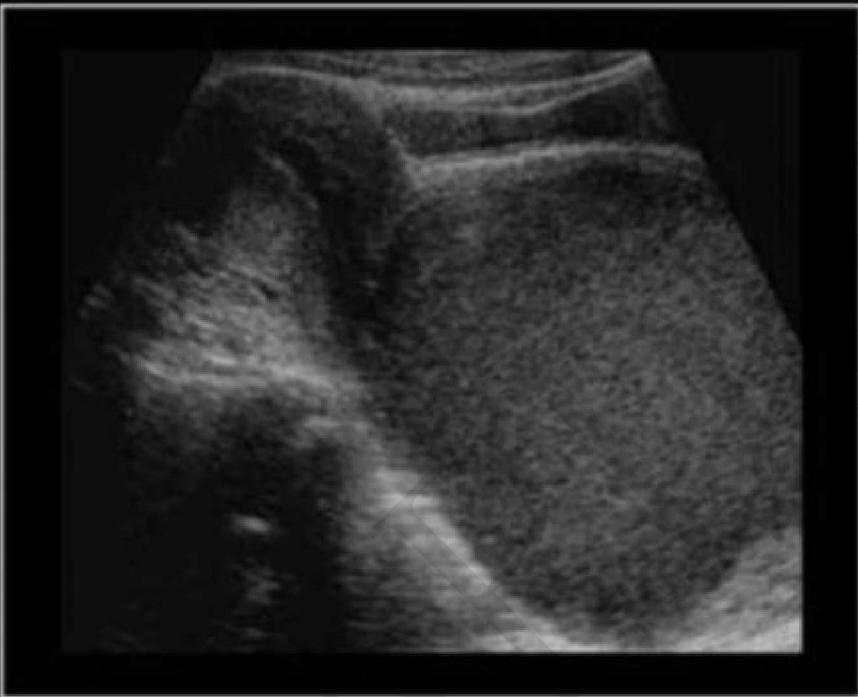


Courtesy of Dr. Taco Geertsma  
[www.ultrasoundcases.info](http://www.ultrasoundcases.info)

## Hematometra

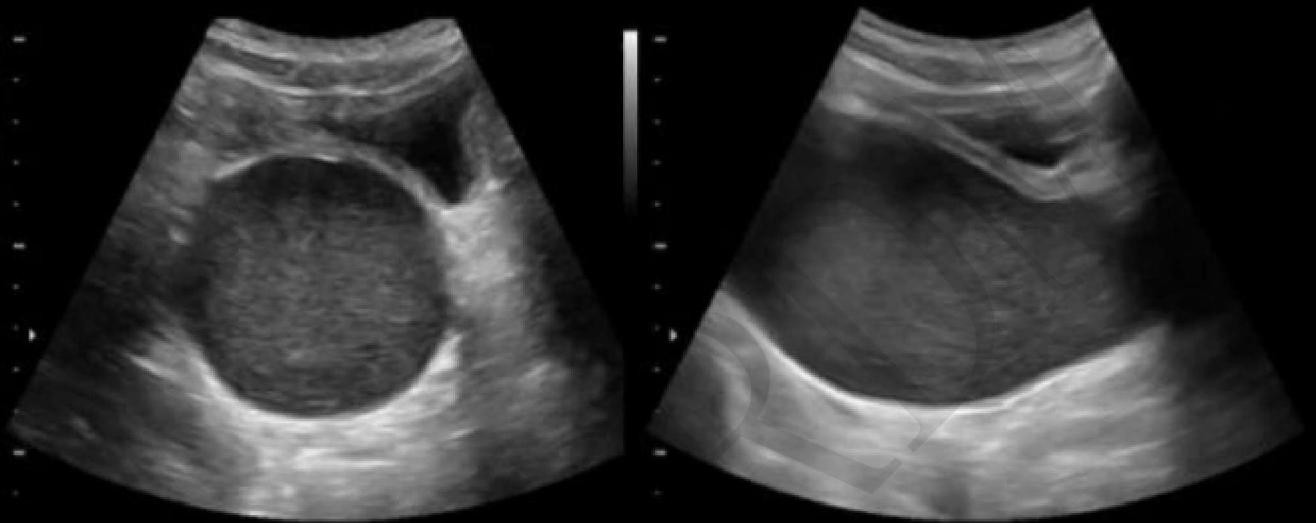


# Hematocolpos



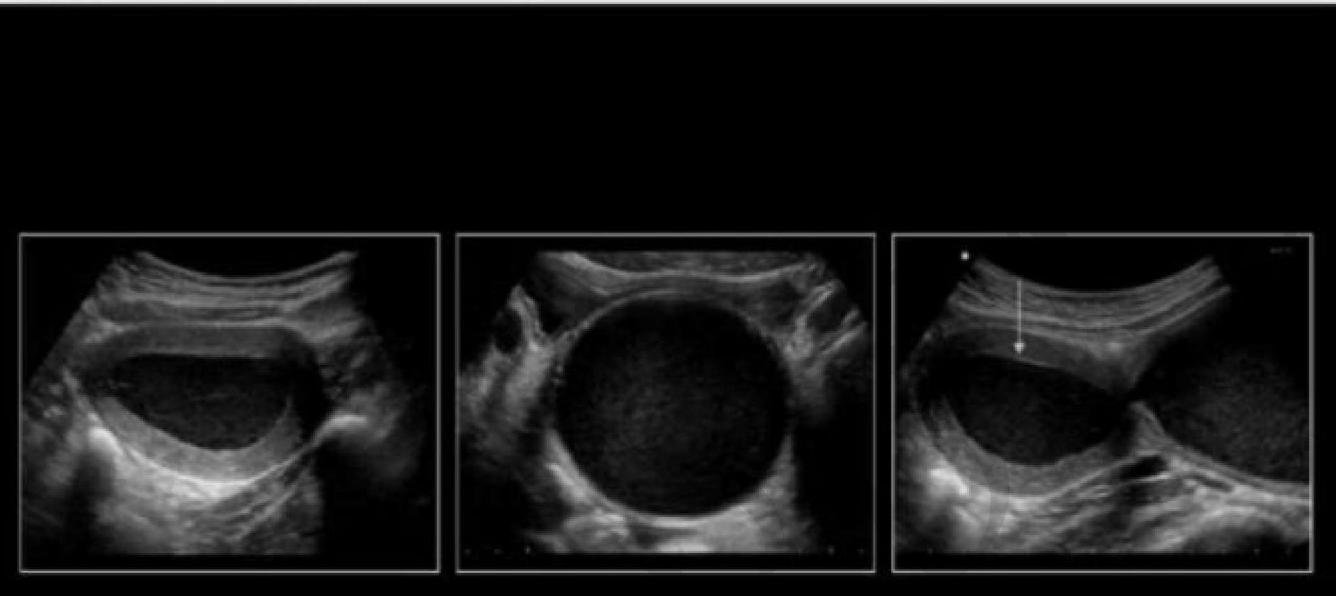
Courtesy of Dr. Taco Geertsma  
[www.ultrasoundcases.info](http://www.ultrasoundcases.info)

## Hematometrocolpos



Effendi Mansoor, MD  
Courtesy of: [www.obgyn.net](http://www.obgyn.net)

## Hematometrocolpos



WP-AH

# Hematometrocolpos



Courtesy of Dr. Taco Geertsma  
[www.ultrasoundcases.info](http://www.ultrasoundcases.info)

## Agenesis of the Uterus:

- *Failure of the uterus to form*
- *Partial agenesis more common than complete agenesis*
- *May or may not have cervix attached to blind ended vaginal pouch*

## Uterine Agenesis



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# Uterine Agenesis



## **Gynatresia:**

- *Absence of the vagina*
- Ovaries and tubes developed
- Underdeveloped uterus

## **Double Vagina:**

- Septum of tissue separating the vagina into two sections
- Normal pelvic structures otherwise

## **Imperforate Hymen:**

- Most common anomaly of the female reproductive system
- If not diagnosed on the postnatal clinical exam, it is usually identified at the onset of menarche
- Ultrasound demonstrates distention of the vagina and uterus with fluid
- Can be associated with hematometrocolpos when menarche occurs

***Uterine Didelphys:***

- Failure of fusion of the Mullerian ducts
- Two separate reproductive tracts: 2 vaginas, 2 cervix and 2 uterus
- Best evaluated in the secretory phase of the menstrual cycle
- Commonly associated with unilateral renal agenesis

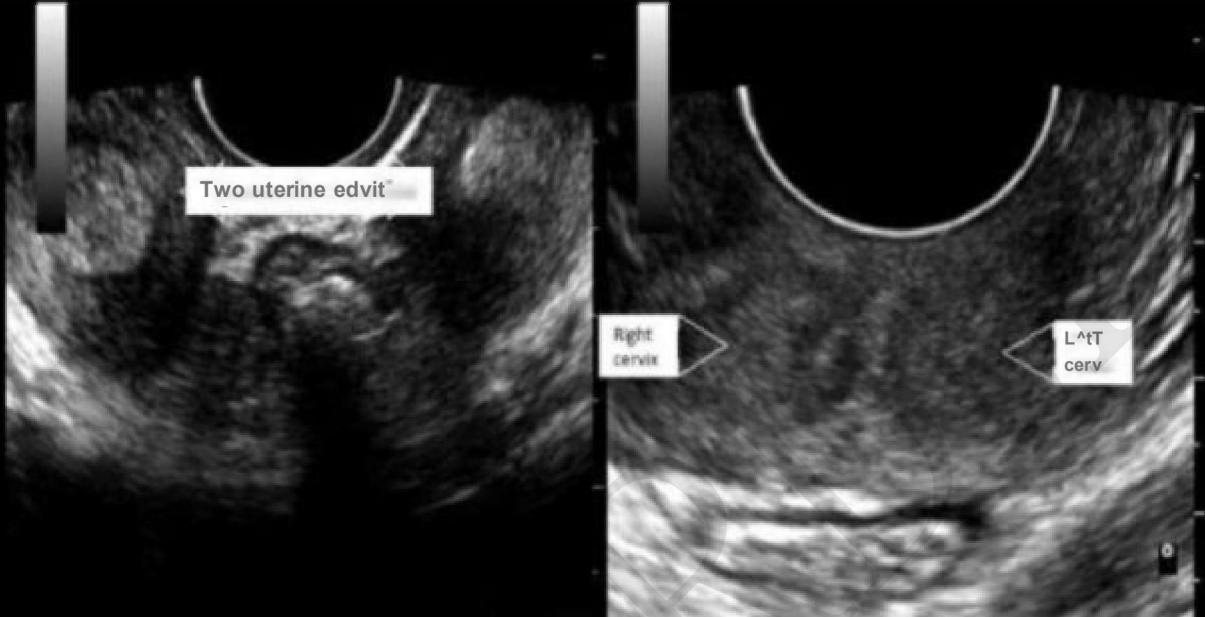
# Congenital Uterine Anomalies

## Uterine Didelphys

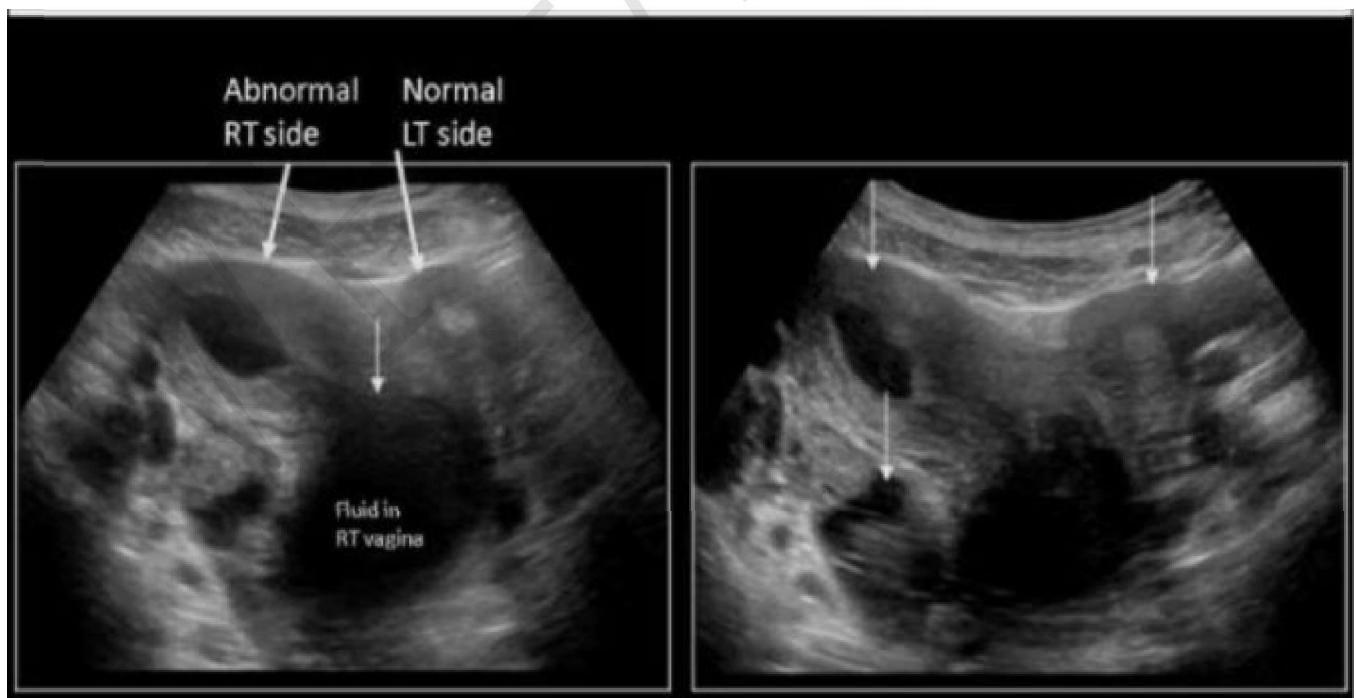
- Two separate reproductive tracts: 2 vaginas, 2 cervices and two uteri



## Uterine Didelphys



**UTERINE DIDELPHYS**  
*with hematometrocolpos in right side*



***Unicornuate Uterus:***

- Failure to form defect
- One mullerian duct never forms
- Results in uterus with one horn
- Appears asymmetric with loss of pear shape and lateral uterine displacement
- Associated renal defects - ipsilateral renal agenesis or pelvic kidney, horseshoe kidney

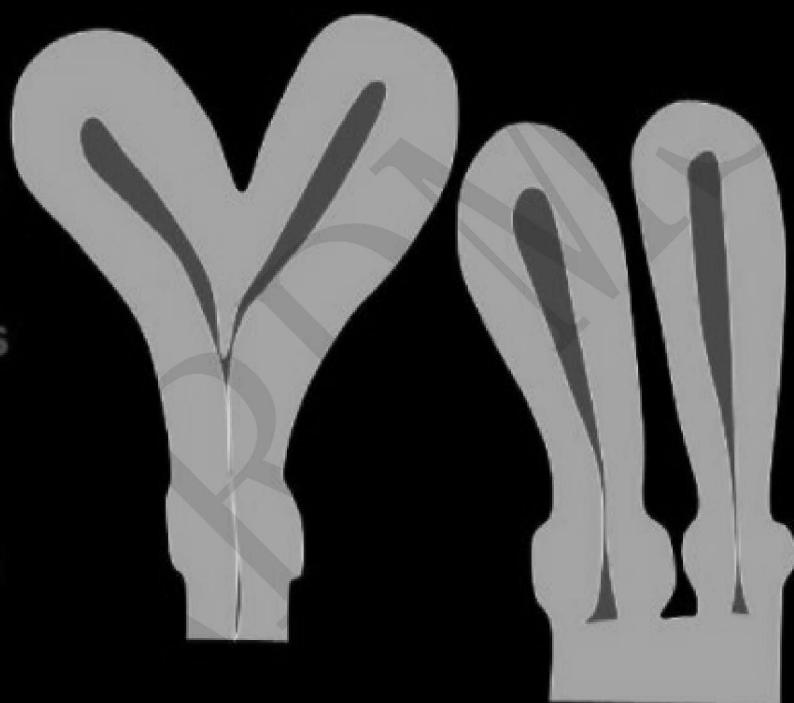
***Bicornuate Uterus:***

- Bicornis, Bicollis - two uterus and two cervix
- Bicornis, Unicollis - two uterus and one cervix
- Partial fusion of the Mullerian Ducts
- Two separate uterine cavities sharing a body/fundal wall
- Most common abnormality of fusion
- Best evaluated in the secretory phase of the menstrual cycle
- The fundus is convex, flat, or indented greater than 1 cm
- 3D ultrasound can be helpful in differentiating bicornuate uterus from septated uterus(>1cm fundal cleft between the two horns = bicornuate uterus)
- 80% of patients also have associated renal anomalies, such as unilateral renal agenesis or horseshoe kidney

# Congenital Uterine Anomalies

## Bicornuate Uterus

- Partial fusion of the Mullerian Duct
- Two separate uterus cavities sharing a body/fundal wall
- More common type congenital anomaly

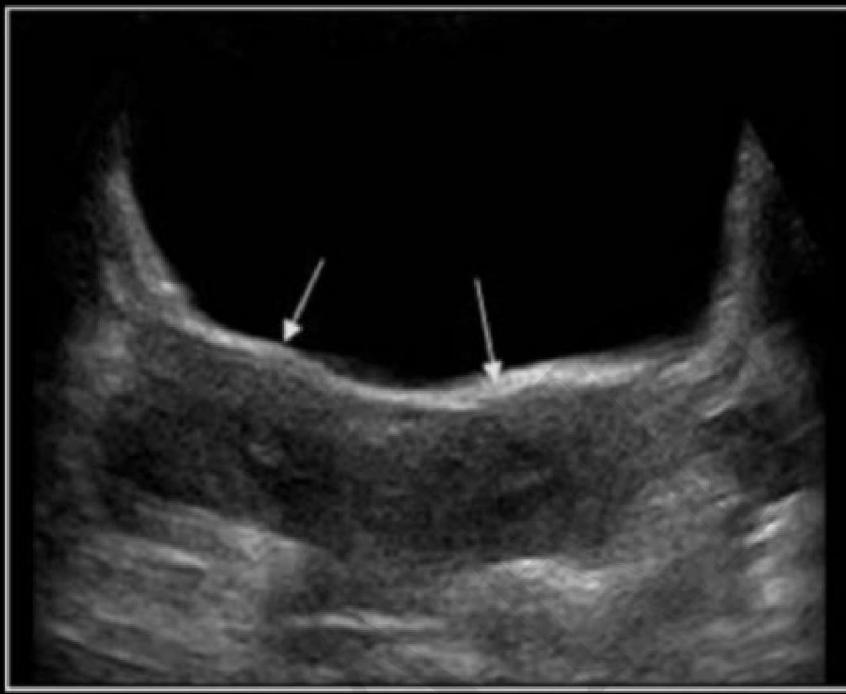


# Bicornuate Uterus

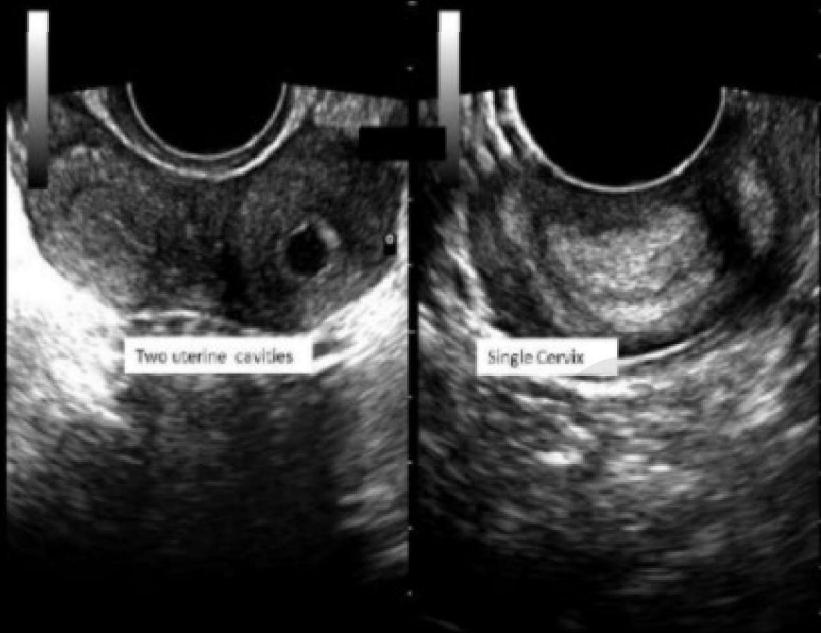


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## Bicornuate Uterus



# Bicornuate Uterus

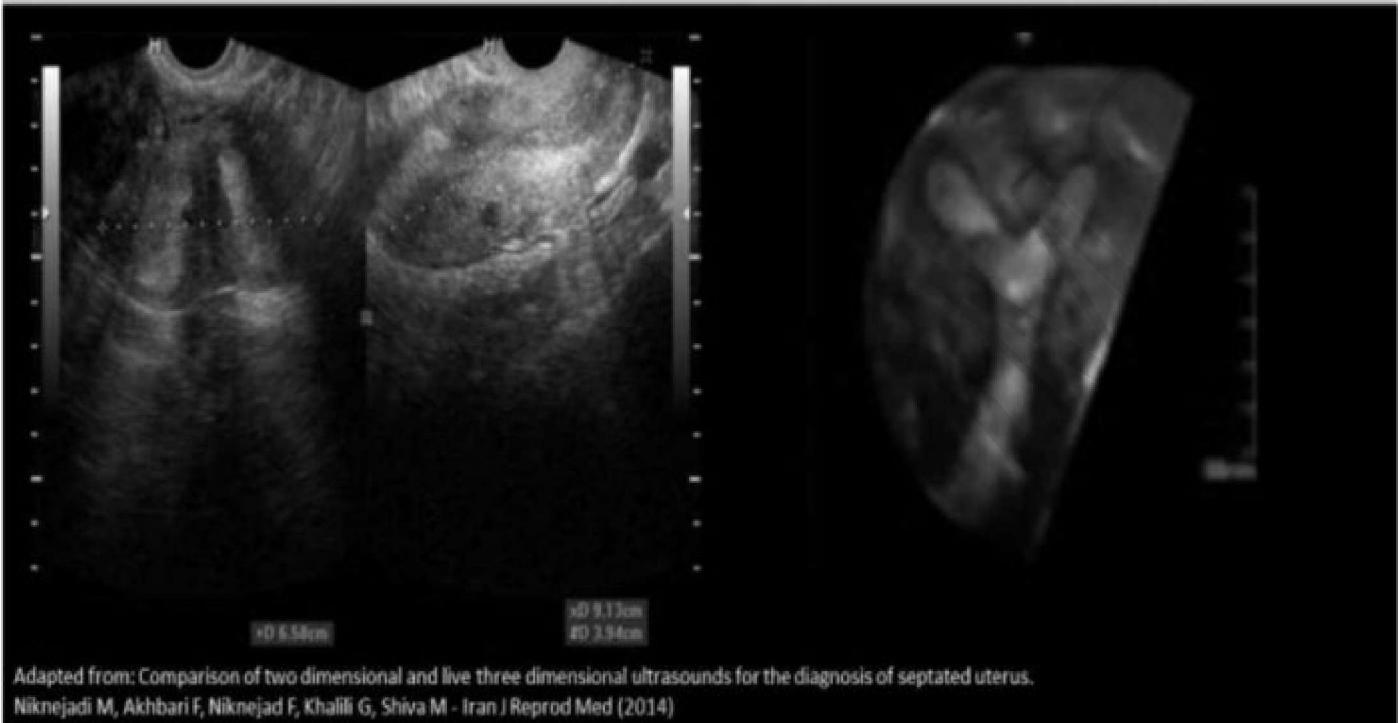


Courtesy of Prof. A. Abdel-Gadir MBBS, PhD, FRCOG

## **Septate Uterus:**

- Incomplete reabsorption of the sagittal septum, tissue remains causing a vertical separation of the fundus and body
- Failure of dissolution or resorption anomaly
- Most common congenital anomaly of the uterus
- The fundus is convex, flat, or indented less than 1 cm
- The septum may be partial or complete
- Best evaluated in the secretory phase of the menstrual cycle
- Not easily identified on 2D imaging, 3D ultrasound preferred for evaluation and diagnosis
- Increased incidence of 1st trimester miscarriage
- Poorest reproductive outcomes of all mullerian duct abnormalities

# Septate Uterus



## ***Uterus Arcuatus:***

- Thickened fundal wall creating a "dip" of tissue into the uterine cavity
- Failure of dissolution or resorption anomaly
- Best evaluated in the secretory phase of the menstrual cycle
- Hysterosalpinogram demonstrates a single saddle shaped uterine cavity

## ***DES and T-shaped Uterus:***

- Mothers took a synthetic estrogen called diethylstilbestrol or DES between 1940 and 1960 to prevent spontaneous abortion
- Associated with uterine malformation (in their children), congenital renal anomalies, ectopic pregnancy, and cervical cancer
- Daughters have T-shaped uterus, greater transverse dimension with decreased fundal thickness
- Causes an increased risk of spontaneous abortion
- Daughters also have a higher risk of developing breast cancer

# Congenital Uterine Anomalies

**Uterus Septus**

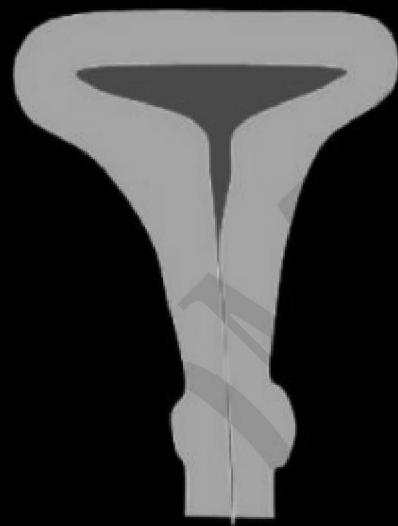
**Incomplete reabsorption  
of the sagittal septum**



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## DES and T-shaped Uterus

- Mother's took diethylstilbestrol or DES between 1940 and 1960
- Daughter's have T-shaped uterus
  - Greater transverse dimension
  - Decreased fundal thickness



## CYSTS

### Nabothian Cyst:

- Cervical cyst formation; usually seen after pregnancy
- Usually anechoic but some may have debris or hemorrhage within
- Usually asymptomatic and no treatment necessary

### Gartner Duct Cyst:

- Most common failure of disappearance defect
- Usually occurs in patients in their reproductive years
- Cyst formation in the glands/ductal system for the vaginal secretion glands
- Usually located in the anterolateral wall of the vagina
- Usually anechoic, but some may have internal debris or hemorrhage
- Usually asymptomatic and no treatment necessary



# Nabothian Cysts



# Vaginal Duct Cysts



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