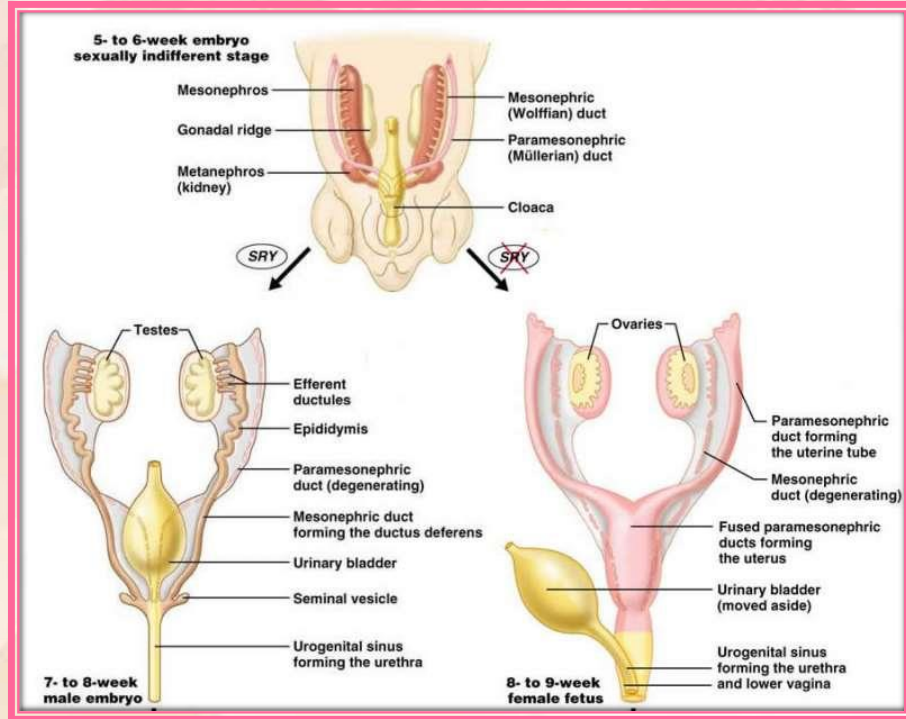


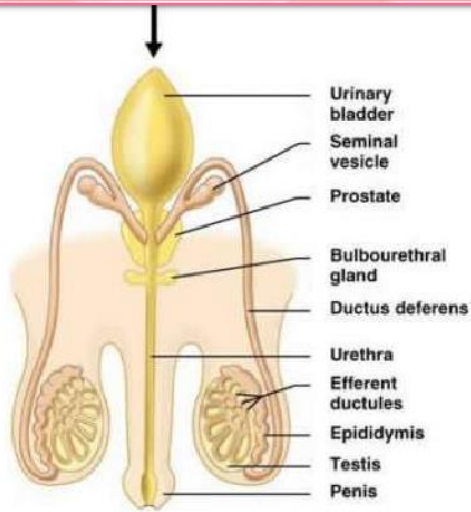


IMAGING ANATOMY OF FEMALE REPRODUCTIVE SYSTEM

Dr Roshan Valentine
Moderator : Dr Rakesh CA
St Johns Medical College
Bangalore

EMBRYOLOGY





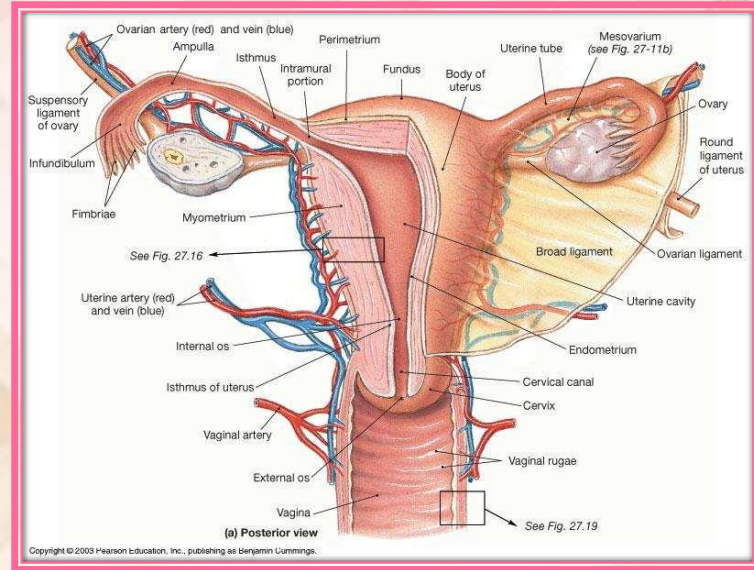
**At birth:
male development**



**At birth:
female development**

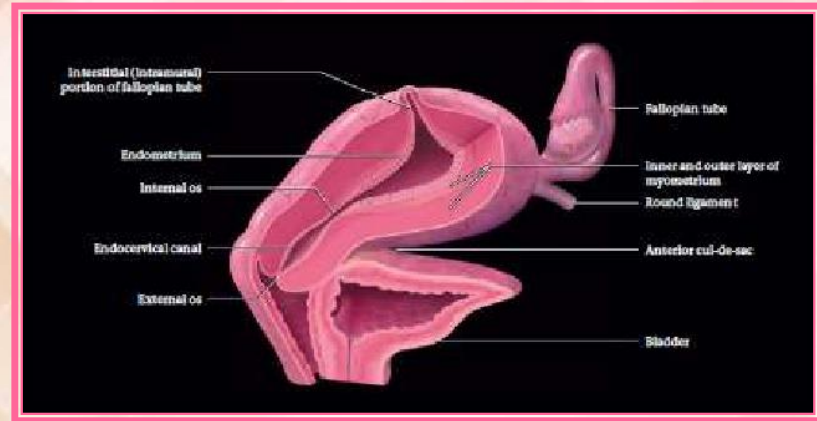
UTERUS

- Thick walled fibromuscular organ
- Composed of myometrium and endometrium
- 2 divisions
 - Body(Corpus Uteri)
 - Fundus
 - Isthmus
 - Cornua
 - Cervix
- Endometrium – mucosal lining
- Myometrium : smooth muscle + connective tissue and elastic fibers



UTERUS

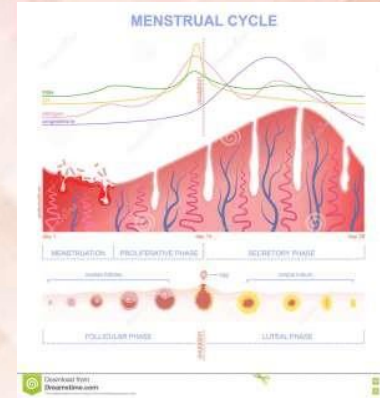
- PreMenarche : Cervix > Corpus
 - Uterus : 2.5-3.5cm
- Menarche
 - Nulliparous corpus = cervix (6-8cm in length)
 - Parous non pregnant women : corpus is 2/3 of uterine mass (L- 9-10cm)
- Post Menopausal : Corpus atrophies to premenarche size



UTERUS

MENSTRUAL CYCLE

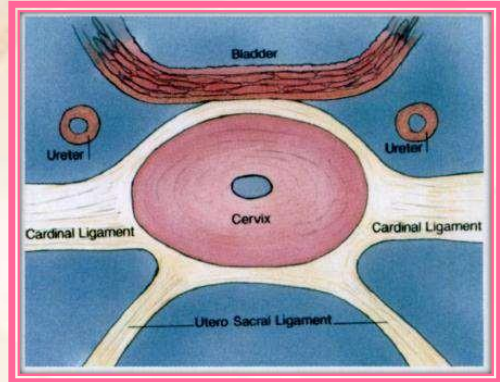
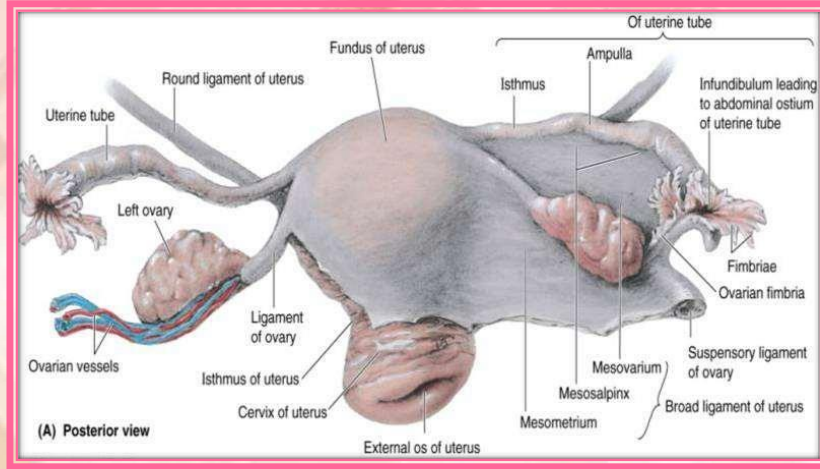
- Menstrual Phase
 - Sloughing of functionalis layer of endometrium
- Proliferative Phase
 - D1-D14
 - Estrogen dependent – proliferation of functionalis layer
 - Correspond to FOLLICULAR phase of Ovary
- Secretory Phase
 - D15 – Menstruation
 - Progesterone dependent – endometrium secrete glycogen and mucus
 - Correspond to LUTEAL phase of ovary
 - Endometrial glands hypertrophy



UTERUS

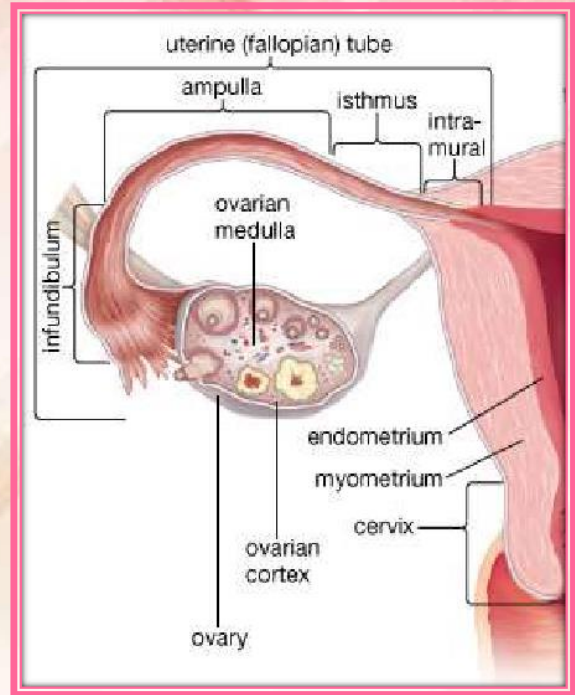
SUPPORTING STRUCTURES

- Broad Ligament – Laterally to pelvic wall
- Round Ligament
- Transverse cervical ligaments(Cardinal Ligaments)
- Uterosacral ligaments
- Vesicouterine/vesicocervical ligaments – lateral margin of cervix and vagina to bladder



FALLOPIAN TUBE

- Connects uterine cavity to peritoneal cavity
- Attached to mesosalpinx
- 8-14cm in length
- 4 segments : interstitial, isthmus, ampulla and infundibulum



UTERUS VASCULAR SUPPLY

ARTERIAL SUPPLY

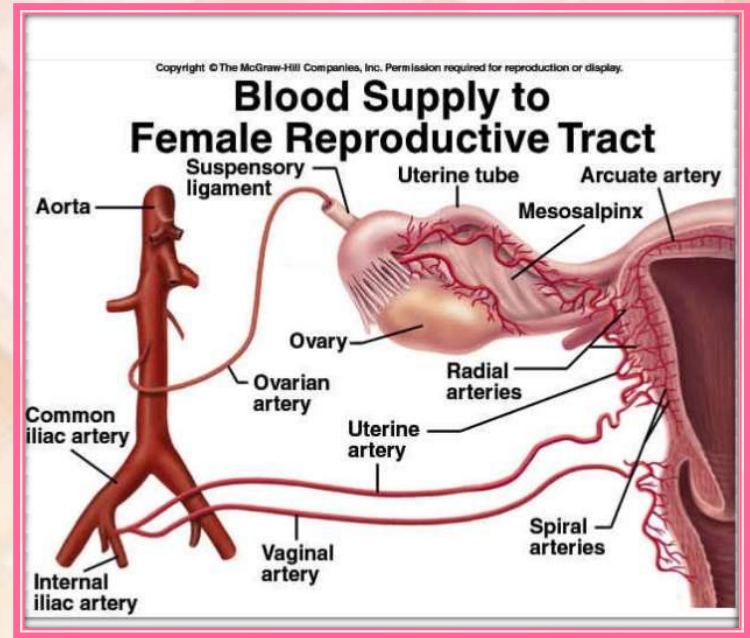
- Uterine artery(Ant br int iliac artery)
 - gives off arcuate arteries
 - radial arteries – spiral arteries
- Ovarian arteries

VENOUS SUPPLY

- Myometrial veins
- Drains into uterine or ovarian vein in broad ligament

LYMPHATIC DRAINAGE

- Int iliac nodes



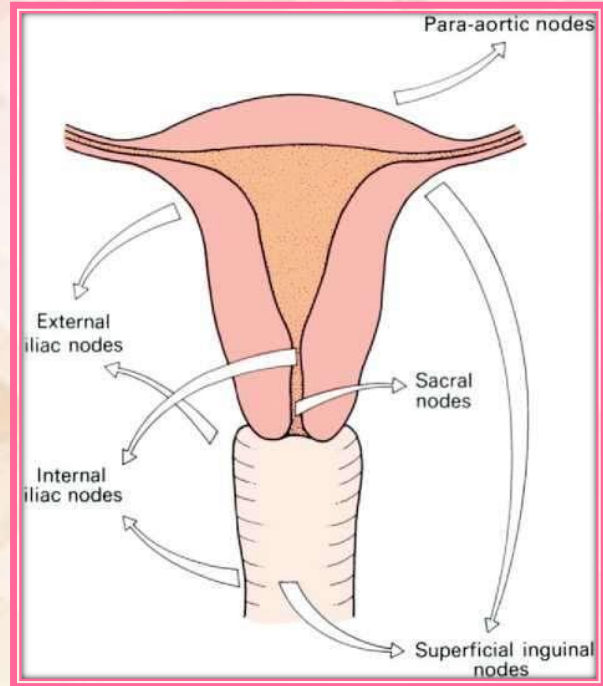
UTERUS - LYMPHATIC DRAINAGE

USA ME LIES

U Upper- S superficial inguinal A
aortic

M middle- E external iliac

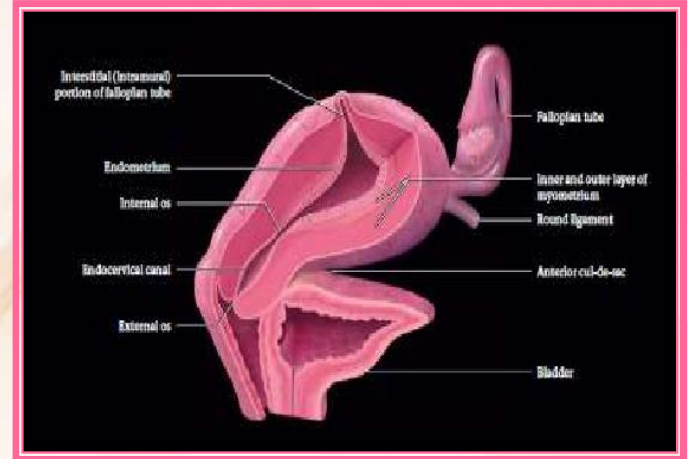
L lower- I internal iliac, E external
iliac, S sacral



CERVICAL ANATOMY

CERVIX UTERI

- Fibromuscular caudal segment of the uterus that communicates with vagina
- 2 segments
 - Supravaginal segment – internal Os
 - Vaginal segment - External Os
- Size
 - 2.5-3 cm in non gravid
 - <6cm in pregnancy



CERVICAL ANATOMY -BLOOD SUPPLY

ARTERIAL SUPPLY

- Descending cervical branch of uterine artery
- Superior branches of vaginal artery

VENOUS DRAINAGE

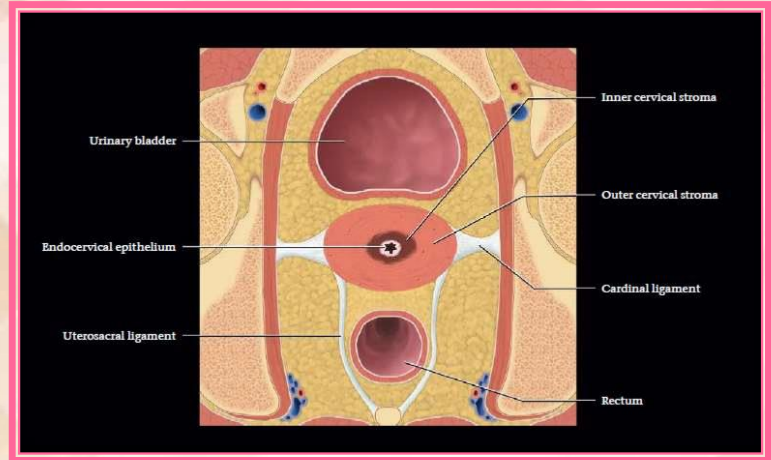
- Parametrial venous plexus – uterine vein – int iliac vein

LYMPHATIC DRAINAGE

- External iliac nodes (via broad ligament)
- Internal iliac nodes
- Presacral nodes

CERVICAL ANATOMY - Age related changes

- Increases in volume till 5th decade and then reduce
- Premenarche : Cervix = uterine body
- Puberty : Body > cervix
- Menopause : Cervix > body



VAGINAL AND VULVALANATOMY

Fibromuscular tube with mucosal lining

Interposed between bladder/urethra and rectum

- Separated from bladder/urethra by connective tissue (vesicovaginal septum)
- Separated from rectum by rectovaginal septum

Morphology

- classic "H" morphology on axial imaging
- Upper vagina folds around cervix to form recessed vaginal fornices

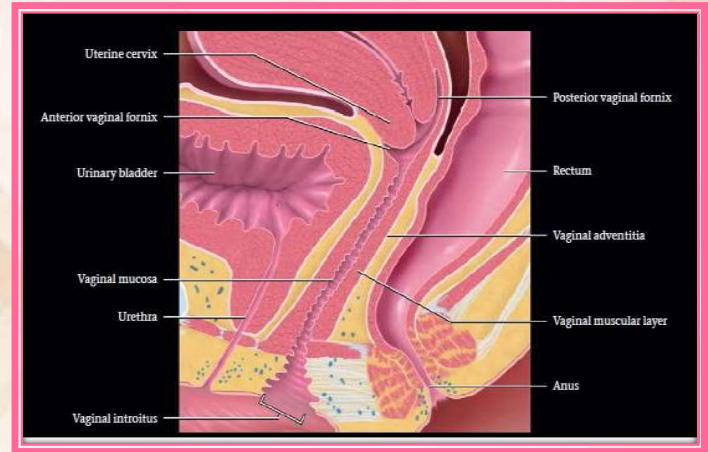
VAGINAL AND VULVALANATOMY

Vagina divided into thirds

- Upper 1/3: At level of vaginal fornices
- Middle 1/3: At level of bladder base
- Lower 1/3: Below bladder base, at level of urethra

Size : 4-12 cm in length

- Anterior wall : 4-8cm(shorter in length)
- Posterior wall : 8-10cm(longer)



VAGINAL AND VULVAL ANATOMY- BLOODSUPPLY

ARTERIAL ANATOMY

- Descending cervicovaginal artery (upper 1/3 of vagina)
- Inferior vesicular artery (middle 1/3 of vagina)
- Middle rectal/inferior pudendal arteries (lower 1/3 of vagina)

VENOUS DRAINAGE

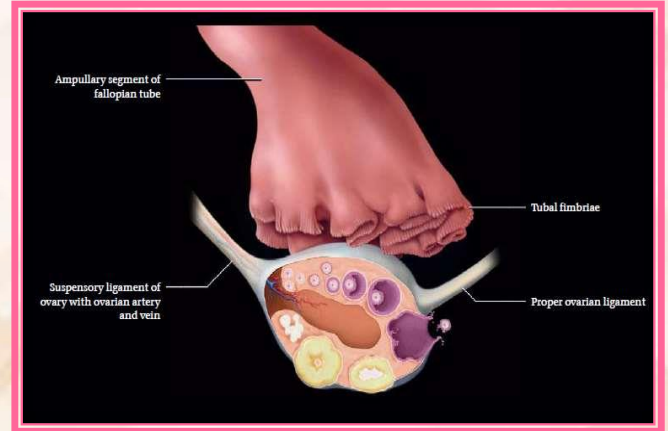
- Drain into internal iliac system by perivaginal venous plexus

LYMPHATIC DRAINAGE

- Upper vagina: Internal and external iliac nodes (similar to cervical drainage pattern)
- Middle vagina: Internal iliac nodes
- Lower vagina: Superficial inguinal nodes (similar to vulvar drainage pattern)

OVARIAN ANATOMY

- Paired intraperitoneal reproductive ova producing organs
- Size
 - Premenarche : 3cc
 - Pre menopausal : 4-16cc
 - Multiple bilateral developing follicles
 - Volume increase in follicular phase
 - Peaks at ovulation
 - Post menopausal : 6cc
 - Follicles and cysts less common



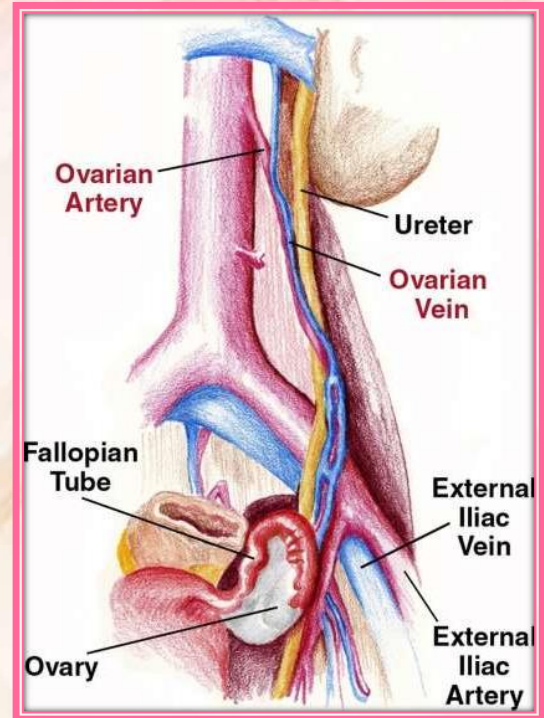
OVARIAN ANATOMY

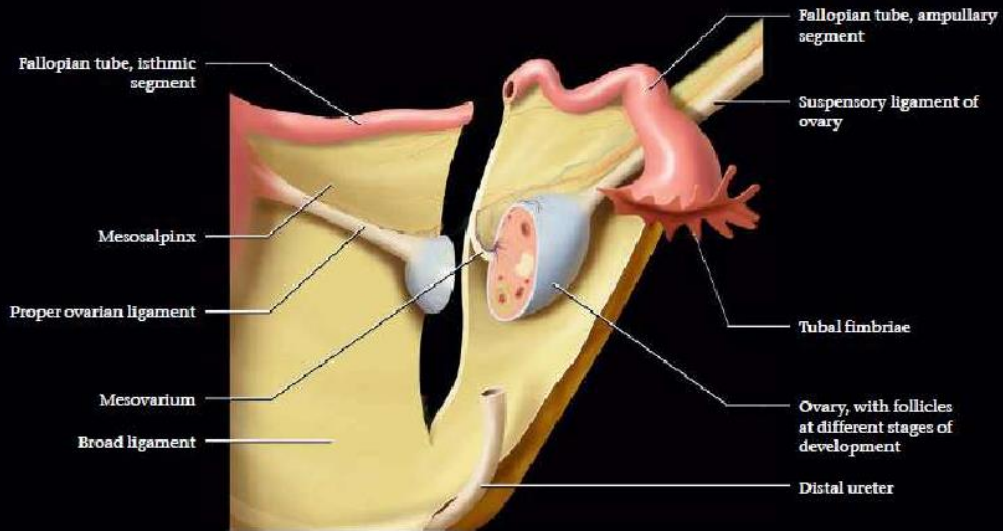
Position

- Neonates : Above pelvis
- Nulliparous : Ovarian fossa
 - Anterior : oblit Umbilical artery
 - Superior : Ext iliac A
 - Post : Ureter and Int Iliac A

Ligamentous Support

- Suspensory Ligament
- Utero-ovarian ligament





OVARY – VASCULAR SUPPLY

Arterial Supply

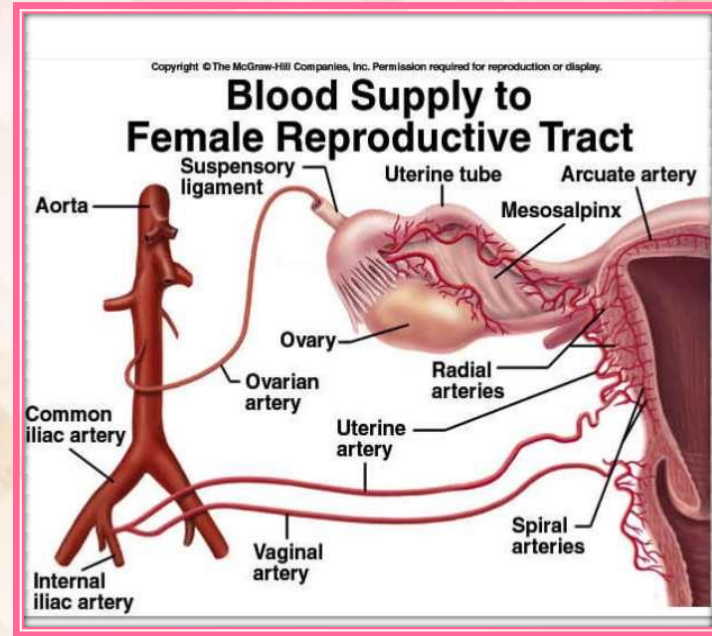
- Ovarian arteries
 - Enter ovaries at renal hilum
- Minimal from Uterine artery

Venous Supply

- Ovarian Veins (rt to IVC and left to Renal vein) Lymphatic

Drainage

- Aortocaval and para aortic nodes



IMAGING ANATOMY

HSG

Reference radiologic method for assessing tubal patency

Indications

- Infertility and recurrent miscarriages
- Congenital uterine anomalies
- Uterine tube pathologies

Contraindications

- Metrorrhagia
- Acute and sub acute PID
- Contrast allergy
- Pregnancy (UPT/Bhcg mandatory)

HSG

- D8-D12 of menstrual cycle
- Lithotomy position
- Use of atraumatic catheter , uterine injector(<250-300mmhg)
- Non ionic contrast media(10-20 ml)
- Sequence of images
 - Scout
 - Beginning of uterine filling
 - Uterus completely distended
 - Uterine tube opacification
 - Peritoneal spill

HSG

COMPLICATIONS

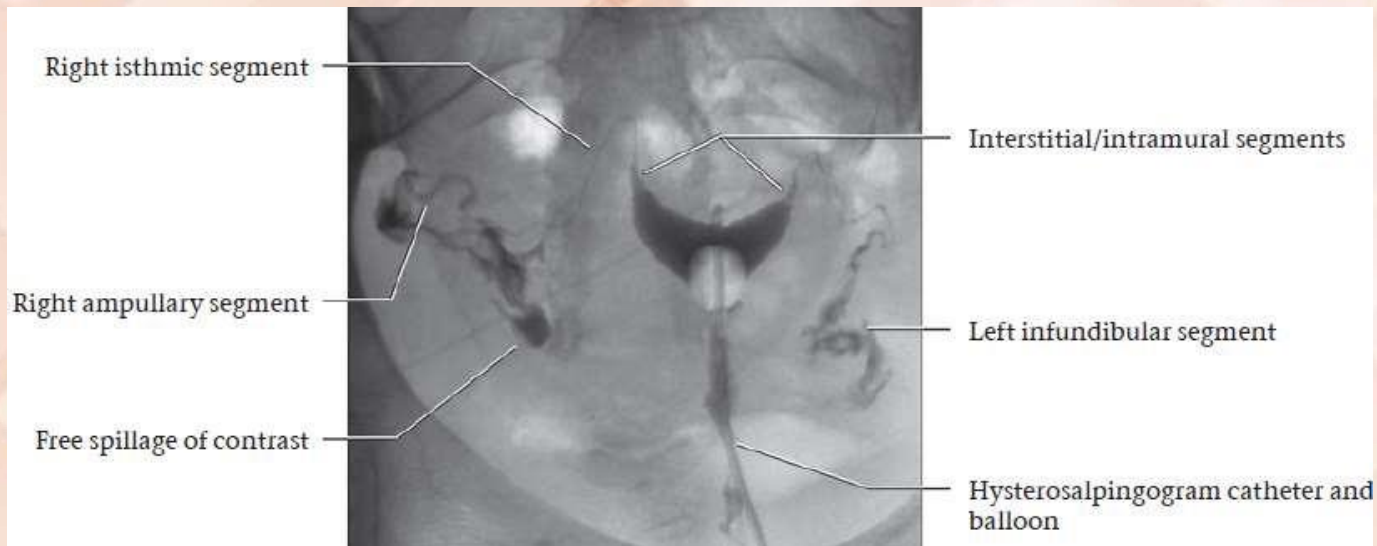
Pain

Bleeding

Infection

Contrast media reactions

HSG



ULTRASOUND

- Trans- abdominal and trans-vaginal USG

TAS

- Equipment : 3.5-5Mhz curved transducer
- Wide field of view
- Requires a filled bladder
 - Displace bowel loops
 - Acoustic window
 - Straightens anteverted/anteflexed vertebra

ULTRASOUND

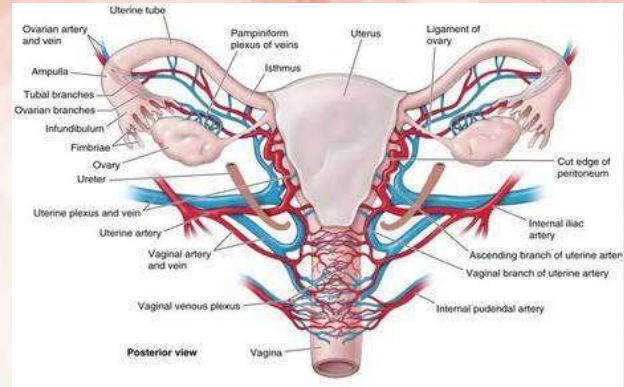
OVARIES

LOCATION

- Ovarian fossa
- Medial to external iliac , levator ani
- Anterior to int iliac artery and ureter
- Left ovary – difficult to visualize

FEATURES

- Central echogenic stroma with peripheral anechoic follicles(3-4mm)
- Surrounding hyperechoic Tunica
- Size : 3 x 2 x 1 cm



ULTRASOUND

CYCLICAL VARIATION

D1-D5 (Follicular Phase)

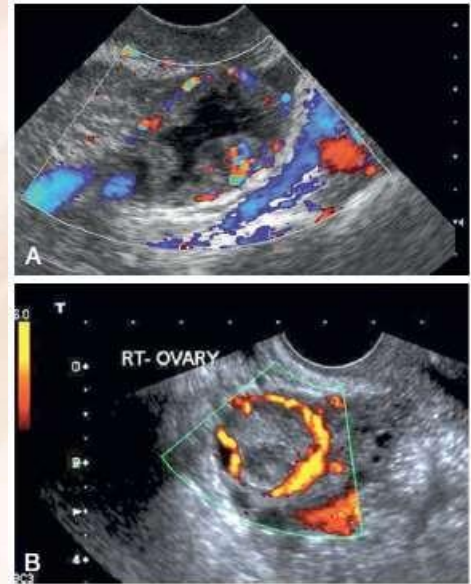
- Avg diameter of follicles 3-5mm(antral follicles)

D6-D8

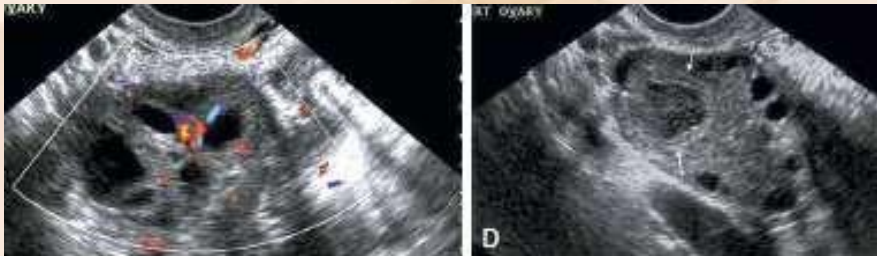
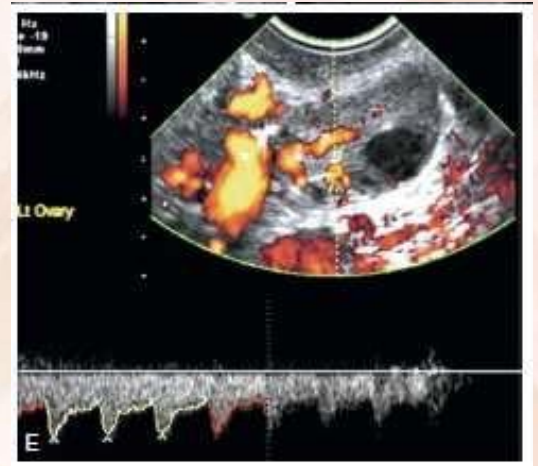
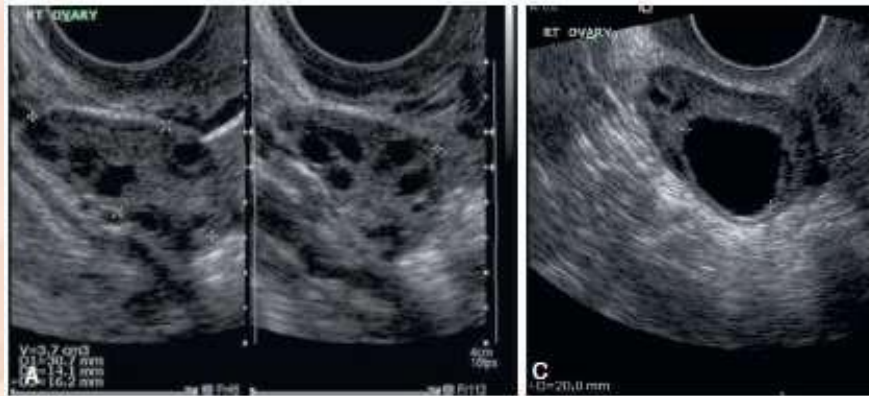
- Increase in size ; 20mm(max) – dominant follicle
- Anechoic with central hyperechogenicity (granulosa cells)

Ovulation

- Dec in size
- Increased echogenicity with wall thickening
- Luteal Body – Inc echogenicity due to prolifern of granulosa cells



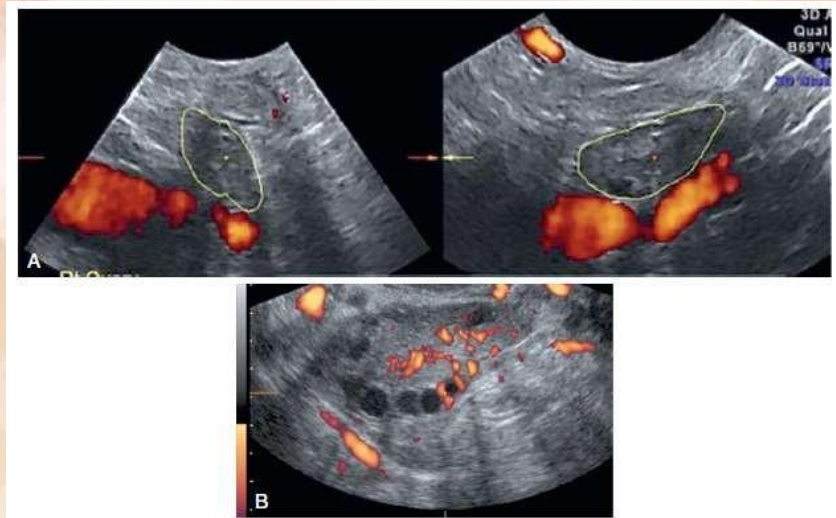
ULTRASOUND



ULTRASOUND - OVARY

POST- MENOPAUSAL

- Smaller in size – difficult to identify
 - More hypoechoic
 - Fewer/smaller cysts
- atretic follicles
- Punctate peripheral hyperechoic foci of calcification (dystrophic)



ULTRASOUND

FALLOPIAN TUBES

Normally not seen

Seen in hydrosalpinx/ascites

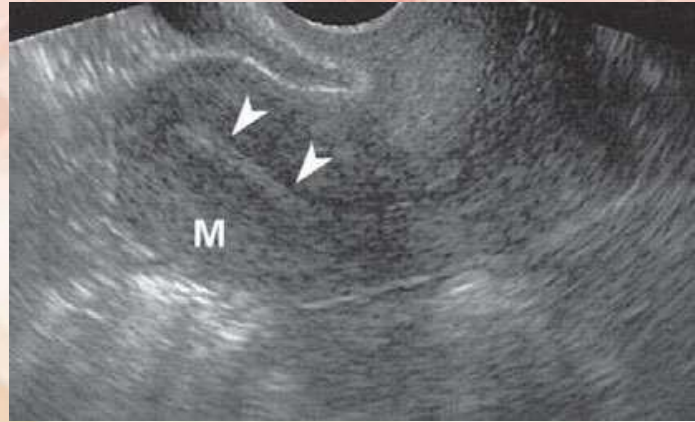
Seen as continuation of uterine body



ULTRASOUND

UTERUS

- Size : 7 x 5 x 4cm
- Echogenicity
 - Myometrium :
 - Thin hypoechoic inner layer - subendometrial halo
 - Thicker echogenic middle layer
 - Thinner hypoechoic outer layer
 - No change with menstrual cycle

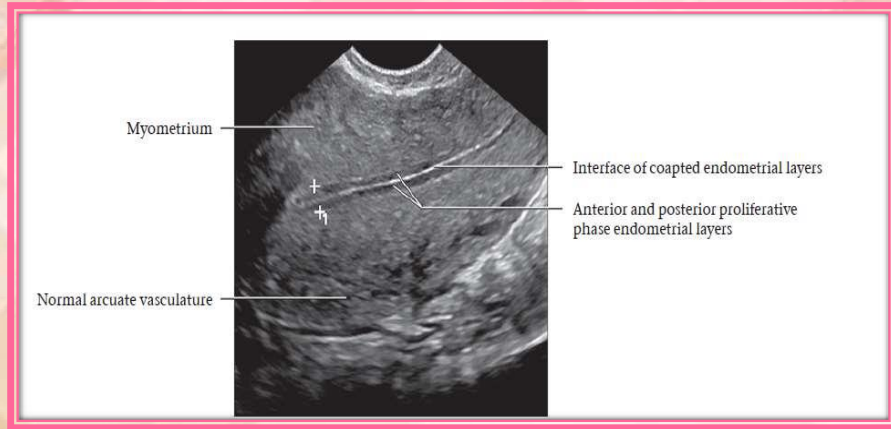


ULTRASOUND - UTERUS

ECHOGENICITY

Endometrium

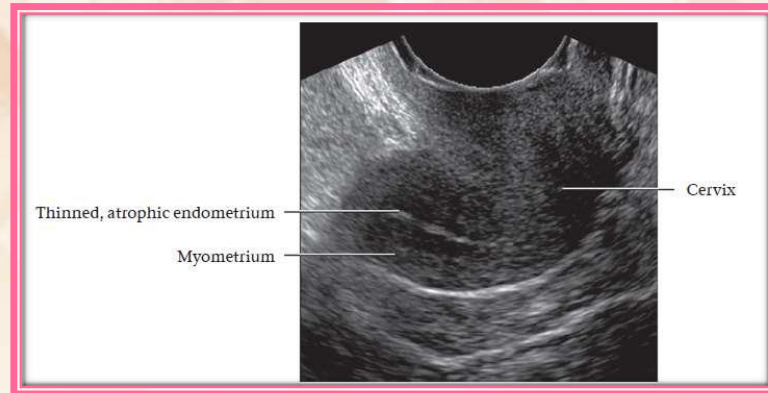
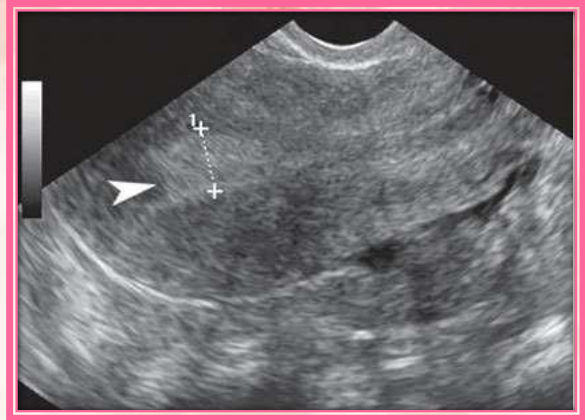
- Menstrual Phase: Extremely thin with hyperechoic line
- Follicular Phase: TRILAMINAR appearance
 - ET : 8-11mm
- Ovulatory Phase : hyperechoic endometrium(secretions)



ULTRASOUND

UTERUS

- Luteal phase
 - ET: 14-16mm
 - Inc echogenicity due to stromal edema and proliferation of glands
- Post menopausal period
 - With HRT : more thickened
 - w/o HRT : ET < 5mm
 - Thin hyperechoic line /not visible
 - Min fluid within – mucus secretion





ULTRASOUND - CERVIX

USG

Fluid in endocervical canal: Anechoic linear stripe

- Echogenic foci of air occasionally can be seen in endocervical canal

Endocervical mucosa: Hyperechoic inner band

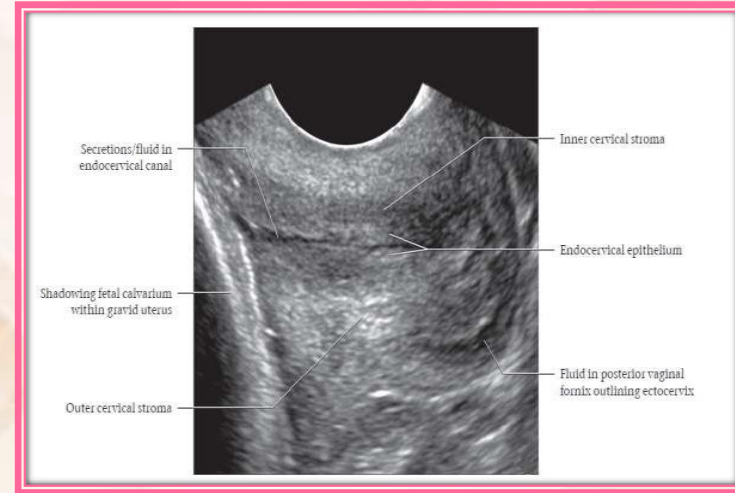
- Contiguous with endometrial echocomplex

Inner cervical stroma: Hypoechoic middle band

- Contiguous with junctional zone of uterine body

Outer cervical stroma: Slightly echogenic outer band

- Contiguous with outer uterine body myometrium



ULTRASOUND

CERVIX

- Walls may have Nabothian cysts

RECTOUTERINE POUCH

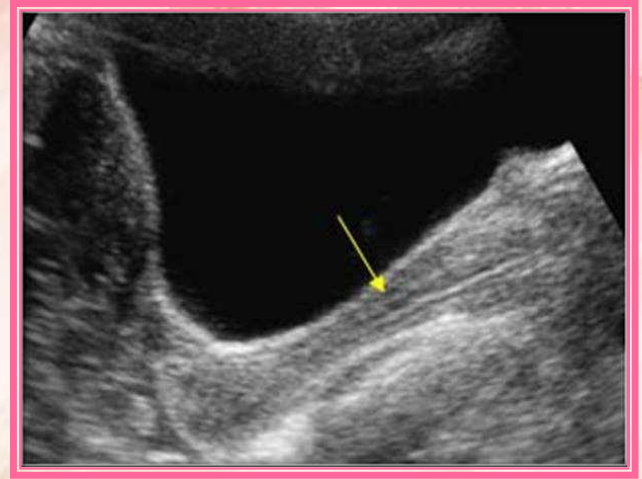
- Minimal fluid during menstruation and periovulatory phase

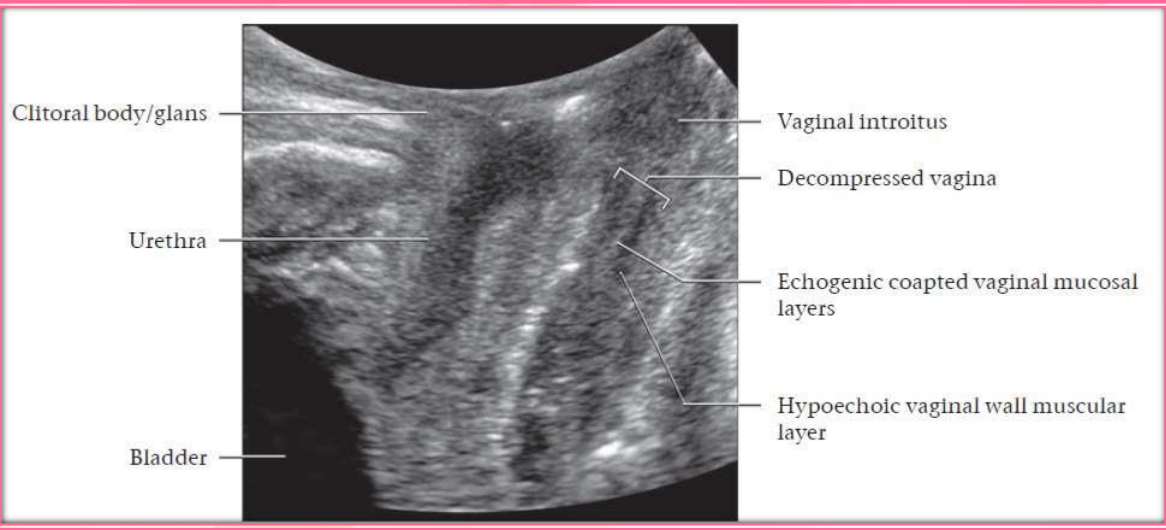


ULTRASOUND

VAGINA

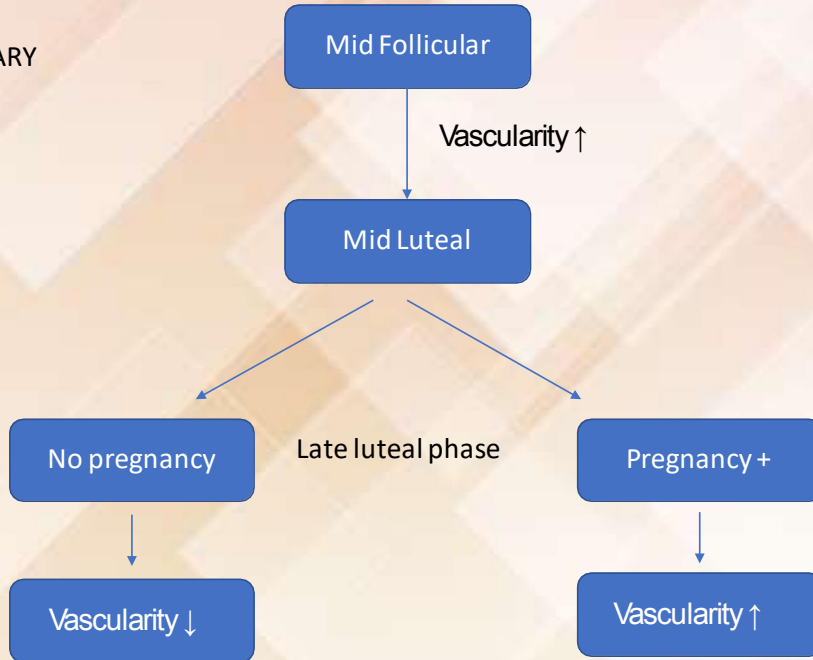
- Normal Length : 7-10cm
- Trilaminar appearance
- Vaginal wall with TVS – hypoechoic and uniformly thin
- Coated vaginal mucosal layers – echogenic linear interface
- Lumen appreciable if menstrual blood +
- Posterior fornix crescent shaped anechoic area





ULTRASOUND - DOPPLER

- FLOW IN OVARY



ULTRASOUND - DOPPLER

OVARIAN AND UTERINE ARTERIES

- Luteal Phase : Inc volume flow compared to follicular phase
- Pre –pubertal phase : High impedance with absent diastolic flow
- Menarche :: Low impedance with diastolic flow

TABLE 14-1 Variation in Doppler Indices in the Uterine and Ovarian Arteries during the Menstrual Cycle

	RI OVA	PI OVA	VEL OVA (cm/s)	PI UTA
Early follicular	0.65–0.7	1.8–2.2	20	1.67 ± 0.22
Late follicular/ ovulation	0.55–0.6	1.0–1.3	40	1.89 ± 0.4
Luteal	0.6–0.65	1.3–1.8		2.23 ± 0.67
Non-conception	0.6–0.7	1.8–2.2		3.85 ± 1.1
Postmenopausal	0.6–1.0	1.3–4.0		1.8–3.8

COMPUTED TOMOGRAPHY

- Less often use due to dec soft tissue resolution
- Used to see calcification in various lesions (ex : leiomyoma) and In lymph nodes

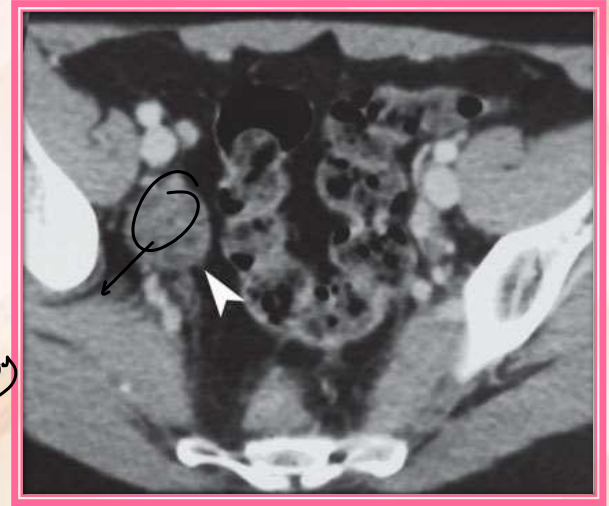
TECHNIQUE

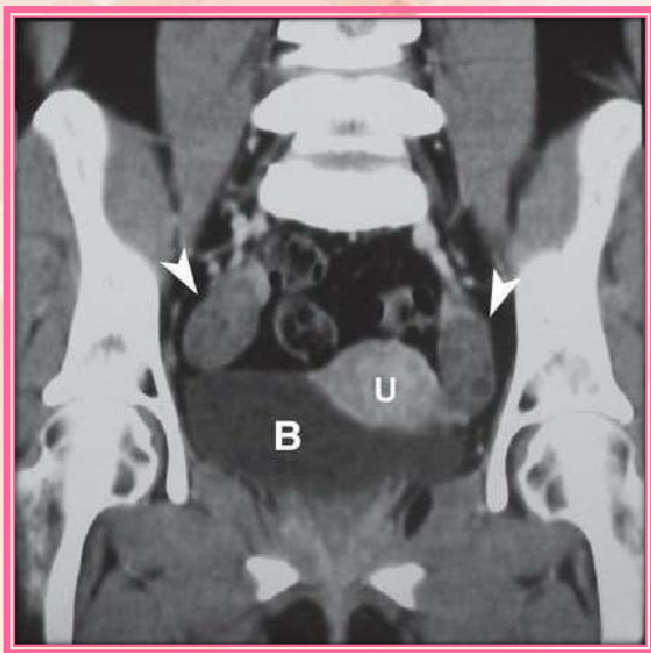
- Partially distended bladder required
- NECT
- CECT
 - 100-120 ml of non ionic contrats at 2-3 ml/s
 - Delayed scan(3-5mins) – assess bladder and distal ureter involvement

COMPUTED TOMOGRAPHY

OVARY

- During acute pelvic pain
- Identified by following ovarian vessels
- Ovoid structures with decreased attenuation
- Ovarian ligaments in presence of free fluid
- Corpus luteum may show prominent thickened enhancing wall







COMPUTED TOMOGRAPHY

UTERUS

NECT

Uterus : homogenous soft tissue density

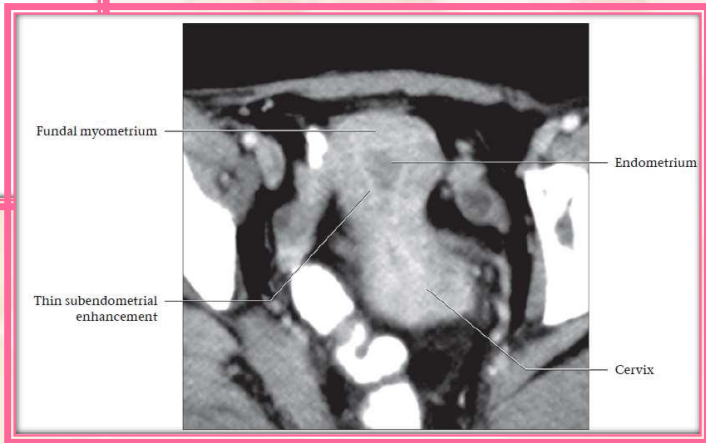
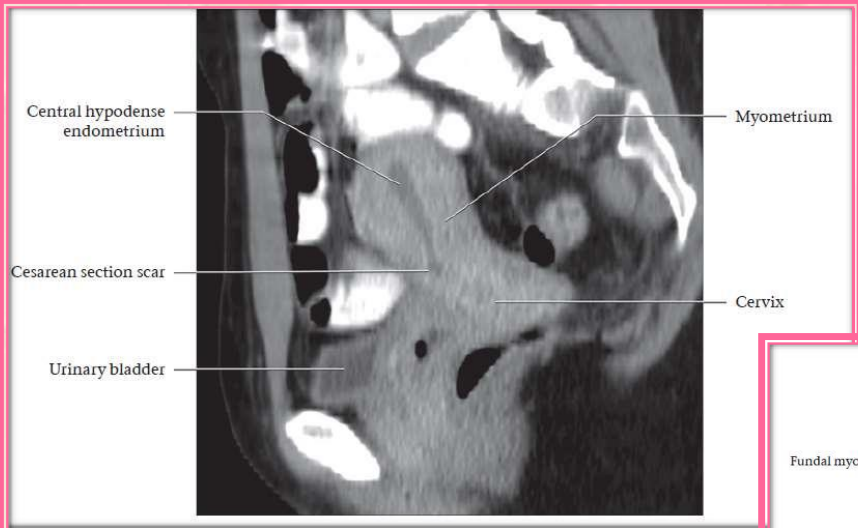
Endometrium : hypodense

CECT

Myometrium : variable CE , hypoenhancing in postmenopausal state

Endometrium : hypodense central stripe





POST CONTRAST



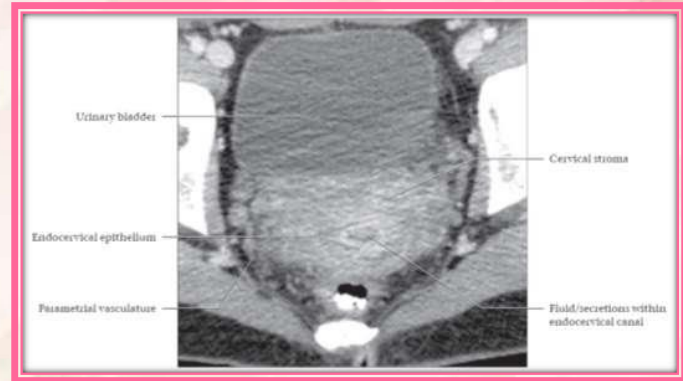
COMPUTED TOMOGRAPHY

CERVIX

NECT: Cervix is of homogeneous soft tissue density

CECT: Cervix may demonstrate targetoid enhancement

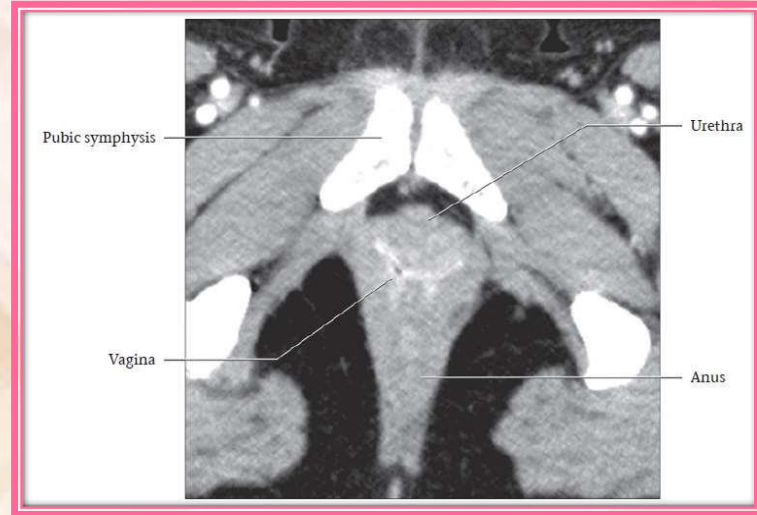
- Central secretions/fluid: Hypodense
- Inner cervical mucosa: Intense enhancement
- Inner stroma: Hypoenhancing
- Outer stroma: Intermediate enhancement
- Cervix often displays diffuse hypoenhancement compared to uterine body



COMPUTED TOMOGRAPHY

VAGINA

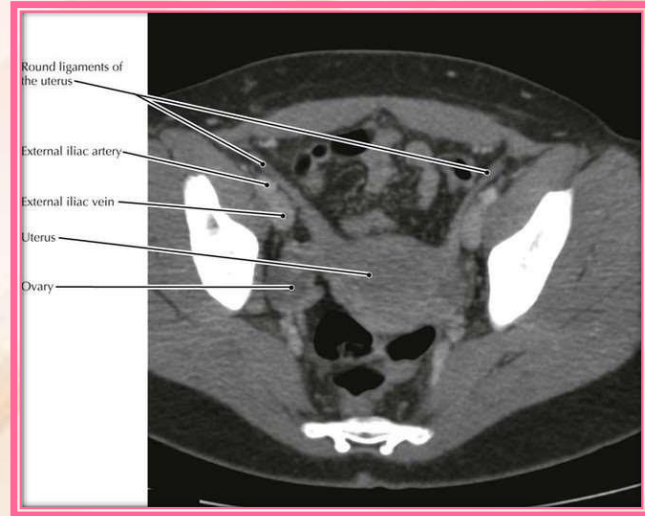
- Mucosa may show prominent smooth, early enhancement in premenopausal patients
- Hypoenhancing in postmenopausal women
- Muscular layer is hypoenhancing when compared to mucosa



COMPUTED TOMOGRAPHY

PARAMETRIUM

- Visible on CT are
 - Round ligament(ribbon like appearance)
 - Uterine ligaments(thickened post RT)
 - Broad Ligament
 - Cardinal ligament (less often visualized)



MAGNETIC RESONANCE IMAGING

Indications

- Better soft tissue resolution
- Characterization of pelvic masses
- Staging of pelvic malignancies
- Evaluation of congenital (müllerian) anomalies
- Treatment follow-up
- Pelvic floor assessment (dynamic)
- Evaluation of pelvic lymphadenopathy
- Pelvimetry
- Evaluation of pelvic pain in pregnancy

MAGNETIC RESONANCE IMAGING

CONTRAINDICATIONS

Metallic implants

Claustrophobia

GETTING STARTED

Anxiolytics

Anti-peristaltic agents (small bowel motion artefacts)

MAGNETIC RESONANCE IMAGING

PATIENT PREPERATION

- Empty Bladder
- Reduce motion artefacts
 - Fasting 4-5 hrs
 - Anti-peristaltic agents
- Bacteriostatic vaginal surgical lubricant
 - Intra luminal contrast
 - Improved visualization of Cx and Vagina

MAGNETIC RESONANCE IMAGING

PROCEDURE

Position

- Supine

Equipment Preparation

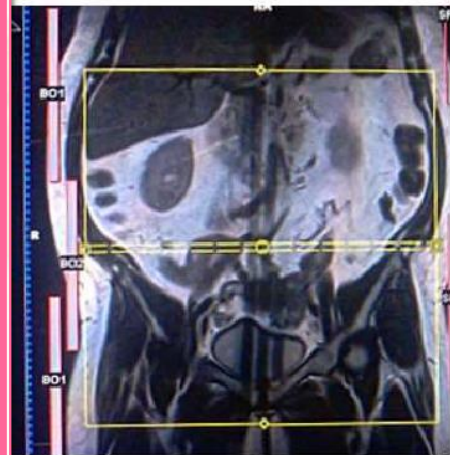
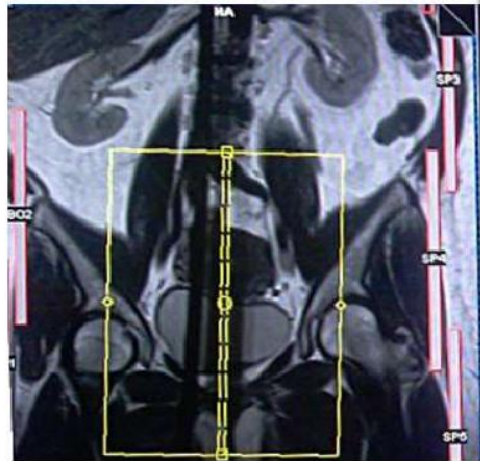
- Surface array multi channel coil
- Abdominal/pelvic coil provides for larger field of view but decreased resolution/signal
- Phase-array coil increases resolution and decreases imaging time
- Endoluminal coils (endorectal and endovaginal coils)

MAGNETIC RESONANCE IMAGING

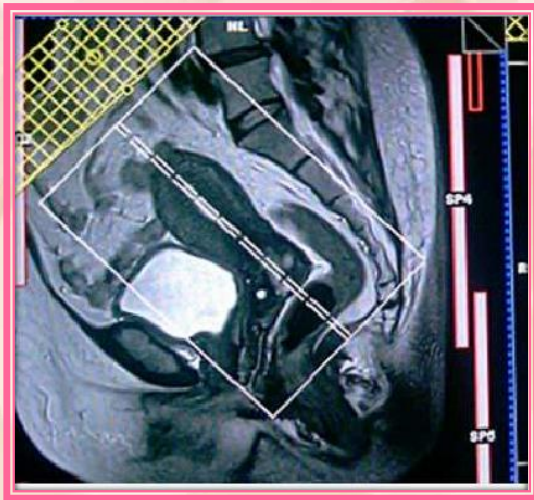
IMAGING PLANES

- Axial : pelvic anatomy and parametrial assessment
- Sagittal : Uterine zonal anatomy
- Coronal : complementary information in assessment of uterus, cervix, parametrium, vagina, and ovaries
- Oblique : evaluation of parametria in cervical Ca
 - Characterisation of mullerian duct anomalies

MRI PLANNING



MAGNETIC RESONANC IMAGING



MAGNETIC RESONANCE IMAGING

SEQUENCES

T2WI : Better uterine , ovarian and cervical anatomy

- w/o Fat suppression : pelvic fat acts as intrinsic contrast

T1WI : pelvic soft tissues, lymph nodes, and bone marrow T1WI +

FS : Differentiate fat and blood

T1WI c+ FS :

- Characterising adnexal lesions
- Ovarian and cervical ca staging
- Assessing vascularity of leiomyoma prior to therapy

MAGNETIC RESONANCE IMAGING

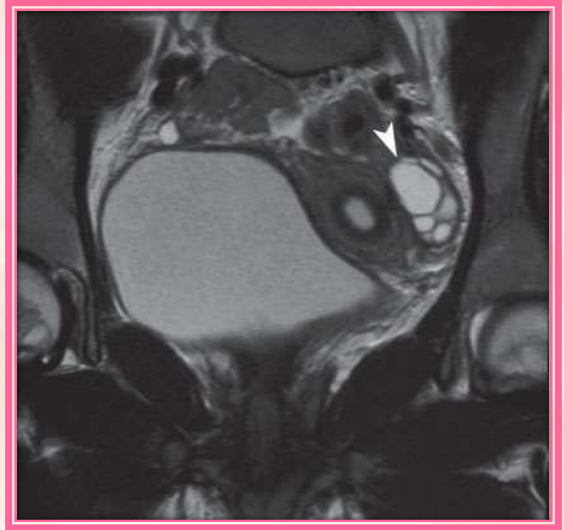
DWI/ADC

- Water mobility/tissue cellularity/ integrity of cellular membranes
- Low ADC often associated with malignancy(overlap do exist)
- Low cellularity tumors and mucinous tumors – high ADC
- Peritoneal implants from ovarian Ca have low ADC

MAGNETIC RESONANCE IMAGING -OVARY

T2WI

- Outer cortex – slightly decreased SI
- Inner medulla – intermediate to slightly increased signal intensity
 - Reduced in menstruation – decreased water content
- Pre menopausal : rounded hyperintense follicles within the cortex
- Post menopausal: homogenous low SI



MAGNETIC RESONANCE IMAGING -OVARY

T1WI

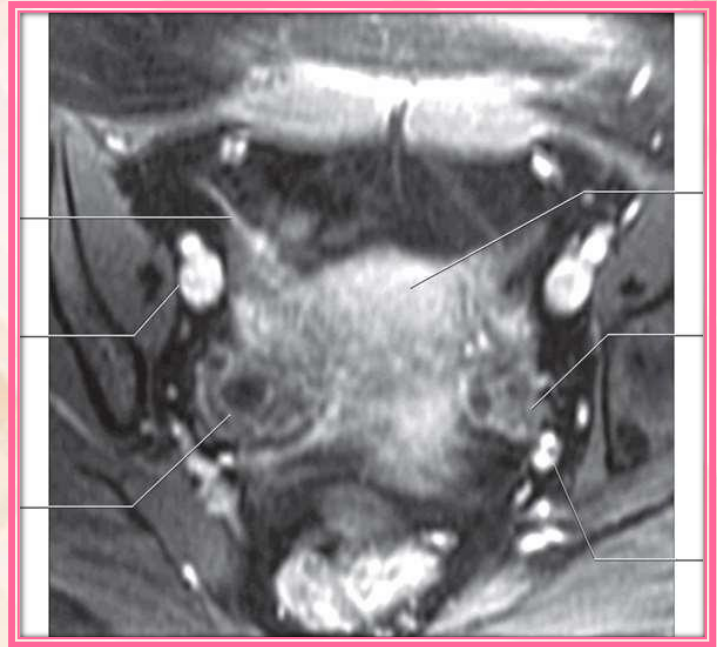
- Homogenous low to intermediate signal
- Cysts as hypointense foci
- Hemorrhagic cyst are hyperintense

T1WI + C

- Ovarian parenchyma enhances to lesser degree than myometrium
- Myometrium enhancement = Ovary (Post menopausal)
- Functional cysts and corpus luteum show peripheral enhancement

DWI

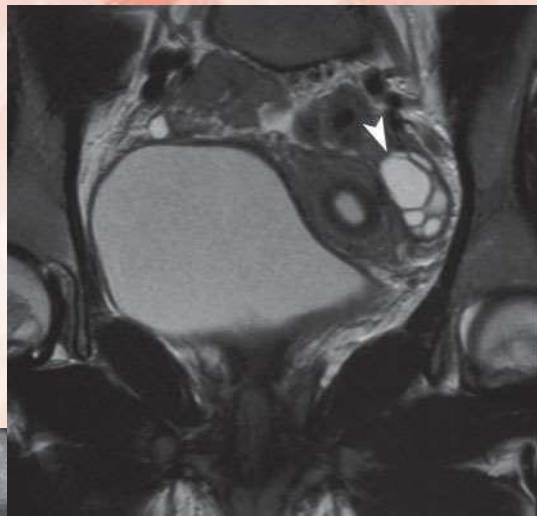
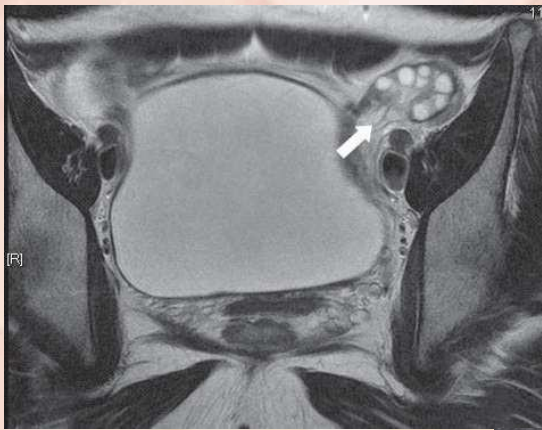
- Low signal in menstruation
- High signal in periovulatory period



MAGNETIC RESONANCE IMAGING -OVARY

Post menopausal – difficult to identify

- Decreased size
- Intermediate to low signal on T1WI
- Hypointense on T2WI
- Fewer/smaller cysts
- Iso to hypoenhancing to myometrium



MAGNETIC RESONANCE IMAGING

PARAMETRIUM

- Loose connective tissue between layers of broad ligament
- Contains blood vessels and lymphatics
- T1WI: low-intermediate
- T2WI : variable
- Other ligaments seen better in presence of ascites

MAGNETIC RESONANCE IMAGING

UTERUS

- T1WI : Uterus and cervix have uniform intermediate signal
- T2WI : Three zones – Endometrial cavity, Junctional zone, myometrium
- Endometrium
 - Central hyperintense layer (basal layer + secretions)
 - ET 1-3mm(post menstruation/follicular phase) to 3-7mm(Luteal phase)
 - During menstruation – Low SI areas within cavity
 - Abnormal : >12mm



MAGNETIC RESONANCE IMAGING

UTERUS

- Junctional Zone
 - Hypointense layer
 - Deepest zone of myometrium
 - Greater concentration of smooth muscle cells compared to periphery
- Myometrium
 - No significant change in size during the cycle
 - But SI changes occur
 - Luteal phase : inc due to edema (hence the junctional zone become less distinguishable)
 - Arcuate vessels will be identifiable

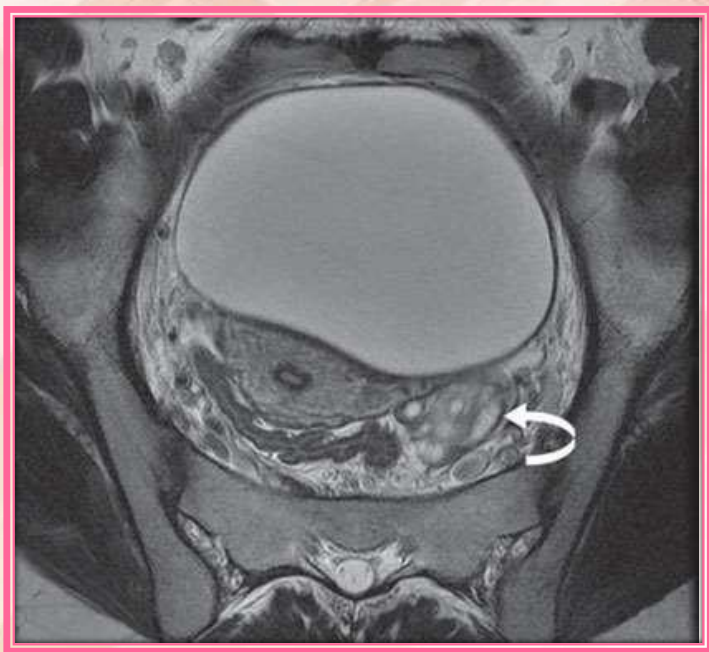


MRI

UTERINE APPEARANCE

- Premenarche : body is small and zonal anatomy is indistinct
- Premenopausal(postmenarche)
 - Endometrium thickens throughout proliferative and secretory phase
 - Myometrial T2 signal increase in secretory phase - inc water content and vascular flow
 - Menstruation : Thickness and T2 signal decrease
 - Junctional zone shows no change
- Post menopausal : endometrial and myometrial atrophy , Decreased T2 signal





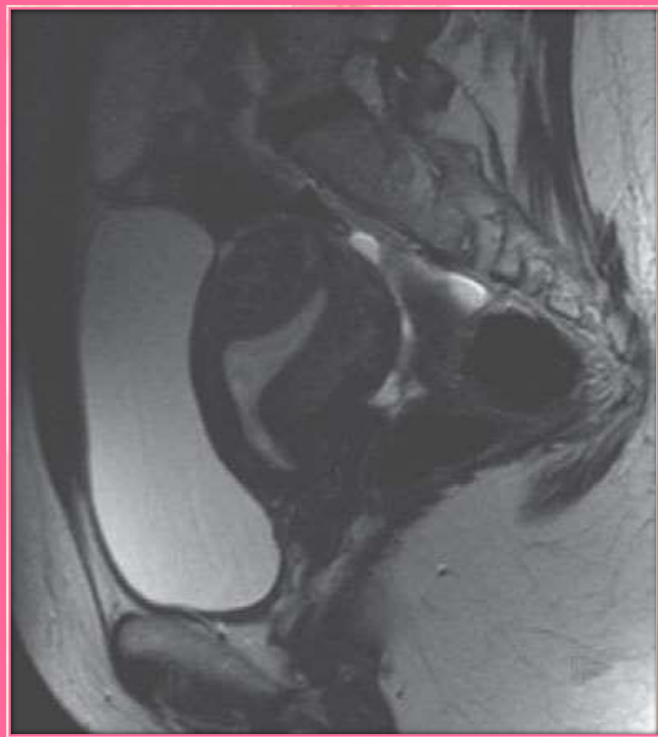
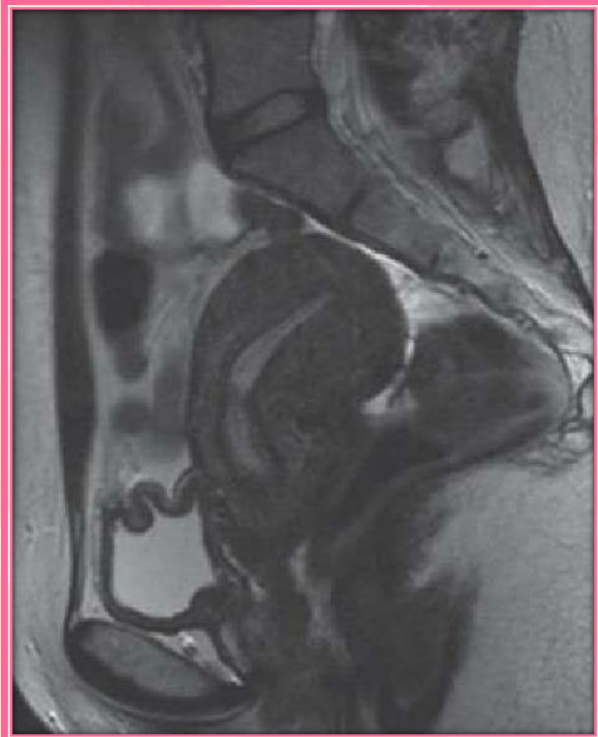
MAGNETIC RESONANCE IMAGING

UTERUS

- Post menopausal
 - W/o HRT – zonal anatomy unclear , thin endometrium , myometrium shows dec SI
 - W/ HRT
 - Inc T1 and T2 SI
 - Junctional zone – difficult to identify /absent
 - In presence of GnRH replacement : dec estrogen – endometrial atrophy and hypointense myometrium
 - Estrogen replacement therapy – Identifiable trilaminar appearance
- CE MRI
 - Myometrium enhances
 - Junctional Zone : Decreased enhancement



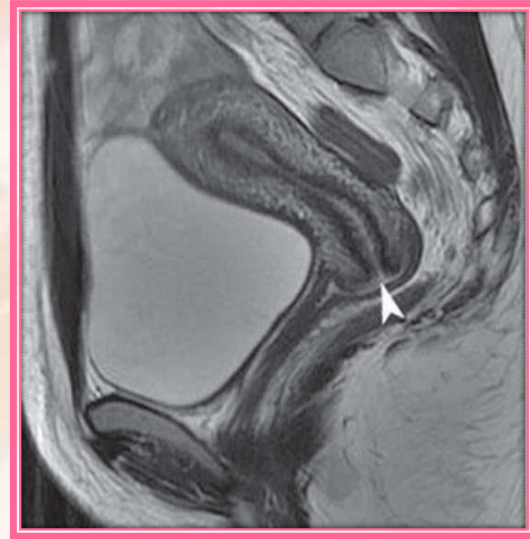




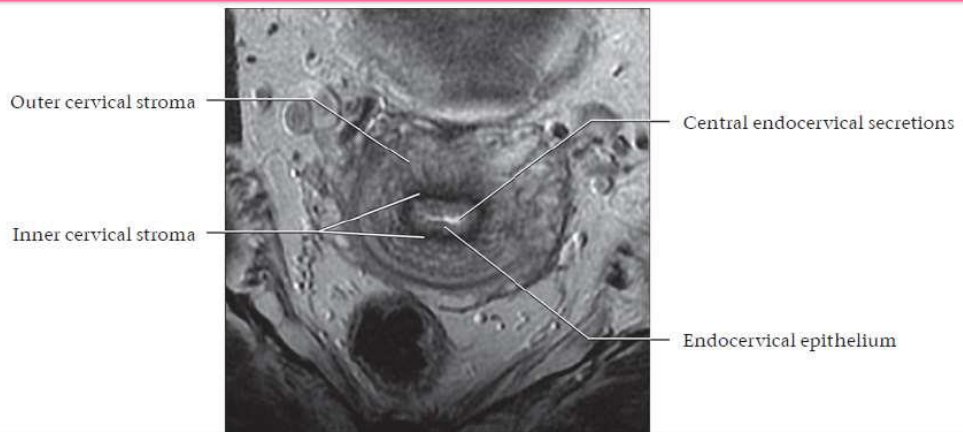
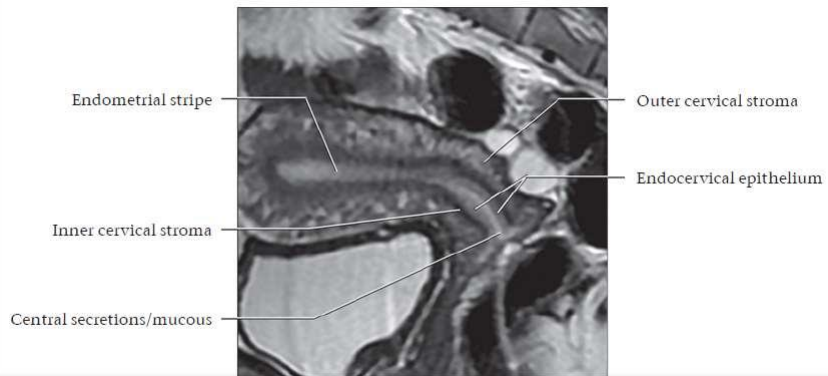
MAGNETIC RESONANCE IMAGING

CERVIX

- Three zones in T2WI
 - Cortical Zone – Hyperintense zone(mucus secretions)
 - Intermediate zones – Hypointense (deep part of fibro muscular stroma)
 - Peripheral zone – iso/hypointense (smooth muscle cells prevail)
- CEMRI
 - Inner cervical mucosa enhances to greater degree than cervical stroma







Cervical stroma

Enhancing endocervical epithelium

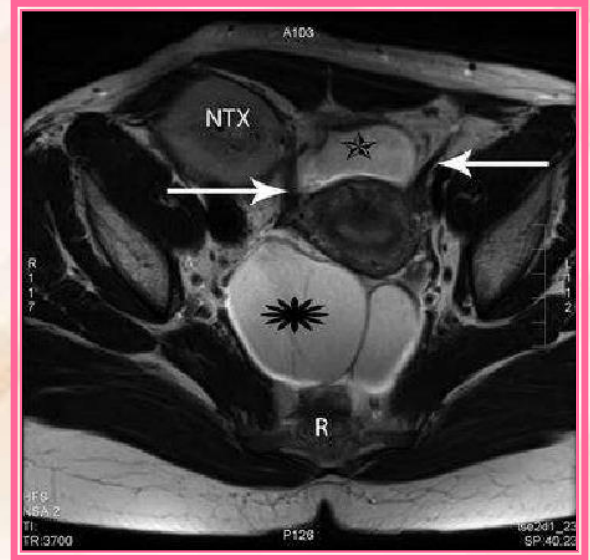
Enhancing parametrial vasculature



MAGNETIC RESONANCE IMAGING

PARAMETRIUM

- T1 – intermediate SI
- T2 – variably higher signal
- Suspensory ligaments – Dec T1 and T2



MAGNETIC RESONANCE IMAGING

VAGINA

MR is preferred modality

- superior soft tissue differentiation
- Allows for delineation of vulvar anatomy
- Superior evaluation of vaginal wall and characterization of associated lesions

CT is most useful in

- Staging of vaginal/vulvar malignancy
- Evaluation for nodal and metastatic disease

MAGNETIC RESONANCE IMAGING

VAGINA

- Endoluminal secretions
 - T2WI hyperintense and T1WI hypointense
- Mucosal Layer
 - T2WI hyperintense (more in proliferative phase)
 - T1WI hypointense
 - Smooth enhancement on CE
- Submucosal and muscular layers
 - Hypointense on T1WI and T2WI images

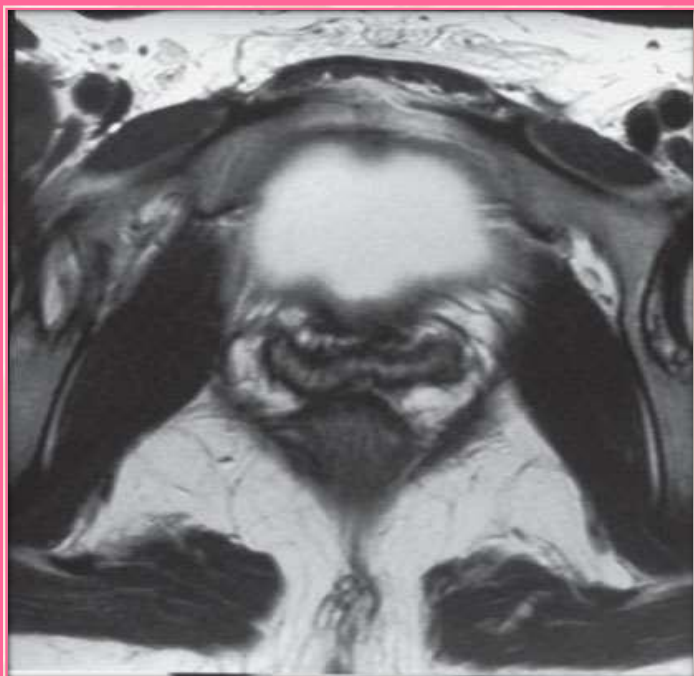


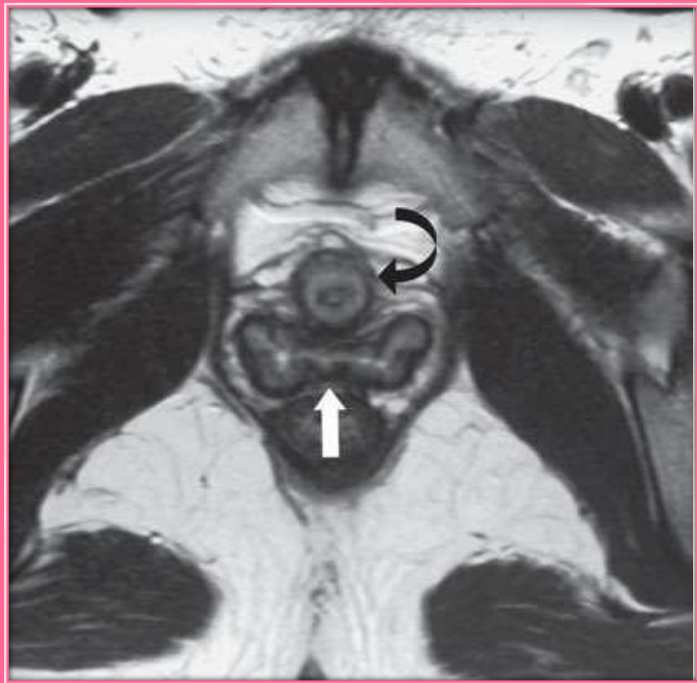
MAGNETIC RESONANCE IMAGING

VAGINA

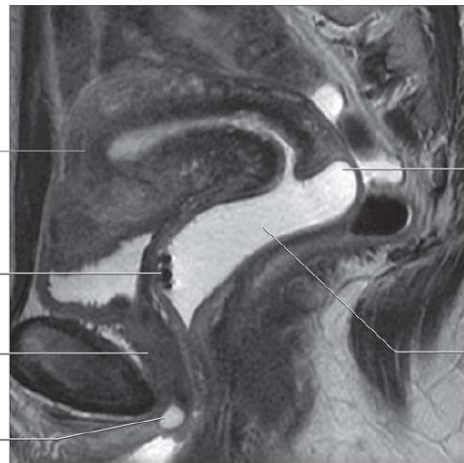
- Pre-pubertal
 - Central thin hyperstrip on T2
 - T2 hypointense wall
- Early follicular phase : T2 central hyper with peripheral hypointensity
- Luteal phase
 - mucus component inc
 - Vaginal wall SI inc , hence dec structural differentiation
- Post Menopausal
 - w/ HRT – similar to follicular phase
 - w/o HRT
 - Thin central mucus layer
 - Dec T2 SI of vagina

CEMRI – enhanced vaginal wall and mucosal compartment









Uterine fundus

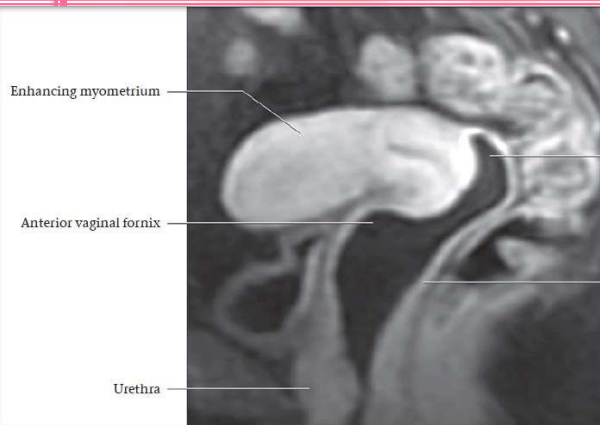
Air bubbles

Urethra

Skene gland cyst

Posterior vaginal fornix

Vaginal lumen distended with gel



Enhancing myometrium

Anterior vaginal fornix

Urethra

Posterior vaginal fornix

Vaginal wall

MISC

BOLD (BLOOD OXYGENATION LEVEL DEPENDENT) MR

- Measures differences in paramagnetic deoxyhemoglobin in blood as a marker of tumor hypoxia
- Tumors with higher levels of hypoxia may be more aggressive and resistant to therapy
- Identifies higher grade portions of tumor to help guide therapy

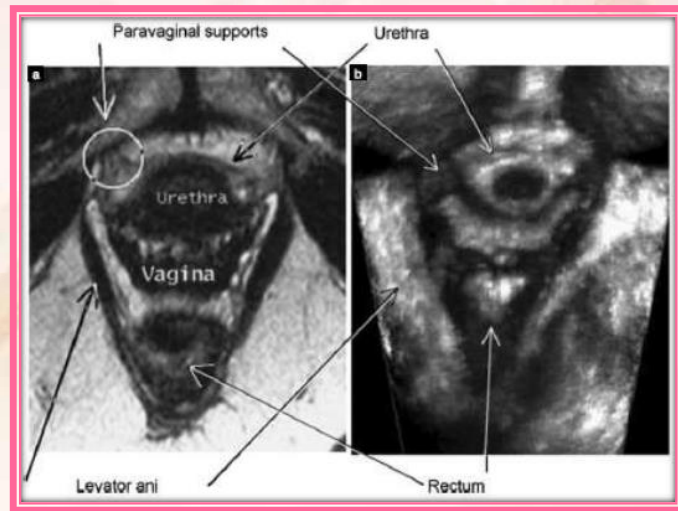
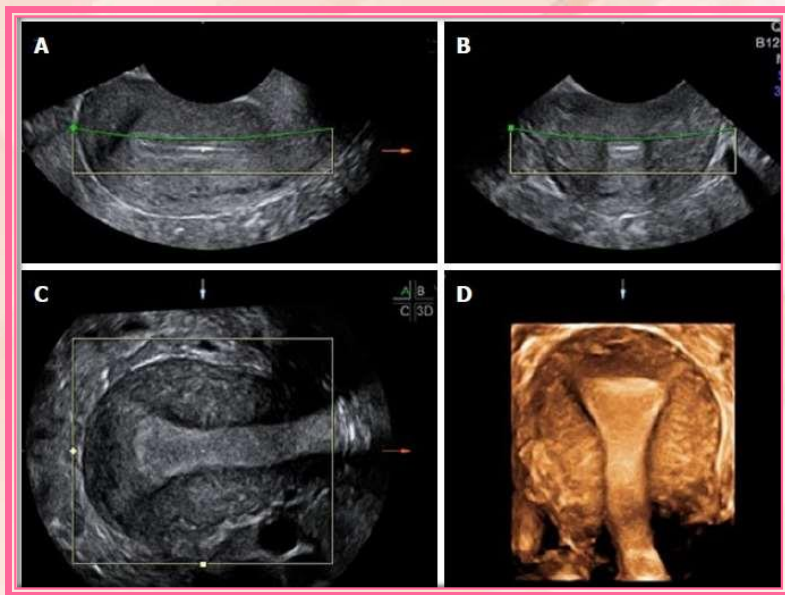
DIFFUSION TENSOR IMAGING (DTI)

- Can help detect and quantify defects/asymmetries in pelvic floor musculature
- Provides 3D representation of pelvic floor skeletal muscle

MR DEFECOGRAPHY

- Imaging performed after rectal administration of contrast (typically ultrasound gel) to evaluate pelvic floor
- Multiphase dynamic imaging performed (at rest, strain, defecation) typically with fast T2 imaging or bright-blood techniques

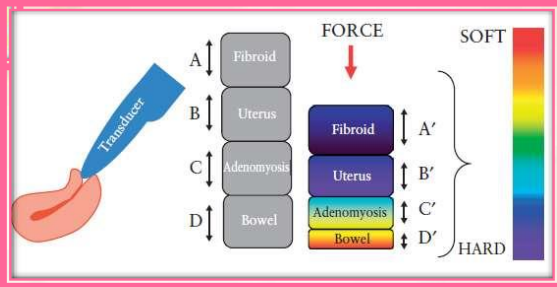
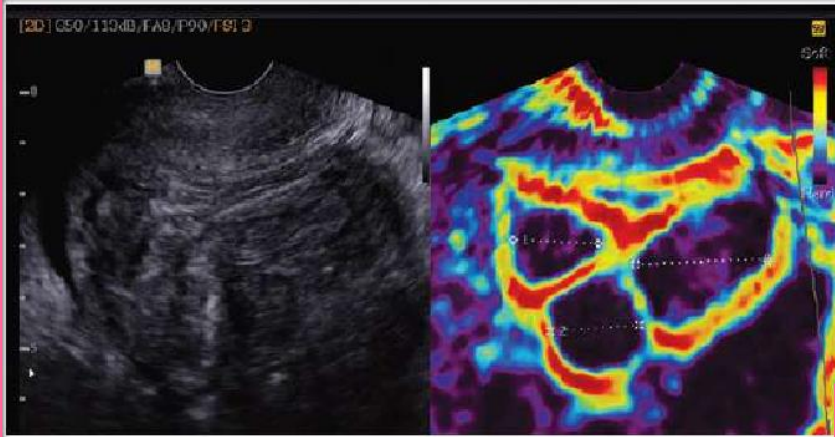
3D/4D USG



SONO HSG

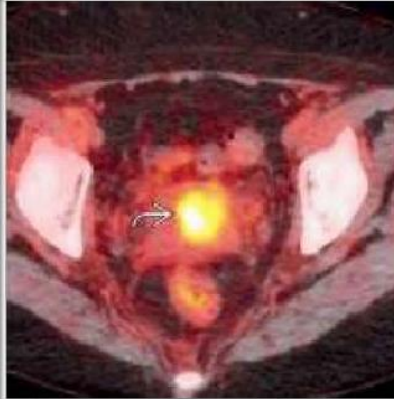


ELASTOGRAPHY

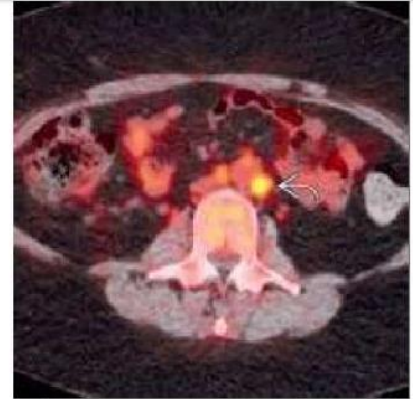


PET CT

- PET imaging relies upon increased glucose uptake and metabolism by malignant cells
- FDG-18 is the most widely used tracer in clinical practice



Axial PET/CT image in a patient with a diagnosis of cervical carcinoma shows local FDG-18 uptake within the cervix  with a SUV(max) of 12.5. Due to limited spatial resolution, local staging with PET can be difficult.

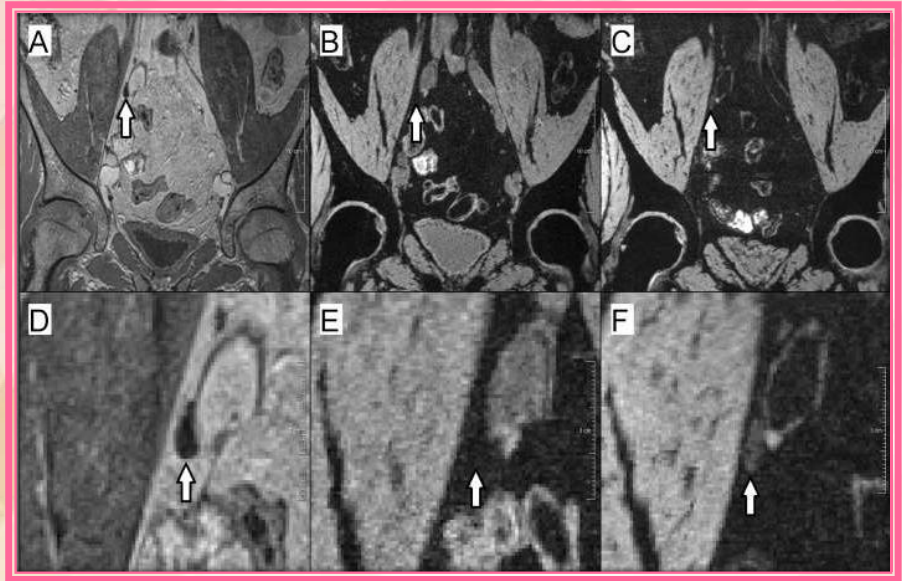


Axial PET/CT, same patient, shows a hypermetabolic paraaortic lymph node  < 1 cm in short axis diameter, representing metastatic nodal disease. PET/CT is most useful in detecting metastases or nodal involvement.

OTHERS

MR LYMPHOGRAPHY

- Can detect metastases in normal size lymph nodes with very high sensitivity and specificity
- Requires intravenous injection of Ultra small Superparamagnetic Particles of Iron Oxide (USPIO)
- USPIO is taken up by normal lymph nodes, whereas metastatic lymph nodes show no uptake



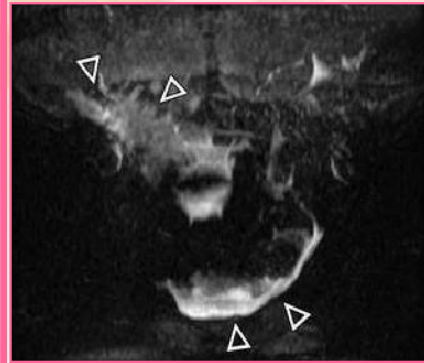
PELVIC MRA

- Vascular involvement in pelvic malignancy
- Prior to uterine artery embolization



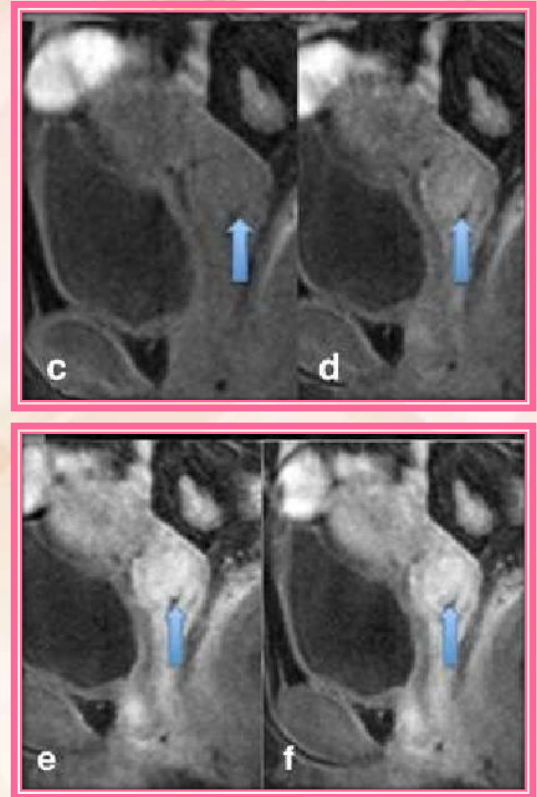
MR HSG

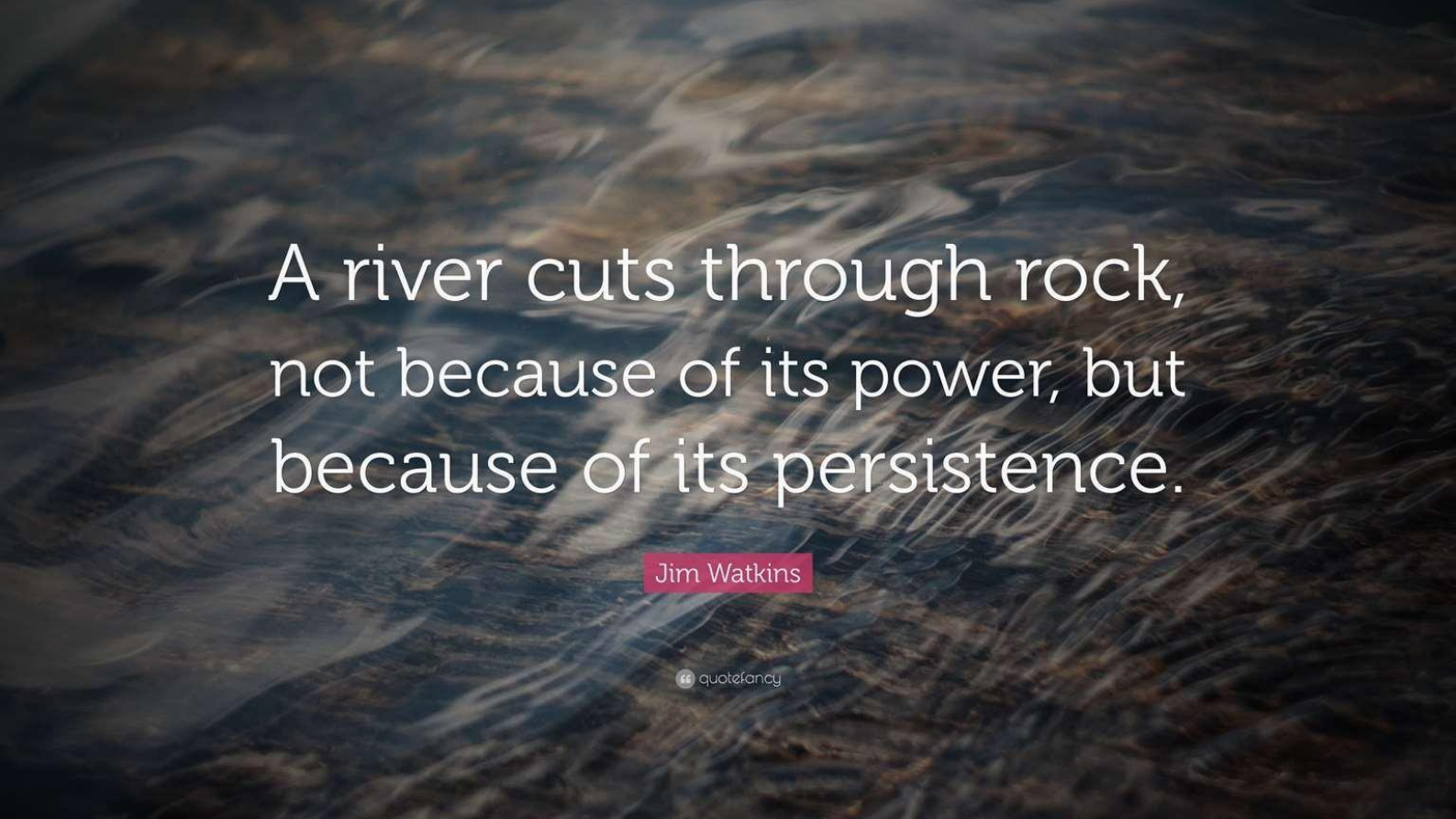
- MR imaging is performed after cannulation of cervix and injection of dilute gadolinium contrast into endometrial cavity
- Can evaluate for tubal patency as well as structural abnormalities



DYNAMIC CONTRAST ENHANCED MRI (DCE-MRI)

- Evaluate the microcirculation of tumors
- Hypovascularity may suggest poor-oxygenation status and poor response to treatment
- Marked enhancement, which indicates high tumor perfusion or good blood supply, was associated with higher local control.





A river cuts through rock,
not because of its power, but
because of its persistence.

Jim Watkins