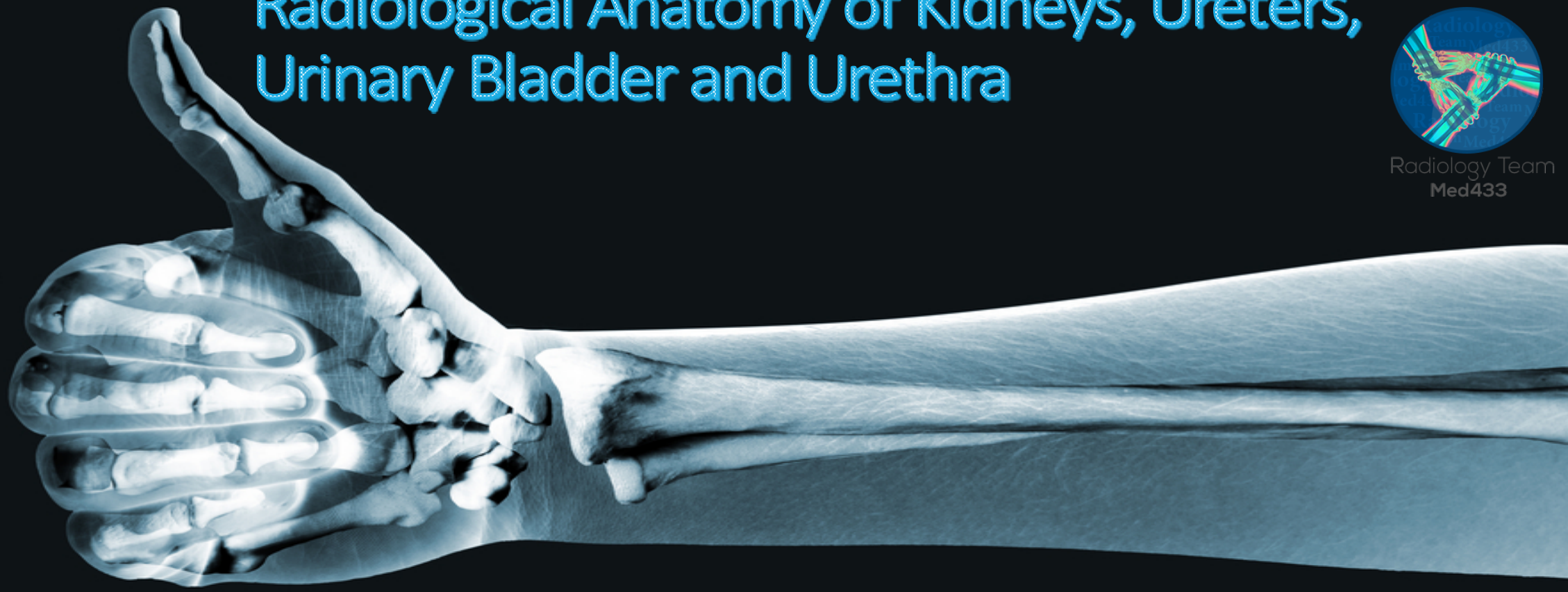
Lecture 8:

Radiological Anatomy of Kidneys, Ureters, Urinary Bladder and Urethra



Radiology Team
Med433

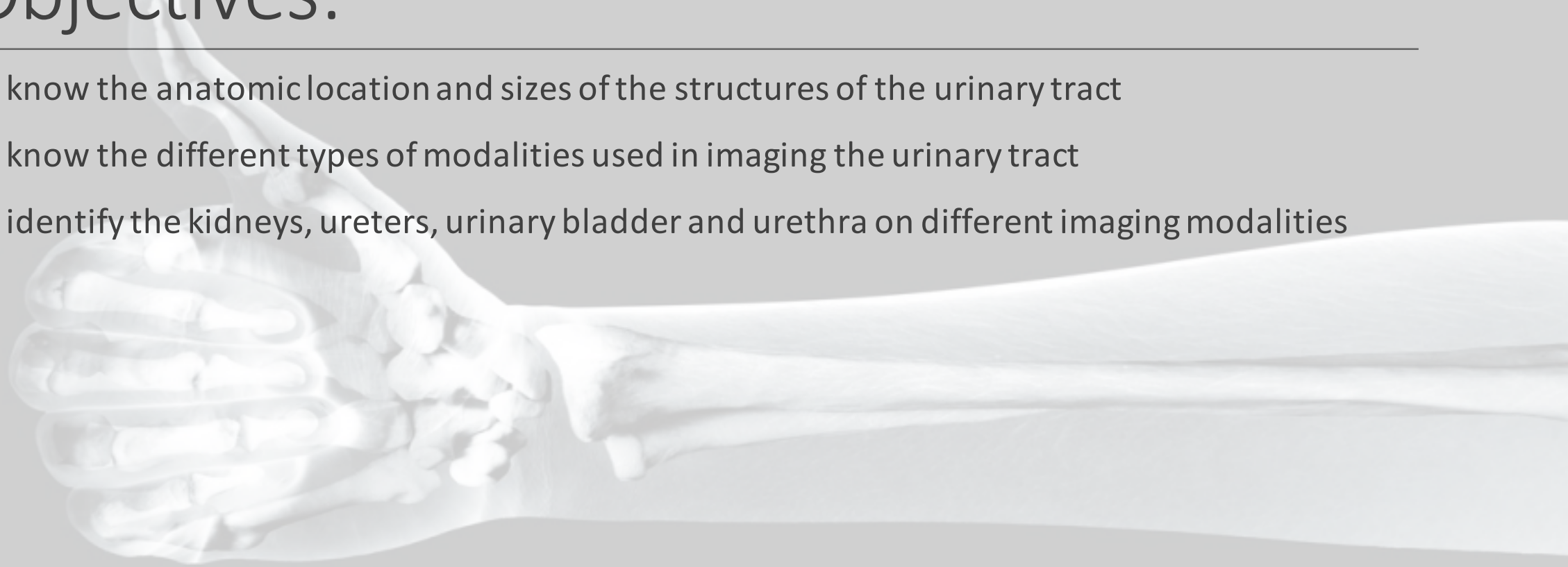
● Slides ● Explanation ● Notes ● Additions ● Important

Objectives:

To know the anatomic location and sizes of the structures of the urinary tract

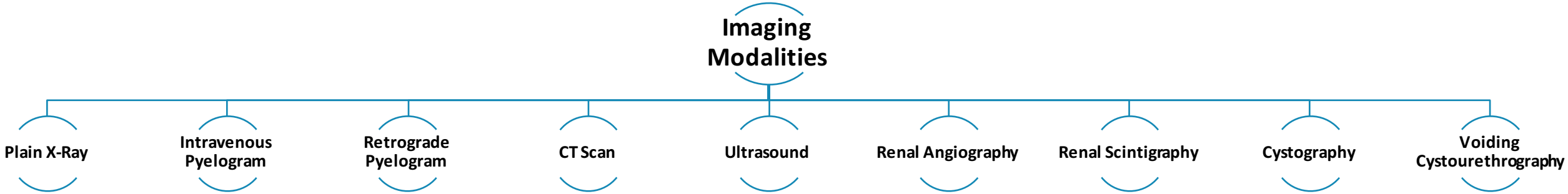
To know the different types of modalities used in imaging the urinary tract

To identify the kidneys, ureters, urinary bladder and urethra on different imaging modalities



Genitourinary System

- Kidneys are retroperitoneal organs.
- Their function is to maintain electrolyte homeostasis and waste excretion.
- They empty medially into the ureters.
- Ureters course inferiorly into the pelvis and enter the urinary bladder.
- The urine is temporarily stored in the urinary bladder till it is cleared to the exterior through the urethra.

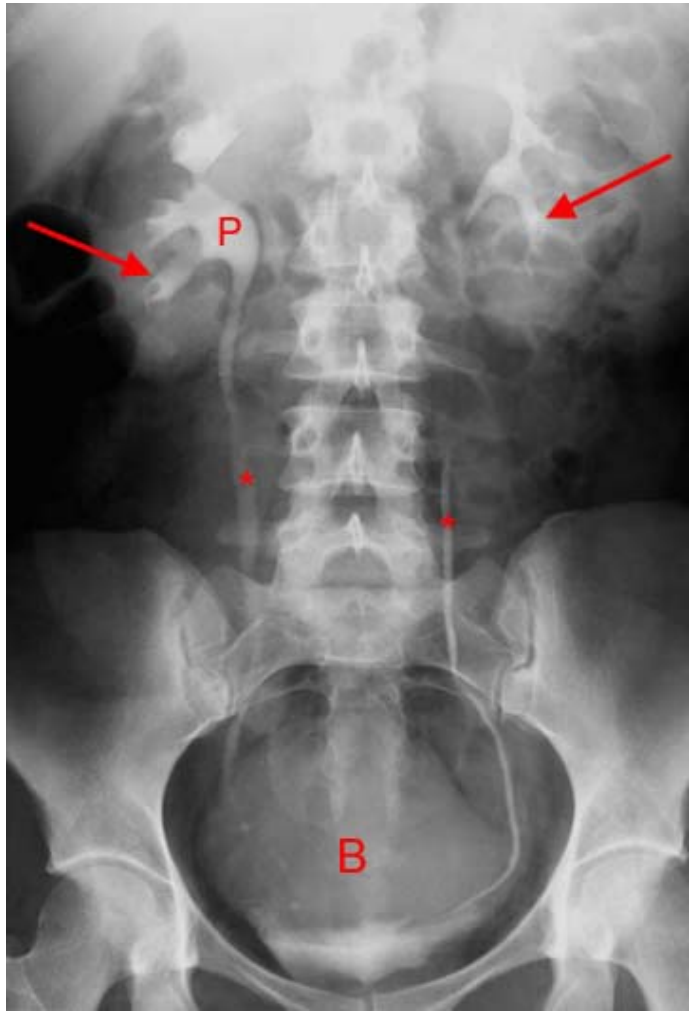


Kidneys

Site:

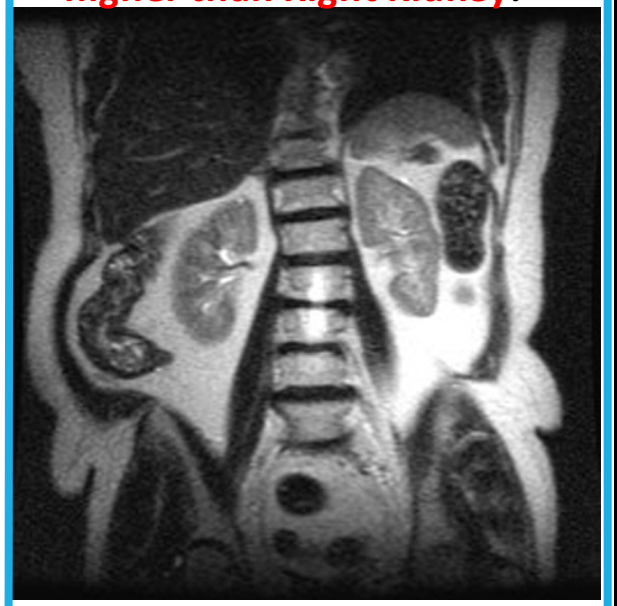
- On either side of the lower thoracic and upper lumbar spine.
- **Usual location**: between upper border of 11th thoracic vertebra and lower border of 3rd lumbar vertebra.
- In upright position the kidneys descend by 2 or 3 cm.
- Both kidneys **move with respiration**.
- Right kidney is 2 cm lower than the left kidney.
- Long axis of the kidneys is directed **downward and outward**, parallel to the lateral border of the **psoas muscles.**
- In lateral plane, the axis is directed downward and anteriorly.
- Lower pole is 2-3 cm anterior to the upper pole.

Kidneys are retroperitoneal organs and may be obscured by bowel loops

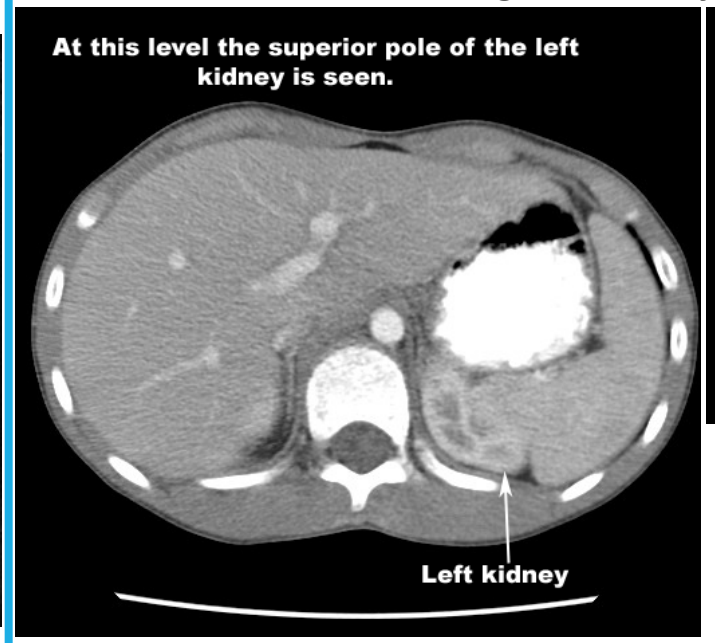


Kidneys (cont.)

MRI showing Left Kidney is higher than Right Kidney:



CT Scan showing left kidney higher than right:

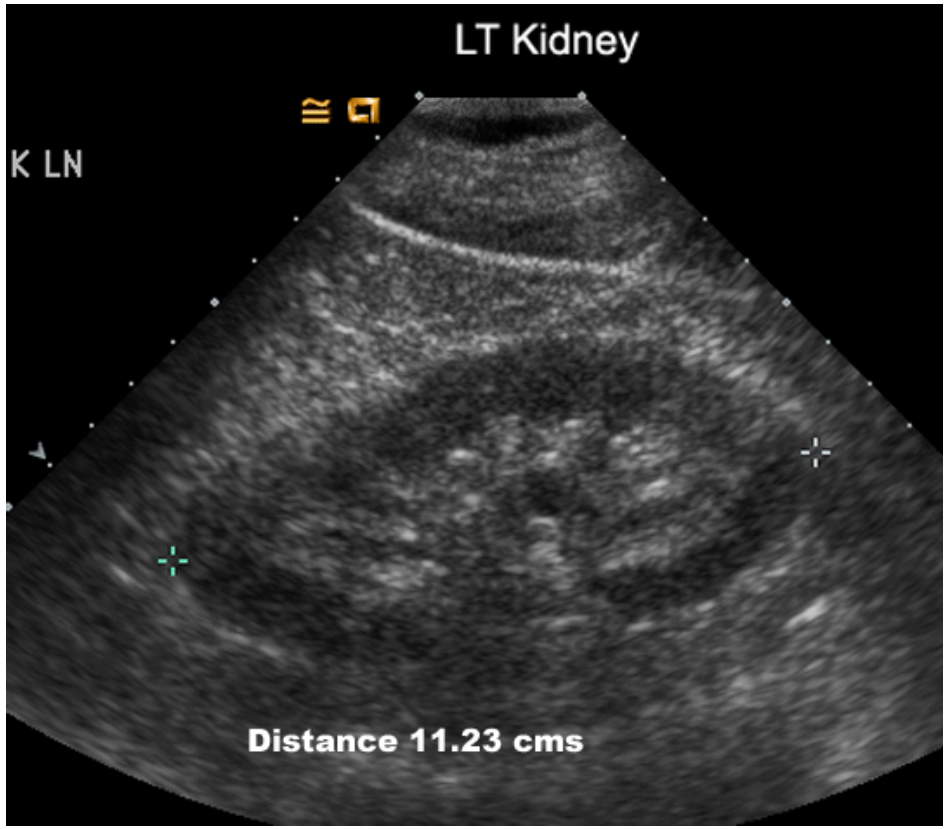


Long axis of the kidneys is directed downward and outward, parallel to the lateral border of the psoas muscles

Kidneys (cont.)

Size:

- Normal size: in adults 11 cm.
- Right kidney is shorter than left kidney by not more than 1.5 cm.
- As a rule: the length of the kidney is 3.7 +/- 0.37 times the height of the 2nd lumbar vertebra measured on the same film using the posterior margin of the vertebral body.



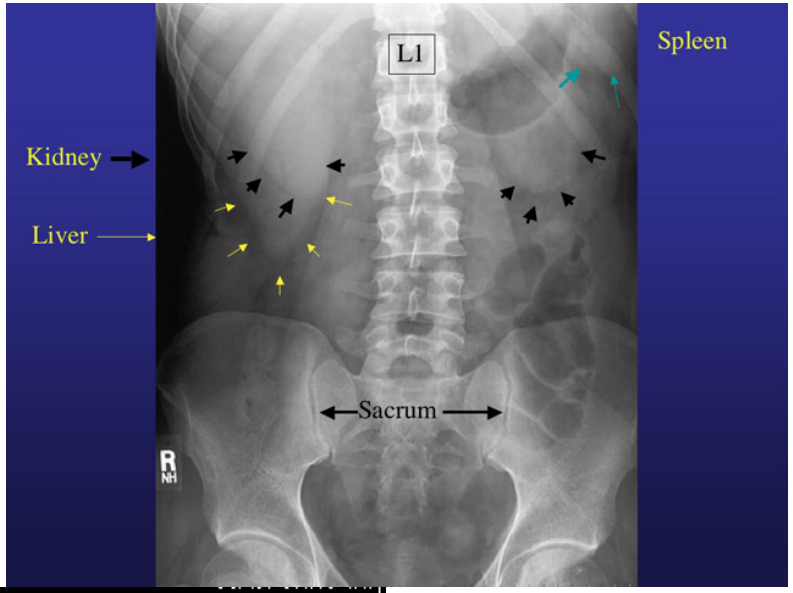
Ultrasound is the best method to measure the size of the Kidney

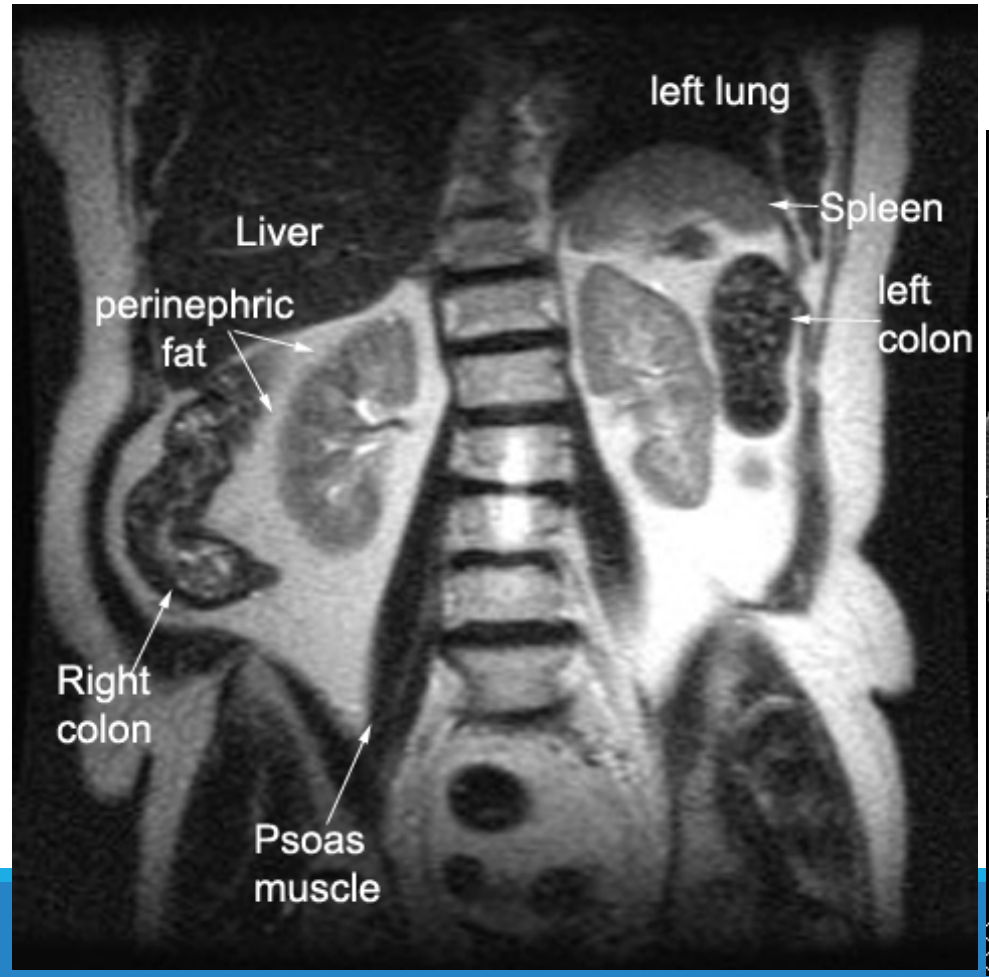
Shape:

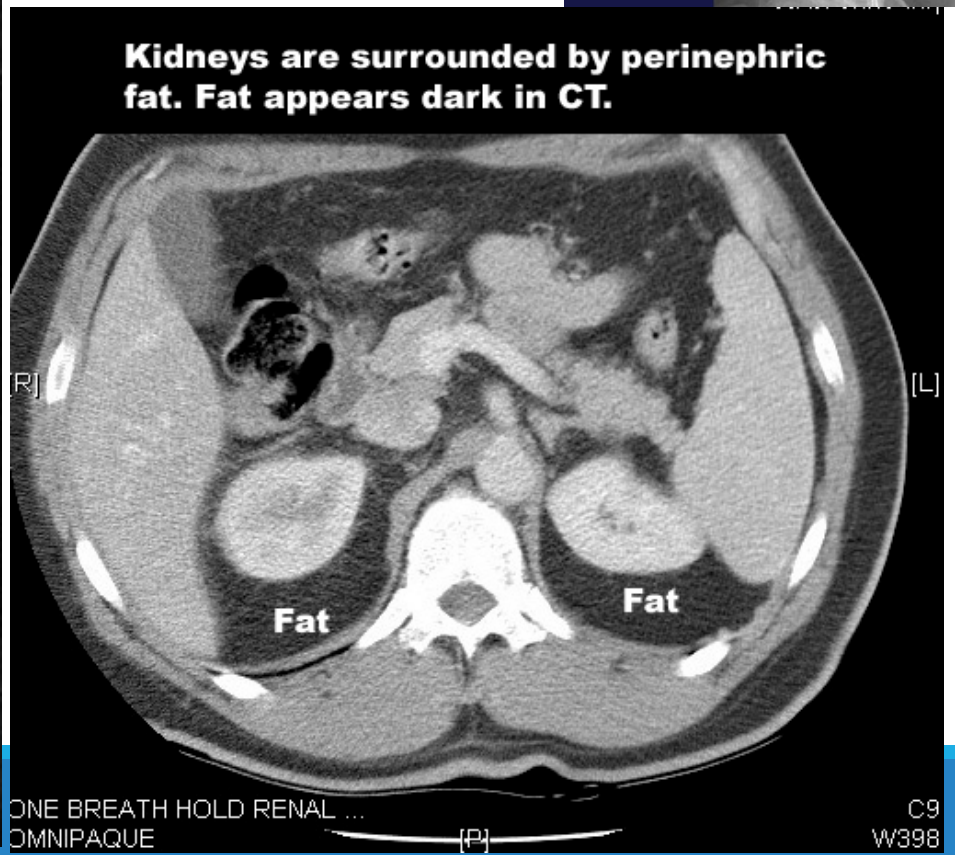
- **Bean shaped** structure.
- There may be **fetal lobulations** – present as notches on the lateral aspect of the kidneys.
- Local bulge or convexity may be seen along the lateral aspect of **left kidney** – called **dromedary hump**.
- This may be either due to impression of the spleen or fetal lobulation or both.

Kidneys (cont.)

- Kidneys are visualized on the X-Ray due to presence of **perirenal fat.**
- Kidneys are contained within the renal capsule and surrounded by perirenal fat and enclosed within the **Gerota's fascia.**
- Perirenal hemorrhage, pus and urine are contained within the fascia are detected on CT and Ultrasonography.
- A layer of **paranephric fat surrounds and cushions the kidneys**.

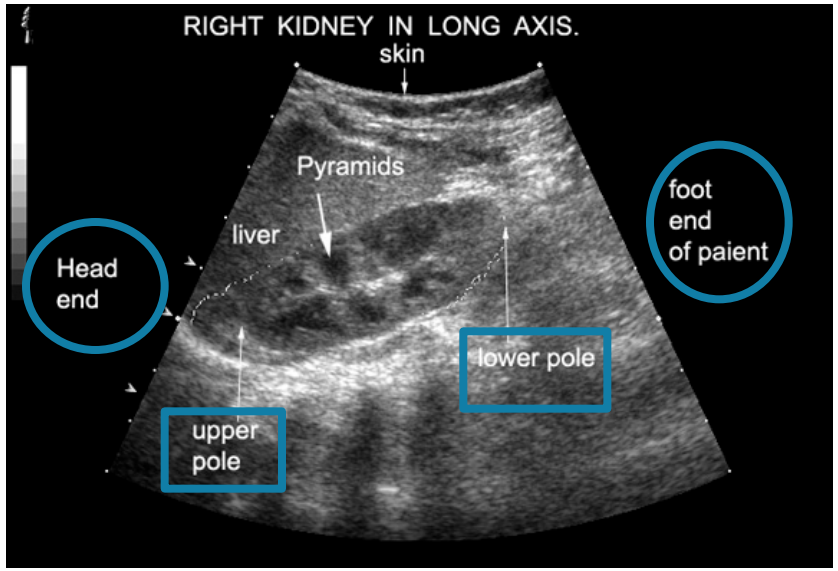


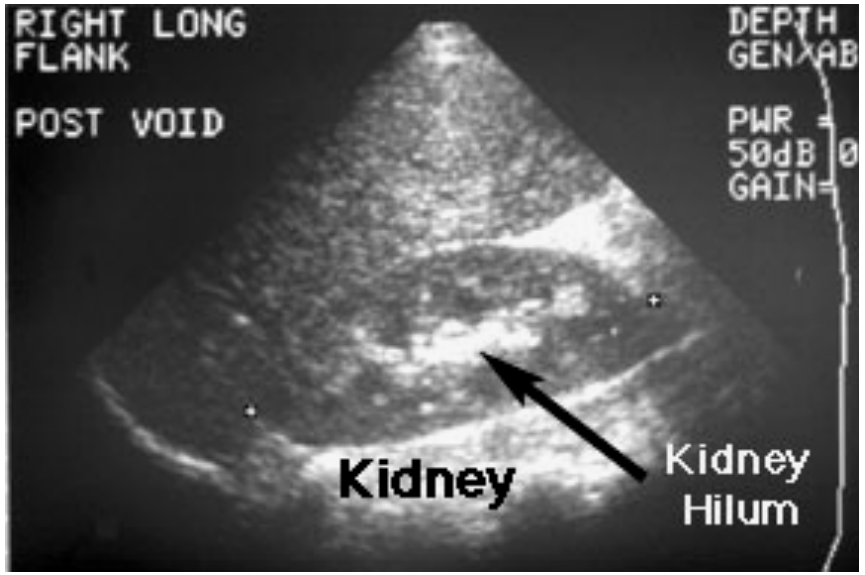


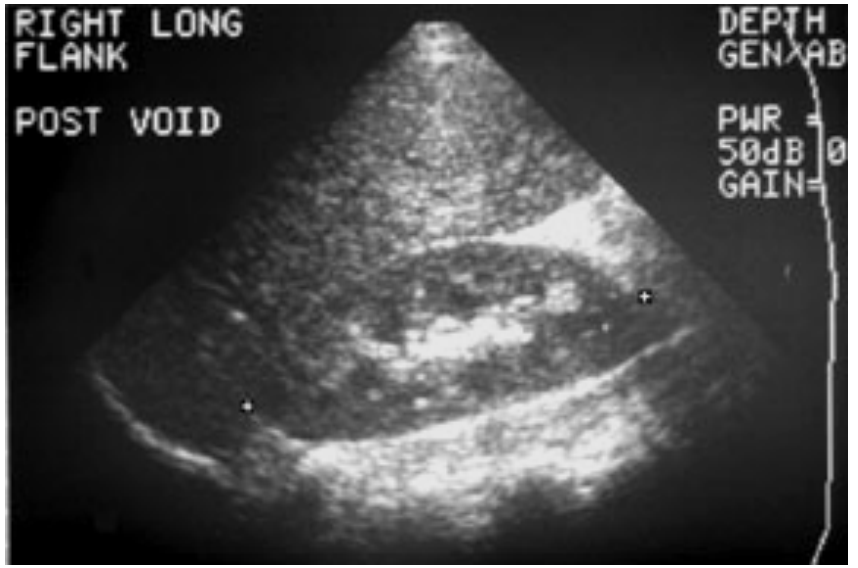


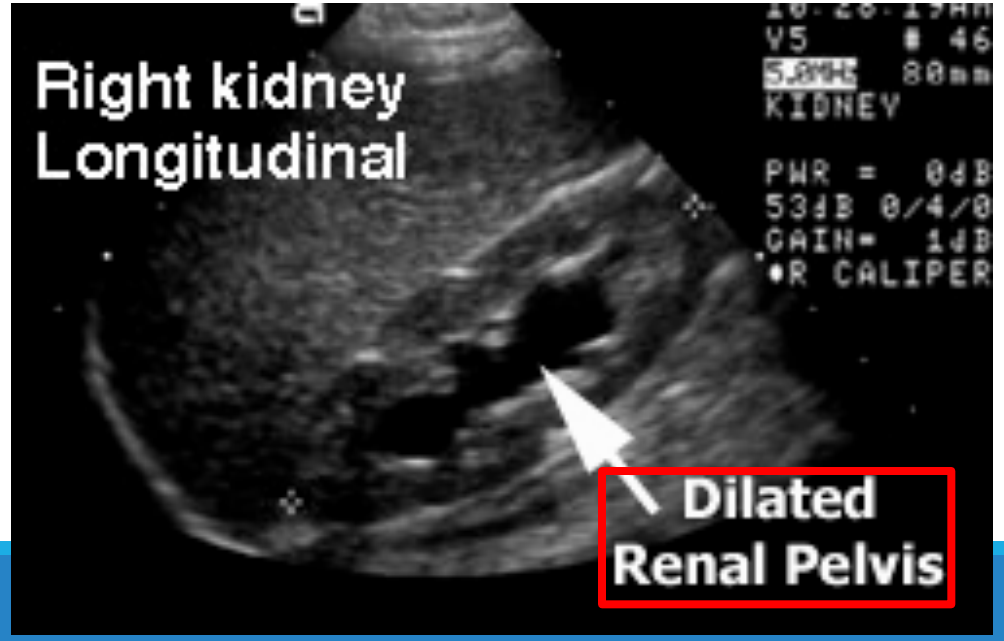
Kidneys (cont.)

Normal Ultrasound of Right Kidney:







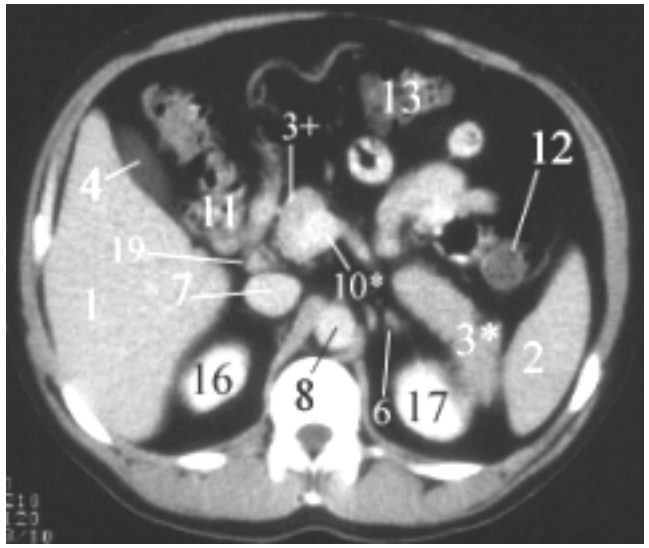


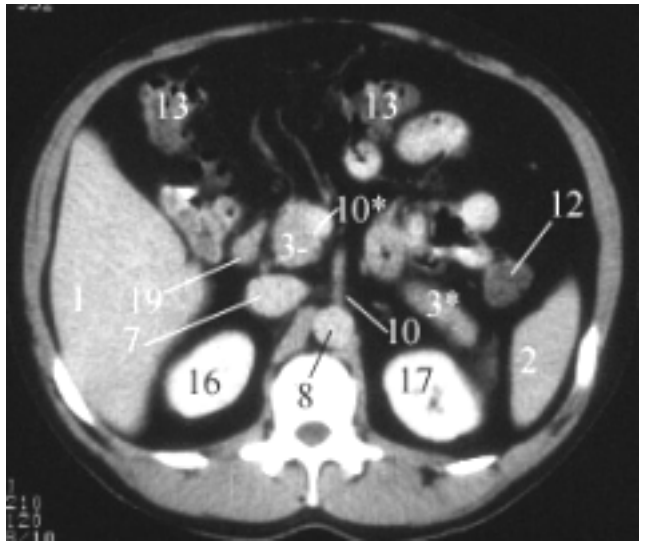
Due to presence of stones

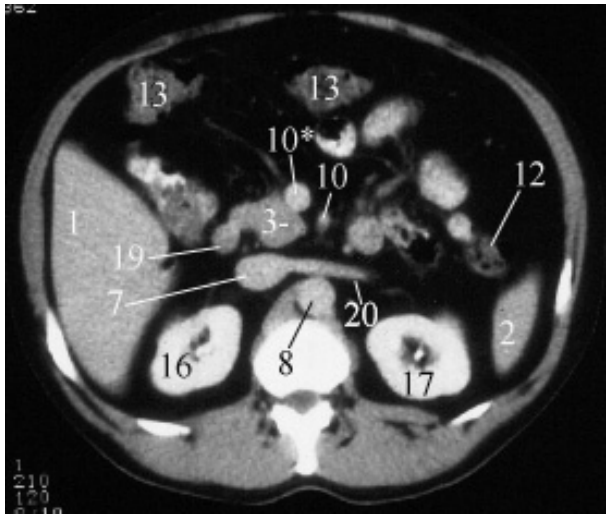
Kidneys (cont.)

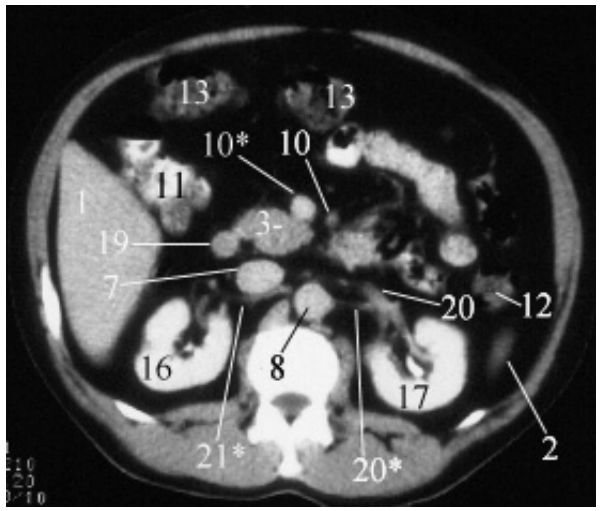
1- Liver.
2- Spleen.
3+ -Head of pancreas.or
3- -Uncinate process of the pancreas
3* -Body and tail of pancreas.
4- Gallbladder.
6- Left adrenal gland.
7- Inferior vena cava.
8- Aorta.
10- Superior mesenteric **artery.**
10*Superior mesenteric **Vain.**
11- Ascnding colon.
12- Descending colon
13- Transvers colon.
16- Right kidney.
17- Lift Kidney.
19- Duodenum, 2ed part.
20- Left renal vein
20*- Left renal artery.
21*- Right renal artery
21- Right renal vein
22-Small intestine.

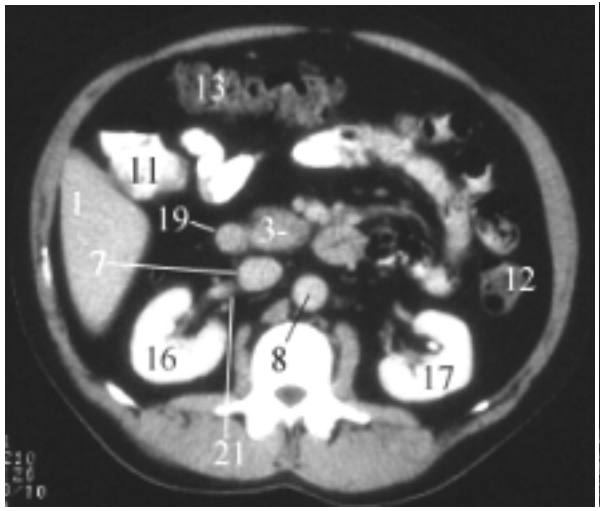
Normal CT of Kidney:

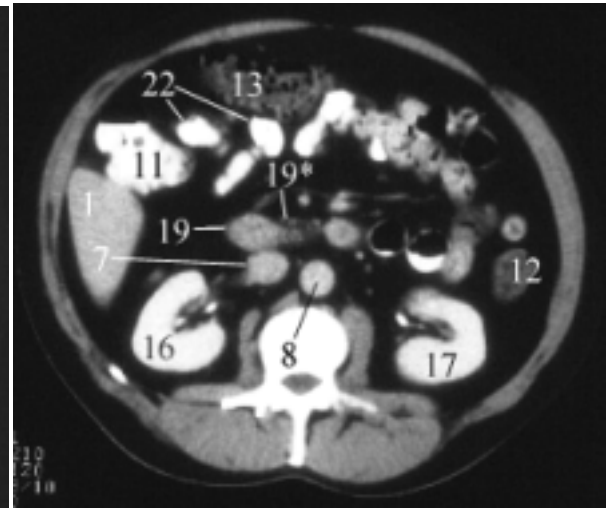












Spaces Around the Kidney:

- **Perirenal Space:**
  - Bounded by: the leaves of the Gerota's fascia
  - The leaves fuse superiorly, laterally and medially It encloses the kidneys, adrenal glands, renal vasculature and proximal ureter .
- The fascial envelope is functionally open caudally just above the pelvic brim.
- Ureter emerges from the perirenal space and traverses caudad in anterior pararenal space.

Anterior Pararenal Space:

Bounded by:

- Posteriorly: the anterior portion of the renal fascia
- Anteriorly: the posterior parietal peritoneum
- Laterally: the lateral conal fascia
- Contains: pancreas, 2nd,3rd and 4th portions of the duodenum, ascending and descending colon, vascular supply to the spleen, liver, pancreas and duodenum

Posterior Pararenal Space:

Bounded by:

- Posteriorly: the transversalis fascia
- Anteriorly: the posterior portion of Gerota's fascia
- Contains: only fat, scattered vessels and nerves

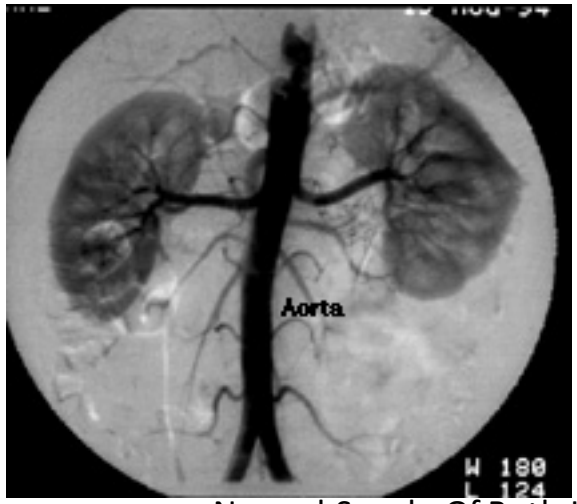
- All three spaces potentially communicate at the pelvic brim

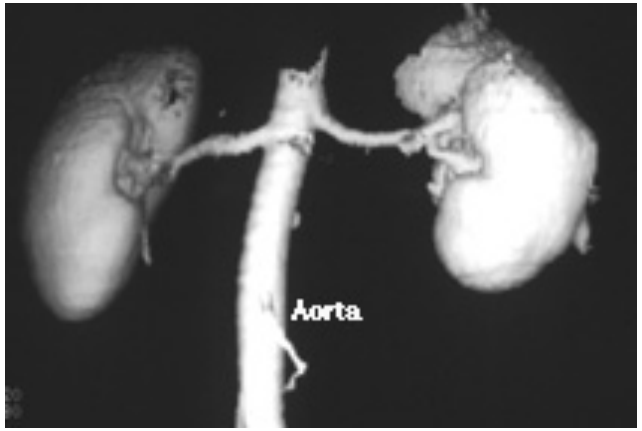
Renal Vasculature:

- There are many variations of the renal vasculature.
- **Renal arteries** branch from the **abdominal aorta** laterally between L1 and L2, below the origin of the **superior mesenteric artery**.
- The **right renal artery passes posterior to the IVC**.
- There may be **more than one** renal artery (on one or both sides) in 20-30% cases .
- **Renal veins** drain into **inferior vena cava**.
- Renal veins lie anterior to the arteries.
- **Left renal vein** is **longer** and **passes anterior to the aorta** before draining into the inferior vena cava.
- **The left gonadal vein** will drain into to **left renal vein** while the **right gonadal vein** drains directly into the **inferior vena cava**.
- Common variants include retroaortic circumaortic left renal veins.

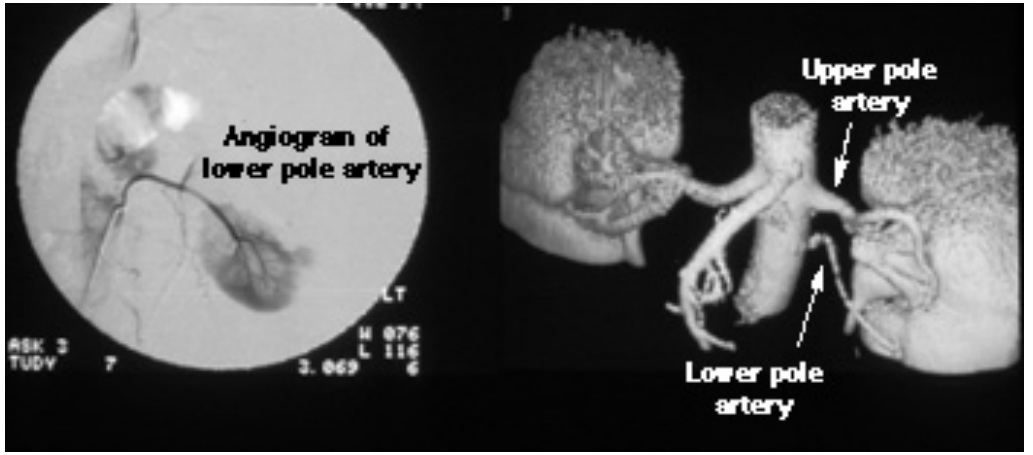
Kidneys (cont.)

Renal Angiography:

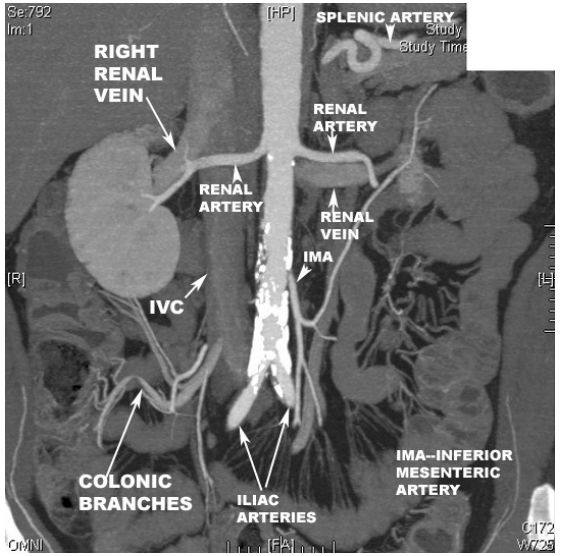




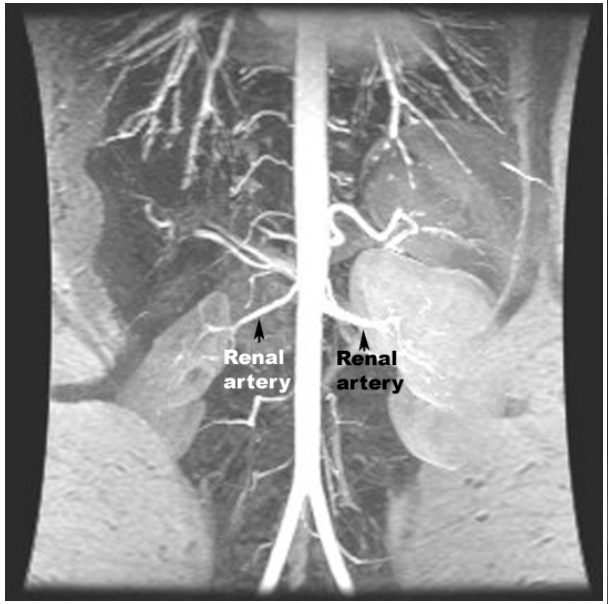
Normal Supply Of Both Kidneys By Single Renal Artery



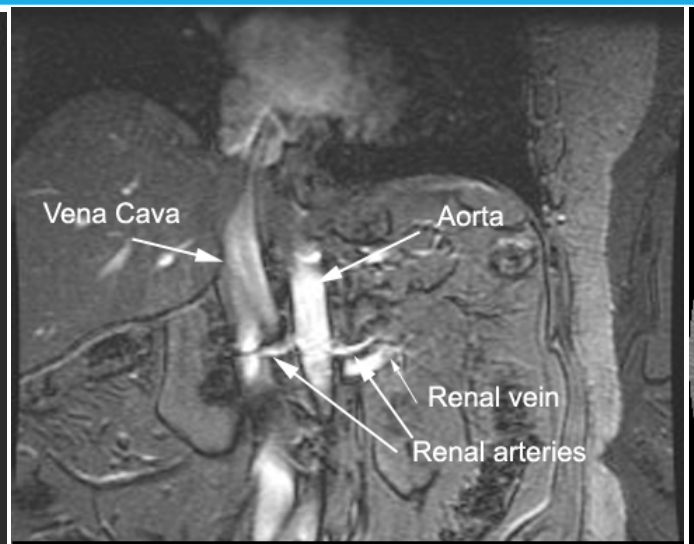
Left Kidney Supplied By Two Renal Arteries



Coronal CTA (Angio): Aorta calcified from Atherosclerosis

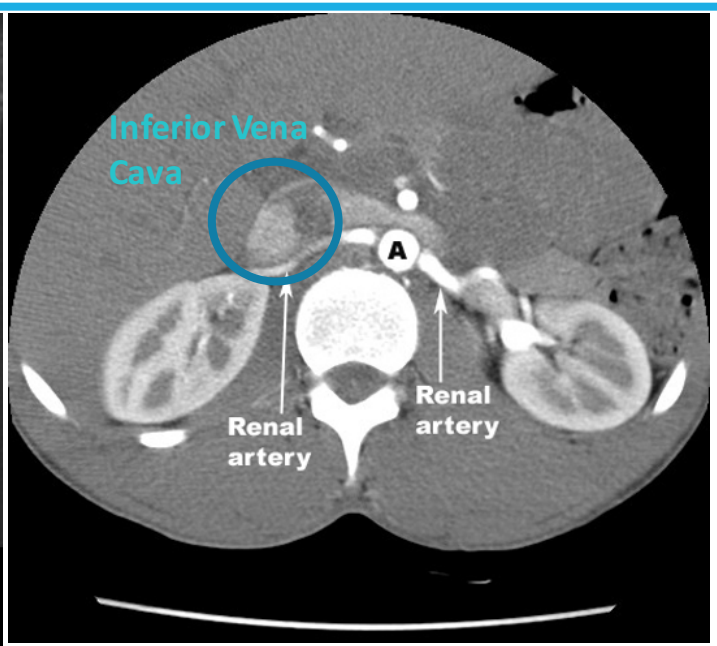


Coronal MRA (Angio)



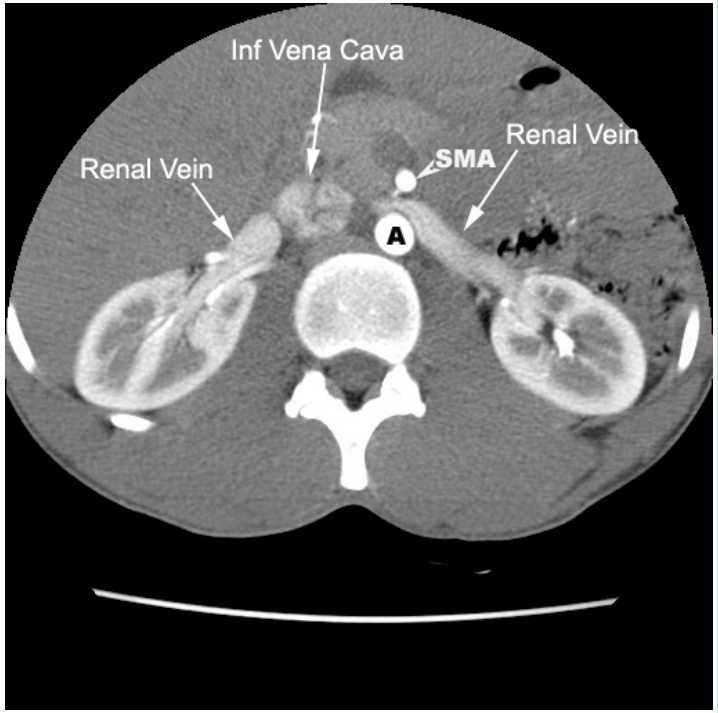
RENAL ARTERIES ARISE FROM THE AORTA. THERE MAY BE MORE THAN ONE RENAL ARTERY ON EACH SIDE. RIGHT RENAL ARTERY PASSES BEHIND THE INFERIOR VENACAVA TO REACH THE RIGHT KIDNEY.

Coronal MRA (Angio)

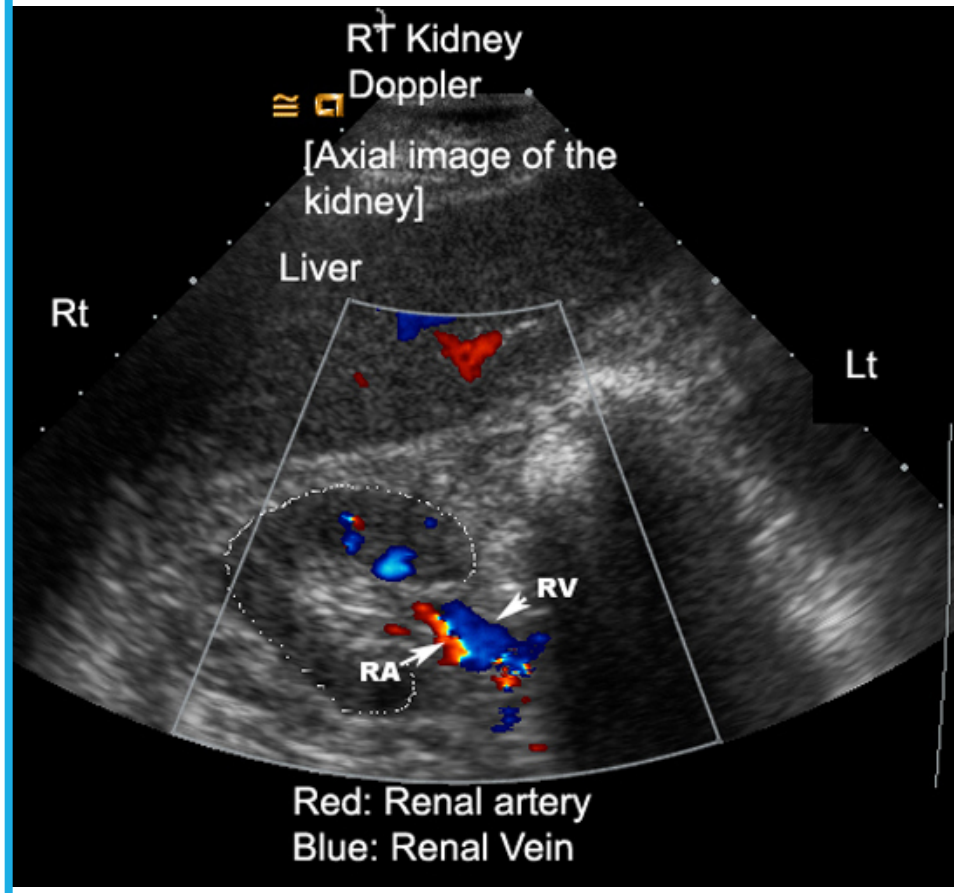


Transaxial CTA (Angio).

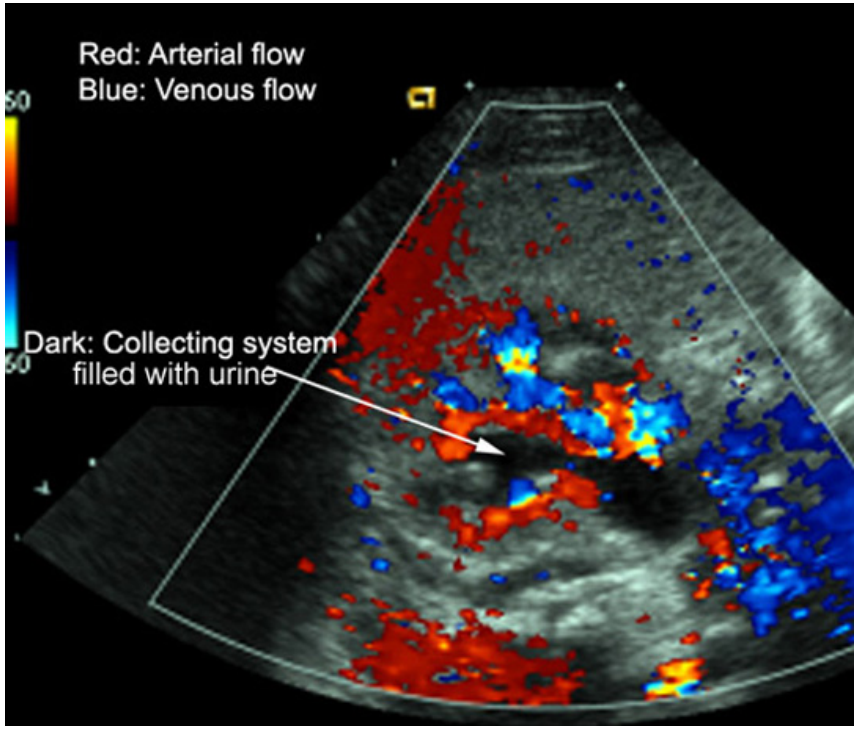
Renal Angiography:



Left renal vein passes anterior to the abdominal aorta

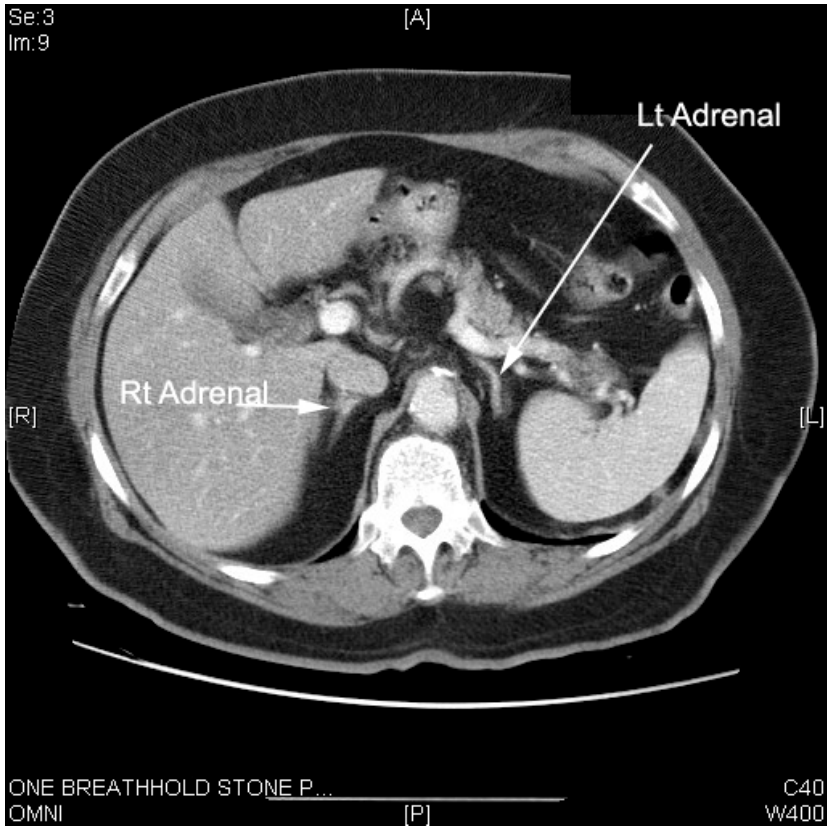


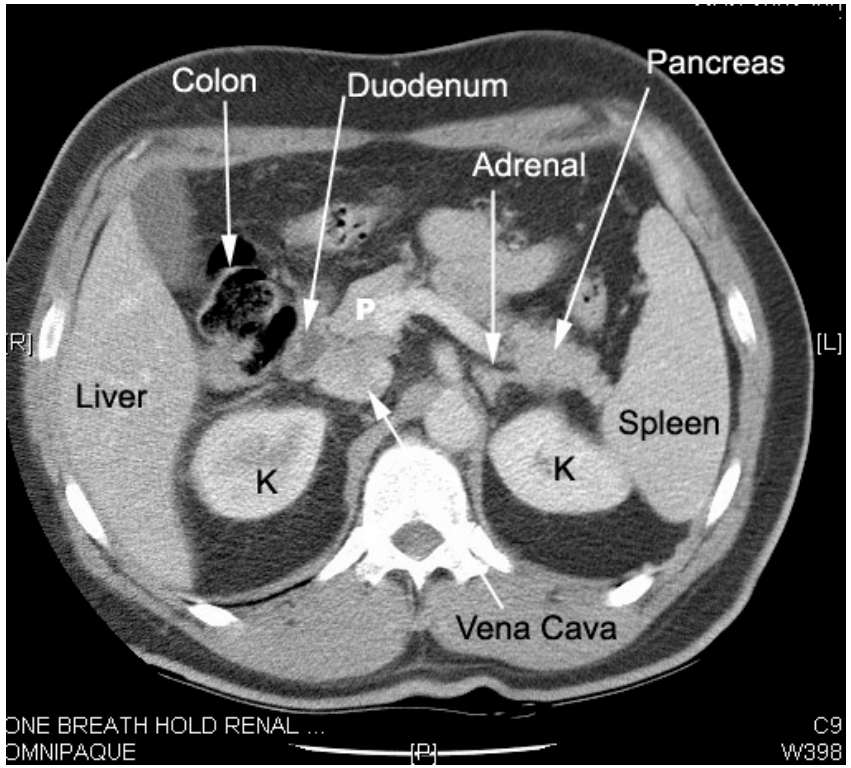
Renal veins lie anterior to the arteries

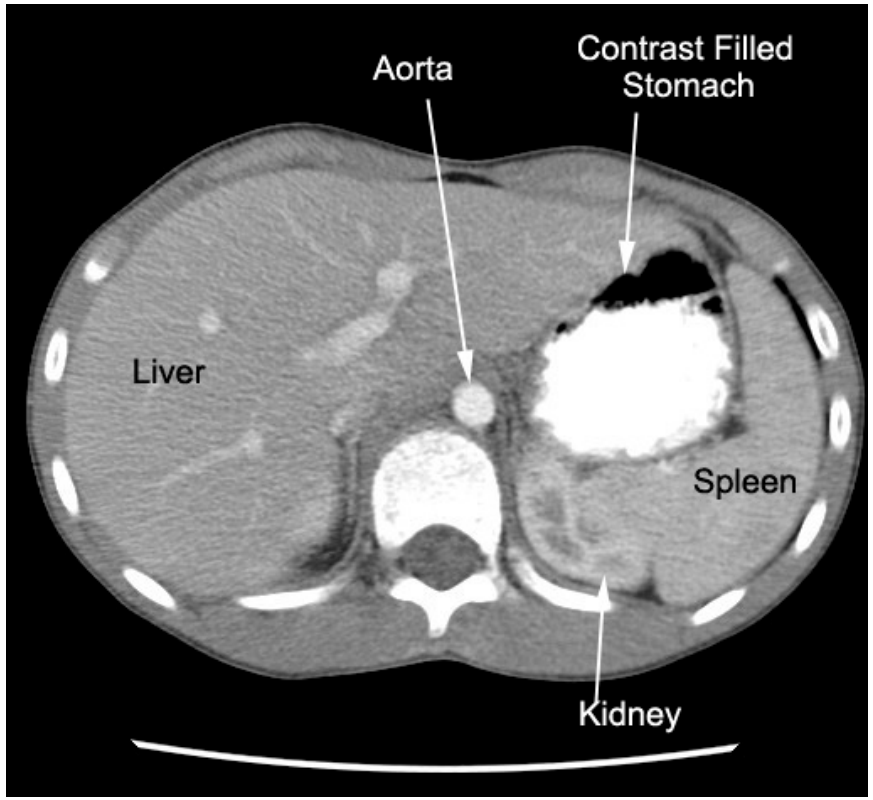


Ultrasound doppler show the renal vessels flow and it is good for evaluating the artery stenosis

Relationships of the Kidneys:







Adrenal Glands are superior to the Kidneys

Renal Structure:

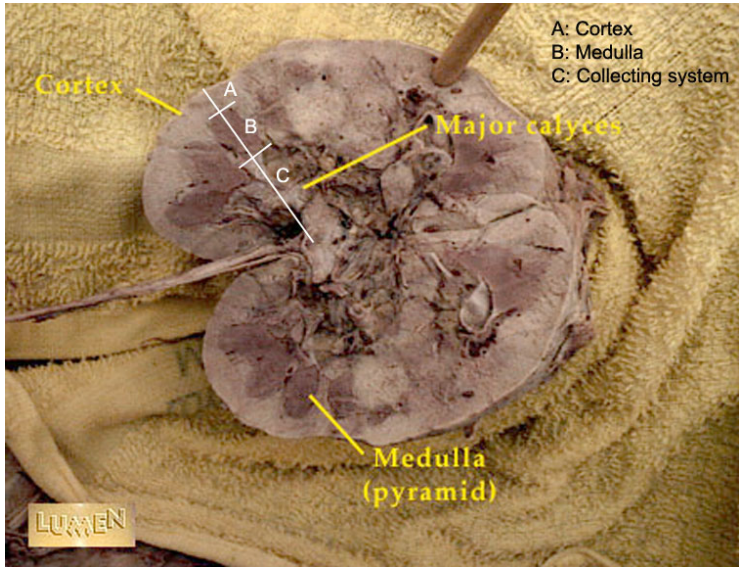
1-Thin capsule

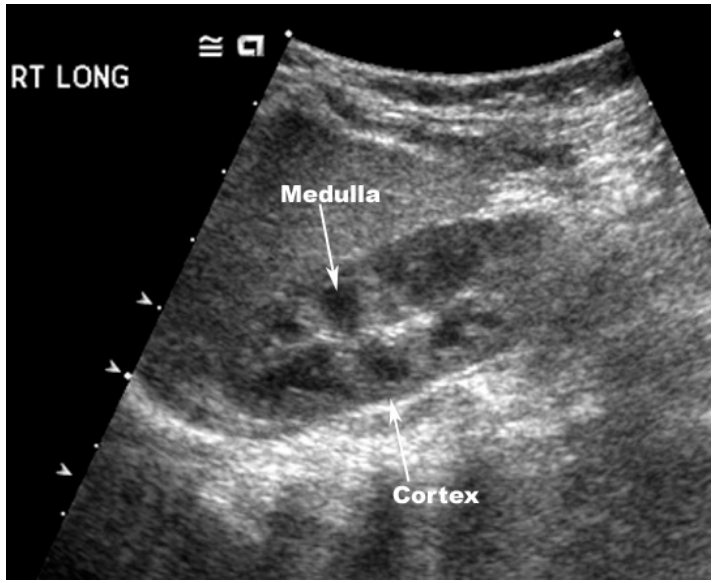
2-Renal cortex

Renal cortex consists of glomeruli and renal tubules
Normal thickness is 2.5 cms

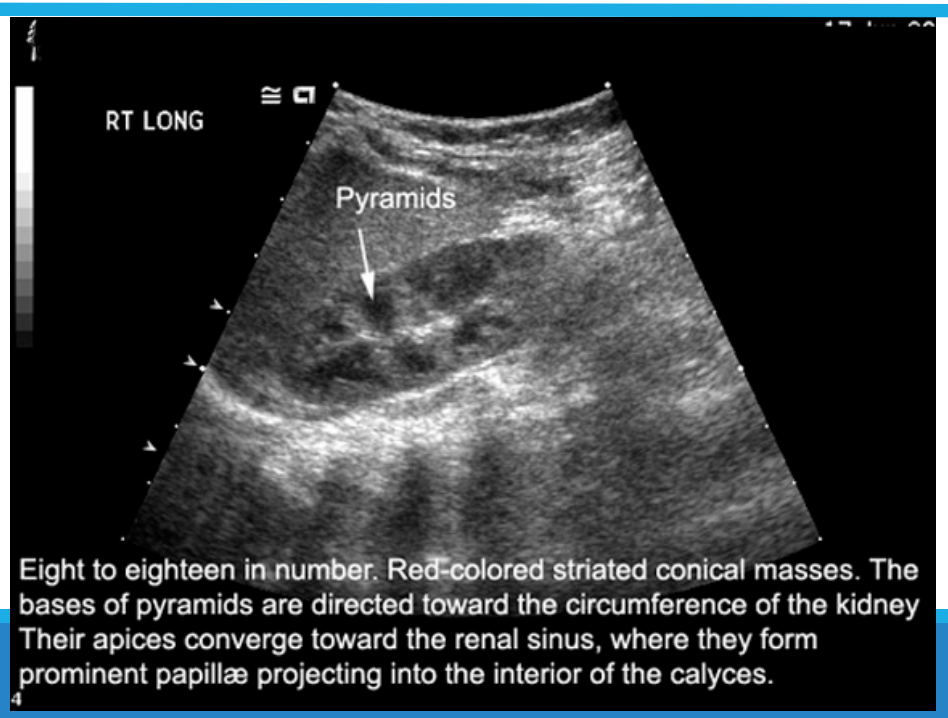
3-Renal Medulla

Consists of multiple renal pyramids which have their base to the periphery and their conical end directed towards the renal hilum
Their tips are called papillae
Each minor calyx receives 1-3 papillae





Ultrasound of Right Kidney



MRI of Kidneys (shows cortex)

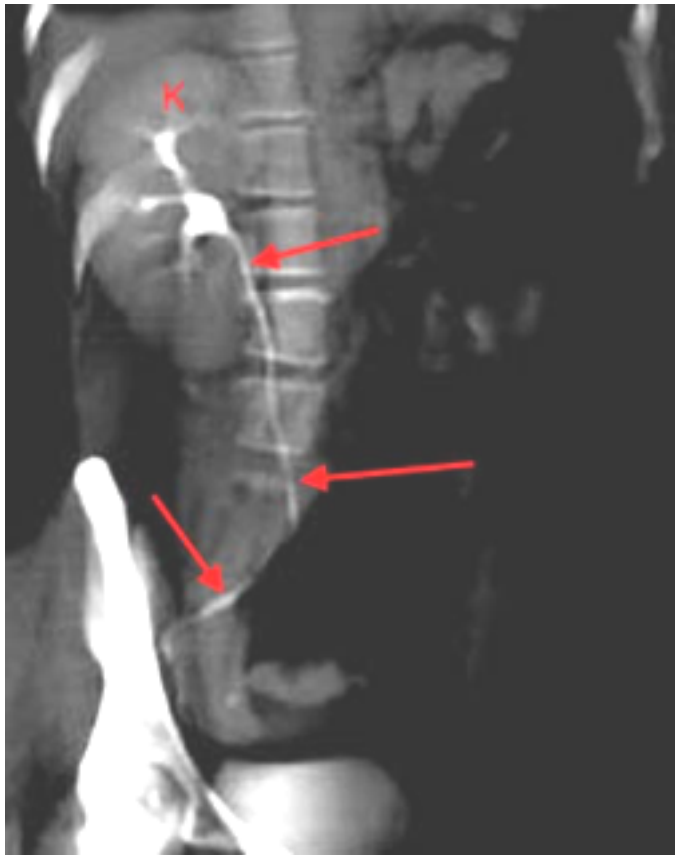
Renal Structure:

Contrast enhanced CT scan through the kidneys in nephrogram phase (showing corticomedullary differentiation)

This is approximately 100 seconds following contrast administration and would show renal lesions well

Contrast enhanced CT scan through the kidneys in pyelogram phase (showing excretion of contrast into the collecting system)

This is approximately 8 minutes following contrast administration and would show urothelial lesions well, such as transitional cell carcinoma, stones, blood clot



3D reconstructed image from CT scan of the abdomen and pelvis known as CT IVP.

This exam is quickly replacing the conventional IV Urogram

3D reconstruction is performed through the right kidney (K) and follows the normal ureter (arrows) all the way to the ureter's insertion into the bladder

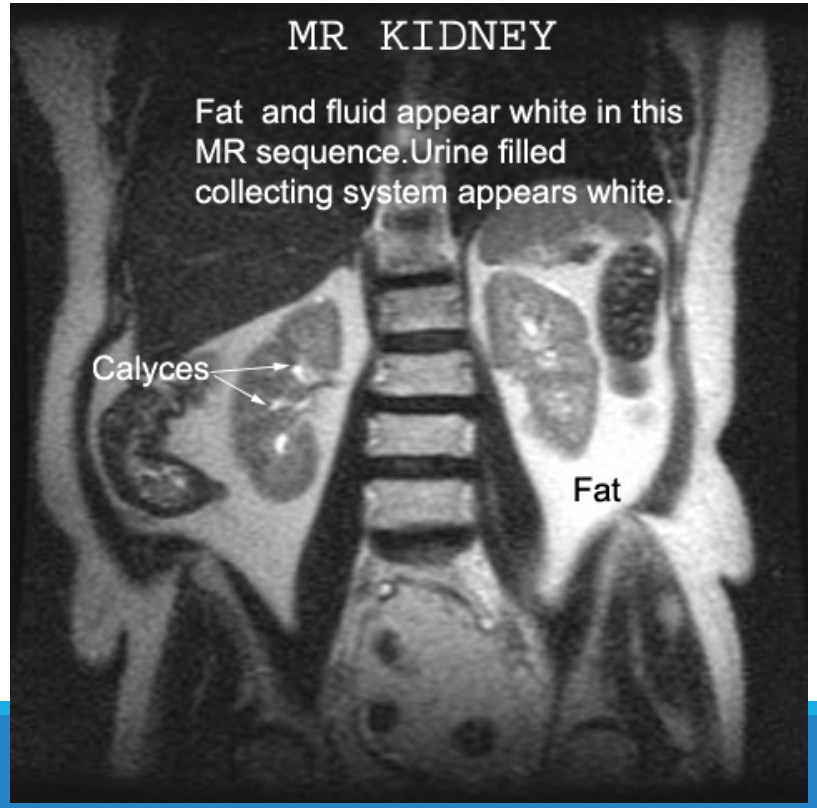
Renal Collecting System :

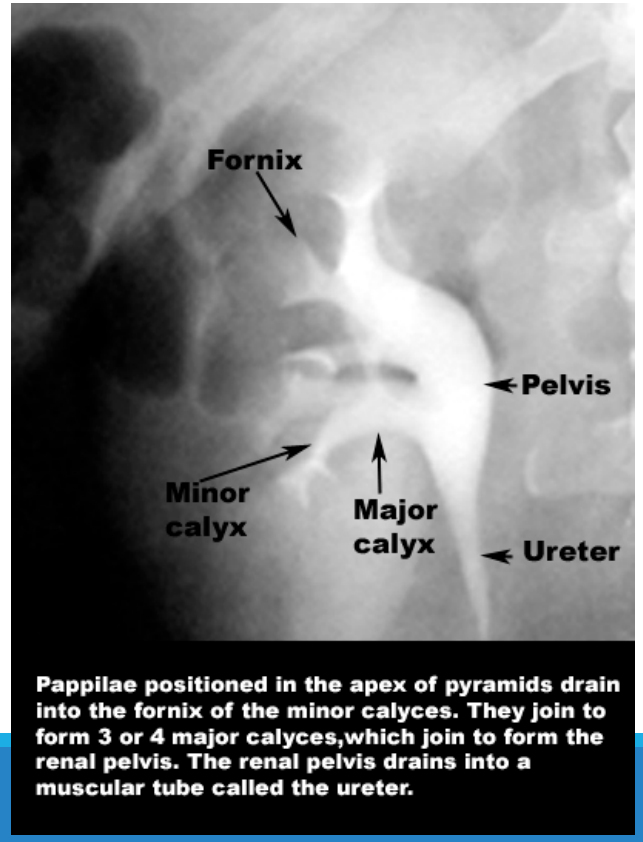
Calyces:

- Medulla sits in the fornix of the minor calyx
- Fornix is sharp and concave
- Papillae drain into minor calyces
- Minor calyces coalesce to form 3 or 4 major calyces
- Major calyces combine to form the pelvis

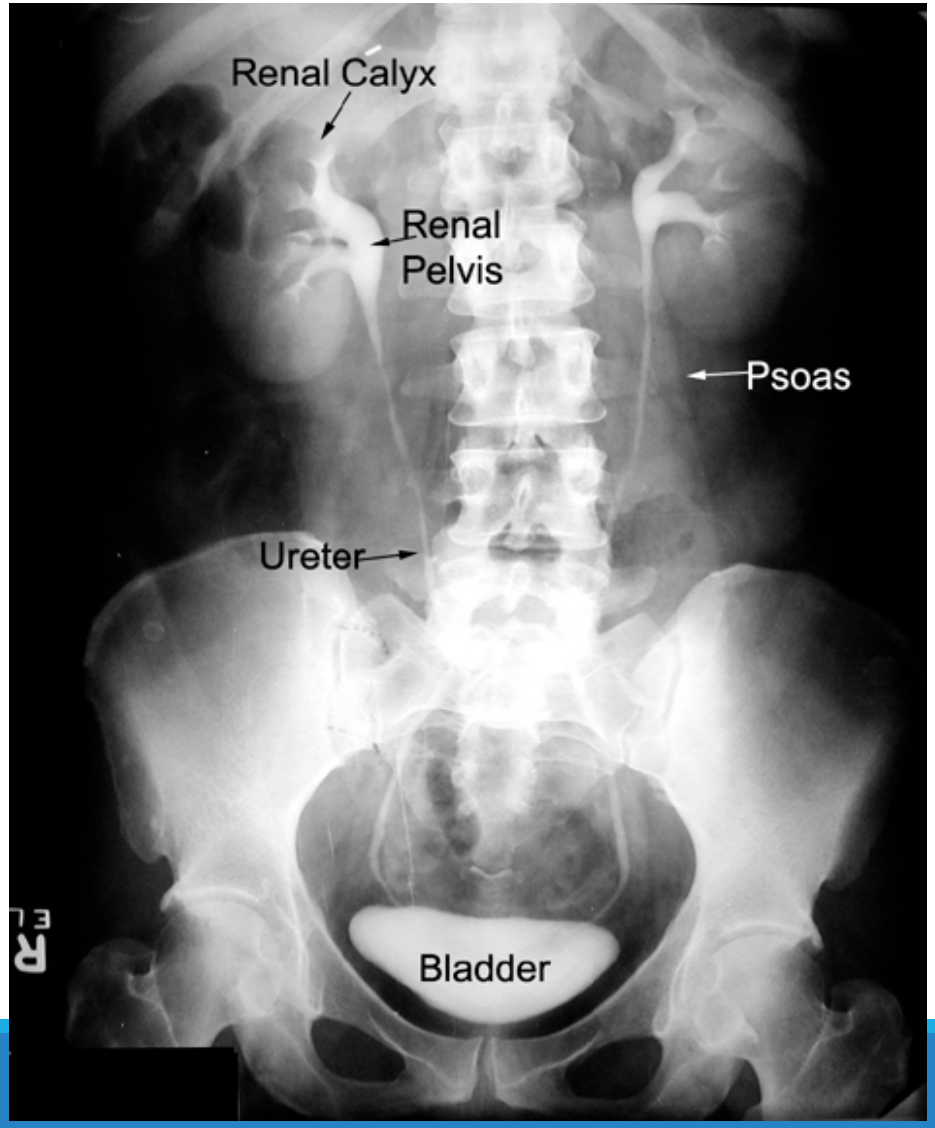
Pelvis:

- Broad dilated part of the urine collecting system, located in the hilum
- Renal pelvis drains into the ureter





Pappilae positioned in the apex of pyramids drain into the fornix of the minor calyces. They join to form 3 or 4 major calyces,which join to form the renal pelvis. The renal pelvis drains into a muscular tube called the ureter.



Ureters

About Ureter:

- 25-30 cm in length and 3 mm diameter
- Course downwards from the most dependent portion of the pelvis to the midscale region
- Then turn posterolateral and course in an arc downwards
- Then inward and anteriorly to enter the trigon of the bladder on either side of the midline

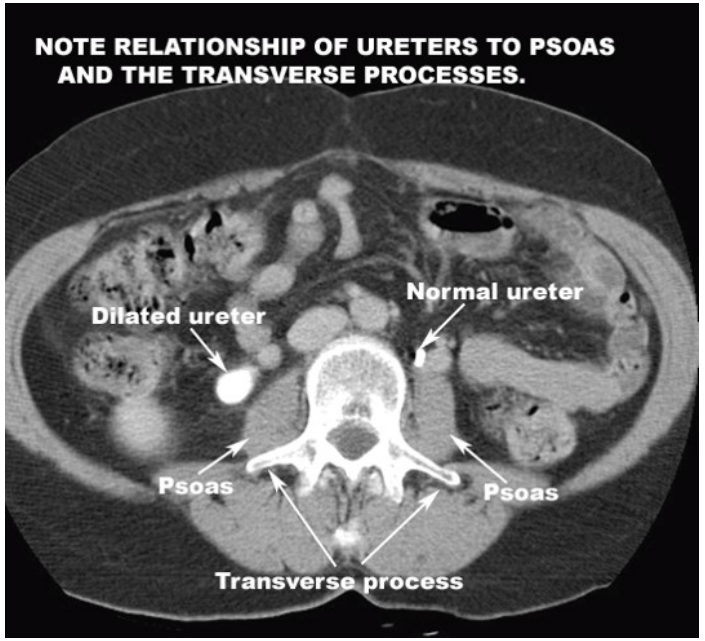
Areas of Narrowing: MCQ's

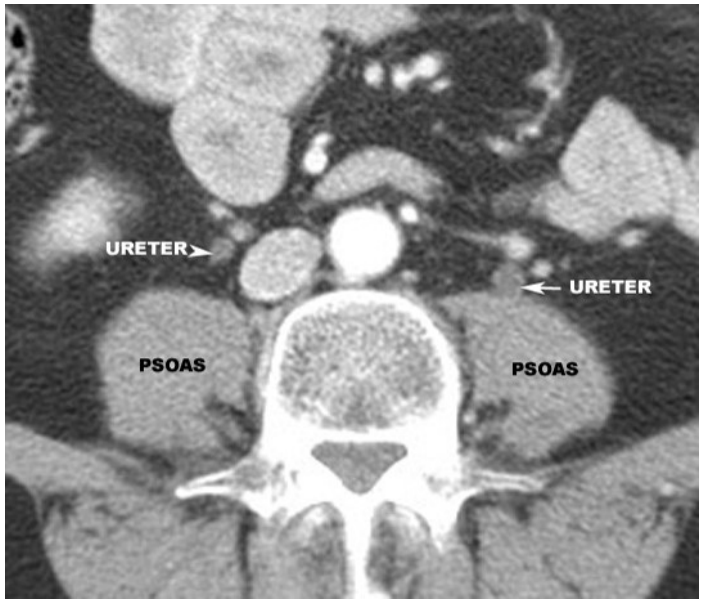
Three areas of normal narrowing:

- Ureteropelvic Junction
- Bifurcation of the iliac vessels
- Uretervesicle Junction

Ureteral Vasculature

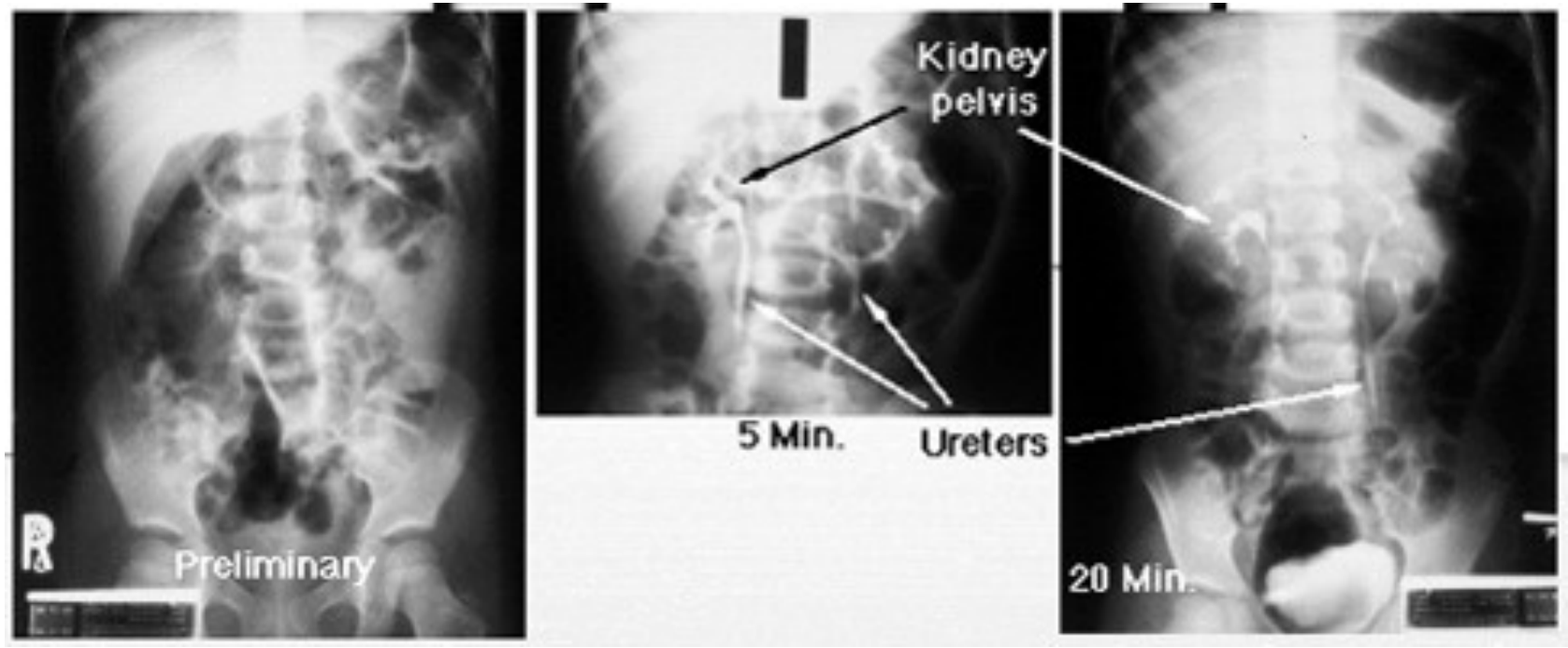
- Blood is supplied by the ureteral branches of renal and testicular or ovarian arteries, and abdominal aorta
- Renal and testicular or ovarian veins supply venous drainage





Ureters (cont.)

Intravenous Pyelogram:



Intravenous pyelogram (Normal) Not used this days and CT is the alternative.

Urinary Bladder

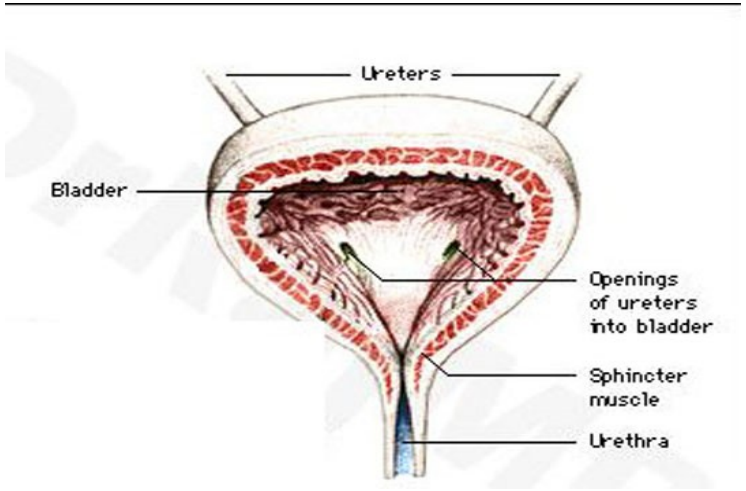
- Hollow muscular vesicle for storing urine temporarily.
- Bladder is higher in position in children and slightly higher in males than females.
- It is relatively larger in children than in adults.

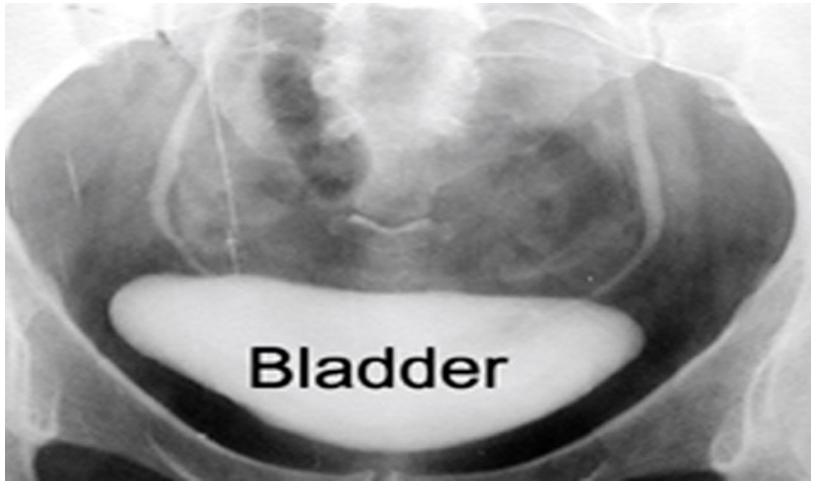
Size and shape:

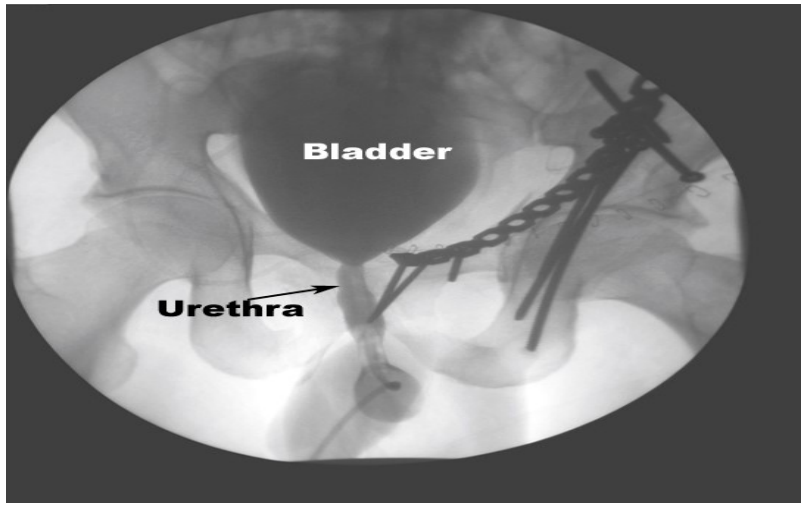
- Size and shape vary considerably.
- Shape: tetrahedral when empty, transversely oval or round when full.
- When empty, it is completely within the pelvis.
- Inferior aspect projects 5-10 mm above the symphysis pubis.
- Separated from pubic bones by retropubic space.
- Floor is parallel to superior aspect of the pubic rami.
- Dome is rounded in male and flat or slightly concave in female.

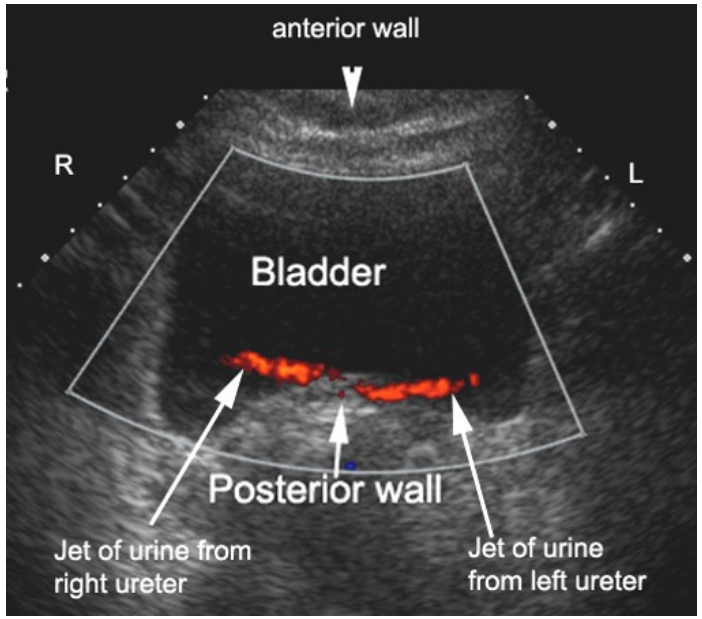
Neck of bladder

- lies 3-4 cm behind lower part of symphysis pubis and rests on the prostate in the male.
- It has the urethral orifice.
- **In females:** the peritoneum is reflected from the superior surface of the bladder to the anterior wall of the uterus at the junction between the body and cervix.
- The enclosed space is the **vesicouterine pouch.**
- **In males**: the peritoneum is reflected from the bladder to the superior surfaces of the ductus deferens and seminal vesicles.
- Bladder is relatively free to move except at the neck which is fixed by the puboprostatic ligaments (males) and pubovesicle ligaments (females).
- **Peritoneal reflection**: **Rectovesicle pouch** in males and **vesicouterine and rectouterine pouch** in females.

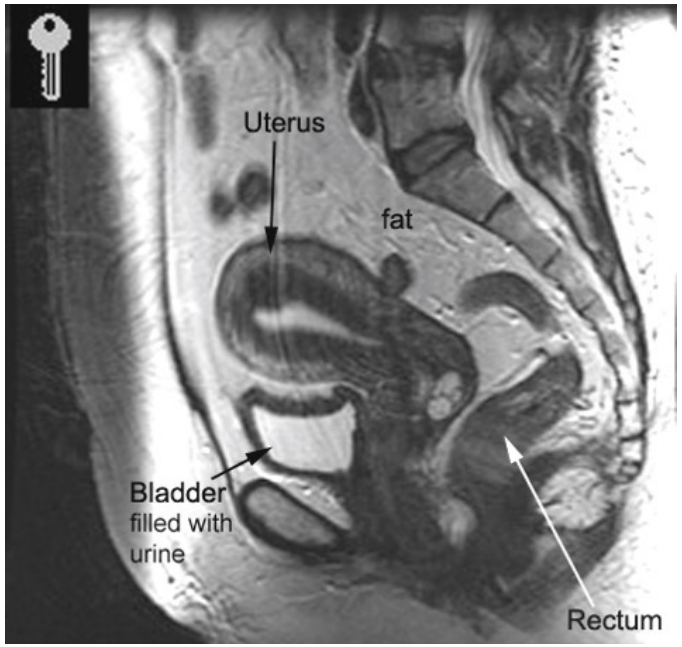


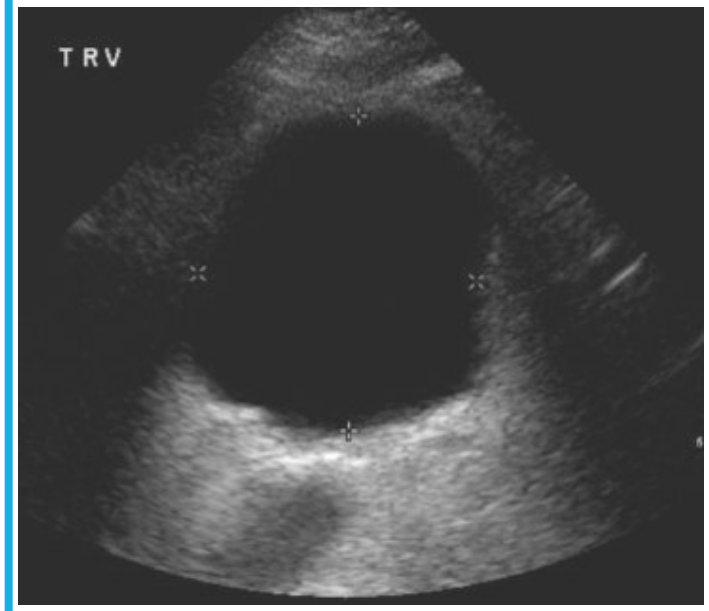






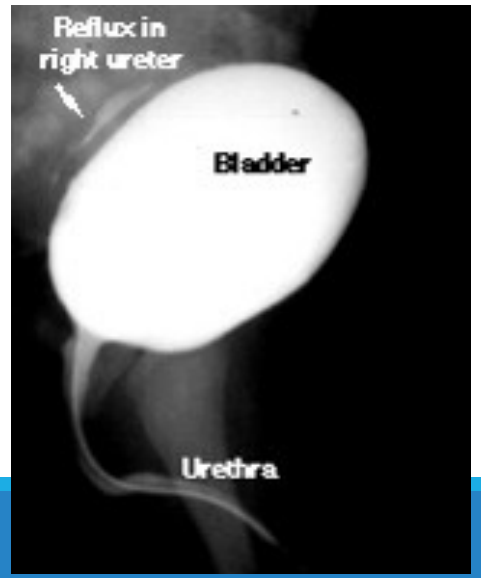
Sagittal MRI of female pelvis



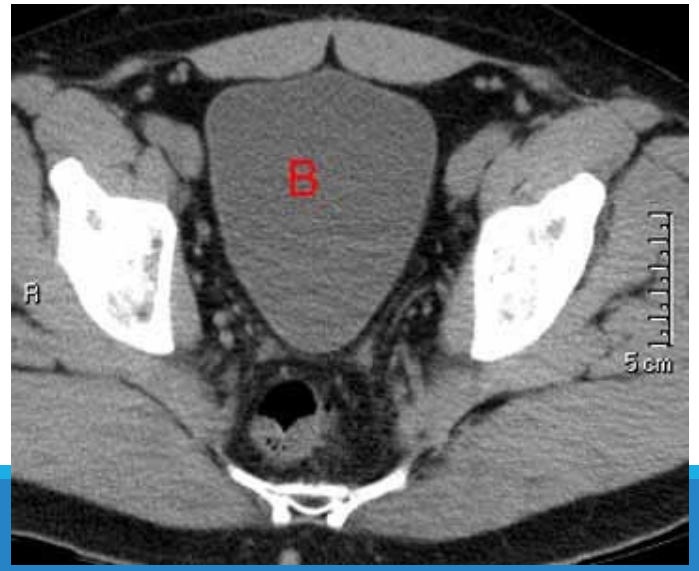


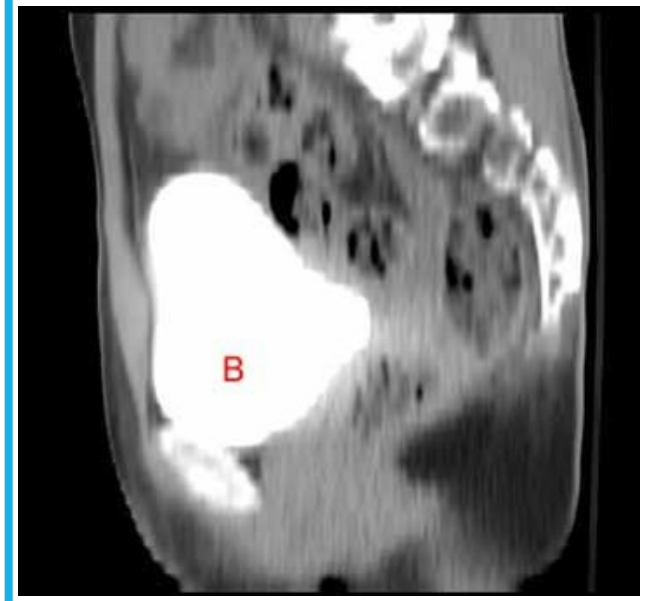
Transverse image through a normal bladder (callipers "x" and "+" outline the bladder wall) using ultrasound shows normal anechoic structure (anechoic = no echoes = black) Black means fluid

Voiding Cystourethrogram Inject the contrast into the bladder then ask Pt to urinate.



Unenhanced CT scan through a normal bladder (B) shows a normal fluid density structure (less than 10 Hounsfield units on CT density scale)





3D reconstructed image of a normal bladder in the sagittal plane following CT IVP

This is delayed image 10 minutes following IV contrast administration, excreted contrast fills an otherwise normal bladder (B)

Prostate Gland

- Largest accessory gland of male reproductive system.
- Partly glandular and partly fibromuscular.
- Lies around the first part of the urethra at the base of the bladder .
- (Tr) 4 cm x 3 cm (height) x 2 cm (AP) in size .
- Lies behind the symphysis pelvis .
- Surrounded by dense fibrous capsule.
- Enclosed within a loose sheath derived from the pelvic fascia called the prostatic sheath.

Parts:

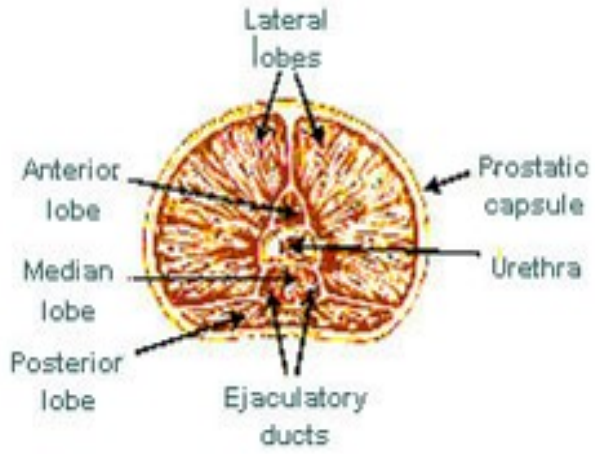
Base
Apex
Four surfaces

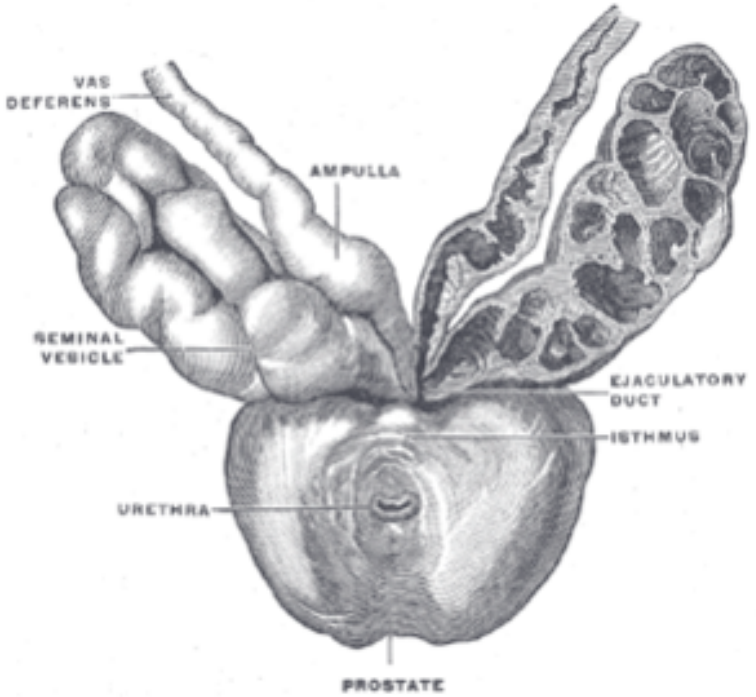
Base closely related to neck of bladder
Urethra enters the base in the middle near its anterior surface
Apex is related to urogenital diaphragm

Posterior surface
Anterior surface
Anterolateral surfaces

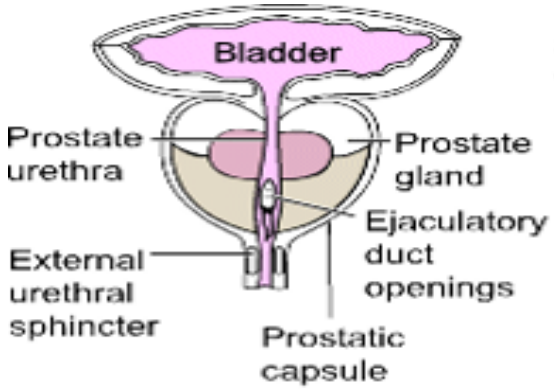
Prostate gland can be divided into:

- An inner gland transition zone.
- An outer gland central and peripheral zones.
- Transition zone which lies in periurethral location is the site of benign prostate hypertrophy which can occlude the urethra.
- Peripheral and central zones lie posterior and lateral to the transition zone.
- Peripheral zone is the primary tumor site in 70% patients.

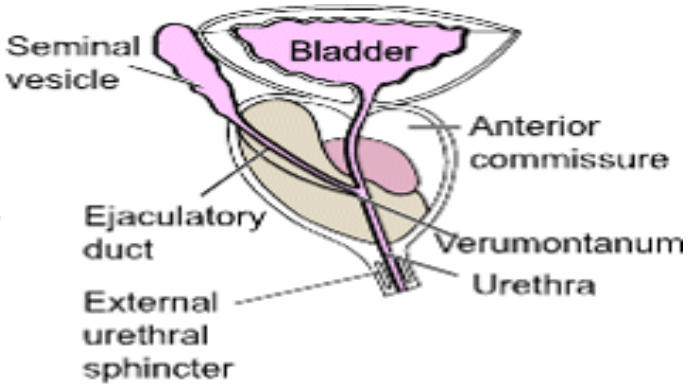




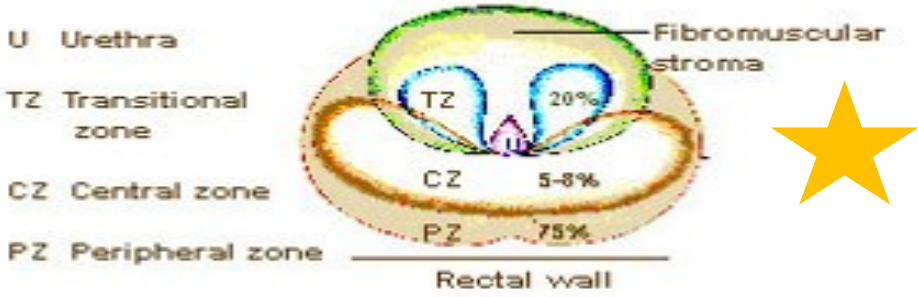
Prostate Gland(cont.)



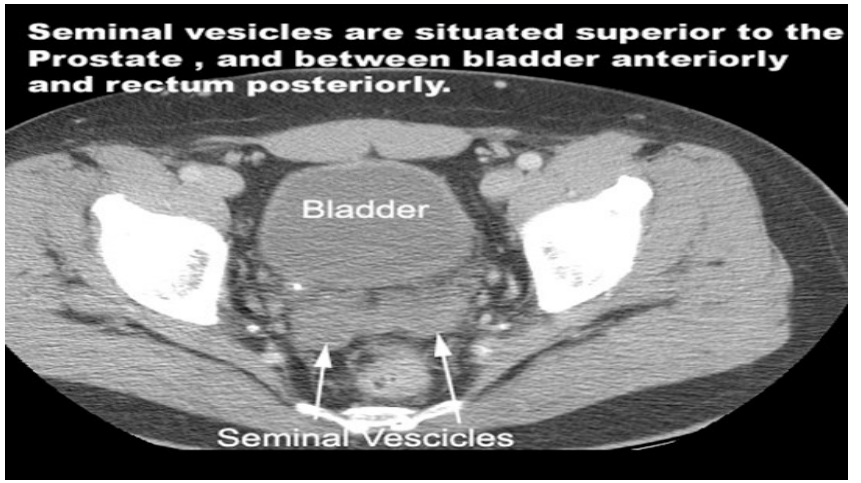
Frontal view of normal prostate

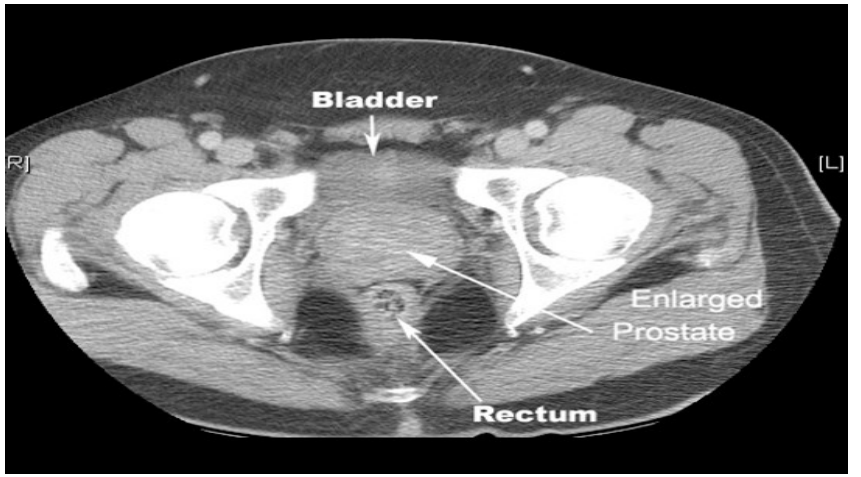


Saggital view of normal

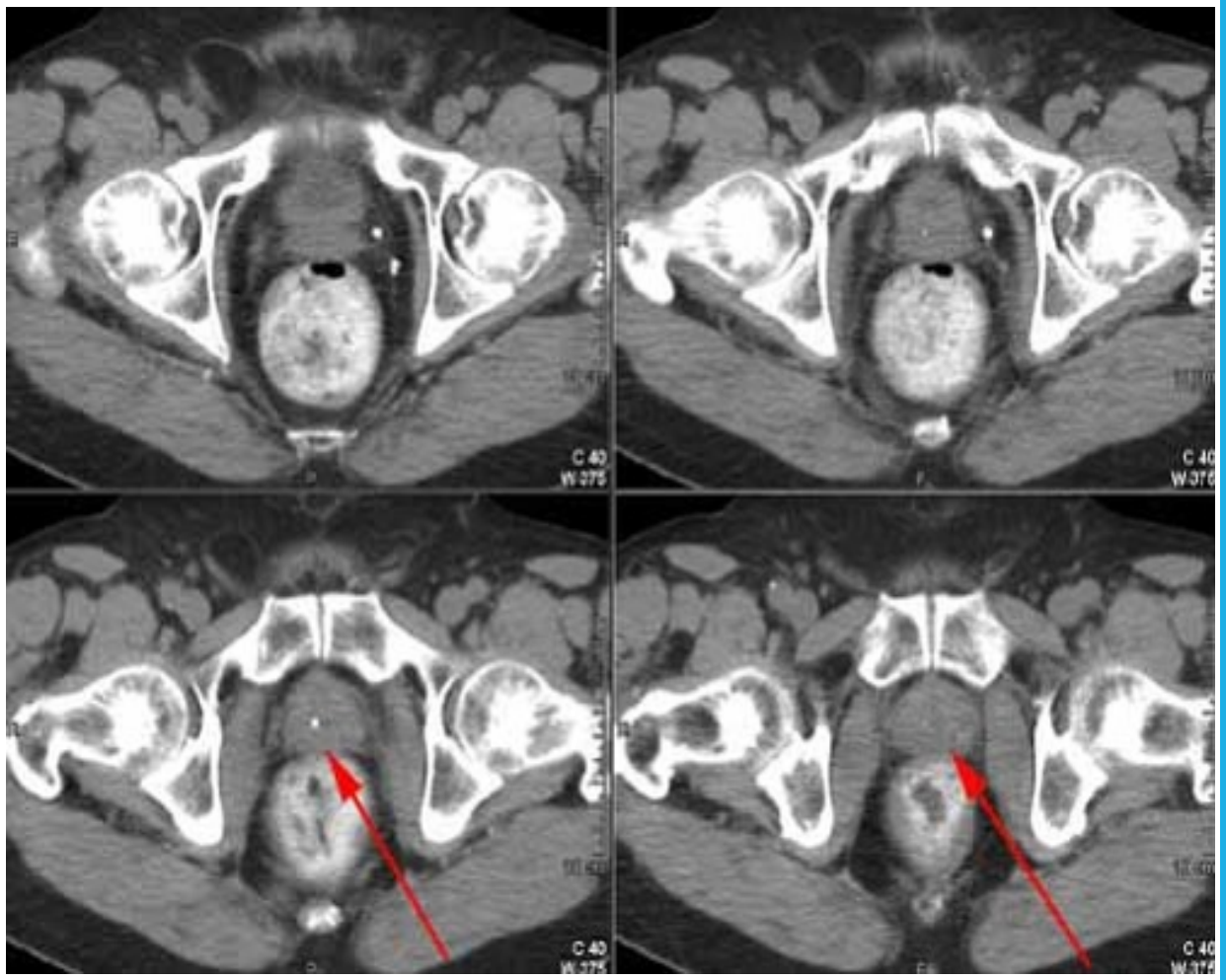


Lobes:	Corresponding zones
Anterior lobe (or isthmus)	roughly corresponds to part of transitional zone
Posterior lobe	roughly corresponds to peripheral zone
Lateral lobes	spans all zones
Median lobe (or middle lobe)	roughly corresponds to part of central zone

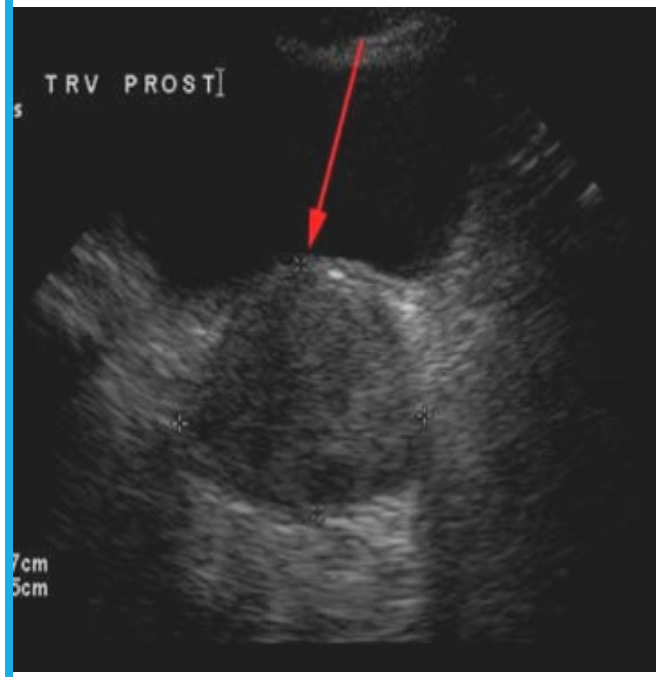


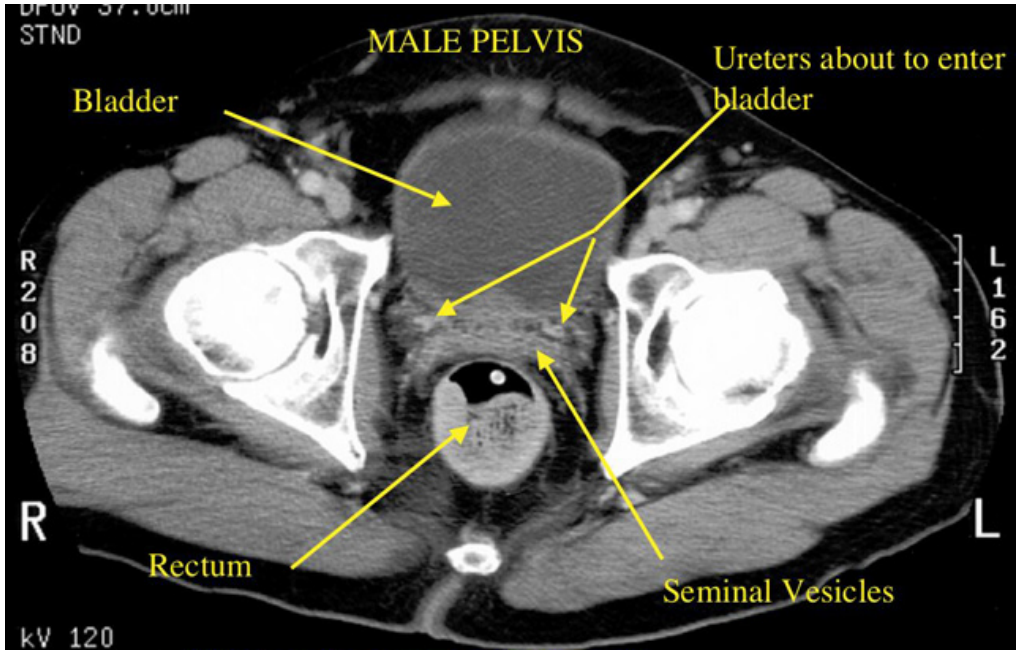


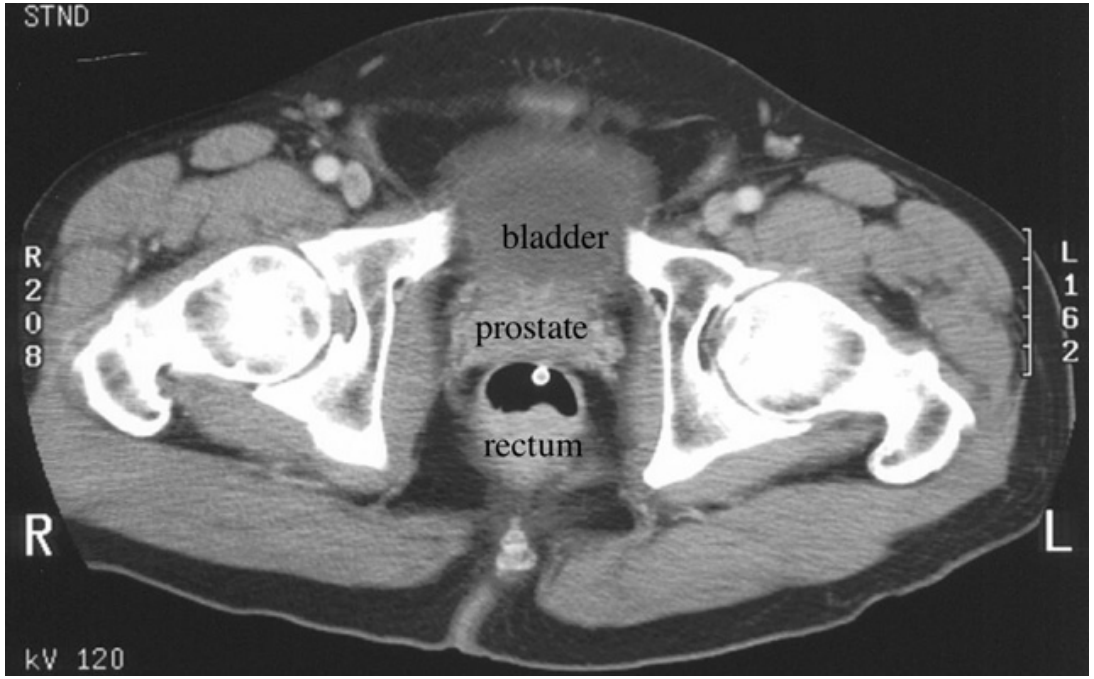
CT Scan of Prostate Gland

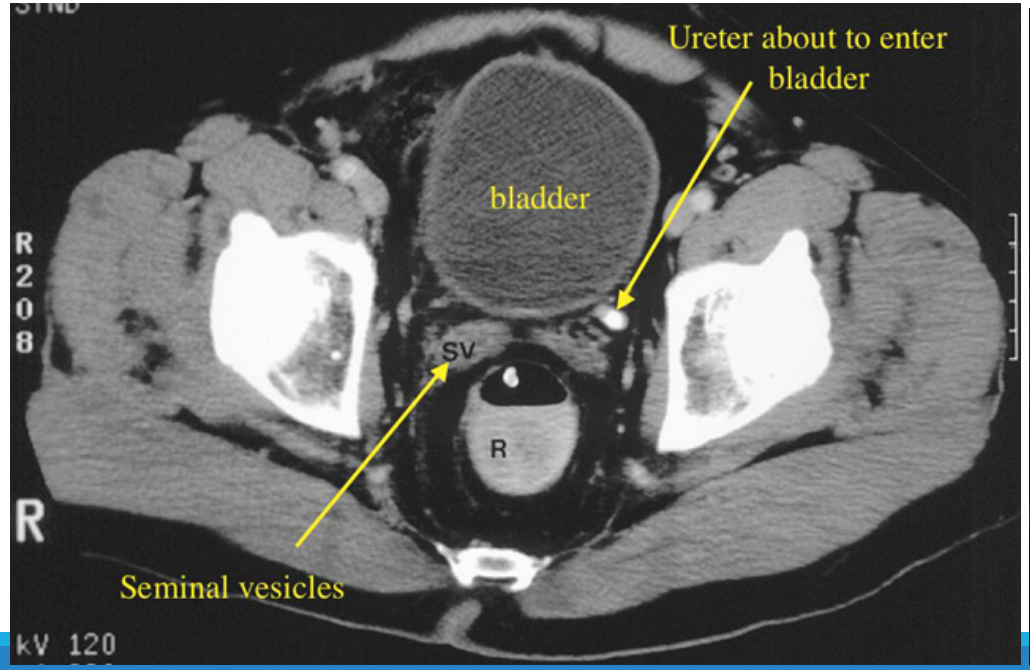


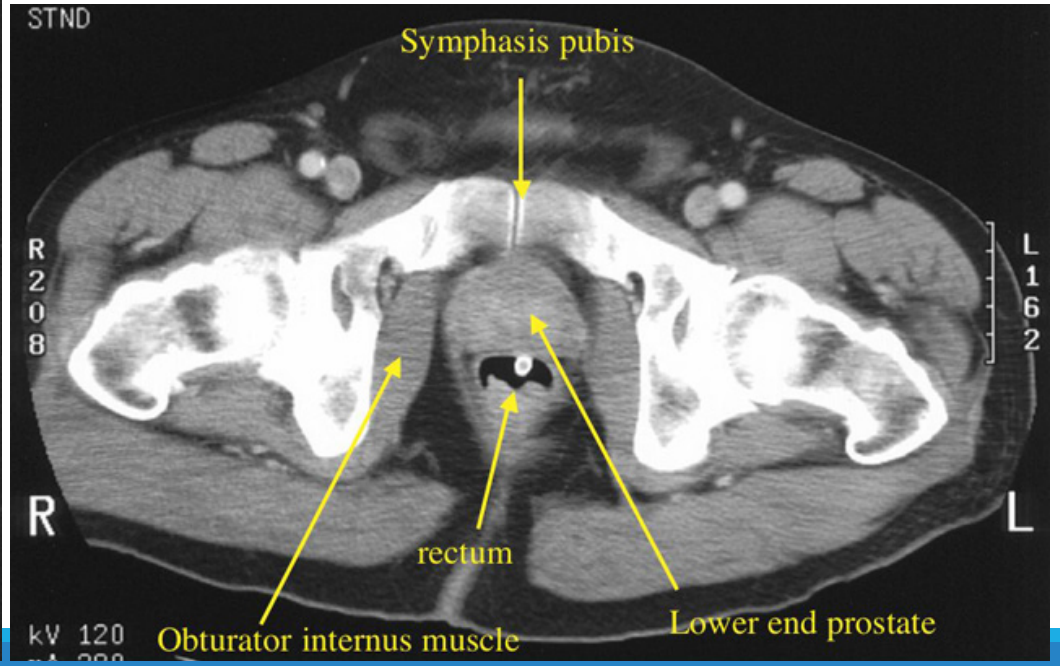
Ultrasound of Prostate Gland



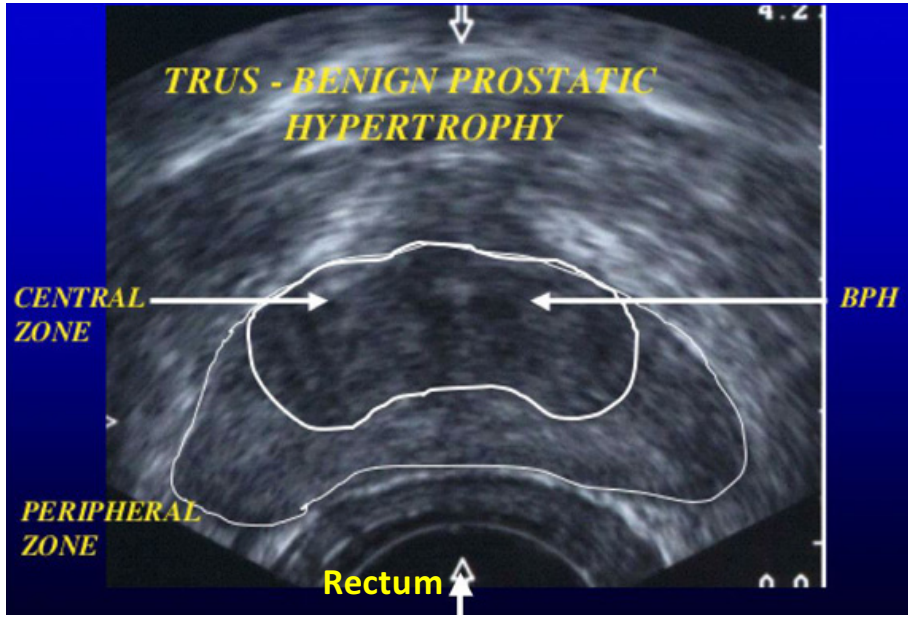




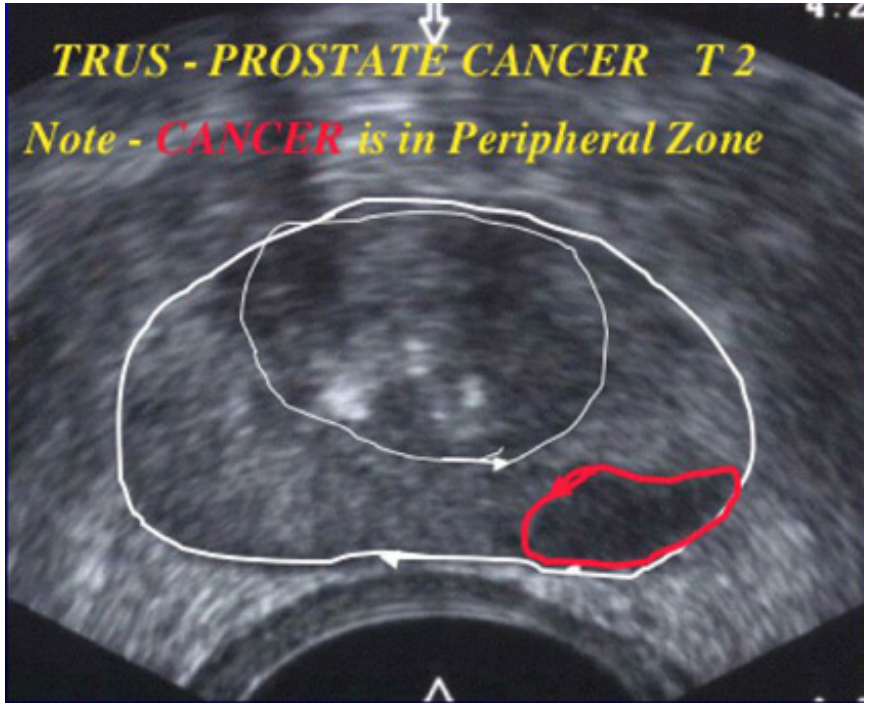


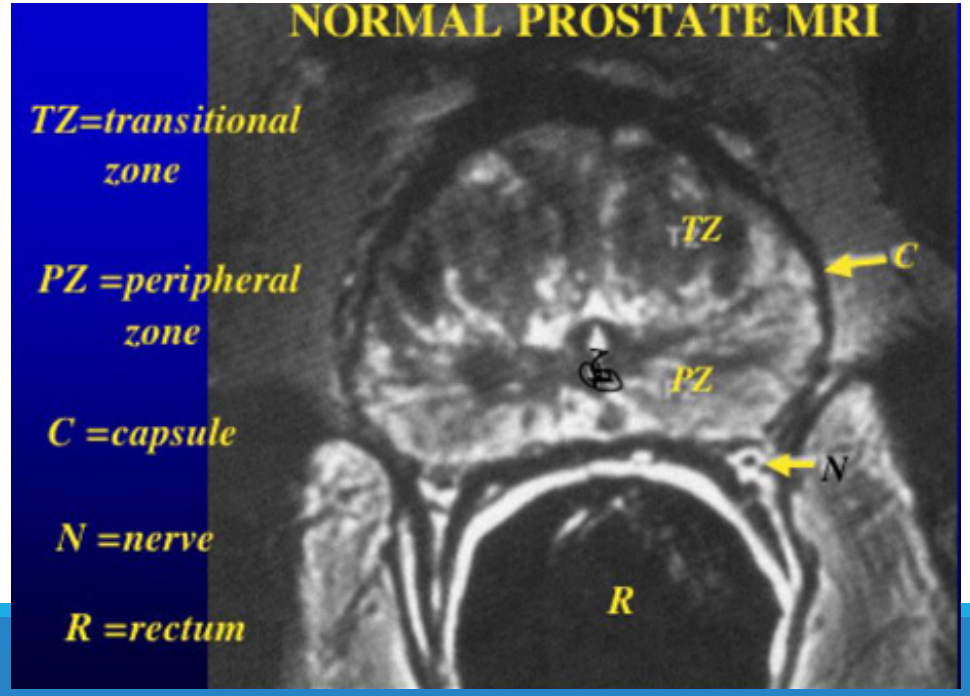


Prostate just anterior to rectum, easy to palpate on digital rectal exam



Transrectal Ultrasound





Note:
Prostate capsule better seen with MRI

Thank You!

We hope you found this helpful and informative.

Done by:

- Sami Alamri
- Abdullatif Alhassan

Reviewed by:

- Ghaida Alawaji
- Abdullatif Alhassan

You can always contact us at Radiology433@yahoo.com