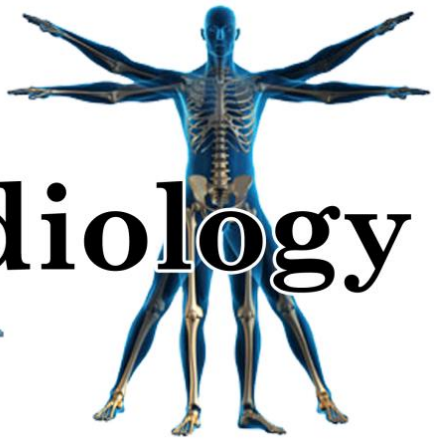


(8): Radiological Anatomy of Kidneys, Ureters, Urinary Bladder and urethra

* Many thanks to 431 team for their helpful notes *

* Please make sour you go through the lecture for more Images*

About the Prostate Gland the doctor side that it is not part of the objectives

Done By: Arwa Almashaan

Reviewed By: Othman.T.AlMutairi

COLOR GUIDE: • Females' Notes • Males' Notes • Important • Additional • 431 team

Objectives

1. To know the **anatomic** location and sizes of the structures of the urinary tract
2. To know the different types of **modalities** used in imaging the urinary tract
3. To **identify** the kidneys, ureters, urinary bladder and urethra on different imaging modalities

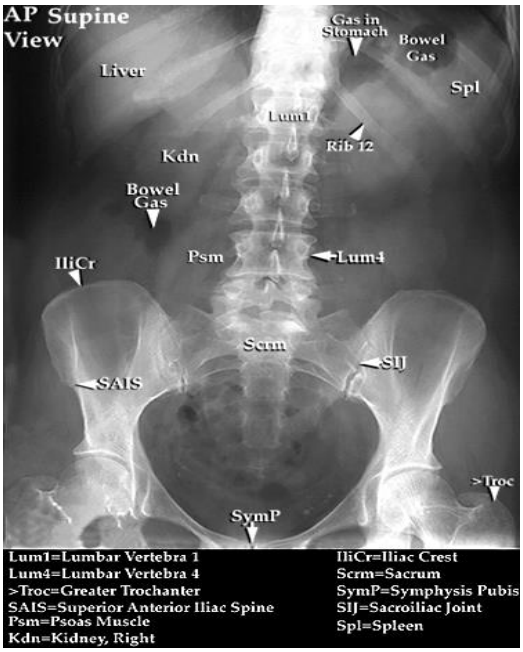
Genitourinary System

Background:

- 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.

Imaging Modalities

- Plain X-Ray
- Intravenous Pyelogram
- Retrograde Pyelogram inject the contrast into the bladder.
- CT Scan
- Ultrasound
- Renal Angiography
- Renal Scintigraphy
- Cystography
- Voiding Cystourethrography



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 MCQ
- In upright position the kidneys descend by 2 or 3 cm
- 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

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

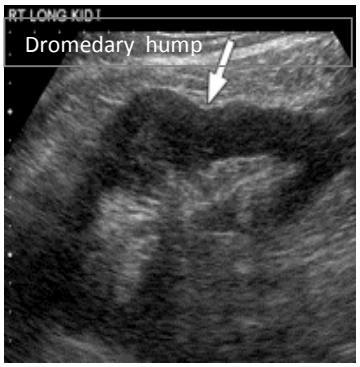
Shape:

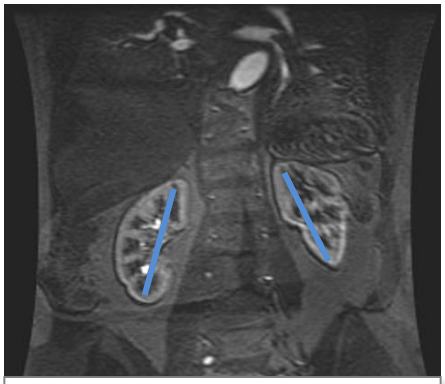
- Bean shaped structure
- There may be fetal lobulations – present as notches on the lateral aspect of the kidneys

- Local bulge or convexity may be seen along the lateral aspect of left kidney – called dromedary hump (To differentiate between normal dromedary hump and a mass: When you see normal cortex, medulla, and normal vascularity then it is dromedary hump)
- This may be either due to impression of the spleen or fetal lobulation or both

Other:

- 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 haemorrhage, pus and urine (fluid) are contained within the fascia and detected on CT and Ultrasonography.
- A layer of paranephric fat surrounds and cushions the kidneys.

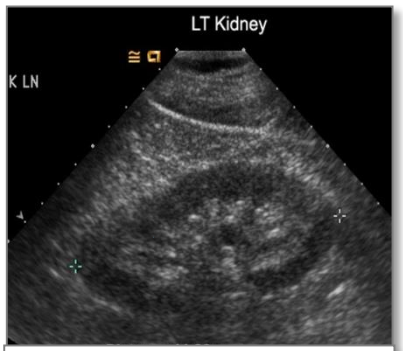




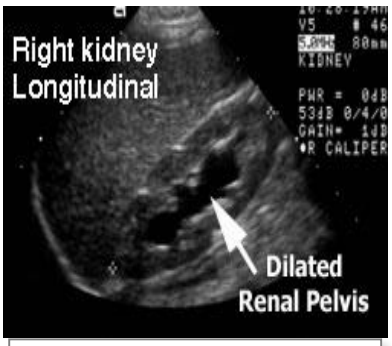
MRI shows Long axis of the kidneys is directed downward and outward, parallel to the lateral border of the psoas muscles

431 Team

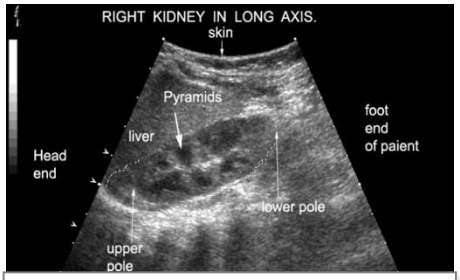
Plan X-Ray	CT-Scan	Ultrasound
Used for: • **Screening for urinary calculi (stones).** • **Diffuse abdominal pain.** • **Essential part of IVP.** • **The good thing that opaque (Calcified) structure are more visualized.** • **The kidney as a soft tissue can be seen some time because it is surrounded by fat. The difference between the density of the fat and kidney (soft tissue) give some kind of visualization.**	• **Used selectively for specific indication. (to see if there is renal tumor)** • **Not done for every patient because of the radiation and not available in every facility** • **Excellent anatomic details.** • **Ionized radiation. (Not to pregnant women).** • **Usually requires IV contrast. (Not in renal failure patients).**	• **Excellent renal and bladder anatomy** • **Can assess blood flow. (By Doppler can detect stenosis)** • **To differentiate between solid and cystic masses. (Cyst fluid appears black).** • **Can be used to evaluate the prostate or to guide biopsies.** • **Poor urethral anatomy. (Because it's difficult to follow their course).** • **No functional information. (It's an anatomical modality).**
Our FIRST choice is usualy X-Ray, then Ultrasound. If needed we order CT.		



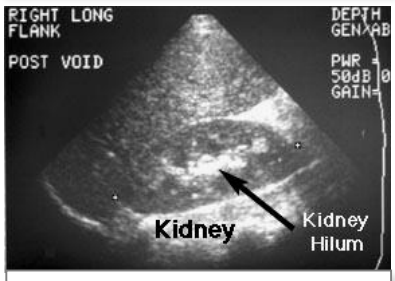
Ultrasound is the best method to measure the size of the Kidney



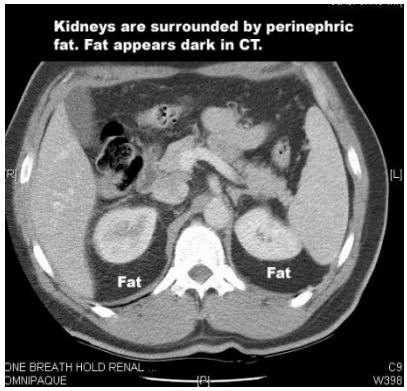
DILATED RENAL PELVIS. By ultrasound. Hydronephrosis.

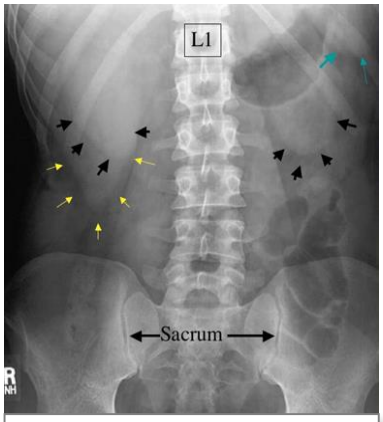


Cortex: Gray
Medulla: consist of pyramids



Ultrasound of the kidney shows the hilum hyperechoic





Kidney, Liver, Spleen.

Relationships of the Kidneys See Here

- The doctor said that it is important to know the structure related to the kidney and these pictures are important to identify these structure. MCQ's

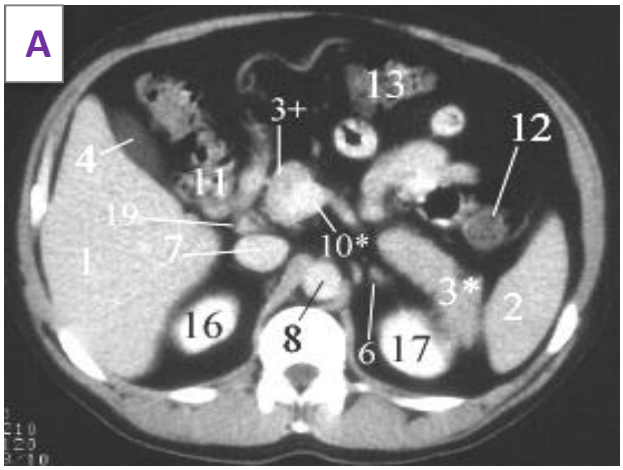
431 Team

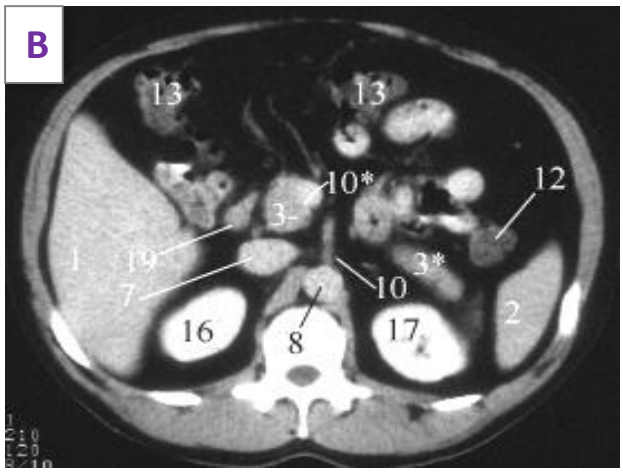
A:

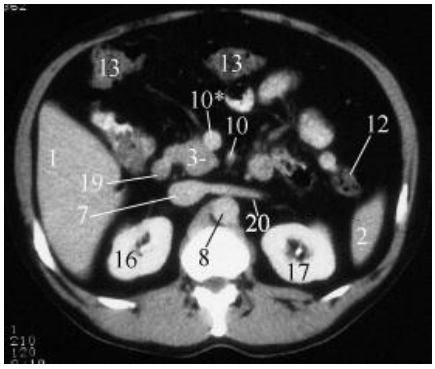
1- Liver.
2- Spleen.
3+ -Head of pancreas.
3* -Body and tail of pancreas.
4- Gallbladder.
6- Left adrenal gland.
7- Inferior vena cava.
8- Aorta.
10*Superior mesenteric **Vain**.
11- Ascnding colon.
12- Descending colon.
13- Transvers colon.
16- Right kidney.
17- Lift Kidney.
19- Duodenum, 2ed part.

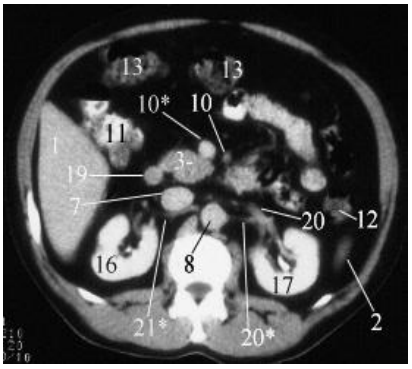
B:

3- -Uncinate process of the pancreas.
10- Superior mesenteric **artery**.

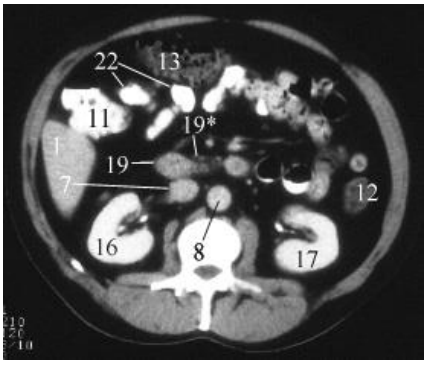




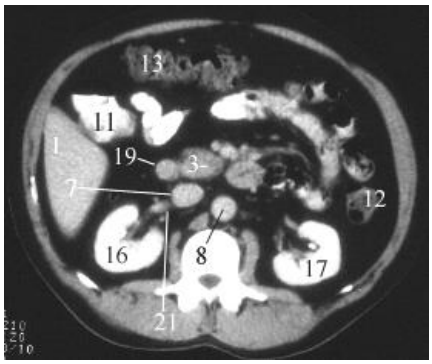




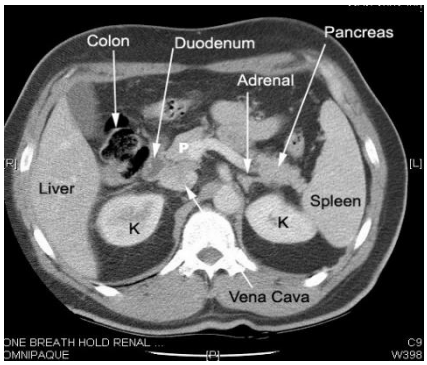
20- Left renal vein. 20*- Left renal artery. 21*- Right renal artery



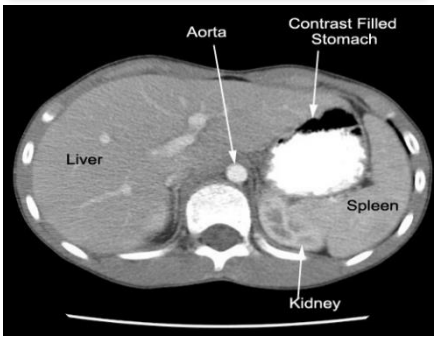
19- Duodenum, 3ed part.
22- Small intestine.



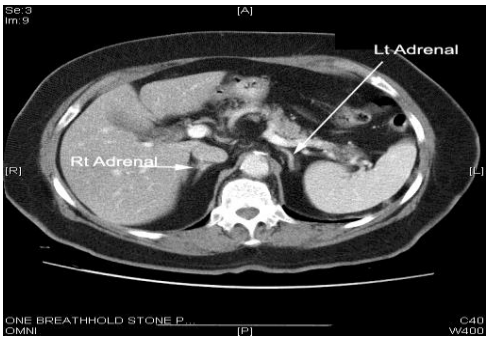
21- Right renal Vain



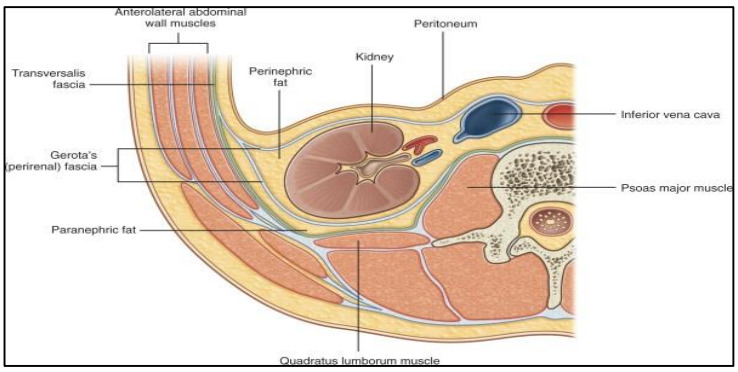
Transaxial CT scan



Superior pole of the left kidney appear first because it is higher than the RK



Adrenal glands are superior to the Kidneys



Gerota's Fascia: It is important because if its increase in size that's mean there is collection of pus or fluid and you may think of abscess.

431 Team

- Dilated renal pelvis could be due to hydronephrosis or cyst.
- To differentiate between the two, look at the shape and location.
- Cyst will be regular in shape and not involving the entire kidney

431 Team

Ultrasound show Renal Cyst

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 caudally in anterior Pararenal space.

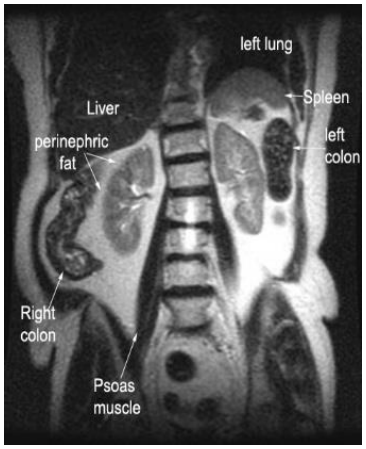
Anterior Pararenal Space: bounded

- Posteriorly by the anterior portion of the renal fascia.
- Anteriorly by the posterior parietal peritoneum.
- Laterally by 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

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

All three spaces potentially communicate at the pelvic brim.



Coronal MRI

Renal Vasculature:

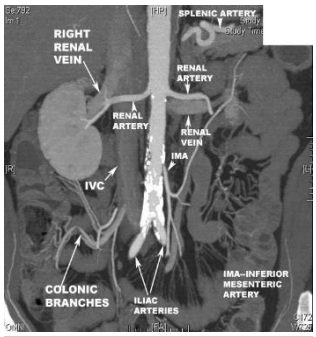
- There are many variations of the renal vasculature
- Renal arteries branch from the abdominal aorta laterally between L1 and L2, below the origin of the superior mesenteric artery
- The right renal artery passes posterior to the IVC
- There may be more than one renal artery (on one or both sides) in 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 and circumaortic left renal veins.
  - Left kidney supplied by two renal arteries(U+L pole A).

432 team:

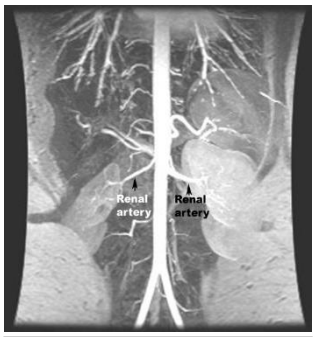
Angiography:

- *Is used to evaluate the renal vessels (Golden Standard).*
- *Urinary tract (UT) hemorrhage.*
- *Renal Artery Stenosis and hypertension.*
- *Partial Nephrectomy as therapeutic use.*
- *Significant risk of complication.*
- *Very expensive.*
- *Ultrasound Doppler can be used, but it's difficult especially in obese patients or if the abdomen is gassy.*
- *CT scan sometime be used as a choice over angiography, because it is less invasive. However, angiography has the advantage of having therapeutic use.*

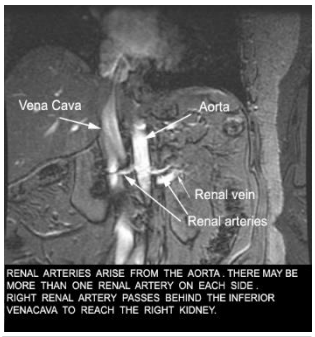
Renal Angiogram



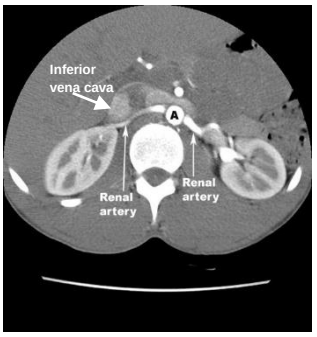
Coronal CTA (Angio): aorta calcified from Atherosclerosis



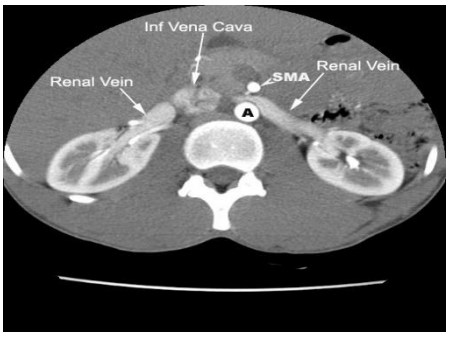
Coronal MRA (Angio)



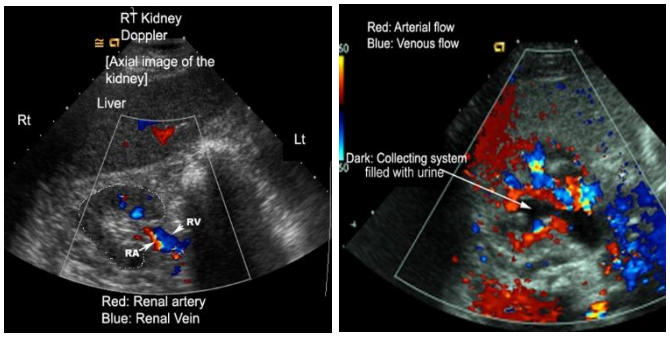
Coronal MRA (Angio)



Transaxial CTA (Angio)



Transaxial CTA: Left Renal Vein Passes Anterior to the Abdominal Aorta



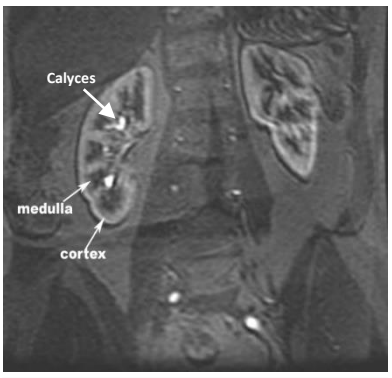
Ultrasound Doppler show the renal vessels flow and it is good for evaluating the artery stenosis

Notes:

- *Depending on the time of imaging the contrast will move e.g. the contrast in the first 30 seconds will show the artery, after 60 sec the artery and vein appears, after 90 sec the veins only will be clear.*
- *The Difference between CTA and MRA: is that MRA contrast has less toxicity.*

Renal Structure:

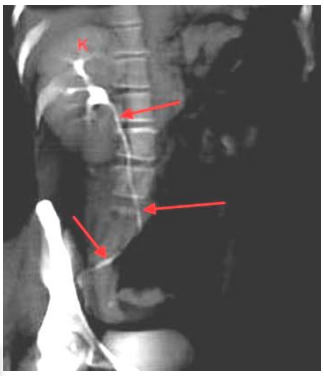
1. Thin capsule
2. Renal cortex
   - Renal cortex consists of glomeruli and renal tubules
   - Normal thickness is 2.5 cm.
3. Renal Medulla
   - Consists of multiple renal pyramids which have their base to the periphery and their conical end directed towards the renal hilum
   - Their tips are called papillae
   - Each minor calyx receives 1-3 papillae



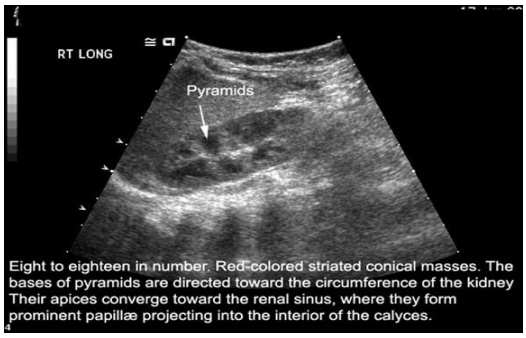
Coronal MRI

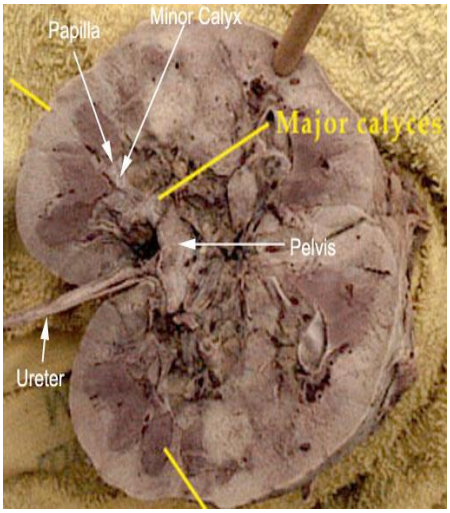
- Contrast enhanced CT scan through the kidneys in nephrogram phase (showing cortico-medullary differentiation).
- This is approximately 100 seconds following contrast administration and would show renal lesions well

- 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.



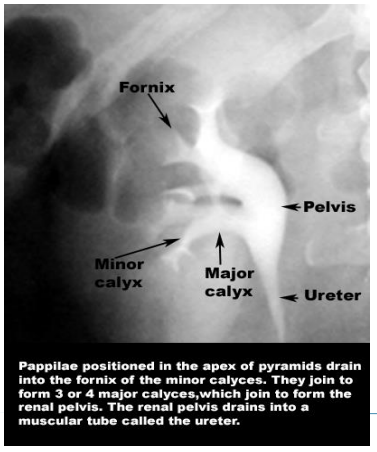
- 3D reconstructed image from CT scan of the abdomen and pelvis known as CT IVP
- This exam is quickly replacing the conventional IV Urogram.
- 3D reconstruction is performed through the right kidney (K) and follows the normal ureter (arrows) all the way to the ureter's insertion into the bladder.

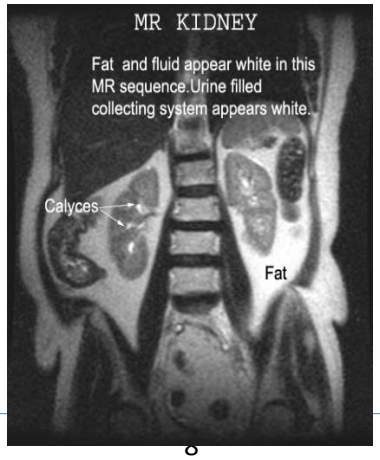


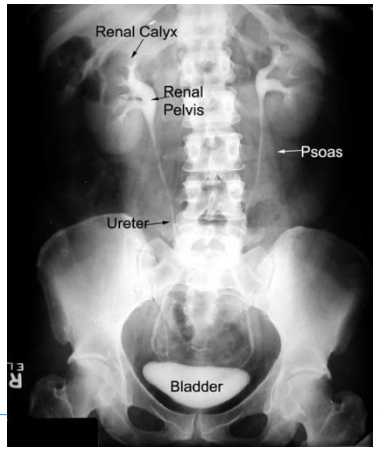


Renal Collecting System:

- 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







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 posterolaterally and course in an arc downwards
- Then inward and anteriorly to enter the trigon of the bladder on either side of the midline

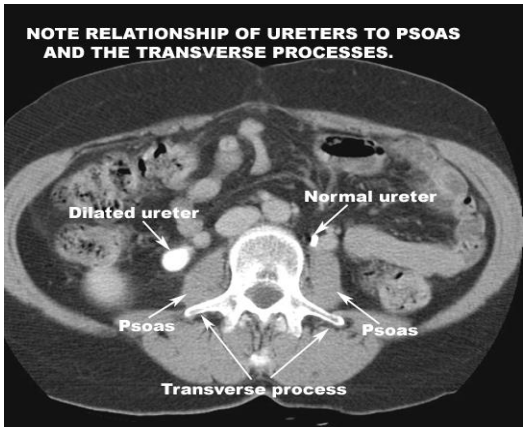
Areas of Narrowing: MCQ's

Three areas of normal narrowing:

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

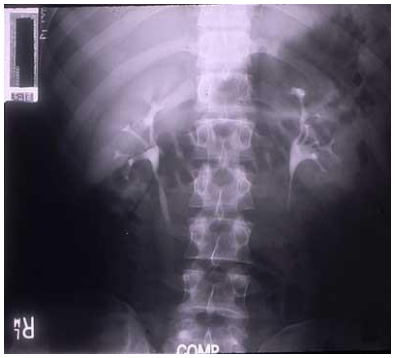
Ureteral Vasculature

- Blood is supplied by the ureteral branches of renal and testicular or ovarian arteries, and abdominal aorta

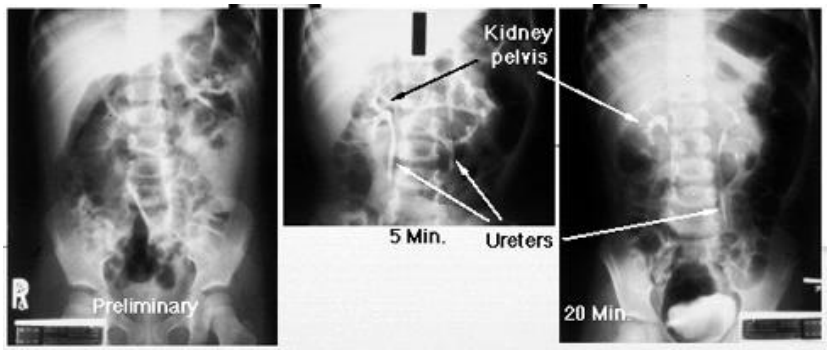


- Renal and testicular or ovarian veins supply venous drainage

CT without contrast could be used to find stones or ureter dilatation.



Intravenous pyelogram



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

Urinary Bladder

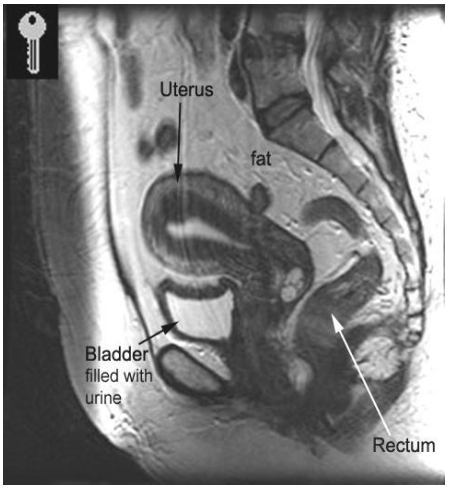
- Hollow muscular vesicle for storing urine temporarily
- Bladder is higher in position in **children** and slightly higher in **males** than females
- It is relatively larger in **children** than in adults

Size and shape

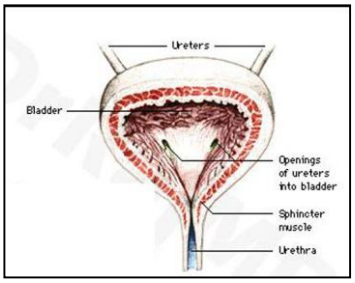
- Size and shape vary considerably
- **Shape:** tetrahedral when empty, transversely oval or round when full
- When empty, it is completely within the pelvis.
- Inferior aspect projects 5-10 mm above the symphysis pubis
- Separated from pubic bones by retropubic space
- Floor is parallel to superior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

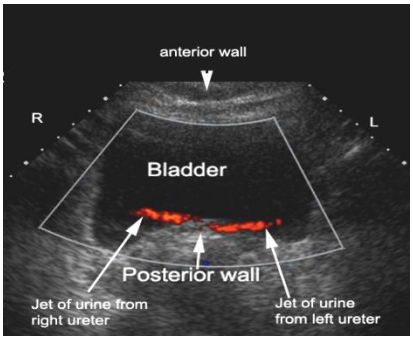
Neck of bladder

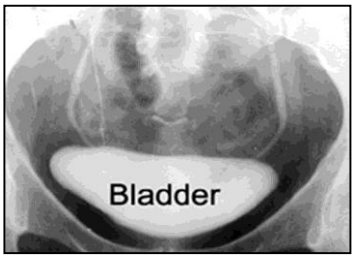
- lies 3-4 cm behind lower part of symphysis pubis and rests on the prostate in the male
- It has the urethral orifice
- In females the peritoneum is reflected from the superior surface of the bladder to the anterior wall of the uterus at the junction between the body and cervix
- The enclosed space 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

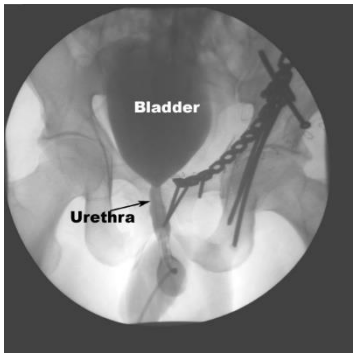


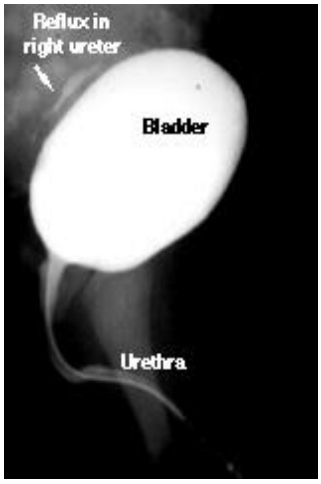
Sagittal MRI of female pelvis.







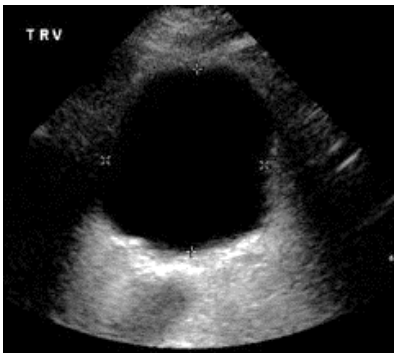




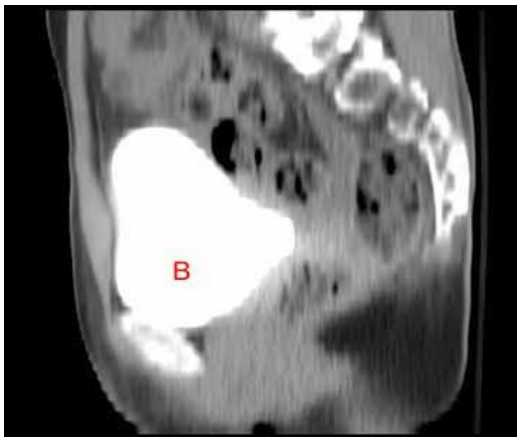
Voiding Cystourethrogram

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

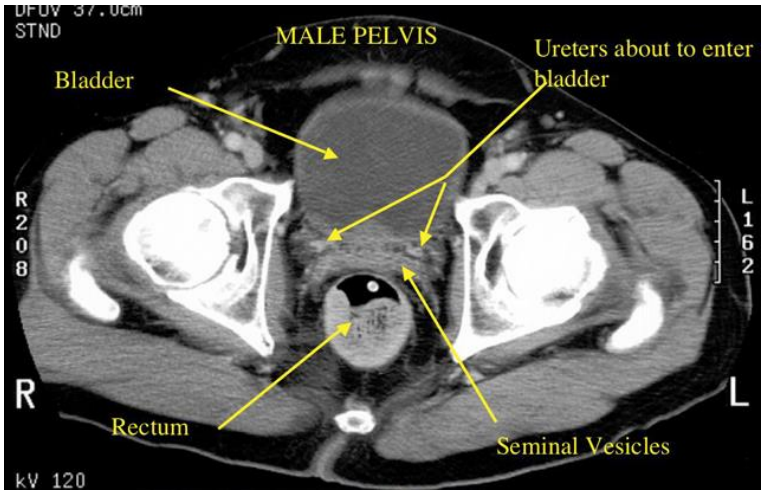
Unenhanced CT scan through a normal bladder (B) shows a normal fluid density structure (less than 10 Hounsfield units on CT density scale)



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.



- 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)



	Left kidney	Right kidney
Moving with respiration	Both kidneys move with respiration	
Size in adult	~11	Shorter by <1.5 cm
Position	Ranging from 11T to 3L but the right is lower by 2 cm	
Vasculature	Longer vessels	Shorter vessels

SUMMARY

1. Dromedory hump is the lateral convexity on the lateral aspect of the left kidney.
2. the kidnesy are visualized due the presence of perirenal fat and are surrounded by Gerotis Fascia where blood and pus may be detected by a CT or US.
3. The First modality of imaging is X-ray then US and CT if needed.
   X-ray:Renal Calculi. US:Blood flow,Size,cystic or solid. CT: Tumors.
4. All renal spaces are bounded and potentially communicate at the pelvic brim.
5. Renal artery branch from abdominal aorta laterally at the level of L1-L2.
6. MRA is less toxic than CTA.

7.papillae drain into the fornix of minor calyces into 3-4 major calyces fusing into a pelvis.

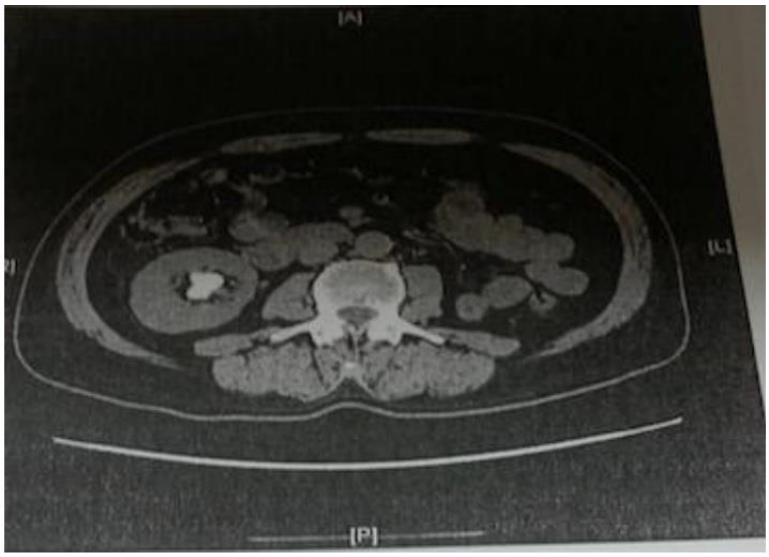
8.The ureter is 25-30 cm in length and 3mm in diameter with three normal anatomical narrowing(1.Ureteropelvic junction.2.Bifurcation of Iliac fossa.3.uretriovesicular junction.)

9.The bladder is mobile, is higher and larger in children but the neck of the bladder is stabilized by puboprostatic ligament(M) and Pubovesicular Lig.(F).

Questions

1) A 35 yo male presented with right flank pain and hematuria. Temp: 37.1C , HR: 88 BPM. BP: 115/7?

a. Pyelonephritis.
b. Renal Stone.
c. Ureteric Stone.
d. Renal Tumor.



2) A 40 yo Female presented with lower abdominal Pain?

a. Urinary Bladder stone.
b. Bilateral Kidney stone.
c. Bilateral Ureteral stone.
d. Bilateral Ovarian Cyst.

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Answers:

1st Questions:B

2nd Questions:A