Radiology Team 429

URINARY TRACT RADIOLOGICAL ANATOMY & IMAGING MODELITIES

Radiology Team 429

In this team we used the outlines from the:

Doctor's slides

Lecture notes

427 Radiology team

Diagnostic Imaging –PETER ARMSTRONG – 6Th Edition

Sorry we don't hold responsibility for any missing information or perhaps – perhaps -wrong material.

We tried our best to present this lecture in the best way, and we hope what we wrote is enough to cover the subjects.

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Best Wishes :)

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, and urinary bladder on different imaging modalities

Imaging Modalities

1. Intravenous Pyelogram (IVP)
2. Retrograde Pyelogram
3. CT Scan
4. Ultrasound
5. Renal Angiography
6. Renal Scintigraphy
7. Cystography
8. Voiding Cystourethrography

Note:

- Ultrasound, CT, MRI: provide anatomical information, functional information is limited
- Radionuclide examinations: provide functional information mostly
- IVP: provides both anatomical and functional information

Urinary System

- Kidneys are retroperitoneal organs, bean shaped structures
- 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

- 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
- 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

Kidneys

- MRI coronal section
- **Noticed in the MRI:**

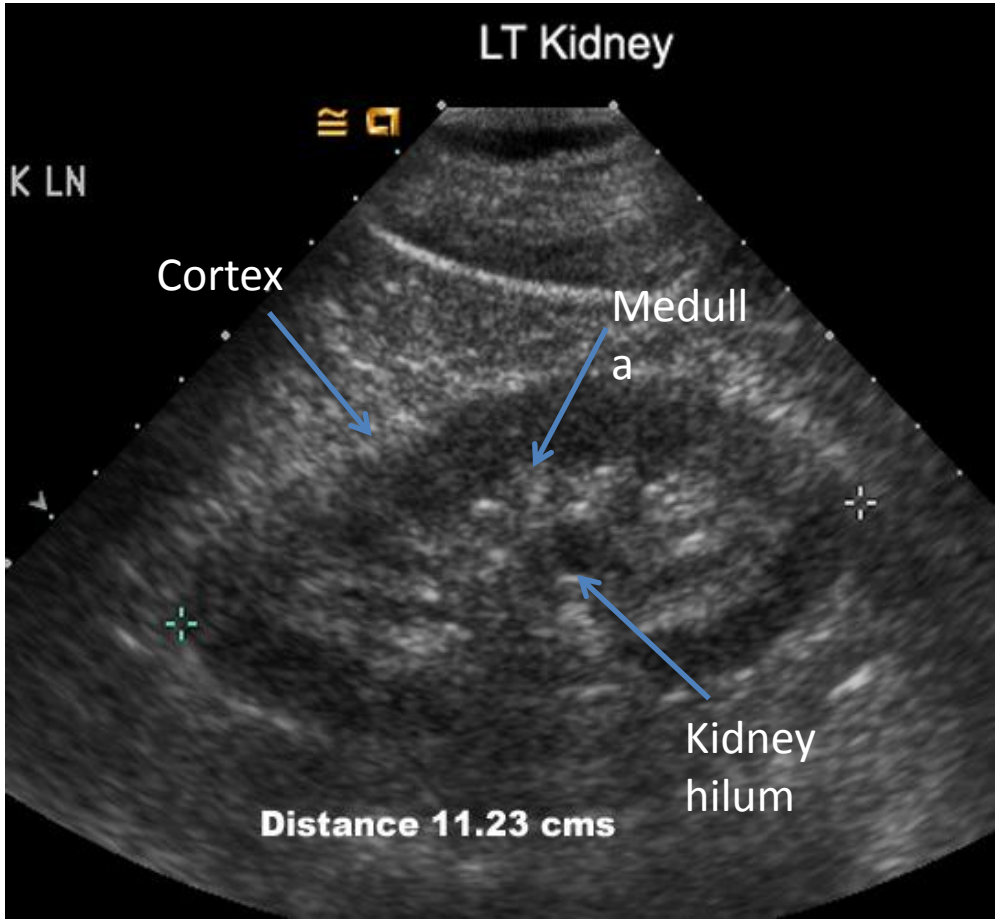
1- Rt. Kidney is lower than Lt. kidney

2- kidneys are directed downward and outward and anteriorly

3- by MRI Fat is white as we can see surrounding the kidney (Perinephric fat) .. By CT the fat is black.

Kidneys

- Length of kidney can be measured by ultrasound or in relation to Lumbar vertebral 2 (L2)
- The length of the kidney is 3.7 times the height of L2 +/- 0.37 to be exact
- Ultrasound is the best method to measure the size of the Kidney

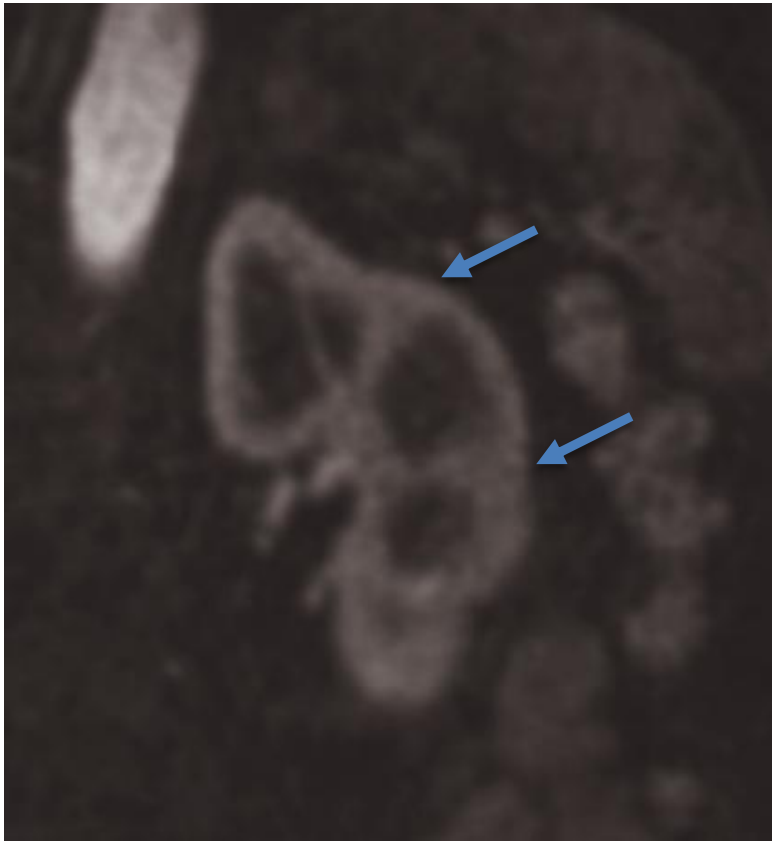


Kidneys

Upper pole of left kidney is higher than the upper pole of right kidney.

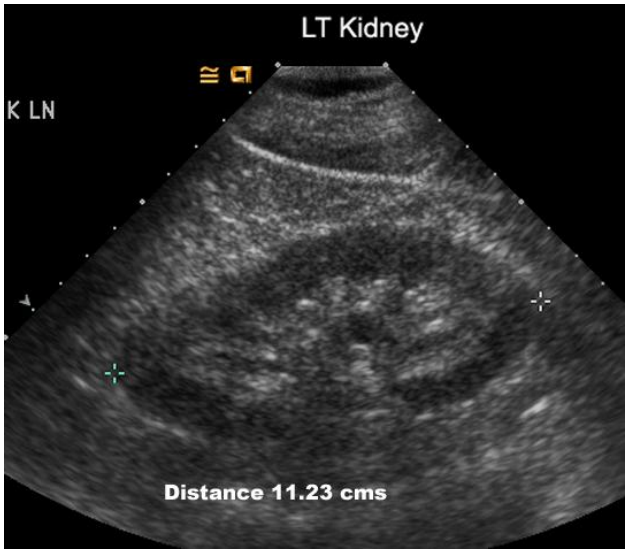
Kidneys

- 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
- There may be fetal lobulations: present as notches on the lateral aspect of the kidneys between the calices



Kidneys

- There are some normal variant between individuals in the shape of the kidney
- There is a bulge next to the arrow which is usually seen only in the Lt. kidney due to spleen indentation (dromedary hump)
- **BUT** if there is a bulge on other site or even on the Rt. Kidney we need to investigate because it's not normal



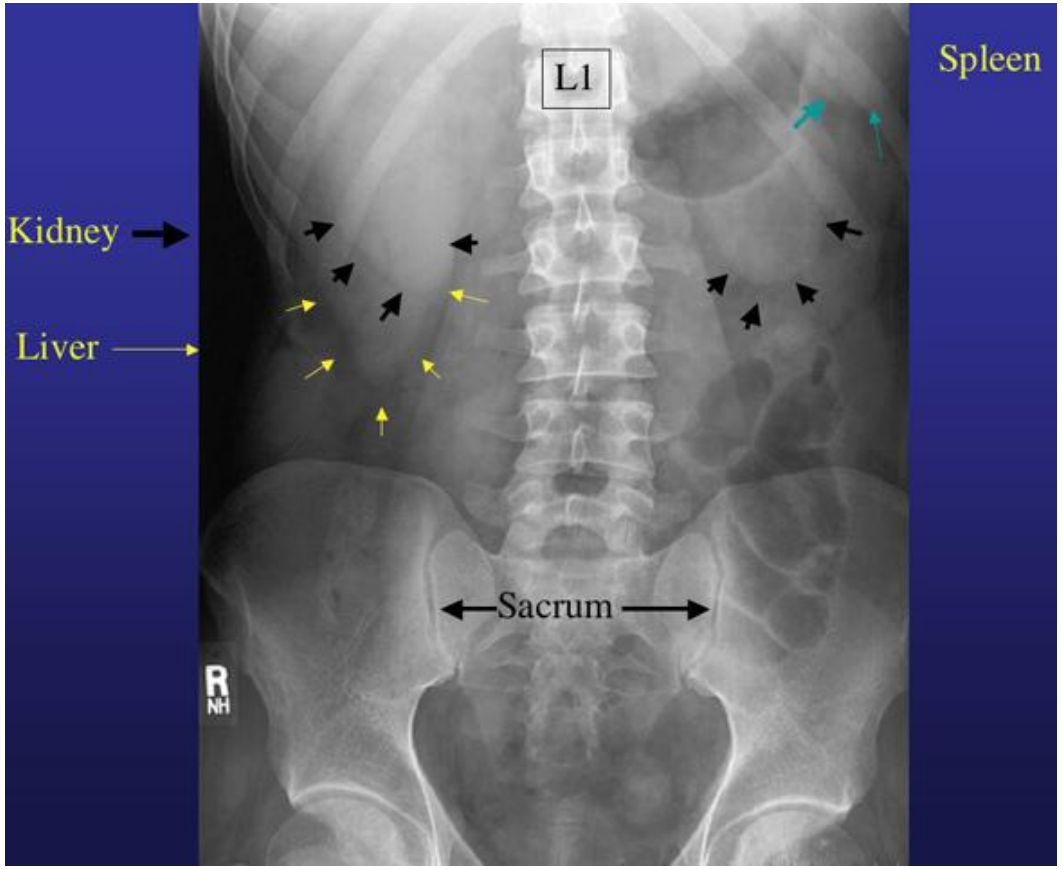
Kidneys

- 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 and detected on CT and Ultrasonography
- A layer of paranephric fat surrounds and cushions the kidneys

Kidney Imaging

1. **X-ray:**
   - Screening for urinary calculi
   - Diffuse abdominal Pain
   - Essential part of IVP (intravenous pyelogram)
   - Shows organs shadow or stones “unless they are radiolucent”

Kidney Imaging
X-ray



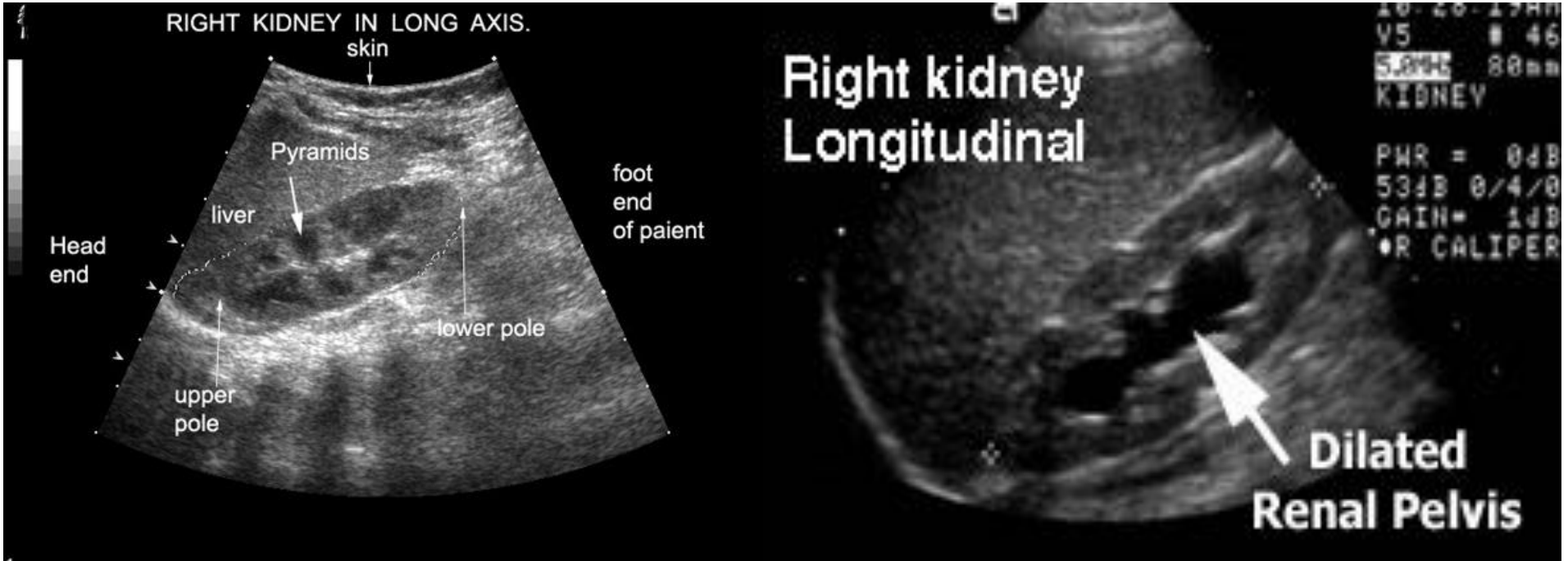
Kidney Imaging

2. Ultrasound:

- Excellent renal and bladder anatomy
- Can assess blood flow
- Useful in helping differentiate between solid and cystic masses
- Can use TRUS (Transrectal Ultrasonography)to evaluate the prostate or guide biopsies
- Poor urethral anatomy
- No functional information

Kidney Imaging
Ultrasound

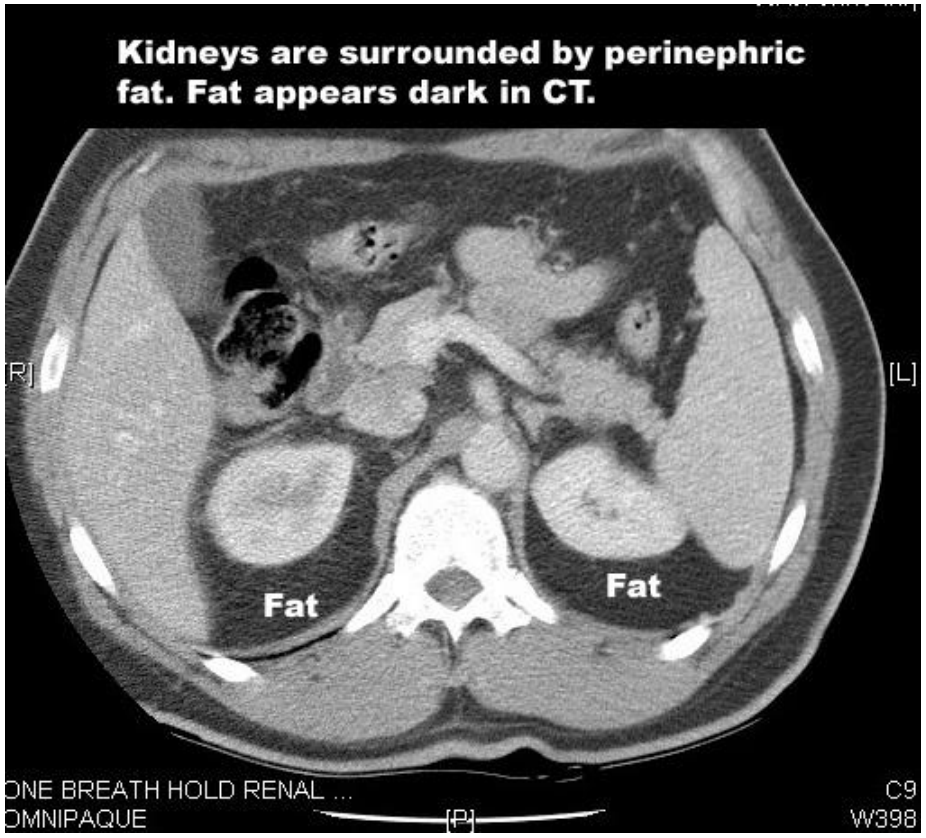
- Normal Kidney
  - The dark shadows in the kidneys are the pyramids which are located in the medulla.
- Dilated Renal Pelvis
  - Hydronephrosis



Kidney Imaging

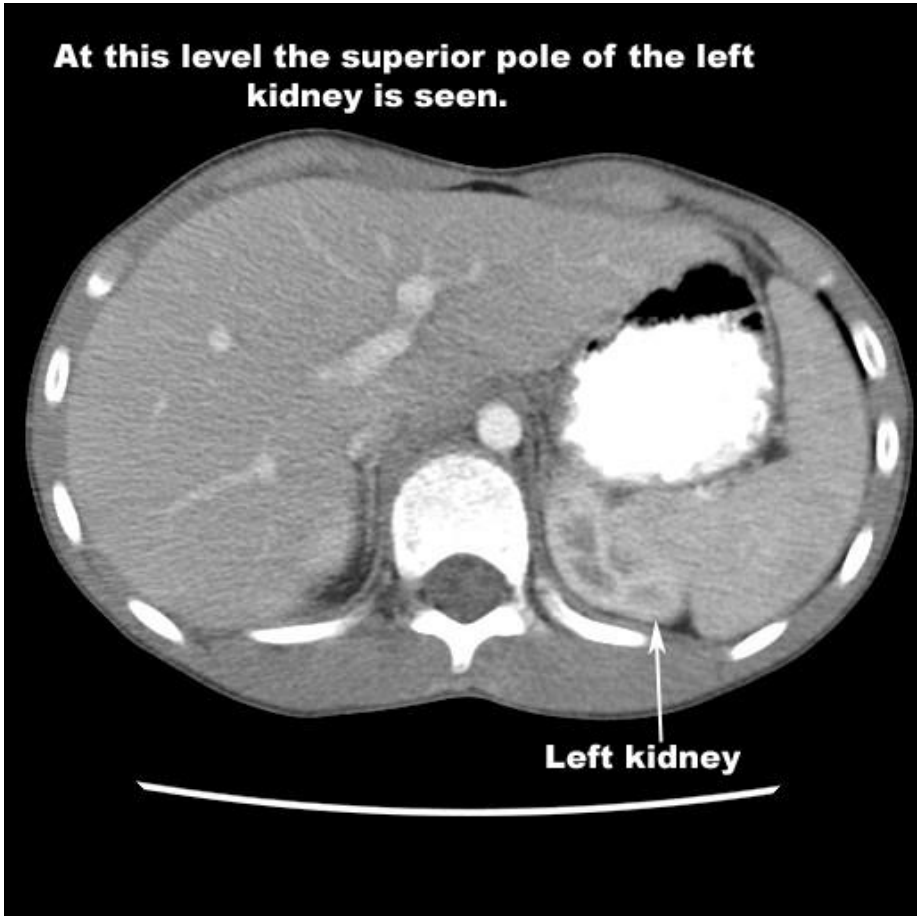
3. CT:

- Used selectively for specific indication
- Excellent anatomic detail
- Ionizing radiation: disadvantages because of it's a hazard
- Usually requires IV contrast
- Types: Non-contrast CT KUB (kidney, ureter, and bladder) or contrast CT
- Avoid CT scan as much as you can specially in pregnant women and children (use US instead)



Kidney Imaging
CT

CT Scan showing left kidney higher than right
The bright area in the stomach is the contrast, the black is air

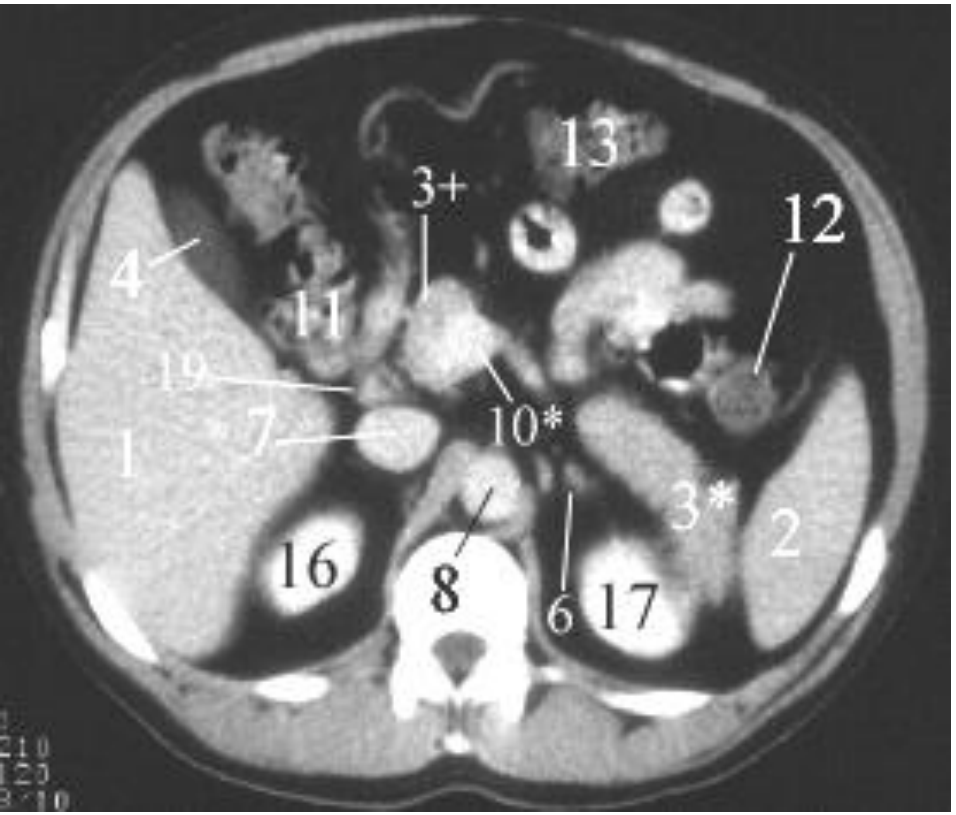


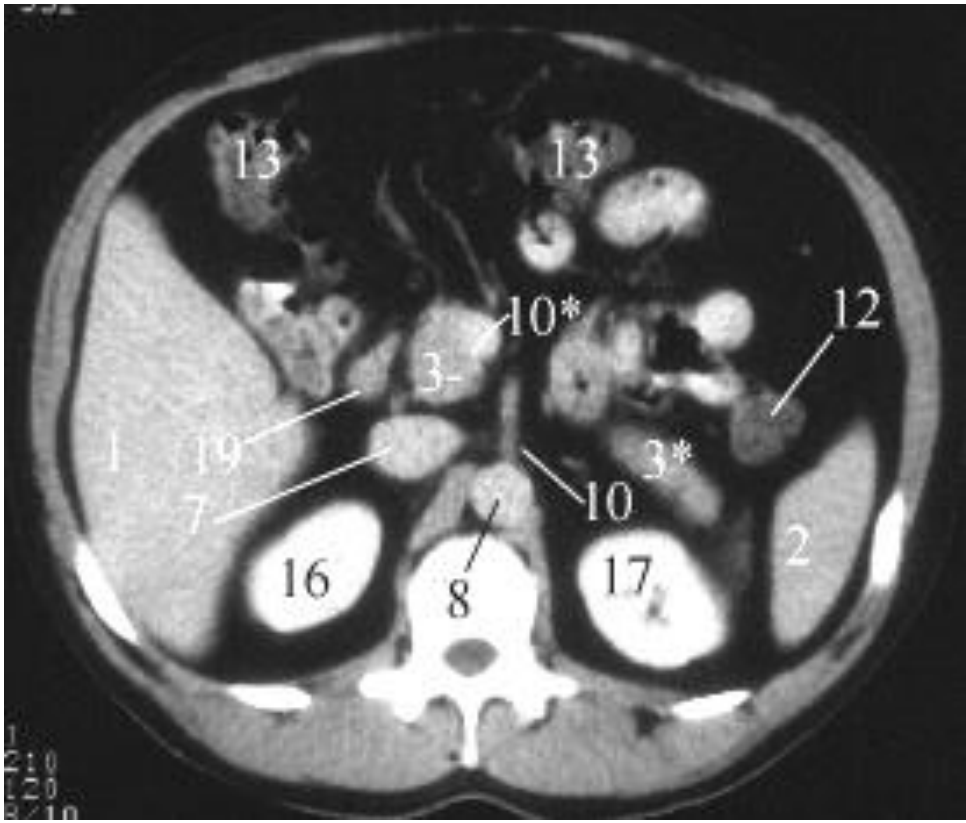
Kidney Imaging
CT

Relationship of kidneys:

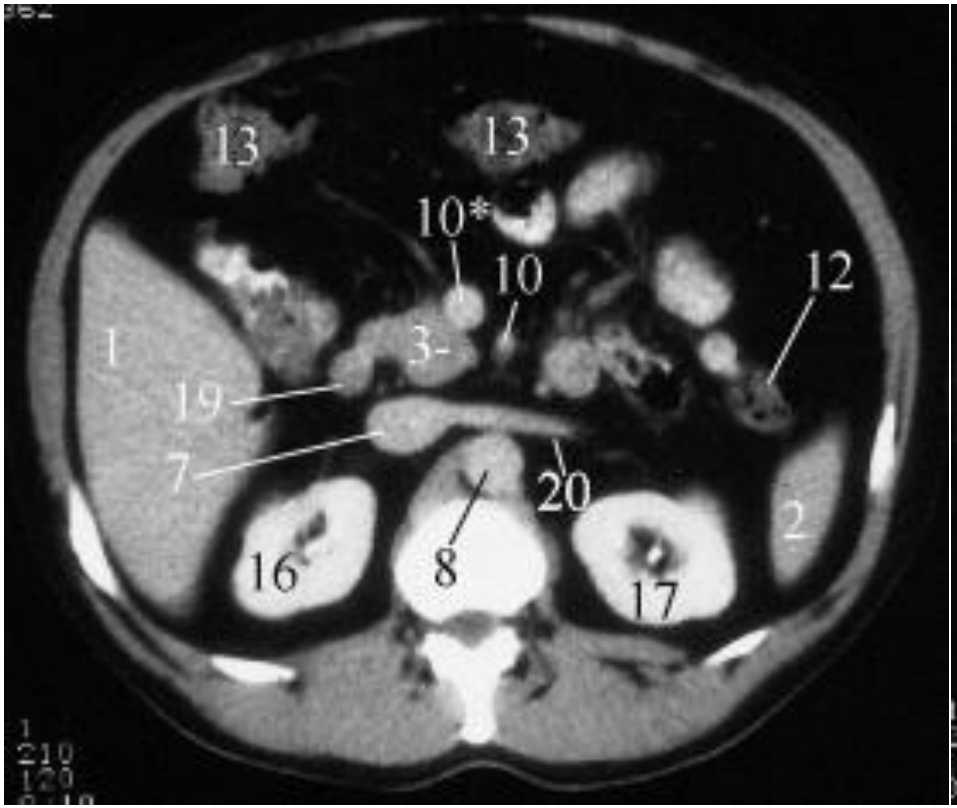
1. Liver
2. Spleen
3. Pancreas: 3+ head, 3* tail, 3- uncinate process
4. Gallbladder
5. Right adrenal gland
6. Left adrenal gland
7. Inferior vena cava
8. Aorta
9. Portal vein
10. Superior mesenteric artery
    10* Superior mesenteric vein
11. Ascending colon
12. Descending colon
13. Transverse colon
14. Stomach
15. Distal Stomach
16. Right Kidney
17. Left kidney
18. Inferior mesenteric artery
19. Duodenum
20. Left renal vein
21. Right renal vein
22. Small intestine

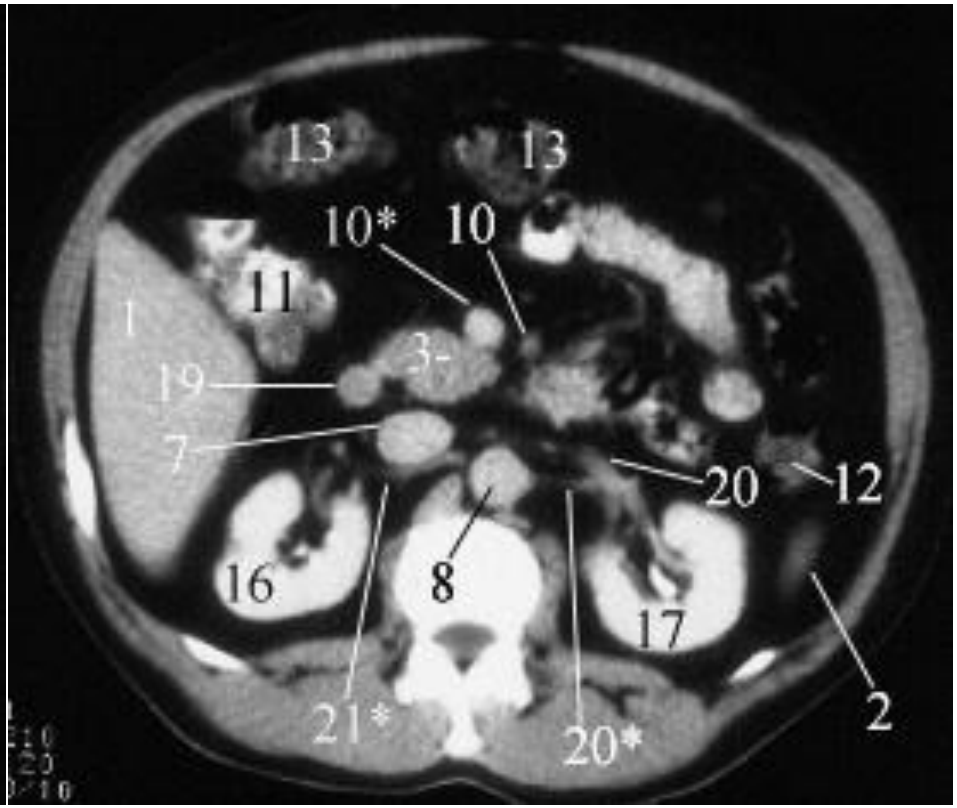
Kidney Imaging
CT



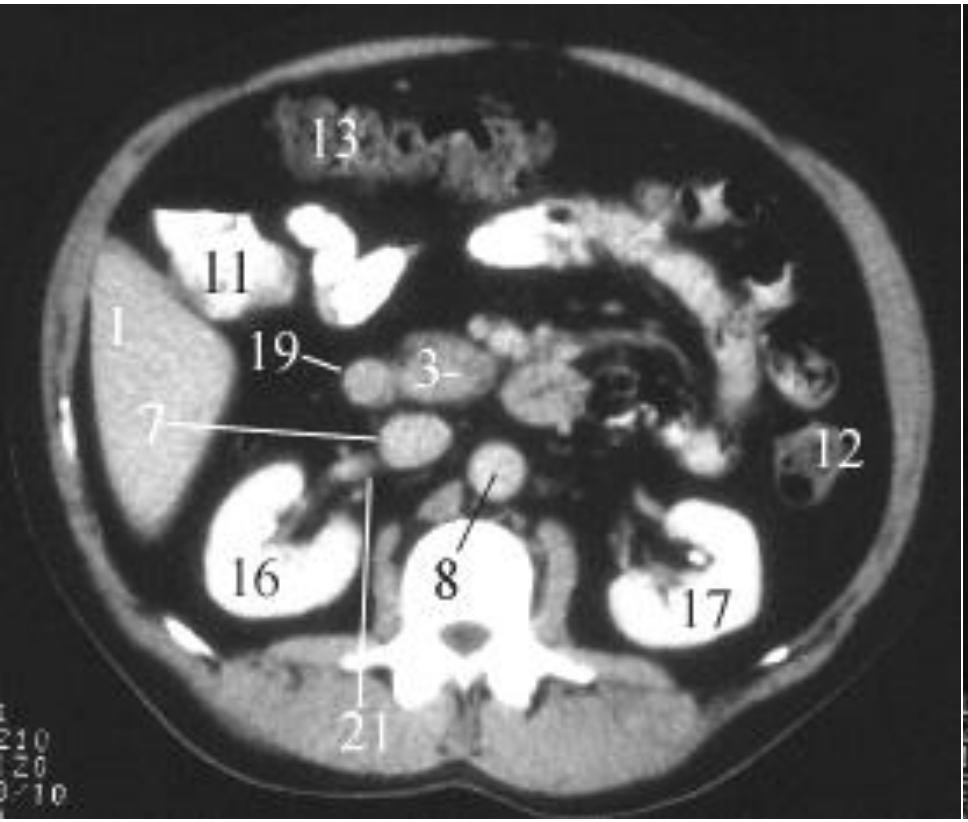


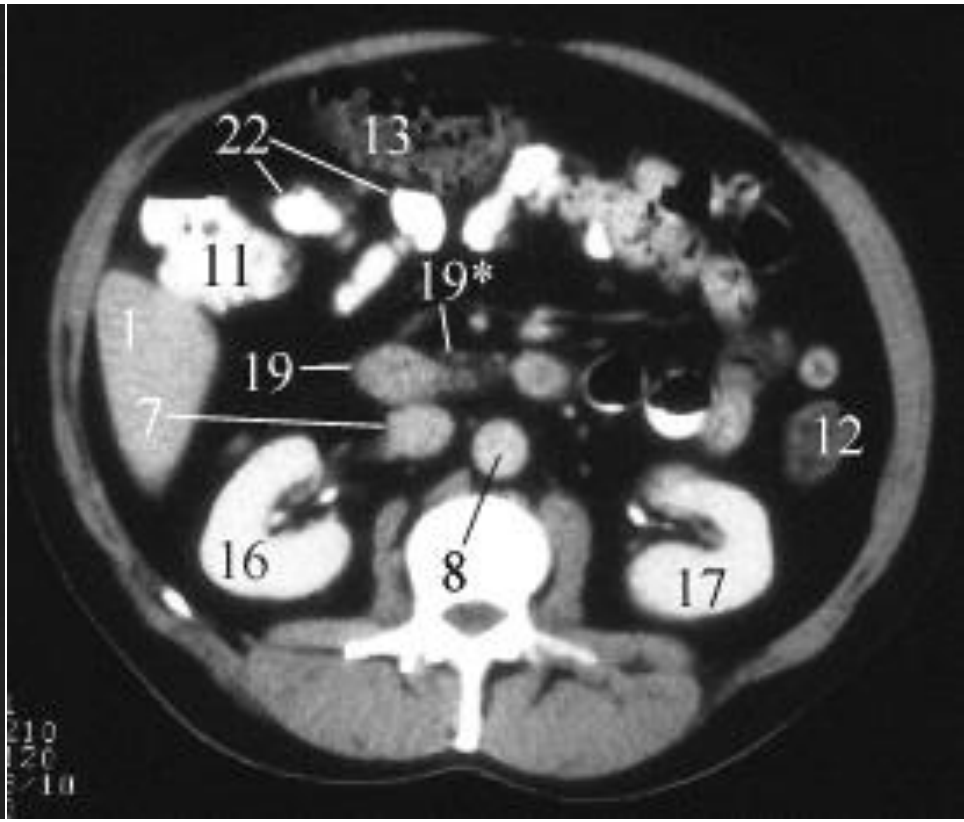
Kidney Imaging
CT



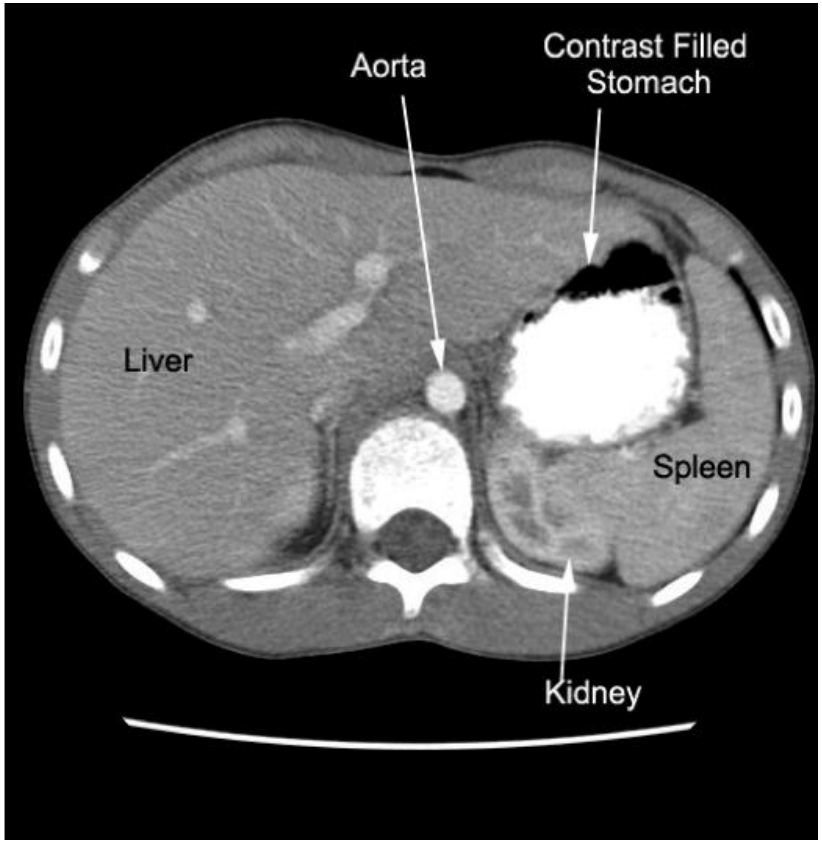


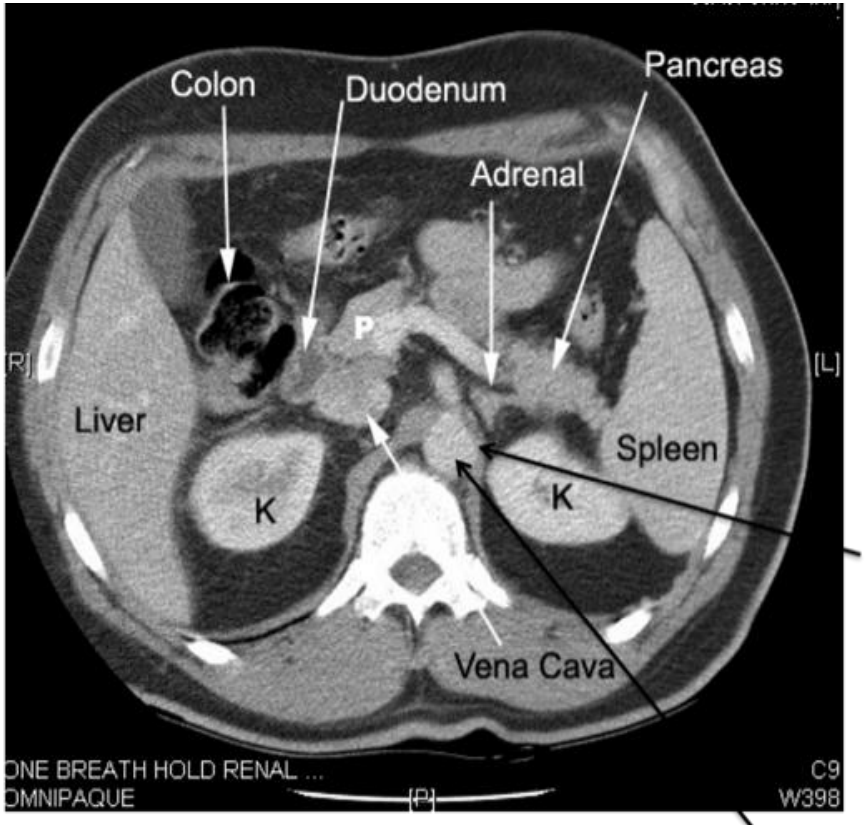
Kidney Imaging
CT





Kidney Imaging
CT

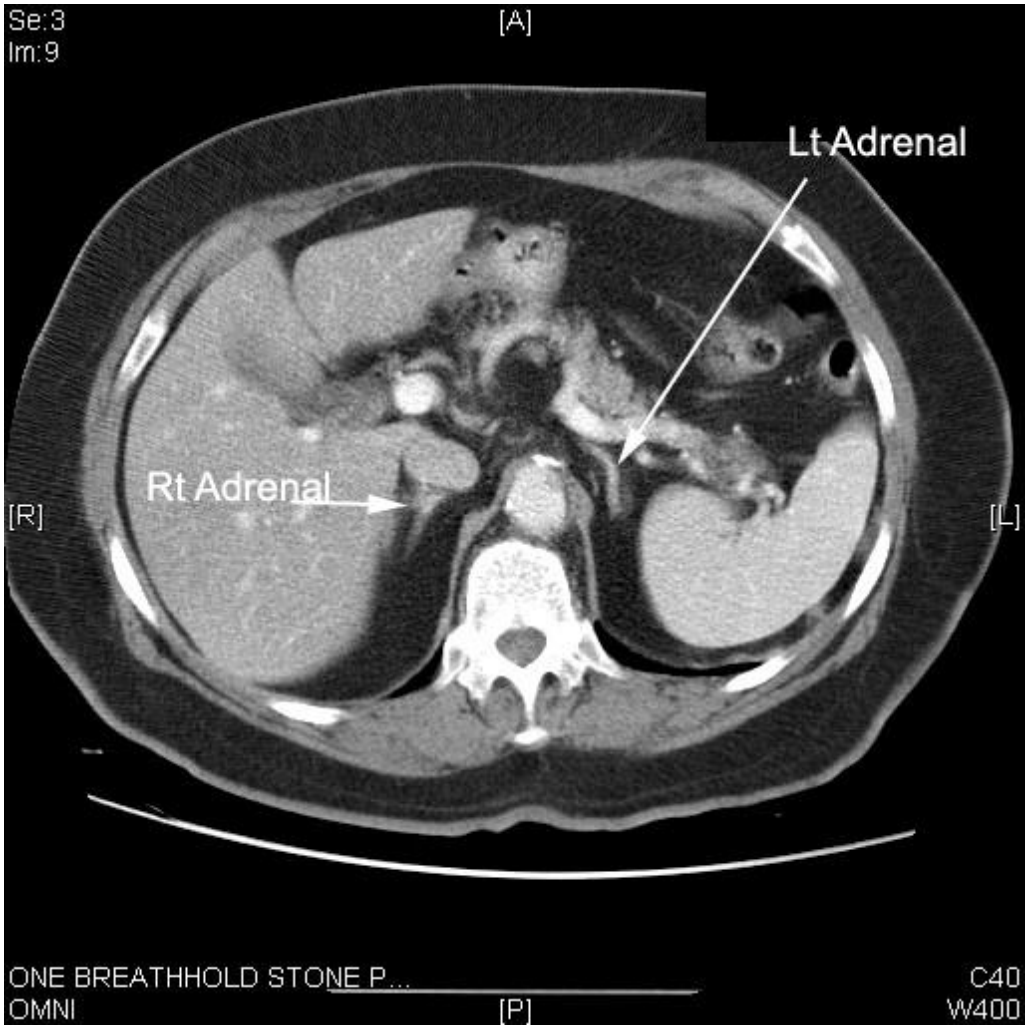




aorta

Diaphragmatic cross

Kidney Imaging
CT

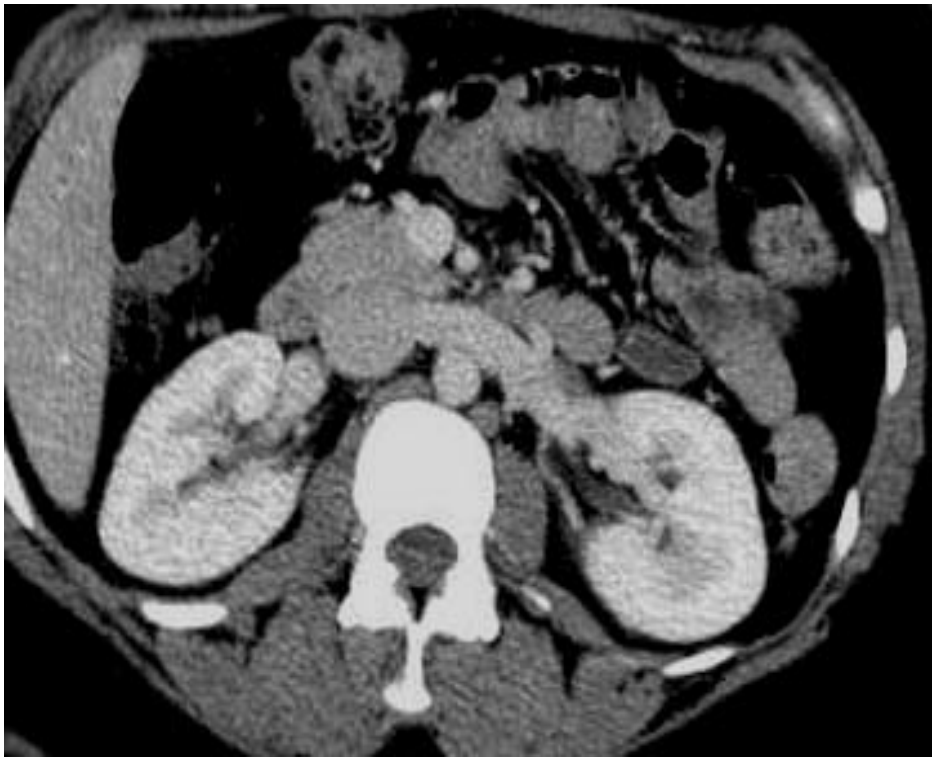


Adrenal Glands are superior to the Kidneys

Kidney Imaging

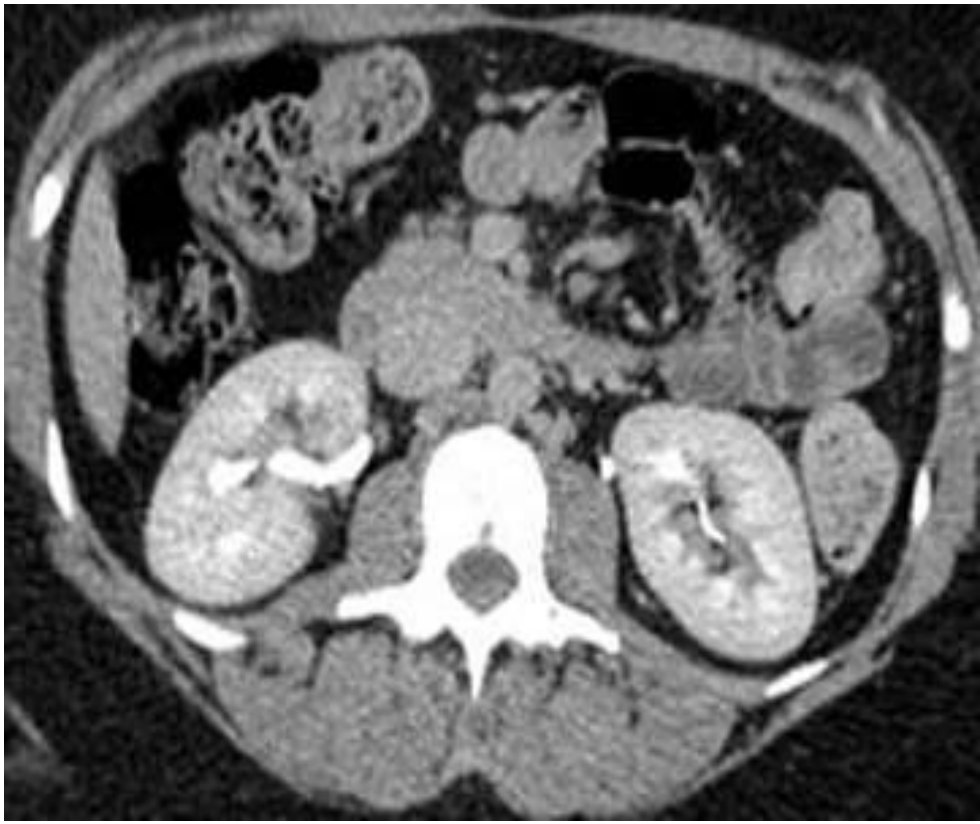
3. Contrast Enhanced CT:

- Contrast enhanced CT scan through the kidneys in nephrogram phase (showing corticomedullary differentiation)
- Contrast needs time to get to the kidneys.This particular picture was taken after 100 sec after injecting the contrast.
- This is approximately 100 seconds following contrast administration and would show renal lesions well



Kidney Imaging

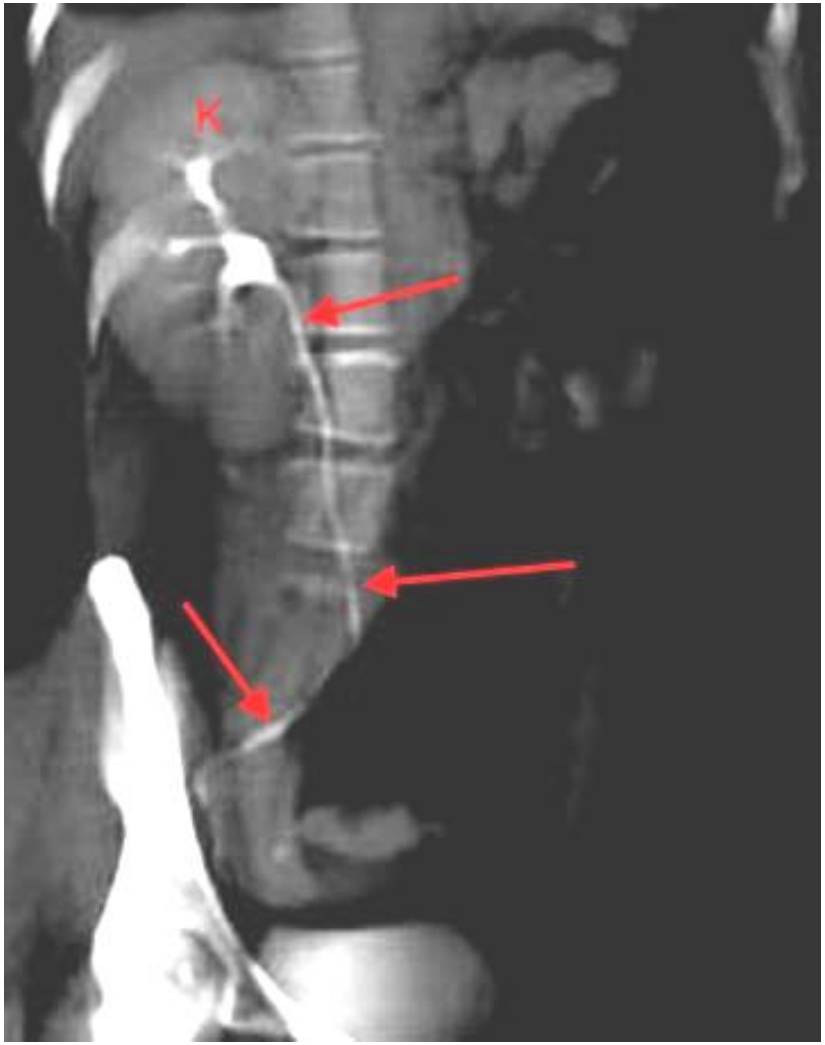
- Contrast enhanced CT scan through the kidneys in pyelogram phase (showing excretion of contrast into the collecting system)
- This is approximately 8 minutes following contrast administration and would show urothelial lesions well, such as transitional cell carcinoma, stones, blood clot



Kidney Imaging

4. CT Intravenous Pyelogram

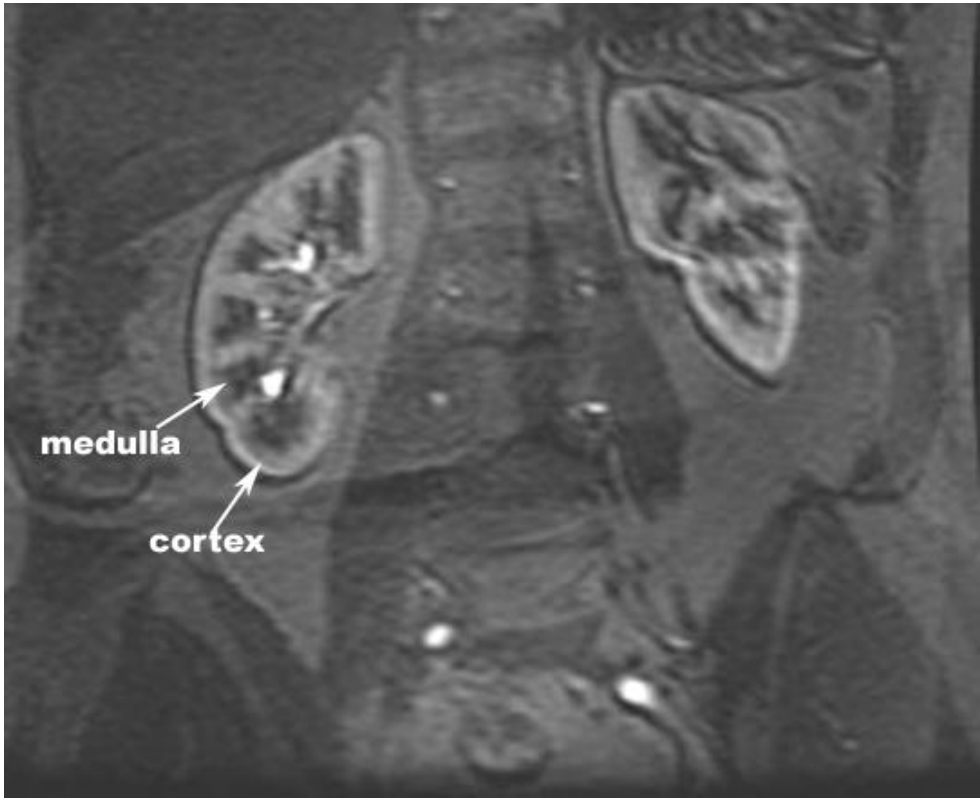
- 3D reconstructed image from CT scan of the abdomen and pelvis known as CT IVP
- This exam is quickly replacing the conventional IV Urogram
- 3D reconstruction is performed through the right kidney (K) and follows the normal ureter (arrows) all the way to the ureter's insertion into the bladder



Kidney Imaging

5. **MRI:**

- Used selectively for specific indication
- Excellent anatomic detail of kidneys
- Safely performed in renal failure
- If the pt. is allergic to contrast, MRI is the best option (No Ionizing radiation) "advantage"
- But it is expensive & time consuming



Spaces Around The Kidney

1. PerirenalSpace: bounded by the leaves of the Gerota's fascia fascia (is a layer of fascia that surround the perirenal space and separating it from para-renal space)

- 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
- Significance:
  - if there is any trauma to the kidneys and there is bleeding the blood will go to the peri-renal space
  - If there is any inflammatory process or infection within the kidneys that produced pus will be also in this space and that is helpful to locate the site of the pathology : within the kidny peri-renal space or out side in the para-renal space

Spaces Around The Kidney

2.Anterior Pararenal Space- bounded

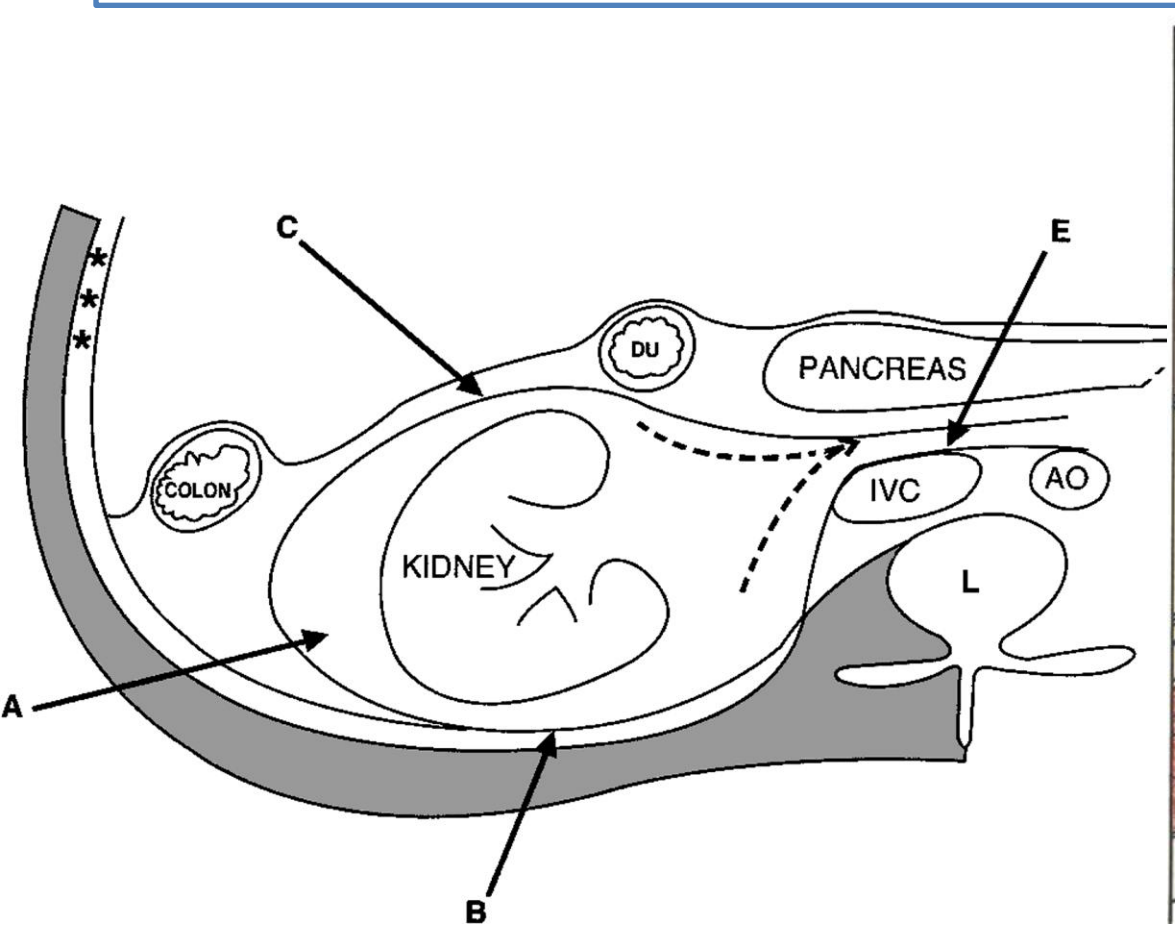
- Posteriorly by the anterior portion of the renal fascia,
- Anteriorly by the posterior parietal peritoneum
- Laterally by the lateral conal fascia
- Contains – pancreas, 2nd,3rd and 4th portions of the duodenum, ascending and descending colon, vascular supply to the spleen, liver, pancreas and duodenum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

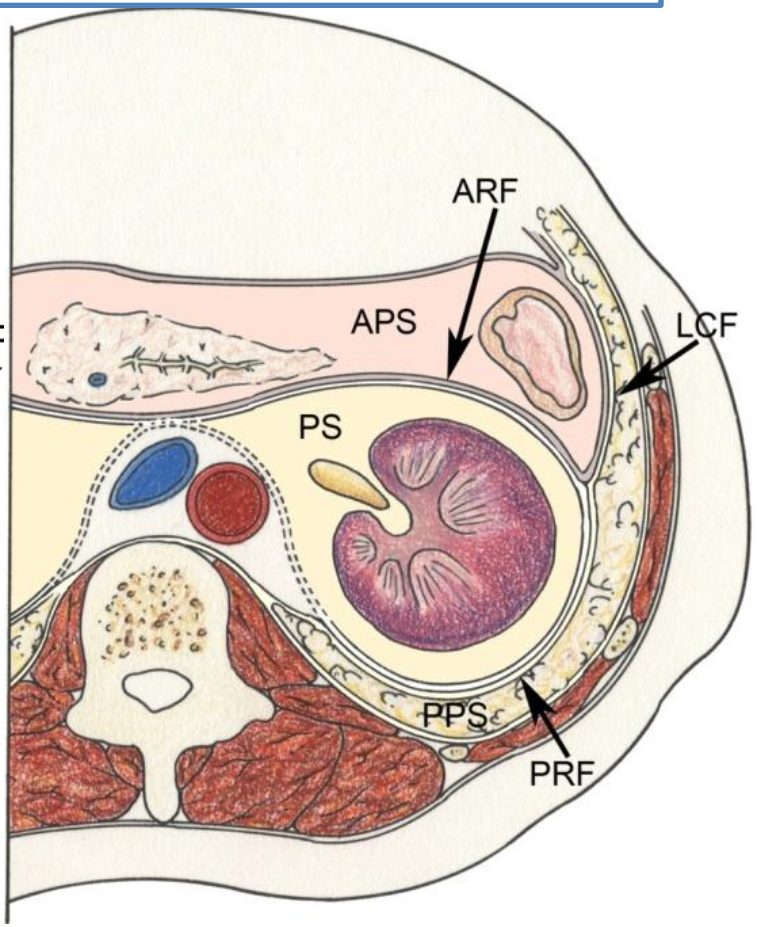
3.Posterior Pararenal Space – is bounded

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

Spaces Around The Kidney

All three spaces potentially communicate at the pelvic brim





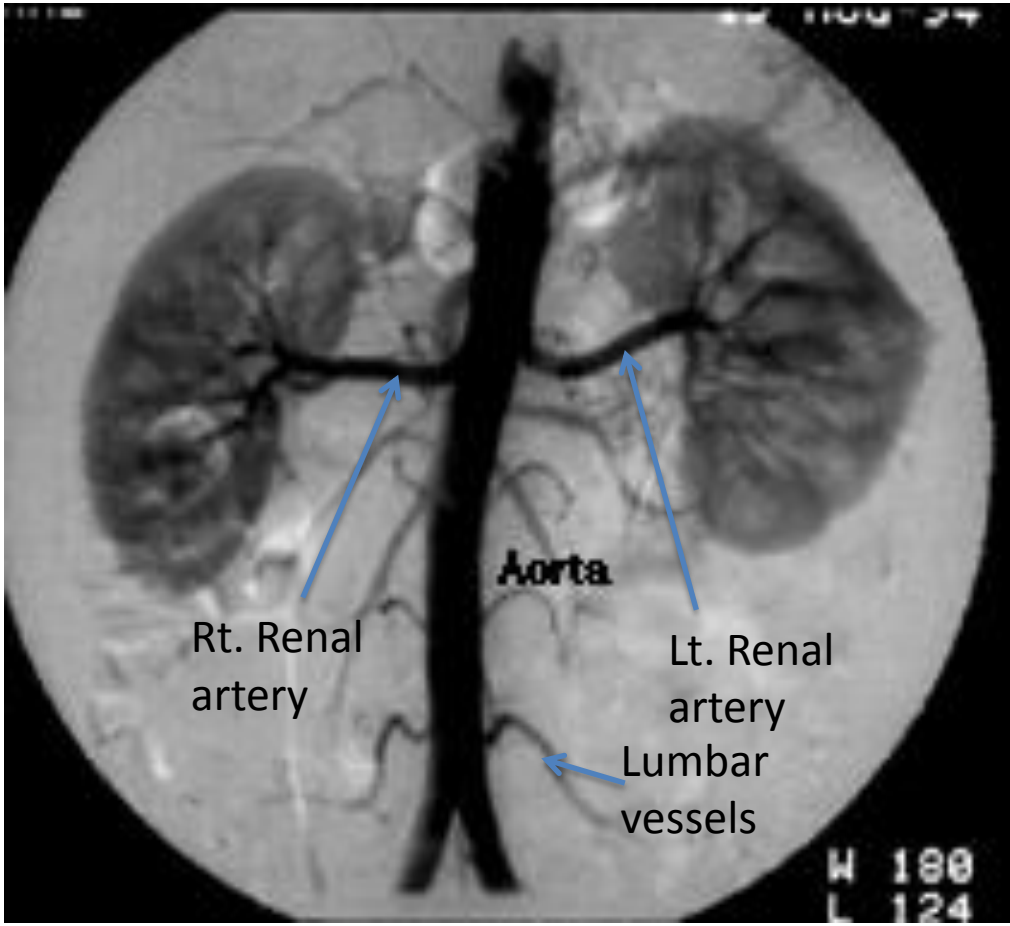
Renal Vasculature

- 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 the left renal vein while the right gonadal vein drains directly into the inferior vena cava
- Common variants include retroaortic and circumaortic left renal veins

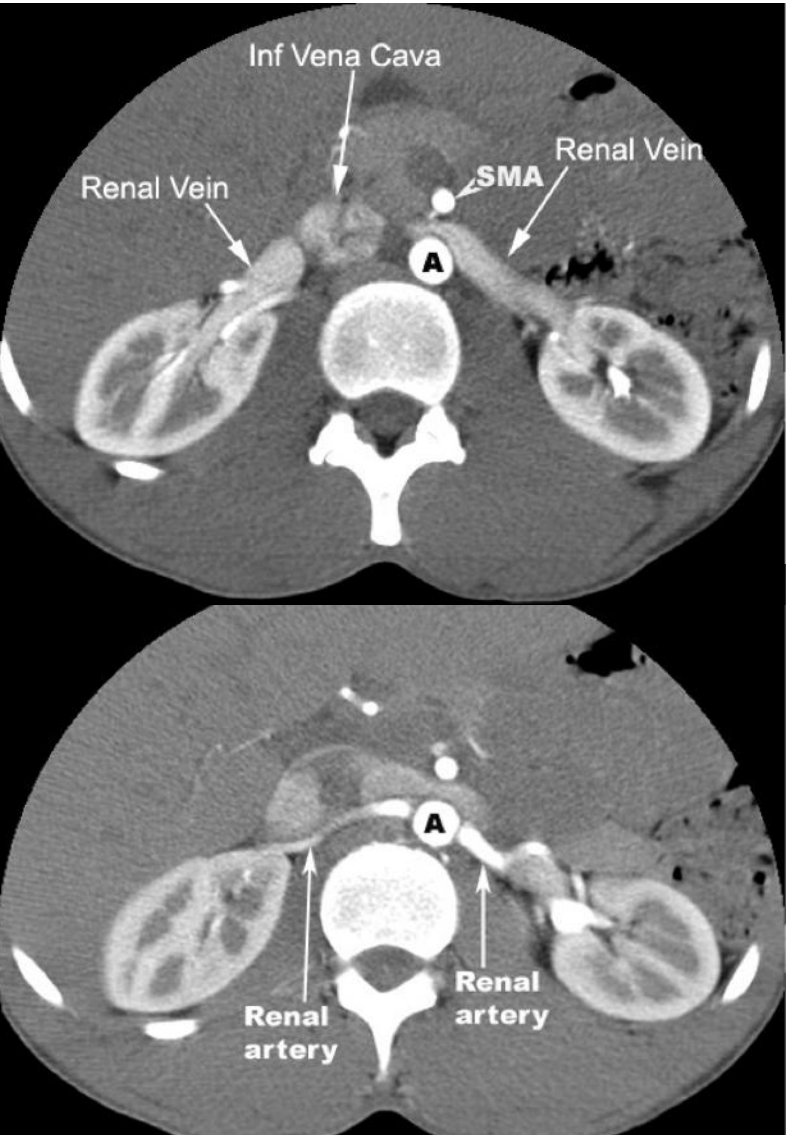
Renal Vasculature Imaging
1. Angiography

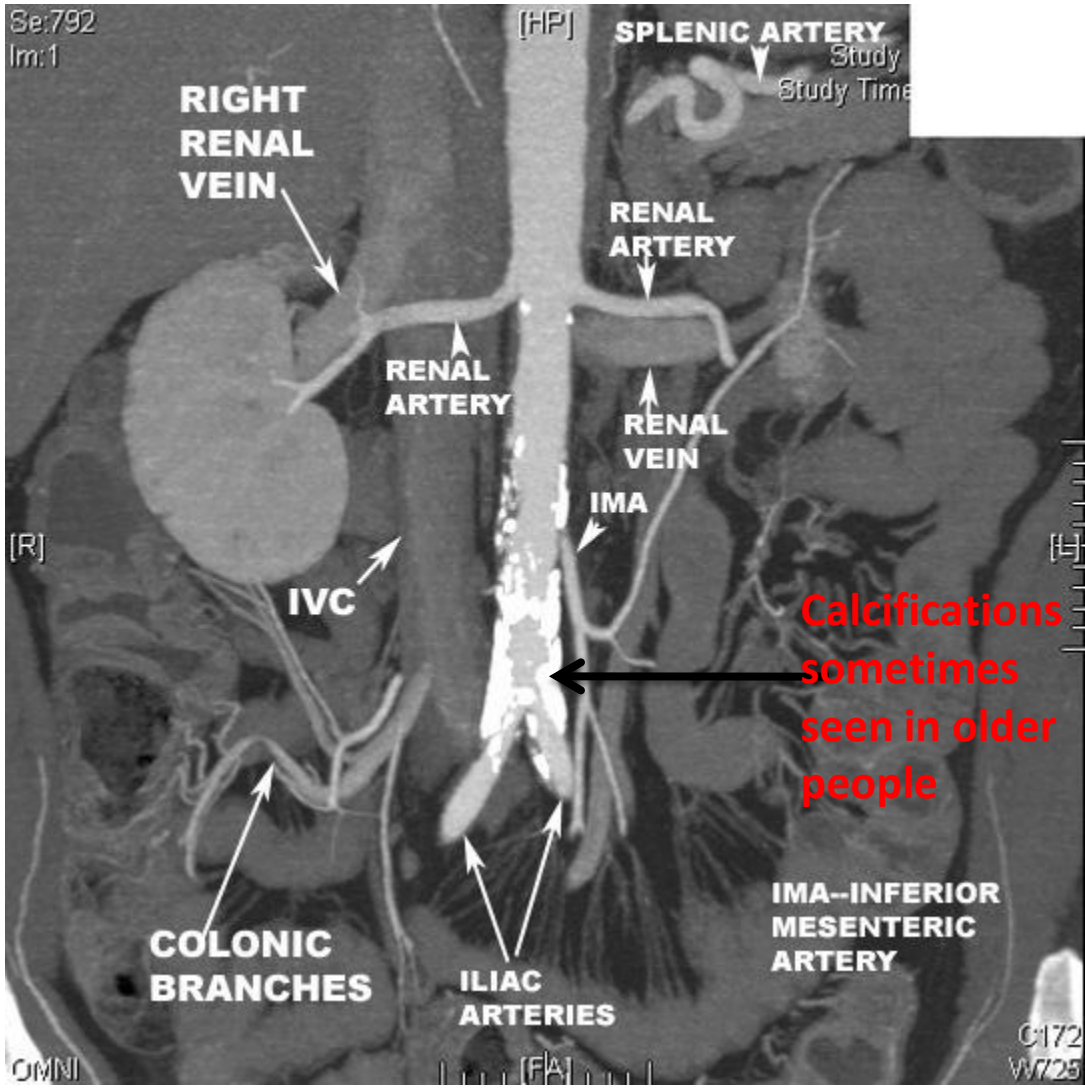
- It is the best modality (gold standard) for investigation of arteries and veins
- Urinary tract hemorrhage
- Renal artery stenosis
- Partial nephrectomy
- Significant risk of complication because of the contrast and very expensive

Picture: The typical image of an angiogram. We can see if there is any stenosis which will appear as narrowing or occlusion within thevessel and the vessels will not appear dark. If there is any tumor in the kidney,we will see it enlarged with abnormal vessels

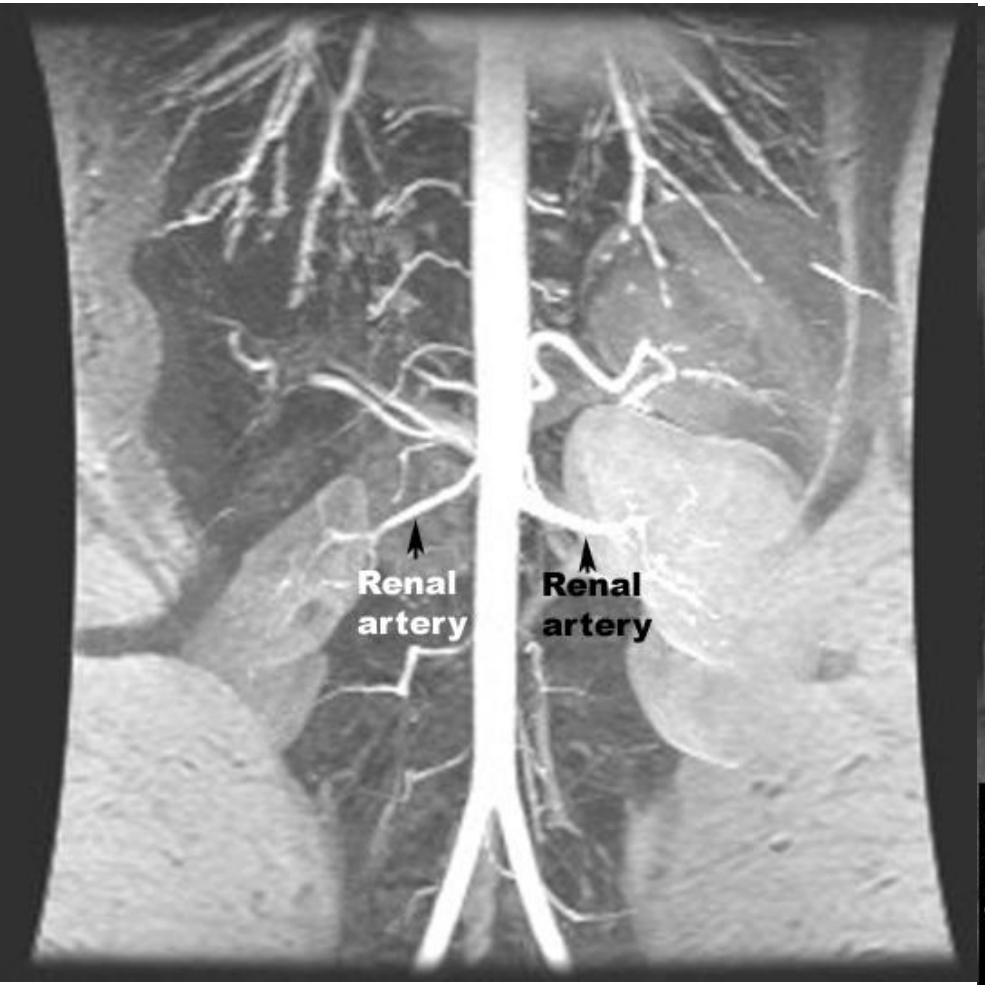


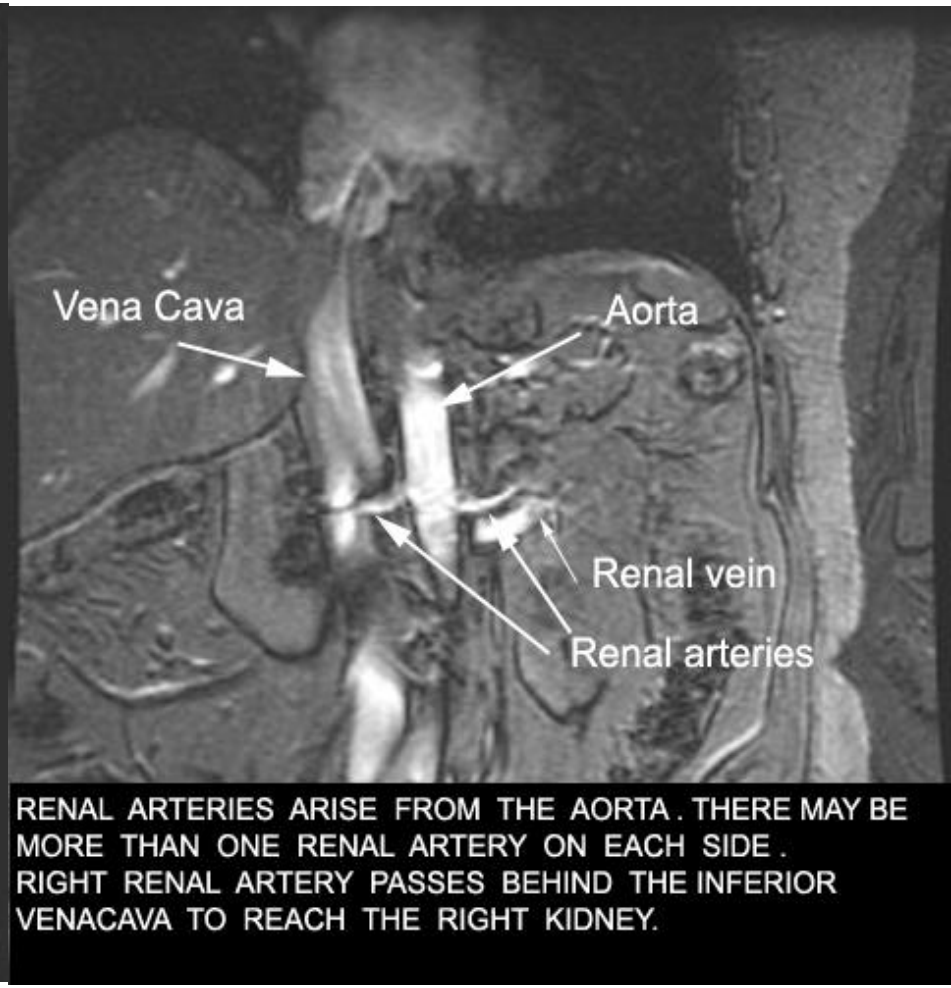
Renal Vasculature Imaging
2. CT angiogram (CTA)





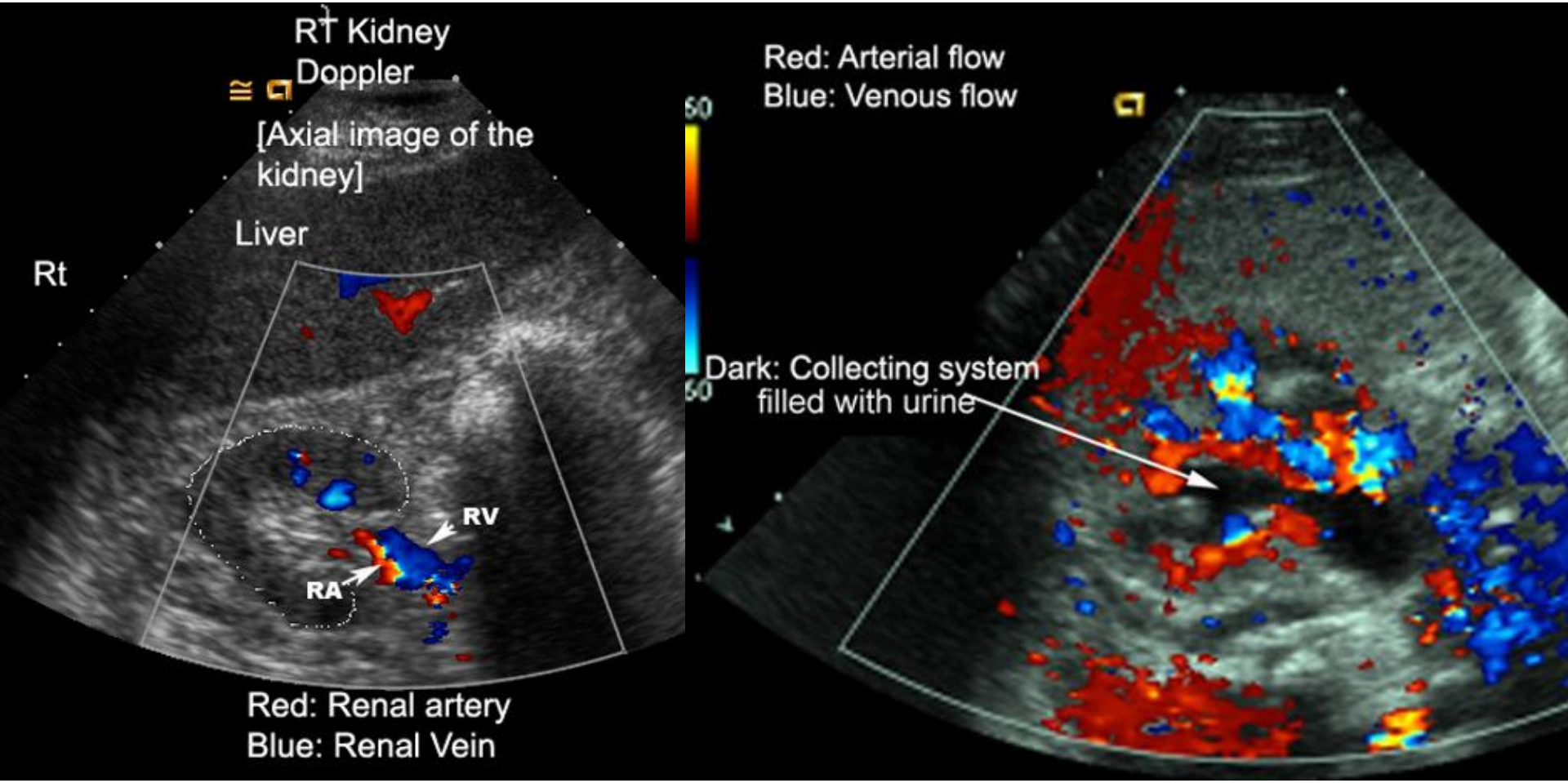
Renal Vasculature Imaging
3. MRI angiogram (MRA)





Renal Vasculature Imaging
4. Doppler ultrasound

- The renal veins are **anterior** to the arteries



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

4. 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

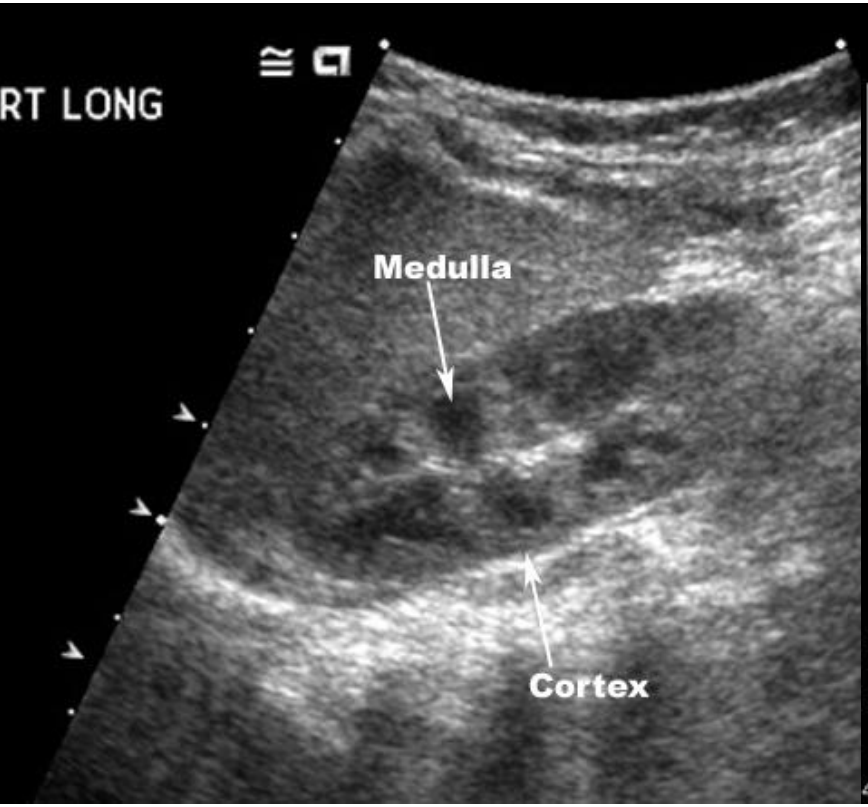
–Major calyces combine to form the pelvis

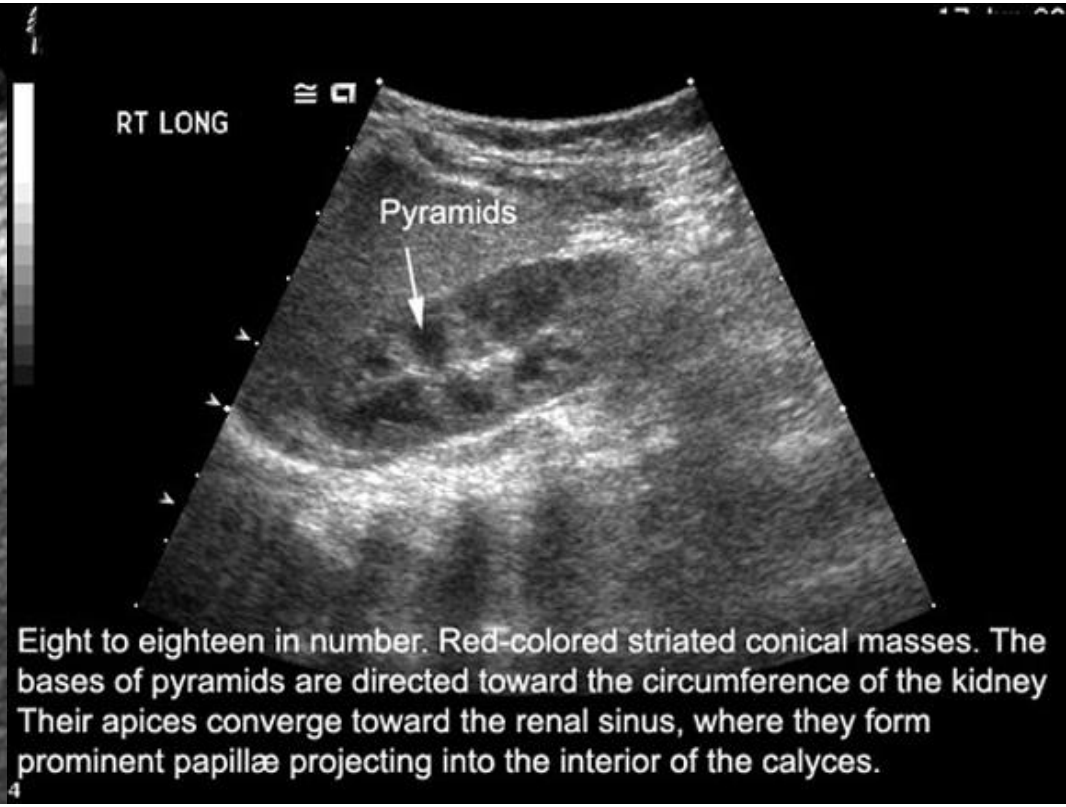
- Pelvis

–Broad dilated part of the urine collecting system, located in the hilum

– Renal pelvis drains into the ureter

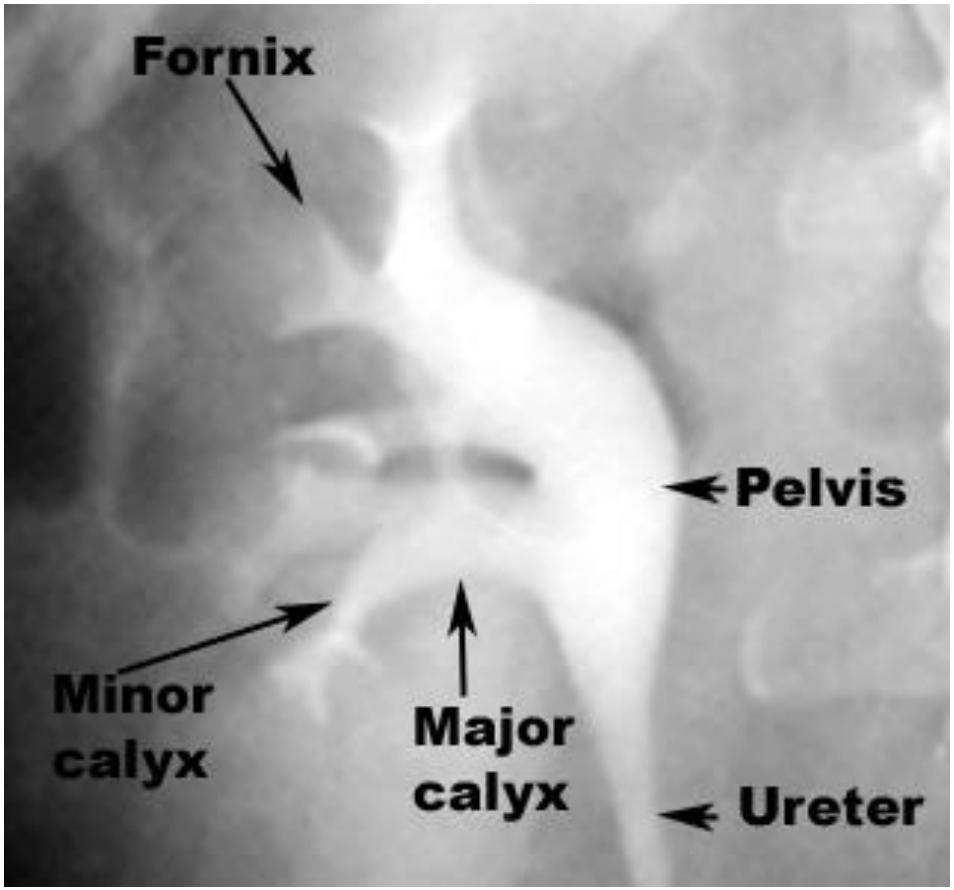
Renal Structure
Cortex, Medulla, Pyramids

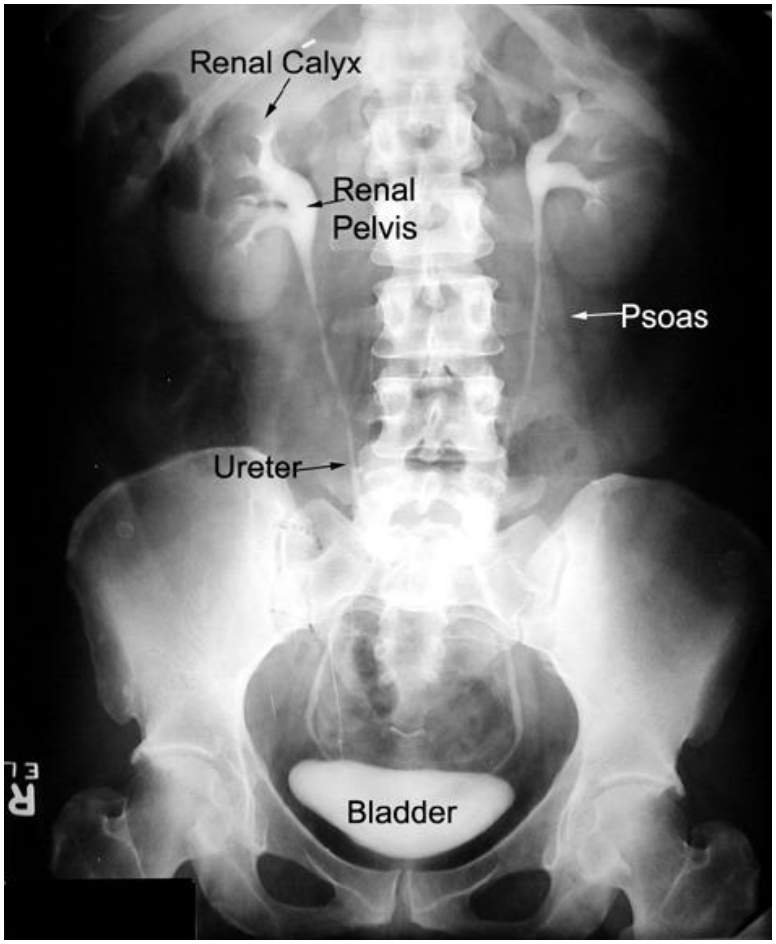




Eight to eighteen in number. Red-colored striated conical masses. The bases of pyramids are directed toward the circumference of the kidney Their apices converge toward the renal sinus, where they form prominent papillæ projecting into the interior of the calyces.

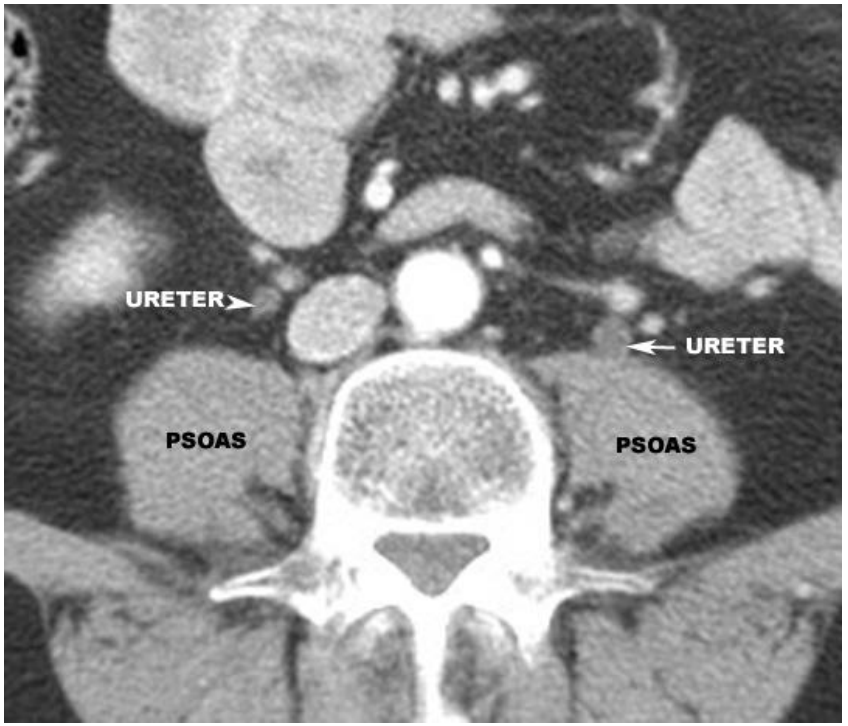
Renal Structure
Calyces and Pelvis





Ureters

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



Ureters

- **Areas of Narrowing**

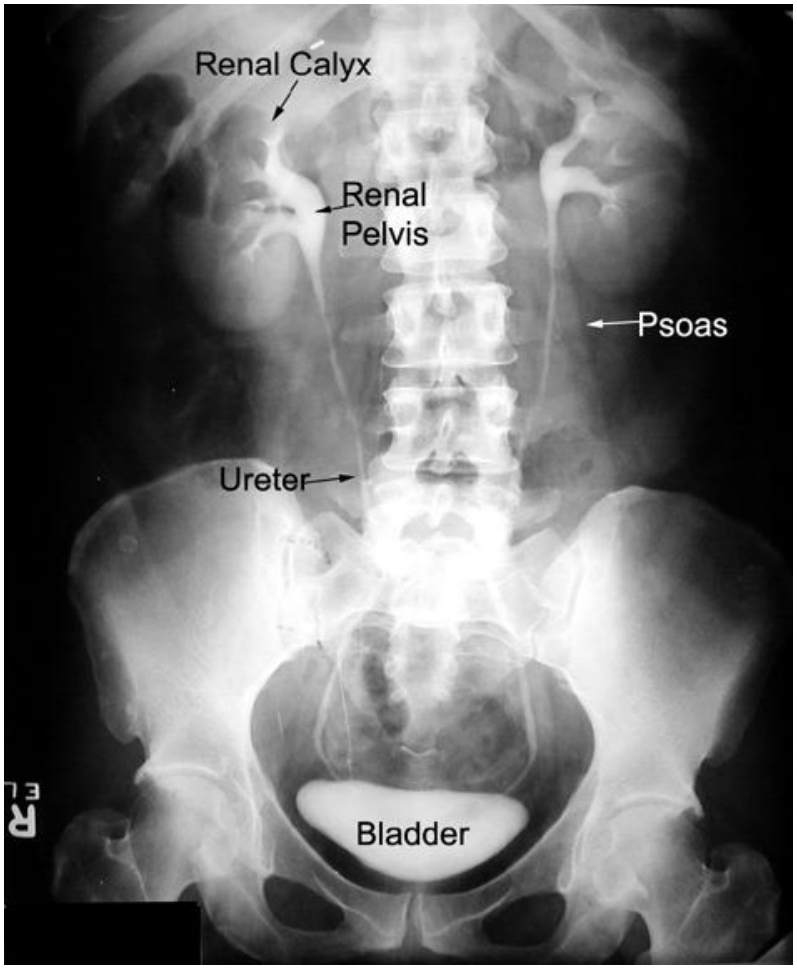
Three areas of normal narrowing:

1. Ureteropelvic Junction
2. Bifurcation of the iliac vessels
3. Ureterovesicle Junction

- **Ureteral Vasculature :**

The ureteral branches of renal and testicular or ovarian arteries, and abdominal aorta supply blood

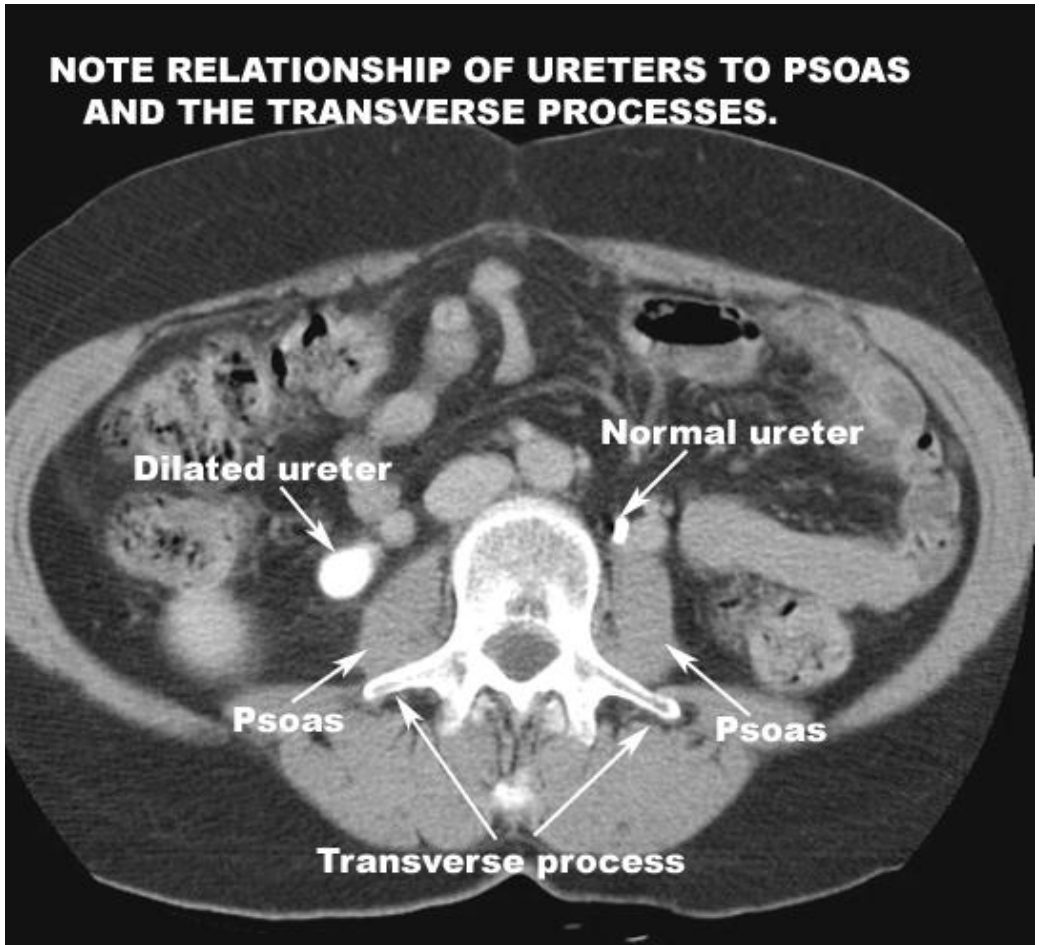
Renal and testicular or ovarian veins supply venous drainage



Ureters

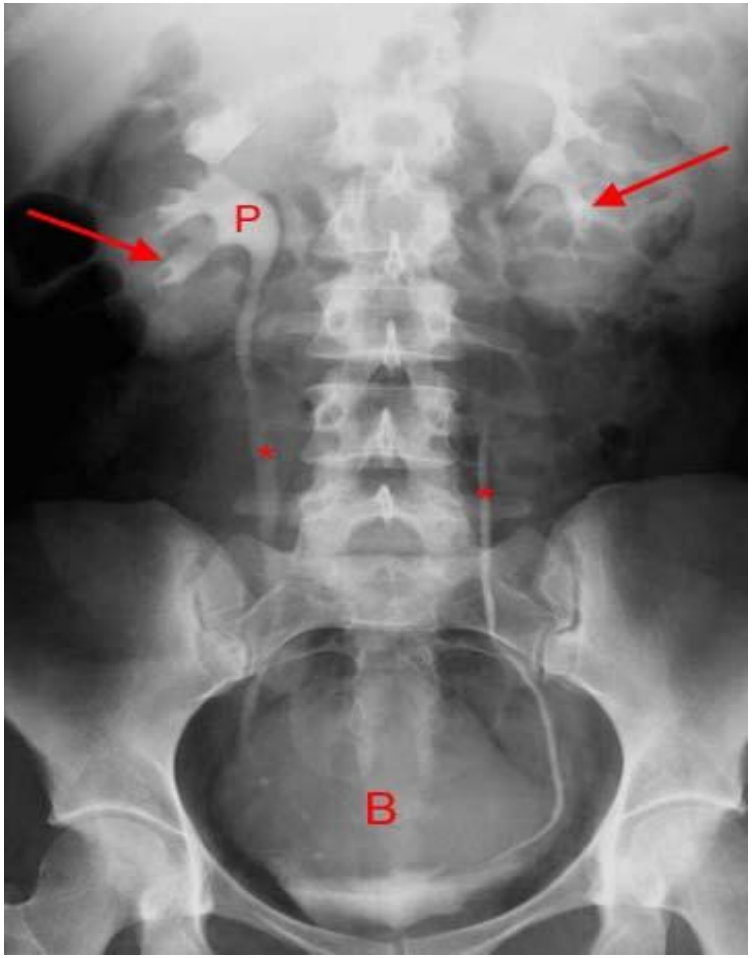
Ureters are bright due to contrast.

Right ureter is dilated in the CT due to **a distalobstruction**

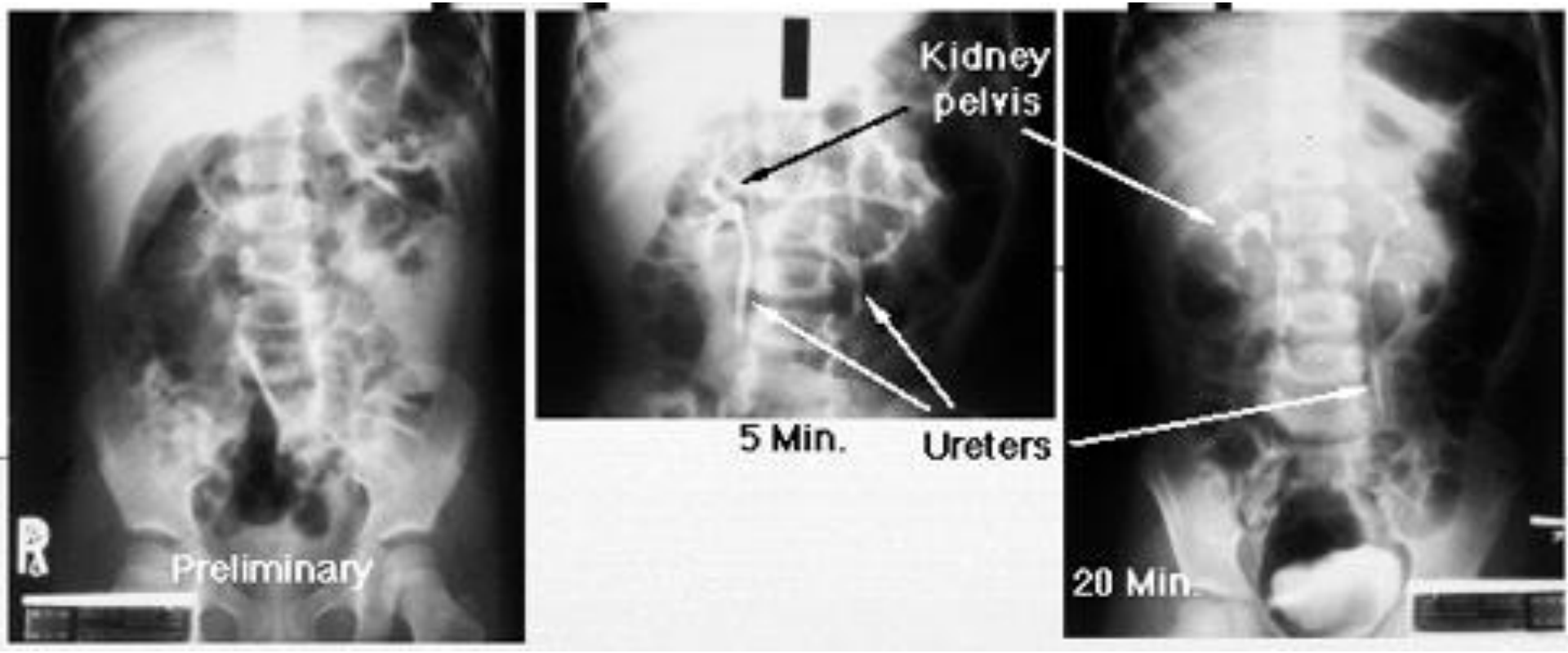


Ureters Imaging
IVP

- Demonstrates renal, uretral, and bladder anatomy
- Gross estimate of function
- Ionizing radiation
- Requires IV contrast
- Patient prep
- IVP shows if the kidneys are functioning well or not, if there are any stones or obstruction
- It works by injecting a contrast in the patient. The contrast is removed from the bloodstream through the kidneys. X-rays are taken to capture the contrast as it travels through the urinary system



Ureters Imaging
IVP



Ureters Imaging
Retrograde Pyelogram

- Uses a contrast to determine whether a kidney stone or something else is blocking the urinary tract.
- Contrast is injected into the urethra in order to visualize the ureter and kidney. The flow of contrast (up from the bladder to the kidney) is opposite the usual flow of urine.

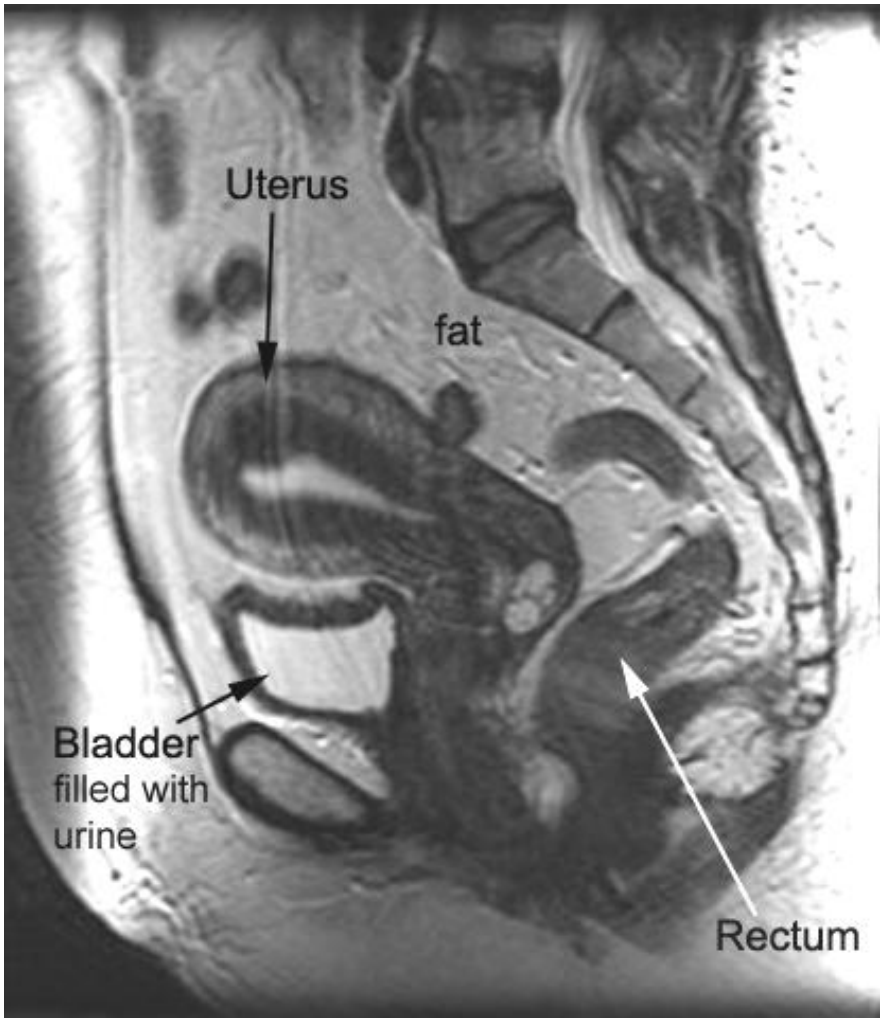
Urinary Bladder

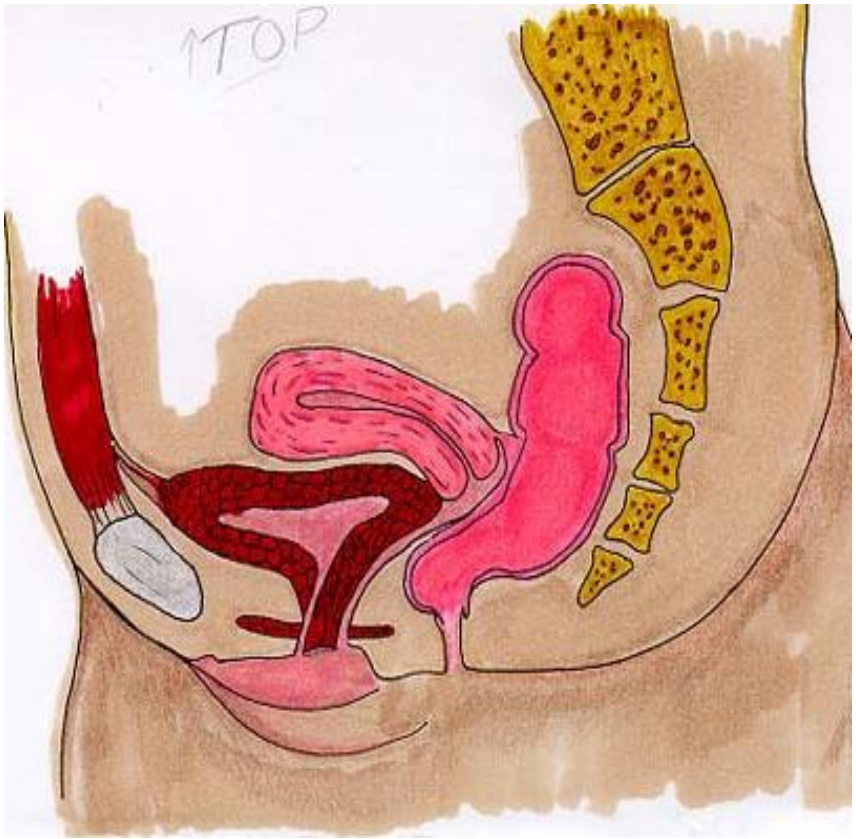
- Hollow muscular vesicle for storing urine temporarily
- Bladder is higher in position in children and slightly higher in males than females
- It is relatively larger in children than in adults
- Size and shape vary considerably
- Shape – tetrahedral when empty–transversely oval or round when full
- 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

Urinary Bladder

- 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

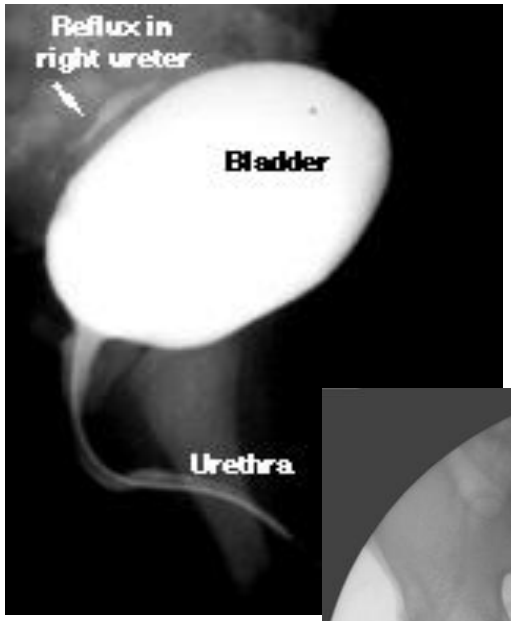
Urinary Bladder
Anatomy of Female Pelvis

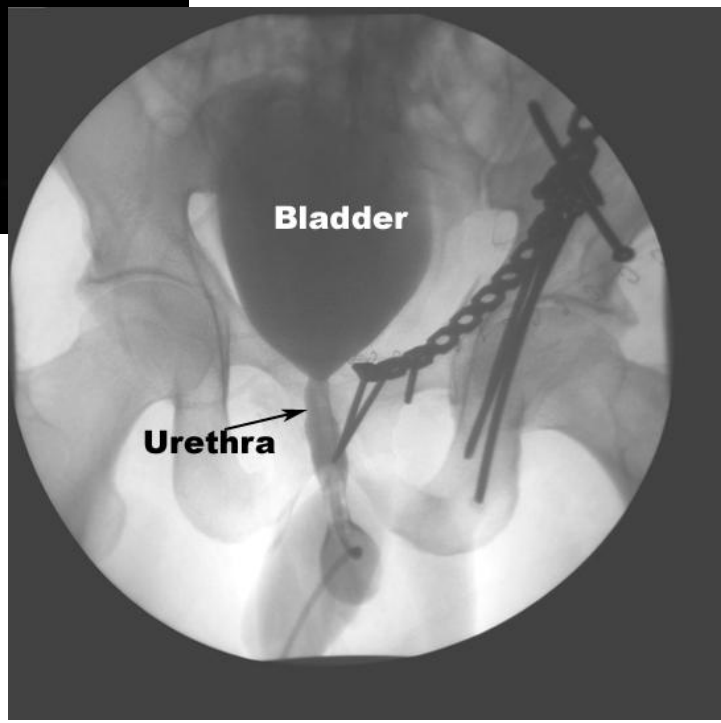




Urinary Bladder Imaging
1. Voiding Cystourethrogram

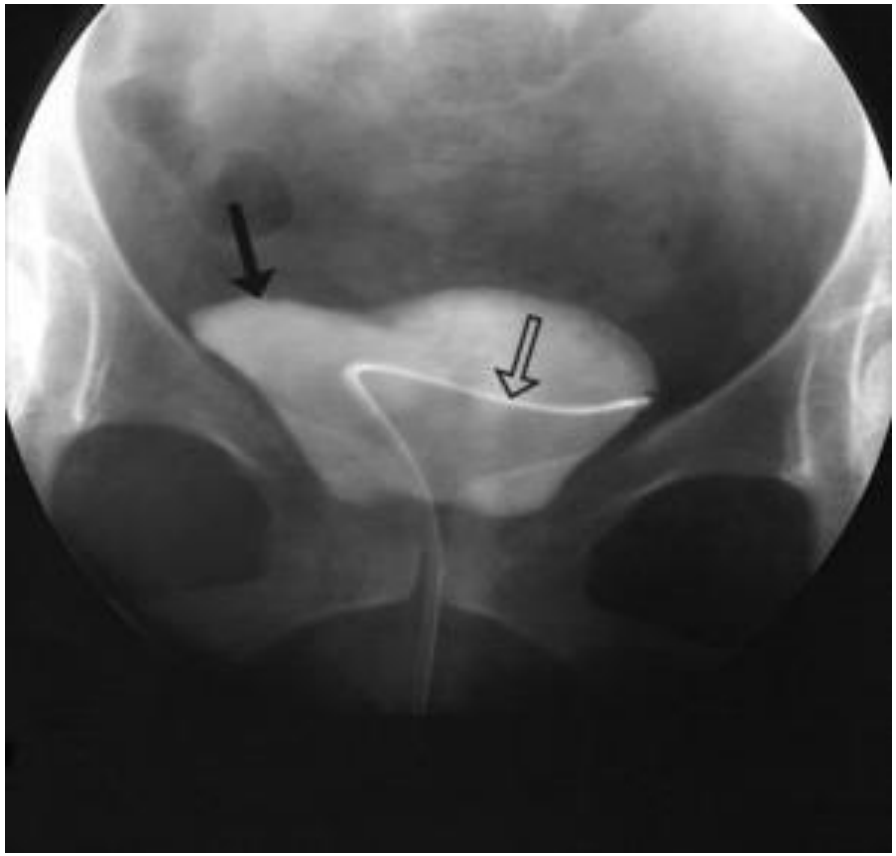
- Indicated mainly in pediatric pt. for VUR (vasicouretric reflux), urinary bladder and urethra abnormality.
- A catheter is applied through the urethra to the bladder. Once the catheter is in the bladder we inject the contrast. If there is a reflux, the contrast appear in the ureter.





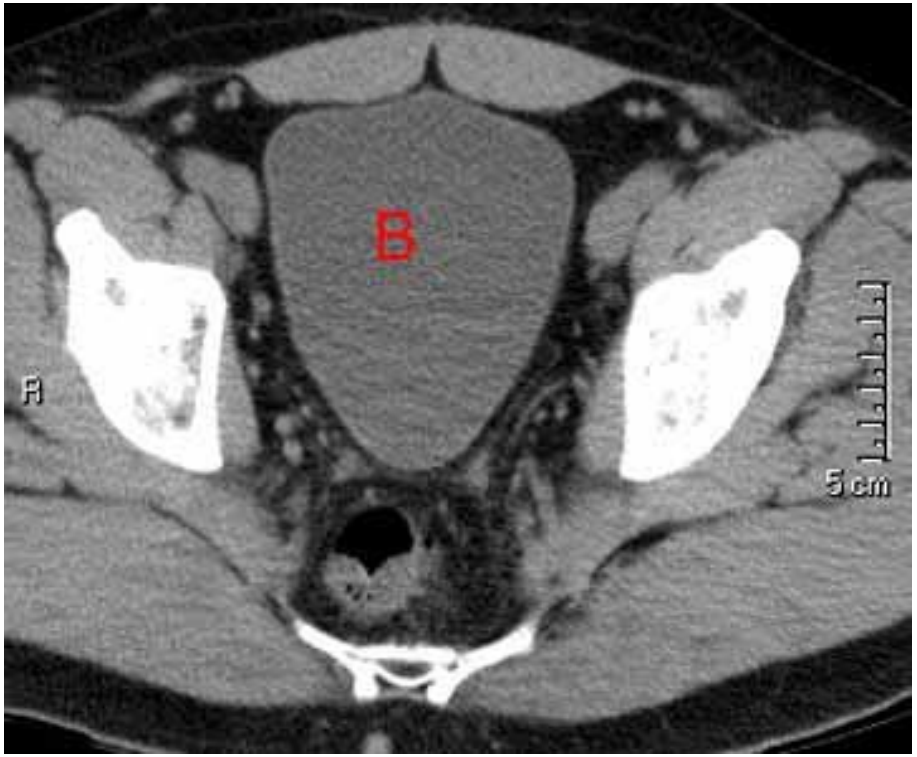
Urinary Bladder Imaging
2. Cystogram

- Catheter can only be placed at the tip of the urethra
- No need to go in the bladder unless she is a female pt. (mostly done with adults)
- A cystogram can asses the bladder's position shape, injury, and fistula.



Urinary Bladder Imaging
3. Unenhanced CT scan

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

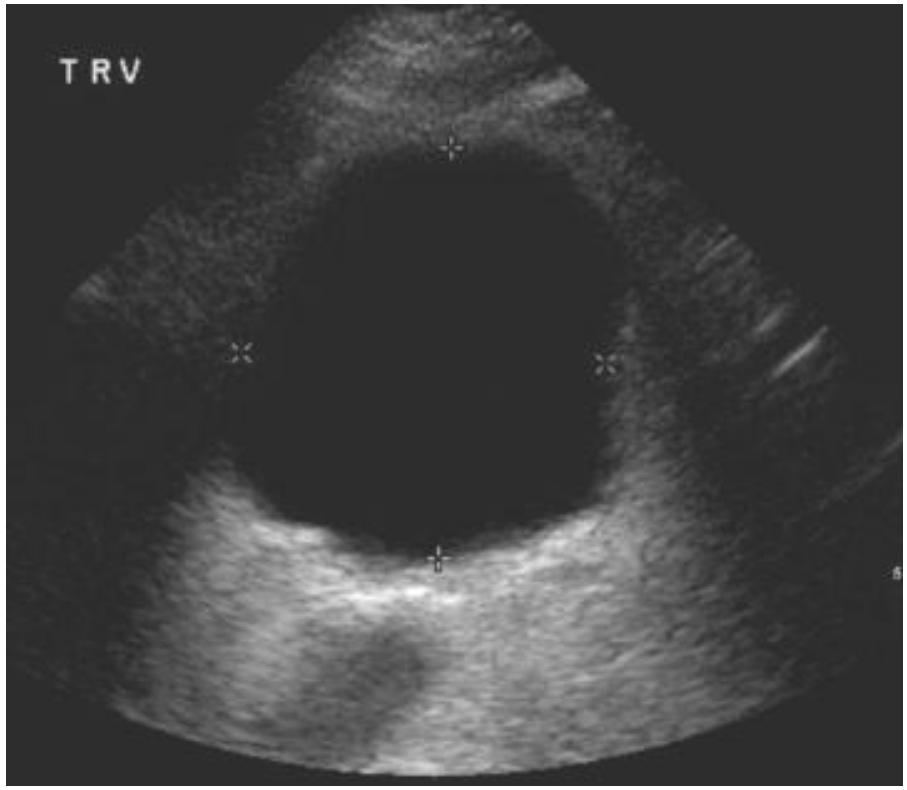


Urinary Bladder Imaging
4. CT IVP 3D reconstruction

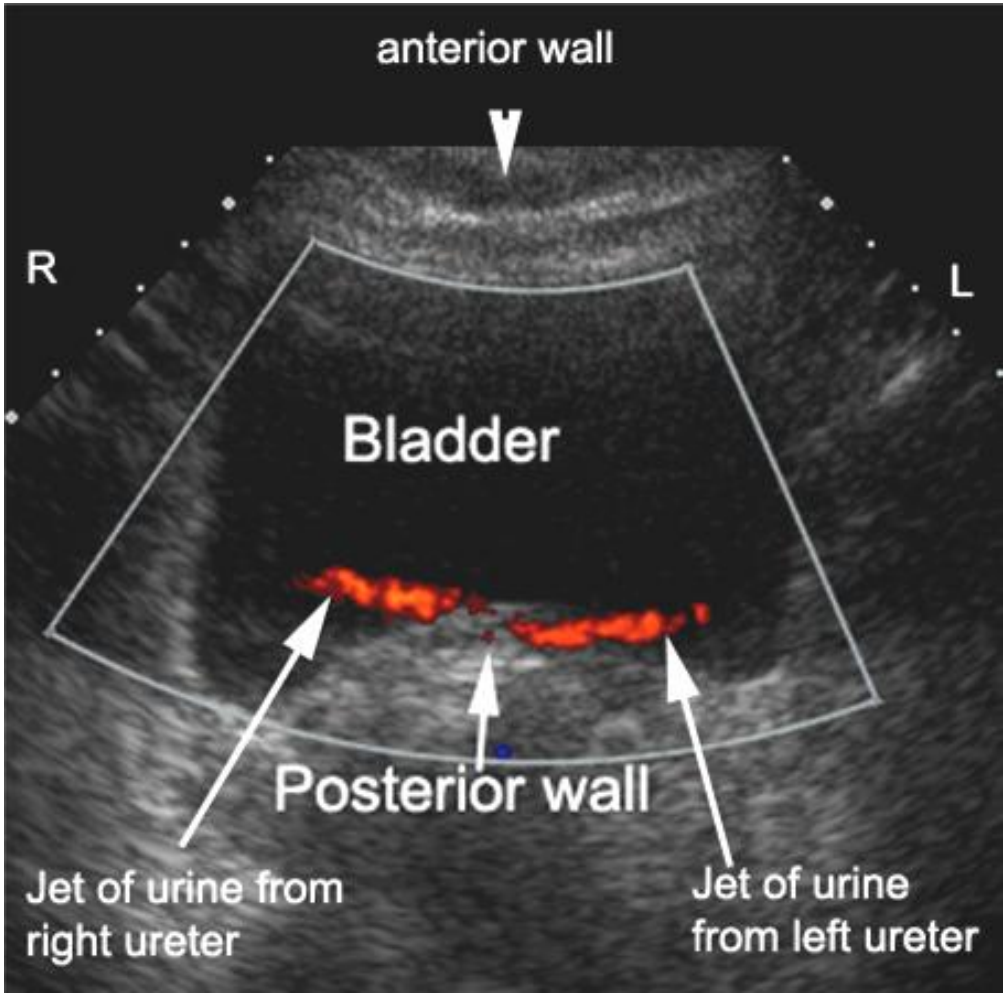
- 3D reconstructed image of a normal bladder in the sagittal plane following CT IVP
- This is delayed image 10 minutes following IV contrast administration, excreted contrast fills an otherwise normal bladder (B)

Urinary Bladder Imaging
5. Ultrasound

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



Urinary Bladder Imaging Ultrasound



Nuclear Imaging of Urinary System
Renal Scintigraphy

- Used in evaluation of Renal anatomy and function
- Radioactive materials are injected in the patient
- And then the pt is placed under the gamma camera, so **in this modality the pt. is the source of the radiation , this is why it is contraindicated in children & nursing mothers**
- Renal Radiopharmaceuticals:

  Perfusion MAG3 (mercaptoacetyltriglcine)
  DTPA(diethylenetriaminepentacetic acid)

  Morphology DMSA (dimercaptosuccinic acid)

Renal Scintigraphy
Normal Kidney Function and Anatomy