



Radiology of urinary system diseases

Objectives

1. To know the principle disease entities of the urinary system organs and how they look in imaging.
2. To correlate the clinical manifestations with radiological images

The original lecture is presented by

Dr. Husain Turkistani

Done By

Team Leaders:



Khalid Alshehri



Hanin Bashaikh

Team Members:



Fahad Alzahrani



Khalid Aleedan



Allulu Alsulayhim



Laila Mathkour

Revised by:



Basel Almeflh

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Urinary diseases



1- Renal Colic

- It's caused by renal calculi.
 - **Classic presentation** (if the calculus is obstructing the urinary tract the following symptoms will appear): **sudden onset of severe flank pain, Radiating inferiorly and anteriorly to groin area +/- nausea and vomiting**) This pain has been described by the patient as the most excruciating pain ever felt. The experienced ER physician could diagnose it just from the first moment after seeing the patient.

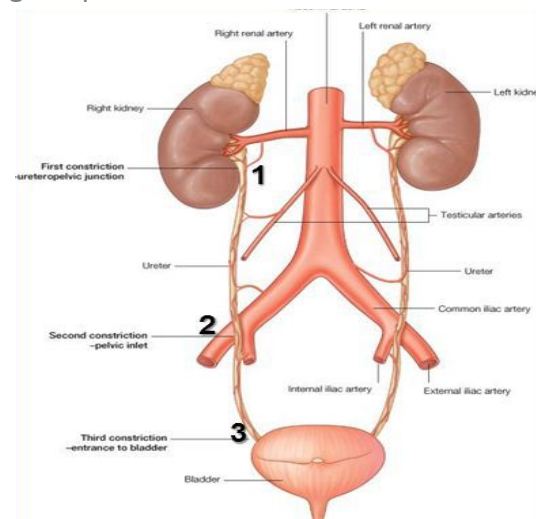
- Small, non obstructing or staghorn calculi may be asymptomatic or cause mild to moderate symptoms which are tolerable.

- Diagnosis often made clinically¹.

- **Imaging: to confirm and evaluate calculi.**

The common sites for stone obstruction:

- 1) Ureteropelvic junction.
- 2) Cross of iliac artery.
- 3) Vesicoureteral junction.



Questions to ask:

- Are urinary stones present? If so, what is the level and size?

Depending on the size the management will be different either conservative (medically) or interventional (surgery).

- Is obstructions present? If so, what is the level and severity?

Severity: is it completely occluding the ureter and causing severe hydronephrosis? (we can see it on US and CT). If yes, it can cause severe sepsis which is fatal if it's ignored.

- Is urgent intervention required? Think about intervention if the patient have the following symptoms:

Factors include:

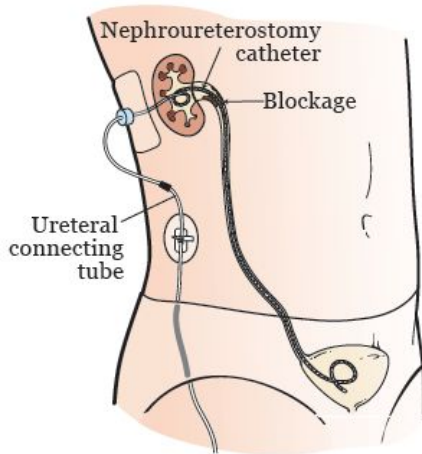
1. **Urosepsis** (increased creatinine - hyperkalemia, it must be treated fast to prevent septic shock).
2. **Solitary kidney** (should be treated fast and taken seriously because the patient have only one kidney and you want to save it to save the patient's renal function).
3. **Severe pain** not respond to analgesics.

¹ usually the patient comes to the ER and the physician from the severity of pain and the position of the patient so the physician will know the patient has renal colic .

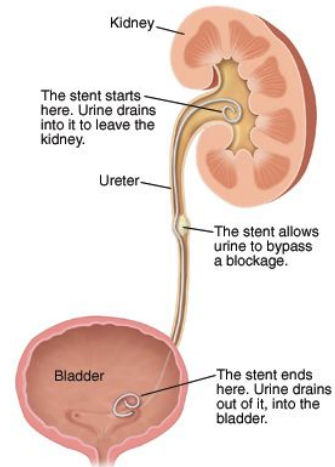
Treatment:

Percutaneous nephrostomy insertion of a catheter through the skin and into the renal pelvis or Ureteric stent.

If there is obstruction we need to relieve this obstruction. For example; if there is renal obstruction like a mass or a calculus we need to remove it, how? We go percutaneously and 1- by fluoroscopy guidance we insert nephrostomy catheter so the hydronephrosis will be relieved. or 2- by ureteric stent where we can go percutaneously through nephrostomy under fluoroscopic guidance and put JJ stent (it has J shape on the upper and lower ends, the first J will be fixed on the bladder and the other J will be fixed on renal pelvis) or we can put the ureteric stent by cystoscopy.

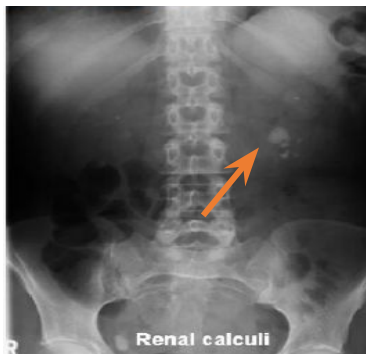


Percutaneous nephrostomy



Ureteric stent

1- Renal Colic (cont')



Left radiopaque opacity, and it is about 9 mm or 1 cm.

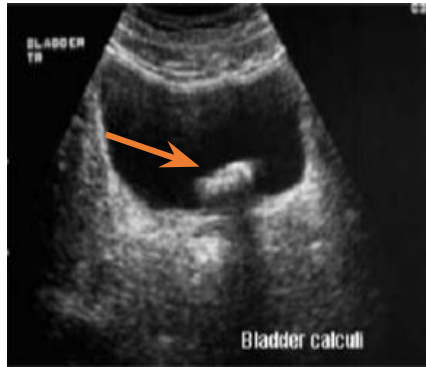
KUB: to assess total stone burden, size, shape, location (is it on the pelvis, mid ureter, bladder?) Often US or CT is required in conjunction.



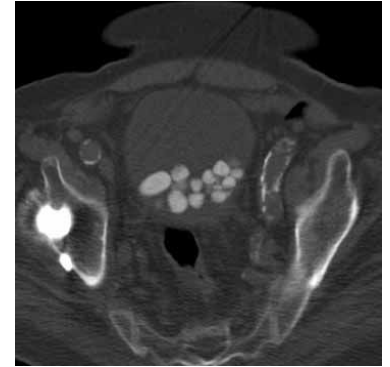
Bladder calculi (microscopic hematuria)



Multiple radiopaque opacities in the bladder. An example of bladder calculi in KUB

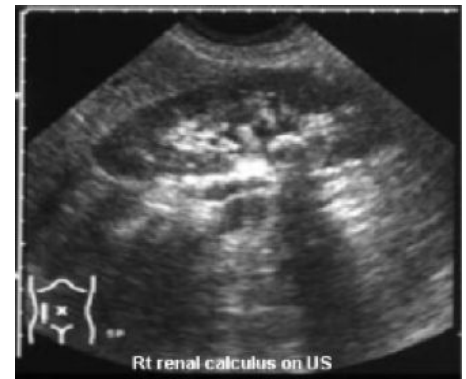


In US: hyperechoic structure (stone) with shadow behind



In CT: axial section; multiple bladder stones²

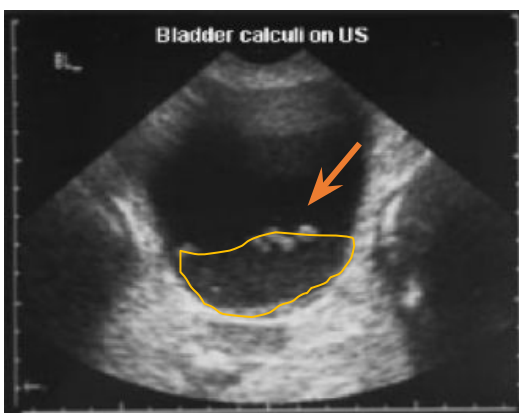
Renal calculus - Ultrasound



Renal stones in US (hyperechoic structure) with a shadow behind.

The shadow is important because we can't say it's stone without the shadow.
(no obstruction = no dilation)

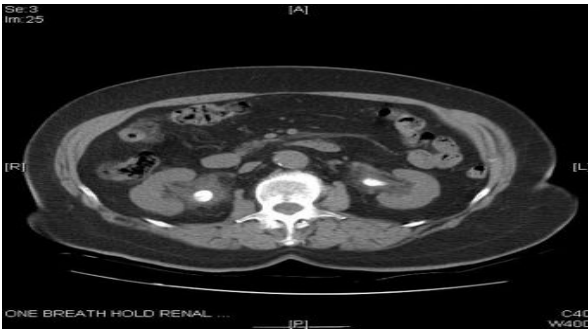
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- **Bladder stone** with some turbulent urine that could be infected.
- Stones will appear white, The reason of the absence of shadow is (the urine in the bladder is dark and the shadow is dark).
- **Fluid (urine)** will appear black (it appears grey instead of black because it is turbid due to inflammation).

² for the renal stones we need CT without contrast bc Ca itself is contrast. Radiolucent stones are very rare renal colic, but if we sceptic it we will see high uric acid in the blood + the CT will show the stone.

Renal calculus - CT scan



Bilateral multiple hyperdense structure (stone) with some dilation which means there is obstruction

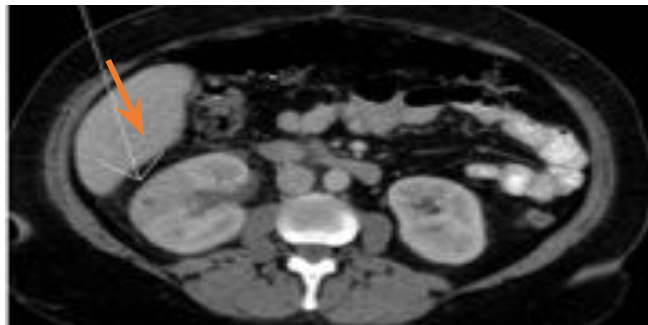


Non obstructive renal stone with no dilation of renal calyceal system "pelvic/renal"

2- infection

1. Acute Pyelonephritis:

- Acute pyelonephritis is a sudden and severe kidney infection. It causes the kidneys to swell and may permanently damage them. Pyelonephritis can be life-threatening.
- Life threatening infection & medical emergency **it can cause urosepsis and septic shock.**
- Bacteria can be sent through lower urinary tract (**ascending upper urinary tract infection**).
- Early diagnosis and management has significant impact on patient outcome.
- **Risk factor:** obstruction, diabetes, obesity, female anatomy (short urethra).
- **Presentation:** (Fever, loin pain, nausea/vomiting, **sometimes microscopic hematuria**).
- **Pregnant women are more prone to acute pyelonephritis, why? because they have short urethra** and the changes in the hormones slows the flow of the urine, as a result, bacteria have more time to grow in the urine before being flushed out. Also, as the uterus grows, the increased weight can block the flow of urine from the bladder, causing an infection.
- The diagnosis of pyelonephritis is based on clinical diagnosis but we do CT just to confirm the diagnosis and to exclude other diseases.
- In case of Acute Pyelonephritis, the functions of the kidney are decreased; **that's why it doesn't take the contrast** and we can confirm that the patient has pyelonephritis. The correlation always with clinical picture will rule out other infections .



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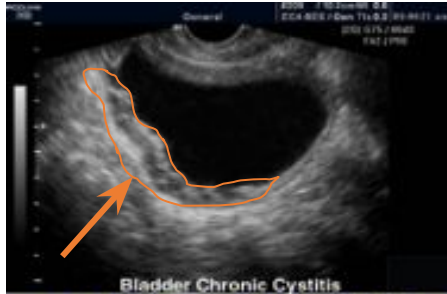
CT with contrast injection pyelonephritis

Wedge shape hypoperfused lesion and the kidney is enlarged.

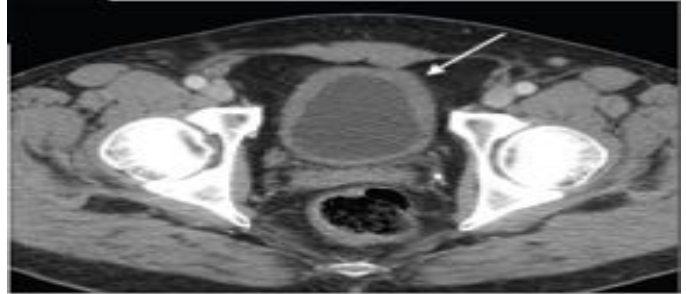
Why there is hypoperfused area? because the the kidney is sub-functional doesn't take the contrast like the normal kidney.

2. cystitis:

- **Presentation:** (Fever, suprapubic pain, frequent urination, sometimes hematuria, dysuria, need to urinate even if there is no urine in the bladder).
- As upper UTI, more common in females because of short urethra.
- E-coli is the most common causative organism.



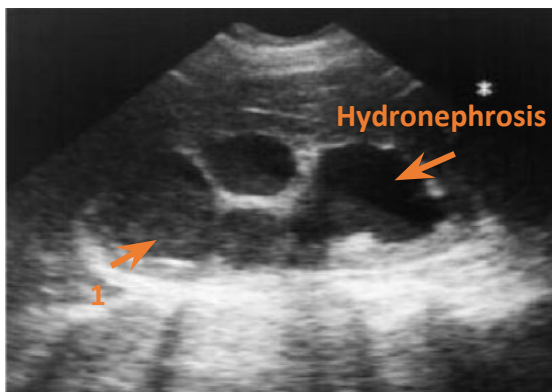
Thick urinary bladder wall normally it's 3mm here it's 6-7mm



Thick regular (well circumscribed) urinary bladder wall with infection. If there is irregular focal thickening we suspect tumor

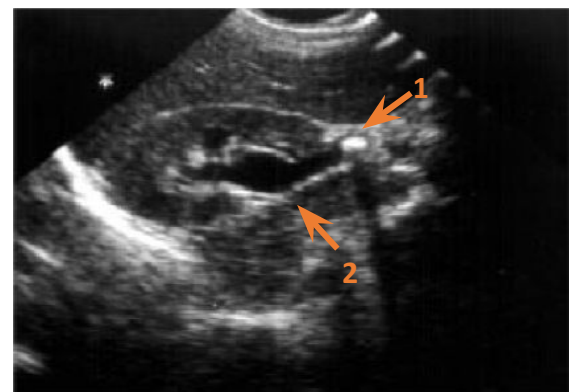
3- Urosepsis

- sepsis from obstruction of infected urine.
- **Risk factors:** if the UTI left untreated and immunocompromised patients.
- Establish a clinical diagnosis (you need to know where did the infection came from): Pyelonephritis, cystitis, prostatitis.
- Urosepsis and obstructed ureter is **urologic emergency!** (If the obstruction is causing persistent dilatation, it can lead to urosepsis which is an emergency case).
- **Renal US is performed to rule out :**
 - 1) Renal obstruction (need to be removed immediately). Obstruction in US (we see dilatation). **How to rule out renal obstruction?** by checking for hydronephrosis which appears as dilatation on ultrasound.
 - 2) Renal or perirenal abscess (need to be drained).



Left pyonephrosis

Pyo=pus, nephrons=kidney. So it's an infection of kidneys' collecting system. We see severe dilated pelvic calyces with echogenic content which should be black., but here the echogenicity (not completely black) means there is pus (1) "calciuric sepsis". Also there is severe obstruction and it seems like long-standing that's why it is sepsis.



right UPJ stone causing hydronephrosis & ureteropelvic junction.

Labels:

1- Stone.

2- Hydronephrosis & hydroureter.

4- Renal masses You have to know the simple cyst & mass, nothing other than that.

a. Approach to renal mass:

- Most renal masses are simple cysts and we find them by coincidence when we do the US for other reasons.
- Use the US to characterize the mass.

1) Simple cyst: STOP don't do anything it's completely benign, unless it causes compression symptoms we will drain it. The best way to diagnose it is ultrasound and CT.

2) Solid mass or atypical cyst: CT with contrast.

- US and CT characterize > 90% of masses > 1.5 cm
- In CT if there is renal or liver mass < 1.5 cm it's difficult to characterize.
- Biopsy is rarely warranted. We can diagnose it with CT (CT + US is enough for diagnosis unless the mass is small).
- Solid mass in the kidney is always suspicious (mostly malignant).



Left renal mass on IVP

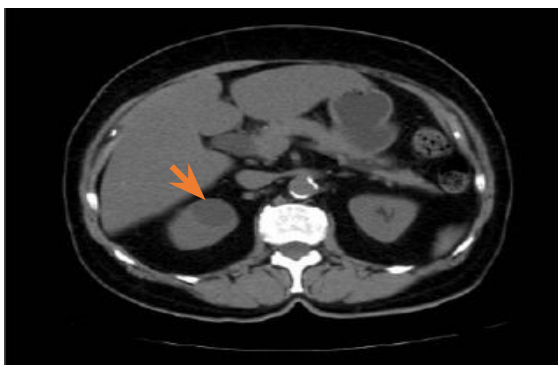
IVP showing mass in the kidney (the contrast doesn't look organized) we don't know whether it is cystic or solid.

b. Renal Cysts:

- US will determine if the lesion is cystic or solid, **There are two types of cysts:**

1) Simple cyst: Important

- Spherical, regular.
- **Echo-free** in US= anechogenic structure inside = black.
- Fluid collection within a thin surrounding wall (no thickening, no calcification, no septation).
- Will show good sound wave transmission.



Spherical rounded region. If we measure the density of the content it will be fluid the wall is not thick, no calcification, so it is simple cyst.



Fluid inside the cyst

2) Complicated cyst:

- Will show the presence of echoes within the cyst it's not only a simple fluid.
- Will have thick wall.
- And /or calcification in the wall.

4- Renal masses (Cont')

C. Renal Carcinoma:

If US indicates that the mass is solid, **we must do CT with contrast** that can characterize the tumor in greater details: delineate extent, show;

- 1) Degree of the vascularity.
- 2) Relationship with other organs.
- 3) Presence/absence of the necrotic tissue center.
- 4) Presence/absence of local invasion of adjacent structures "renal vein or IVC".

*If the patient with renal failure we should hydrate the patient and he must undergo dialysis after the procedure.

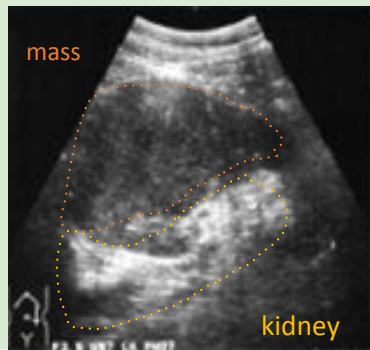
PIC: exophytic renal mass with cystic content.



The lesion is exophytic the wall is thickened wall which is enhanced by the contrast



- Distortion of left Pelvicalyceal System in IVP. because **we don't see the contrast** The right kidney is normal.



- Solid left renal mass in a patient with micro hematuria.
- US shows echogenic structure in the left kidney with hypoechoic on the center.
- CT with contrast shows in left kidney a mass with cystic content, and thick irregular wall enhanced with contrast. This is "malignant" renal cell carcinoma, patient presents with microhematuria.

D. Renal adenocarcinoma:

- 90% of all renal malignancies.
- 15-30% metastatic at diagnosis. It has good prognosis if discovered in (stage 1), 5 years survival rate is more than 80%.
- Hematogenous and lymphatic spread, the first thing you should look for in case of carcinoma look for the regional lymph nodes to exclude metastasis, because any metastasis starts with lymph nodes.
- 10% have venous invasion (renal vein or IVC).

4- Renal masses (Cont')

Treatment:

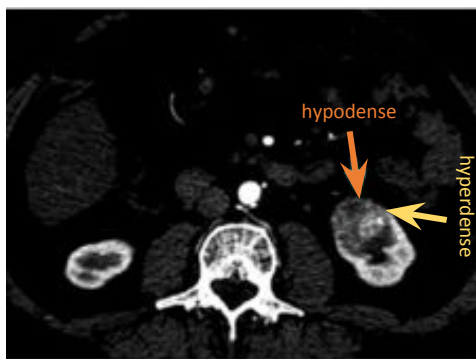
- 1) Radical Nephrectomy (mostly it's the treatment of choice).
- 2) Partial Nephrectomy.

Appropriate imaging workup: After we discover renal cell carcinoma we should do work up to see if there is metastasis.

- Chest X-ray: pulmonary metastases **or** (Pulmonary CT is more accurate).
- CT abdomen: local invasion, lymphadenopathy, venous extension.
- MRI abdomen: renal failure, Contrast allergy. MRI is used if the patient is allergic to the contrast or have renal failure.

70 y/o female presented with painless hematuria:

she is old + painless hematuria (we don't take this easy, think of malignancy)



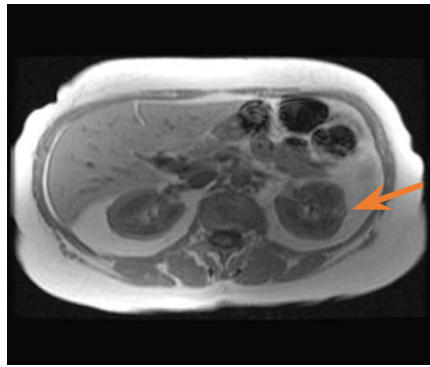
Upper pole malignant mass lesion of the Left anterior part of the Kidney with heterogeneous enhancement (some area taking contrast other area doesn't)

On the coronal view we see a **heterogeneous with enhanced part in lower pole** so this is:

- * Renal cell carcinoma.
- * No invasion.
- * Some effective mass on the left psoas.

E. Renal Angiomyolipoma:

- Benign hamartomatous tumor composed of **fat**, smooth muscle and vessels.
- Angio= vessels, myo= muscle, lipo= fat & oma= benign tumor. **if we can determine the fat in renal lesion we can say this is Angiomyolipoma.**
- Usually asymptomatic.
- Occasionally present with retroperitoneal hemorrhage when large or multiple **and we have to embolize it to control this hemorrhage.**
- **Embolization** is a minimally invasive treatment that occludes, or blocks, one or more blood vessels or vascular channels of malformations (abnormalities).
- **Fat detected in 96% by CT and ultrasound (usually do not need surgical intervention).**
- **diagnostic key to angiomyolipoma is detection of fat surrounding the kidney.**



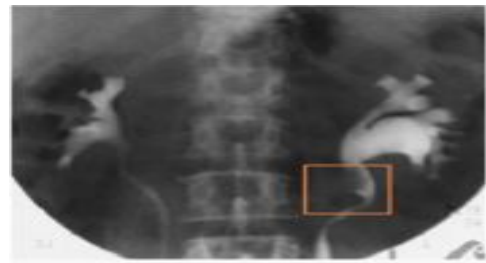
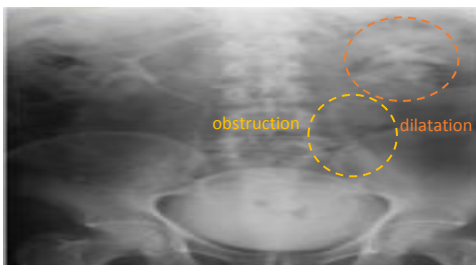
Example of angiomyolipoma in **US**: hyperechogenic cortical rounded regular structure which is **fatty (fat is hyperechoic)**

MRI: hypersignal lesion

CT: Hypodense lesion (so contains fat) of the left kidney on the cortex

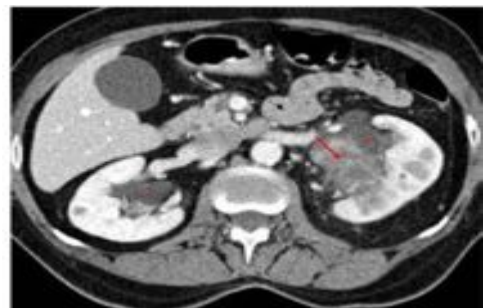
F. Transitional Cells Carcinoma (TCC):

- Most common malignancy of ureter and bladder.
- <10% of renal malignancies.
- Typically present with **gross hematuria**.
- CT for staging and surgical planning.
- Treatment: radical nephrectomy.



IVP (left radiograph) and retrograde pyelogram (right radiograph) TCC proximal left ureter IVP shows distortion of part of the ureter with ureteropelvic junction obstruction and **dilatation**. TCC was discovered here in left proximal ureter as filling defect.

We did IVP and we saw the right kidney is ok but on the left kidney we can see ureteropelvic junction obstruction and dilatation, so we inject the contrast retrograde and we saw there is filling defect in left proximal ureter, so this is Transitional Cells Carcinoma.



CT + contrast in the excretion phase
Large TCC on the right renal pelvis seen as filling defect (the arrow) of proximal ureter, the contrast in the collecting system

Irregular TCC at the ureteropelvic junction

P.S. if we suspect renal cancer it is better to do CT with contrast in excretory phase (8-10 min after the IV contrast injection) to see the contrast in the collecting system.

4- Renal masses



Filling defect which suggests TCC



Irregular thickening (malignant)



- Small TCC of bladder in patient with hematuria.
- Small bladder mass with dilatation of the ureter.

5- Renal failure

Acute and Chronic Renal Failure:

- Clinical categories:

- Prerenal (dehydration, shock, cardiac failure).
- Renal (parenchyma, diabetes, GN, drugs, renovascular e.g. renal stenosis, renal thrombosis).
- Postrenal (obstruction, by chronic mass or chronic stone or malignancy) the only thing we can see on US is small kidney, undifferentiated kidney thin cortex, corticomedullary undifferentiation which are signs for non-functional kidney.

- IV contrast **contraindicated** if creatinine >200 mmol/dl or the clearance is less than 30 ml/min. Sometimes if patient is 90 years old they should be careful when they give the contrast because may develop renal failure so we should do dialysis after the contrast and hydrate very well and give HCO₃ to protect the kidney.

- Use US to assess:

- Renal size (with chronic renal failure the kidney is atrophic & thinning in the cortex).
- Parenchymal thickness (no differentiate between the cortex and the medulla (sometimes it gives indirect sign for non-functioning kidney)).
- US guided renal biopsy to establish diagnosis by taking part of the kidney with biopsy needle percutaneously under ultrasound guidance.

Acute	Chronic
<ul style="list-style-type: none"> • Kidney is enlarged in size. • Oedematous. • Obstruction. 	<ul style="list-style-type: none"> • Kidney is small in size. • No darkness in the cortex. • Bright echo pattern. • cysts can be seen.

5- Renal failure (Cont')



Hydronephrosis post-renal

- Acute, surgically treated.
- Post-renal obstruction will lead to renal failure, and since there is dilation, it means there is obstruction which is a post renal cause.



Atrophic, echogenic kidney

Medical renal disease

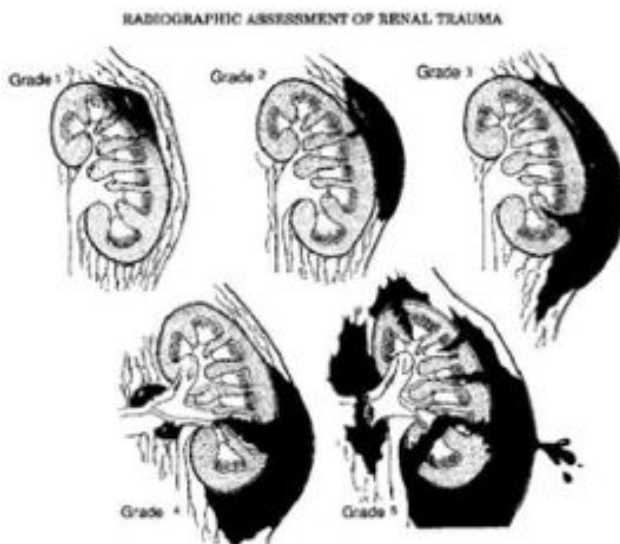
- No differentiation between the cortex and medulla (Undifferentiated kidney = non functioning kidney).
- The arrow is pointing at a simple cyst.
- Medical renal disease (not surgical, treat underlying disease e.g. DM, HTN, glomerulonephritis, congenital disease...).

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6- GU Trauma

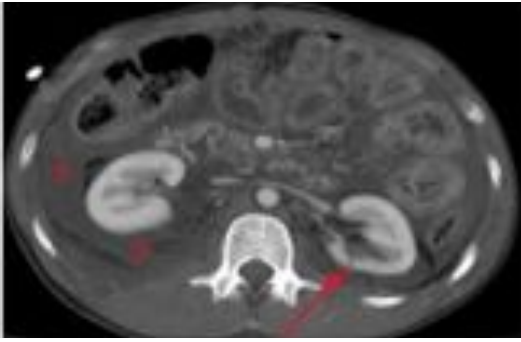
Penetrating Trauma (gunshot, stab):

- Unstable? do surgery or angiography (if there is extravasation of contrast we should embolize).
- Stable? do CT with contrast (used to grade the trauma).



Grade 1	Hematoma, only contusion (a bruise) of the kidney.
Grade 2	Hematoma enter cortex, laceration in the cortex <1cm.
Grade 3	>1 cm but not extending into collecting system.
Grade 4	- Extend to renal pelvis. - Extending to the collecting duct the patient will have severe hematuria.
Grade 5	Shattered kidney completely around the kidney.

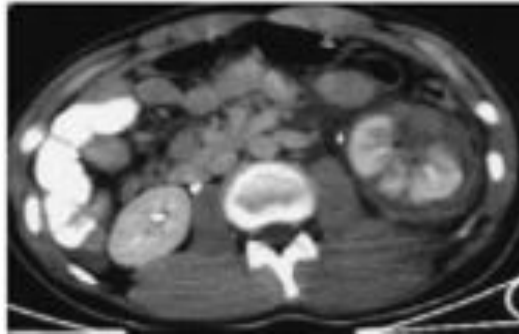
6- GU Trauma (Cont')

**Grade 1-2 injury**

Filling defect means less than 1 cm laceration.

**Grade 3 injury**

Not extending to the collecting system, hypodense non enhanced area in patient with trauma history.

**Grade 4 injury**

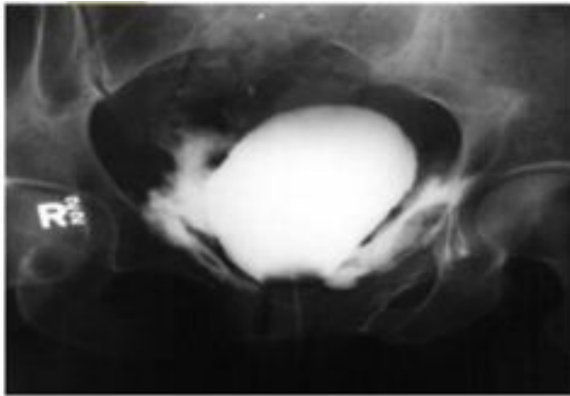
Deep laceration with perirenal hemorrhage, injury extends to the collecting system and there is perirenal hemorrhage and hematoma.

**Grade 5 injury**

Thrombosed renal artery In CT scan, the kidney is non enhanced at all, there is thrombosis of the right renal artery which completely cut down. In angiography, we don't see the right kidney at all.

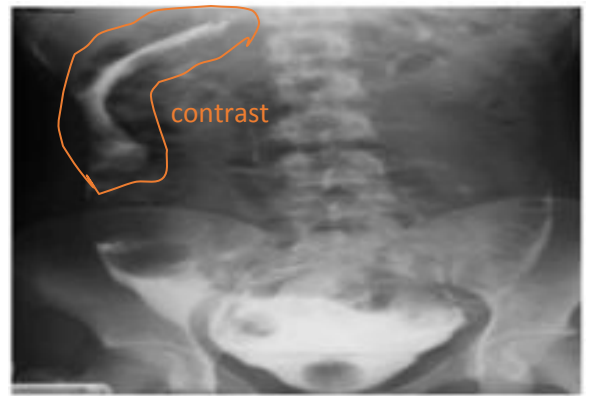
6- GU Trauma

Bladder injury is either extraperitoneal or intraperitoneal. In trauma patient we see blood at urethral meatus we should do retrograde cystography "Inject contrast by retrograde catheter" then can see whether the contrast extra or intra peritoneal.



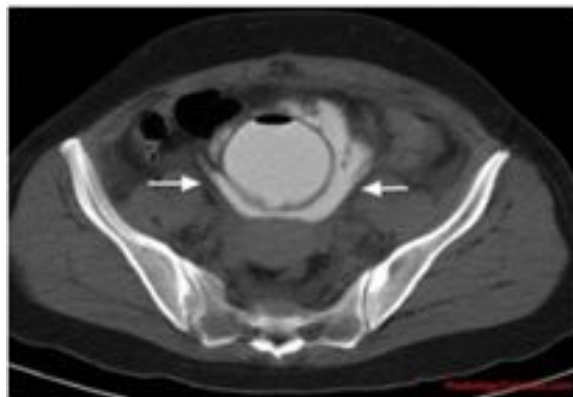
Extraperitoneal bladder rupture

Just apply catheter to drain, until the body heals the injury.

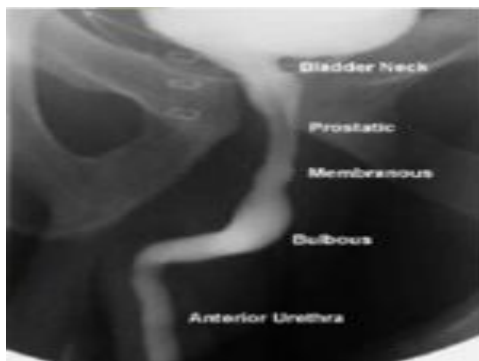


Intraperitoneal bladder rupture

- Surgical management.
- Intraperitoneal we see the contrast over the peritoneum and intraperitoneal bladder rupture usually in pediatric age group when bladder still in the abdomen.



CT showing **bladder injury** with contrast all over Around the bladder and this is extraperitoneal so its limited



Normal retrograde urethrogram

We see all parts of urethra

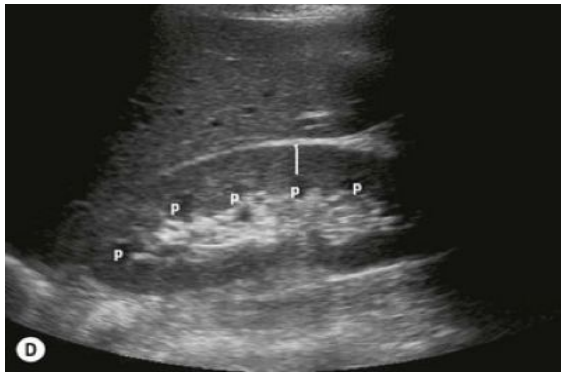


Traumatic rupture of bulbous urethra

The contrast drained out of the urethra (extravasation of the contrast)

Spot Diagnosis

a. Ultrasound



Normal



Normal



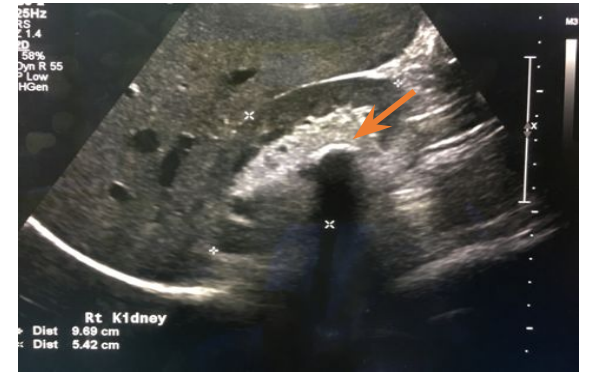
Normal



Normal



Simple cyst thin wall



Stone with shadow

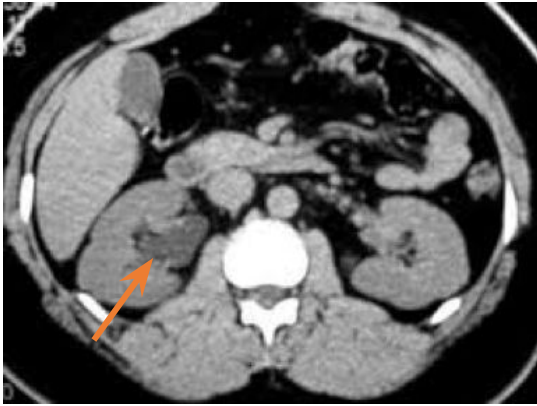
non-obstructive (if there is obstruction the calyces will be dilated and anechoic 'black')



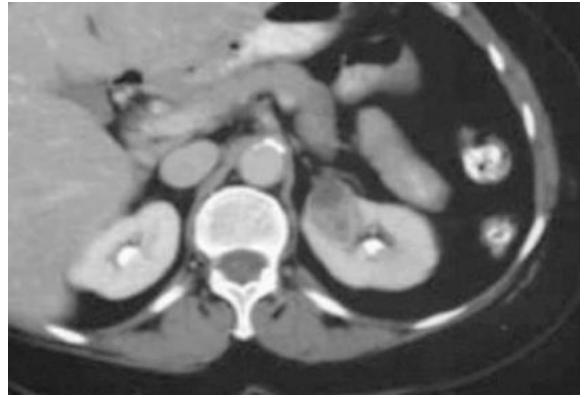
Normal filled bladder

Anechoic (black) content, not turbid urine, regular walls, no thickening, no mass, no diverticula

b. CT scan



Dilated calyces hydronephrosis on the right kidney



Mass



Polycystic kidney disease (multiple cysts, enlarged kidney)



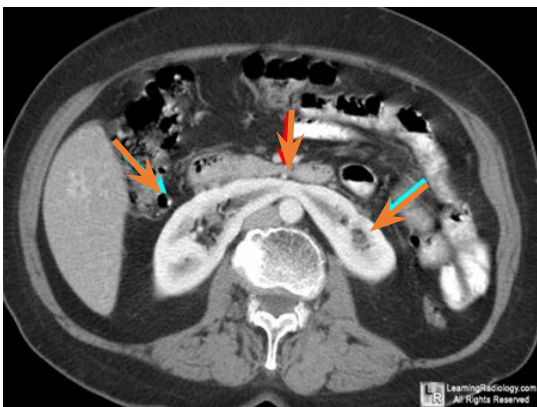
Normal



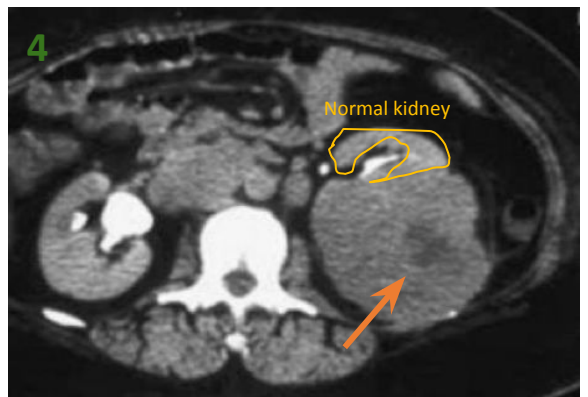
Stone



Normal

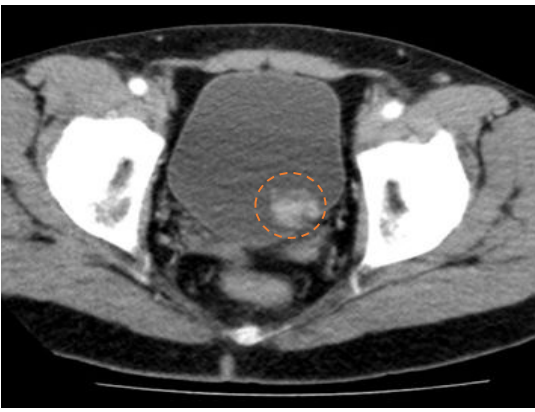


Horseshoe Kidney



Left renal mass irregular border with necrosis on the center, hypodense and heterogeneously enhanced by contrast, most likely renal cell carcinoma

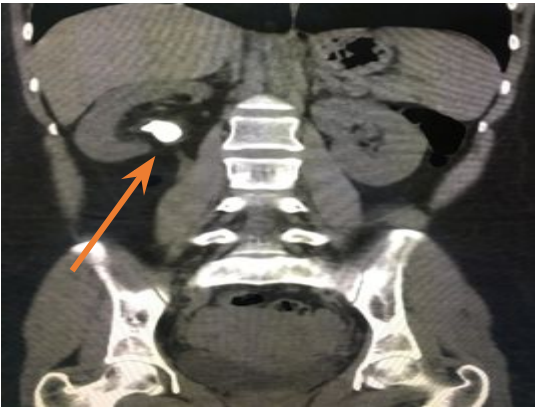
⁴ Excretory phase (the contrast will travel all the way to the body and then will be filtered, when it get filtered we call it the Excretory phase which is 8-10 min after contrast injection)



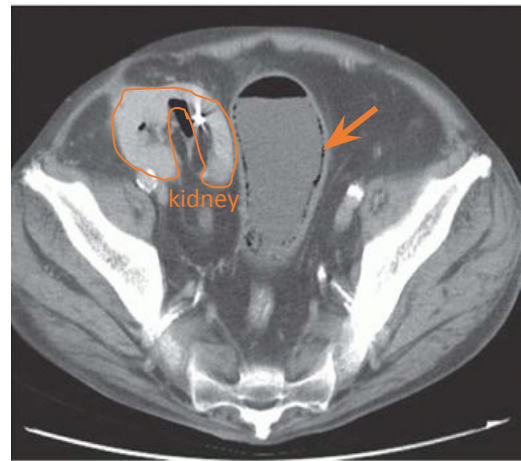
Mass lesion in the bladder



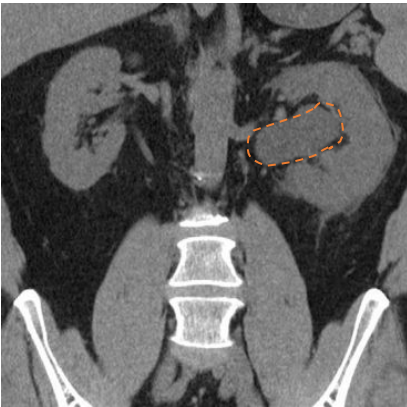
Normal
Regular wall, no masses



Non-obstructive kidney stone



- Regular thickening wall.
- Emphysematous cystitis (the black area between fluid and the wall).



Hydronephrosis on the left kidney and enlarged kidney with fat stranding around, so this could be long standing obstruction.



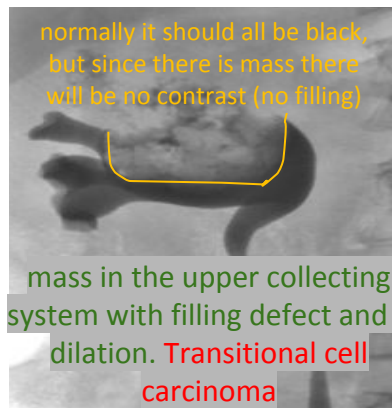
Normal (good differentiation between cortex and medulla)



Simple cyst with enhanced CT (you can differentiate between the cortex and the medulla of the kidney + the aorta looks white and IVC looks grey)

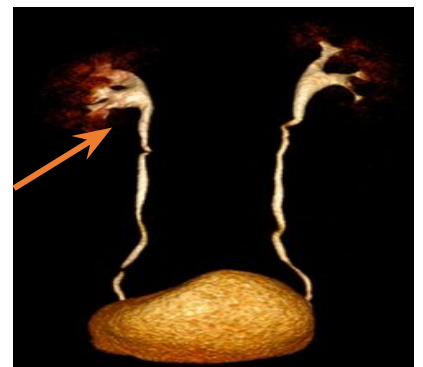


KUP



normally it should all be black, but since there is mass there will be no contrast (no filling)
mass in the upper collecting system with filling defect and a dilation. **Transitional cell carcinoma**

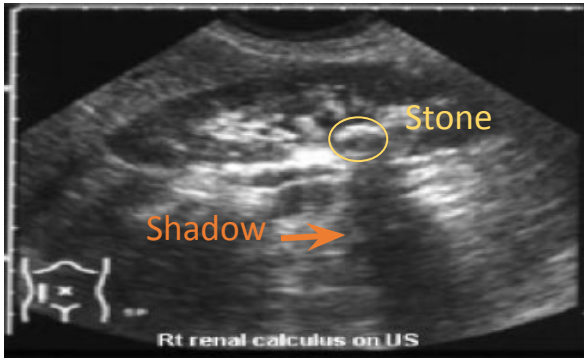
IVP



3D reconstruction CT
Mild dilation of pelvicalyceal system (hydronephrosis)

For better understanding

From slide 4



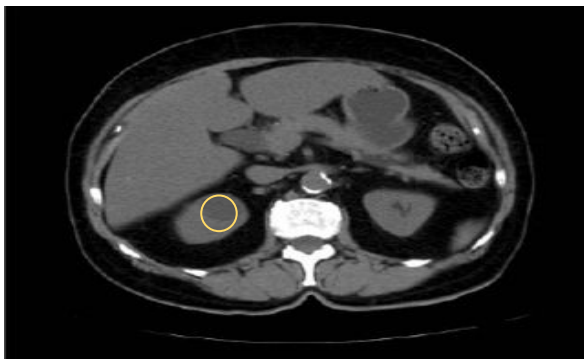
Renal stone

From slide 5



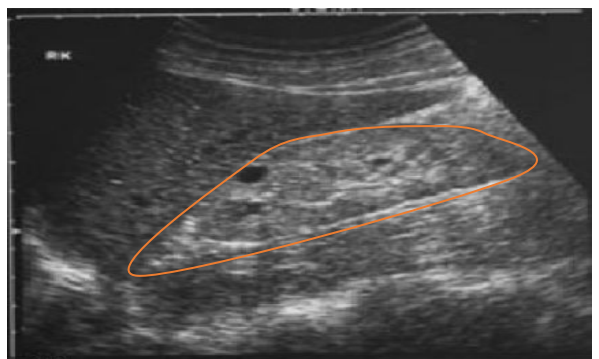
Wedge shaped hypoperfused lesion

From slide 7



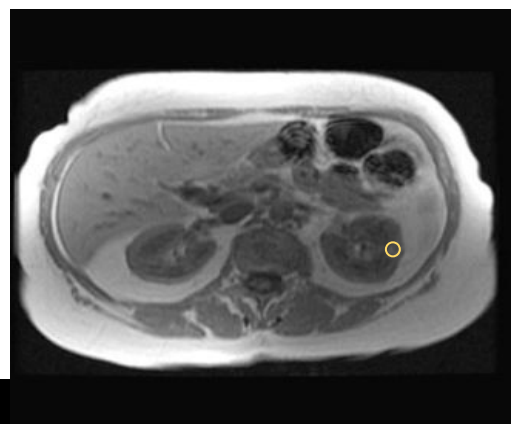
Simple renal cyst

From slide 12



The edges of the atrophic kidney

From slide 10 The added circles clarifies the lesions



Summary

You place your diagnosis on factors:

- Density.
- Borders (regular or irregular).
- Heterogeneity.
- Contrast enhancement.
- Necrotic (hypoperfused).
- Comparison.
- History in clinical scenarios.

Renal Colic		
X-ray	US	CT

radiopaque structure

hyperechogenic structure"
with shadow behind

hyperdense structure

Infections	
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Acute Pyelonephritis

cystitis

Wedge shape hypoperfused lesion in CT
with contrast

Thick regular (well circumscribed) urinary
bladder wall on CT and US

Urosepsis

severe dilated pelvic calyces with echogenic content

Mass				
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Simple cyst

Renal
Carcinoma

Renal
adenocarcinom
a

Renal
Angiomyolipoma

Transitional
Cells
Carcinoma

Spherical,
anechogenic,
no thickening
wall, regular
wall

exophytic renal
mass with
cystic content
and irregular
wall

malignant mass
lesion with
heterogeneous
enhancement

Fat
US: hyperechoic
MRI: hypersignal
CT: Hypodense

filling defect

Renal failure

Post renal:

1. Hydronephrosis (surgical)
2. Atrophic, echogenic kidney (Medical renal disease)

Trauma	
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Renal

Bladder

- Grade 1+2: laceration less than 1 cm laceration
- Grade 3: hypodense not extending to the collecting system
- Grade 4: deep laceration with perineal hemorrhage
- Grade 5: Kidney non enhanced at all + thrombosis in renal artery

1. Extraperitoneal bladder rupture
2. Intraperitoneal bladder rupture

Questions

1- 60 years old male presented to the emergency with gross hematuria CT was done which of the following is correct:

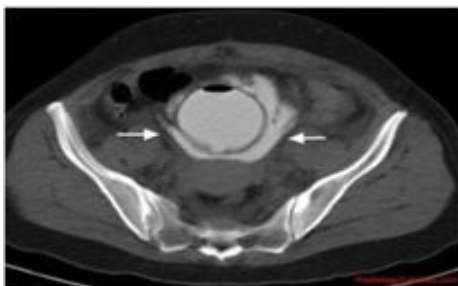


- a- Renal stone.
- b- Acute Pyelonephritis.
- c- Transitional Cells Carcinoma.
- d- Normal CT.

2-which level of creatinine is contraindicated to give IV contrast in renal failure patient?

- a- >200 mmol/dl.
- b- 100 mmol/dl.
- c- 150 mmol/dl.
- d- 133 mmol/dl.

3- a CT was done to a patient after transurethral resection of bladder tumor and the CT shows:



- a- Renal injury.
- b-Bladder injury.
- c- TCC .
- d- Renal mass.

Answers:
1- c.
2- a.
3- b.