CONGENITAL ANOMALIES OF THE URINARY TRACT
Renal agenesis Bilateral incompatible with life, Unilateral is rare, I.V.U and sonography showing absence of kidney.
Renal Duplication: Common due to division of kidney and ureteric buds. There are 4 grades:

**Grade I**: Separation of upper pole major calyx from mid and lower poles together with renal pelvis (bifid kidney)

**Grade II**: Duplication of kidney and ureter with fusion of two ureters during the course.
Grade III: Duplication of kidney and ureter with fusion of two ureters before entry to bladder.

Grade IV: Complete separation with each ureter enter the bladder separately. The orifice of upper moiety ureter is located under the orifice of lower moiety ureter.

Radiological appearance:

- IVU findings:
  1- Large size kidney.
  2- Local indentation of out-line.
  3- Unilateral or bilateral.

- Ultrasound findings:
- Division of renal sinus
duplication
Renal Hypoplasia
Small but otherwise normal kidney.
Reduced number of calyces.
DDX: Renal ischemia

Renal Ectopia
Failure of ascending of kidney with mal-rotation.
The kidney is not seen in its proper position and seen at low level (pre-sacral kidney)
DDX: Renal ischemia
CROSSED ECTOPIA

Migration of one kidney to other side (mainly the left) and fused with lower pole of the normal kidney. It’s ureteric orifice remain in the same side.
HORSE-SHOE KIDNEY

Fusion of lower pole of both kidneys by bridge of renal tissue (isthmus) crossing in front of aorta, spine and IVC.

IVU shows:
The kidneys at low position. Close to the spine with long axis parallel to the spine. Mal-rotation manifested by medially directed calyces. The renal pelvis and ureters are anterior and lateral in position. Fusion of upper poles is rare.
HORSE SHOE KIDNEY
Retro-caval ureter:

* Rare.
* The middle third of right ureter curve medially behind the IVC, then laterally to regain its normal position, this lead to obstruction of upper third of ureter.
Coronal reformatted MIPS image from a CT urogram demonstrates medial displacement of the right ureter at the level of L3 (White arrow). The ureter is medial to the pedicle of the vertebral body (blue arrow).
Congenital cystic dilatation of lower end of ureter (intra-mural part) due to pin-hole meatus. May be simple or ectopic.

**In simple** the orifice is in proper position of bladder.

**In ectopic** the orifice is at the bladder neck, urethra, uterus or vagina.

**On IVU:**
* There is rounded or elliptical dilatation of lower end of ureter with thin lineal filling defect around it, resembling *(cobra head appearance).*
* Proximal dilatation of rest of ureter.
* In advanced cases hydrenephrosis.
* In obstructed ureterocele filling defect in the bladder
Cyst within cyst appearance
Indications

1 – Hematuria
2 – Renal Colic
3 – Recurrent urinary tract infection
4 – Suspected urinary tract pathology
Contraindications

They are the general contraindications to water soluble agents:

- Contrast allergy
- Hepatorenal syndrome
- Thyrotoxicosis
- Pregnancy
- Raised serum creatinine
Advantages of IVU

- Detailed anatomy of the collecting systems
- Demonstration of major calcification
- Sensitive for acute obstruction
- Low cost
Limitations of IVU

- It depends on kidney function
- Do not differentiate solid or cystic lesion
- Requires contrast medium and radiation.
- Missing small stones.
- Quality of study may be limited by inadequate bowel preparation, bowel ileus, swallowed air and technician variability.
- Inconvenience of a long filming sequence.
The procedure
Contrast

LOCM 370 (LOCM = Low osmolar contrast material)

Adult dose = 50 – 100 ml, Pediatric dose = 1ml for each kg
Preliminary film (control film)
Technique

- Dye injection
- Precautions during dye injection
- Taking x-rays
Films

- Immediate film
- 5-15 min film (Nephrogram phase)
- 30-min film (Ureterogram phase)
- 45-min film (Cystogram phase)
- Postvoiding film
Immediate film (Nephrogram phase)

A.P. of the renal areas to show the **nephrogram**, i.e. the renal parenchyma opacified by the contrast medium in the renal tubules.

(taking it after injection equals about 10 to 14 seconds which is the approximate arm-to-kidney time).
5-15 minutes film (Secretory phase)

inspect:

- Both Kidney contour
- Contrast is filling both the Pyelum or not,
- is there any delayed filling?
30 minutes film (Ureterogram phase)

inspect:

Is there any collecting systems and ureters dilatation or filling defect? (normal ureter filling is rarely demonstrate the whole ureter from proximal to distal as there is a peristaltic wave)
45 minutes film (Cystogram phase)

inspect:

- Bladder size and shape
- Contrast is filling the bladder or not
- Bladder surface is smooth or rough
- Is there any diverticula, filling defect or prostate indentation?

Figure 4 – An intravenous urogram showing a small solid tumor as filling defect in the right lateral wall of urinary bladder.
Postvoiding film

look for:

- Residual urine
- Contrast left on upper tract? (normally there is no contrast left on upper urinary tract on postvoiding film)
Examples for abnormal findings
Example for Findings – Before dye injection

Stone in the left ureter
Example for Findings – Kidneys

Horseshoe Kidney - Tissue Bridge Across Midline Causes Abnormal Orientation of Renal Axis
Example for Findings – Kidneys

Extravasation of Contrast from Left Kidney
Secondary to High Grade Obstruction
Example for Findings – renal collecting system and ureters

Pyelo-ureteric Junction Obstruction Shows as Dilation of Right Renal Pelvis and Calyces.
PUJ obstruction
Example for Findings – renal collecting system and ureters

Stab wound of right ureter shows extravasation (at arrow) on intravenous urogram.
Example for Findings – renal collecting system and ureters

Crossed Renal Ectopia on the Left Kidney and Absent Right Kidney.
Example for Findings – Urinary Bladder

Round shadow on right side of bladder later shown to be a bladder cancer.
Nodular squamous cell carcinoma of the bladder. Dilated left lower ureter probably secondary to obstruction by tumor. Nonvisualization of the right ureter caused by complete occlusion.
Intravenous urography showed no obstructive uropathy, but symmetric diverticula could be seen near both ureteral orifices (arrows). These lesions, known as Hutch diverticula, are usually congenital rather than occurring as a result of a neurogenic bladder or an infection or obstruction.
NEPHROCALCINOSIS

- Definition: Deposition of calcium within the renal parenchyma and outside of the pelvi-calyceal system.

1- Medullary nephrocalcinosis: this is usually the product of a metabolic disorder resulting in a raised serum calcium or a tubular defect resulting in hypercalciuria (usually bilateral and diffuse).

2- Cortical nephrocalcinosis: this is seen in acute cortical necrosis of any cause (classically with a ‘tramline’ appearance).

3- Focal nephrocalcinosis:
   - Linear or rim calcification
   - Renal artery aneurysm and Real cyst.
   - Amorphous calcification
   - Calcified haematoma
   - Tuberculosis
   - Renal cell carcinoma
Medullary nephrocalcinosis with the corresponding CT appearances

Cortical nephrocalcinosis
UROLITHIASIS

Stones form when the concentration of two ions in solution exceeds the saturation point

• CLINICAL PRESENTATION
  - Classically there is acute severe ipsilateral loin-to groin pain (nausea and vomiting).
  - Haematuria
  - There is a peak age of onset between 20 and 30 years (2M:F).
RADIOLOGICAL FEATURES

KUB
The majority of calcium-containing stones are radio-opaque
Oxalate stones: these are denser than bone
Cysteine stones: these are less dense than bone
Uric acid stones: these are radiolucent
It has a poor sensitivity due to overlying bowel gas and extrarenal calcification

IVU
A dense nephrogram with delayed excretion.
A column of contrast may be seen down to the point of obstruction
The degree of ureteric dilatation is not related to the stone size

US
An echogenic focus (acoustic shadowing).
There can be pelvicalyceal or ureteric dilatation
Stones within the pelvicalyceal system can only be reliably identified if they are greater than 5mm in size (as small stones are less likely to cast an acoustic shadow).
Ureteric stones are poorly visualized unless they are located within the proximal ureter or VUJ

NECT
This is the investigation of choice
It detects greater than 99% of stones (including those that are radiolucent on AXR).
Bilateral staghorn calculi are seen on the control image of an IVU series.
US demonstrating a small solitary renal calculus which is seen as an echogenic focus with marked posterior acoustic shadowing.
Ureteric stones on CT
U Bladder
RENAL CELL CARCINOMA

• THIS ACCOUNTS FOR 85% OF ALL MALIGNANT RENAL TUMOURS.

• THE CLASSIC CLINICAL TRIAD OF A PALPABLE MASS, FLANK PAIN, HAEMATURIA, AND WEIGHT LOSS.

• IT USUALLY PRESENTS DURING THE 5TH–7TH DECADES (2M:1F)
RADIOLOGICAL FEATURES

X-ray:
Renal calcification may be visible

IVU:
- Distortion of the pelvicalyceal system.
- A demonstrable mass.

US:
- Small tumours are usually hyperechoic.
- Larger tumours can be isoechoic (central necrosis).
- Cystic tumours have thick or irregular walls with variably sized intracystic tumour nodules

CT:
- The preferred method for staging
- NECT: a solid mass of heterogeneous attenuation (>20HU) with low-density central areas.
- Calcification can be present (5-10%)
- CECT: increased attenuation (>10HU) suggests a solid mass ▶ increased attenuation > 20HU is consistent with malignancy.

MRI:
This is used for staging if a CECT is contraindicated or if frequent follow-up is required in high-risk patients
- T1WI: low-to-intermediate SI.
- T2WI: slightly high SI.
- T1WI Gad: immediate heterogeneous enhancement which decreases on delayed images.
- Homogeneous enhancement is more likely in small, low-grade tumours.
Renal cell carcinoma on IVU appears as a large left lower pole mass distorting the adjacent pelvicalyceal system.
CECT demonstrating a renal cell carcinoma extending to the kidney margin with some local nodular extension through the capsule
Right renal cell carcinoma invading the psoas muscle and anterior abdominal wall.†

T2WI demonstrating a heterogeneous mass of renal carcinoma extending along the right renal vein into the IVC.†
RENAL ABSCESS

DEFINITION

- A renal parenchymal collection secondary to acute pyelonephritis (Gram-negative or anaerobic bacilli) or haematogenous spread of infection (S. aureus)

RADIOLOGICAL FEATURES

**US** A heterogeneous renal mass with areas of cystic necrosis (± shadowing due to gas)

**CT** There is a heterogeneous central portion of near-fluid density (with no enhancement) ► there are enhancing thick irregular walls (± perinephric inflammatory change) ► gas within the lesion is diagnostic

Renal abscess. CT demonstrates a poorly enhancing mass in the right kidney with thick irregular walls in a patient who had a severe urinary tract infection. The central fluid collection contained pus.*
WILMS’ TUMOUR (NEPHROBLASTOMA)

DEFINITION

• A renal tumour arising from metanephric blastema cells (the primitive embryonic renal parenchyma).

CLINICAL PRESENTATION:

• It most commonly presents as an asymptomatic abdominal mass, haematuria, less commonly pain, fever or hypertension.
• Peak incidence at 3 years (M ¼ F)
• It is the 3rd most common childhood malignancy after leukaemia and brain tumours.
RADIOLOGICAL FEATURES:

- **Ultrasound:**
  - A solid hyperechoic mass (cystic areas).

- **CT:**
  - Typically a large heterogeneously enhancing renal mass (enhancing less than normal kidney).
  - ‘Claw’ sign: normal renal tissue is typically stretched at the periphery of the lesion.
  - Tumour spread: typically by direct extension with displacement of any adjacent structures.
  - Vascular invasion: this is seen in 5–10% (involving the renal vein, IVC and right atrium) – it can also invade the renal pelvis and ureter

- **MRI:**
  - T1WI: low SI.
  - T2WI: high SI.
  - T1WI, Gad: heterogeneous enhancement.
Wilms’ tumour. (A) Axial CECT of the abdomen showing a large mass arising from the right kidney which is of heterogeneous attenuation. The mass is seen to displace the normal enhancing renal parenchyma to the left.
Wilms’ tumour MRI Axial T2WI
Contrast enhanced CT of abdomen
(Wilm's tumour) outlined by red line with claw sign seen in association with a displaced right kidney (yellow arrow) confirming the renal origin of the mass.
METHODS OF IMAGING IN OBSTRUCTION

RADIOLOGICAL FEATURES

- US
  - This is an excellent method of detecting obstruction – however does not provide functional information and it can be difficult to distinguish a prominent extra renal pelvis from mild hydronephrosis.
  - False negative results may arise if there is a large staghorn calculus.
  - Dilatation of the pelvicalyceal system is a poor indicator of the severity of obstruction (the absence of dilatation does not exclude obstruction).

§ Grade I: minimal calyceal dilatation
§ Grade II: mild hydronephrosis
§ Grade III: moderate hydronephrosis
§ Grade IV: severe hydronephrosis
IVU
- Obstructive nephrogram: an increasingly dense nephrogram (lasting up to 24 h with a peak density at 6 h) ▶ this is seen with acute obstruction and only in kidneys with normal renal blood flow, GFR and tubular function (i.e. not with pre-existing parenchymal disease)
- Delayed contrast excretion: the delay in contrast excretion depends on the degree of obstruction.
- Ureteric or pelvicalyceal dilatation: this may be minimal during the first few days
  - Urinoma: a persistent encapsulated collection of urine

CT
NECT: hydrenephrosis and hydroureter to the level of the obstruction
CECT:
- Acute obstruction:
  There is prolongation of the usually transient, early corticomedullary nephrogram.
- Chronic obstruction:
  - hydrenephrosis.
  - Parenchymal thinning (a shell or rim nephrogram)
Ultrasound of the kidneys showing hydronephrosis and cortical atrophy.
(A) Plain abdominal XR. Bilateral large ureteric calculi (arrows). (B) Unenhanced axial CT at the level of the stones. (C) Coronal multiplanar reformation (MPR) sections demonstrating the same bilateral ureteric calculi with bilateral hydronephrosis and renal atrophy.*
BLADDER TUMOURS

- Transitional cell carcinoma (TCC): 90% of all epithelial tumours.
- Squamous cell carcinoma (SCC): 1.5–10% of all epithelial tumours.
- Adenocarcinoma: 1% of all epithelial tumours.

CLINICAL PRESENTATION
- Haematuria.
- Dysuria.
- Pelvic pain (due to side wall invasion)
RADIOLOGICAL FEATURES

IVU/cystogram:
A lobulated filling defect within the bladder (it may miss infiltrative tumour types).

- US:
A sessile or pedunculated mixed echogenicity mass projecting into the bladder lumen (vasculaity)
CT:
- A sessile or pedunculated soft tissue mass projecting into the bladder lumen (overlying calcification
- Localized bladder wall thickening
- Perivesical fat invasion with increased perivesical fat density
- Adjacent visceral invasion (rectum, uterus, prostate or vagina).

MRI:
- T1WI: Similar SI to normal wall ► Higher SI to urine
- T2WI: Higher SI to normal wall ► Lower SI to urine
- T1WI GAD: A higher SI relative to normal bladder wall (with similar enhancement characteristics with CT)
Noncontrast CT image through the pelvis shows a polypoid lesion (arrow) arising from the left posterior wall of the bladder.
TCC by Ultrasound
T2WI MRI for posterior wall TCC of Bladder
Anteroposterior view from an IVU demonstrates a filling defect within a right base of a contrast-filled bladder. Cystoscopic evaluation and eventual biopsy confirmed the diagnosis of TCC.
BLADDER INJURY

Trauma to the bladder can be due to:
- Blunt abdominal trauma: the most common cause (90% follow a motor vehicle accident).
- External penetrating agents: stab wounds or bone fragments.
- Internal penetrating agents: cystoscopes.

Classification of traumatic bladder injuries:
- Bladder contusion.
- Intramural (partial-thickness) laceration.
- Full-thickness laceration with intra- or extraperitoneal rupture

Clinical presentation:
- Gross haematuria, suprapubic pain and Inability to void.
- CT cystography: This is more accurate than standard cystography for the detection of bladder injuries.

- Intraperitoneal bladder rupture: free intraperitoneal contrast medium is seen outlining the peritoneal recesses and bowel loops.

- Extraperitoneal bladder rupture: contrast extravasates into the surrounding extraperitoneal space, often spreading in an irregular and often streaky manner along the fascial planes (with a 'flame-shaped' appearance).

Urine can dissect into the following:
- The anterior prevesical space.
- The anterior abdominal wall.
- The inguinal region and upper thigh.
- The lateral paravesical and presacral spaces.
- The perineum, scrotum, and rarely the retoperitoneum.
CT of extraperitoneal bladder rupture. (A) Delayed CECT across the pelvis reveals urine extravasation into the extraperitoneal fascial planes around the bladder and tracking to the presacral space. The bladder wall defect is directly observed (curved arrow). (B) A coronal reformat shows the distribution of leaked iodinated urine, including the right lateral abdominal wall, elevation of the bladder and comminuted fractures of the superior pubic rami.*
Conventional cystogram demonstrating an intraperitoneal bladder rupture.
Intraperitoneal injury:
contrast material outlines loops of bowel.

Extraperitoneal injury:
Dense, flame-shaped collection of contrast material in the pelvis
Chronic cystitis

- This follows repeated bacterial infections (Usually with E. coli)
- Predisposing factors: Reflux, bladder outlet obstruction, bladder diverticulae.
- Diffuse bladder wall thickening by Ultrasound
Bladder Chronic Cystitis
Normal Bladder wall thickening
BENIGN PROSTATIC HYPERTROPHY (BPH)

Benign nodular enlargement of the prostate gland involving the transitional and periurethral zones (carcinoma typically affects the peripheral zone)

- Cystourethrography:
  An elongated and compressed urethra.

- IVU/retrograde cystogram:
  - Bladder outlet obstruction producing bladder trabeculation, diverticulae or calculi formation (hydroureters and hydronephrosis)
  - J-shaped or ‘fish-hook’ ureters: as the prostate enlarges, the bladder floor is elevated and the trigone pushed upwards.

- TRUS:
  - A prostate volume > 30ml.
  - Enlarged central gland with well-defined or poorly demarcated hypoechoic or mixed echogenicity nodules (hyperechoic foci).

- CT:
  - A prostate gland seen 2–3cm above the symphysis pubis is unequivocal evidence of enlargement
Benign nodular hyperplasia demonstrated on a (A) suprapubic US scan: markedly enlarged prostate gland (P) with enlargement of the intravesical portion (arrow) which protrudes into the urinary bladder (B). Benign nodular hyperplasia on (B) IVU and (C) coronal plane T2WI. On the IVU study the enlarged prostate gland (P) elevates the bladder floor and causes a J-hooking (fish-hooking) deformity of the distal ureters (arrow). No obstruction is seen. The MRI provides direct visualization of the prostate (P) and its impression upon the bladder floor (arrows).*
TESTICULAR TORSION

- An abnormal twist of the spermatic cord as a result of testicular rotation.
- It can be complete (at least 360 of rotation) or incomplete.
- The degree of torsion determines the severity of testicular ischaemia and the rapidity of any irreversible changes.
- Acute: lasting between 24 h and 10 days ➔ subacute or chronic: > 10 days.
- It is commonly seen during the 1st year of life or during adolescence (when the testicle is rapidly enlarging).
- Intravaginal: this affects an older age group and is common.
- Extravaginal: this affects infants and is rare.
Radiological features

- **Ultrasound:**
  - Acute: an enlarged heterogeneous testis and epididymis.
  - Chronic: a reactive hydrocele.

- **Color Doppler Ultrasound:**
  - Absent or markedly reduced testicular blood flow.
  - The demonstration of normal blood flow does not exclude torsion (which can be intermittent)
Gray scale ultrasound of testis. Normal homogeneous echogenicity is finding that characterizes normal testicle. The linear echogenic band running through the testis is a normal structure called the mediastinum testis (arrow).
Infarcted testicle. There are extensive areas of reduced echogenicity within the testicle and the adjacent epididymis is also markedly swollen.
Doppler of an enlarged testis showing no Doppler flow within the infarcted testis and only in the surrounding epididymis.
VARICOCELE

- Dilated tortuous veins of the pampiniform plexus, it is associated with male infertility.
- Causes: idiopathic (invariably left sided due to more indirect drainage of left testis into left renal vein). Secondary to incompetent valves within the spermatic vein.

- Ultrasound:
  - Multiple serpiginous tubules > 2mm in diameter superior and posterior to the testis (they may extend to the inferior pole of the testis).
  - Spontaneous flow may not be seen – flow may be demonstrated with coughing, rapid inspiration or the Valsalva manoeuvre.
US of an asymptomatic left varicocele. At rest (A), there is little detectable flow on colour Doppler. During Valsalva manoeuvre the flow is enhanced (B).*
VARICOCELE
VARICOCELE
Film Reading
Staghorn Calculus
Staghorn PUJ Calculus
Staghorn Calculus X-ray
CT scan – Horseshoe Kidneys
Intravenous urography film showing incomplete duplication (white arrow) on right side and complete duplication (black arrow) left side with ureterocele (curved arrow) of upper moiety ureter.
IVP showing Horseshoe kidney
Ultrasound of Ureterocele
IVU of bilateral Ureterocele
IVU of obstructed Ureterocele
Sagital CT of Renal Cell Carcinoma
CT scan of Renal Cell Carcinoma
CT scan of Bladder TCC
Ultrasound of BPH
IVU image demonstrating BPH
Ultrasound of Bilateral Hydrocele
Testicular Torsion
Varicocele
CT Scan of left ureteric stone
Crossed Fused Ectopia
THANK YOU