Imaging of the urinary tract

- Plain kidney, ureters and bladder [KUB]
- Intravenous urogram [IVU]
- Cystography and urethrogram
- Ultrasonography [US]
- Nuclear medicine
- Computed tomography [CT] scan
- Magnetic resonance imaging [MRI] scan
- More invasive tests

Plain UT [KUB]

- Simple procedure
- Requires adequate patient preparation

Diagnostic value

- Radioopaque calculi
- Calcifications
- Gas pattern
- Organomegaly
- Bony abnormalities
Intravenous urography [ IVU ]

Requirements :
- Fasting 4-6 hours, good hydration is essential
- Adequate bowel preparation
- Renal function tests beforehand [ serum creatinine level below 3 ]
- Non ionic contrast media are used to guard against contrast nephropathy

Water soluble contrast media for IV administration
Non Ionic

Ionic
Optiray 160 is an injectable low osmolar, nonionic, contrast media agent intended to be therapeutically and biologically inert when injected intra-arterially.

Diagnostic value
- Show the renal function
- UT obstruction
- Renal an bladder masses
- Congenital anomalies

Contraindicated in patients with :
- Renal impairment
- Hypersensitivity to contrast media

Normal IV urography
IVP series

PUT showing no radiopaque calculi: IVP showing normal renal function with normal appearance of both pelvicalyceal systems, ureters and urinary bladder

Cystourethrography [ CUG ]

- Urethral lesions
- Vesicoureteral reflux
- Stress incontinence

Contrast is inserted into the bladder and images are obtained. The patient is then asked to void and images are also taken.
Ultrasonography [US]
- Non-invasive
- Reliable
- Affordable

Requirements:
- Fasting 4-6 hours
- No bowel preparation
- No contrast media
- No radiation hazards

Ultrasonography [US]
Diagnostic value
- Show the renal parenchymal changes
- Detection of UT calculi
- UT obstruction
- Renal an bladder masses
- Differentiates cystic from solid masses
- Congenital anomalies
- Doppler assessment of the renal vessels

Computed tomography [CT]
- More sensitive
- Considered with care

Requirements:
- Fasting 4-6 hours
- May need bowel preparation
- May use contrast media
- Consider radiation hazards

Computed tomography [CT]
Diagnostic value
- Detection of UT calculi
- UT obstruction
- Renal an bladder masses
- Differentiates cystic from solid masses
- Congenital anomalies
- CT angiography
CT anatomy

Serial CT sections through the kidneys showing normal renal configuration and function

CT urinary tract [ CTUT ]
Serial CT sections taken for the whole urinary tract showing no evidence of radiopaque calculi.
CT urinary tract [ CTUT ] Reconstructed images

Reconstructed CT images along the ureteric course are very valuable in assessment of small ureteric stones

CT urography [ CTU ]

Reconstructed CT images for the urinary system obtained after IV contrast injection
Flush aortography

Flush aortogram in a young hypertensive patient demonstrating minor aneurysmal beading of the right main renal artery but no definite stenosis consistent with FMD. This was abolished following angioplasty.

CT angiography [ CTA ]

CT renal angiography in a case of horse – shoe kidney showing triple arterial supply for the left kidney
Magnetic resonance imaging [MRI]
- Functional imaging
- Morphological imaging

Requirements:
- Fasting 4-6 hours
- No bowel preparation
- May use contrast media
- No radiation hazards

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MRI
- Patients at risk of contrast nephropathy
- Patients who have an allergy to contrast agents

MR urography [MRU]

MR urography obtained without IV contrast injections

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Diagnosis of UT pathology
- Stone disease
- UT neoplasms
- UT infection
- UT trauma
- Miscellaneous lesions
  - Congenital lesions
  - Vesico-ureteric reflux
  - Urethral lesions
  - Reno-vascular hypertension
Diagnosis of UT pathology

- Stone disease
- UT neoplasms
- UT infection
- UT trauma
- Miscellaneous lesions

Radio-opaque renal stones

- Stone disease
- UT neoplasms
- UT infection
- UT trauma
- Miscellaneous lesions

Radiolucent renal stone

- Large stage-horn left renal stone
- Small left renal stone
- Multiple large urinary bladder calculi
- Radiolucent left renal stone seen occupying the renal pelvis with no back pressure effect
Small radio-opaque ureteric stone

IVP showing small stone at the distal end of the right ureter with proximal back pressure changes. Compare to the normal urogram in the right image.

Distal ureteric stone, US

US images showing dilated pelvicalyceal systems and ureter down to a stone (arrow) at the ureterovesical junction.
Ureteral calculus

**Left flank pain**

**Put and IVP:** A small radiopaque calculus is seen on the left side of the pelvis with proximal back pressure effect seen in the urography film.

**? Left ureteral calculus**

IVP showing distended left pelvicalyceal system and ureter proximal to a suspected distal ureteric stone which was confirmed in the CT images.
Ureteral calculi

Small ureteric calculi detected by CTUT, in the upper ureter [left] and lower ureter [right].

Distal ureteric calculus

Flank pain and fever

CECT scan shows a swollen right kidney with a striated pattern of enhancement with dilation of the right renal pelvis. An image at the level of the bladder base shows a calculus in the right ureterovesical junction, which was causing the right hydronephrosis and predisposed the right kidney to infection.
Small renal & ureteric calculi, CT UT

Non contrast CT of the urinary tract showing multiple bilateral renal and left upper ureteric stones with proximal back pressure effect.
Ureteral calculus

NCCT shows a small calculus in the distal right ureter surrounded by a rim of edema (soft tissue rim sign)

The calculus is also identified on the coronal CTU image (arrow) with mild proximal dilatation of the ureter and collecting system.

Diagnosis of UT pathology

- Stone disease
- UT neoplasms
- UT infection
- UT trauma
- Miscellaneous lesions

Renal masses benign & malignant

Intravenous urography showing the difference between a benign renal mass (simple renal cyst, left image) splaying the calyces and a malignant renal mass (RCC, right image) destroying the calyces
Renal masses benign & malignant

- Renal US showing the difference between cystic (left image) and solid (right image) renal masses, compared to the normal kidney in the middle image

CT scan showing large left RCC in a patient with pulmonary metastases.

CT, MRI Other findings affecting the management and prognosis

- Renal vein invasion
- IVC invasion
- Perinephric invasion
- Lymph node enlargement
- Adrenal metastasis
Renal cell carcinoma

US & CT scan show a large right renal mass. The mass (M) is hyper echoic with heterogeneous texture, low areas consistent with necrosis (n) and enhancing areas consistent with viable tumor (t) which is less enhancing than the normal renal parenchyma (p).

Wilm's tumor

CT scan and surgical specimen showing a large solid left renal mass in a child diagnostic of nephroblastoma (Wilm’s tumors)
TCC

- The most common renal pelvic tumor
- Multiple lesions in about 30% of cases
- M:F = 4:1 above 60 Years
- Diagnosed by IVP, CTU, MRU
- Filling defect in the pelvis

Simple renal cyst, CT

US and CT images showing the typical appearance of simple renal cyst
Bladder carcinoma

IVU of a patient with hematuria clearly shows a large, irregular filling defect within the bladder caused by a tumor, compared to the normal bladder seen in the right image.

Urinary bladder carcinoma

IVU and CT scan showing an intravesical filling defect (arrows) representing a TCC.

Bladder carcinoma

IVU of a patient with hematuria clearly shows a large, irregular shaped filling defect within the urinary bladder proved to be transitional cell carcinoma.
Transitional cell carcinoma

Other findings affecting the management and prognosis of bladder cancer include:

- Extra-vesical extension
- Perivesical invasion
- Lymph node enlargement
- Abdominal metastasis

IV urogram and pelvic US showing a filling defect inside the urinary bladder representing vesical carcinoma

Pelvic CT scan showing a large tumor mass involving the right side of the urinary bladder representing vesical carcinoma
Diagnosis of UT pathology

- Stone disease
- UT neoplasms
- UT infection
- UT trauma
- Miscellaneous lesions

Traumatic renal injuries

- Perinephric hematoma
- Renal laceration
- Avulsion of the vascular pedicle

CT of the abdomen with intravenous and oral contrast shows no enhancement of the right kidney denoting avulsion of its vascular pedicle. Note relatively small amount of perinephric or intraperitoneal hemorrhage.
Hematuria and abdominal pain after trauma

**Diagnosis of UT pathology**
- Stone disease
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- UT infection
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**Common manifestations in acute renal conditions:**
- Swollen kidney
- Poor renal function
- Dirty perinephric fat

CECT scan shows normal-sized kidneys with no fluid collection, but the left kidney does not enhance. A DSA abdominal aortogram shows complete lack of enhancement of the left kidney denoting complete occlusion of the left renal artery, which prompted an emergent surgical procedure to restore blood flow.

Acute bilateral pyelonephritis. Contrast enhanced CT scan demonstrates patchy, striated nephrograms.
Acute right pyelonephritis

Renal abscess
- UT infection, trauma, UT obstruction, blood born
- Well defined marginally enhancing lesion
- Air loculi inside ?!
- May extend into the perinephric space

Contrast enhanced CT scan shows swollen right kidney with patchy, striated nephrogram compared to the normal left kidney

Contrast enhanced CT scan showing a marginally enhanced left renal abscess involving its posterior aspect

CT scans of two different cases showing the difference between simple renal cyst (left image) and renal abscess (right image) which shows thick enhanced margin
**Emphysematous pyelonephritis**
- Gas shadows within and around the kidney
- Surgical emergency that is lethal if treated medically

CT scan of the left kidney showing almost total replacement of the renal tissue by gas shadows also involving the perinephric spaces

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**End-stage renal tuberculosis**

PUT showing totally calcified left kidney representing late sequelae of renal TB
Renal TB

- GU tract 2nd most common site of TB infection after lungs
- Males are more infected than females
- Usually above the age of 50 years
- Spread is hematogenous and is usually primary exposure
- Infection may remain latent for decades
- Active pulmonary TB seen only 4-8% of time
- 25% of patients with GU TB have a known pulmonary TB

Renal TB: Axial and coronal CT images showing small sized totally calcified left kidney (end stage kidney)

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  - Vesico-ureteric reflux
  - Urethral lesions
  - Reno-vascular hypertension
Congenital lesions
- Absent & hypo plastic kidney
- Duplex kidney and ureter
- Ectopic kidney
- Horseshoe kidney
- PUJ obstruction
- Urethroceles
- Bladder diverticulum

Horseshoe kidney

Intravenous urography showing ectopic pelvic left kidney seen above the urinary bladder

IVP and coronal reconstructed CT image showing horse-shoe kidney
**Right renal agenesis**

CT urography shows normal left kidney but no right kidney in renal fossa or anywhere along the path of ascent of the kidney from the right pelvis through the right paravertebral regions.

**Duplex kidney and ureter**

This intravenous urogram shows a single right ureter but a complete left ureteral duplication, with the two left ureters extending down to the bladder, where their distal course was obscured by contrast in the bladder.

**Bilateral ureteroceles**

This intravenous pyelogram demonstrates a congenital variant with dilatation of the distal ureter as it enters through the bladder wall. This produces a typical "cobra head" deformity which is usually of little clinical significance.
Congenital PUJ obstruction stages

PUJ obstruction with renal calculi

CT scan demonstrates right hydronephrosis due to PUJ obstruction with multiple calyceal stones. Note that the left renal collecting system is almost normal.

Congenital PUJ obstruction

CT urography showing markedly distended left pelvi calyceal system proximal to a narrow pelviuretric junction. Normal right collecting system as well as both ureter.
Vesicoureteric reflux

Voiding cystourethrogram demonstrates reflux into both kidneys, with dilatation of the ureters and renal collecting system. The calyces are distended and blunted. The urethra appears normal.

Grades of vesicoureteric reflux

Cystogram showing grade I vesicoureteric reflux on the right side
Grade III vesicoureteric reflux

Ascending cysto-urethrography showing grade III vesicoureteric reflux in a duplex right kidney

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Ascending and voiding cystourethrogram

Normal ascending (left) and micturating (right) cystourethrogram

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Stricture urethra

Ascending cystourethrogram showing a tight stricture in the penile urethra
Traumatic rupture of the urethra

The patient had painful, swollen and bruised perineum after a direct kick during a fight. He was also bleeding per urethra and was unable to micturate. US showed marked soft tissue swelling of the perineum only.

In conclusion

Patients with renal colic

- Start by PUT & US
- Inconclusive
- CT urinary tract
- Site & size of calculi
- Back pressure effects
- IVU to seen the renal function
In conclusion

Patients with hematuria
Start by PUT & US

Stone OR tumor

CECT urinary tract
Site & size of tumor
Extensions and lymph nodes
Vascular invasion & metastases

If IV contrast is contraindicated

MRI

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In conclusion

If IV contrast is contraindicated

MRI & MRU

Traumatic injuries

CECT urinary tract

Perinephric hematoma
Renal laceration
Renal pedicle avulsion
In conclusion

If IV contrast is contraindicated

MR urography

Suspected congenital anomalies

Intravenous urography (IVU)

- Absent & hypoplastic kidney
- Duplex kidney and ureter
- Ectopic kidney
- Horseshoe kidney
- PUJ obstruction
- Ureteroceles
- Bladder diverticulum