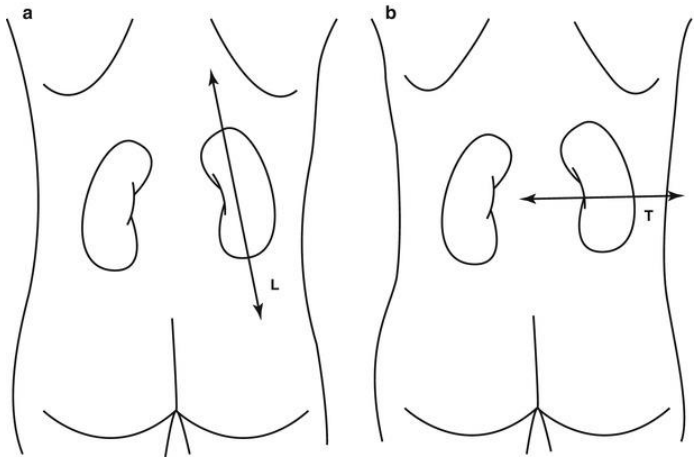
KARNATAKA RADIOLOGY EDUCATION PROGRAM

Anatomy and Applied Radiology Kidneys – 2

Normal Radiological Anatomy of the Renal system

Conventional Radiography

The longitudinal and transverse represent the two fundamental planes employed for renal imaging. The conventional plain radiography of the abdomen, or kidney–ureter–bladder (KUB) radiograph, is a first-line imaging technique in the assessment of the kidney. It is performed in the anteroposterior projection with the patient in the upright or supine position. It is indicated to evaluate the renal shape, margins, dimensions, and location and to identify renal calcifications, stones, or transparencies due to fat or gas.



(a, b) Fundamental planes employed for renal imaging. The longitudinal axis (a) is parallel to the major diameter of each kidney. The transverse axis (b) is perpendicular to the major diameter of each kidney.

On the abdomen plain radiography, both kidneys are clearly visible due to the natural contrast provided by the perirenal fat and can be assessed regarding their position, morphology, margins, and dimensions. In normal adults both kidneys present a longitudinal diameter of 9–12 cm, and a latero-lateral diameter of 3–5 cm, and should not have a difference in the largest longitudinal diameter higher than 1.5 cm. In the long body habitus subjects, the longitudinal diameter may exceed the highest range, while in the short body

habitus subjects, the normal 15–20° inclination of the renal longitudinal diameter on the frontal plane may be much higher with an apparent reduction of the longitudinal diameter on the anteroposterior projection. The psoas muscle profile is another important parameter to evaluate since it is conceled by the intestinal meteorism or by retroperitoneal effusions.

Conventional plain radiograph of the abdomen. The kidneys (arrows) are easily identified due to the natural contrast provided by the perirenal fat which allows the differentiation between the kidneys and the psoas muscle

IVU

In a normal intravenous urography (IVU) or intravenous pyelogram (IVP) radiography, the kidneys, ureters, and bladder appear as well-defined structures with smooth outlines, and the contrast medium (dye) should be excreted and visualized in the collecting system (pelvicalyceal system) without any obstructions or abnormalities.

IVU, also known as intravenous pyelography (IVP) or excretory urography (EU), is a radiographic study of the urinary tract (kidneys, ureters, and bladder) using intravenous contrast medium.

It involves injecting a dye into the bloodstream, which is then filtered by the kidneys and excreted into the urinary tract, allowing visualization on X-rays.

The procedure helps evaluate the size, shape, and position of the kidneys, ureters, and bladder, as well as to investigate the cause of hematuria, pyuria, or suspected calculi or masses.

Normal Findings on IVU/IVP Radiography:

Kidneys:

Normal size, shape, and position.
Smooth outlines with no evidence of masses, cysts, or other abnormalities.
The contrast medium should be filtered and visualized in the renal parenchyma (nephrogram phase) and collecting system (pelvicalyceal system).
Ureters:

Normal caliber and patency.

The contrast medium should pass smoothly through the ureters into the bladder.

Bladder:

Normal size and shape.
The bladder should be visualized with the contrast medium, and there should be no evidence of masses or other abnormalities.

Indications

IVU is rarely performed if CT is available. However if a CT IVU demonstrates delayed excretion due to obstruction, a delayed radiograph following CT IVU can identify the site of obstruction.

IVU can provide important information:

- **ureteric obstruction: severity, site and cause e.g. urolithiasis**
- **synchronous or metachronous upper tract tumor: detailed evaluation of pelvicalyceal and ureteral morphology in patients with bladder transitional cell carcinoma (TCC)**
- **papillary necrosis**
- **anatomical variants such as horseshoe kidney**
- **the course of the ureters**
- **renal function**

Patient preparation

- **fasting for 5 hours prior to the examination is preferred; laxatives to reduce fecal loading do not improve image quality [4]**
- **check eGFR**
- **check for allergies and contrast medium reactions and obtain written informed consent according to hospital guidelines**
- **emergency medications and equipment must be available to treat clinically significant contrast medium reactions**

Technique

Exposures in the 65-75 kV range optimize radiographic contrast, mA of 600-1000 and exposure time < 0.1 second.

There are various IVU techniques [4]. 18 or 19G gauge IV access is required for bolus injection of a water-soluble iodinated contrast agent; nonionic contrast medium has a better safety profile. A dose up to 1.5 ml/kg body weight is well tolerated.

For suspected ureteric obstruction the following radiographs will suffice:

- **control AP radiograph of the kidneys, ureters and bladder to show calculi which can be obscured by contrast medium**
- **3 minute post injection AP radiograph of the kidneys to show contrast medium beginning to appear in the pelvicalyceal systems. Unilateral absent excretion indicates obstruction. Cortical and medullary nephrogram is normally well seen at 3 minutes but attenuation may be reduced on the obstructed side**
- **10 minute full-length AP radiograph, optional obliques**
- **full-length post-micturition radiograph to confirm ureteric obstruction and delineate the lower ureter which can be obscured by contrast medium in the bladder**
- **if the obstruction is severe and the ureter is insufficiently opacified, perform delayed full-length radiographs at 1 hour +/- 24 hours**

High-grade obstruction can significantly delay excretion. The nephrogram on the obstructed side will be delayed, and will persist and increase in attenuation. If the site of obstruction is not delineated at 1 hour, then a 24-hour delayed radiograph is indicated.

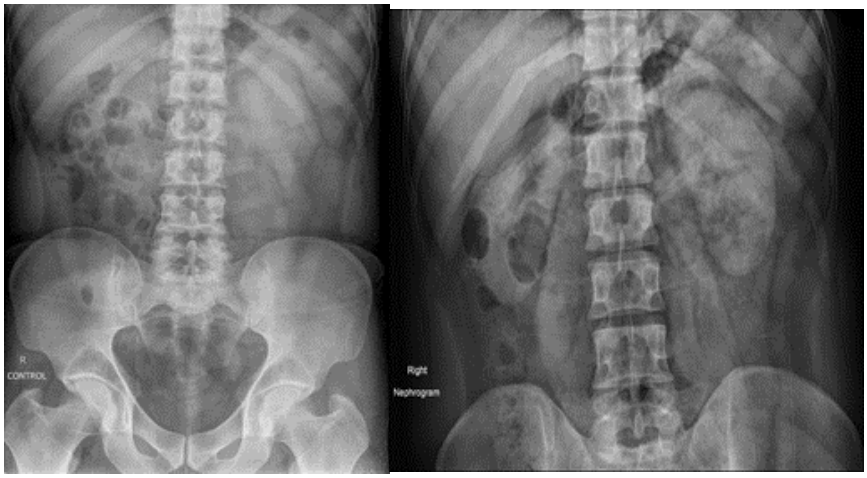
Contrast medium is heavier than urine and this property can be used to advantage. An erect full-length radiograph will demonstrate a full ureter to the point of obstruction. If the patient cannot stand, lie them prone to demonstrate the mid ureter and then supine to show the distal ureter.

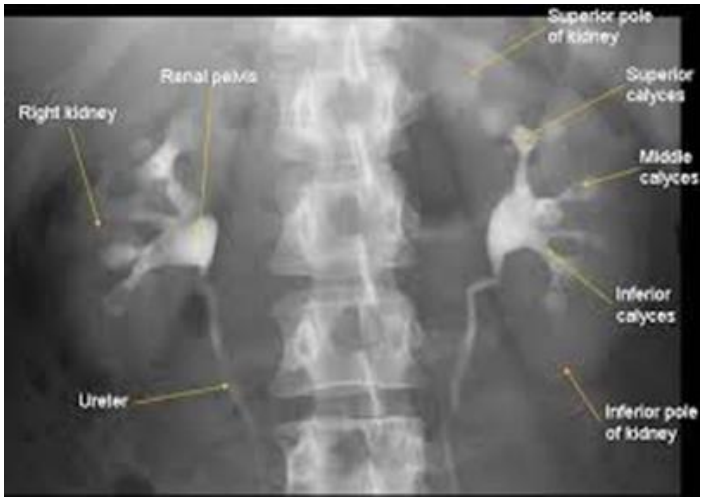
The technique for synchronous or metachronous upper tract urothelial tumors includes detailed views of the pelvicalyceal systems and ureters.

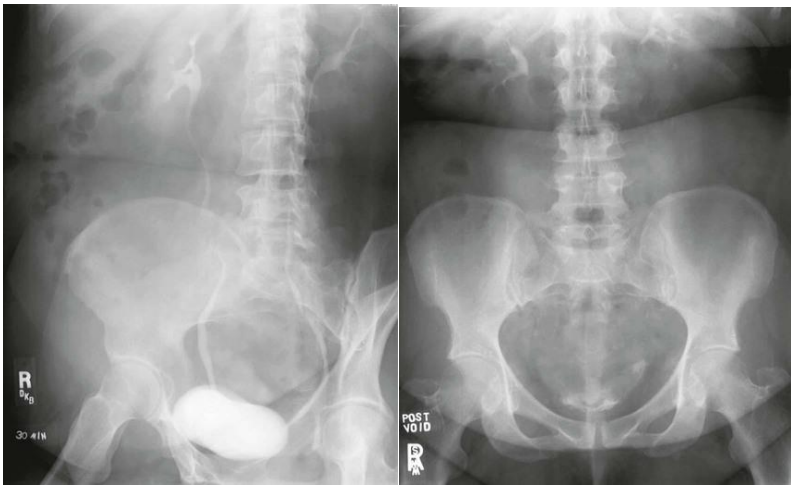
- **5 minute AP radiograph of the kidneys then apply a lower abdominal compression band to distend the upper tracts**
- **AP and both oblique radiographs of the kidneys at 10 minutes**
- **full length AP radiograph and both obliques on compression release**
- **prone views are optional to show the mid ureters**
- **multiple images help overcome the problem of non-visualization of ureteric segments due to normal peristalsis**
- **AP full-length post void view**

Compression is contraindicated in:

- renal trauma
- large abdominal mass
- abdominal surgery (post operative)
- abdominal aortic aneurysm

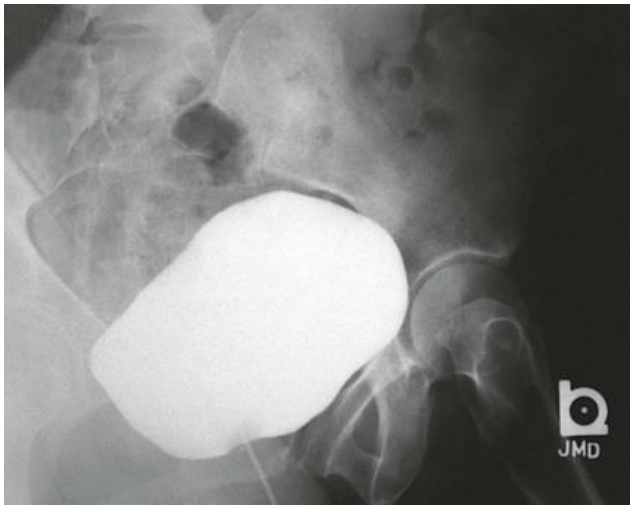






Cystography

Cystography is a common radiographic examination for studying the lower urinary tract. This involves insertion of a urinary catheter into the urethra and retrograde filling of the bladder with iodinated water-soluble contrast material .



A frequent indication for this procedure is to identify vesicoureteral reflux (VUR). In the normal bladder, increased pressure as the bladder fills effectively shuts down any chance of reflux. Bladder infection, however, may render the ureteral "valve" incompetent, refluxing the infection into the kidney.

Urethrography refers to the radiographic study of the urethra using iodinated contrast media and is generally carried out in males.

Terminology
When the urethra is studied with instillation of contrast into the distal/anterior urethra it has been referred to as:

retrograde urethrography (RUG)
ascending urethrography (ASU)

When the posterior urethra is studied during micturition, this has been referred to as:

voiding cystourethrography (VCUG)
descending urethrography
micturating urethrography

The resulting images are known as urethrograms.

Examination technique (RUG/ASU)

place the patient in supine position 4. Retract the foreskin and clean the tip of the penis with Betadine® (povidone-iodine) or antiseptic solution

inject a small amount of topical local anesthetic (e.g. lidocaine gel) into the urethra with a syringe

local anesthetic helps to relax the sphincter as the patient may contract it during the procedure thus leading to a diagnosis of a stricture

some advocate against the use of lidocaine gel on the basis that an inadequate seal is formed

the patient position should be oblique to visualize the full length of the urethra

place the tip of the metallic adaptor into the urethral orifice and attach the contrast loaded syringe to it

an alternative is to place a Foley catheter tip in the navicular fossa and gently inflate the balloon with 2 to 3 ml of sterile water until a seal is formed 4 making sure not to cause the patient pain or damage the distal urethra

gently pull the catheter to straighten the penis and prevent overlapping on the urethra 4

inject the contrast and image as soon as a major part of the contrast has been injected, taking spot images when appropriate

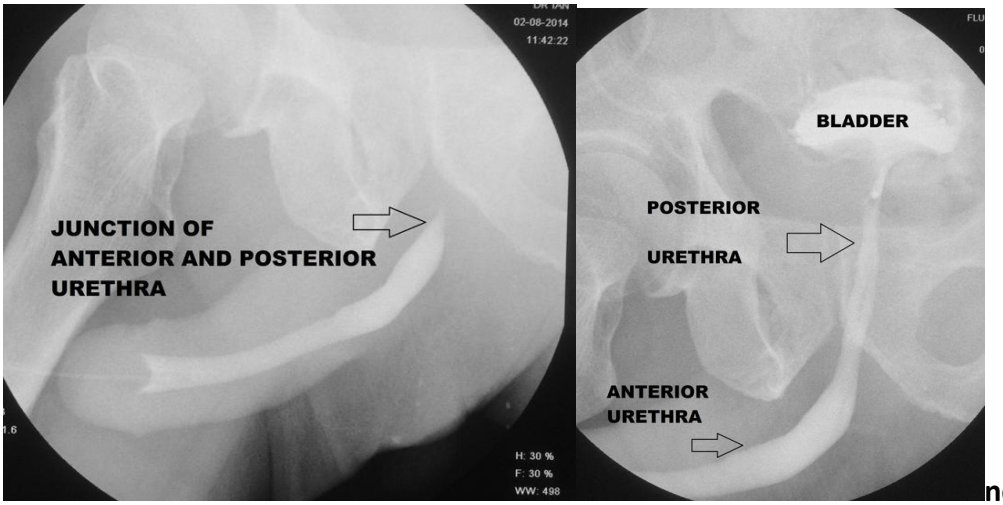
Ideal images demonstrate the entire length of the urethra with contrast beginning to fill the bladder.

RUG/ASU may be followed by VCUG/MCU if there is no contraindication to catheterize the bladder (e.g. false passage or stricture). If the patient is able to relax the bladder neck, then bladder catheterization can be avoided because contrast is able to flow into the bladder retrogradely from the urethra 4.

RUG/ASU vs VCUG/MCU

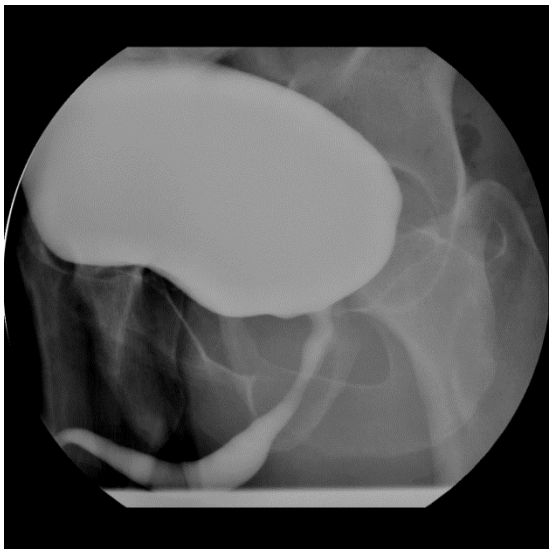
Generally, a RUG/ASU is carried out to visualize anterior urethral abnormalities and a VCUG/MCU for posterior urethral abnormalities.

Additionally, although the bladder is not generally the main target of the exam, as with a cystogram, a VCUG/MCU may be useful in the detection of bladder abnormalities and vesicoureteric reflux (VUR).



normal ASU

MCU



Normal VCUG

RGU

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