Investigation of the urinary system

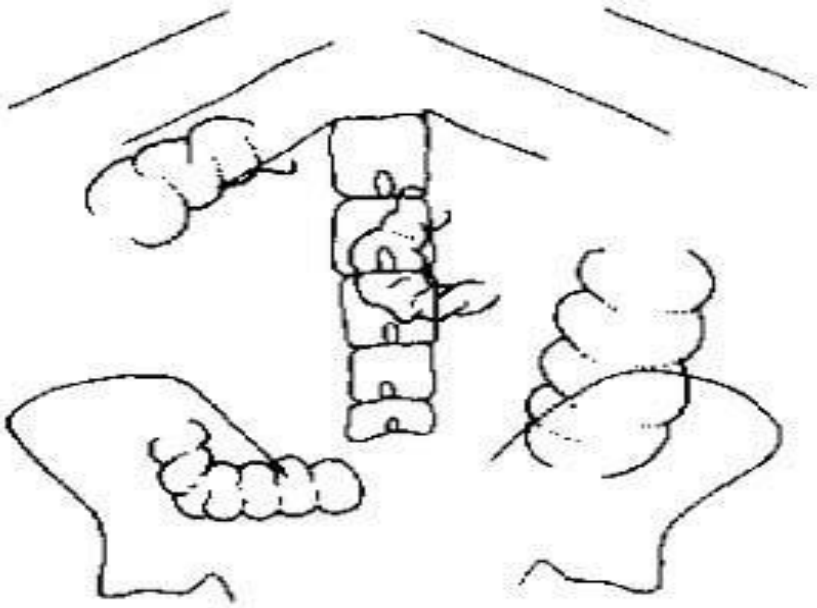
Plain Film:

- Plain film is taken in supine position. The radiograph should include the upper poles of both the kidneys and lower border of symphysis pubis (for prostatic urethra).
- A plain abdominal film is essential prior to urinary tract investigation.

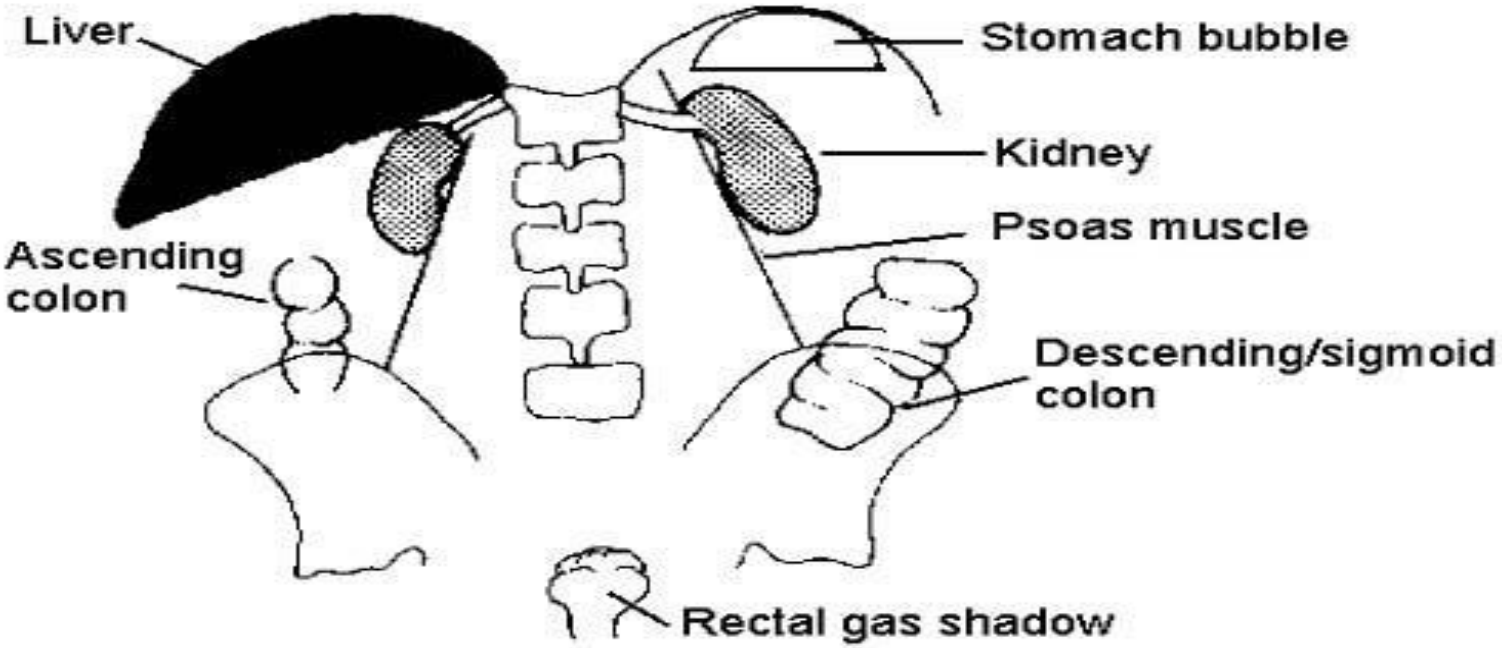
This may show

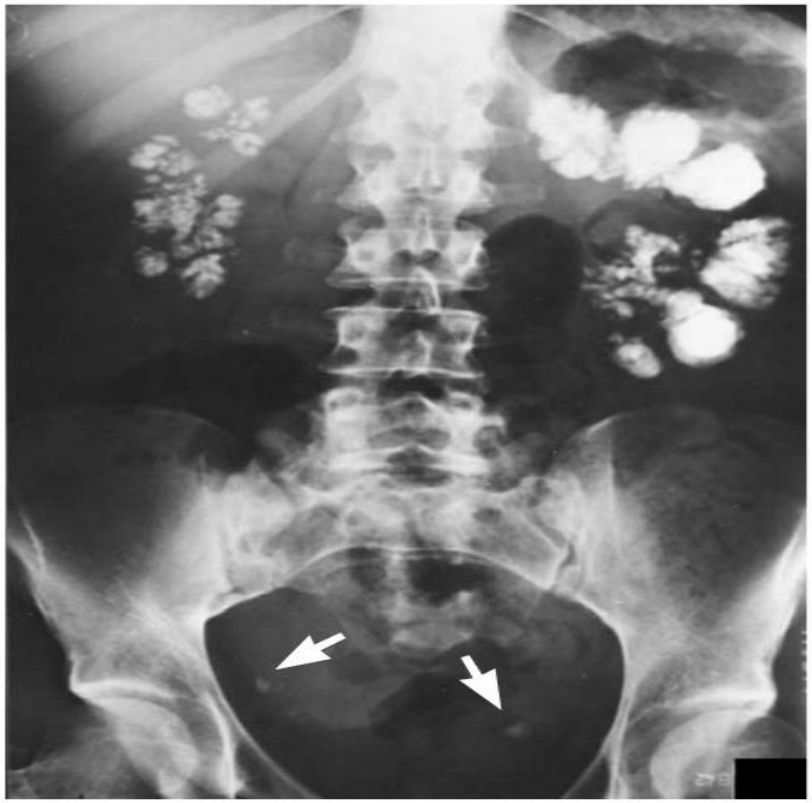
- renal calculi in the pelvicalyceal system
- renal parenchymal calcification
- ureteric calculi
- bladder calcification and calculi
- prostatic calcification or sclerotic bone deposits

- Caution should be used in interpreting renal-tract calcification as overlying calcified mesenteric glands and pelvic vein phlebolitis are often mistaken for ureteric calculi. Inspiration and expiration films change the position of the kidneys and often confirm that a calcified area in the upper abdomen is a calculus.



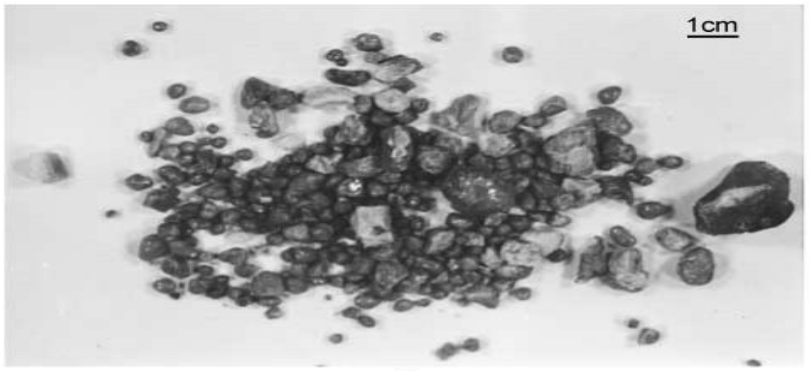
Plain abdo film (structures visible)





A

B



C

Intravenous Urography (IVU):

- **IVU** is frequently performed in the evaluation of hematuria. Urography may also be performed in the pre- or post theraupetic evaluation of stone disease that has been discovered with other imaging modalities.

Indications

- obstructive calculi
- hematuria or pyuria
- diseases of renal collecting system and renal pelvis
- abnormalities of the ureter
- tuberculosis of the urinary tract
- prior to endourological procedures and surgery of the urinary tract
- suspected renal injury
- renal colic or flank pain
- in children – polycystic kidney diseases, pelvi-ureteric junction obstruction, anorectal anomalies
- pelvic malignancies to see uretic involvement

Patient preparation

- blood urea and serum creatinine level should be within normal limits
- if patient is asthmatic premedication in the form of steroids is administered two days prior
- fasting after 10 pm (previous night) (as contrast injection sometimes induces nausea which might lead to vomiting and aspiration)

- patient should be well hydrated (dehydrated patients are prone for renal damage)
- bowel preparation is necessary, as gas and faecal matter filled bowel loops will obscure the kidney shadows
- low residue diet with plenty of oral fluids, the day previous to the IVU

- Bowel wash is given till bowel is clear of faecal matter on previous night.
- Laxatives (ducolax, castor oil) are recommended to eliminate faecal matter from colon and gas absorbing agents (flatulex) are given to reduce the amount of gas in the bowel.
- In young children no special preparation is needed, only 4 hours fasting is sufficient.

Procedure

- Patient is placed in supine position. The patient is asked to void the bladder before the procedure.
- A plain film is taken which includes the kidneys, ureters, bladder and urethral regions on a large size film, called as the scout film.

- Contrast media is injected intravenously into a prominent vein in the arm. Test injection of 1ml of contrast is given and patient observed for 5 min for any contrast reactions. Then the rest of the contrast is rapidly injected within 30-60 seconds.
- The dose of contrast media is 2 ml/kg body wt.

Contrast media

- Contrast materials currently in use are excreted almost exclusively by glomerular filtration, with subsequent concentration in the renal tubules and progressive opacification of the urinary tract.
- **They are two types:**
- ionic (urograffin, angiograffin)
- non-ionic (omnipaque, ultravist)
- Ionic contrast media have a higher incidence of reaction but they are cheaper as compared to the non-ionic contrast media.

Filming technique and interpretation

- ***Plain x-ray (scout film)***
- It gives information about:
- renal outlines
- psoas muscles
- bony structures such as vertebra and its appendages, pelvis
- any stones
- abdominal mass
- foreign body

- ***5-10 min film***
- Shows nephrogram, renal pelvis

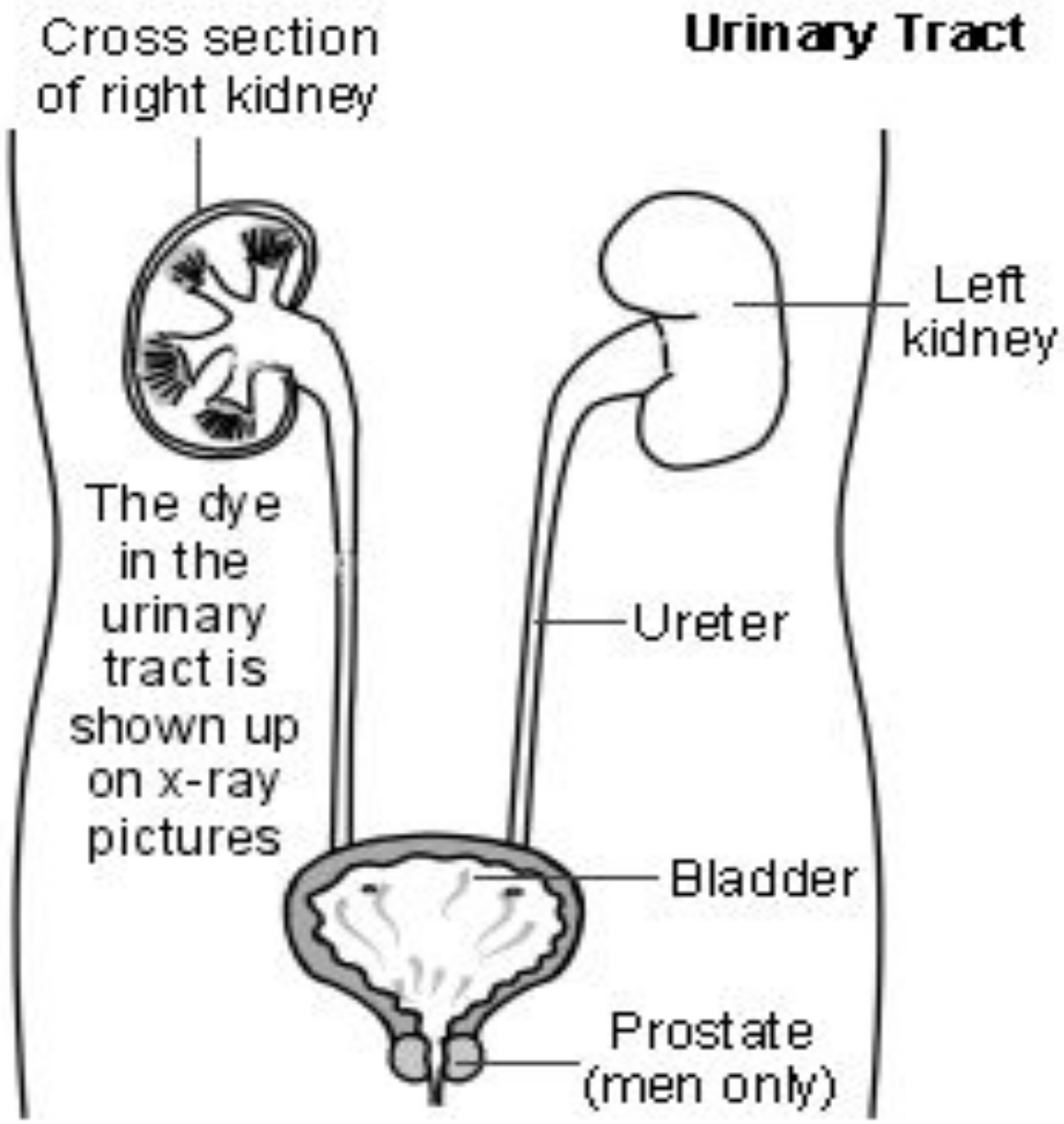
- ***15-20 min film***
- A complete visualization of the pelvicalyceal system entire ureters is possible in this film, especially with the patient in prone position as the ureters will be antedependent in prone position.

- ***30-35 min film***
- A complete visualization of the urinary tract: kidney, ureter, bladder can be done and bladder distension can be evaluated in the later film.

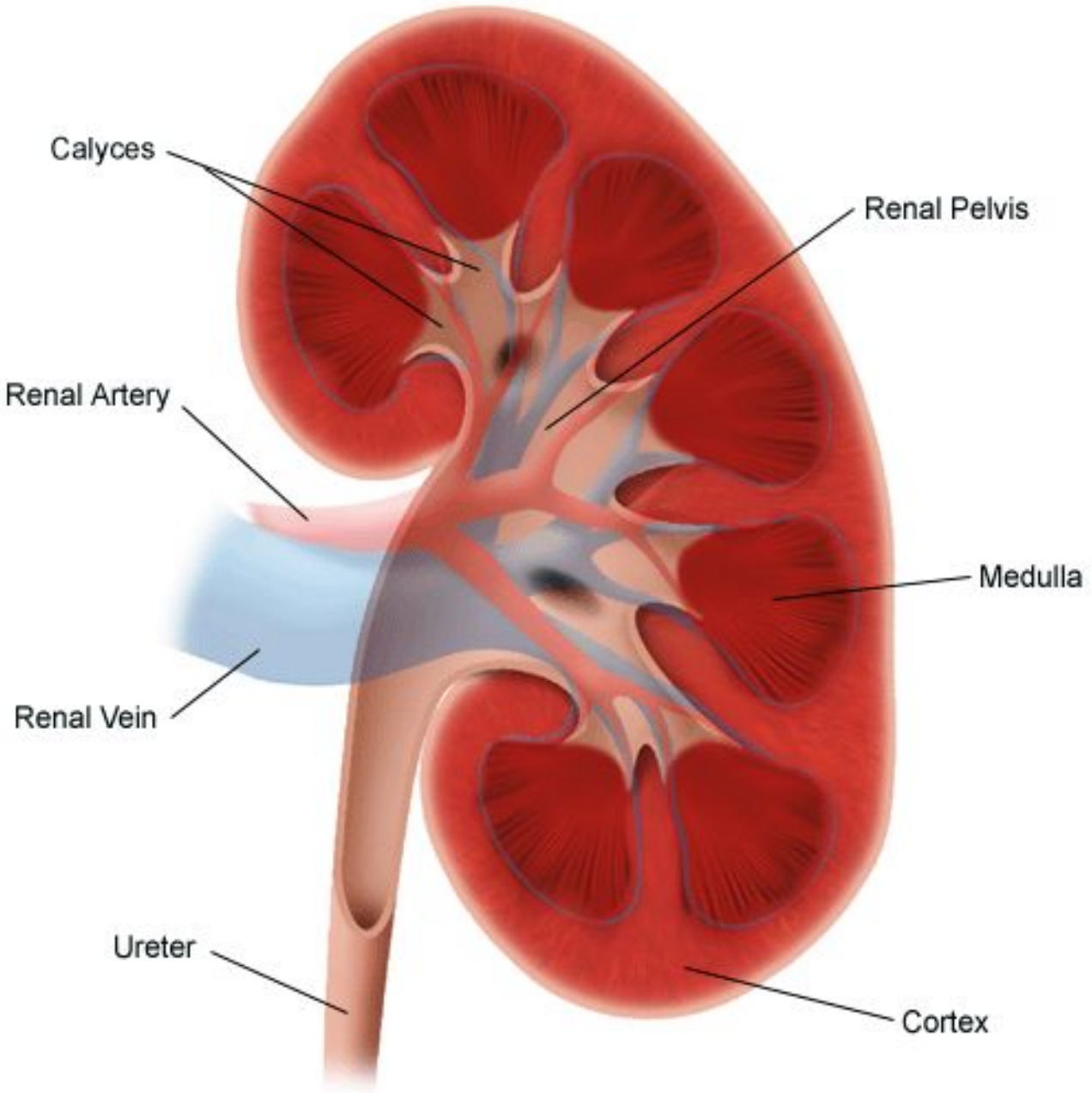
- The series is varied according to the individual patient. Renal obstruction may require a delayed study up to 24 hours to outline the pelvicalyceal system.

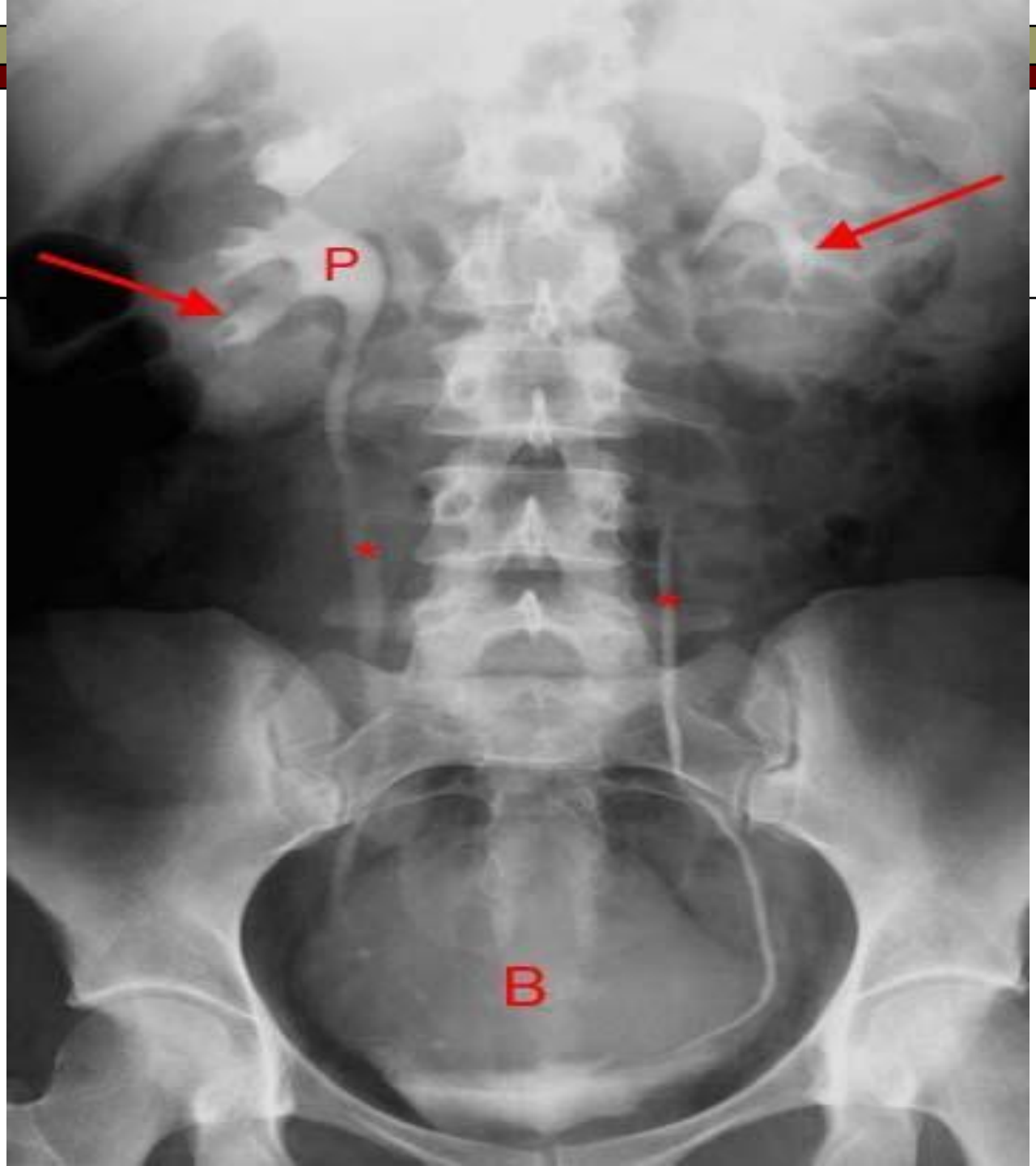
Post void film

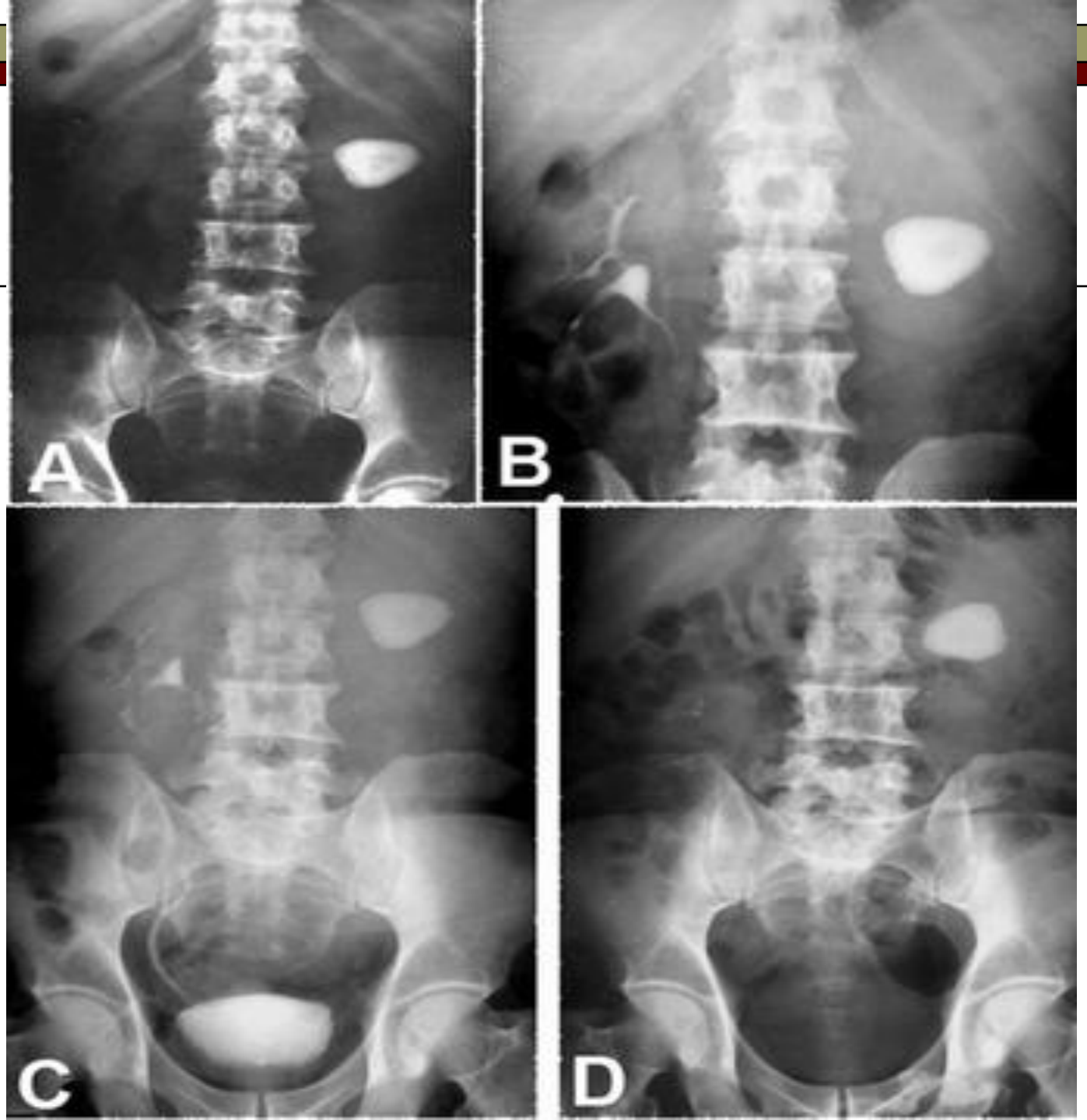
- It taken immediately after voiding.
- **To assess for:**
- residual urine
- bladder mucosal lesions
- diverticula
- bladder tumors
- outlet obstruction


Urinary Tract
Cross section of right kidney
Left kidney
The dye in the urinary tract is shown up on x-ray pictures
Ureter
Bladder
Prostate (men only)

Anatomy of the Kidney




P
B


A
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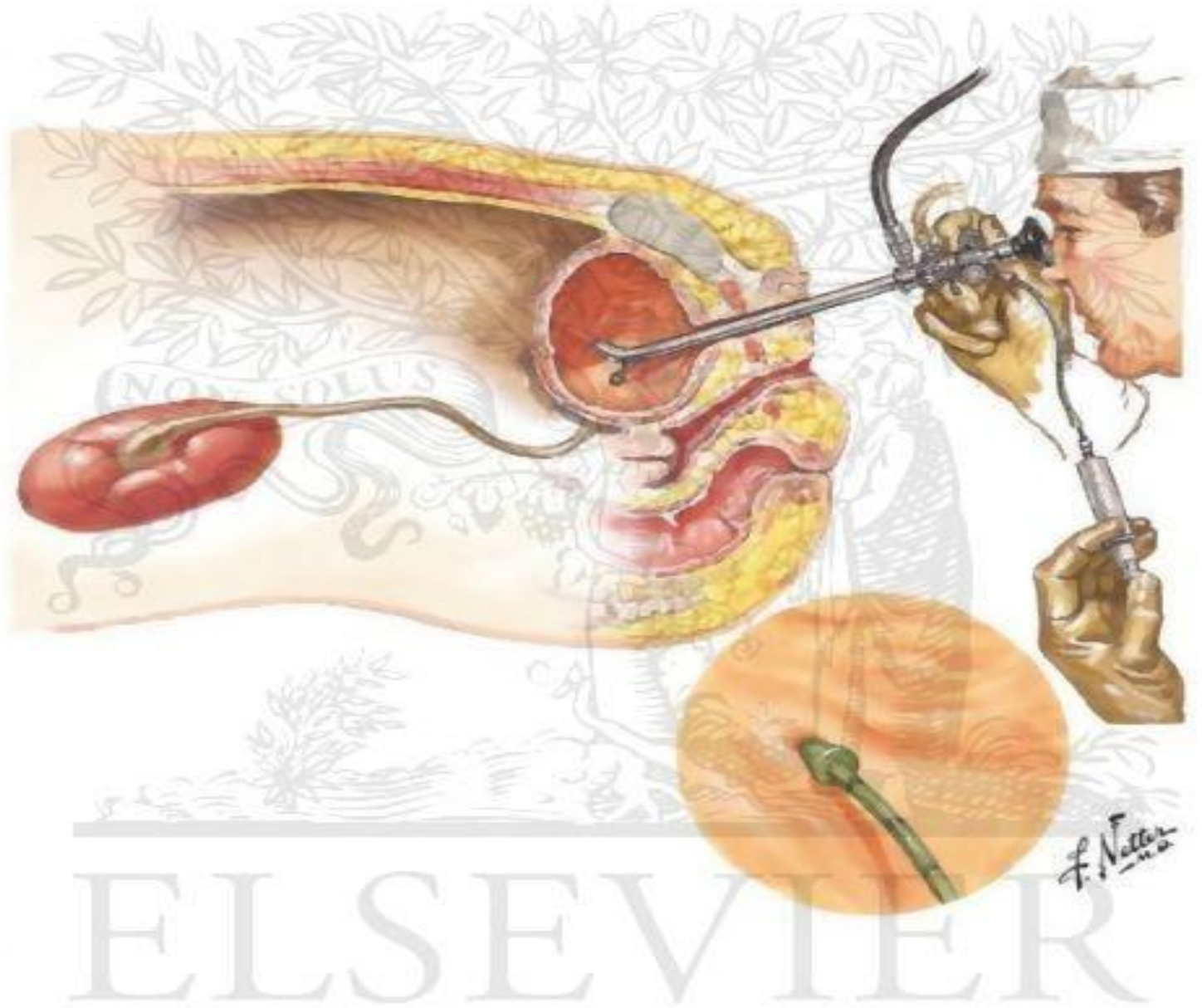
C
D

Retrograde pyelography

- A retrograde pyelography is occasionally necessary when detail of the pelvicalyceal system and ureter is not adequately delineated by intravenous contrast, especially when there is suspect ion of an epithelial tumor of the urinary tract.
- A catheter is placed into the ureter after a cystoscopy; contrast injected trough the catheter outlines the pelvicalyceal system and ureter.




4

Antegrade pyelography

- A fine-gauge needle, under local anesthetic, can be inserted directly into the pelvicalyceal system and contrast injected to visualize the calyces, pelvis and ureter. The patient lies in a prone position and the examination is carried out under either ultrasound or fluoroscopic control. This procedure, not requiring a general anesthetic, accurately localizes the site of an obstructing lesion, such as a calculus or stricture.

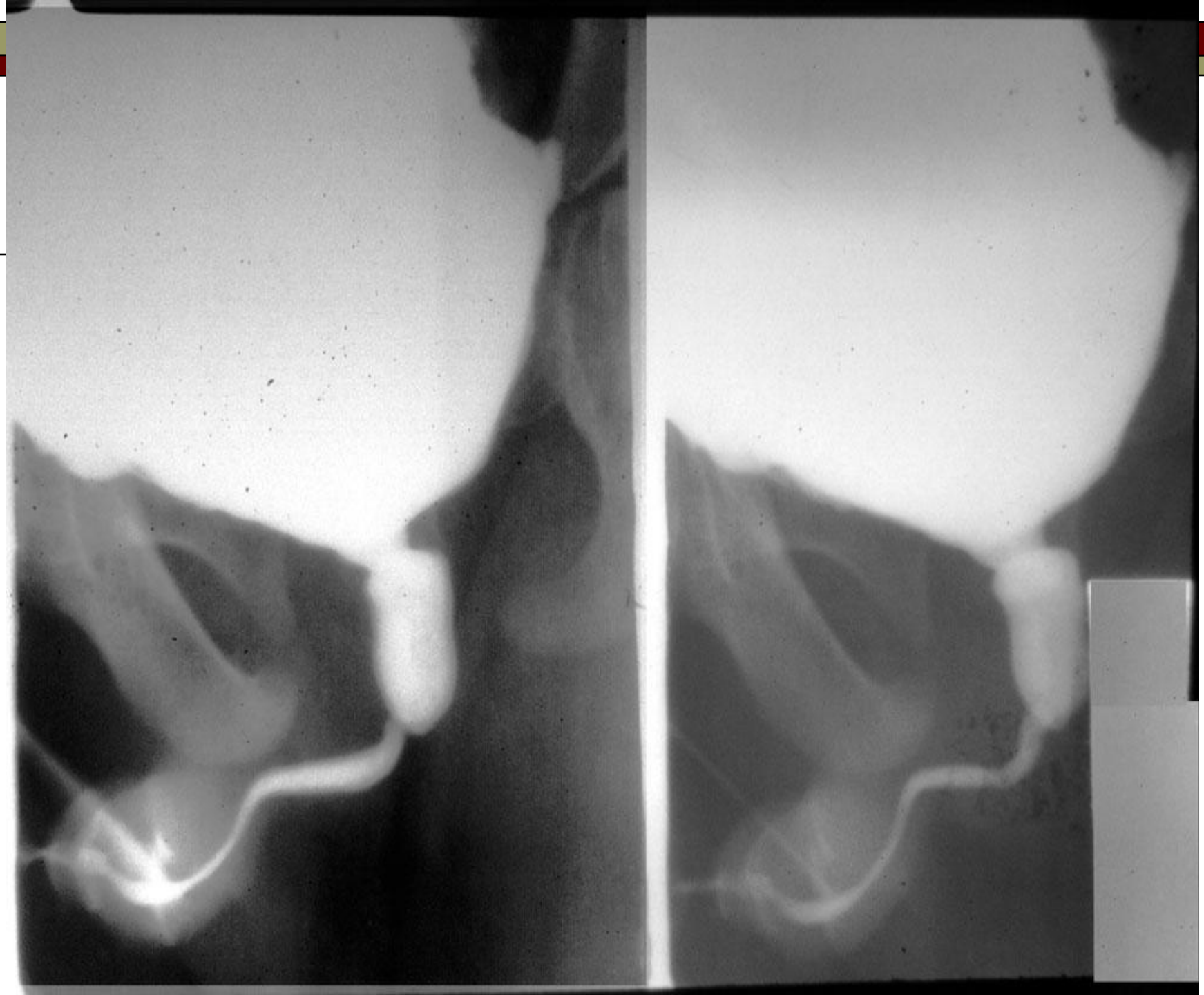
Micturating cystogram

- A catheter is inserted in the bladder which is filled to capacity with contrast. After catheter removal, films are taken of the renal tract as the patient is micturating, looking for vesico-ureteric reflux. Careful examination of the urethra in the oblique position is necessary in suspected urethral valves, as they are usually only demonstrated during micturition.

Indications

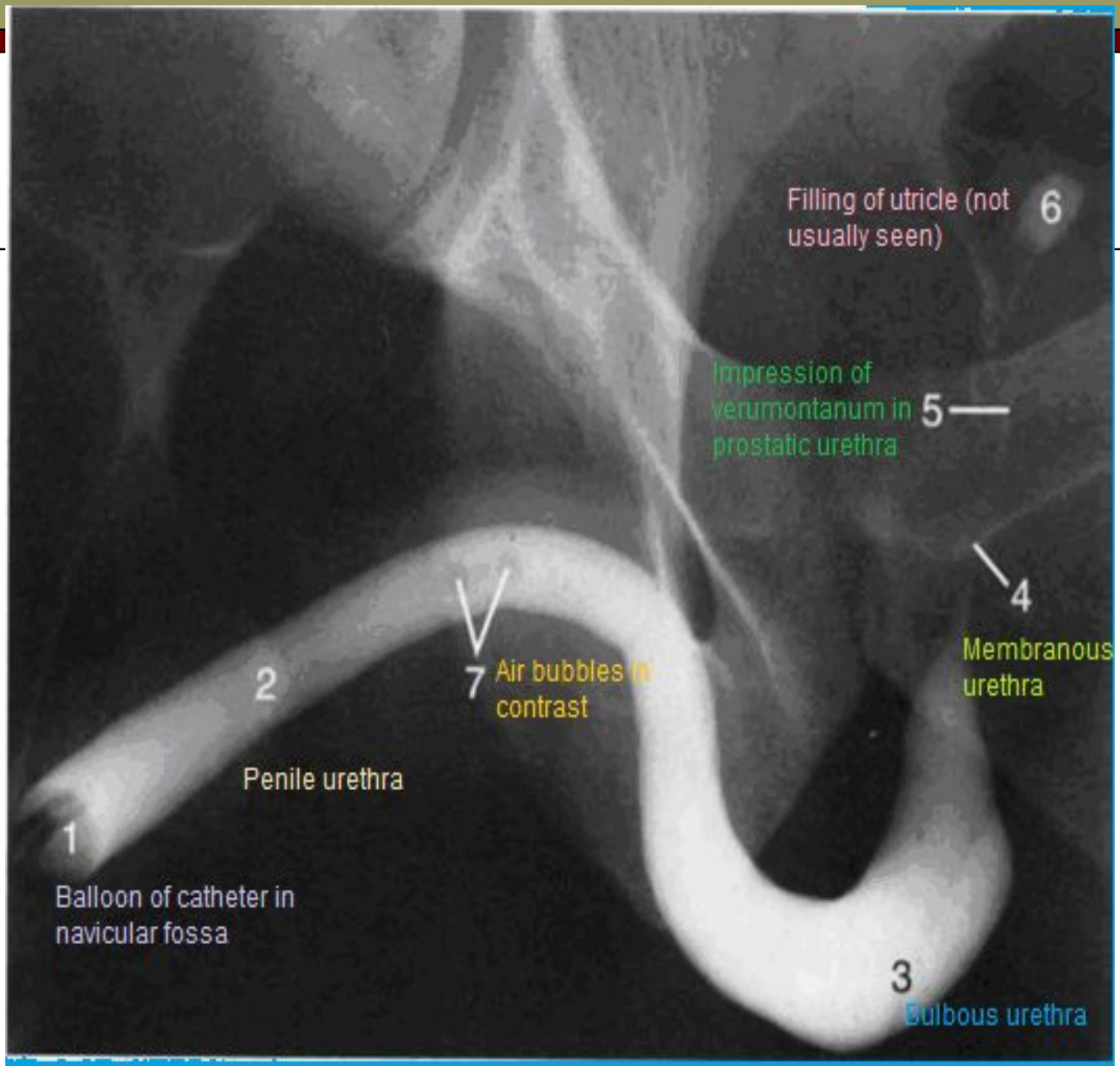
- **Children:**
- vesico-ureteric reflux
- post urinary tract infection
- trauma
- hematuria
- posterior urethral valve
- voiding difficulties like dysuria, thin stream, frequency and urgency
- in case of genitor-urinary anomalies

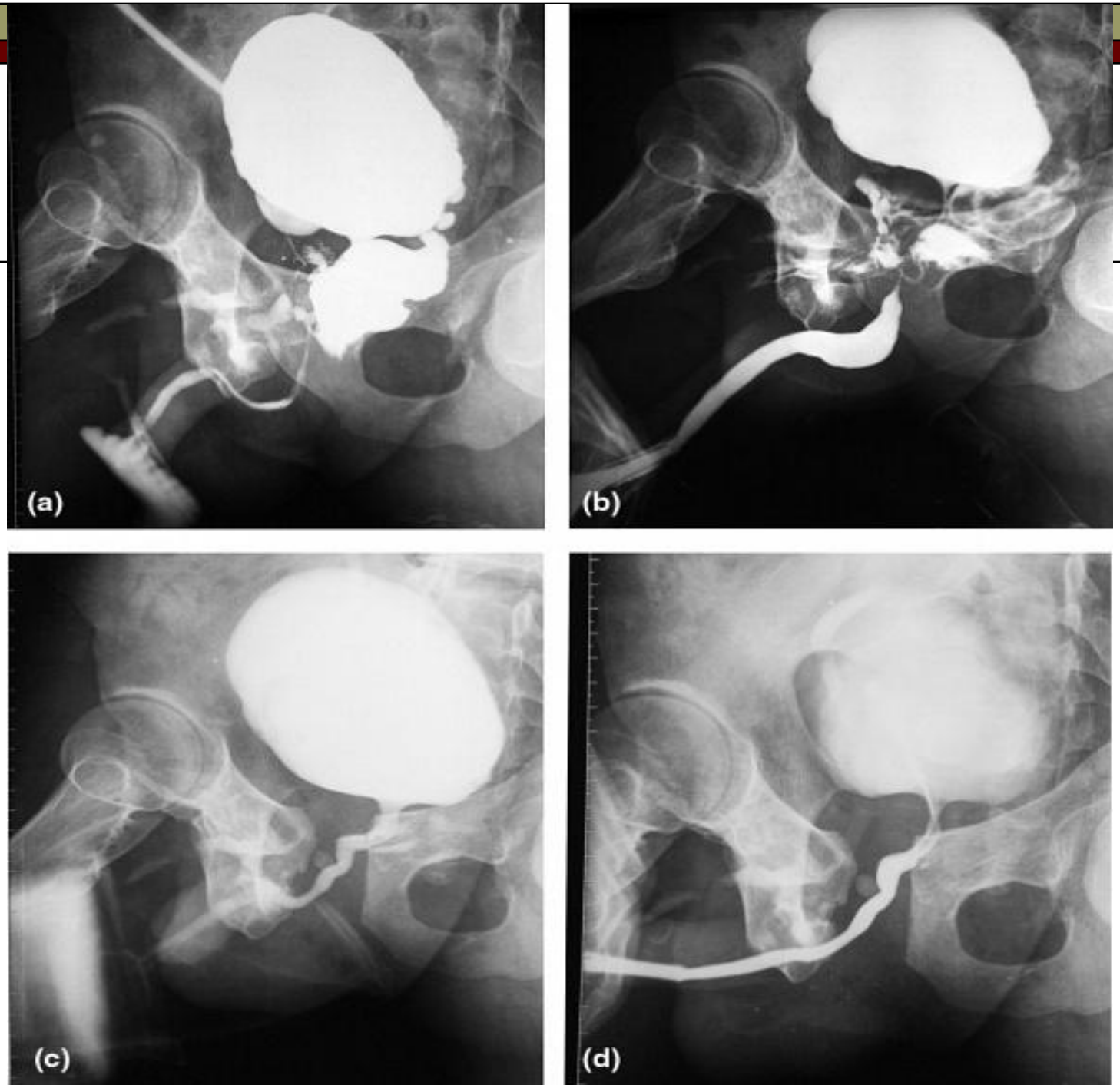
- **Adults:**
- trauma to urethra
- urethral stricture
- urethral diverticula
- vesico-ureteric reflux



Urethrography

- The adult male urethra can be visualized by:
- ascending urethrography: contrast is injected into the meatus and films obtained of the urethra
- descending urethrography: after filling the bladder with contrast, the catheter is removed and films of the urethra are taken during micturition
- In both studies, the entire urethra must be studied.


Filling of utricle (not usually seen)
6
Impression of verumontanum in prostatic urethra
5
4
Membranous urethra
7
Air bubbles in contrast
2
Penile urethra
1
Balloon of catheter in navicular fossa
3
Bulbous urethra


(a)
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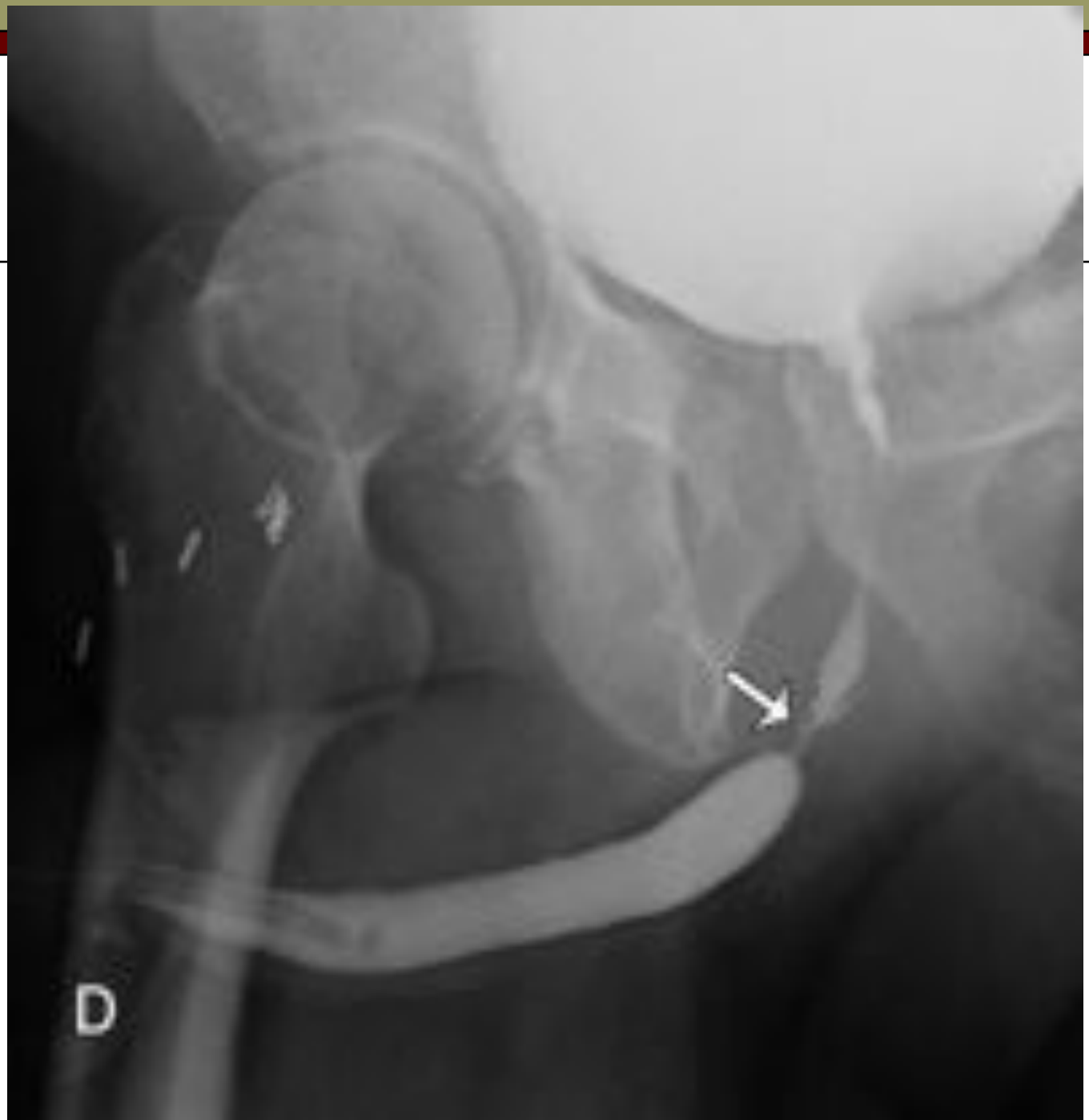
(c)
(d)

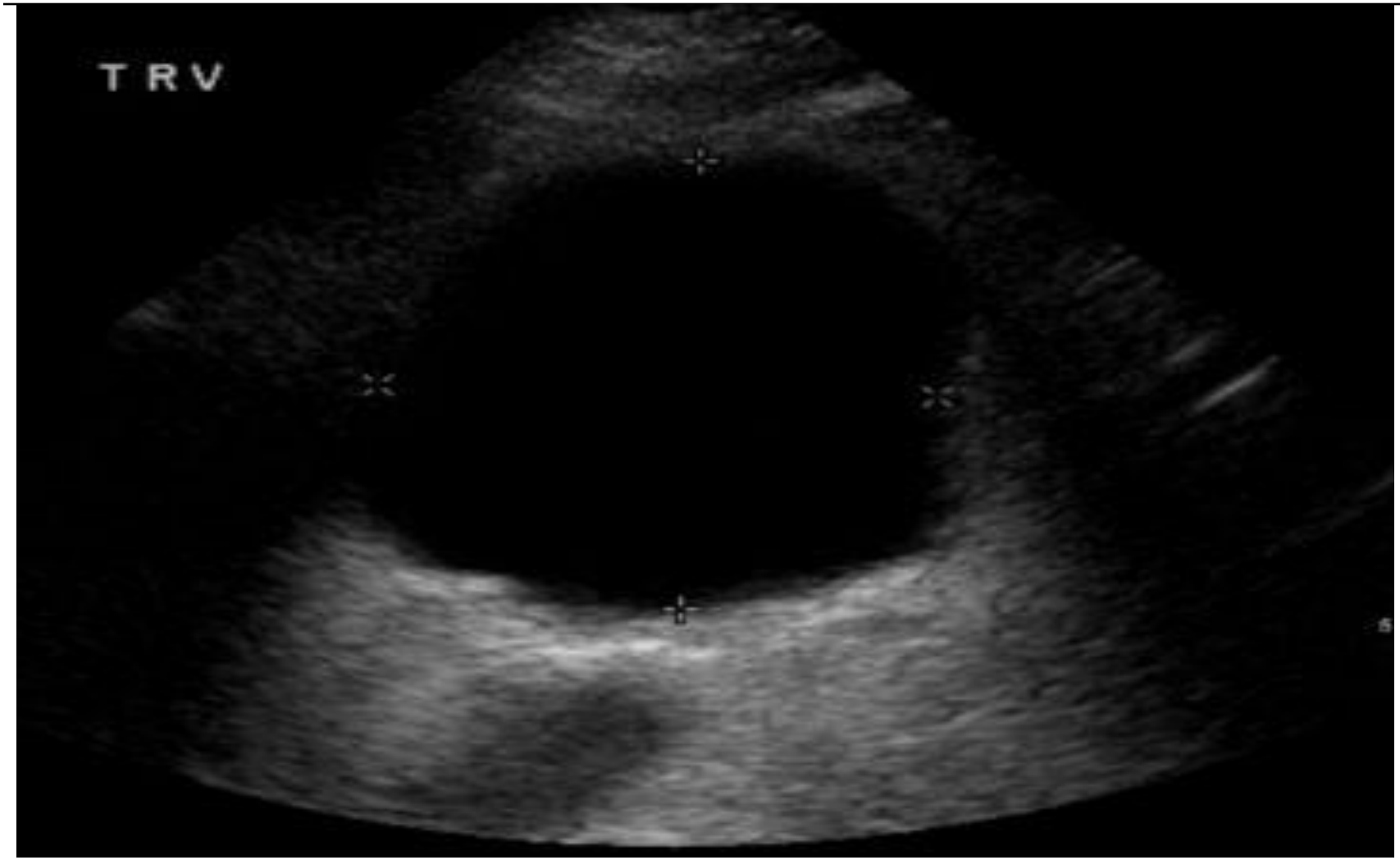

D

Ultrasound

- Ultrasound is one of the most valuable investigations of the urinary tract and the investigation of choice in children.
- It is extremely effective in evaluating:
- renal size
- growth
- masses

- renal obstruction
- urinary tract infection
- hematuria
- congenital abnormalities
- renal failure
- transplants
- bladder residual volumes
- prostatic size
- it is non-invasive and can be repeated frequently.

Urinary bladder



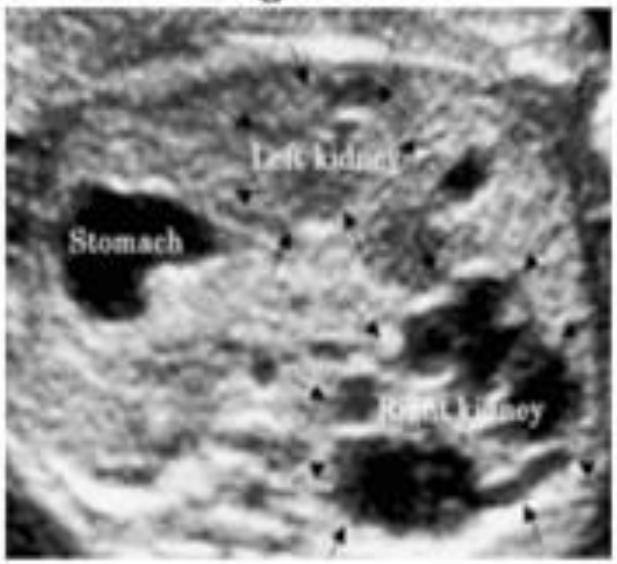
Isotope Scanning:

- ***Static Scanning: Technetium-99m DMSA:***
- Selective uptake by the renal cells with stagnation in the proximal tubules produces images of the renal parenchyma. The isotope is used to assess function, position, size and scarring of kidneys.

- ***Dynamic scanning: Technetium-99m DTPA*:**
- Isotope clearance by glomerular filtration produces a dynamic scan, providing information on renal blood flow and renal function. The function of each individual kidney can be assessed as well as total renal function.

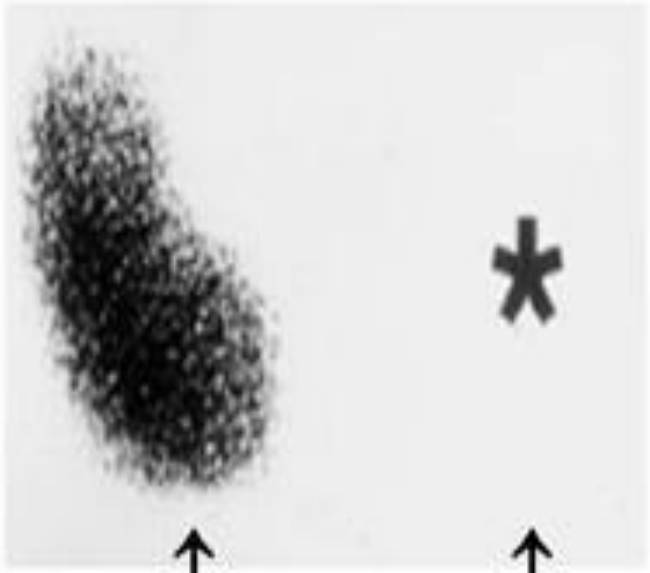
MULTICYSTIC DYSPLASTIC KIDNEY (MCDK) - RADIOLOGY

Ultrasound scan
32 weeks gestation



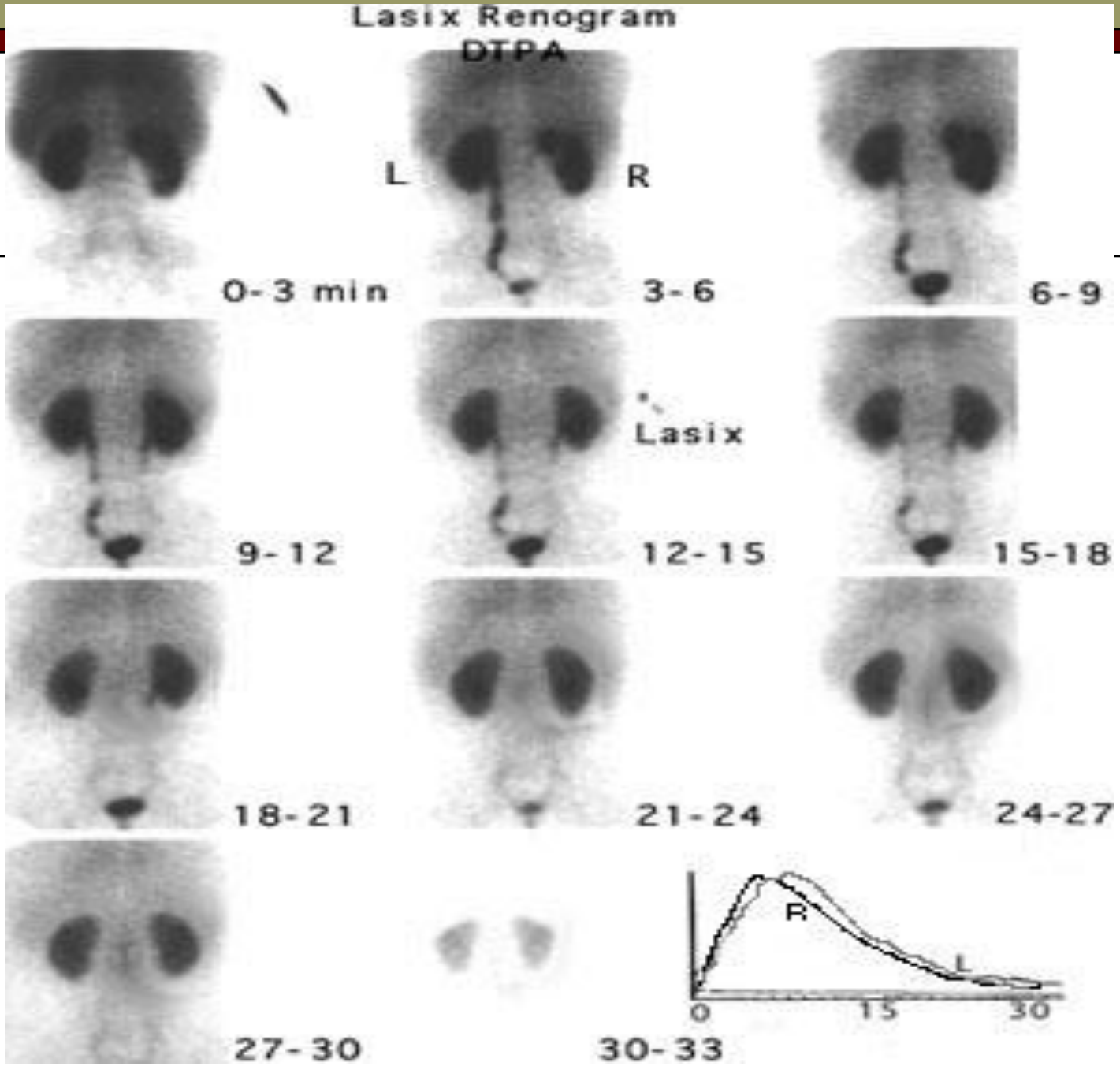
Shukunami K *et al*
J Obstet Gynaecol
24:458-459, 2004

Postnatal renal isotope scan



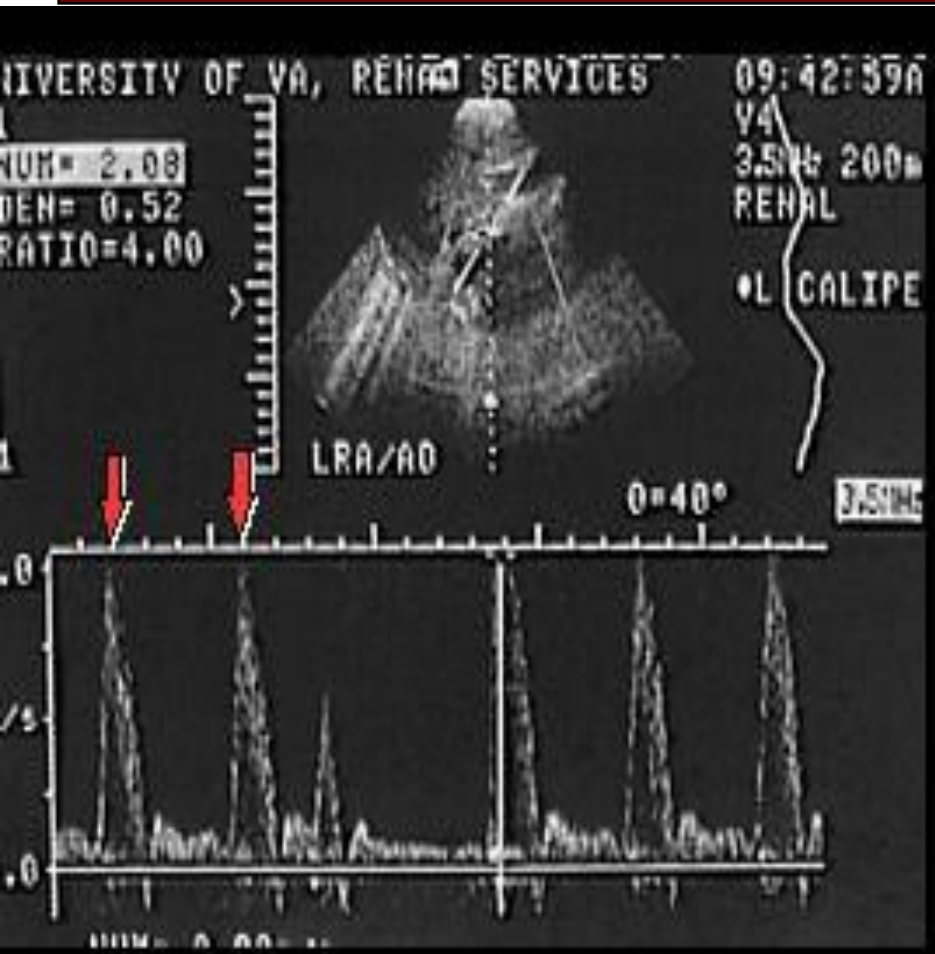
'Normal' kidney

MCDK (no uptake)


Lasix Renogram
DTPA
L
R
0-3 min
3-6
6-9
Lasix
9-12
12-15
15-18
18-21
21-24
24-27
27-30
30-33
R
L
0
15
30

Arteriography:

- Evaluation of the renal arterial circulation may be necessary for:
- further investigation of equivocal renal masses: renal cell carcinoma are usually hypervascular with a pathological circulation
- arteriovenous malformation
- renal artery stenosis
- anatomical details prior to renal transplantation
- suspected vascular occlusion after surgery

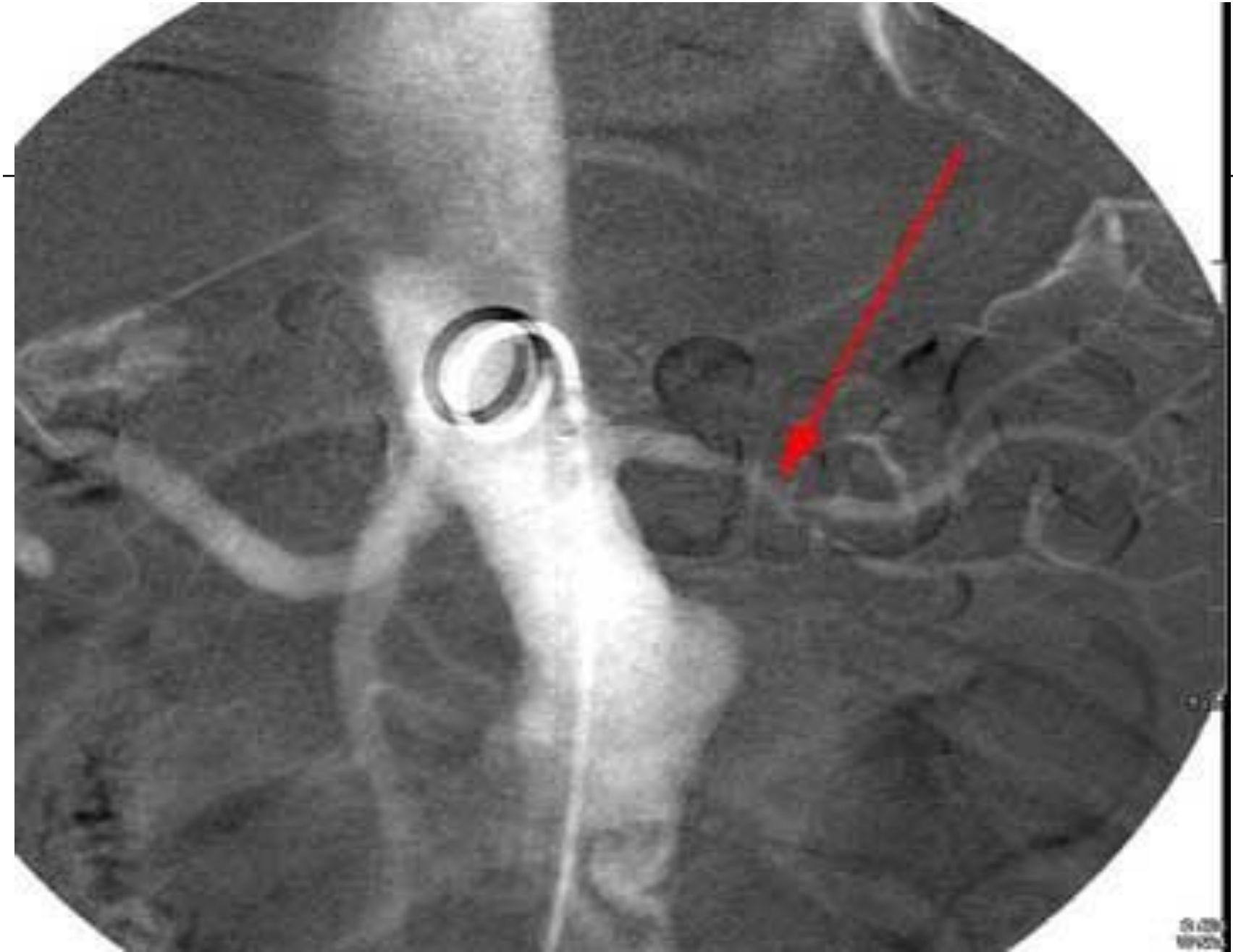


Ultrasound

High velocity>2m/sec

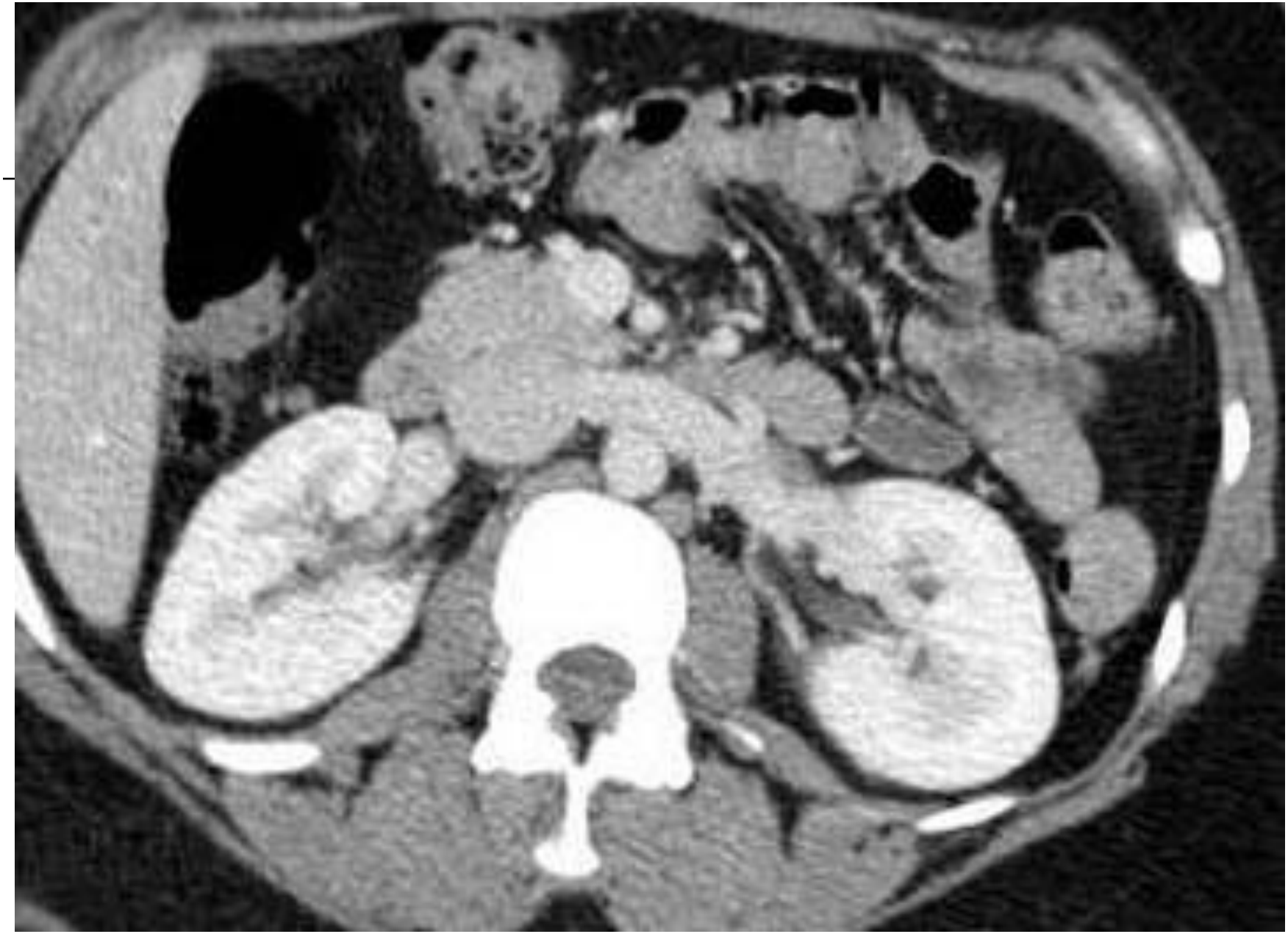
Arteriography

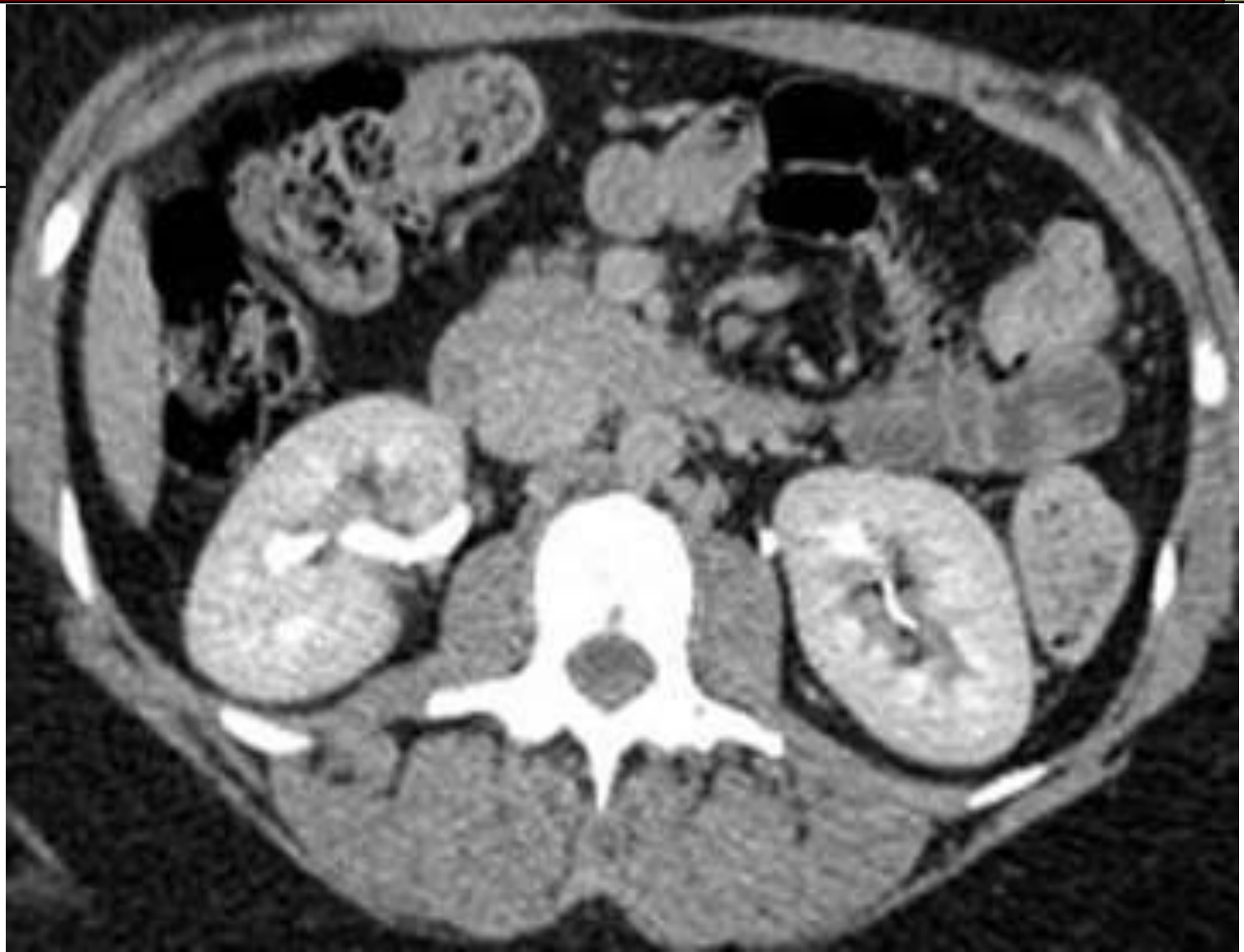
High grade stenosis



Computed tomography

- **This aids assessment of:**
- renal masses – especially differentiation of solid and cystic lesions
- obstruction
- retroperitoneal disease
- staging of renal and bladder neoplasm
- tumor invasion into the renal vein or inferior vena cava
- evaluation after trauma, surgery or chemotherapy
- inflammation
- trauma

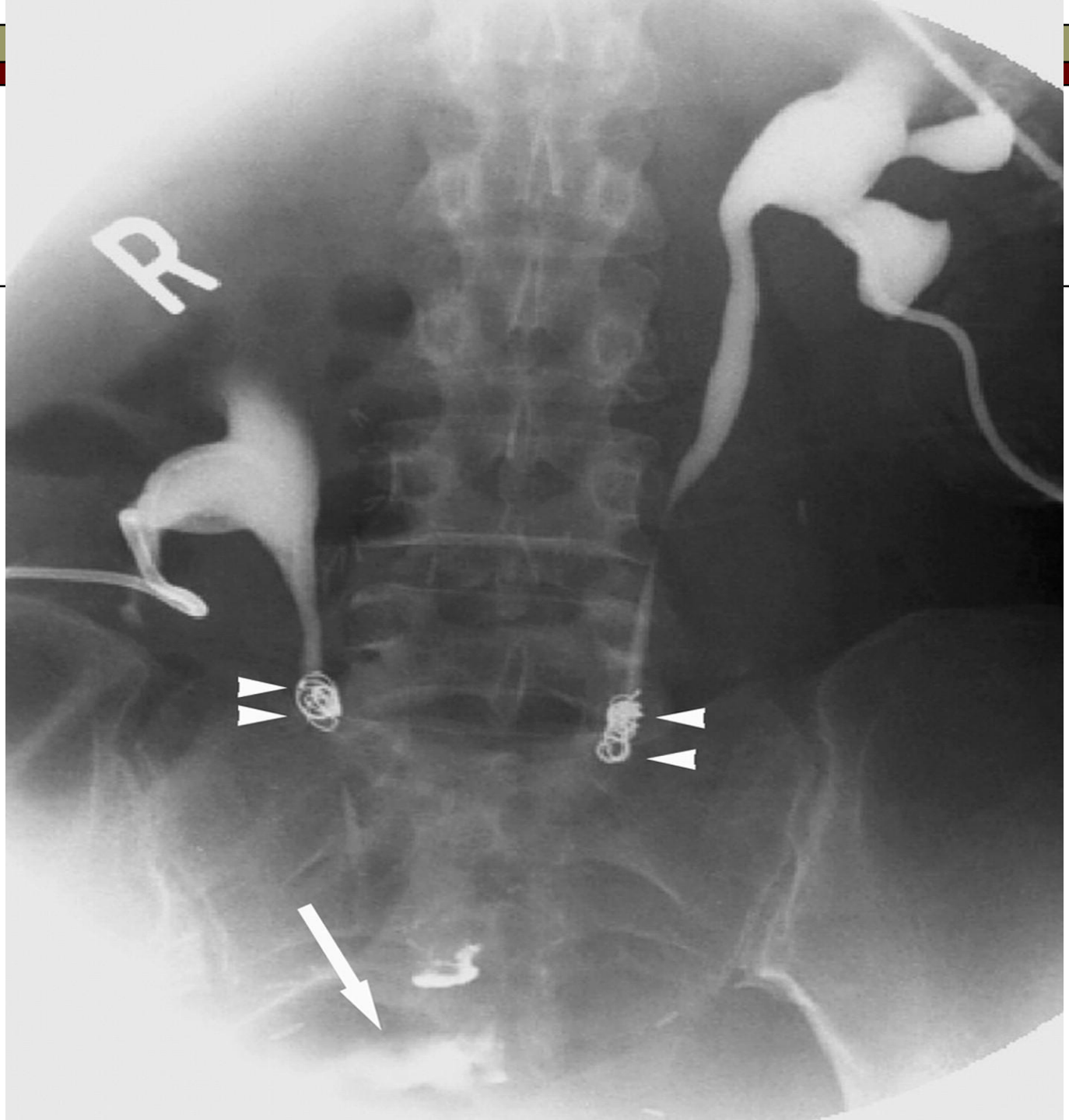





B
A
5 cm

Congenital anomalies

- ***Ectopic kidney***
- Normally the kidneys are located in the abdomen adjacent to the upper three lumbar vertebrae. The final position of kidney and associated length of ureter is determined by extent of ureteral bud elongation, which if ceases earlier than normal stage will result in ectopic location of kidneys like:
- pelvic
- sacrum
- lower lumbar levels
- intrathoracic kidneys – commonly occurs on left side of thorax


R

Crossed fused ectopia

- The two renal masses fuse with each other however the ureters draining the two renal masses are separate and insert into the bladder trigone distally.

Horse shoe kidney

- Is a fusion of lower poles of both the kidneys occurs by either renal or fibrous tissue.

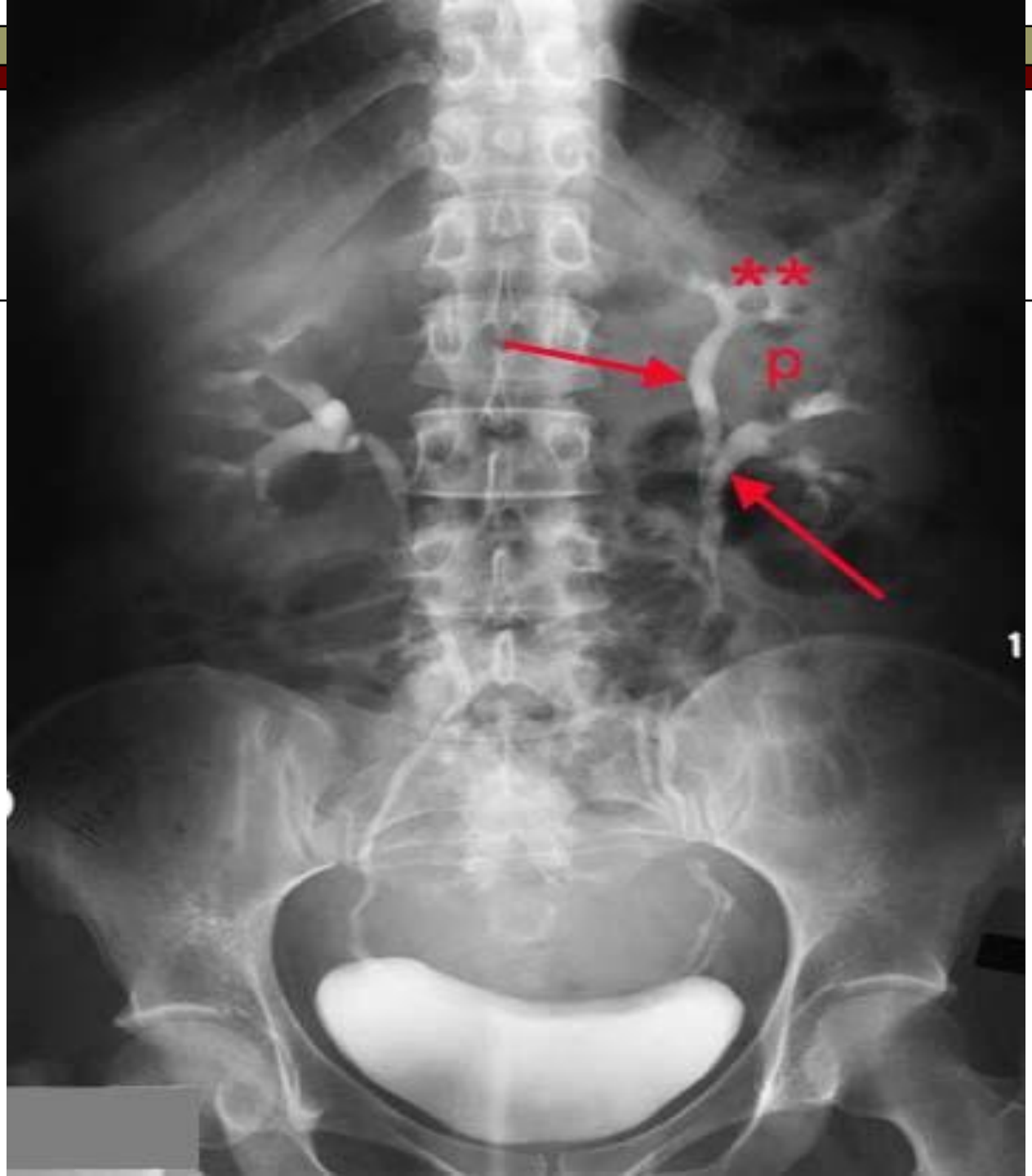
- ***Plain radiograph***: the axis of each kidney is markedly altered, the upper pole being more lateral and the lower pole being more medial.

- *IVU:* may demonstrate the isthmus which connects the two kidneys. There is some degree of malrotation with renal pelvis lying anteriorly, and calyces lying posteriorly, medially or laterally. The ureters are seen to course anteriorly over the lower pole or over the isthmus.
- *CT shows:* the parenchyma of the horseshoe kidney is well visualized. Isthmus can be very well depicted in CT.


CT

Duplex Kidney:

- the commonest renal anomaly with a variable degree of duplication ranging from minor changes of the renal pelvis, to total duplication of the renal pelvis and ureter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p
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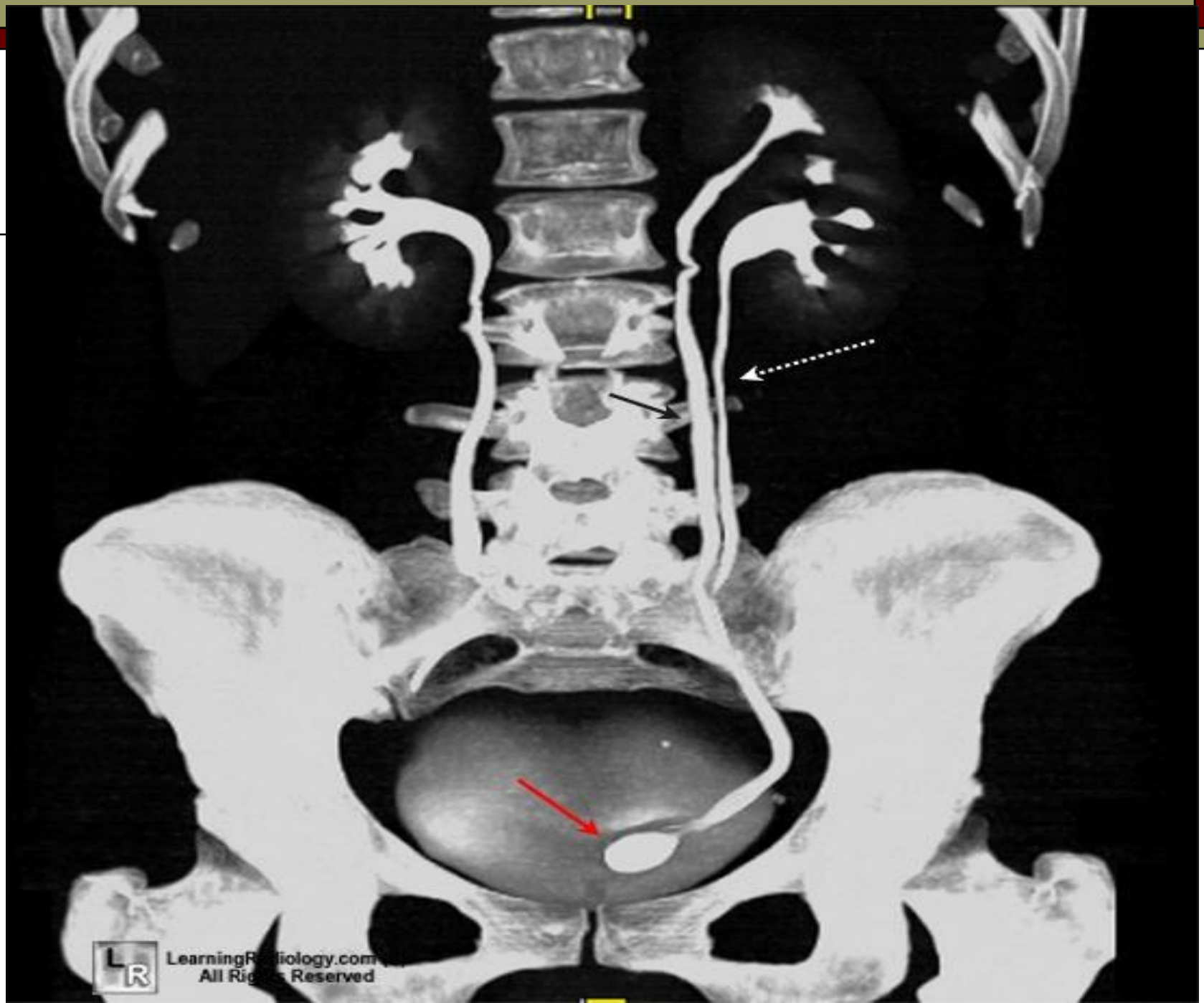
DUPLICATED RENAL TRACTS

- Duplex urinary tracts
- Occur in 1% of individuals

- Now can be detected by fetal ultrasound in mid-gestation

(Whitten M and Wilcox DT *Prenat Diag* 2001, 21:952-957)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Agenesis

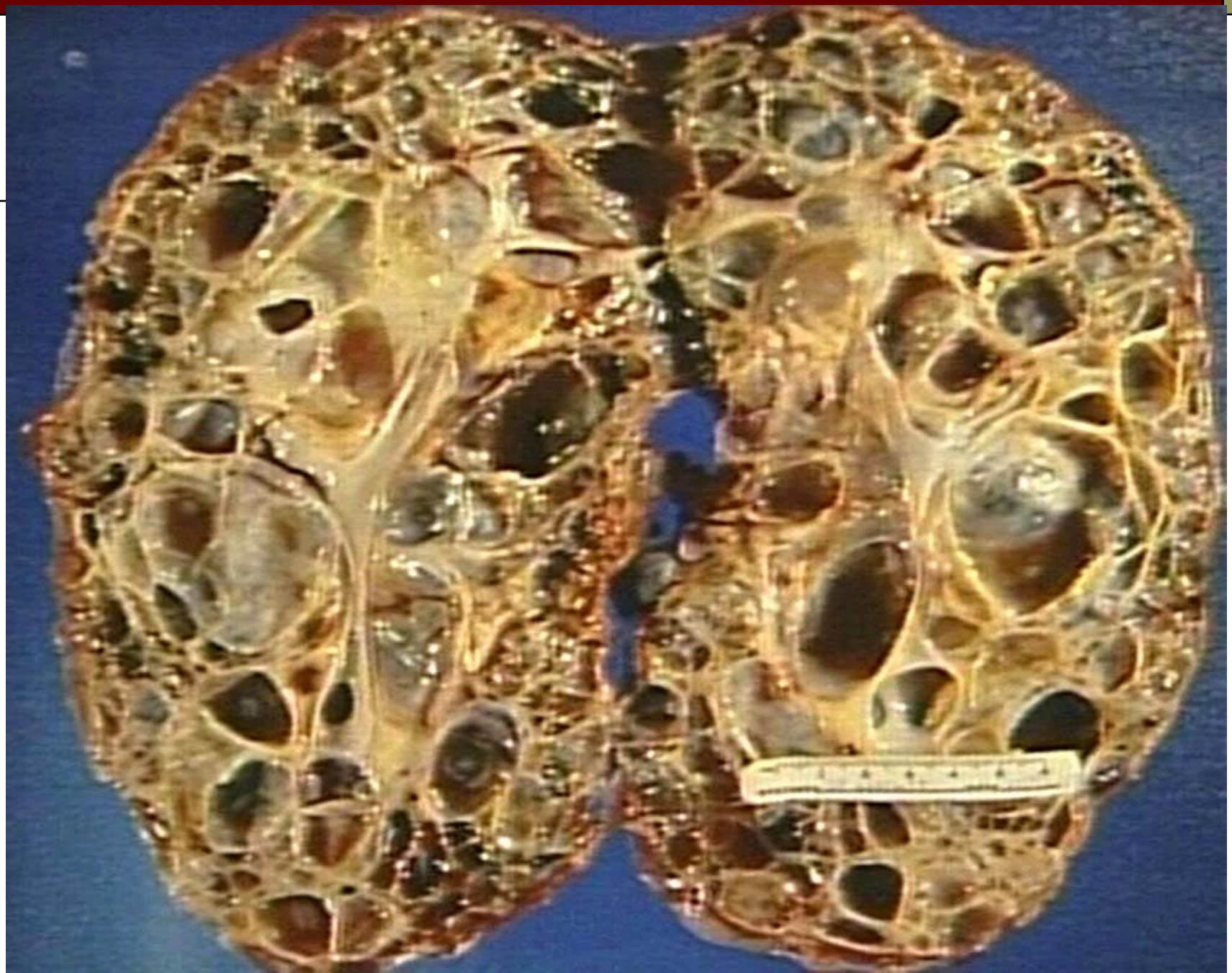
Polycystic kidney disease

- *Clinical features*
- hypertension
- bilaterally enlargement kidneys as masses per abdomen
- loin pain rarely
- *Plain film*
- enlargement kidneys seen as soft tissue masses bilaterally
- occasionally dystrophic calcification in cyst seen

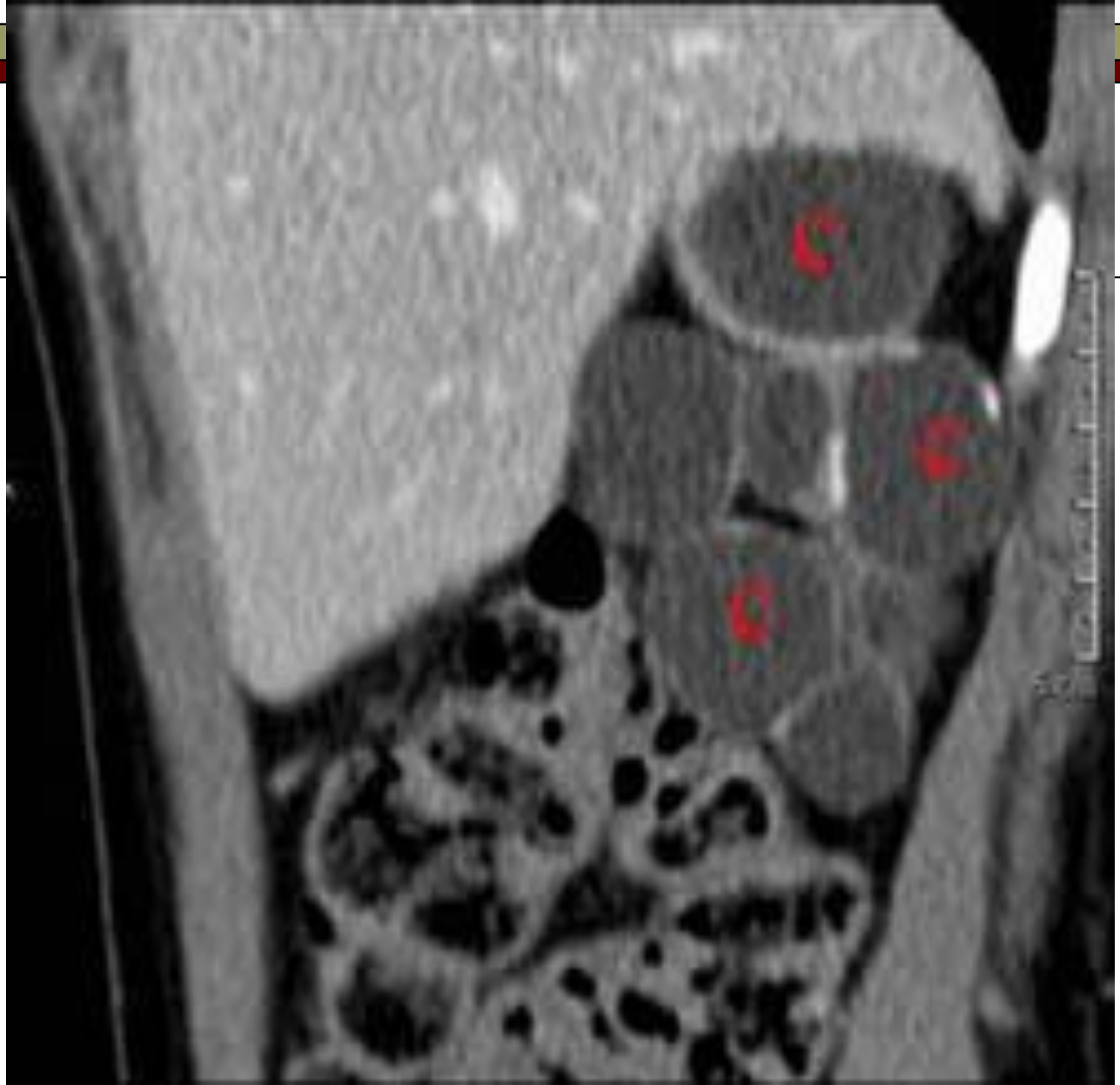
- ***IVU***
- major calyces may be displaced, narrowed and elongated by adjacent cyst
- in advanced cases there will be deformity of both major and minor calyces forming a typical "spider-leg" appearance
- also large doses of contrast will be needed for opacification of the pelvicalyceal system

- *Ultrasound*
- enlarged kidneys
- cysts are seen as anechoic lesions (black) with distal acoustic enhancement

- *CT*
- cysts will be seen as multiple hypodense lesions with density of fluid




SAG RK

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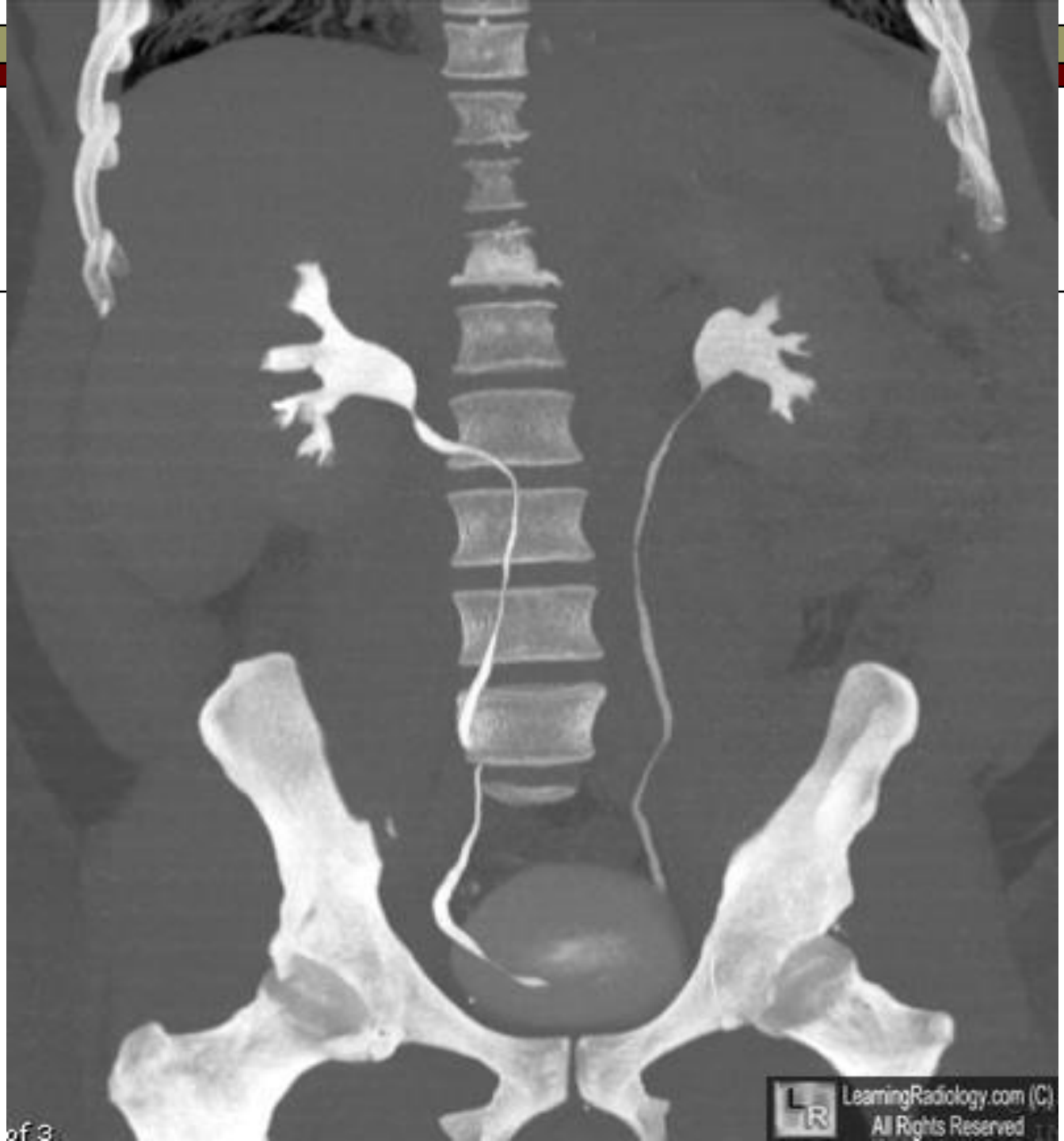
PHOTORESEARCHERS

Retrocaval ureter

- Normally the right ureter lies anterolateral to the inferior vena cava.
- Occasionally the right ureter takes an aberrant course running sharply medially and behind the inferior vena cava and then courses anterior to the vena cava and then drops inferiorly into the pelvis.
- It may be associated with hydronephrosis due to its abnormal course.


L
R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Urinary tract stones

- Urinary tract stones are the stones within the collecting system which are due to metabolic, environmental, structural and genetic abnormalities.

- ***Radio opaque stones:***
- calcium oxalate and phosphate stones
- cysteine stones – they contain sulphur
- struvite stones: this consists of magnesium ammonium phosphate

- *Radio lucent stones:*
- uric acid stones
- xanthine stones

- Radiolucent stones are not visualized on x-ray, however, ultrasound and CT scan can detect these radiolucent stones.

- ***Ultrasound***
- Stones will be seen as hyperechoic (bright) focus within the collecting system with distal shadowing.
- Dilatation of the collecting system may be present in cases of obstruction.
- Ultrasound is especially important in detecting radiolucent stones not seen in IVU and plain x-ray.
- ***Ct scan***
- No enhanced CT scan is the modality of choice for diagnosis calculus.
- Advantages:
- detection of multiple stones
- other causes of abdominal pain which may mimic renal colic


P
P


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Hydronephrosis

- Hydronephrosis is a dilatation of PCS secondary to distal obstruction.
- *Causes*
- ureteric stones
- ureteric stricture
- pyeloureteric junction obstruction
- bladder outlet obstruction

- *IVU*
- Findings may vary with the duration and degree of the obstruction. Renal outline may be enlarged.
- *Crading*
- Grade1: minimal blunting of forniceal angle
- Grade2: blunting of calyces with intact papillary markings
- Grade3: loss of papillary markings
- Grade4: ballooning of the calyces

- ***Ultrasound***
- dilatation of the collecting system will be seen as hypoechogenicity (dark) within the (bright) renal sinus
- renal parenchyma may be thinned out in severe hydronephrosis

Hydroureter

- Hydroureter is ureteric dilatation due to either obstructive or non obstructive causes.
- An absolute ureteral diameter exceeding 8 mm is considered by some authors to represent a criterion for dilatation. In general, asymmetry of ureteral caliber is a more significant findings.
- Early in its course, high-grade ureteral obstruction may be associated with only minimal ureteral dilatation. More chronic forms of obstruction and other chronic ureteral conditions are typically associated with greater degrees of ureteral dilatation.
- No obstructive dilatation may occur as a result of high urine flow, reflux, or inflammatory processes.

- *Causes*
- Ureteric calculus
- Ureteric stricture
- Ureterocele
- Congenital megaureter
- Retroperitoneal tumor/Retroperitoneal fibrosis
- Pelvic malignancies

PRIMARY VESICOURETERIC REFLUX

- **Primary VUR occurs in about 1% of young children**

- **'Reflux nephropathy' accounts for 5-10% of children and adults with end-stage renal failure**

Note clubbed calyces and the intra-renal reflux

Ureterocele

- Submucosal dilatation of the intramural distal ureter which often protrudes into the bladder lumen is called ureterocele.
- ***IVU***
- Ureterocele can be seen as a contrast filled structure with a thin smooth radiolucent wall surrounded by contrast containing urine in the bladder (cobra head appearance).


L


L

Primary megaureter

- Primary megaureter is congenital abnormal musculature of the distal ureter, leading to focal failure of peristalsis.

- Radiological signs
- dilatation usually the distal third of the ureter
- the calyces are normal

Renal cell carcinoma

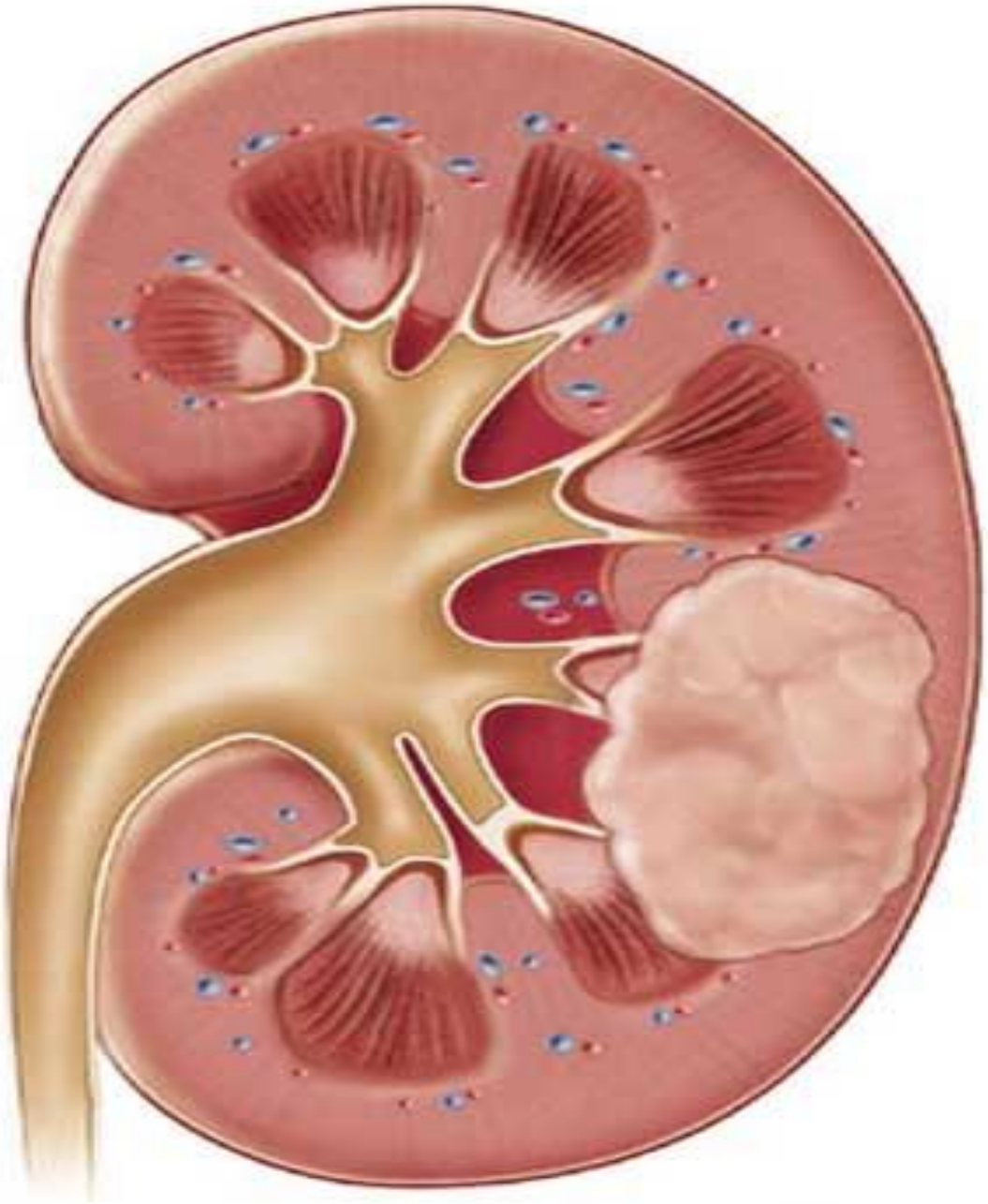
- Common age of presentation between 50 to 70 years. Common urological malignancy in adults, with a male: female ratio of 1:2.

- *Radiological imaging*
- *Plain radiograph abdomen*
- soft tissue density mass in the renal fossa with displaced bowel loops may be seen

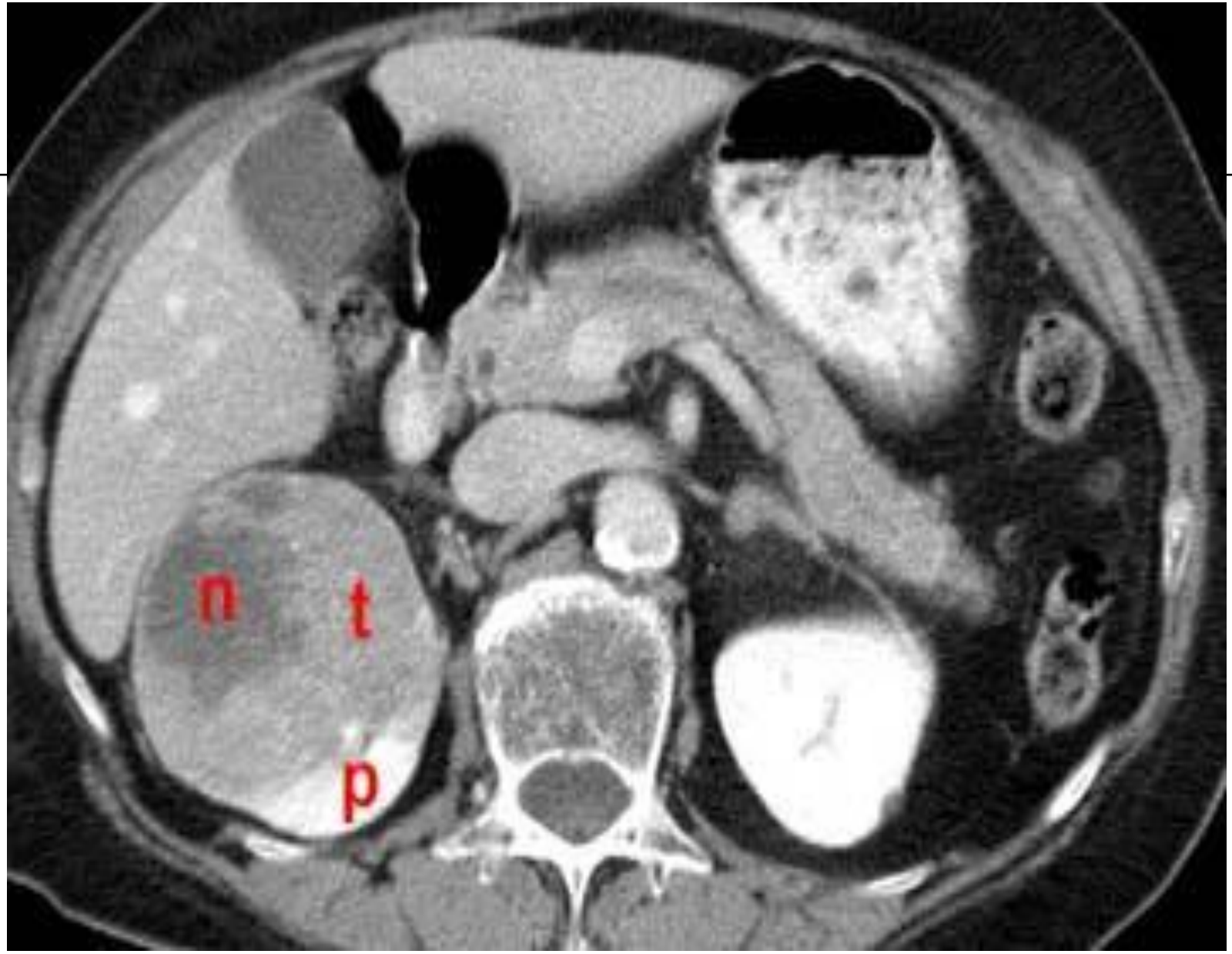
- *IVU*
- displacement, compression and cut off of calyces, change of axis of the kidney
- enlargement of affected part of kidney with focal bulge in renal contour
- large tumor may displace entire kidney across midline
- upper pole tumor may cause caudal displacement of calyces
- large tumor mass obstructing the renal pelvis may cause hydronephrosis

- ***Ultrasound***
- heterogenous echotexture lesion within the renal parenchyma

- ***CT scan***
- highly vascular mass lesion which is heterogeneously enhancing after contrast administration




SAG RK
M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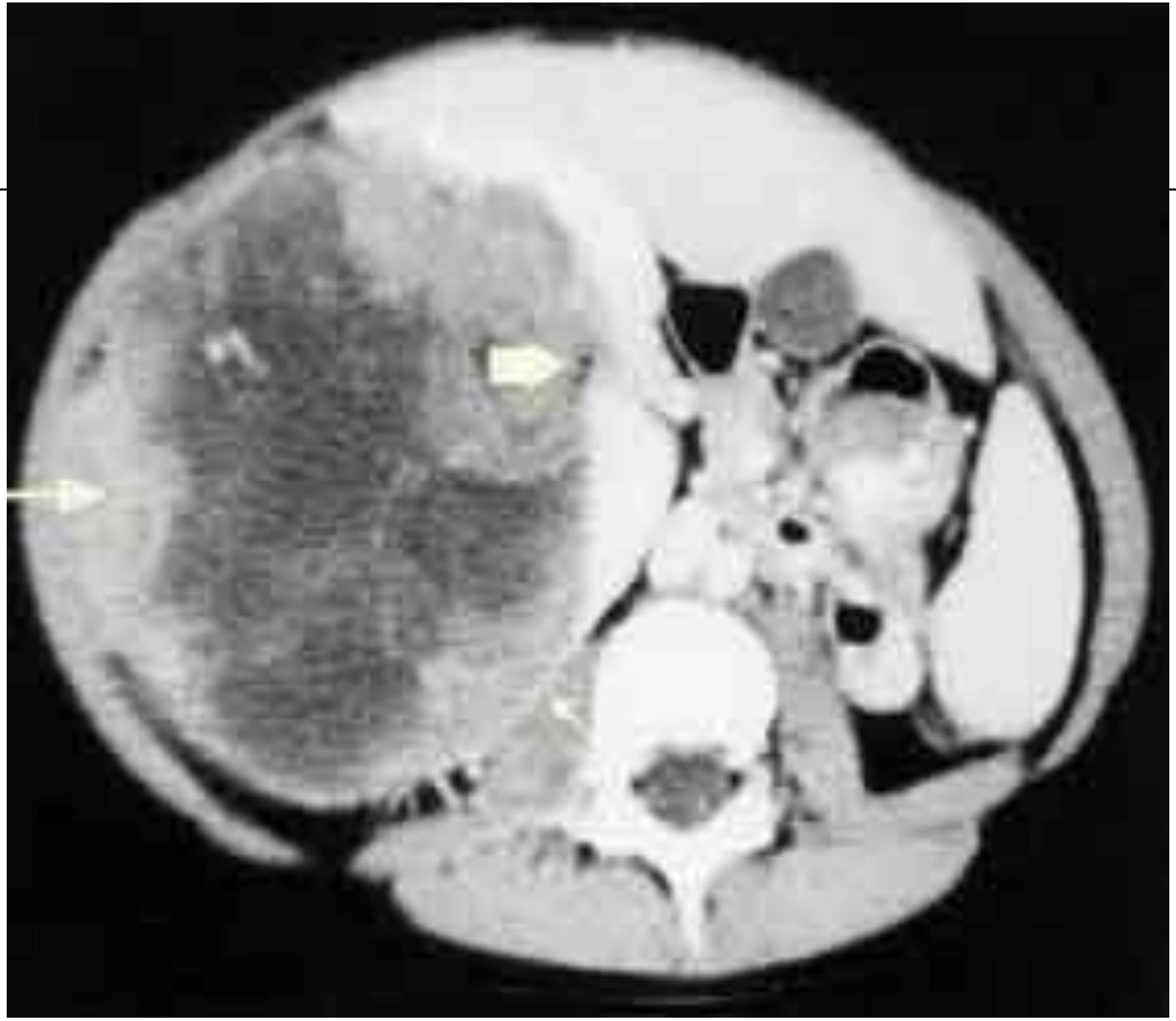
Wilms tumor

- commonest renal malignancy in children
- presents mainly between 1 to 5 years of age with peal incidence at 3 years

- *Radiological imaging*
- *Plain radiograph*
- soft tissue mass in the renal area

- ***IVU***
- enlargement of affected part of the kidney
- distortion of the PCS by a tumor
- ***Ultrasound***
- heterogenous echotexture mass lesion arising from a pole of the kidney
- ***CT scan***
- well defined soft tissue density lesion which enhances heterogeneously after contrast administration arising from a pole of kidney

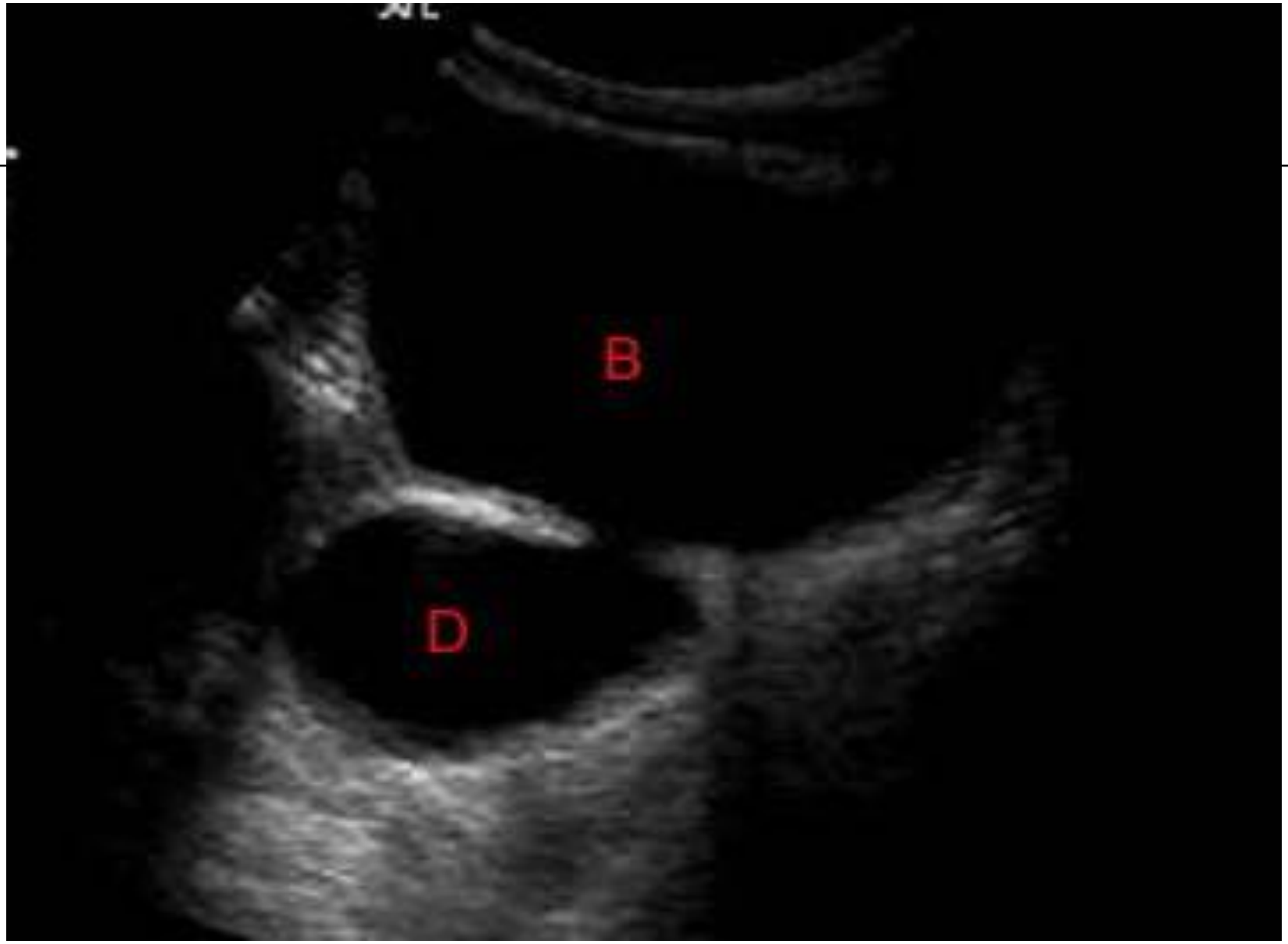


Diverticulum of bladder

- It is outpouching of mucosa trough the walls of the bladder.

- *Types:*
- *congenital* - due to weakness in the muscular layers
- *acquired* - this is usually secondary to distal obstruction

- *Imaging appearances*
- the diverticulum may have wide neck or narrow neck
- in the diverticulum with wide neck the diverticulum gets filled with contrast while contrast enters bladder and empties readily
- in the narrow necked one, stasis of contrast for a long period is noted; this type predisposes to urine stasis, infection and stone formation


B
D


R
10 cm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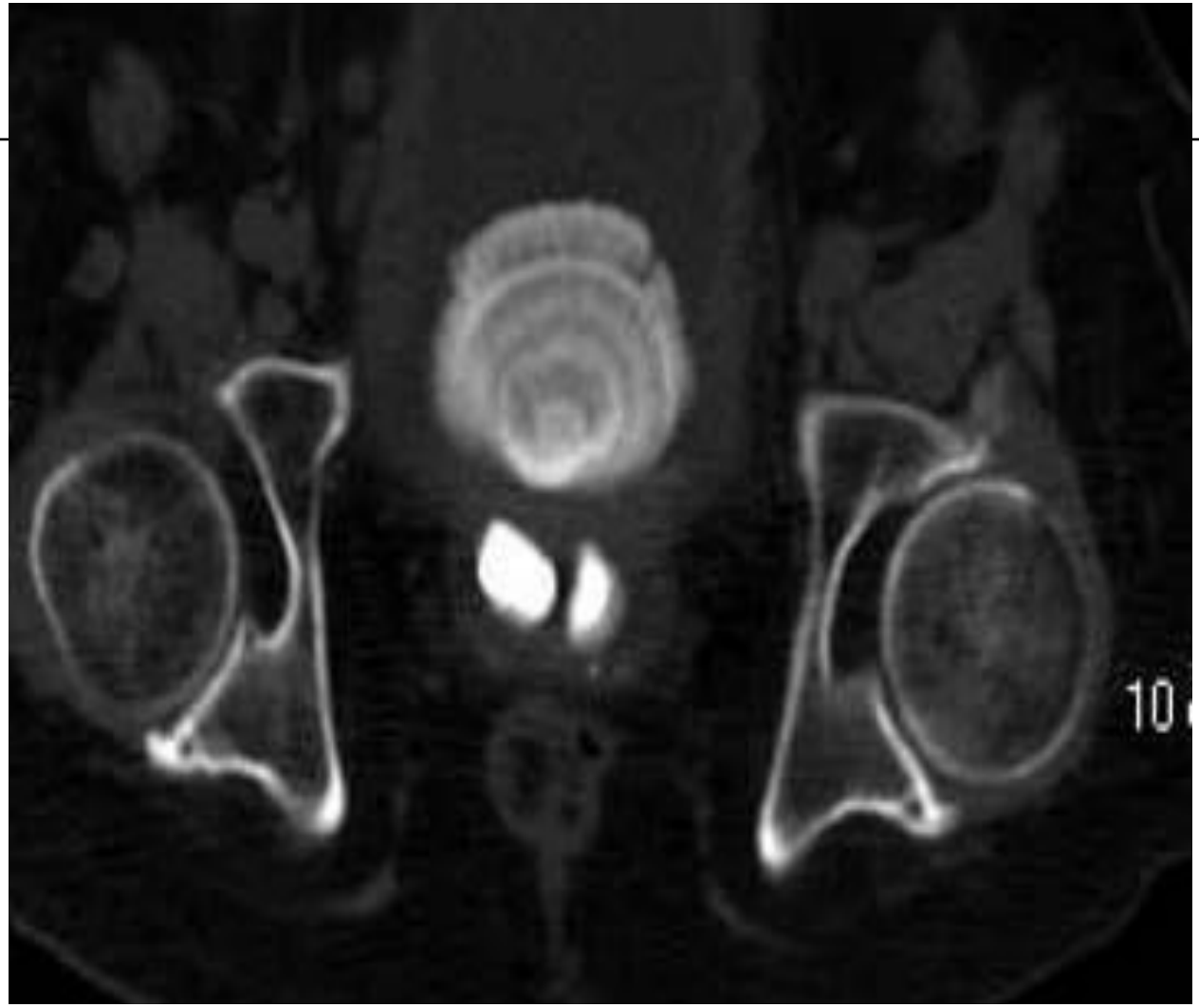
Bladder calculi

- usually secondary to outflow obstruction/bladder diverticula or urinary tract infections
- it may occur in cases of hyperparathyroidism, hyperuricemia or cystinuria
- usually composed of triple phosphate and are radio-opaque

- urinary bladder stones mimics phlebolith (stones in the venous wall) and should be differentiated from it: phleboliths have central lucency; bladder calculi do not have the central lucency
- ultrasound is modality of choice for diagnosis of bladder calculi: calculi will be seen as echogenic structure which show mobility


10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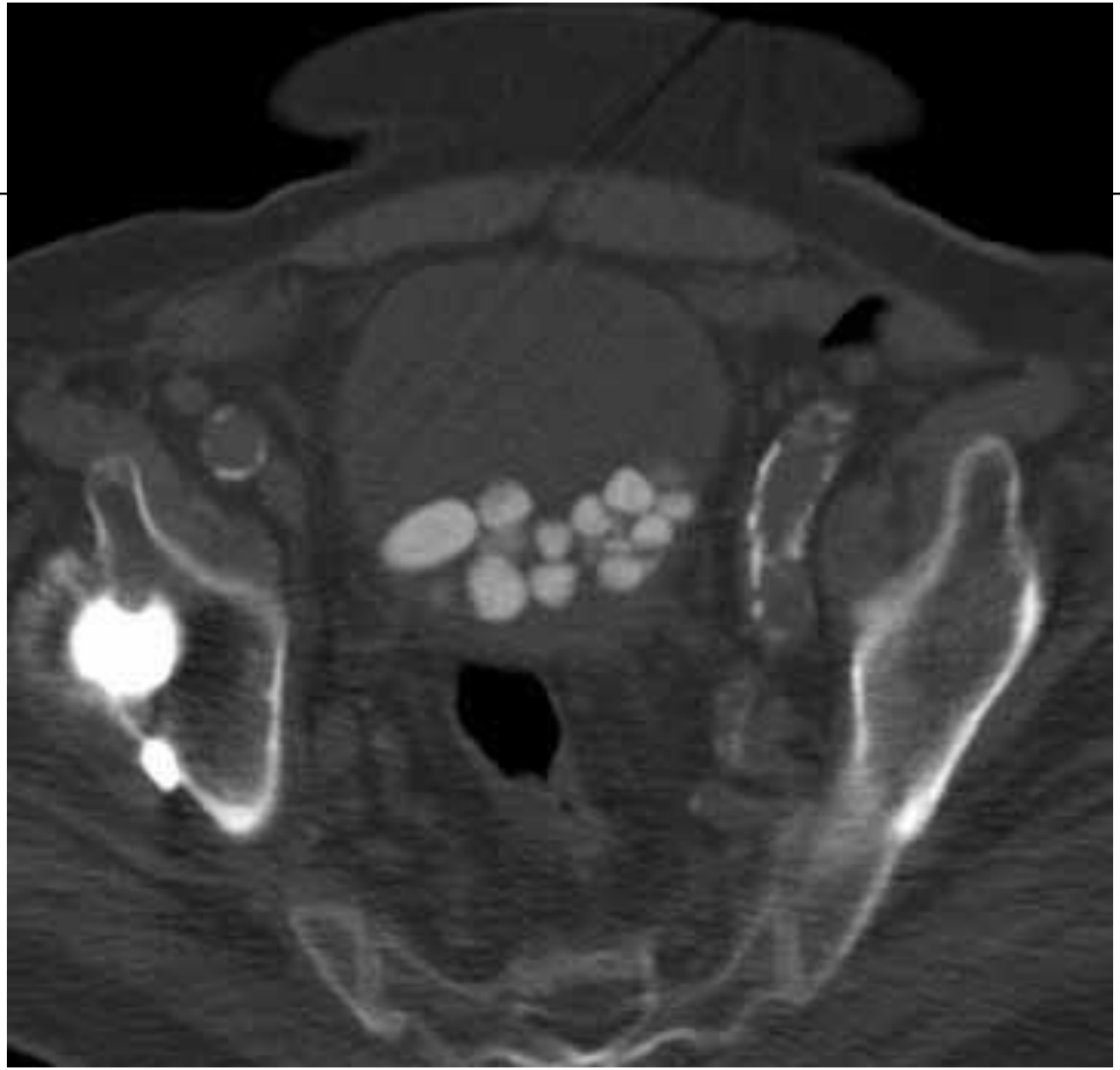
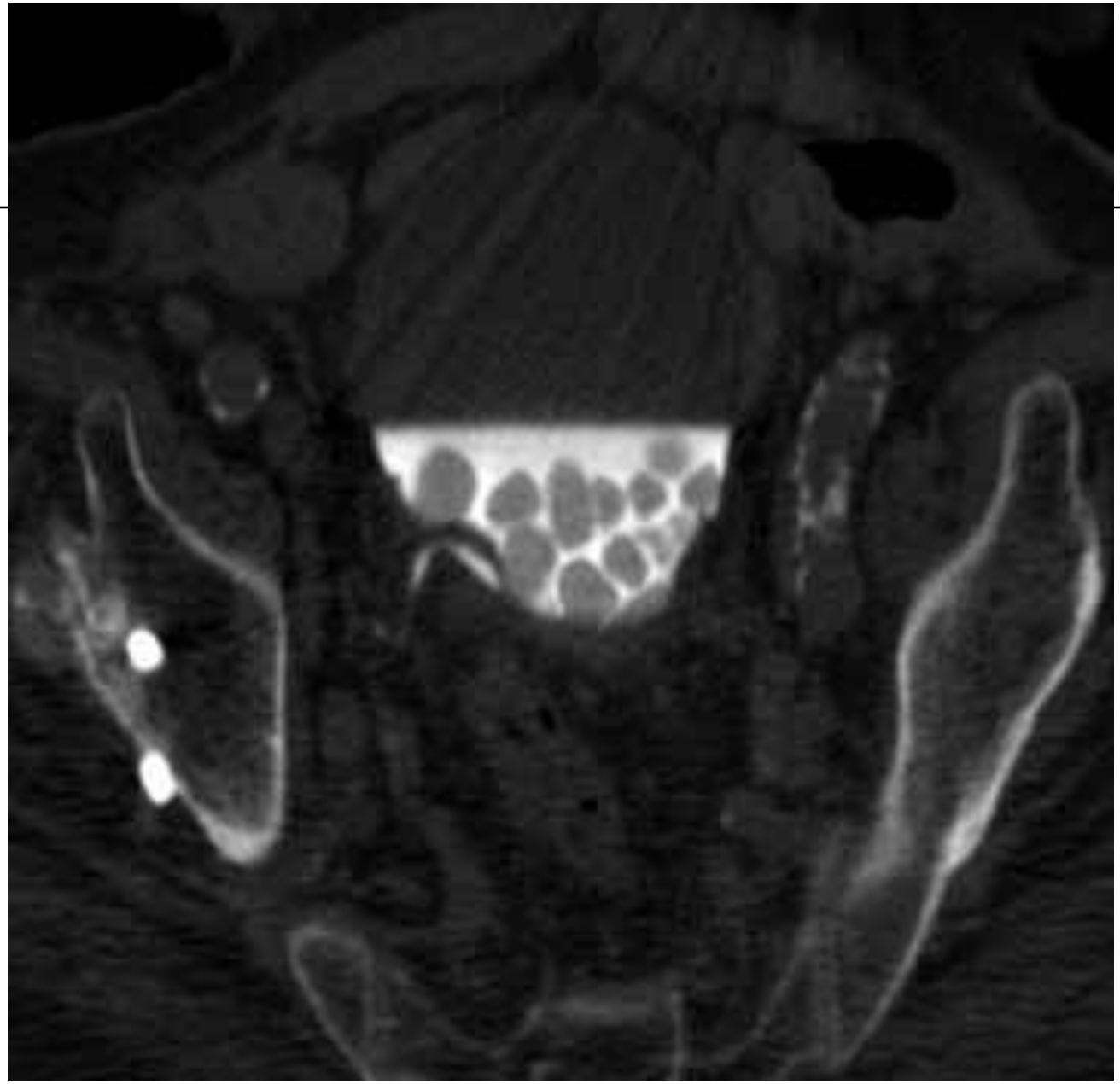
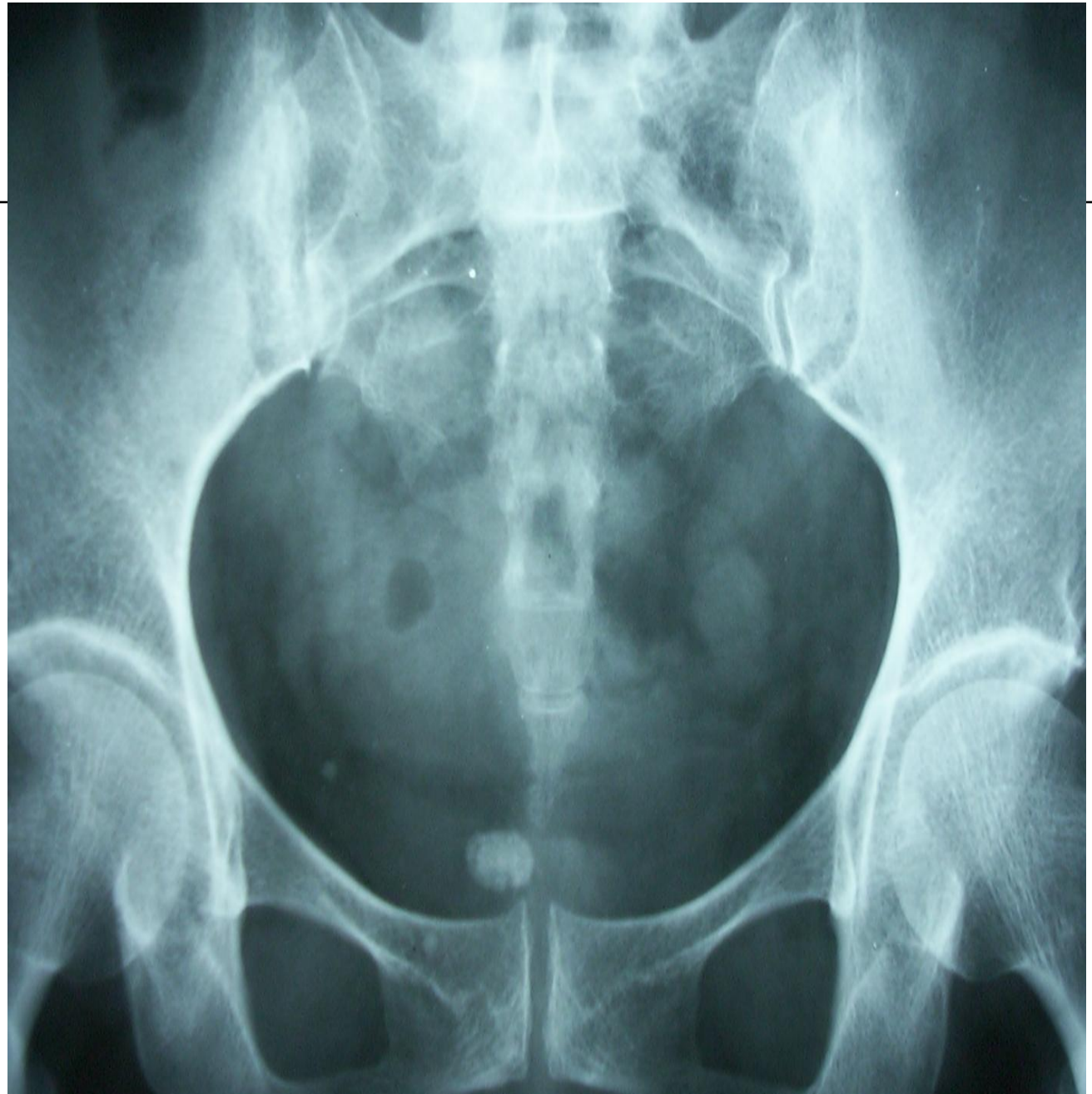






Bladder tumors

- It commonly occurs in posterior and lateral walls near vesico-ureteric junction.

- *Types*
- *epithelial tumors:* almost 90% epithelial tumors are malignant
- *nonepithelial tumor*: 2.1 benign: papilloma, leiomyoma, fibroma

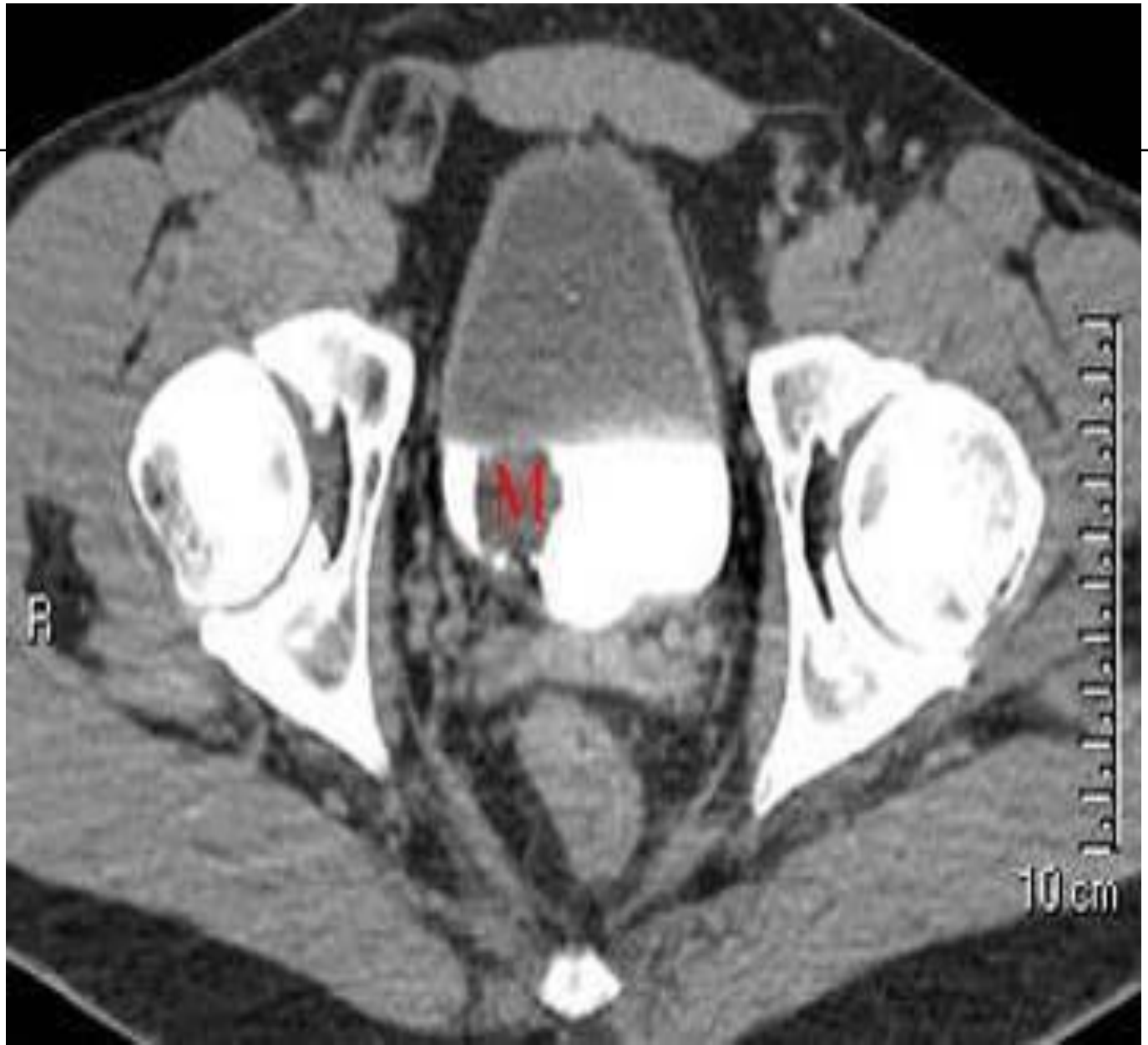
  2.2malignant

- ***Epithelial tumors:***
  - *90%-transitional cell ca*
  - *1-10%-squamous cell ca*

- ***Clinical features***
  - painless hematuria
  - *Imaging*

- ***IVU***
- filling defect in the bladder
- decreased capacity of bladder
- may not detect small tumors

- ***Ultrasound***
- focal irregular wall thickening
- papillary mass protruding into the lumen of the bladder


R
M
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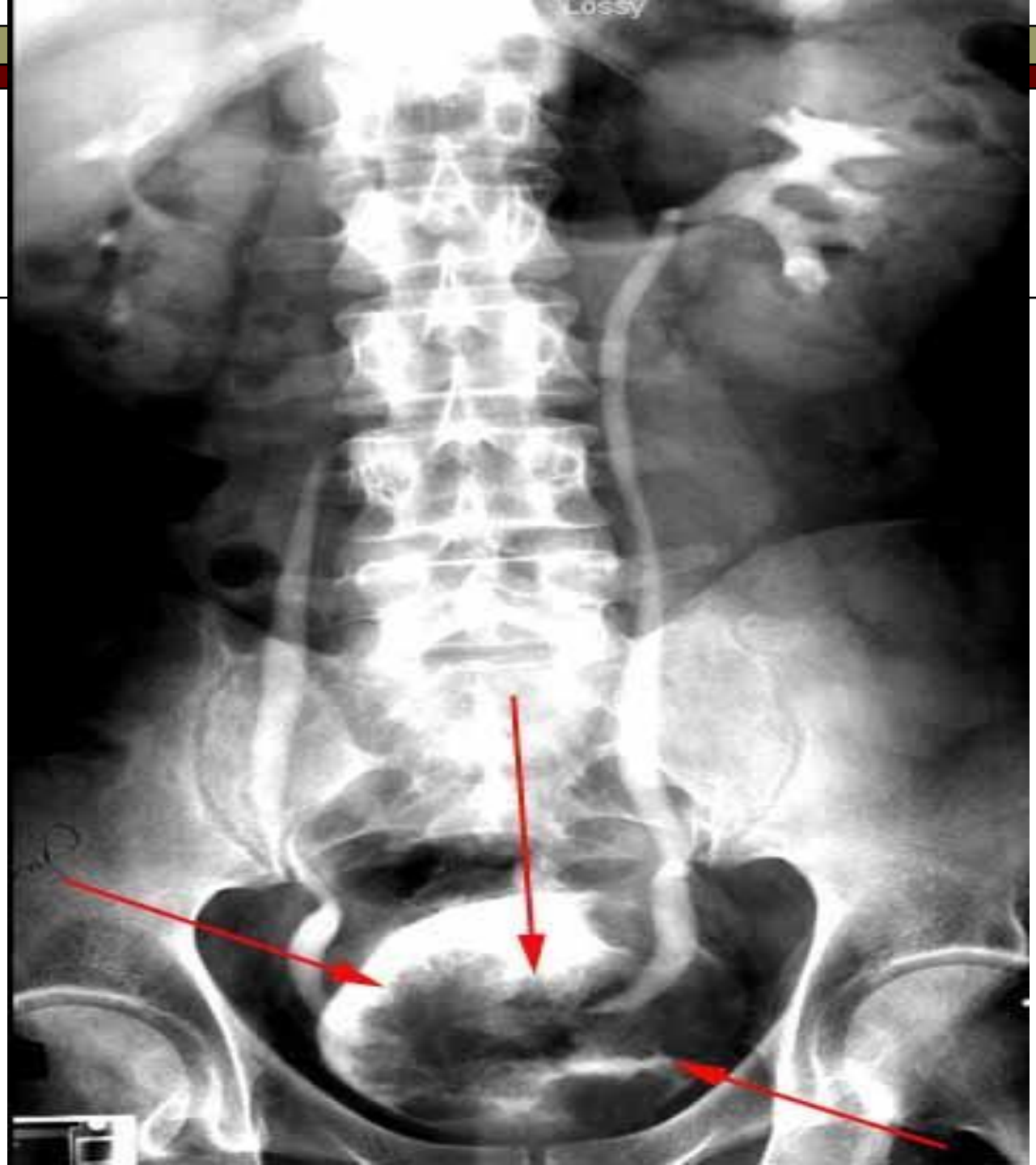
M


Lossy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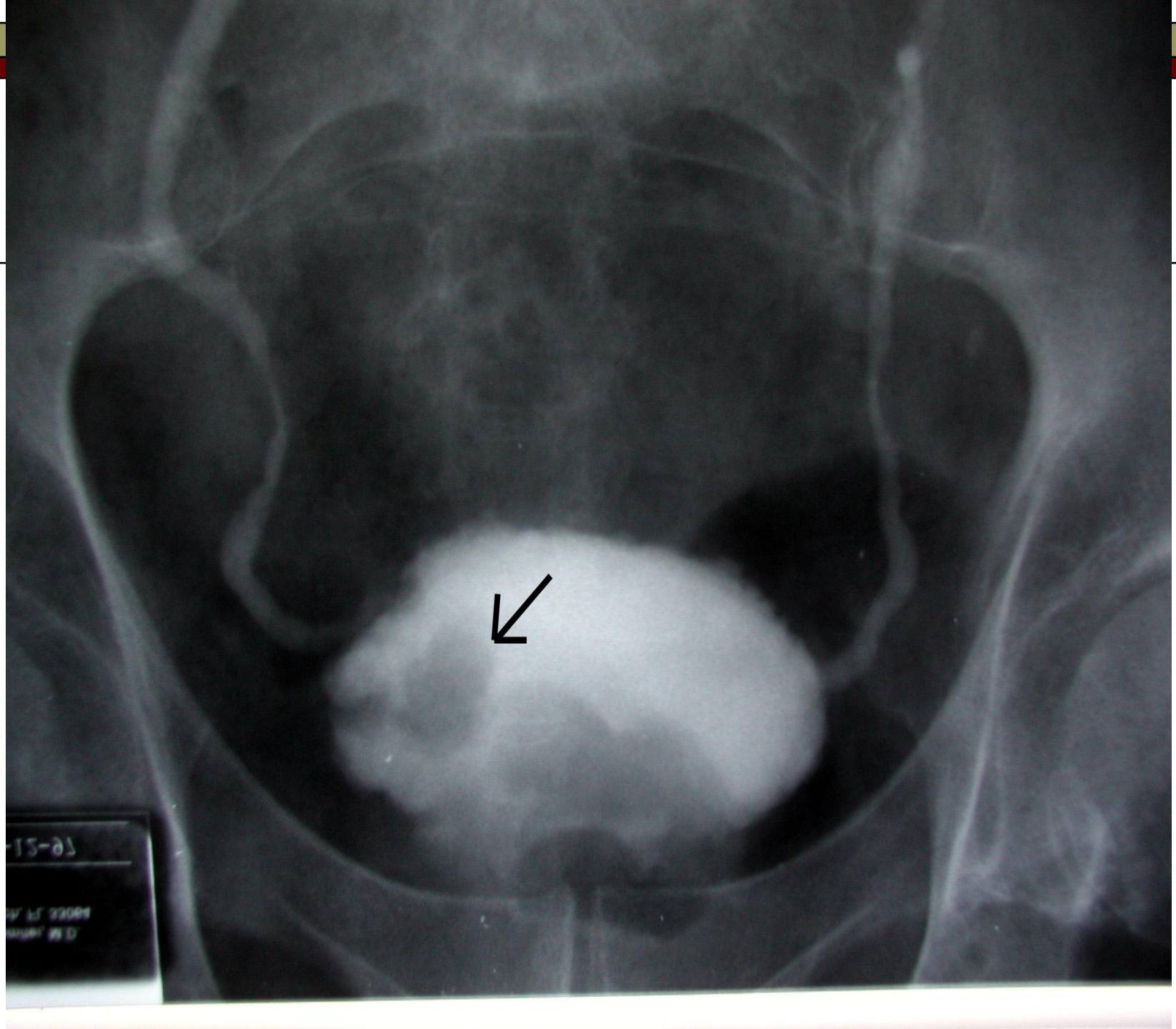

Small smooth kidney

- ***Unilateral***
  - ischaemia due to renal artery stenosis
  - post obstructive atrophy

- ***Bilateral***
  - arterial hypertension
  - chronic glomerulonephritis
  - causes of unilateral small smooth kidney occurring bilaterally

Large smooth kidney

- ***Unilateral***
  - compensatory hypertrophy
  - after trauma due to hematoma
  - gross hydronephrosis
  - Pyonephrosis

- ***Bilateral***
  - inflammatory: acute interstitial nephritis
  - neoplastic: leukemia, lymphoma
  - deposition of abnormal protein: amyloid, multiple myeloma