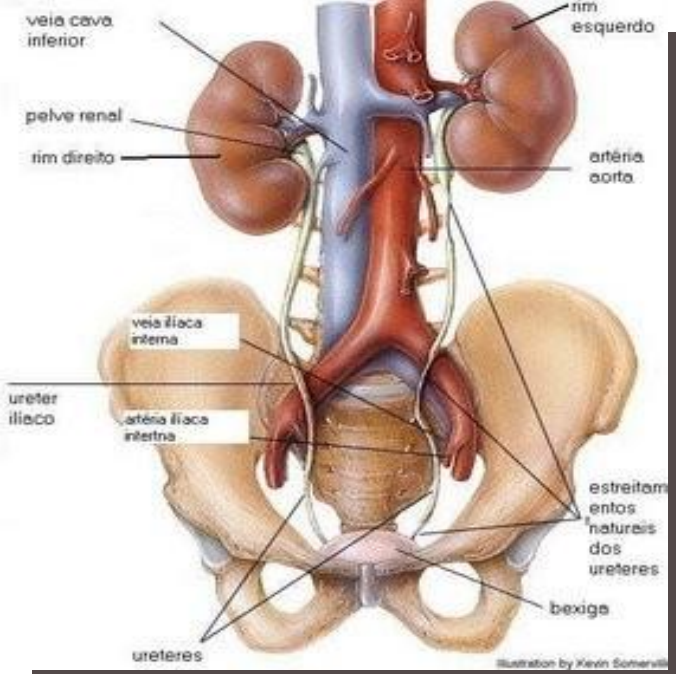
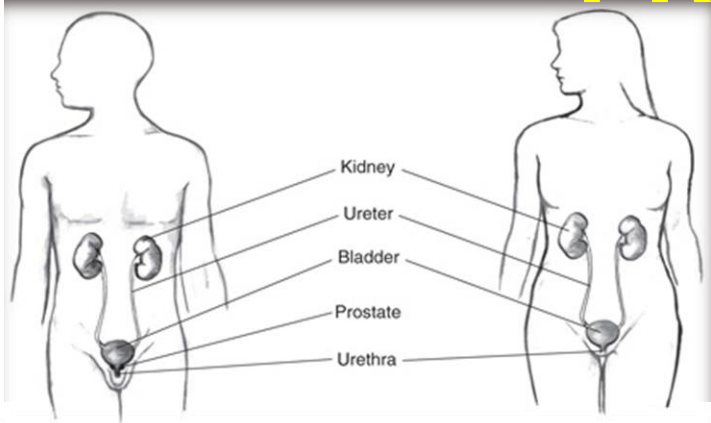


Clinical Radiology

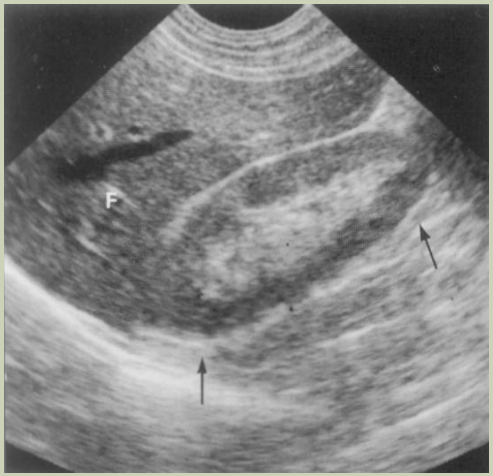
Every physician needs a basic understanding of diagnostic imaging to understand how to order the appropriate studies and to understand the resulting radiologist's report.

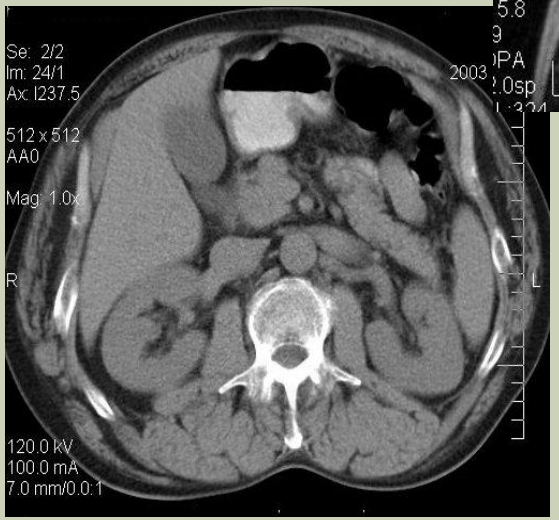
URINARY TRACT IMAGING - BASIC PRINCIPLES



METHODS OF INVESTIGATION

- ULTRASONOGRAPHY
- RADIOLOGY
  - Simple abdominal radiography
  - Intravenous urography
  - Retrograde pieloureterography
  - Cystography
  - Uretrography
- NUCLEAR MEDICINE
  - Static studies: static renal scintigraphy
  - Dynamic studies: renogram
- CT (without, with contrast, Angio)
- MRI (without, with contrast, Angio)





Imaging the urinary tract – which modality to use for first-line examination?

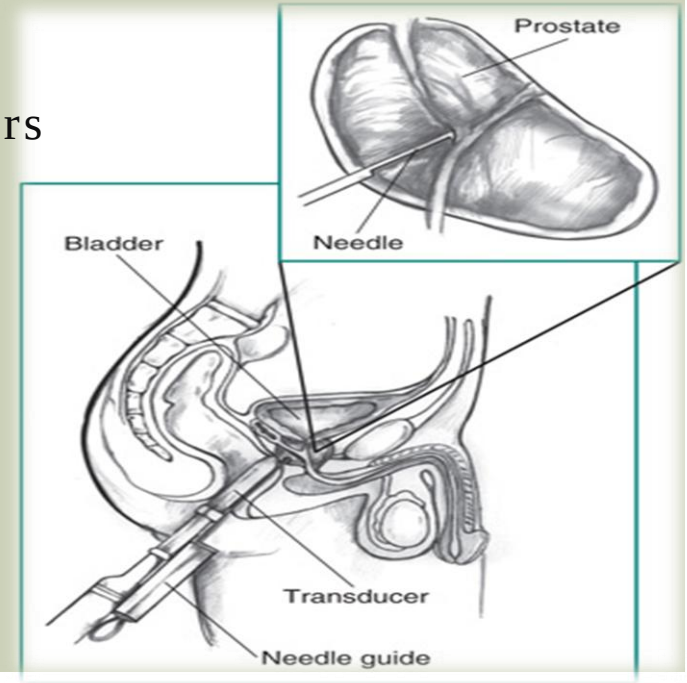
In imaging the urinary tract, the modality of choice for the initial examination will almost universally be ***ultrasound (US).*** US is inexpensive, immediate, painless, requires no sedation or anesthetic, is widely available, and is radiation free. US can be used to scan in any plane at the discretion of the operator, and whereas the technique is entirely operator dependent, most centers have staff with a high level of skill.

ULTRASOUND

- Doppler USG

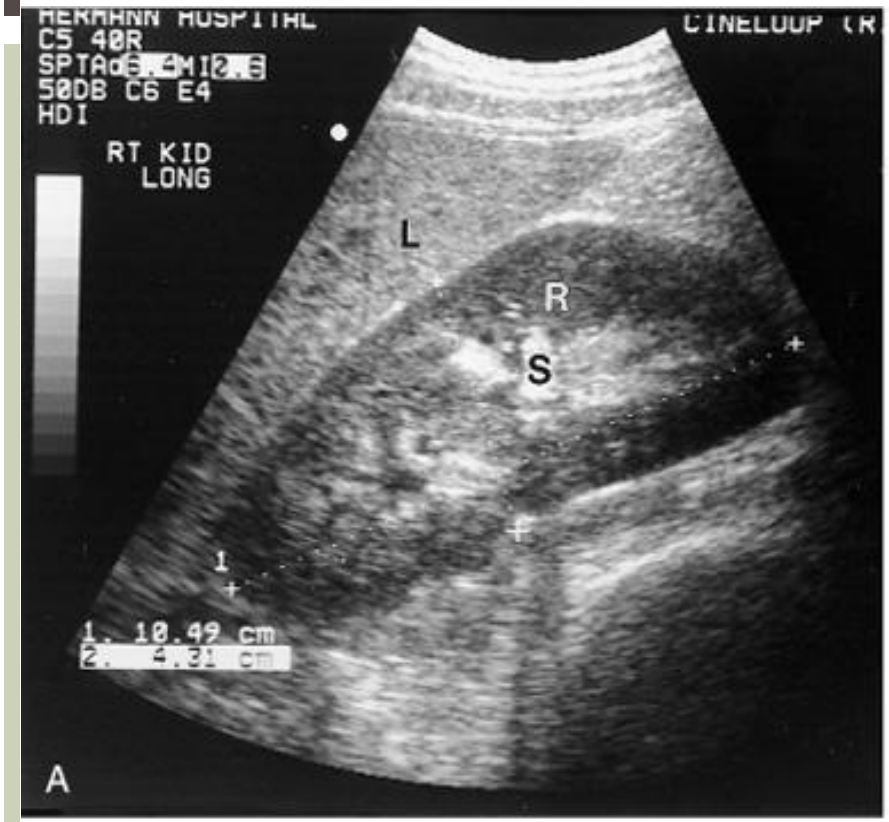
- High frequency- high resolution but low penetration depth
- Renal- parenchyma
  - evaluate hematuria, solid mass, cysts
  - congenital abnormalities, stones
- Adrenal- CT/MRI better

  Nodules, cysts, hemorrhage, location, tumors
- Bladder- examine wall, lesions
  - Transvaginal, transabdominal, transrectal
  - Normal wall >= 6 mm
  - bladder volume
- Prostate- transrectal, access for biopsy



ULTRASOUND

- Scrotal-
  - Evaluate- mass, pain, torsion, orchitis, epididymitis, hydrocele, hernia, varicoceles
  - Testicle- 4 x 3 cm
  - Veins- >2mm= varicocele- evaluate in erect position


HERMANN HOSPITAL
C5 40R
SPTA 6.4MI 2.6
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1
1. 10.49 cm
2. 4.31 cm
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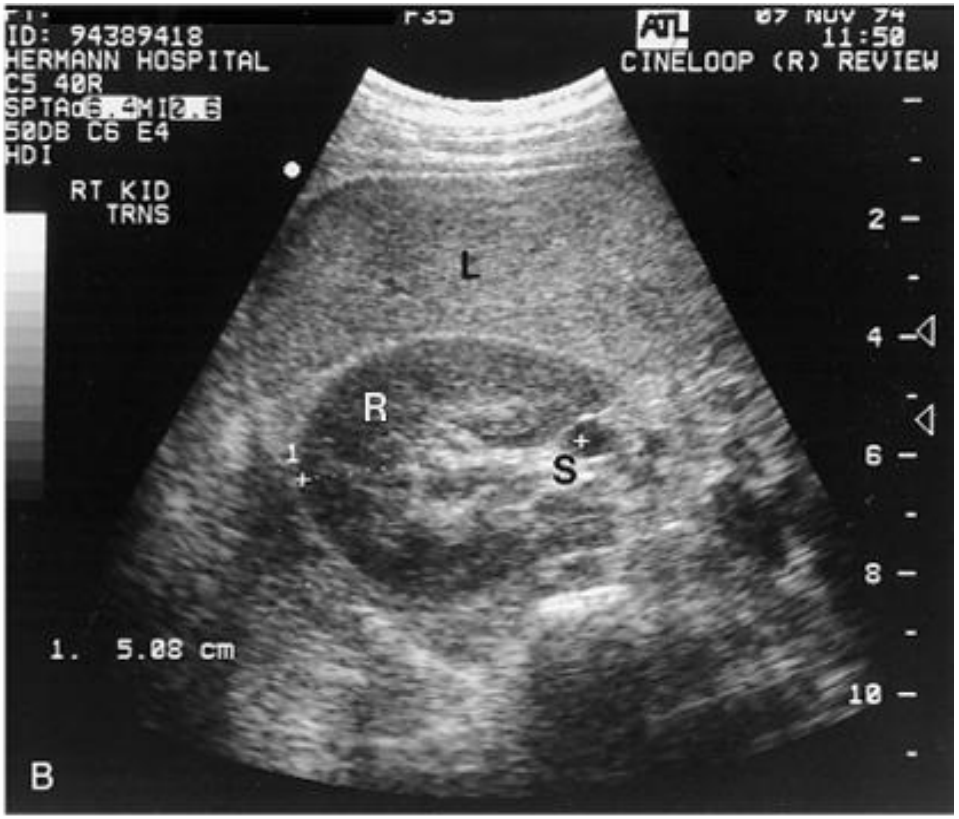
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HERMANN HOSPITAL
C5 40R
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CINELOOP (R) REVIEW
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S
1
1. 5.08 cm
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4
6
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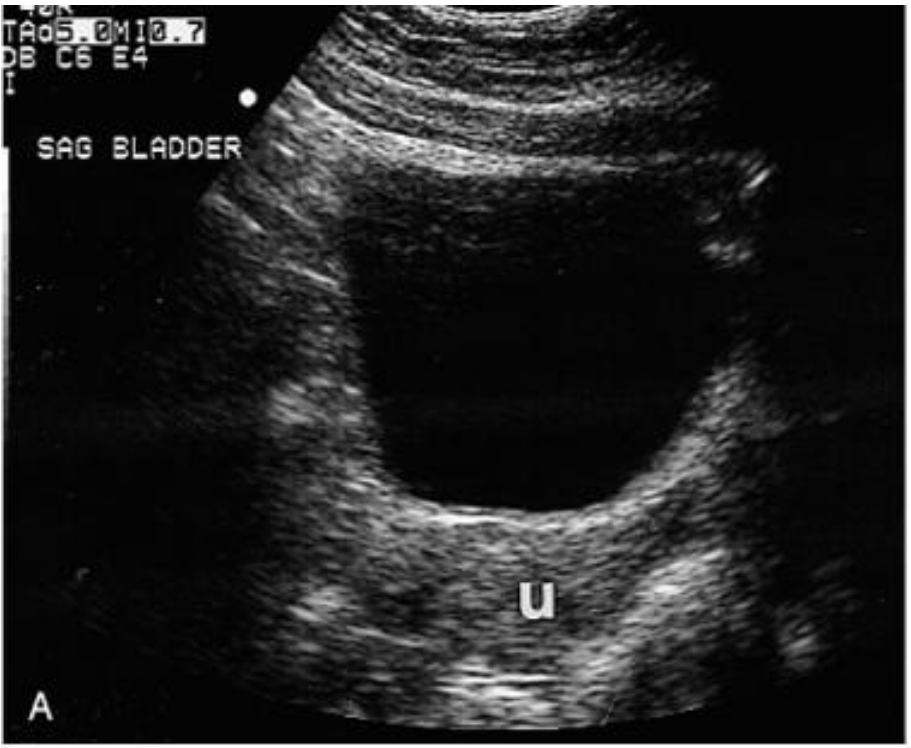
B


SAG BLADDER
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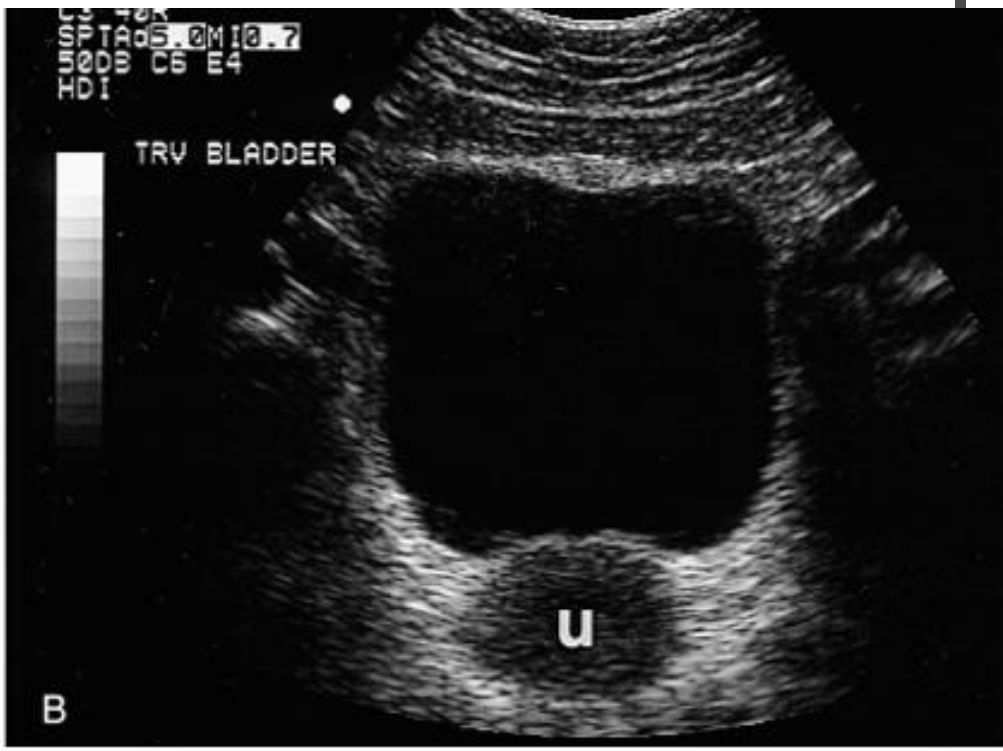
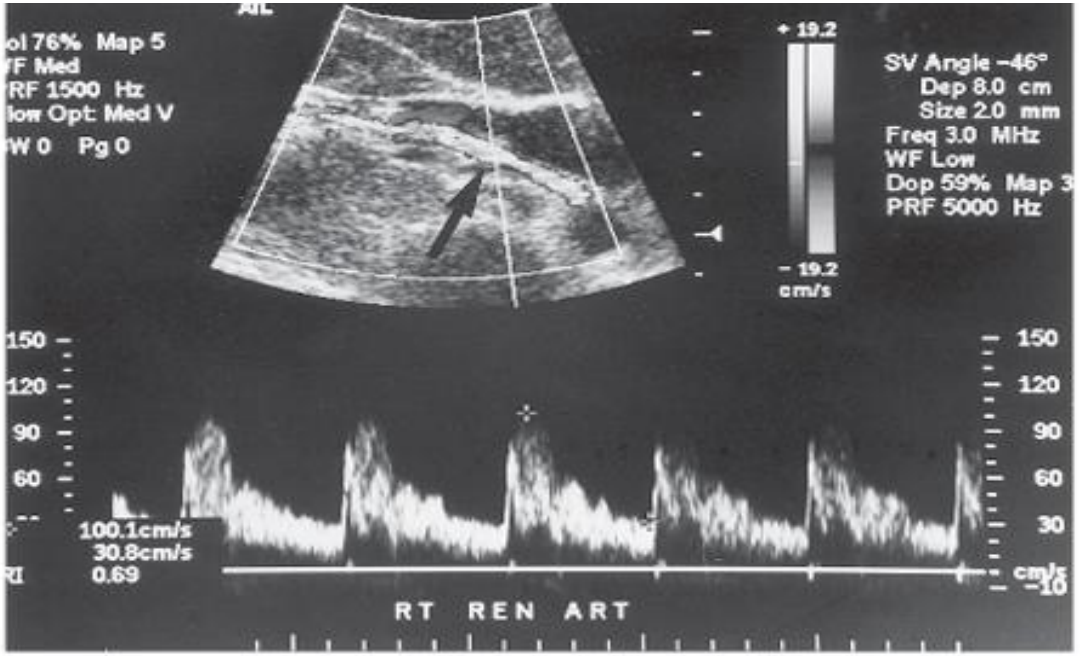
A


TRV BLADDER
u
B

Doppler Ultrasound



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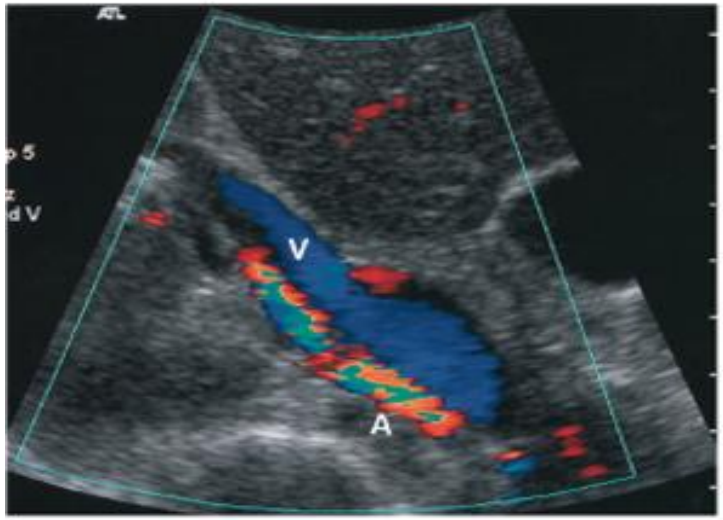


B

C

PLAIN FILM OF THE ABDOMEN

- The kidneys-ureters-bladder is often the first imaging study performed to visualize the abdomen and urinary tract
  - The film is taken with the patient supine and should include the entire abdomen from the base of the sternum to the pubic symphisis
  - Can show bony abnormalities, calcification and large soft tissue masses

Indications

- Plain urinary tract (PUT) film = Kidney Ureter Bladder (KUB) film
- Plain films are widely used in the management of stone diseases.

1. To be a preliminary film in anticipation of contrast administration.
2. To assess renal calculus disease before and after treatment.
3. To assess the presence of residual contrast from a previous imaging procedure.
4. To assess the position of drains and stents.
5. To help the investigation of blunt or penetrating trauma to the urinary tract.

Limitations

1. Bowl gases or stools may obscure small stones.
2. Stones may be obscured by other structures such as bones or ribs.
3. Calcifications in pelvic veins or vascular structures may be confused with ureteral calculi.
4. Stones that are poorly calcified or composed of uric acid may be radiolucent.

CONTRAST FILMS

- Rapidly concentrated by kidneys and opacifies urinary tract
- iodine nonionic contrast material
- Reactions:
  - Allergic, renal toxicity, shock

UROGRAPHY

- Involves instillation of contrast material to better visualize the collecting or lumenal structures of the kidneys, ureters, bladder, and urethra
  - This can be done after i/v injection or direct instillation into the urinary tract
    1) Intravenous urography
    2) Cystourethroography
    3) Retrograde urethrography

INTRAVENOUS UROGRAPHY

- IVU/ intravenous pyelogram is the classic modality of imaging the entire urethelial tract from pyelocalyceal system trhough the ureters and bladder
  - Excellent for indentifying small urethelial lesions as well as the severity of obstruction from calculi
  - Provides anatomical and qualitative functional information about the kidneys

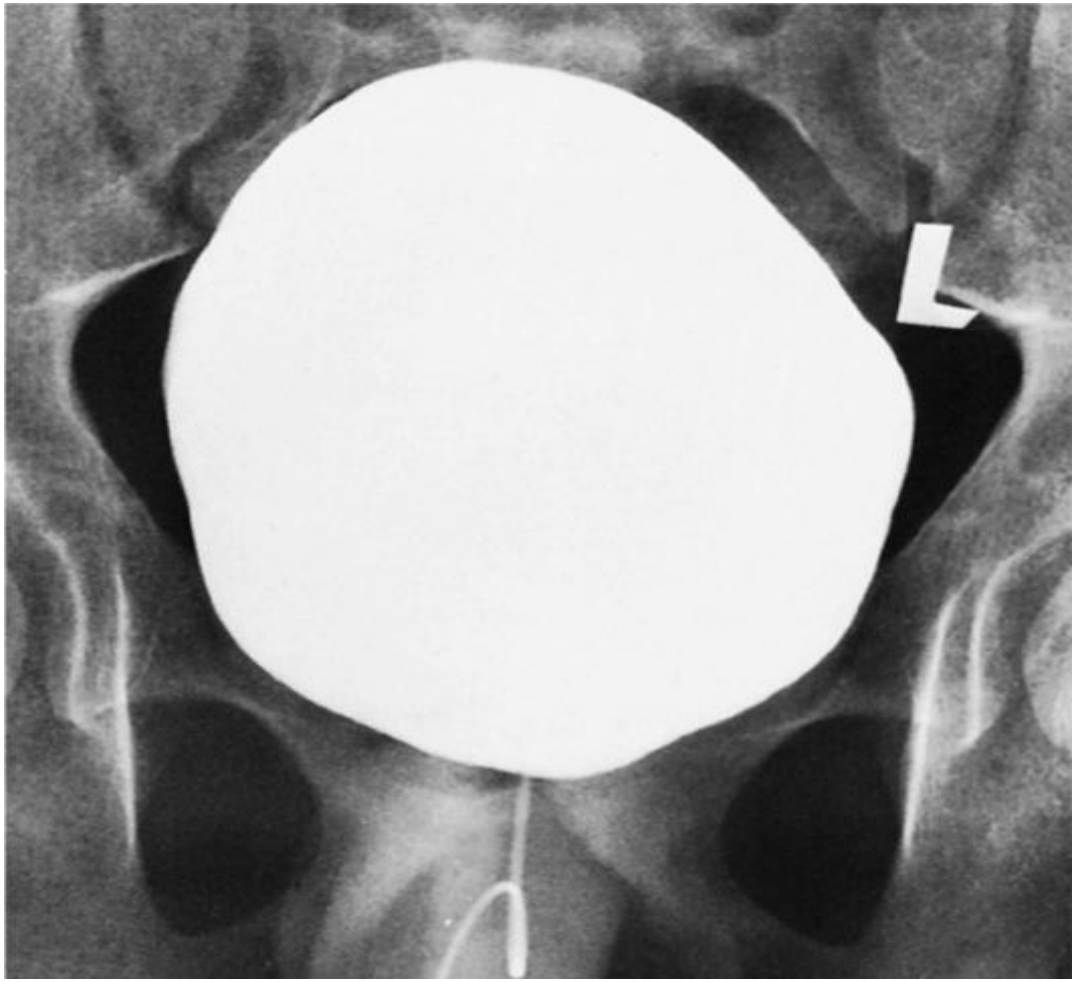
Indications

1. Demonstrate the renal collecting systems and ureters.
2. Investigate the level of ureteral obstruction in renal units displaying delayed function.
3. Demonstrate intraoperative opacification of collecting system during ESWL or Per-cutaneous access to the collecting system.
4. Demonstrate renal function during emergent evaluation of unstable patients.
5. Demonstrate renal and ureteral anatomy in special circumstances (e.g., ptosis, after transureteroureterostomy, after urinary diversion).

CYSTOGRAPHY

- Permits imaging of an opacified urinary bladder after retrograde instillation of contrast media through a urethral or suprapubic catheter
  - Imaging is performed to demonstrate a suspected urine leak, either from traumatic bladder rupture or after bladder surgery
  - Can also demonstrate a presence of a fistula between the bladder and vagina or to characterize bladder diverticuli

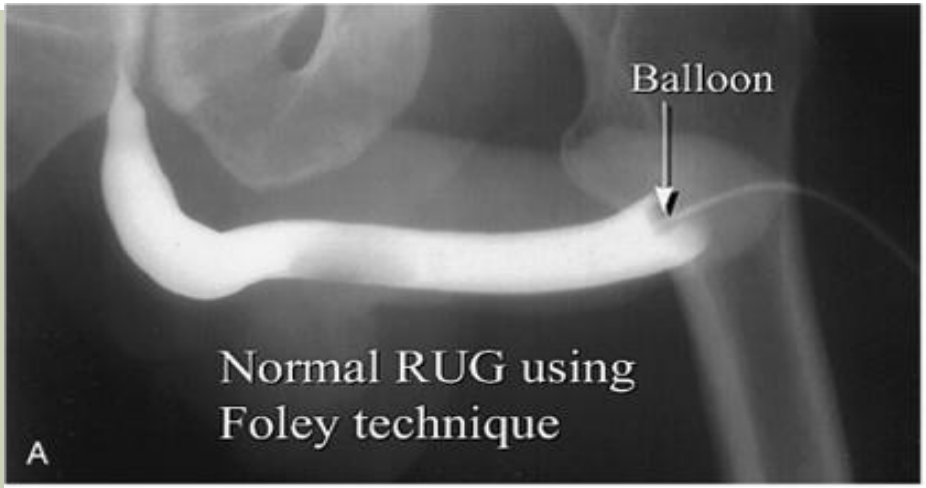
NORMAL MALE CYSTOGRAM

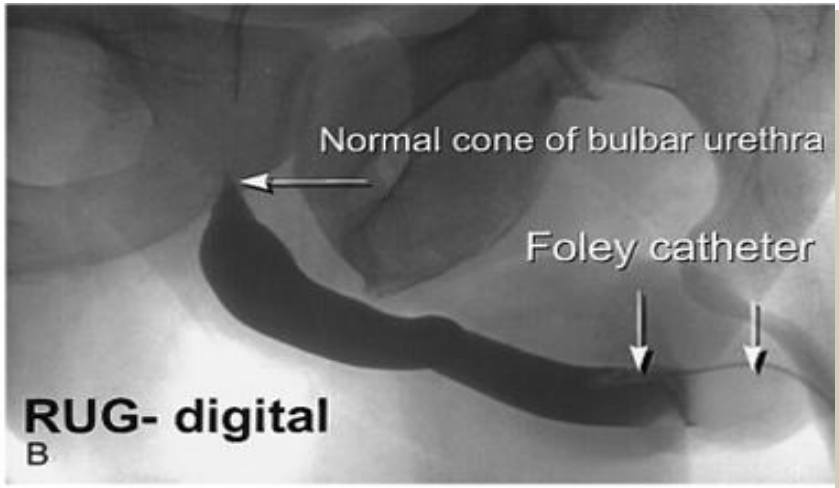


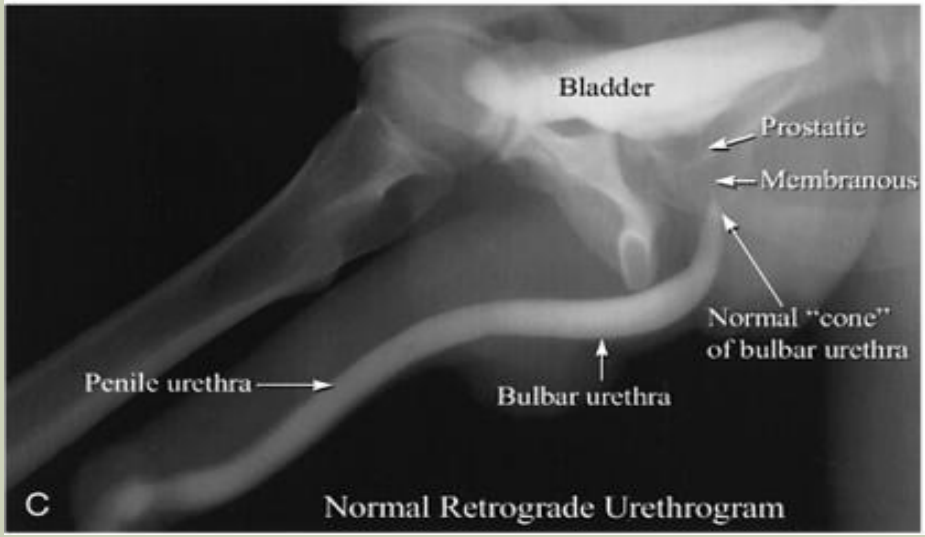
RETROGRADE URETHROGRAPHY (RUG)

- Complete evaluation of the urethra includes both antegrade and retrograde urethrography
  - Allows visualization of the male urethra
  - Used for evaluating a suspected traumatic urethral injury or urethral stricture
  - Can also be useful for diagnosis of a urethral diverticulum in females
  - Evaluate anterior and posterior urethra- strictures, trauma
  - 8-16 F foley in fossa navicularis, fill balloon with 1-2 mL and inject 30-50% contrast while filming obliquely

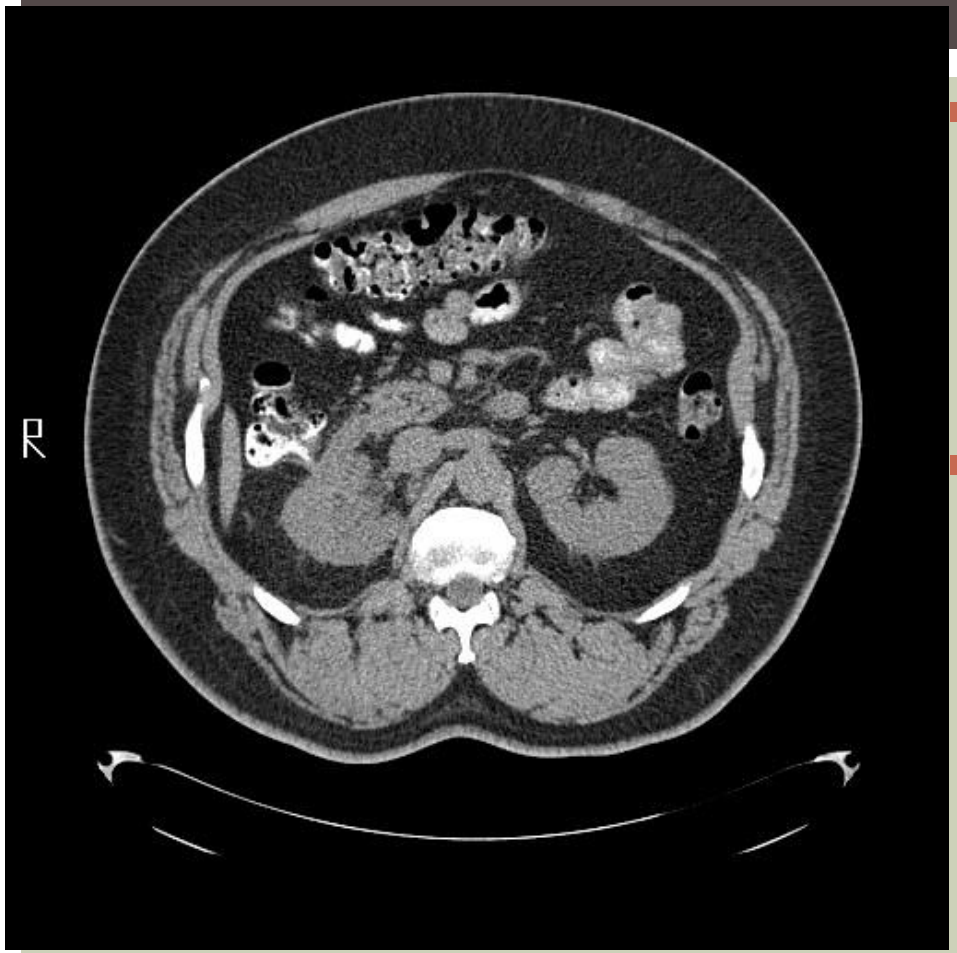
NORMAL RUG


Balloon
Normal RUG using
Foley technique
A


Normal cone of bulbar urethra
Foley catheter
RUG- digital
B


Bladder
Prostatic
Membranous
Normal "cone"
of bulbar urethra
Penile urethra
Bulbar urethra
C
Normal Retrograde Urethrogram

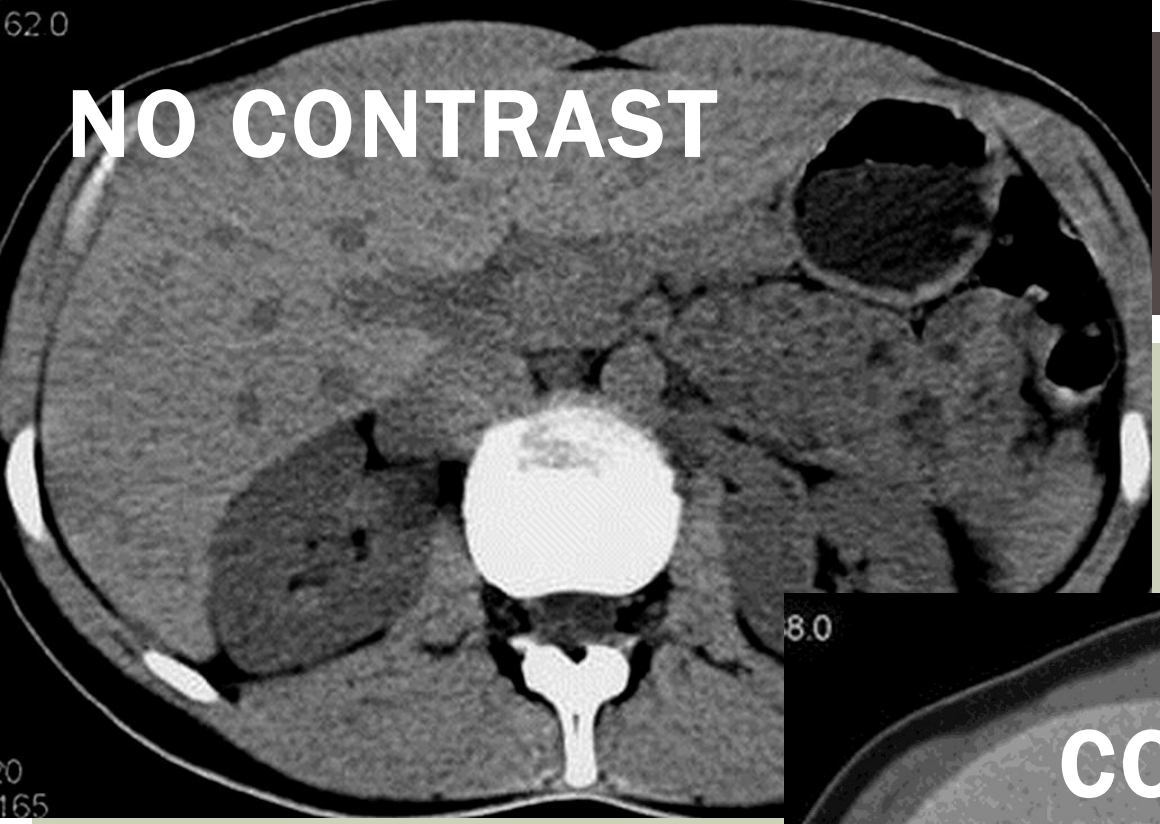
CT + ANGIO CT SCAN

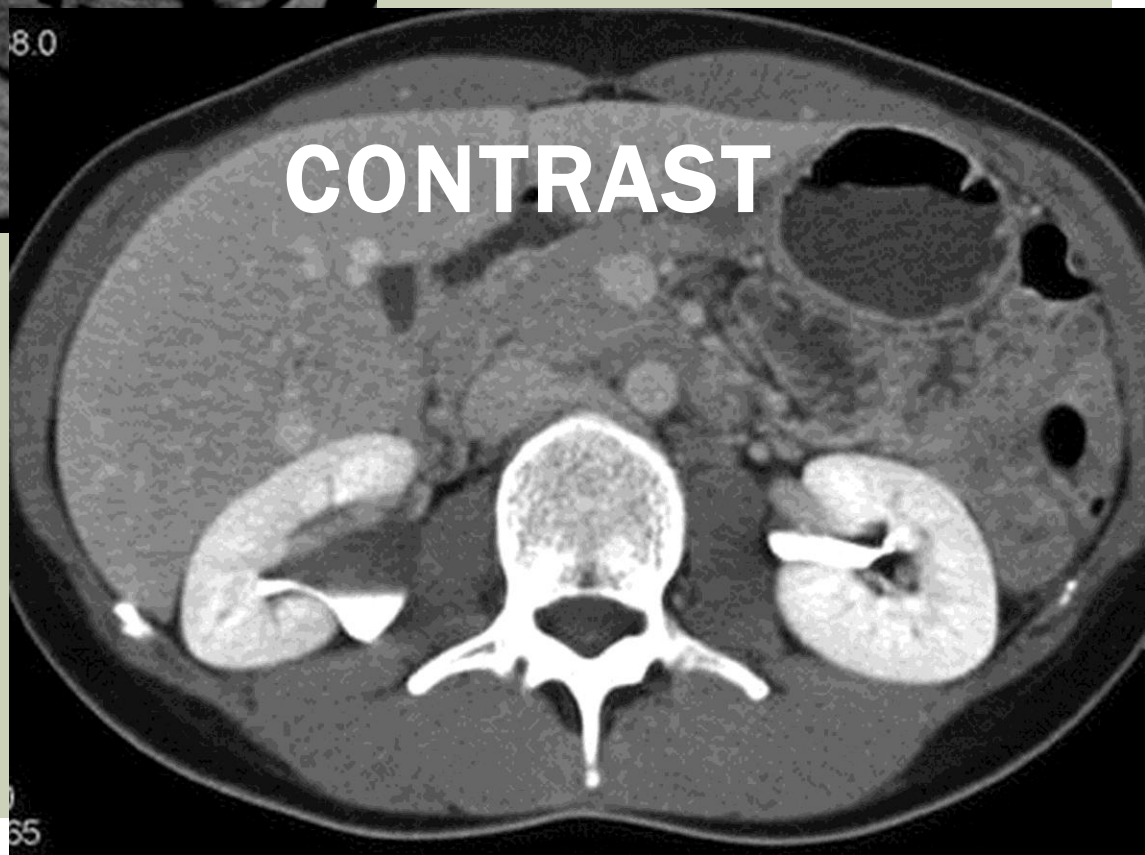


- often used examine structures in the abdomen and pelvis (liver, pancreas, gallbladder, spleen and intestines).
- CT Scans are a diagnostic tool that urologists use to detect and diagnose: recurrent urinary tract infections, sources of blood in the urine (hematuria), kidney stones, renal cysts and masses. It can help urologists rule out prostate, bladder and renal cancers

CT + ANGIO CT

- Contrast- parenchyma, adrenals
- 3-D to evaluate vascular abnormality
- 100-150 mL i/v bolus injection
- Renal- stages:
  - Precontrast- stones, parenchyma, vascular calcifications, renal contour
  - 30 sec- arterial phase
  - Venous phase 100 sec- uniform enhancement of parencyma (masses)
  - Excretory phase - collecting system

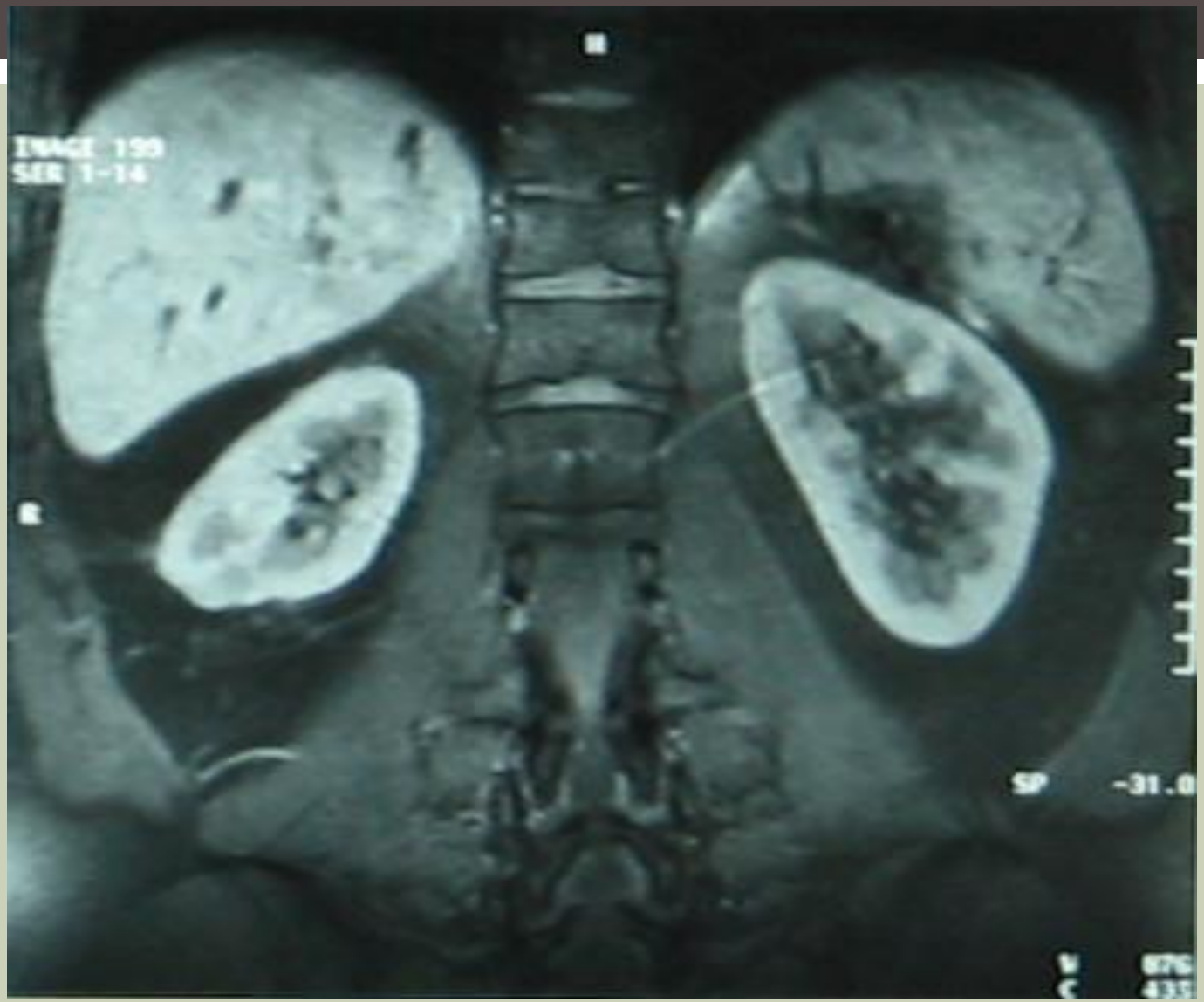

NO CONTRAST


CONTRAST

MRI

- No iodinated contrast
- Soft tissue resolution better than CT
- Contraindications- pacemaker, aneurysm clips
- T1- fluid dark, fat bright
- T2- fluid bright, fat dark

MRI



MRI

- **Renal-** will not evaluate stones, determine tumor
- **Adrenal-** contain more fat than cancers, bright on T2, isodense with liver
- **Bladder-** to determin invasion of wall by cell cancer or other pelvic neoplasms (on T2)
- **Prostate-** evaluate prostate cancer for capsular invasion. T1- distinct from surrounding fat/seminal vesicles (intermediate intensity), T2- peripheral zone (high intensity), central (intermediate), neurovascular bundles bright, seminal vesicles (high)

Table 1

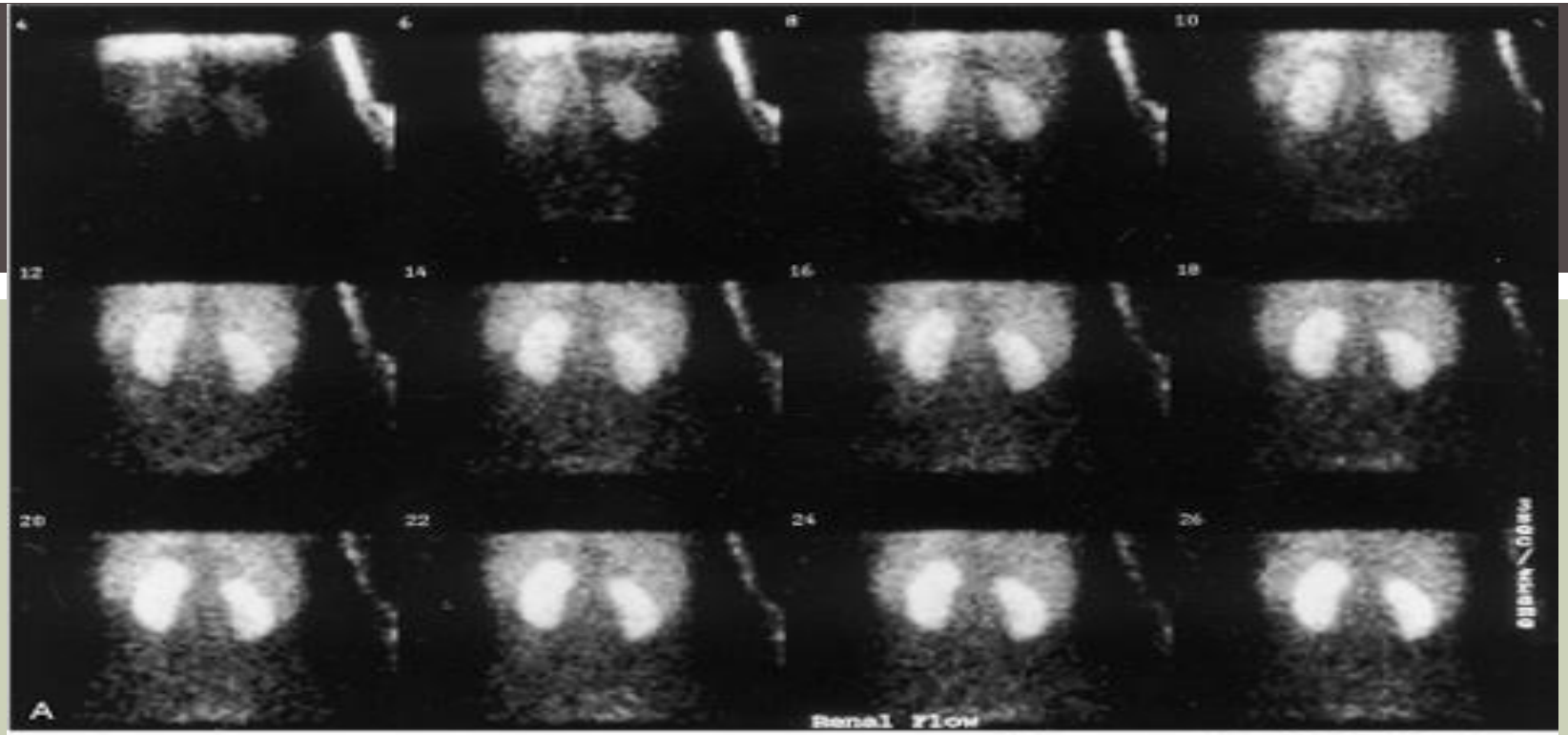
Comparison of advantages and disadvantages between computed tomography (CT) and magnetic resonance (MR) imaging modalities

CT	MRI
Uses ionizing radiation, high-dose procedure	Uses magnetic resonance, no ionizing radiation
Excellent spatial resolution	**Excellent contrast resolution**
Actual scanning time measured in seconds (typically <10 s)	Actual scanning time measured in minutes (typically 45 min)
Rarely requires general anesthetic in children	Frequently requires general anesthetic in children, depending on age

Excellent at showing calcification	Poor at showing calcification (signal void)
Poor at showing edema or pathological changes in specific tissue types	Excellent at showing edema and pathological changes in specific tissue types
Usually requires intravenous contrast (unless looking for calcification when not required)	Usually requires intravenous administration of contrast (but certain sequences can be tailored if this is contraindicated)
No known risk of nephrogenic systemic fibrosis (NSF)	Risk of NSF (rare, but renal patients believed to be at increased risk)
Less expensive	**Expensive**
Usually available as an emergency imaging technique	Not routinely available as an emergency technique
No significant contraindications	Contraindicated in patients with any internal ferrous objects (pacemakers, defibrillators, recent orthopedic metalware, other implanted metallic devices, metallic foreign bodies)
Open-style scanners	Generally quite enclosed scanners – risk of claustrophobia

NUCLEAR MEDICINE

- uses the radiation released by radionuclides (called nuclear decay) to produce images
- A radionuclide, usually technetium-99m, is combined with different stable, metabolically active compounds to form a radiopharmaceutical that localizes to a particular anatomic or diseased structure (target tissue).
- tracer goes to the target organ and can then be imaged with a gamma camera, which takes pictures of the radiation photons emitted by the radioactive tracer
- Physiologic and anatomic info


4
6
8
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14
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18
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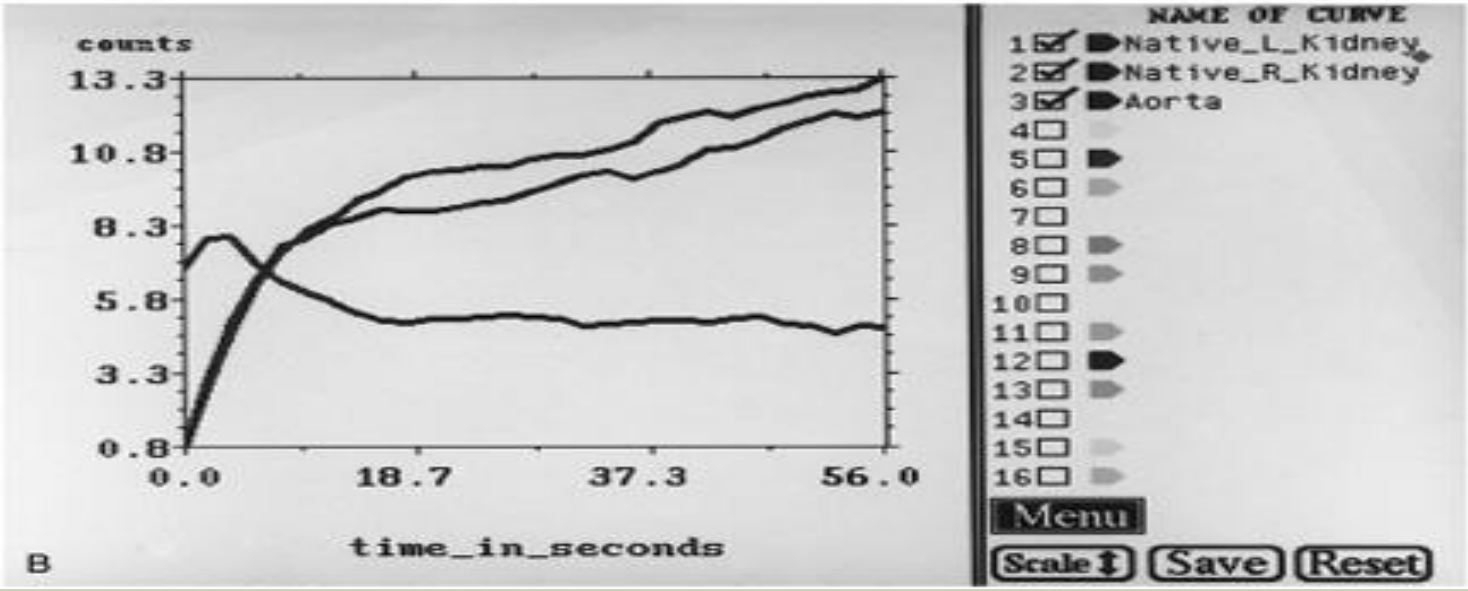
24
26
A
Renal Flow


counts
13.3
10.8
8.3
5.8
3.3
0.8
0.0
18.7
37.3
56.0
time_in_seconds
B
NAME OF CURVE
1 Native_L_Kidney
2 Native_R_Kidney
3 Aorta
4
5
6
7
8
9
10
11
12
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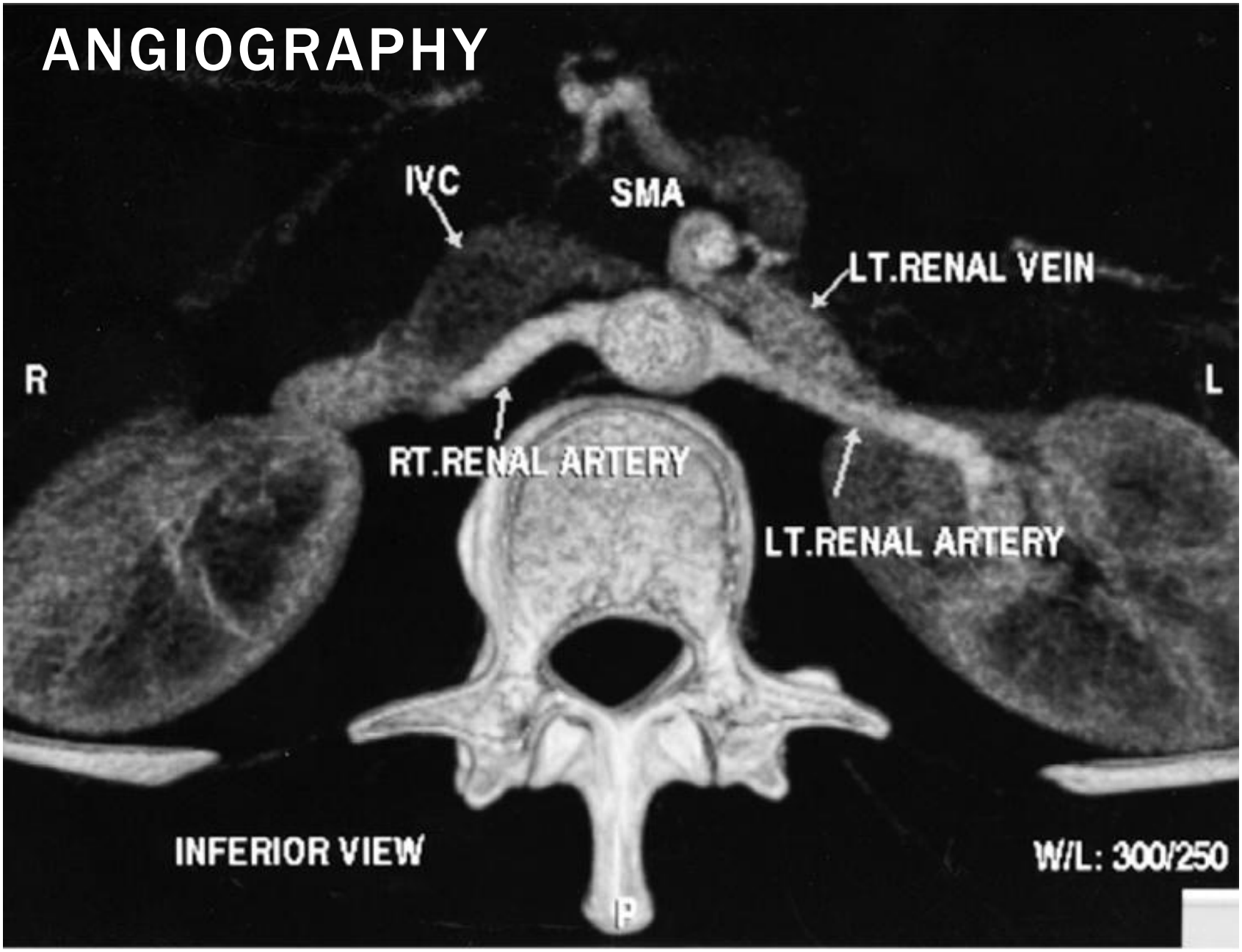
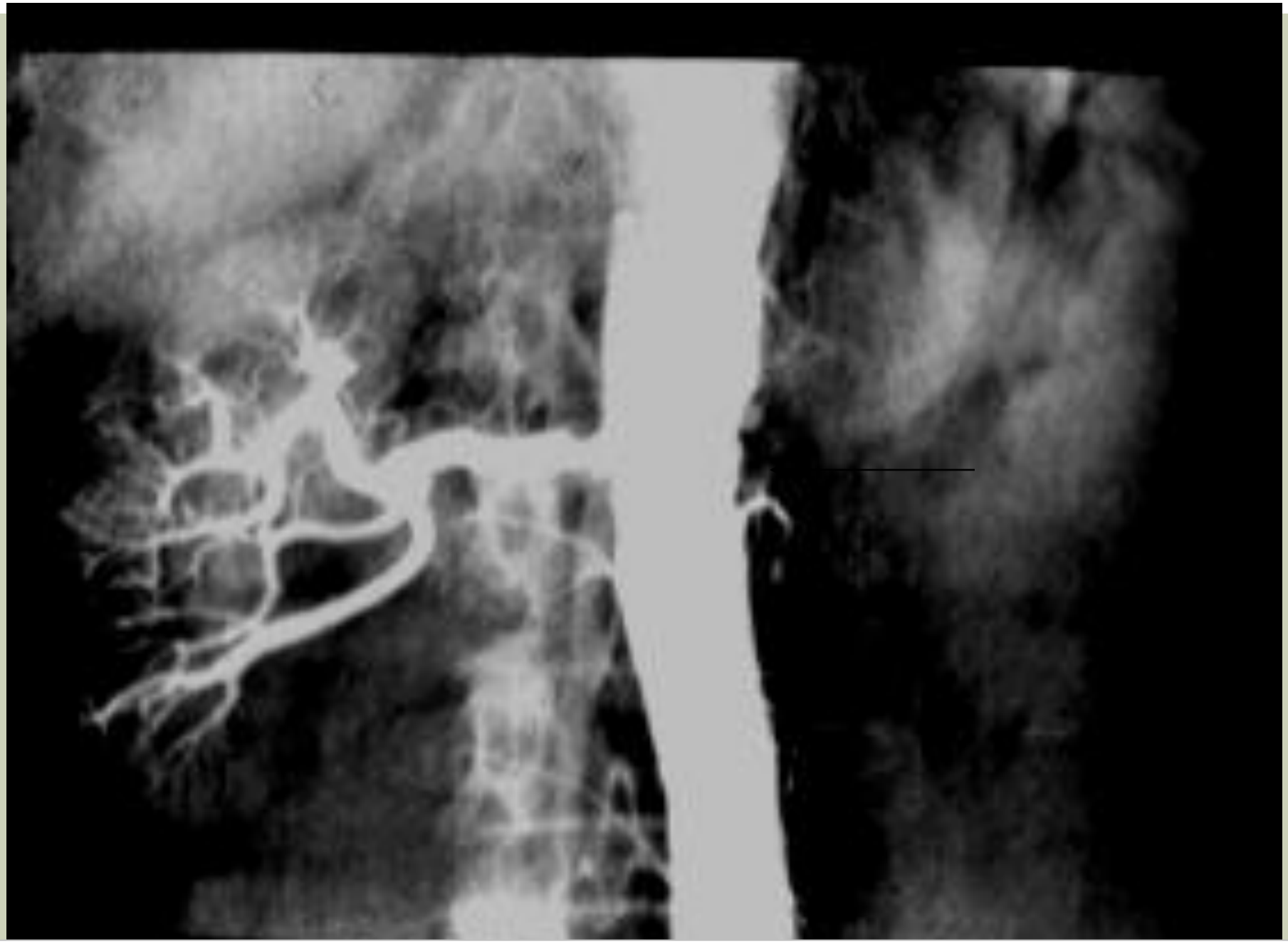
16
Menu
Scale
Save
Reset

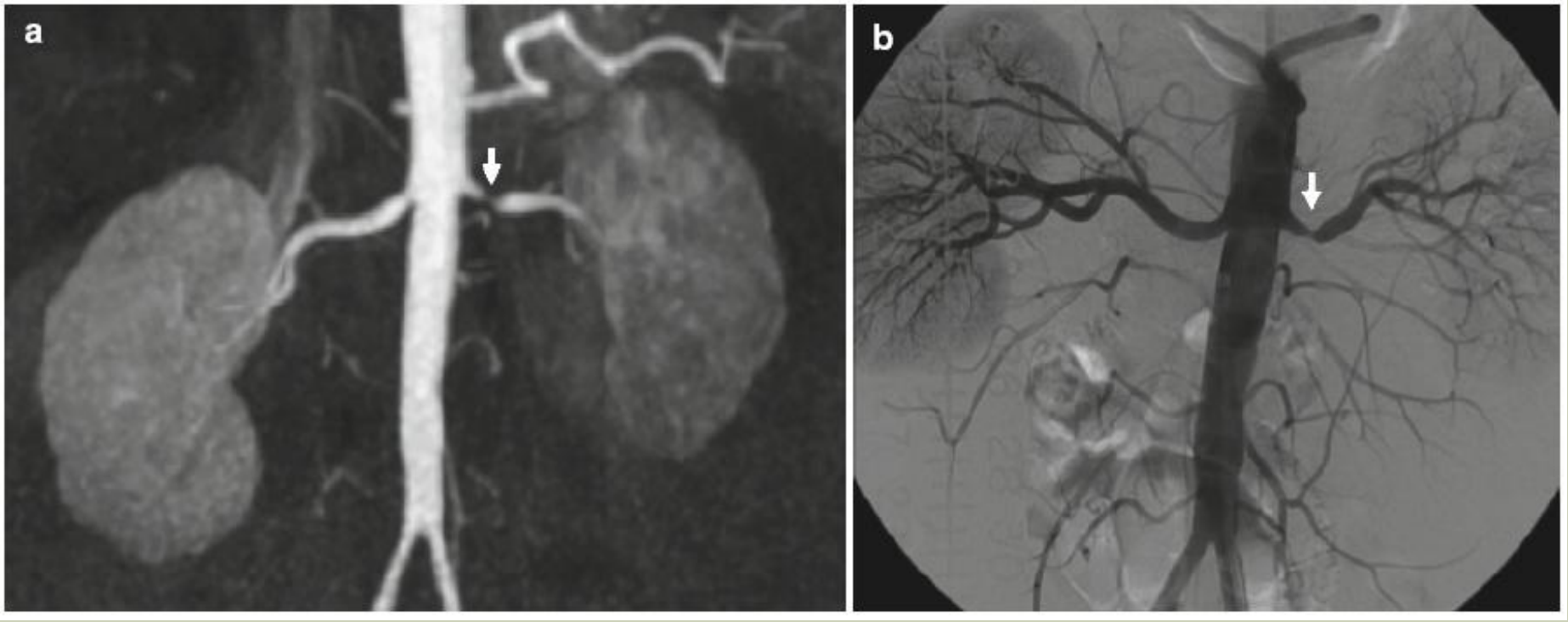
ANGIOGRAPHY





AORTOGRAPHY: LEFT RENAL ARTERY THROMBOSIS

MR ANGIOGRAPHY



- Left renal artery stenosis

RENAL STONES

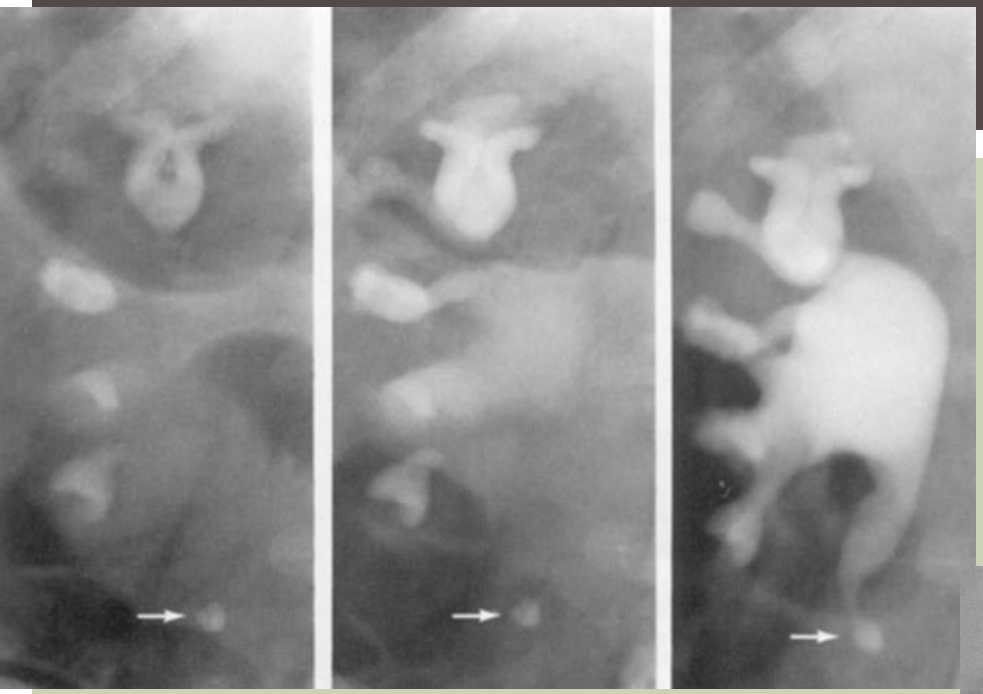
Imaging methods:

1. USG: stone shadow >=3-4 mm
2. Simple radiography of abdomen
3. CT of abdomen without contrast

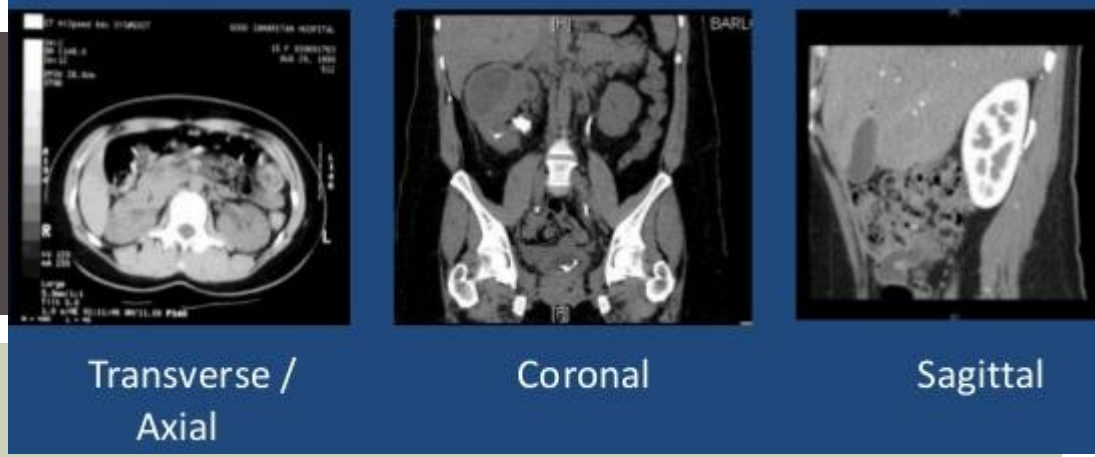
Calcification which appears medullary over the left renal shadow.

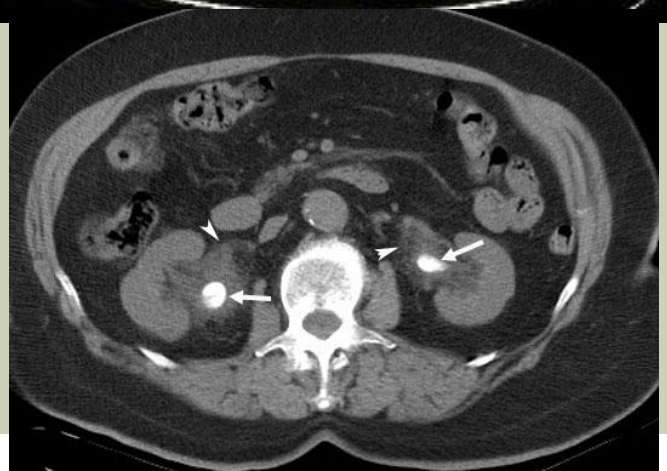
PLAIN FILM-
LEFT DISTAL URETERAL CALCULUS

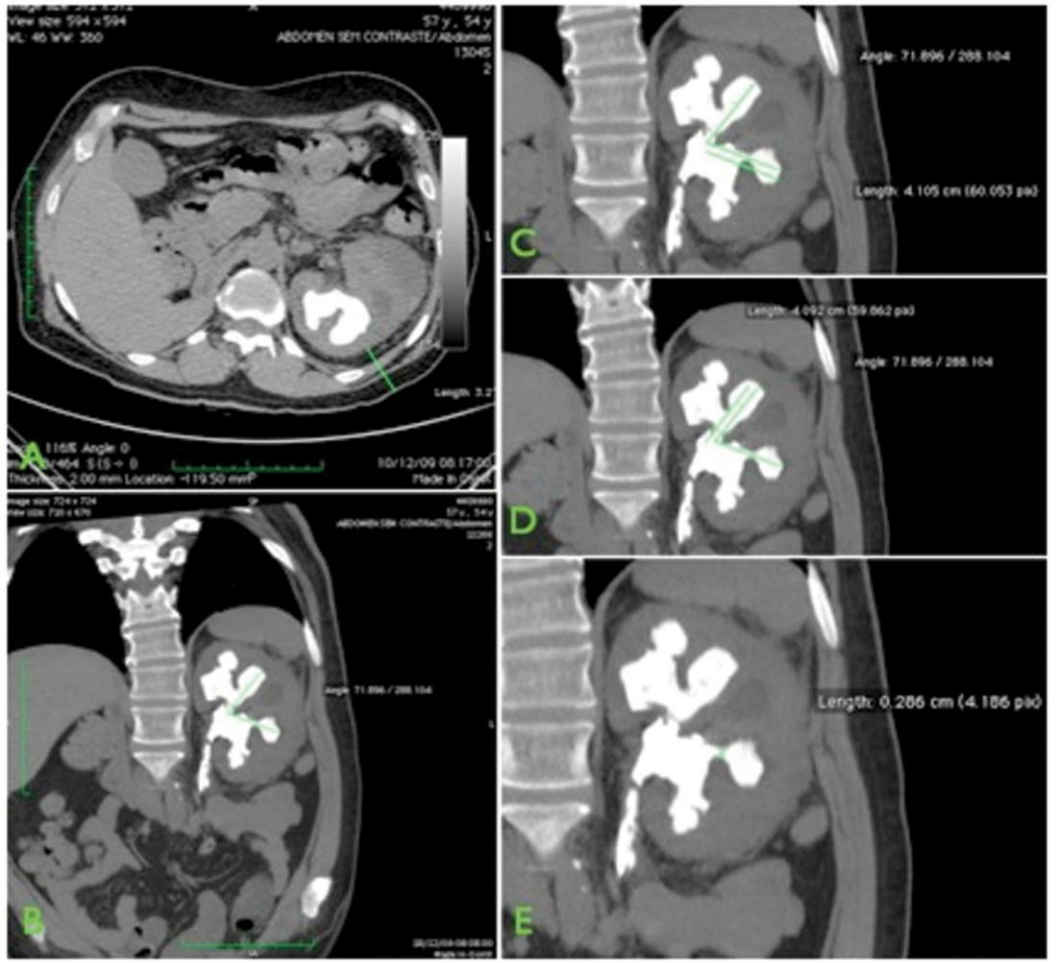
Intravenous urography



CT of abdomen without contrast







Examples

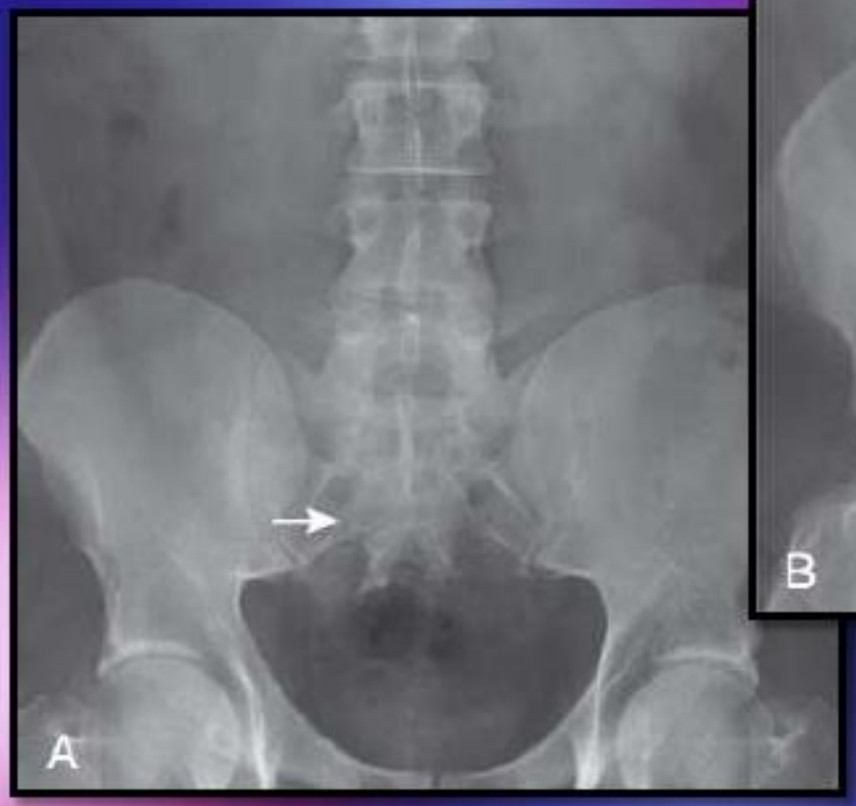


Figure 4–4. A, Right ureteral calculus *(arrow)* overlying the sacrum is difficult to visualize on the plain film. B, The right posterior oblique study fails to confirm the location of the ureteral calculus. C, Computed tomography confirms this 6-mm calculus in the right ureter at the

Malignant kidney tumors at the ultrasound scan are characterized by:

•It deforms the kidney contour with increasing kidney size

•Upon the growth of the formation towards the pelvis, hydronephrosis develops as a result of its compression and displacement by the tumor, with deformation of the pyelocaliceal system.

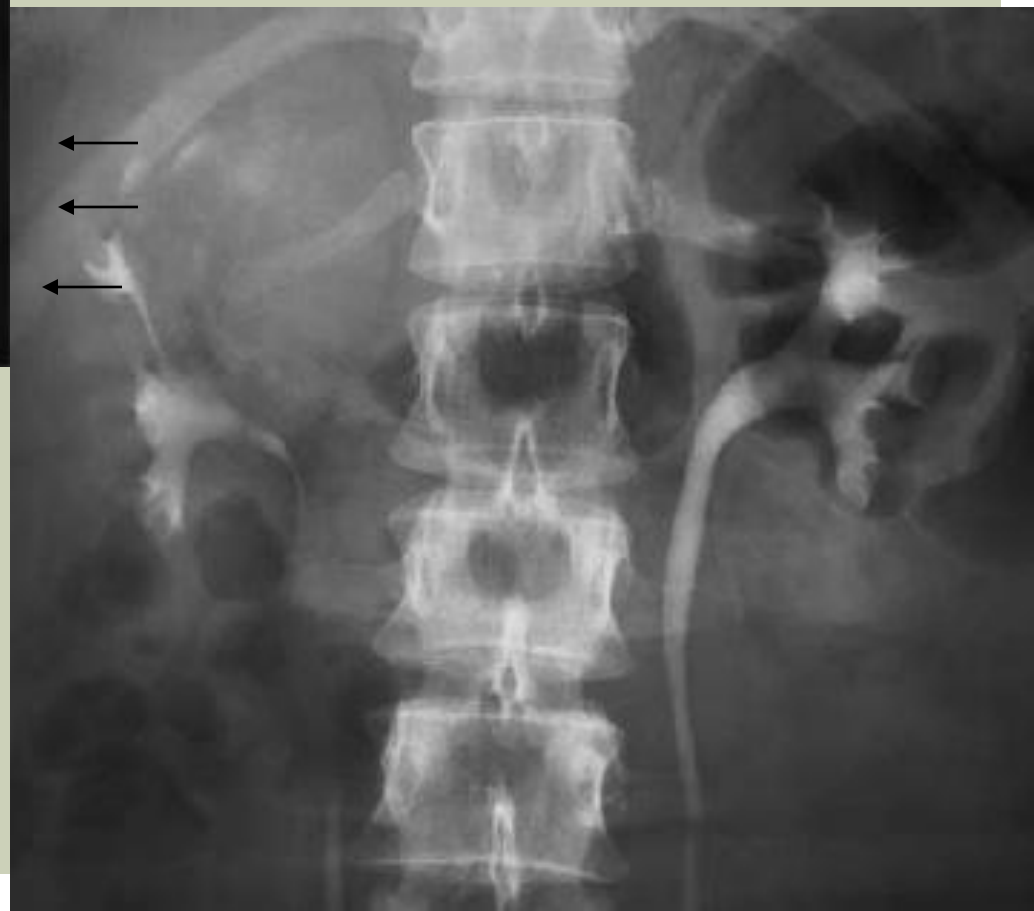
•In most cases, tumors with dimensions of 2.0 cm are determined, those with smaller dimensions have an uncertain contour

•In most cases round or oval

•Predominantly hyperecogenic structure

•Small size formations have a homogeneous structure (iso-, hypo-, or hyperrecognized), often with a complete or incomplete hypoecogen halo, delimiting it from normal renal parenchyma. With tumor growth in size, its structure becomes more uneven due to the occurrence of necrosis, destruction, haemorrhage, cystic degeneration (hypo- or anecogenic), hyperintensive outbreaks of calcinate.

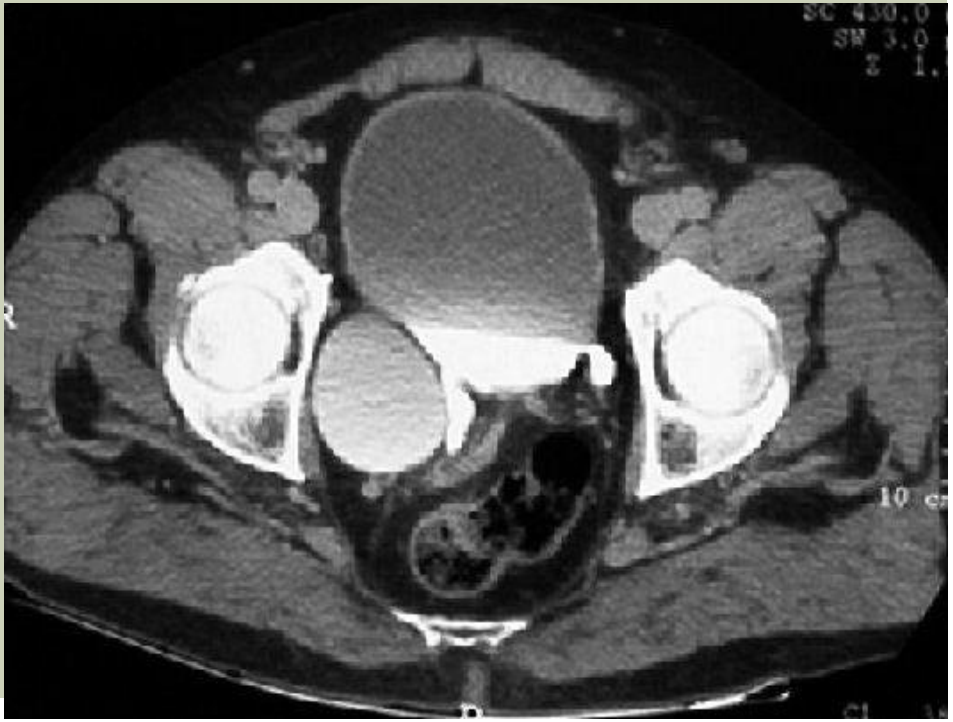
Tumors



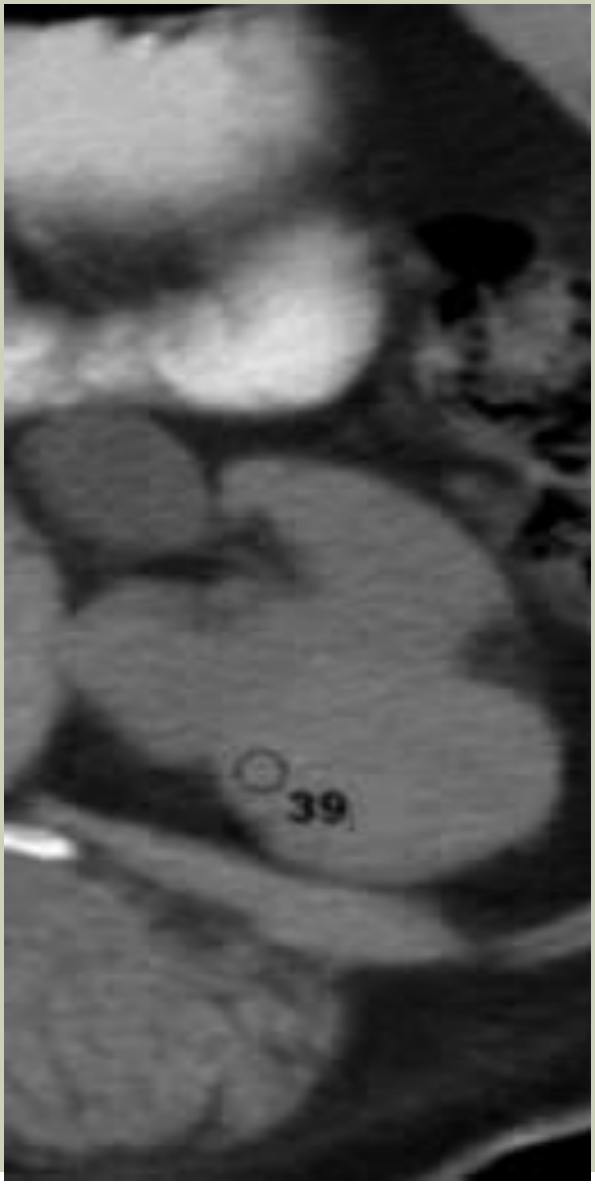
Minus defect in the pyelocaliceal system, with irregular contour, with extension to callyx

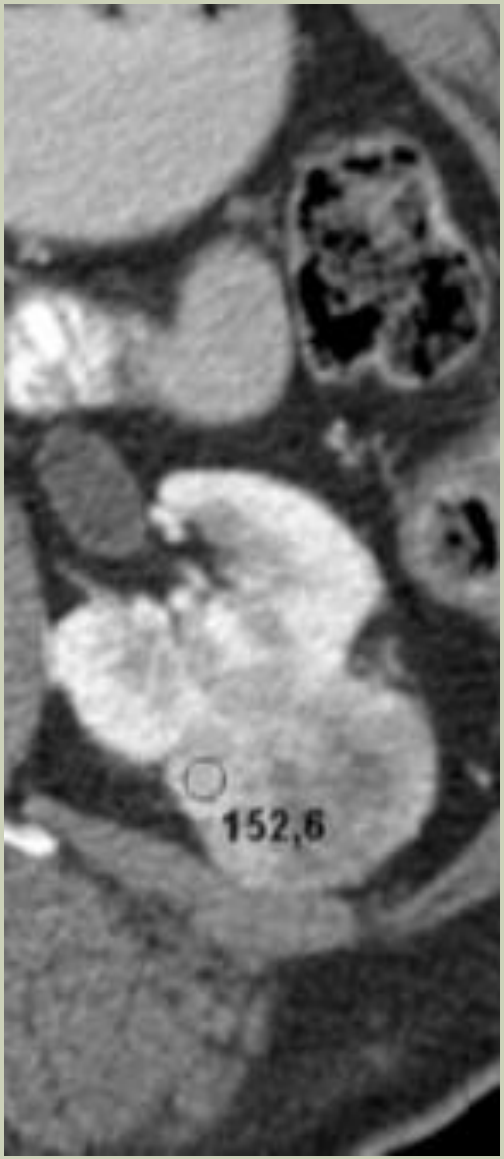
Tumors

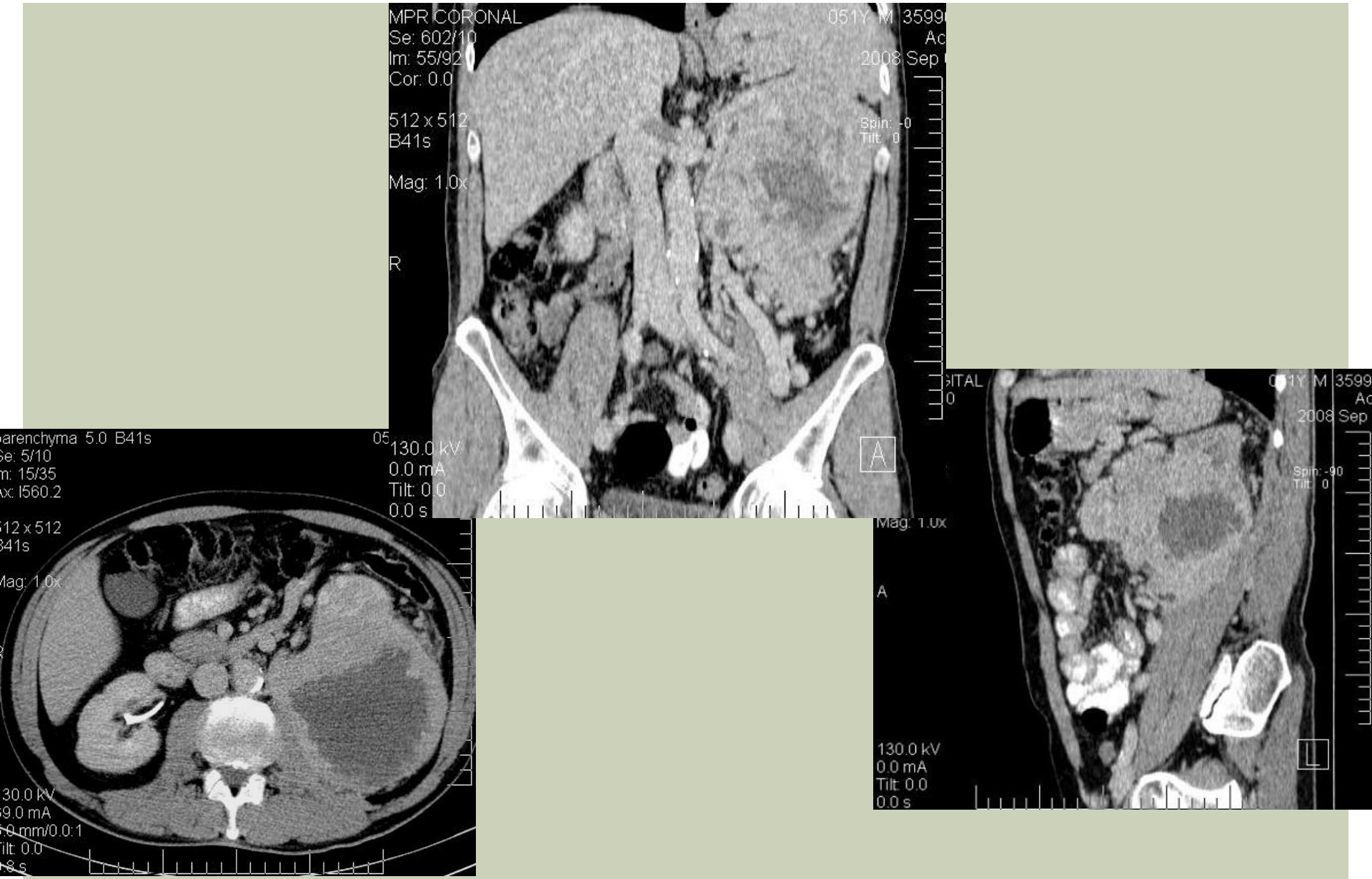
Plus defect in the urinary bladder wall, with regular contour, homogenous structure



Native and postcontrast CT exam, native examination hypodens, nodular mass

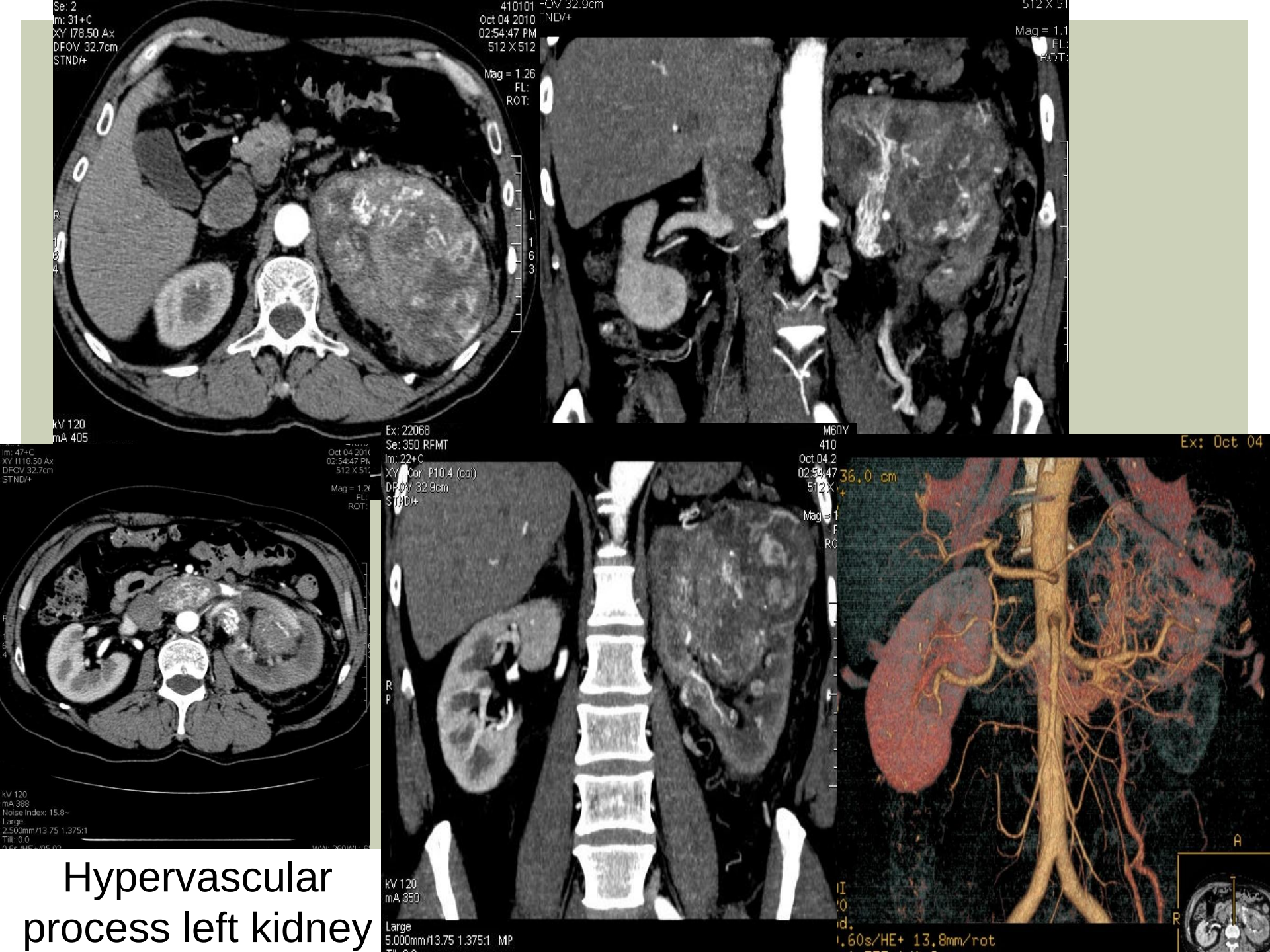






CT with contrast showing left renal mass – malignant tumor

TUMOR



Hypervascular process left kidney

Renal tumour metastases

The most common metastasis :

- Lung 55%
- Liver 33%
- Bones 32%
- Adrenal glands 19%
- Contralateral kidney 15%
- Cerebelum 6%
- Spleen 5%
- Colon 4%
- Skin 3%

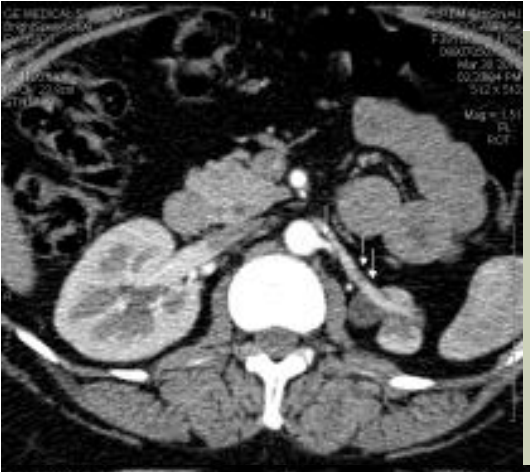
RENAL CONGENITAL MALFORMATIONS

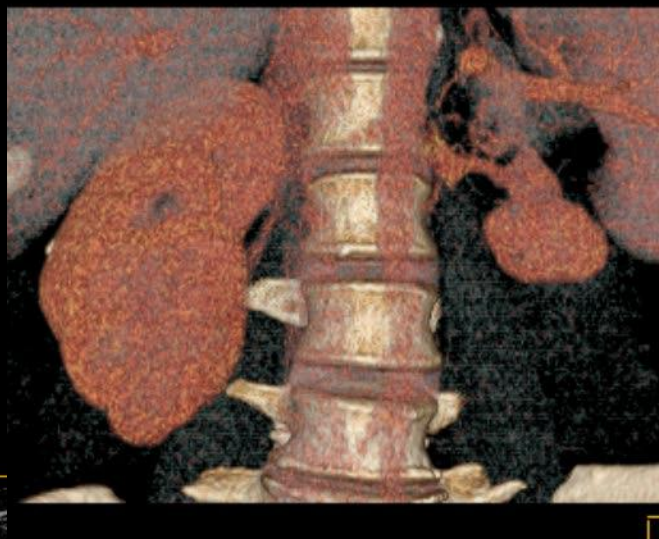
A. NUMBER

1. Single congenital kidney-agenesis
2. Agenesia and bilateral renal aplasia are incompatible with life, from birth.
3. Supernumerary kidneys - double

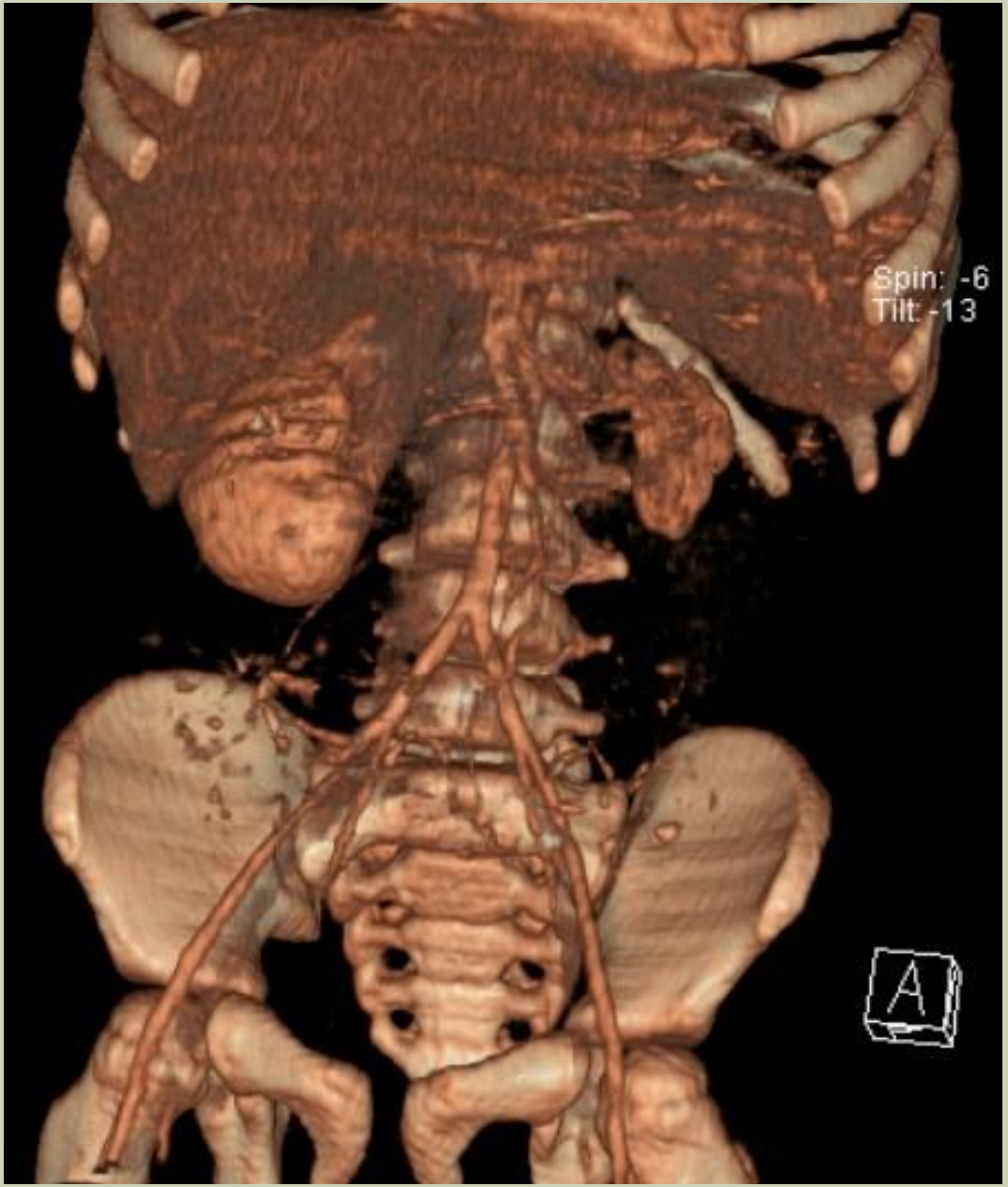
Bilateral Duplication of ureter

Renal hypoplasia



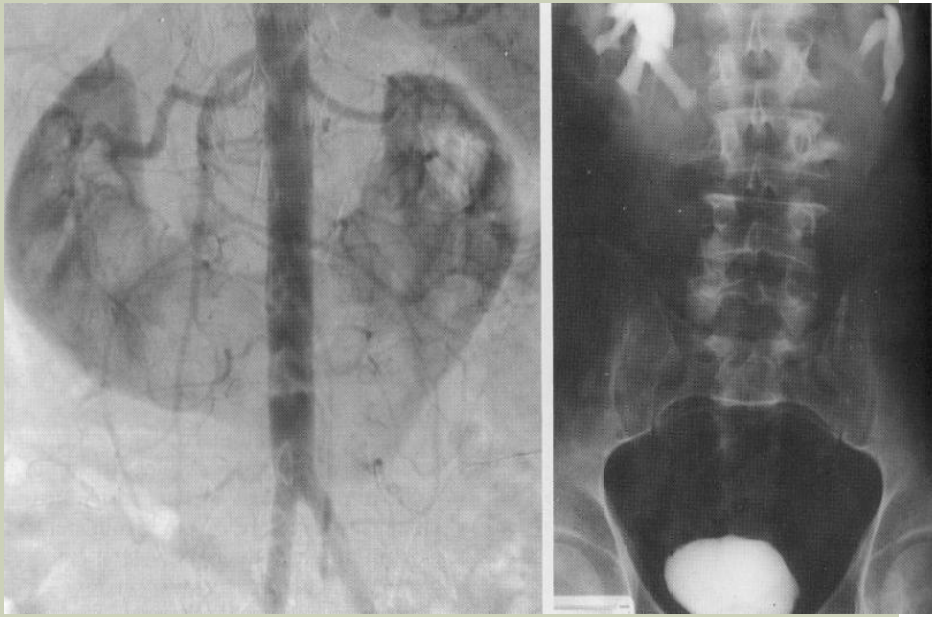


In a 6-year-old male, CT exam - 3D reconstruction - a hypoplasic left kidney

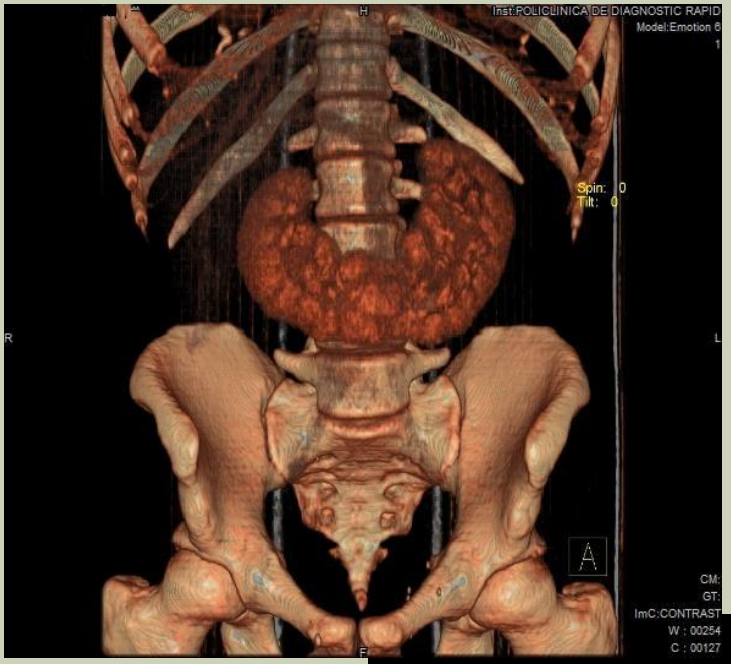


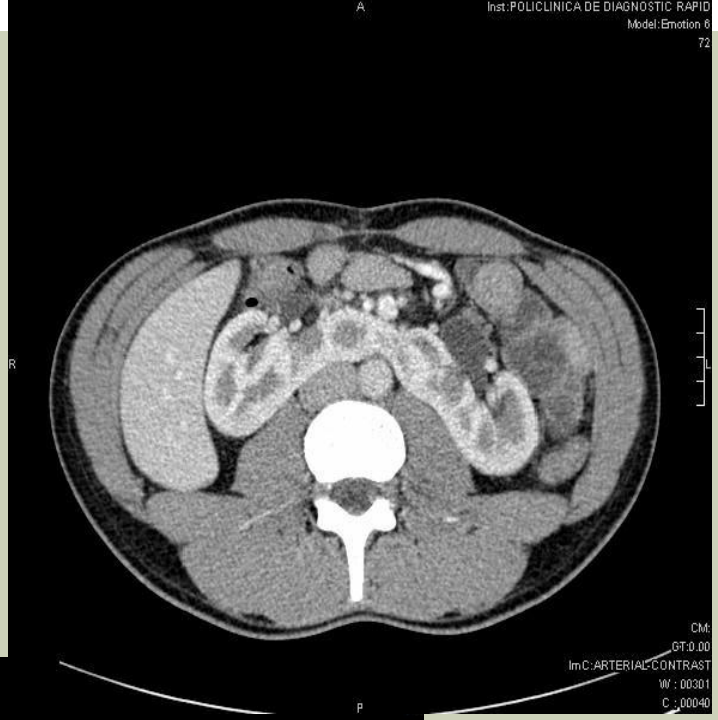
RENAL CONGENITAL MALFORMATIONS

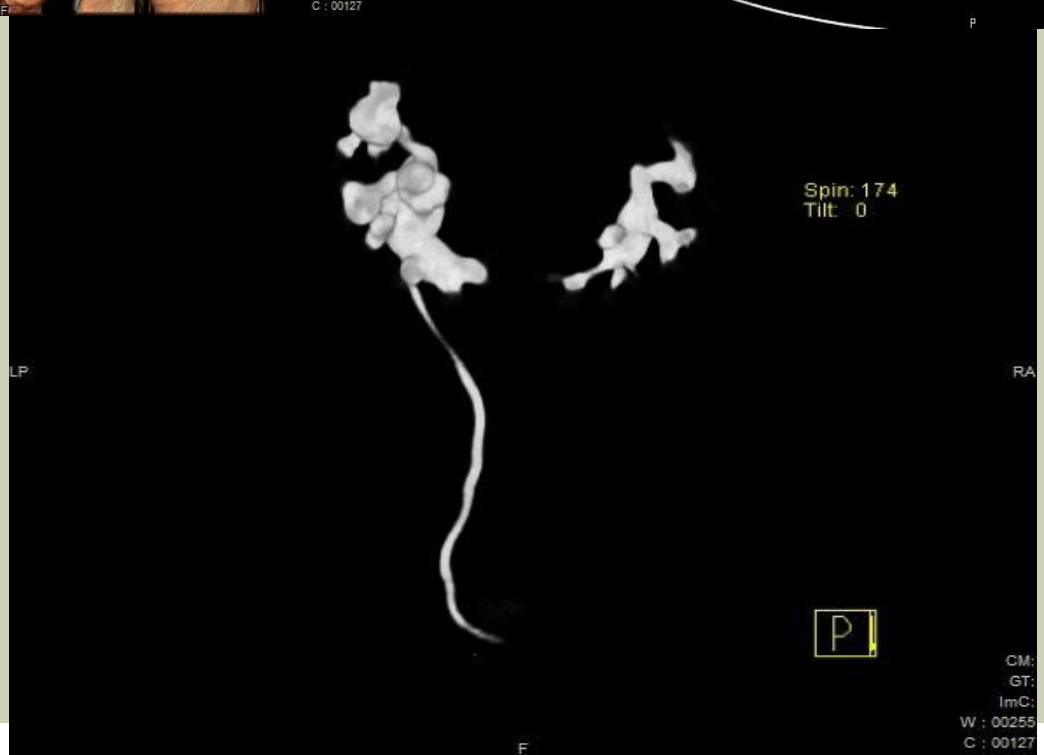
B. SHAPE



HORSESHOE KIDNEY



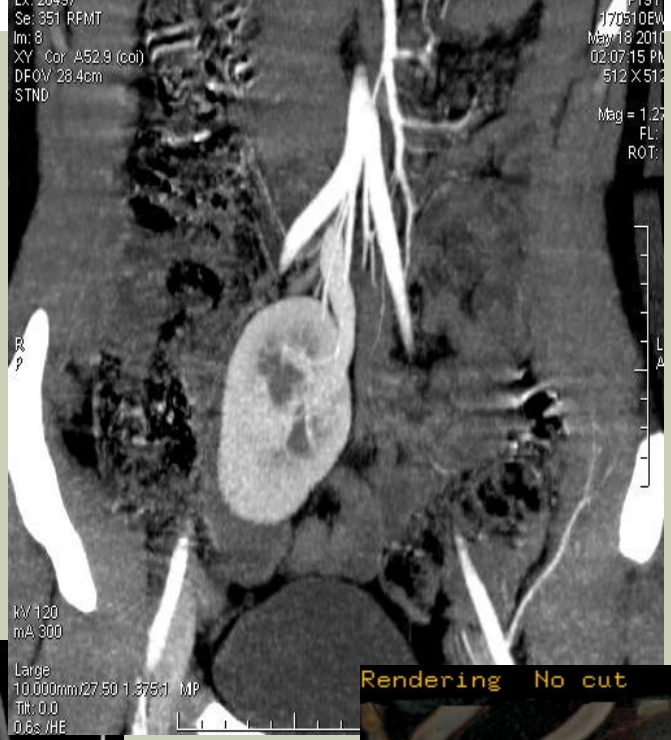


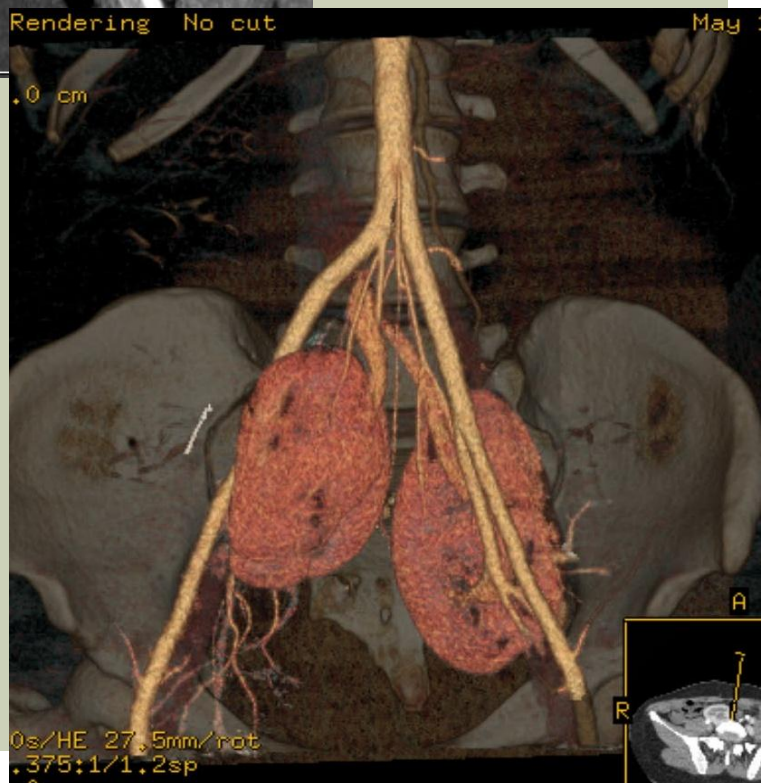


RENAL CONGENITAL MALFORMATIONS

C. LOCALISATION

Ectopic kidney



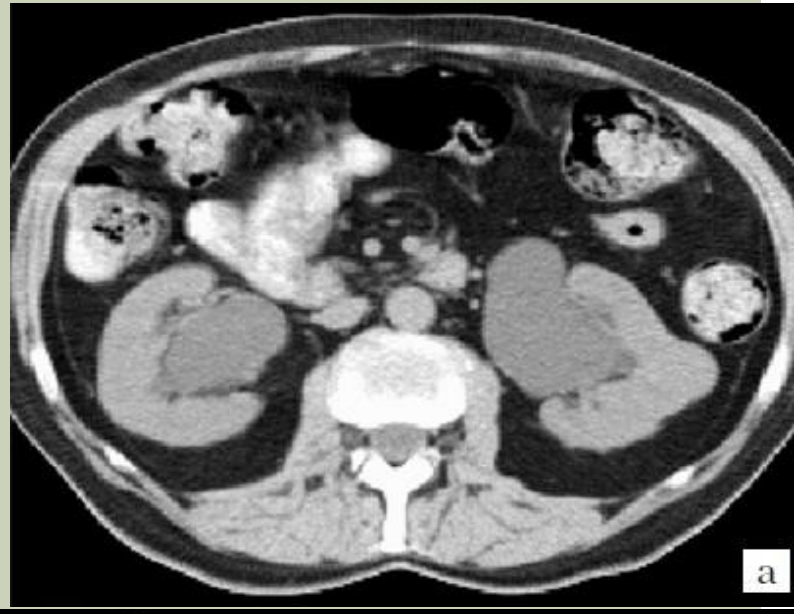


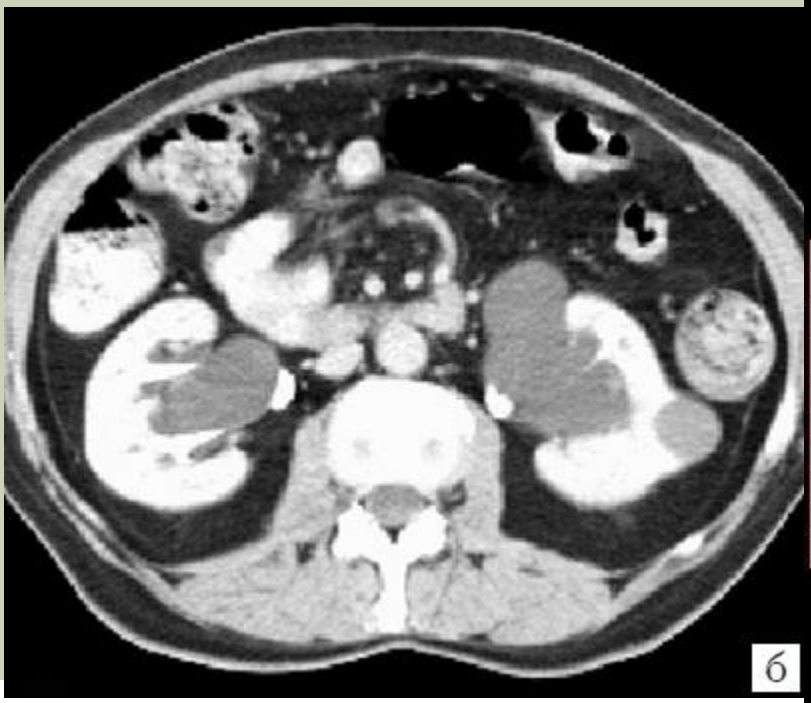
Ectopic kidney

RENAL CONGENITAL MALFORMATIONS

D. CONGENITAL MALFORMATIONS OF RENAL PARENCHIMA

RENAL CYSTS





Bosniak renal cyst classification

The **Bosniak classification system** for CT evaluation of renal cysts is helpful in determining both malignant risk and required follow-up and/or treatment.

Bosniak 1
simple cyst, imperceptible wall, rounded
work up : nil
% malignant : ~ 0%

Bosniak 2
minimally complex, a few thin (< 1mm) septa, thin Ca++; non-enhancing high-attenuation (due to to proteinaceous or haemorrhagic fluid) renal lesions of less than 3 cm are also included in this category; these lesions are generally well marginated.
work up : nil
% malignant : ~ 0%

Bosniak 2F
minimally complex but requiring follow up.
increased number of septa, minimally thickened or enhancing septa or wall
thick Ca++,
hyperdense cyst that is:
> 3 cm diameter, mostly intrarenal (less than 25% of wall visible); no enhancement
work up : needs ultrasound / CT follow up
% malignant : ~ 25 %[6]

Bosniak 3

indeterminate, thick or multiple septations, mural nodule, hyperdense on CT

% malignant : ~ 54%[6]

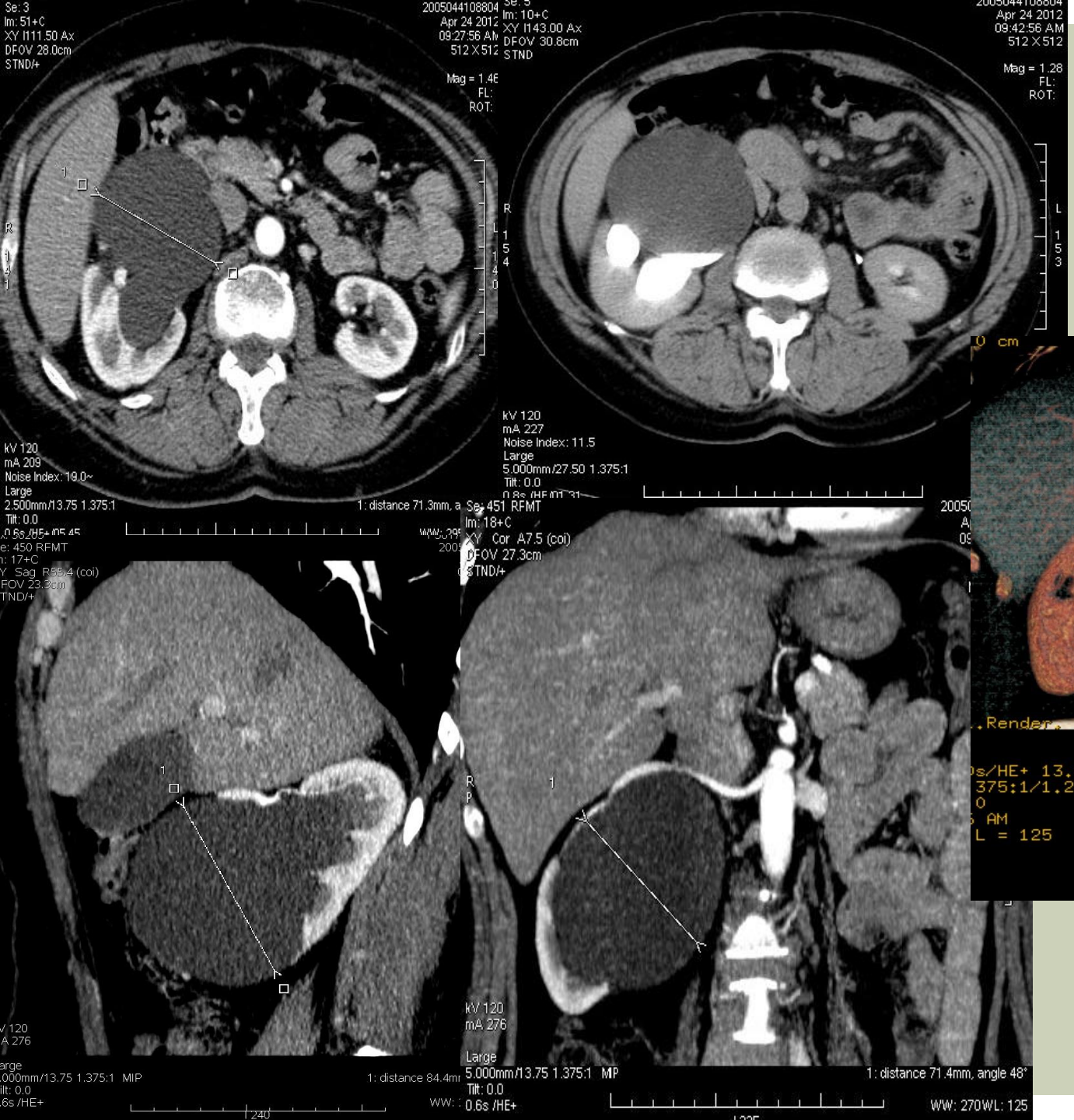
Bosniak 4

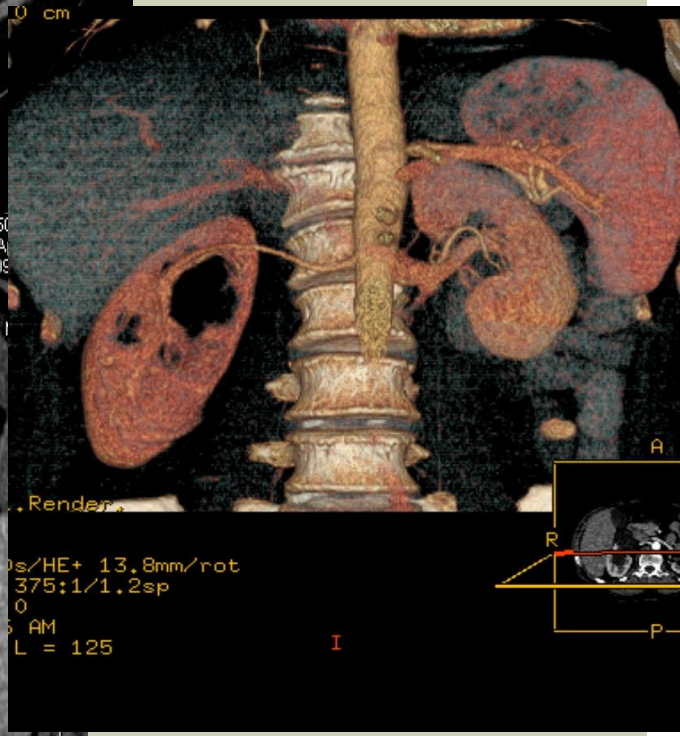
clearly malignant, solid mass with large cystic or necrotic component

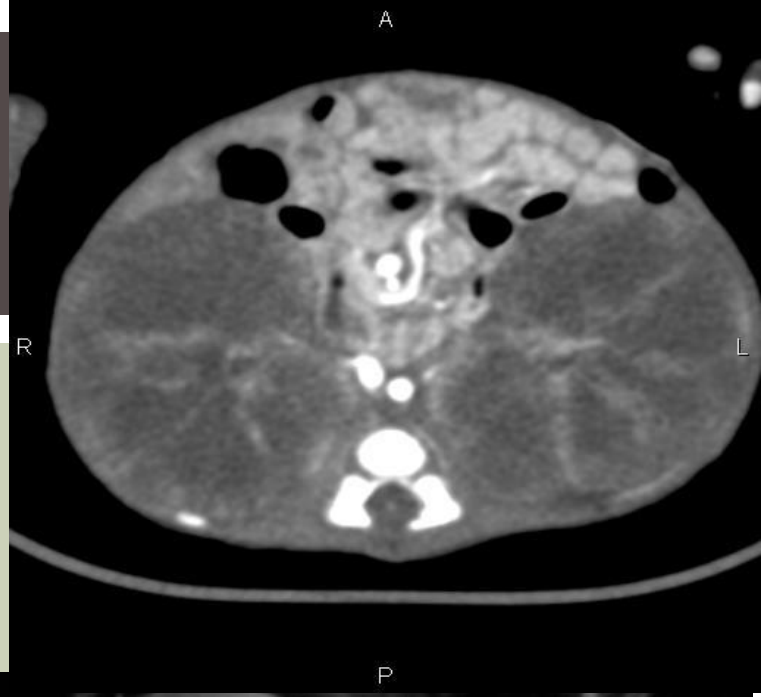
treatment: partial / total nephrectomy

% malignant : ~100%

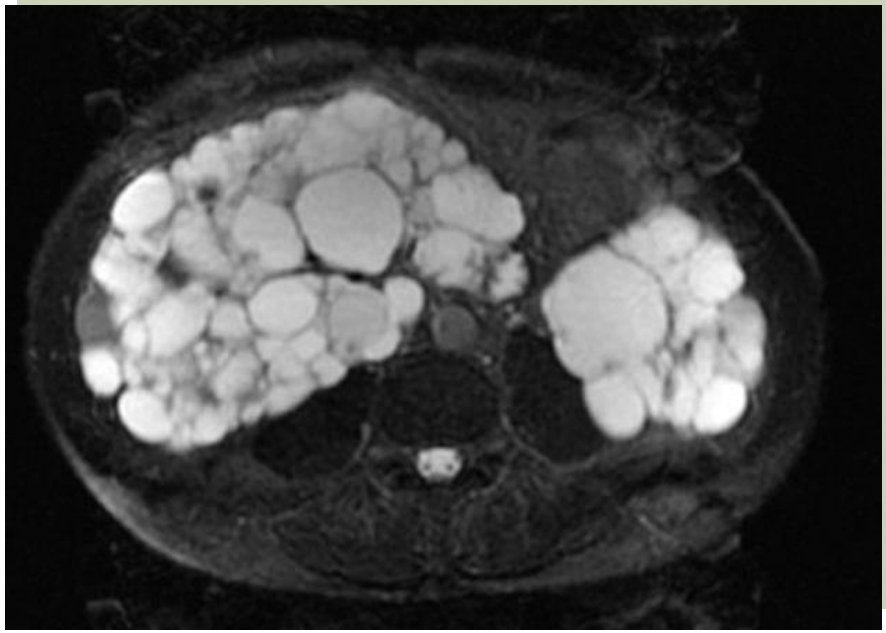
Parapelvical right kidney cyst





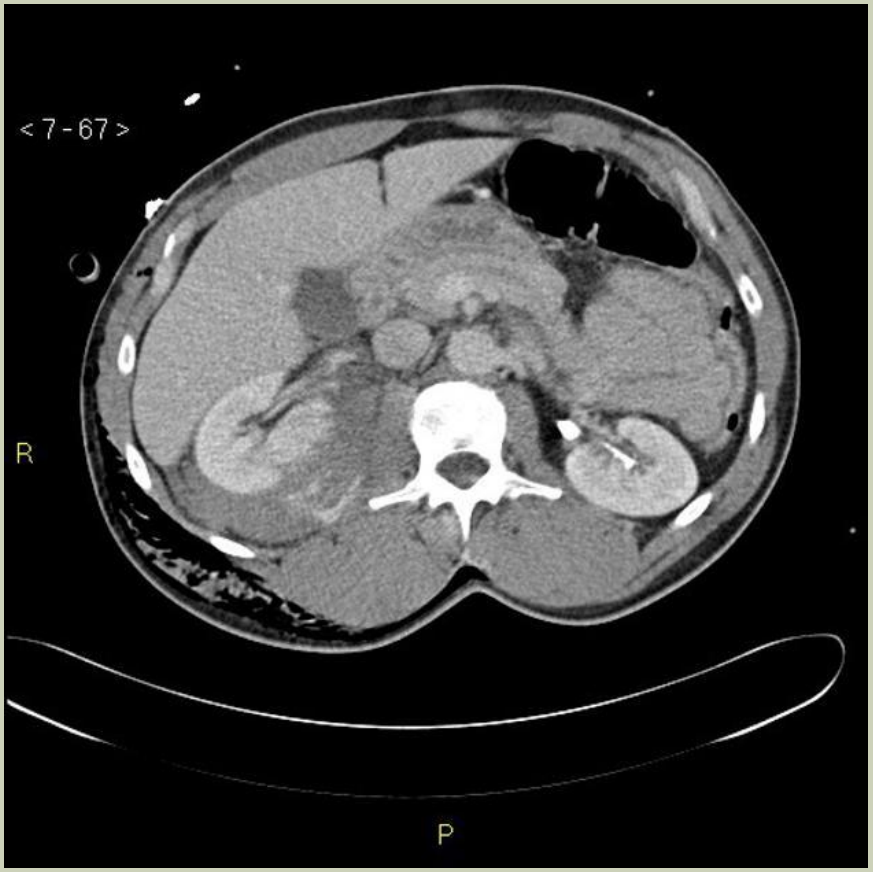


Polycystic kidney disease: CT vs MRI

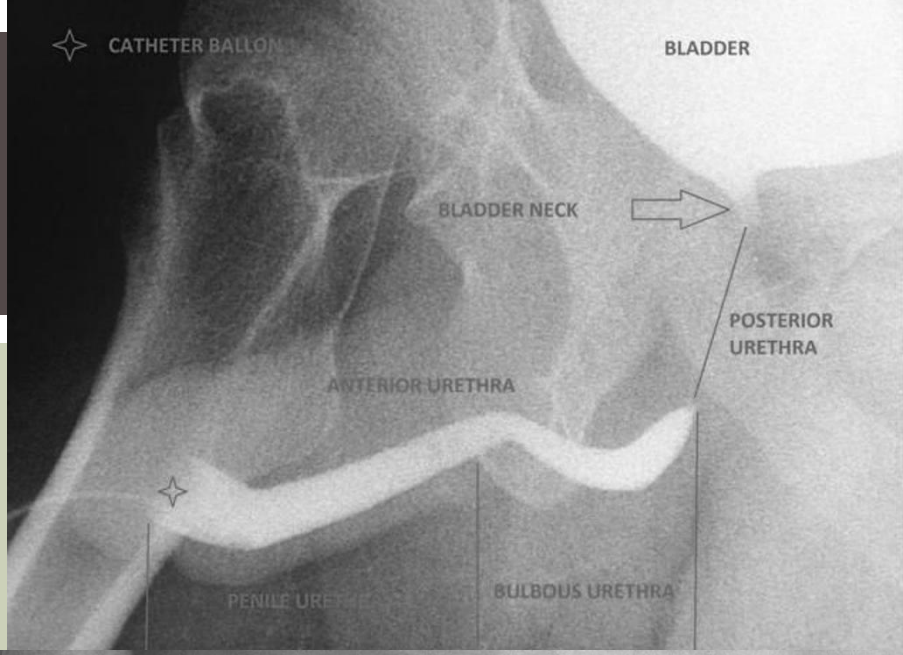


Polytrauma

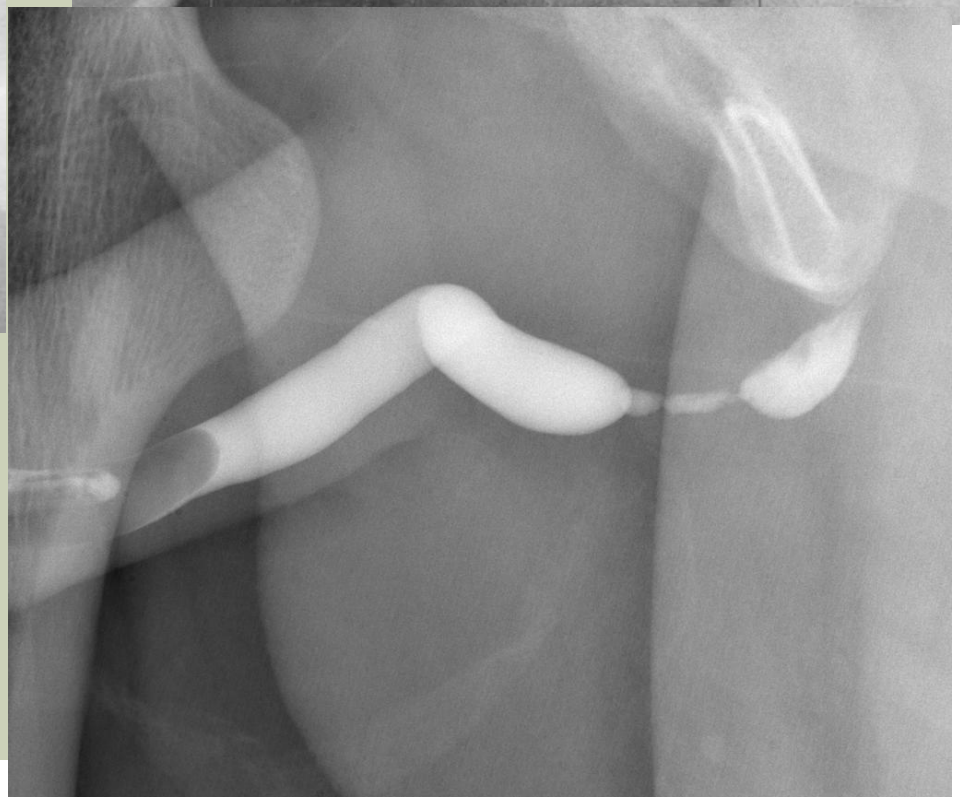
extensive skin emphysema kidney contusion.



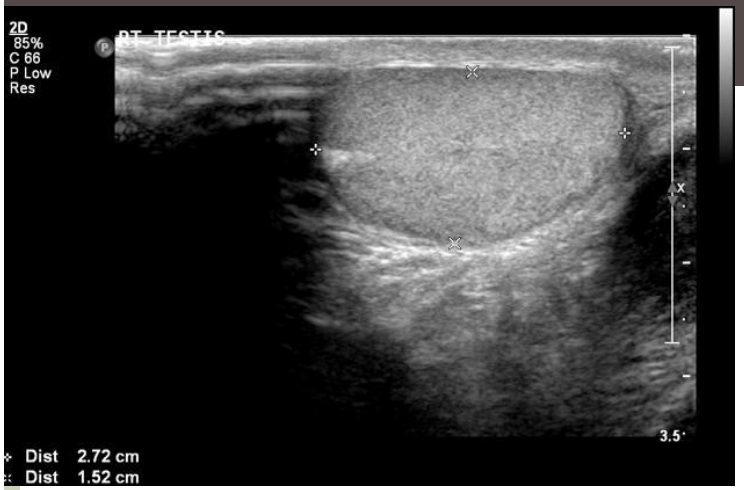
Anatomy of the normal ureter on ascending urethrogram.

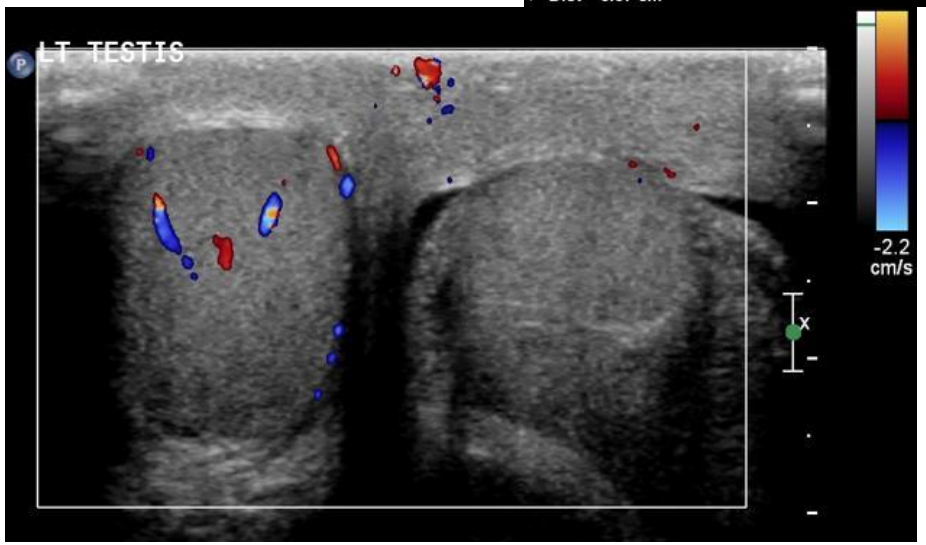


Urethral stricture



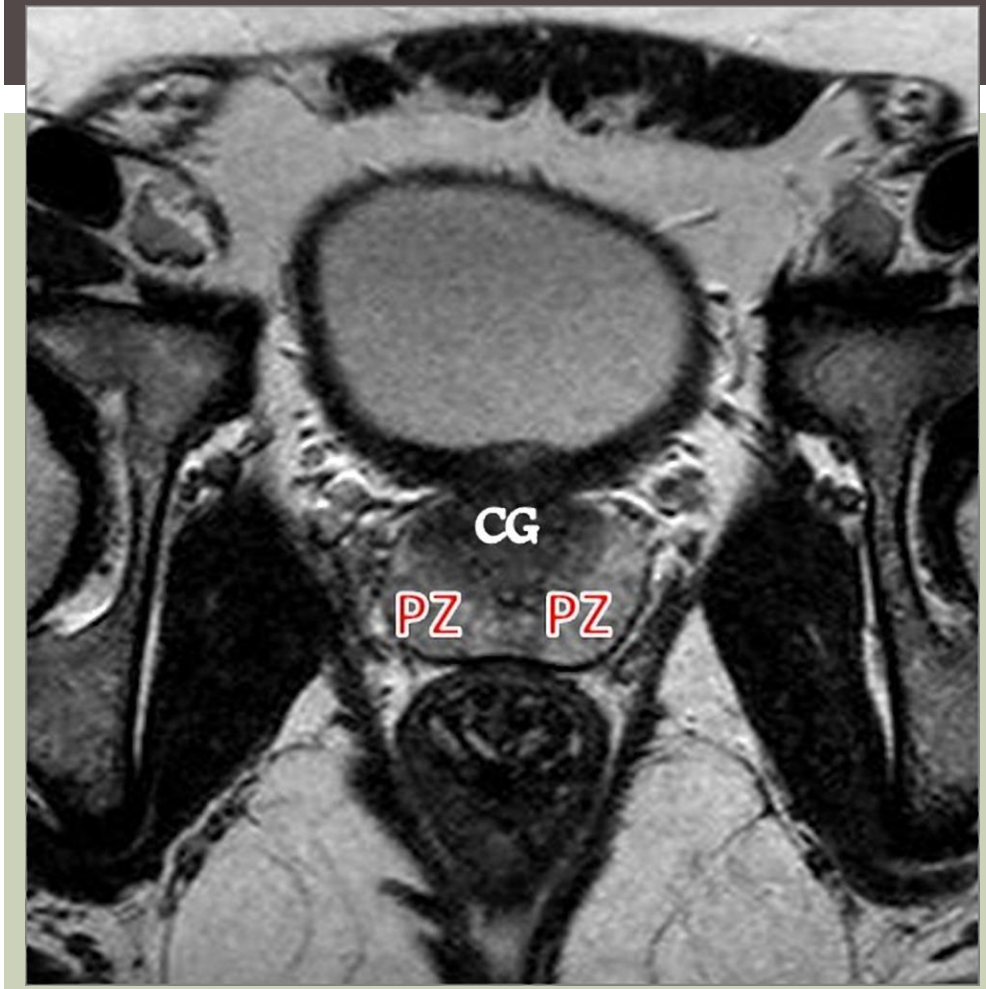
Testicular torsion

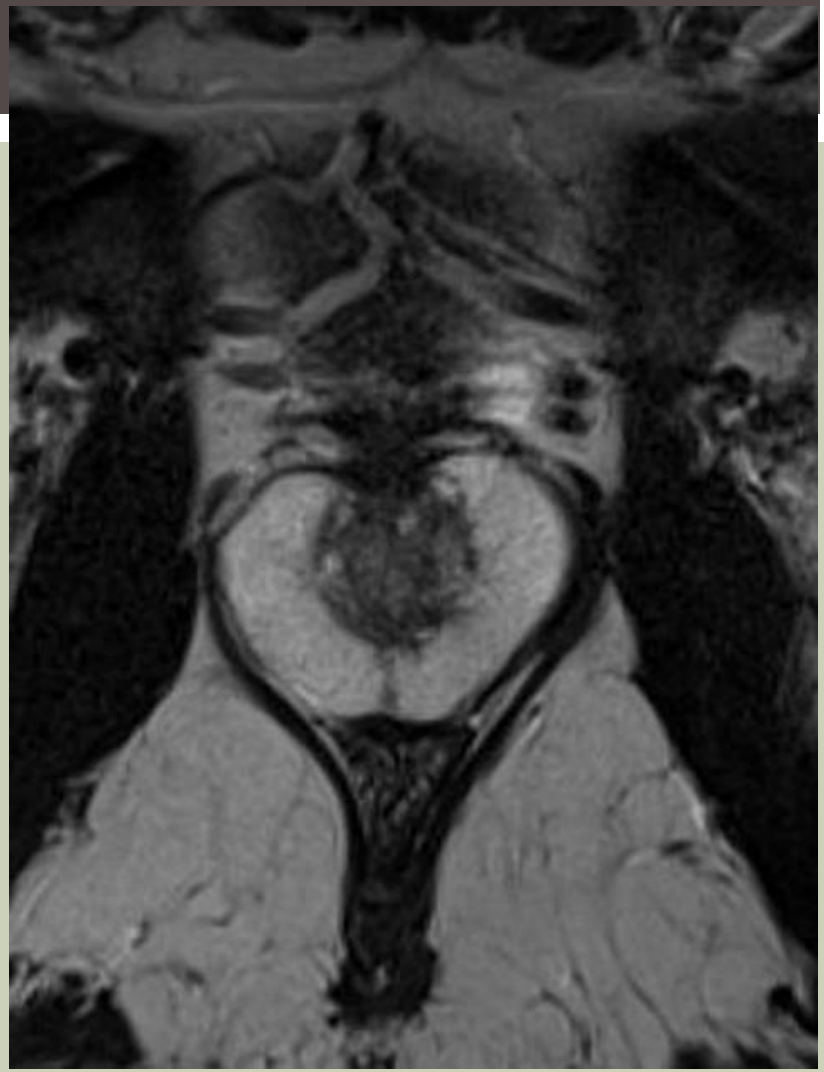




US was performed which demonstrate the left testicle with an abnormal orientation and without Doppler flow with normal echogenicity. The right testicle is normal.

Normal prostate gland





Axial T2


Ps
OI
G

Prostate carcinoma

Axial T2

Ill-defined hypointense lesions in the peripheral zone of the prostate gland - this appearance is highly likely of prostatic carcinoma.

Medical imaging in urology

1. CTin the assessment of urogenital system pathology. Scanning phases. Advantages, disadvantages, indications, contraindications.
2. Magnetic resonance imaging of the kidney, prostate. Advantages, disadvantages, indications, contraindications.
3. Ultrasound investigation of kidneys, prostate. Advantages, disadvantages, limitations of the method.
4. Renal Angiography. Advantages, disadvantages, indications, contraindications.
5. Imaging diagnosis of congenital urogenital malformations.
6. Diagnostic imaging of renal stones.
7. The differential imaging diagnosis of urinary tract tumors.
8. The imaging diagnosis of prostate tumors.