CONTRAST STUDIES IN URINARY TRACT

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INTRODUCTION

- Imaging continues to play indispensable role in diagnosis and management of urologic diseases

- Because many urologic conditions cannot be assessed by physical examination, conventional radiography has long been critical to diagnosis of conditions of the adrenals, kidneys, ureters, and bladder.

- Development of computed tomography (CT) imaging and use of intravenous contrast agents have provided detailed anatomic, functional, and physiologic information about urologic conditions.

IMAGING MODALITIES TO DISCUSS

- PLAIN FILM IMAGING (KUB)
- X RAY IVU
- X RAY RETROGRADE PYELOGRAPHY
- X RAY URETHROGRAM
- CYSTOGRAM
- VCUG
- COMPUTED TOMOGRAPHY

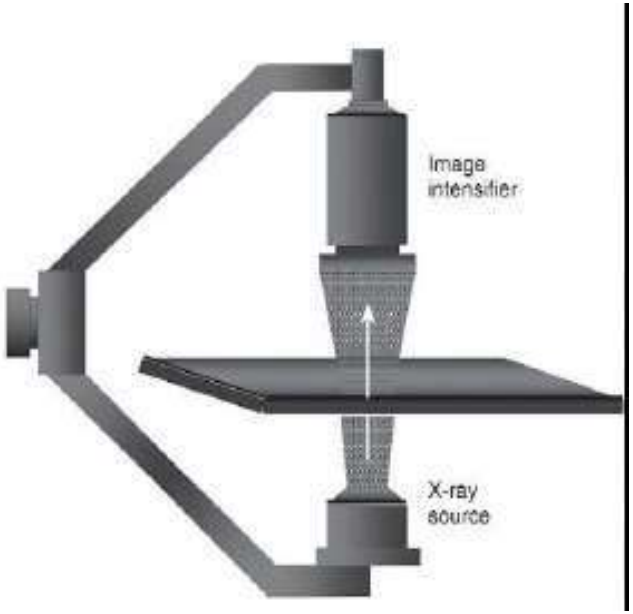
CONVENTIONAL RADIOGRAPHY

- Remains useful for preoperative diagnosis and postoperative evaluation in variety of different urologic conditions.
  - ABDOMINAL PLAIN RADIOGRAPHY
  - INTRAVENOUS EXCRETORY UROGRAPHY
  - RETROGRADE PYELOGRAPHY
  - RETROGRADE URETHROGRAPHY
  - CYSTOGRAPHY

Physics

- The underlying physical principles of conventional radiography involve emitting a stream of photons from an ***x-ray source*** which travel through the air and strike tissue, imparting energy to that tissue.

- Some of the photons emerge from the patient with varying amounts of energy attenuation and strike an image recorder such as a ***film cassette*** or the input phosphor of an ***image intensifier tube,*** thus producing an image.



Units for measuring radiation

- ***Radiation dose***= energy transferred to body by exposure
  - Rad = 0.01 Gray =
  - Gray = 100 Rad
  - Measured by badge (dosimeter)
- ***Radiation exposure***
  - Roentgen (electric charge/kg of air)

Contrast Media

- Iodine is the most common element in general use as an intravascular radiologic contrast medium (IRCM) due to the property of Radio-Opacity.

Properties of Commonly Used Radiocontrast Media

TYPE	GENERIC NAME	IODINE, mg/mL	OSMOLALITY, mOsm/KG	VISCOSITY, CPS AT 37° C
Iso osmolar				
Nonionic dimmer	Iotrolan	300	320	8.1
Nonionic dimmer	Iodixanol	320	290	11.4
Low osmolar				
Ionic dimmer	Meglumine ioxaglate	320	580	7.5
Ionic dimmer	Sodium oxalate	320	580	7.5
Nonionic monomer	Iopamidol	300	616	4.7
Nonionic monomer	Iohexol	300	640	6.3
Nonionic monomer	Ioversol	300	645	5.5
Nonionic monomer	Iopromide	300	610	4.6
High osmolar				
Ionic monomer	Sodium iothalamate	325	1843	2.75
Ionic monomer	Meglumine diatrizoate	306	1530	5.0

Ionic (HOCM) and non-ionic (LOCM)

- ***Ionic = High osmolar contrast media (HOCM)***
- ratio of I : particles = 3:2 = 1.5:1
- Particles are salts of Na or meglumine
- Osmolarity = X5 plasma
- Example: ***Urografin***

- ***Non-Ionic = Low osmolar contrast media (LOCM) and Iso-osmolar contrast media***
- ratio of I : particles = 3:1
- Osmolarity = X2 plasma
- Example: ***Ultravist (Iopromide) & Omnipaque***

Phases of contrast handling by kidney

- Vasculographic phase
- Nephrographic phase (secretory) (renal parenchyma): first few minutes after injection.
- Pyelographic phase (excretory) (collecting system).

Incidence of contrast side effects

- ***Overall complications***

  ionic = 5% & non-ionic=1%

- ***Death***

  Ionic = 1: 40.000 to 1: 70.000

  Non-ionic= 1: 200.000

- ***Nephrotoxicity*** in 10% of patients with Renal Impairment (more with DM, dehydration &MM) usually resolve spontaneously.

RELATIVE RADIATION LEVEL (RRL)	EFFECTIVE DOSE ESTIMATED RANGE	EXAMPLE EXAMINATIONS
None	0	Ultrasonography, MRI
Minimal	<0.1 mSv	Chest radiographs
Low	0.1-1.0 mSv	Lumbar spine radiographs, pelvic radiographs
Medium	1-10 mSv	Abdomen CT without contrast, nuclear medicine, bone scan, ^{99m}Tc-DMSA renal scan, IVP, retrograde pyelograms, KUB, CT chest with contrast
High	10 mSv-100 mSv	Abdomen CT without and with contrast, whole-body PET

TABLE 2-2 Radiation Exposure from Common Urologic Imaging Procedures

PLAIN RADIOGRAPH

- **FILM IS TAKEN WITH PATIENT SUPINE AND SHOULD INCLUDE ENTIRE ABDOMEN FROM BASE OF STERNUM TO PUBIC SYMPHISIS**

Indications

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.

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.

Reading a KUB

1. Spinal and bony pelvis abnormalities → spina bifida, sacral agenesis, fractures, metastases.
2. Organ outlines → liver, spleen, kidneys, bladder and Displacement of normal structures
3. Soft tissue

   a. Psoas muscle : absence may indicate mass/fluid in retroperitoneum

   b. Soft tissue masses
4. Radio-opaque shadows (stones vs phleboli vs calcifications).
5. Stomach and bowel gas (colonic distension or I.O.)

Intravenous Urography

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.

Contraindications

1. Renal insufficiency for worsening of their renal function (contrast induced nephrotoxicit y).

2. Multiple consecutive contrast studies – less than 48 hours (increased possibility for CIN)

3. Documented allergic reaction to contrast such as urticaria, angioedema, laryngeal edema, bronchospasm, and hypotension with tachycardia.

4. cardiac disease as contrast administration can cause worsening of congestive hear t failure, due to the osmotic load.

5. Patients who are on metformin must stop the drug 48 hours before contrast injection as it can cause lactic acidosis which may be fatal.

Technique

- Bowel prep may help to visualize the entire ureters and upper collecting systems *(role proven only in chronic constipation)*.
- Role of dehydration is controversial.
- A KUB to allow determination of adequate bowel preparation, confirms correct positioning, and exposes kidney stones or bladder stones.
- Contrast is administered IV as a rapid bolus injection

Contrast Dose is 1mg/kg Body weight in adults and 1.5-2mg/kg BW in children

- A film is taken at 5 minutes and then additional films are taken at intervals (individulized to each case).
- Postvoiding films are obtained to evaluate the presence of outlet obstruction, prostate enlargement, and bladder filling defects including stones and urothelial cancers.

Complications

Minor Reactions

Nausea, flushing, articaria, headache & Maybe Vomitting, pain at the site of injection

Intermediate Reactions

Worsening minor reactions, bronchospasm, Hypotension in 0.5-2%

Major Reactions

Seizures, Laryngeal spasm, bronchospasm, pulmonary edema, Arrhythmia, respiratory collapse, or cardiac arrest are recorded in 1/1000

staghorn calculus on KUB X-ray.

Normal IVU at 15min.

Retrograde Pyelography

Indications

1. Evaluation of congenital & acquired ureteral obstruction.
2. Elucidation of filling defects and deformities of the ureters or intrarenal collecting systems.
3. Opacification or distention of collecting system to assist percutaneous access.
4. In conjunction with ureteroscopy or stent placement.
5. Evaluation of hematuria.
6. Surveillance of transitional cell carcinoma.
7. In the evaluation of traumatic or iatrogenic injury to the ureter or collecting system.

Technique

- Usually done in the dorsal lithotomy position.
- A KUB film is taken to confirm correct positioning, and exposes kidney stones or bladder stones.
- Cystoscopy is performed and a catheter is inserted in the ureteral orifice through which the contrast medium is injected
- Documentary still images or "spot films" may be saved for evaluation during peristalsis & for future comparison

Retrograde Urethrography

Indications

- Suspected injury of the urethra
- Diminished urinary stream
- Urethral strictures
- Urethral diverticula
- Urethral obstruction
- Suspected urethral foreign bodies
- Urethral mucosal tumors
- Suspected urethral fistula

Retrograde Urethrography

Contraindications

- Urinary tract infection
- Recent instrumentation

Preparation

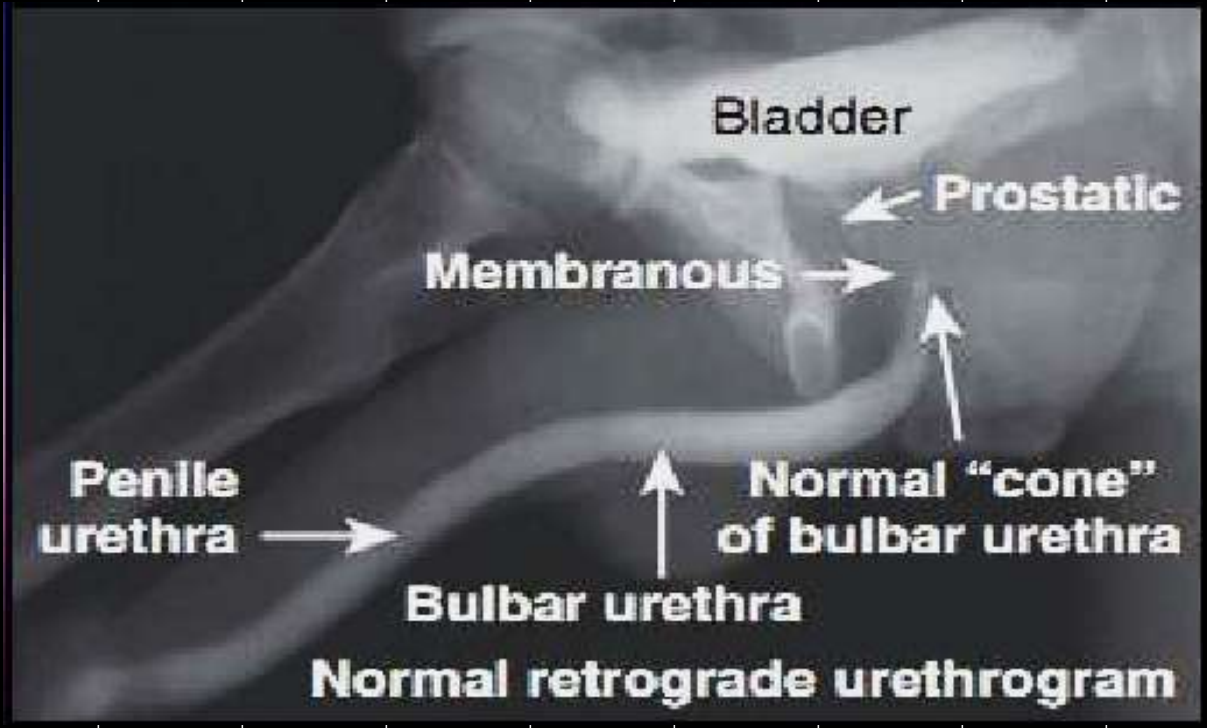
- None is needed

Retrograde Urethrography

Technique

- The patient is usually positioned slightly obliquely (45°) and dependent gip flexed to allow evaluation of the full length of urethra.
- A KUB film is taken to confirm correct positioning, and exposes kidney stones or bladder stones.
- The penis is placed on slight tension.
- A small catheter may be inserted into the fossa navicularis with the balloon inflated to 1 - 2 mL .
- Contrast is then introduced via catheter-tipped syringe.
- Alternatively, a penile clamp may be used to occlude the urethra around the catheter.

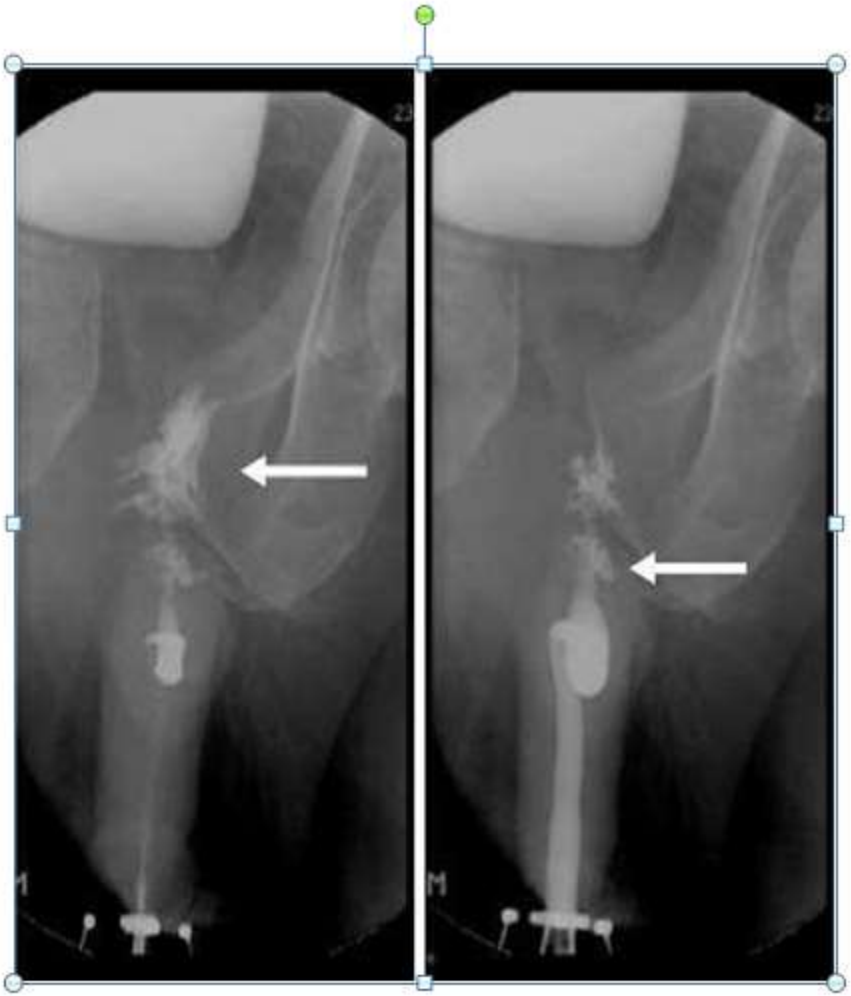
Reading RUG


Bladder
Prostatic
Membranous
Penile urethra
Normal "cone" of bulbar urethra
Bulbar urethra
Normal retrograde urethrogram

- Anterior urethral stricture. Retrograde urethrogram reveals a segment of narrowing in the distal bulbous urethra with opacification of the left Cowper duct (arrow).

- Conventional Retrograde Urethrogram (RUG) following trauma showing urethral injury.

- Note diastasis (i.e., widening) of symphysis pubis (line between two halves of symphysis) related to traumatic injury. Injuries involving the low pelvic ring have a high associated injury rate to the urethra. In this RUG, the urologist is instilling contrast into the urethra at the tip of the penis through a Tummey (SP?) syringe (S). Contrast shows a normal anterior urethra but the contrast does not fill the posterior urethra and stops abruptly at the level of urethral injury at the urogenital diaphragm (arrow). This is the most common level of urethral injury due to the relatively fixed position of the urethra resulting in sheer or distraction urethral injury with pelvic trauma.



- These two radiographs demonstrate why the retrograde urethrogram is the preferred method of demonstrating the urethra. Retrograde filling of the urethra demonstrates the urethra better than with a voiding cystourethrogram. Notice that there is transection of the urethra and extravasation of contrast (white arrows).

Cystography

Indications

1. Evaluation of intravesical pathology
2. Evaluation of bladder diverticula
4. Evaluation of colovesical or vesico-vaginal fistulae
5. Evaluation of bladder or anastomotic integrity after surgical procedure (urine leakage after bladder surgery)
6. Evaluation of blunt or penetrating trauma to the bladder

Technique

- The patient is usually positioned in supine position
- A KUB film is taken to confirm correct positioning, and exposes kidney stones or bladder stones.
- The bladder is filled with 200 to 400 mL of contrast depending on bladder size and patient comfort.
- Oblique films should be obtained because posterior diverticula or fistulae may be obscured by the full bladder.
- A postdrainage film completes the study.

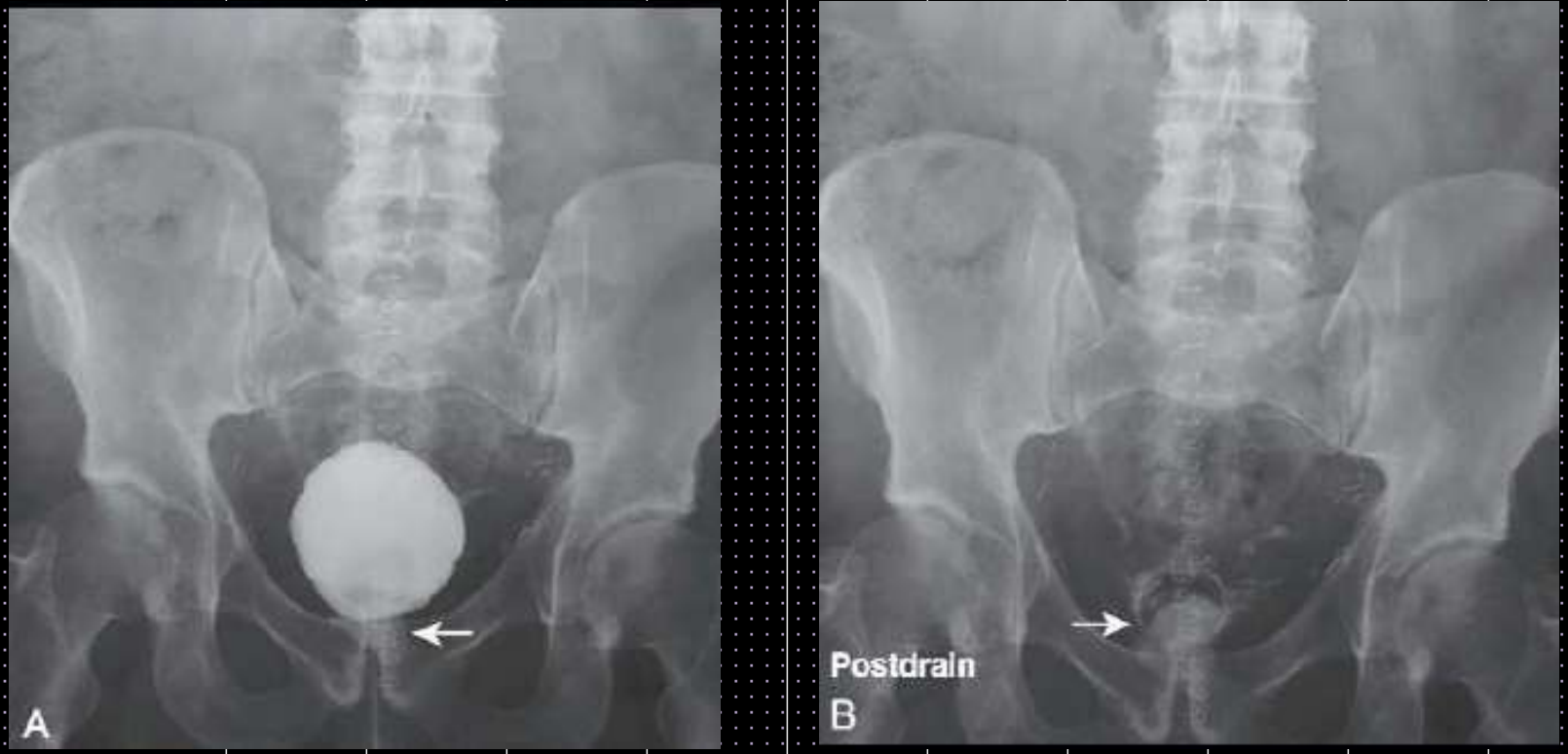


Figure 4–10. The patient has undergone radical retropubic prostatectomy. **A,** During bladder filling, contrast is seen adjacent to the vesicoureteral anastomoses *(arrow)*. **B,** The postdrain film clearly demonstrates a collection of extravasated contrast *(arrow)*.

Voiding Cystourethrography

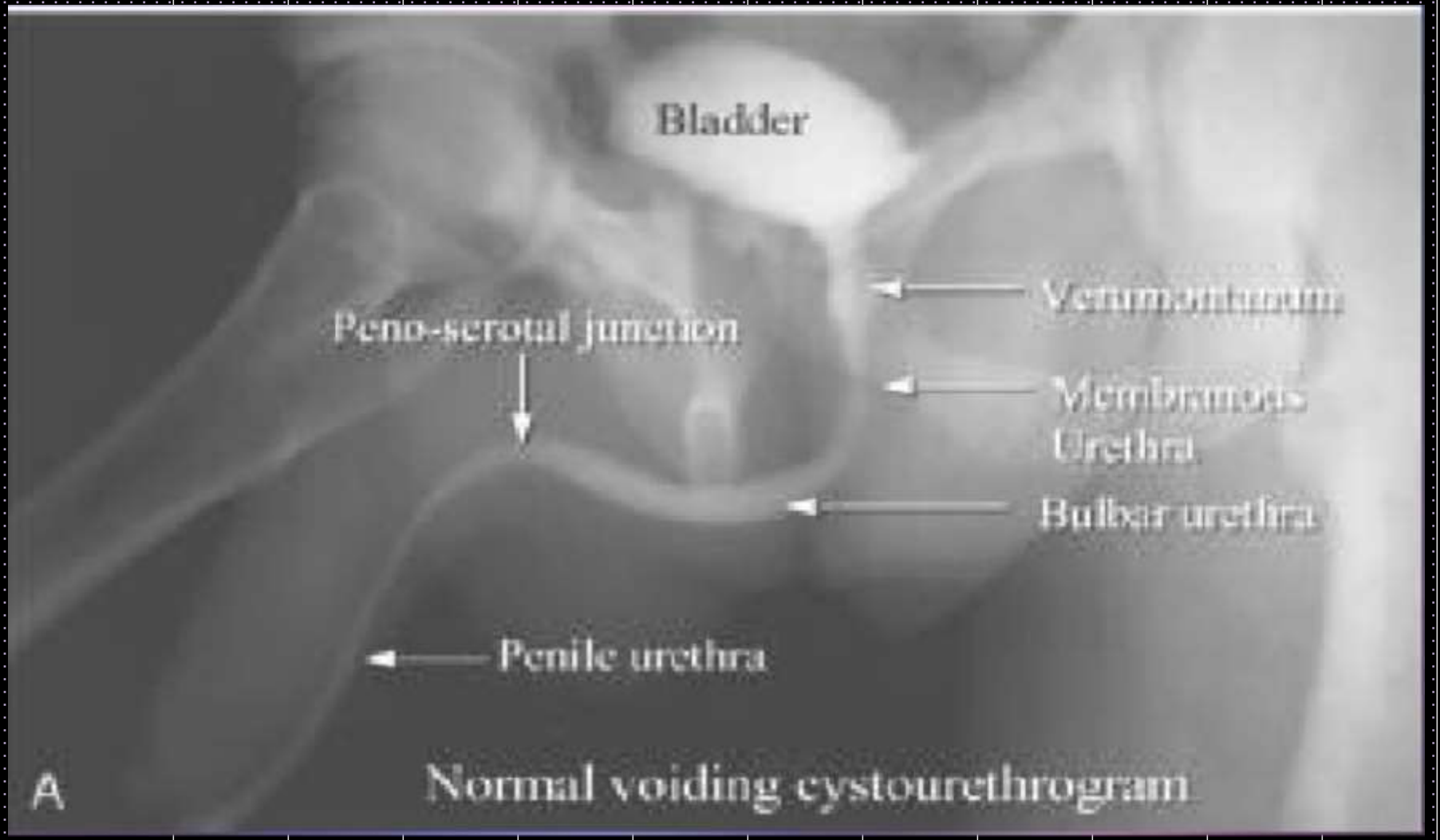
Indications

1. Evaluation of structural and functional bladder outlet obstruction (post. ureth. Strict. and PUV).
2. Evaluation of reflux.
3. Evaluation of the urethra in males and females.

Technique

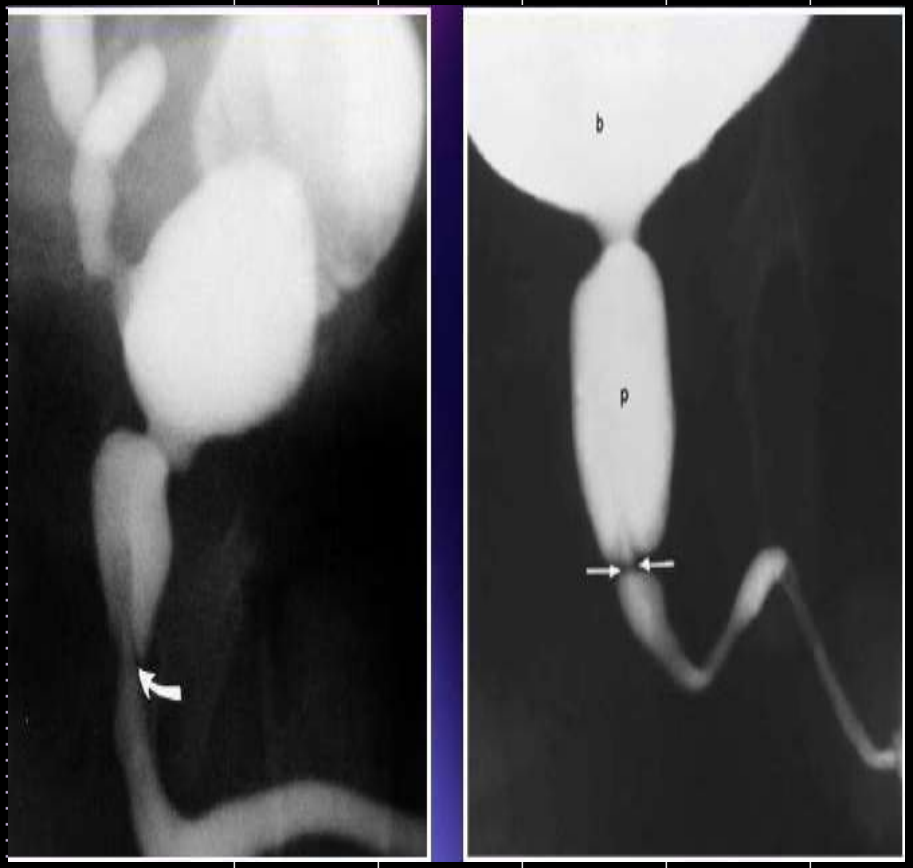
- The patient is usually positioned in supine position
- A KUB film is taken to confirm correct positioning, and exposes kidney stones or bladder stones.
- **Filling film**: The bladder is filled with 200 to 400 mL of contrast (for bladder pathology & early reflux).
- in ped <12 ys, volume (mL) = (age [years] + 2) × 30 (vary widely based on patient comfort)
- **Voiding film**: (for reflux and urethral abnormalities).
- **AP and oblique films** are obtained.
  - ***Oblique films*** should because posterior diverticula or fistulae may be obscured by the full bladder in addition determination of the grade of reflux (grade I may be hidden in AP film)
- **Post-drainage (post-void) film**: completes the study.

Reading VCUG



A urethrogram showing a bulbar urethral stricture.

- Cystography revealed a fistula tract between the contracted urinary bladder and the terminal ileum.



Post. urethral valve (PUV)

Vesico-ureteral reflux (VUR)

C.T SCAN

- It can detect very small differences in X-ray absorption values of tissues
- Allows differentiation between tissues when compared with plain radiography.
- Computer calculates absorption value (attenuation) of each pixel and reconstructs this into an image.
- Attenuation values are expressed on scale from –1000 to +1000 Hounsfield units
- More recently, advances in computing power have enabled data to be reformatted so that images can be produced in sagittal and coronal planes as well as in the more familiar horizontal plane
- Spiral' or 'helical' CT (also known as multidetector CT urography—MDCTU) following intravenous contrast administration) is very rapid scanning while table on which patient is lying is moved though scanner. Multiple images ('slices') of patient are taken.
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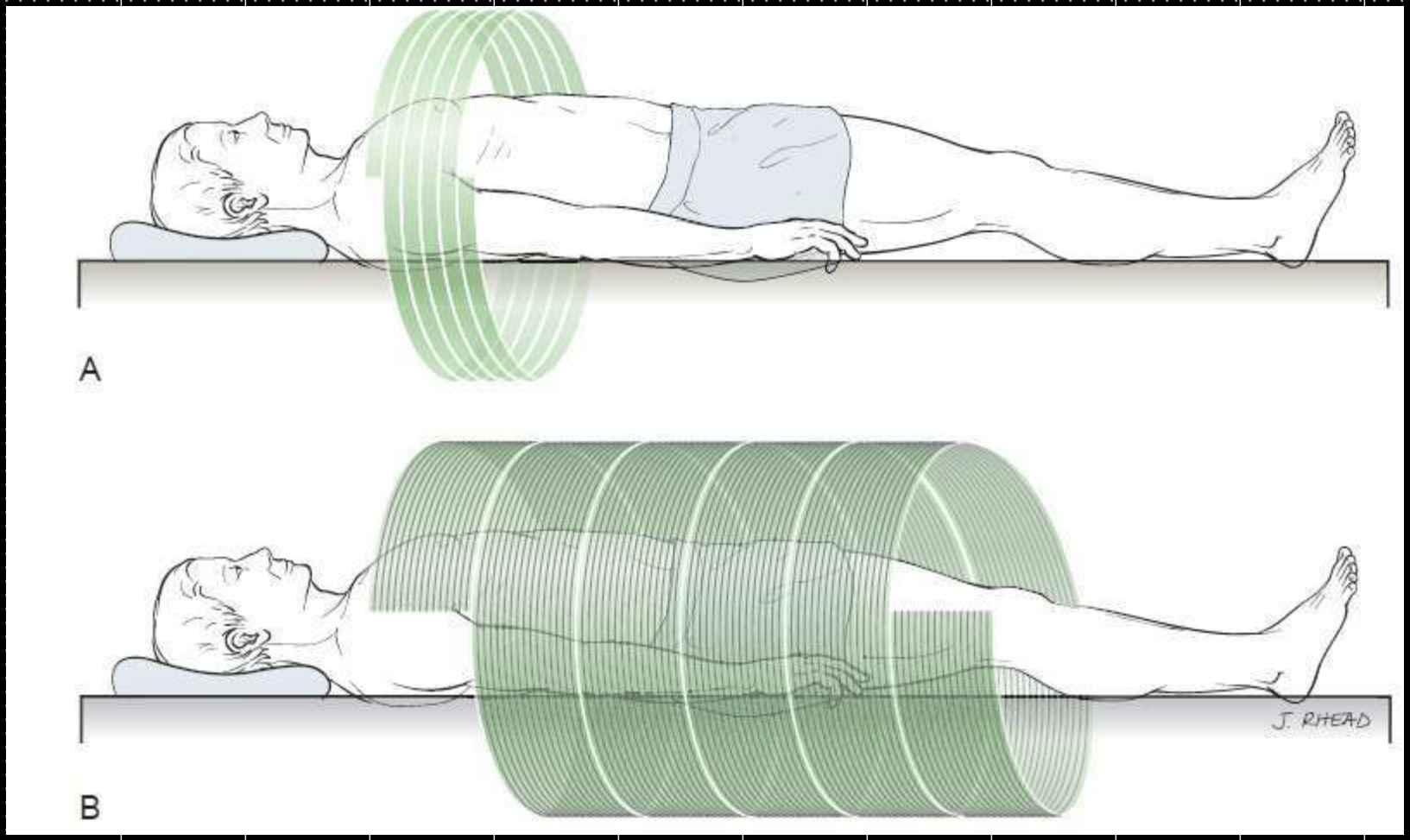

Figure 2-13. A, A computed tomography scanner with a single-row detector requires five circular passes around the patient to image a small area of the patient's body. B, With a 16-slice, multirow detector, the chest, abdomen, and pelvis can be imaged with five circular passes, easily obtained during a single breath hold. The thin slices offered by the 16-slice detector offer much greater detail of internal structures.

USES OF CT

Renal

- Investigation of renal masses—characterizes solid from cystic lesions differentiates benign (e.g. angiomyolipoma) from malignant solid masses (e.g. renal cell carcinoma).
- Staging of renal cancer (establishes local, nodal, and distant spread).
- Assessment of stone size and location (within collecting system or within parenchyma of kidney).
- - Detection and localization of site of intrarenal and perirenal collections of pus (pyonephrosis, perinephric abscess).
- 'Staging' (grading) of renal trauma.
- Determination of cause of hydronephrosis.

ADVANTAGE OF C.T UROGRAPHY OVER IVU

- Can identify non-stone causes of flank pain.
- Is faster, taking just few minutes to image kidneys and ureters.
- An IVU, may take hours to identify tprecise location of the obstructing stone.
- Is equivalent in cost to IVU in high CT volume hospitals.
- Contrast-enhanced ultra low dose CT (uses contrast which increases sensitivity (97%) and specificity (100%) for detecting small renal and ureteric stone disease while limiting radiation dose to levels comparable with IVU (1.7mSv vs 1.4mSv).


Thank You