Genitourinary Imaging Overview

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GU Imaging Overview

- Objectives
  - Present the imaging modalities available for assessment of the genitourinary system
  - Analyze the benefits and limitations of each imaging modality
  - Recognize normal anatomy on multiple imaging examinations

KUB

- KUB: AP view of the abdomen and pelvis (from above the level of the diaphragm through the level of the symphysis pubis)
    - ‘Kidneys-ureters-bladder’
    - ‘Flat-plate’ of the abdomen
  - Initial assessment of:
    - Bowel gas pattern
    - Solid organ size
    - Calcifications
    - Osseous structures

KUB

KUB

- Advantages
  - Readily available
  - Relatively inexpensive
- Disadvantages
  - Ionizing radiation (although a small, permissible amount)
  - Limited soft tissue detail
  - Often necessitates additional (advanced) imaging

Intravenous pyelogram (IVP)

- Dynamic, serial imaging of the urinary tract after intravenous contrast administration
  - Unenhanced ‘scout’ KUB
  - ‘Early’ post-IV contrast image (‘nephrogram phase’)
    - 5 minutes after IV contrast administration
  - ‘Late’ post-IV contrast image (‘pyelogram phase’)
    - 10 minutes after IV contrast administration
  - ‘Delayed’ post-IV contrast image (‘pre-void’ urinary bladder)
    - 20-30 minutes after IV contrast administration
  - Post-void image

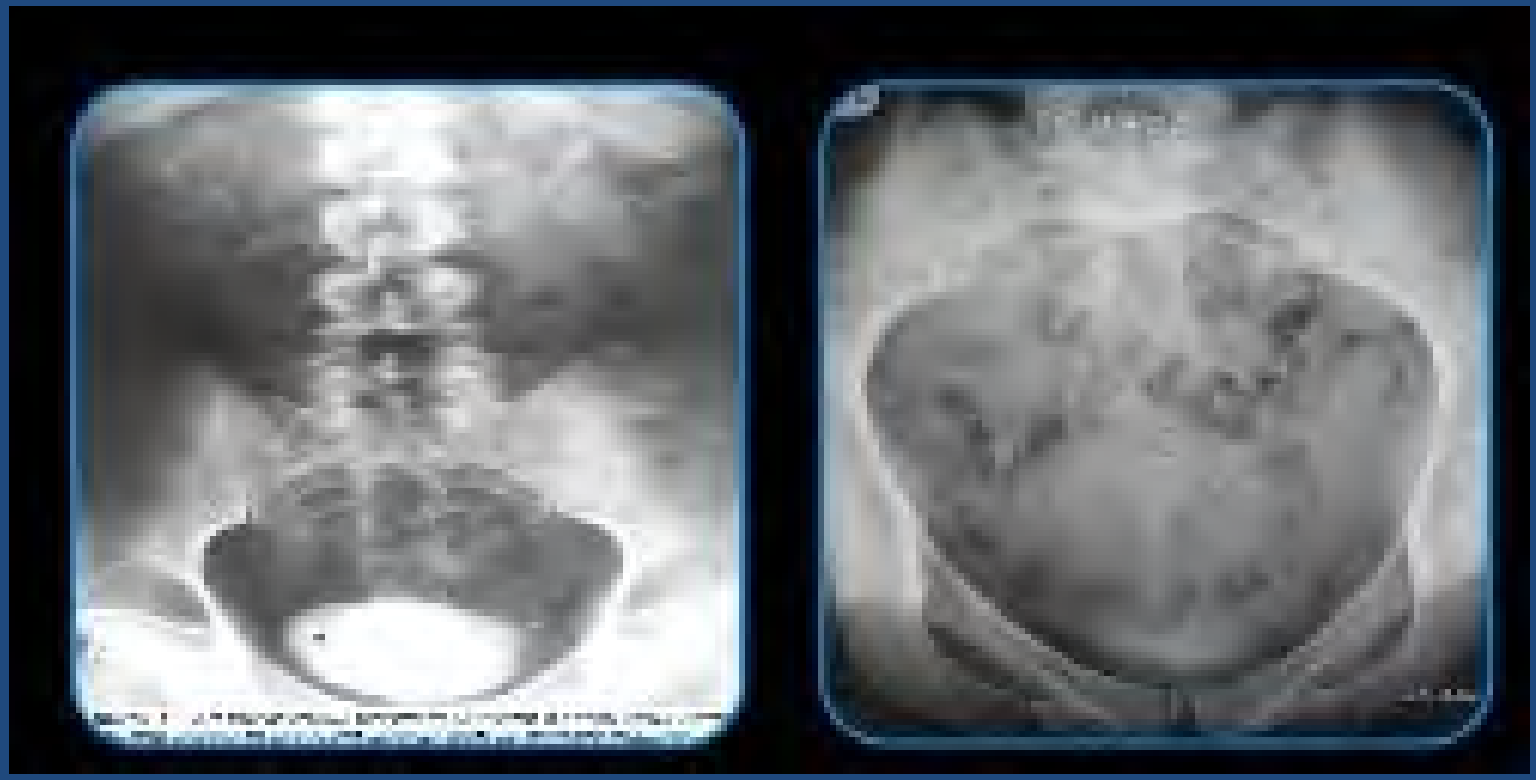
Intravenous pyelogram (IVP)

Scout film

'Nephrogram'

'Pyelogram'

Intravenous pyelogram (IVP)



‘Pre-void’

‘Post-void’

Intravenous pyelogram (IVP)

- Advantages
  - ‘Historically' useful in the initial workup of hematuria and/or obstructive uropathy
  - Functional overview of the urinary tract
- Disadvantages
  - Ionizing radiation
  - Contrast burden
  - Limited characterization of mass lesions

Cystography

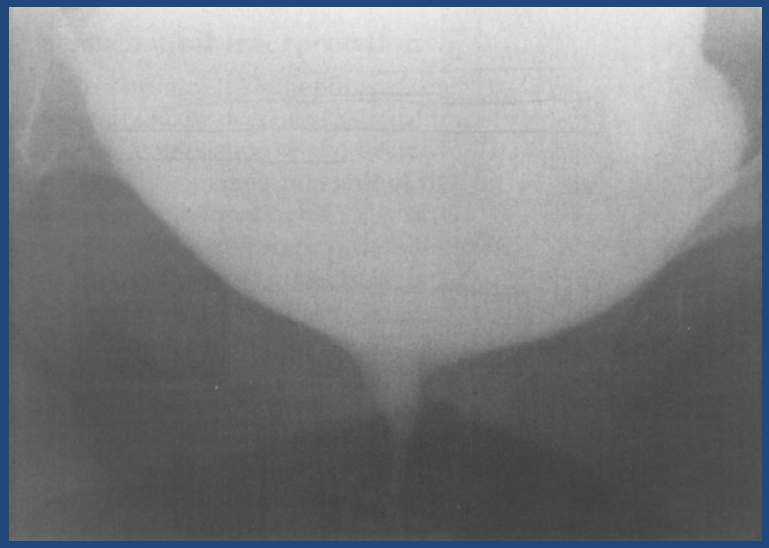
- Cystography: contrast examination of the urinary bladder
  - Utilizes a catheter to instill contrast media into the urinary bladder in retrograde fashion
    - Imaging of the urinary bladder is performed during filling/after voiding (with imaging also possible *during* the act of urination/voiding, if indicated clinically)
    - Useful for assessment of hematuria, neoplastic surveillance, post-operative assessment, infection, trauma
    - Voiding cystourethrogram (VCUG): dynamic imaging of urinary bladder during passive filling/active voiding
      - Commonly used in pediatric population to assess for vesicoureteral reflux

Cystography

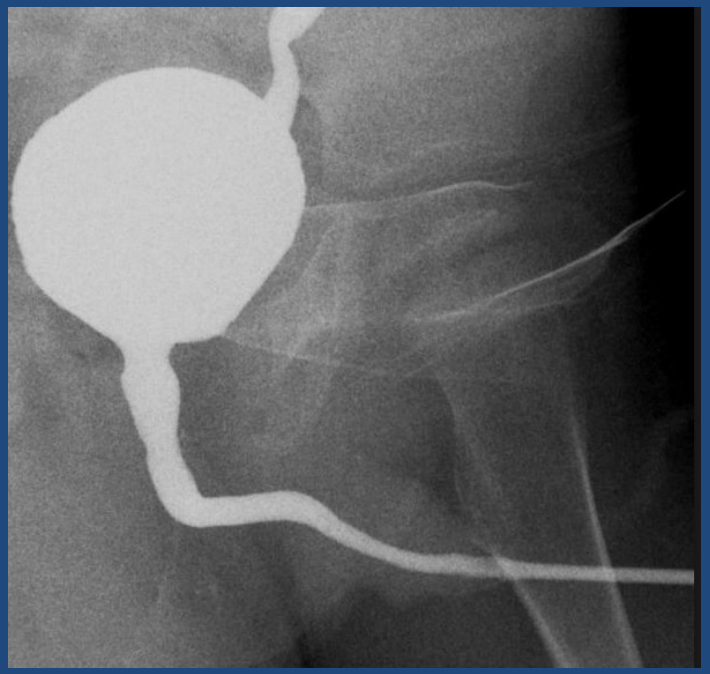
Pre-void image

Post-void image

Voiding cystourethrography (VCUG)



Normal female urethra

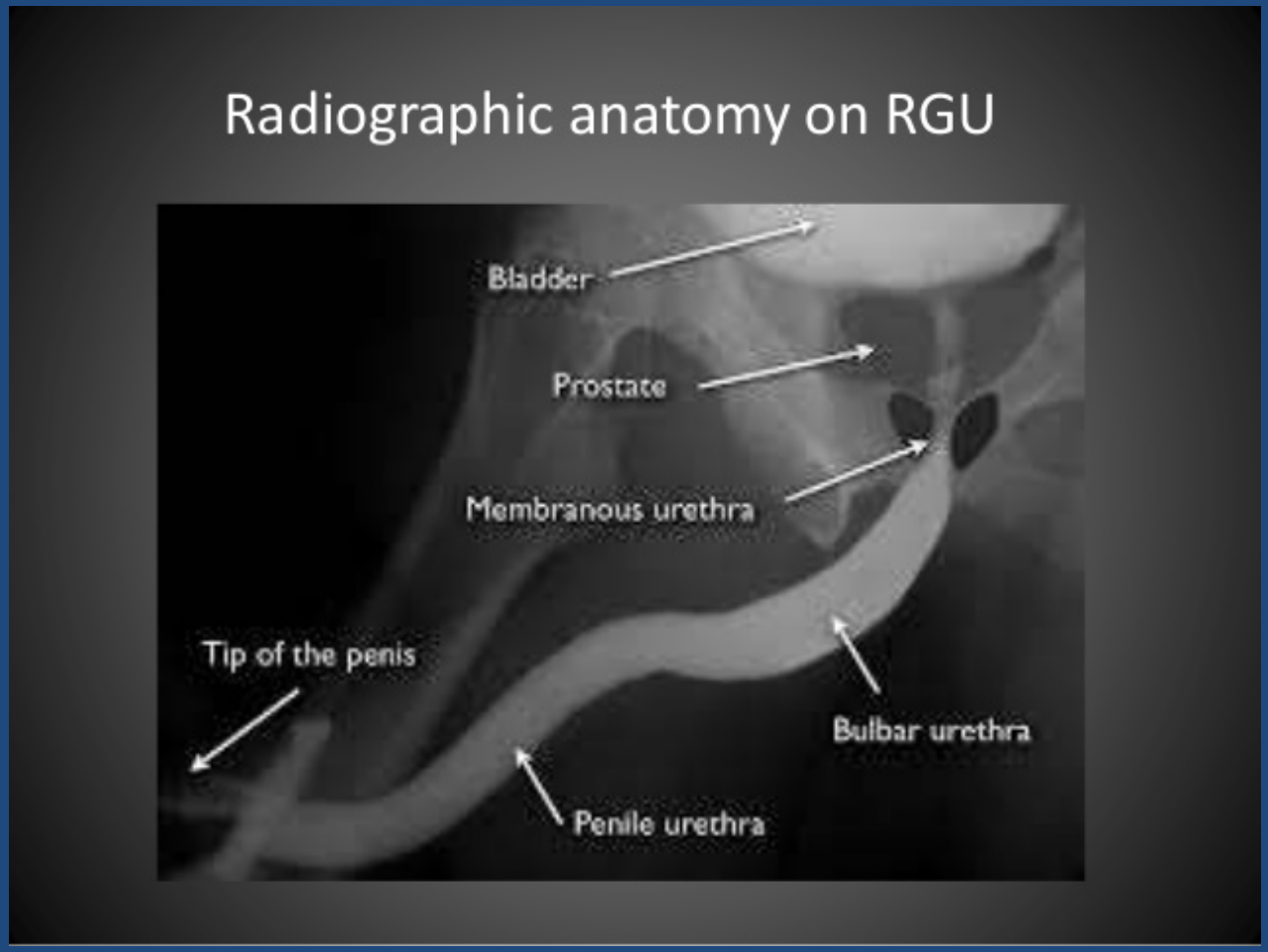


Normal male urethra
(Note: Left-sided vesicoureteral reflux)

Retrograde urethrogram

- Performed by urologist and/or interventional radiologist
- Retrograde instillation of iodinated contrast into the distal urethra (i.e. in males, after localization of catheter at the level of the fossa navicularis)
  - Allows for assessment of urethral integrity (i.e. in acute trauma patients with blood at urethral meatus)
  - Allows for assessment of urethral caliber and contour in patients with history of infection, long-standing catheterization , prior instrumentation, and remote trauma

Normal retrograde urethrogram

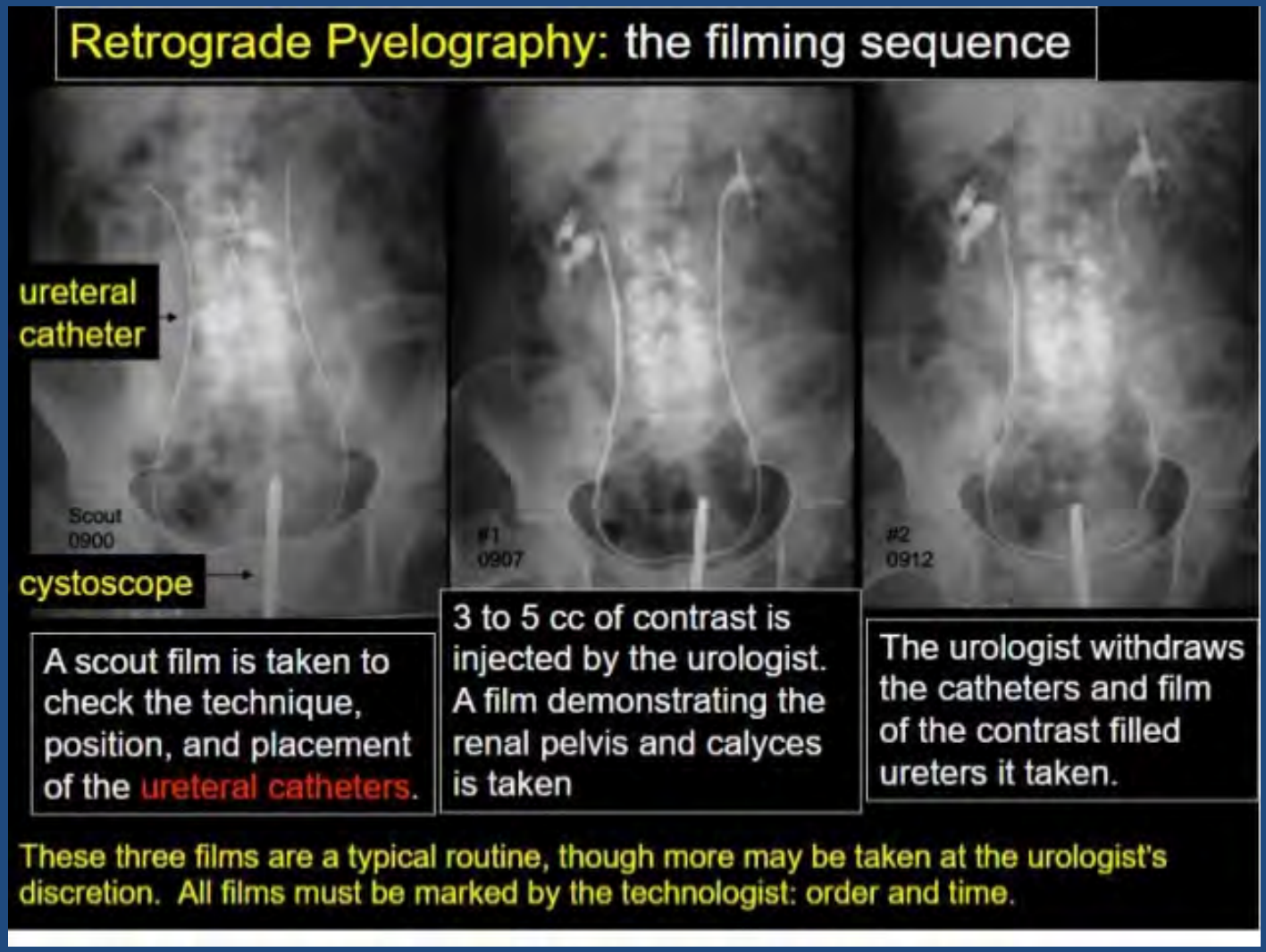


Retrograde pyelogram

- Performed intraoperatively by urologist
  - Cystoscopy allows visualization of ureteral orifices
  - Contrast media is instilled into ureters in retrograde fashion
    - Permits optimal ureteral distension and opacification
      - Augments the workup of hematuria (particularly in the presence of '*negative*' IVP, CT, MR examinations)
  - Ureteroscopy is a possible adjunct to cystoscopy, allowing for direct visualization of the ureters and intrarenal collecting systems

Retrograde pyelogram

Retrograde pyelogram



Cystography, retrograde urethrogram, and retrograde pyelography

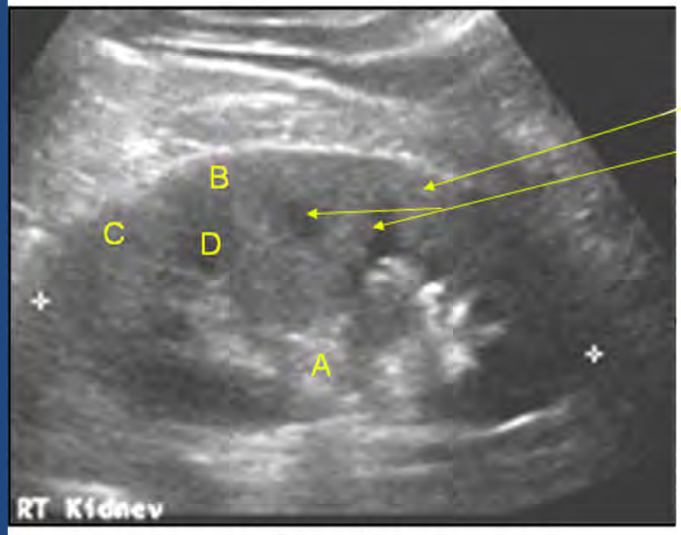
- Advantages
  - Allow for optimal opacification and distension of various levels of the urinary tract
  - In VCUG, allows for a dynamic assessment of voiding
- Disadvantages
  - Ionizing radiation
  - Contrast media exposure

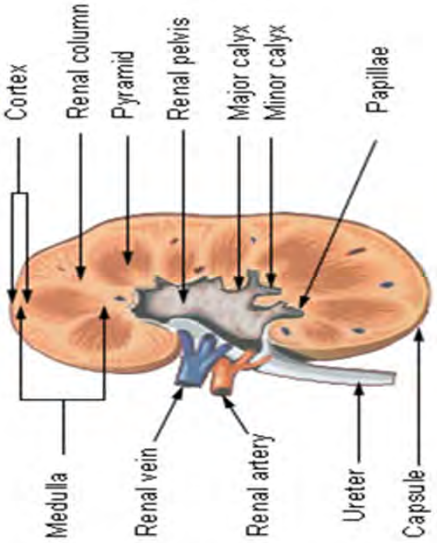
Renal sonography

- Renal sonography allows for non-invasive assessment of the retroperitoneum
- Potential uses
  - Initial assessment of renal failure
    - Medical vs surgical etiology
  - Characterization of renal masses
    - ‘Cystic’ vs ‘solid’
  - Doppler assessment of renal arterial vasculature in screening for renovascular hypertension
  - Potential guidance for renal biopsy

Renal sonography

Normal Kidney on Ultrasound





Terms used in Ultrasound

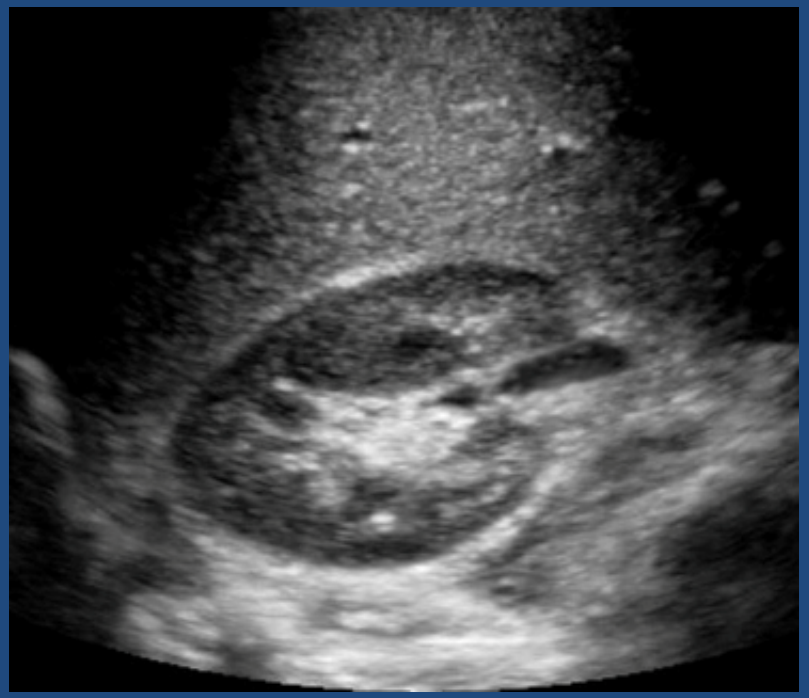
Hyperechoic A compared to B

Isoechoic B compared to C

Hypoechoic D compared to C

Renal sonogram

Sagittal image



Transverse image

Renal sonography

- Advantages
  - Readily available (including portable imaging)
  - No ionizing radiation
  - No contrast burden
- Disadvantages
  - Image quality based on patient's body habitus and sonographer's skills

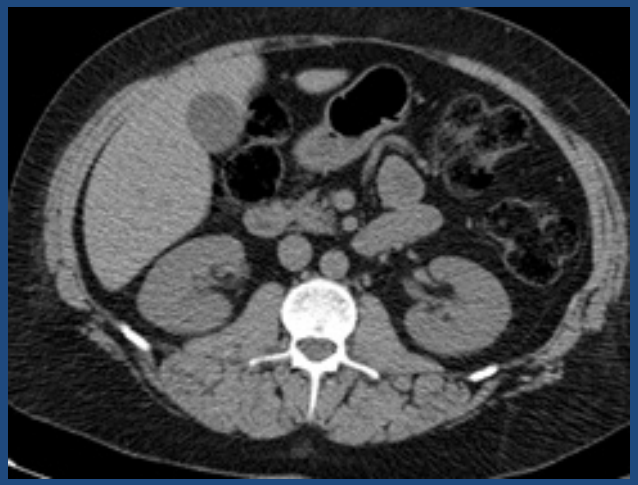
Computerized axial tomography (CT)

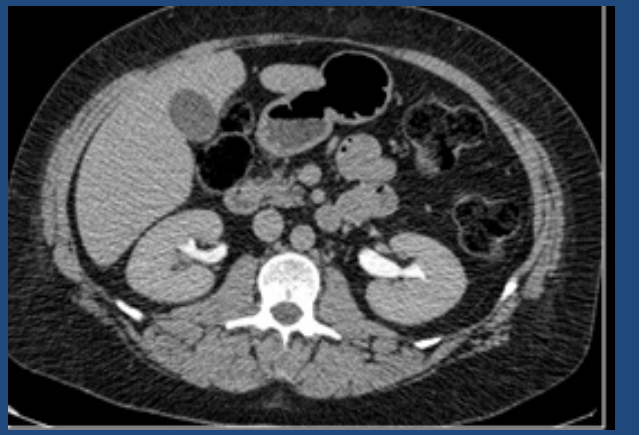
- Cross-sectional imaging (CT and/or MR) of the abdomen and pelvis
  - For assessment of *painful* hematuria, unenhanced abdominal/pelvic CT is utilized
  - Otherwise, abdominal/pelvic CT is ideally performed prior to *and* after the administration of IV contrast enhancement

Computerized axial tomography (CT)

- CTU: CT-urography
  - Specialized type of CT imaging protocol, utilizing tri-phasic imaging of the abdomen and pelvis (after PO ingestion of water)
  - Unenhanced phase
    - Assess for urinary tract calculi
  - Early enhanced phase (90-180 sec after IV contrast): *Nephrogram phase*
    - Assess for renal parenchymal enhancement pattern (including characterization of renal masses)
  - Delayed phase (8-10 min after IV contrast): *Excretory phase*
    - Assess renal collecting system (intra-renal collecting system, ureters, and urinary bladder)

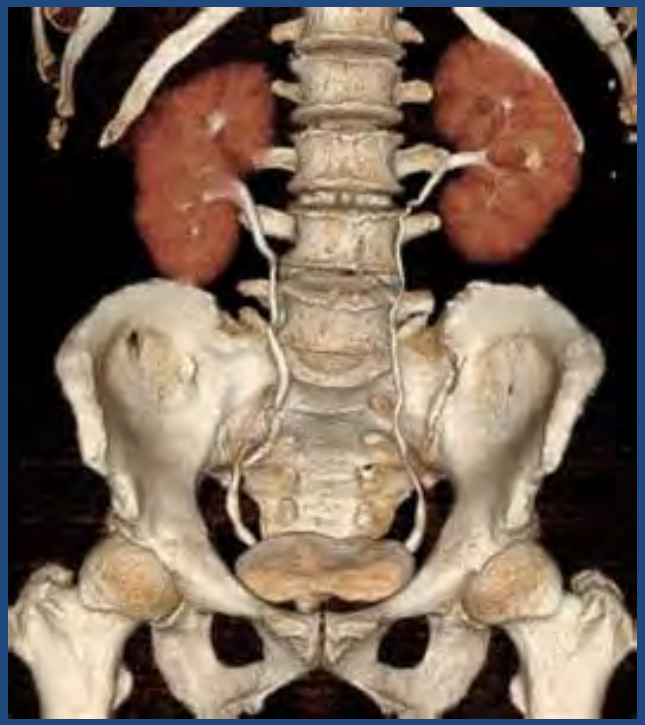
CT-urogram (CTU)





Source data

CT-urogram (CTU)



Normal CTU

Computerized axial tomography (CT)

- Advantages
  - Detailed assessment/characterization of renal and urothelial masses
  - Allows for assessment of adjacent retroperitoneal structures (i.e. lymph nodes, vasculature), intraperitoneal structures, and osseous structures
  - Excellent soft tissue detail
- Disadvantages
  - Ionizing radiation
  - Contrast media burden (with exception of ‘renal colic workup’)
  - Cost

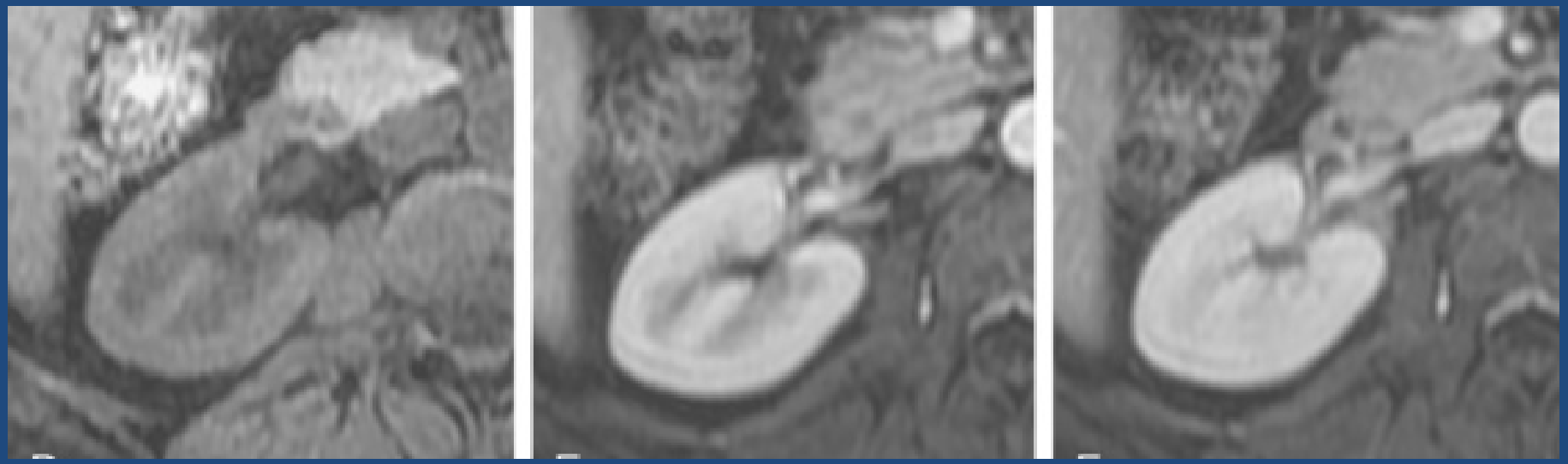
Magnetic resonance imaging (MRI)

- Multi-planar, multi-sequence imaging of the abdomen and pelvis allows for optimal soft tissue assessment
  - Ideally performed prior to and after IV gadolinium (Gd) administration
    - In patients with renal dysfunction, Gd is *not* administered
  - Useful in those patients who cannot undergo enhanced CT imaging (secondary to severe contrast reaction)
- MR imaging allows for characterization of renal masses and urothelial lesions

Magnetic resonance imaging (MRI)

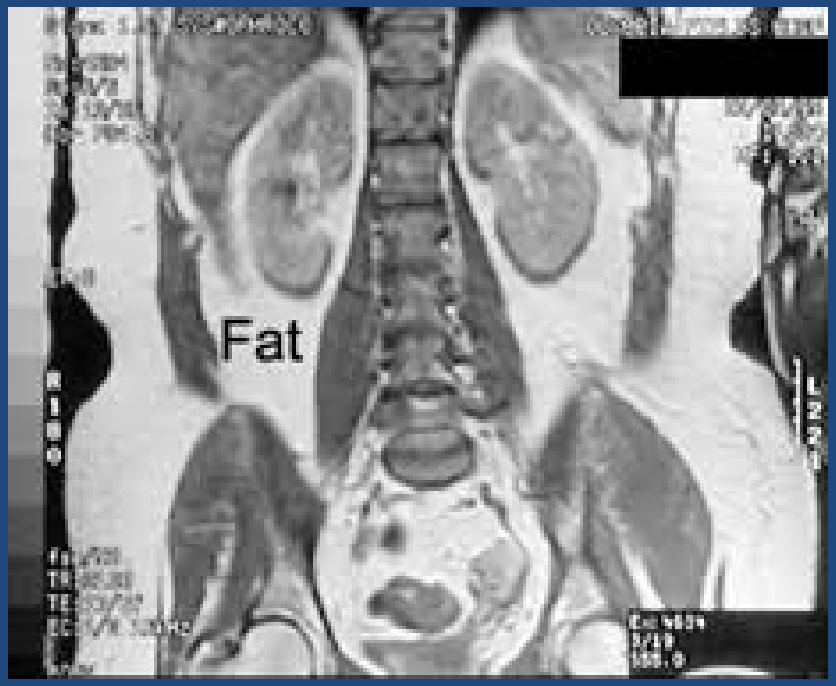
- In addition, assessment of adjacent retroperitoneal structures (such as lymph nodes and vasculature) is feasible
- MR imaging also allows for global assessment of remaining abdomen and pelvis (i.e. intraperitoneal structures and osseous structures)
- *MRU*: akin to CTU

Magnetic resonance imaging (MRI)



Unenhanced (left image) and enhanced (middle/right images) T1-weighted axial images of the normal right kidney

Magnetic resonance imaging (MRI)



T1-weighted coronal image

Enhanced MRA

Magnetic resonance imaging (MRI)

- Advantages
  - No ionizing radiation
  - Useful in patients with severe iodine allergy
  - Excellent soft tissue detail
- Disadvantages
  - Cost
  - Cannot be performed in all patients (i.e. those with unapproved pacemakers, aneurysm clips, etc.)

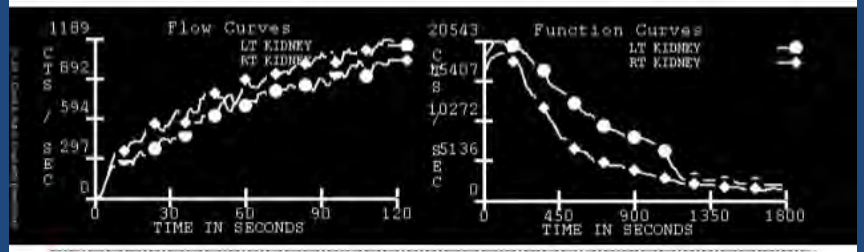
Nuclear medicine

- Renovascular flow and renogram
  - Assess vascular flow to kidneys
  - Assess uptake, excretion, and drainage of radiopharmaceutical by the kidneys
  - Differential renal function can be calculated
- *Lasix* administration allows for differentiation of hydronephrosis from patulous collecting system
- *Captopril* administration allows for performance of a screening examination for renovascular hypertension

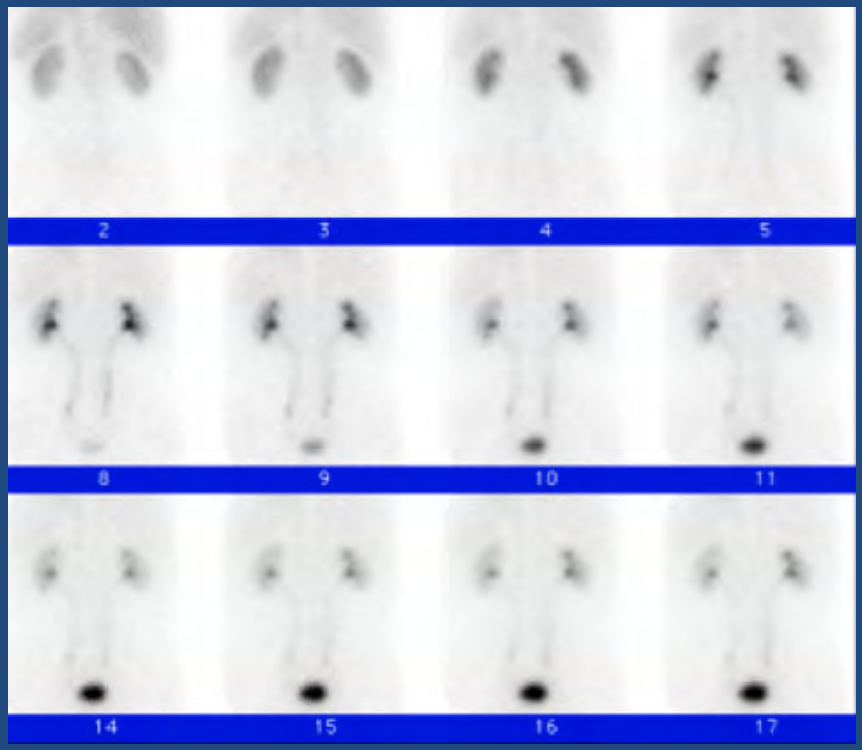
Nuclear medicine

Look at some normal curves.

- Normally, the curves show rapid uptake (flow curve on left) and rapid drainage (function curve on right). Each kidney is plotted separately



Normal renovascular flow/renogram



Normal source images

Nuclear medicine

- Advantages
  - *Functional* and structural assessment of the GU system
  - Additional use of Lasix and Captopril assists in problem-solving
- Disadvantages
  - Ionizing radiation
  - Somewhat limited spatial detail

Summary

- Please correlate this lecture with your additional genitourinary-based medicine, pathology, and pharmacology lectures
- Plan to utilize this ‘Genitourinary Imaging Overview’ lecture in correlation with your ‘Genitourinary Imaging PI session’ preparatory reading (for optimal performance during your genitourinary PI session).