MRI of the Kidneys in Children

Eglal Shalaby-Rana, M.D.

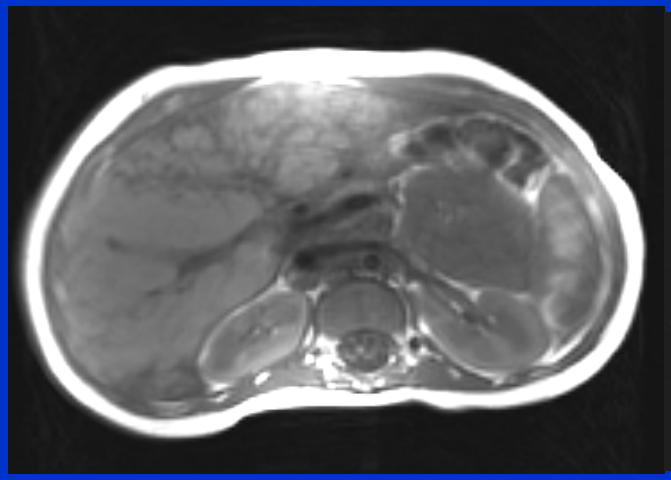
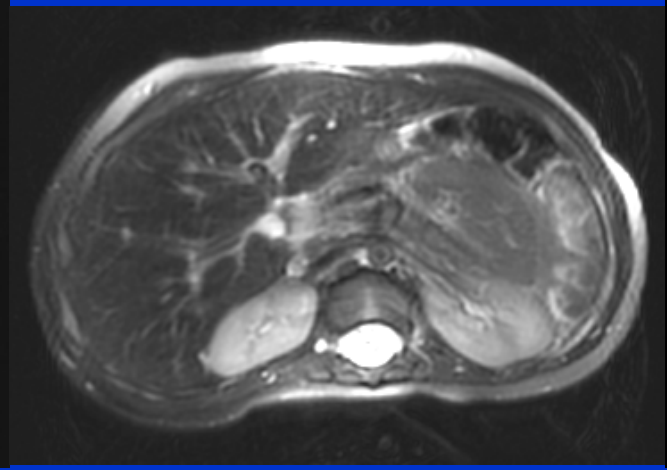
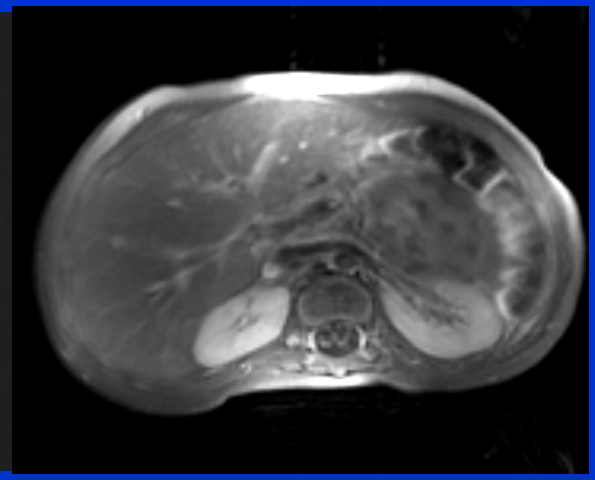
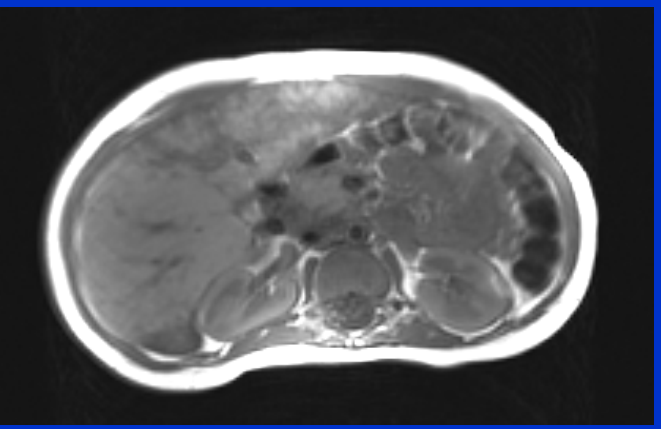
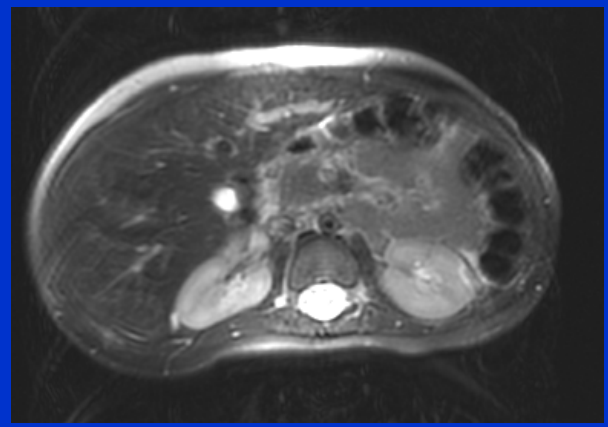
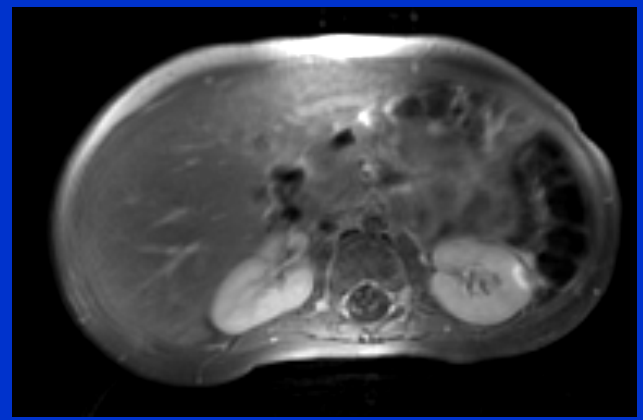
Indications for Kidney MRI in Children

- Neoplasm
- Acute pyelonephritis
- Renal artery stenosis
- MR urography

General imaging of kidney

- Body coil
- 3 to 4 mm slice thickness
- Do pre-gad, dynamic gad imaging and post-gad imaging
- Axial and oblique coronal and sagital post-gad

Normal Kidneys

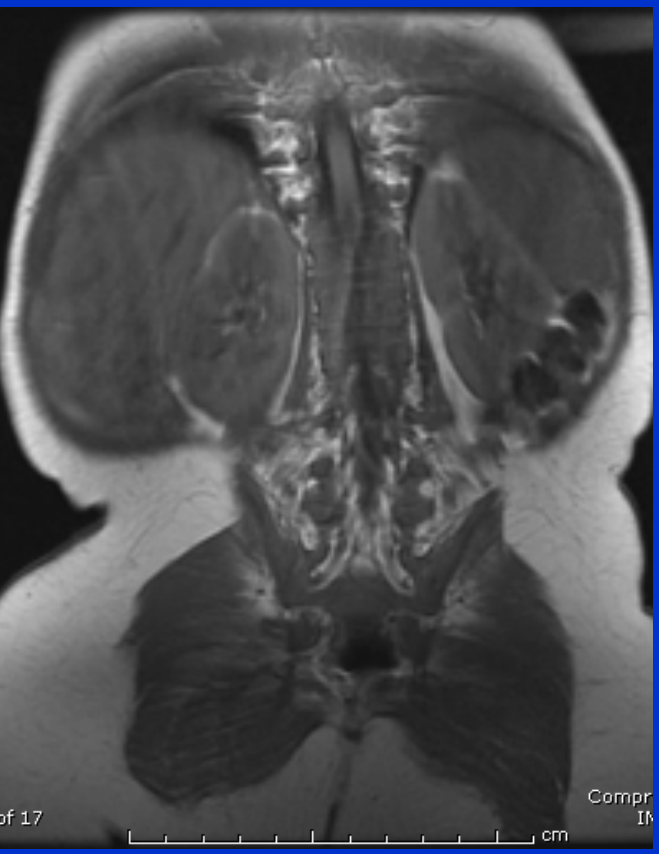







T1

T2 fs

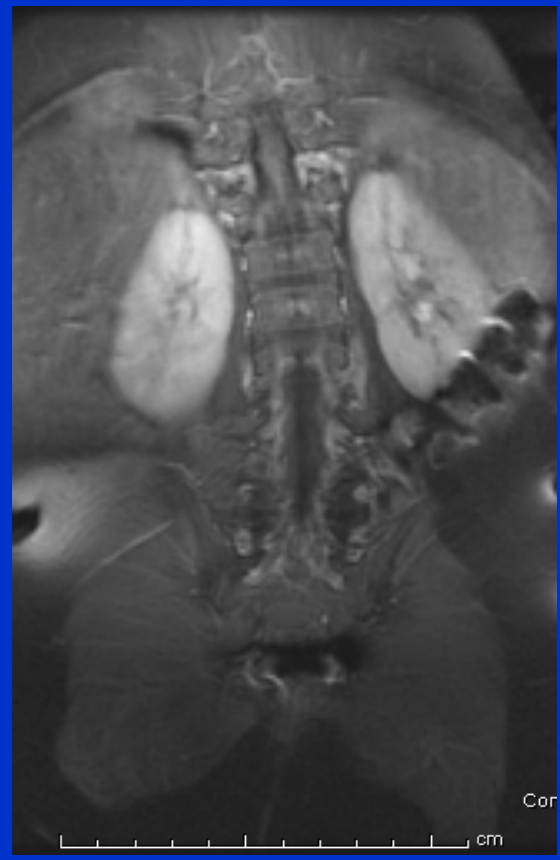
T1 post gad

Normal Kidneys



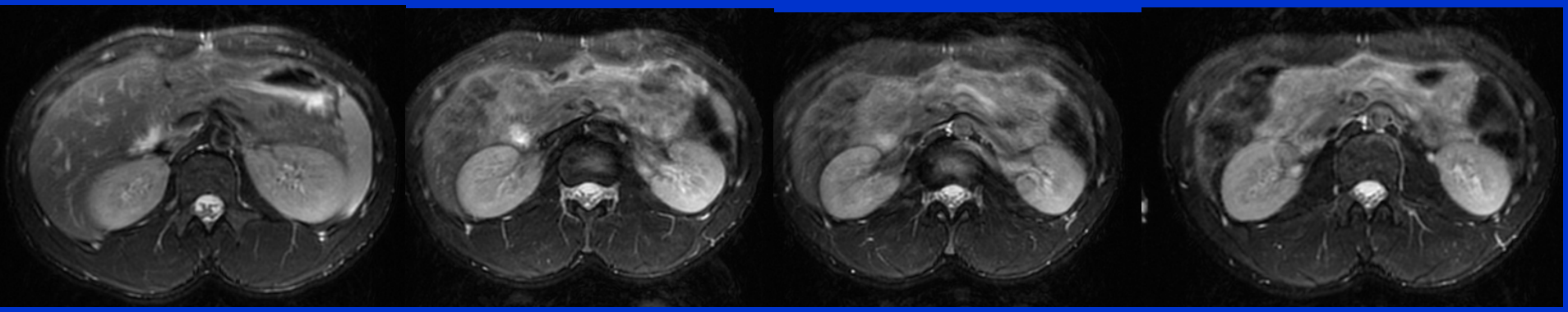
T1

T2 fs

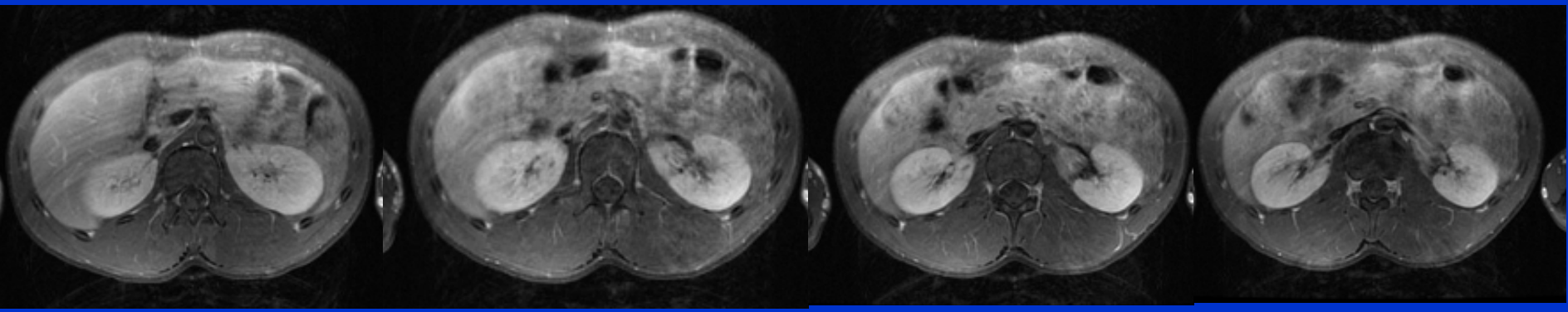


T1 fs post gad

Normal Kidneys



Axial T2 w/ fs

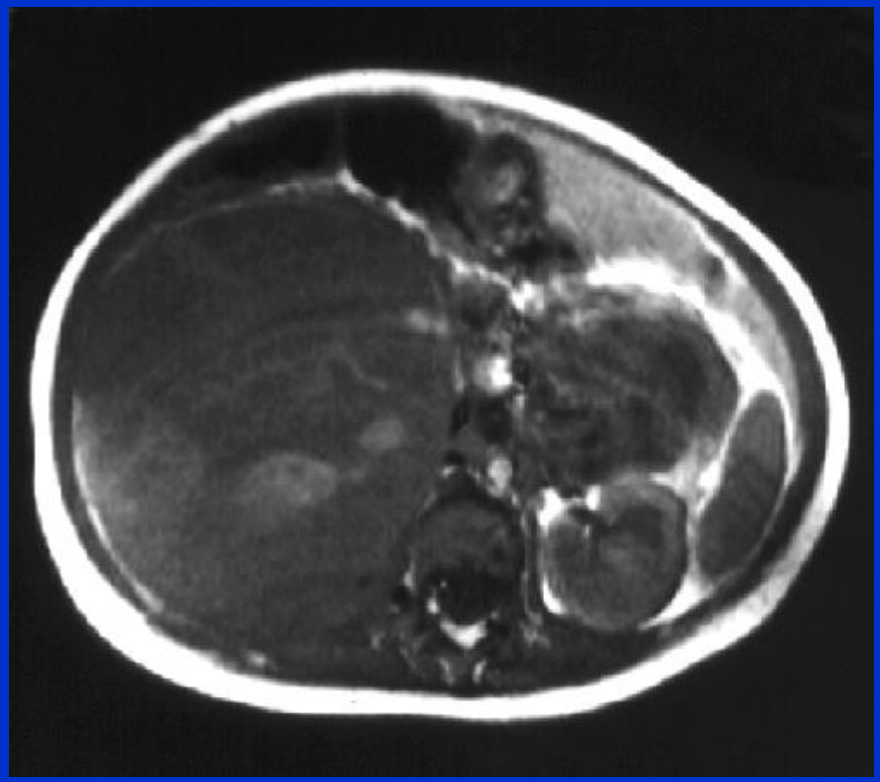


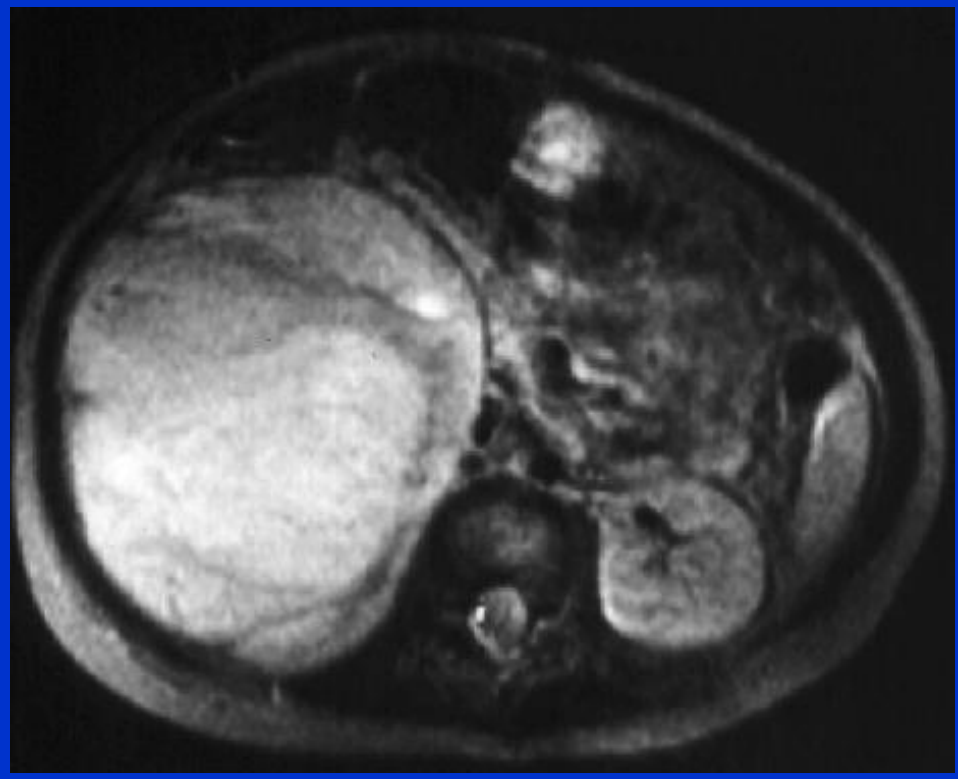
Axial T1 fs post gad

Protocol for Renal Tumors

- Pre-Gad
  - Axial, coronal T1
  - Axial, coronal T2 w/fs (may do sag instead of cor if tumor is exophytic anterior/posterior)
- Gad: dynamic coronal 3D gradient echo
- Post-Gad
  - T1 w/fs all 3 planes

18-month-old female with palpable abdominal mass: Wilm's tumor



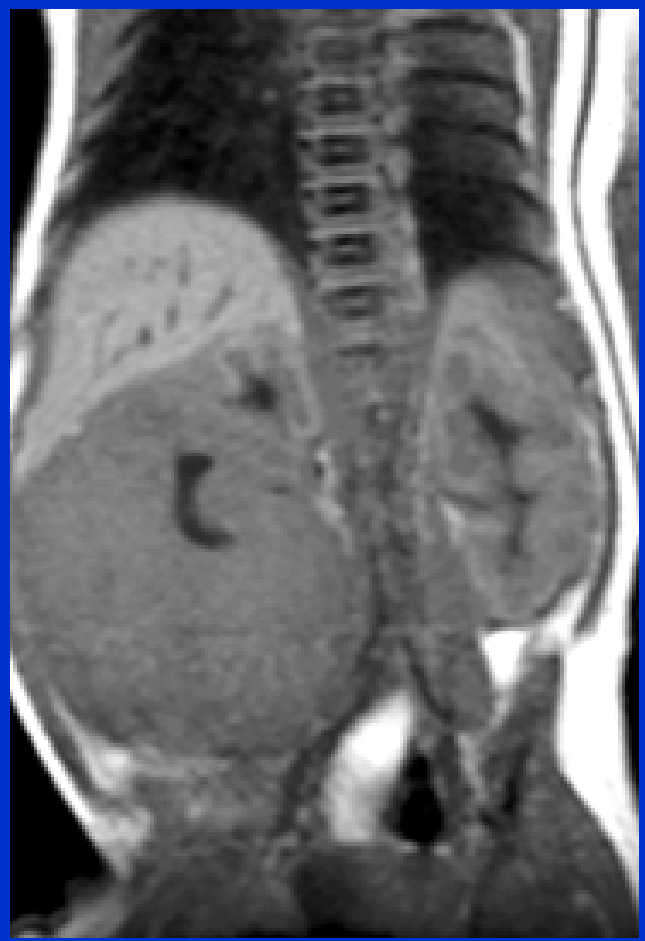


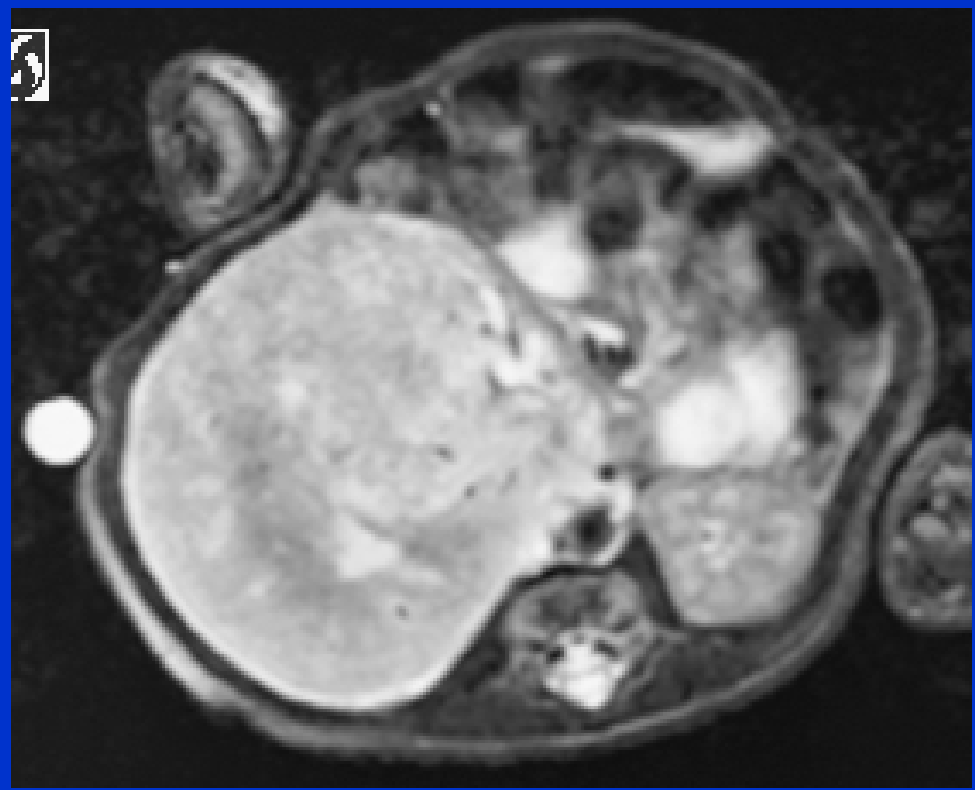
Heterogeneous low T1 and high T2 signal with areas of high T1 signal corresponding with hemorrhage. There is no involvement of the renal vein or IVC.

1 week old baby with well-circumscribed echogenic right renal mass with flow in the right kidney on prenatal ultrasound.

Postnatal MRI: large solid mass occupying the lower 2/3 of the right kidney: Mesoblastic Nephroma

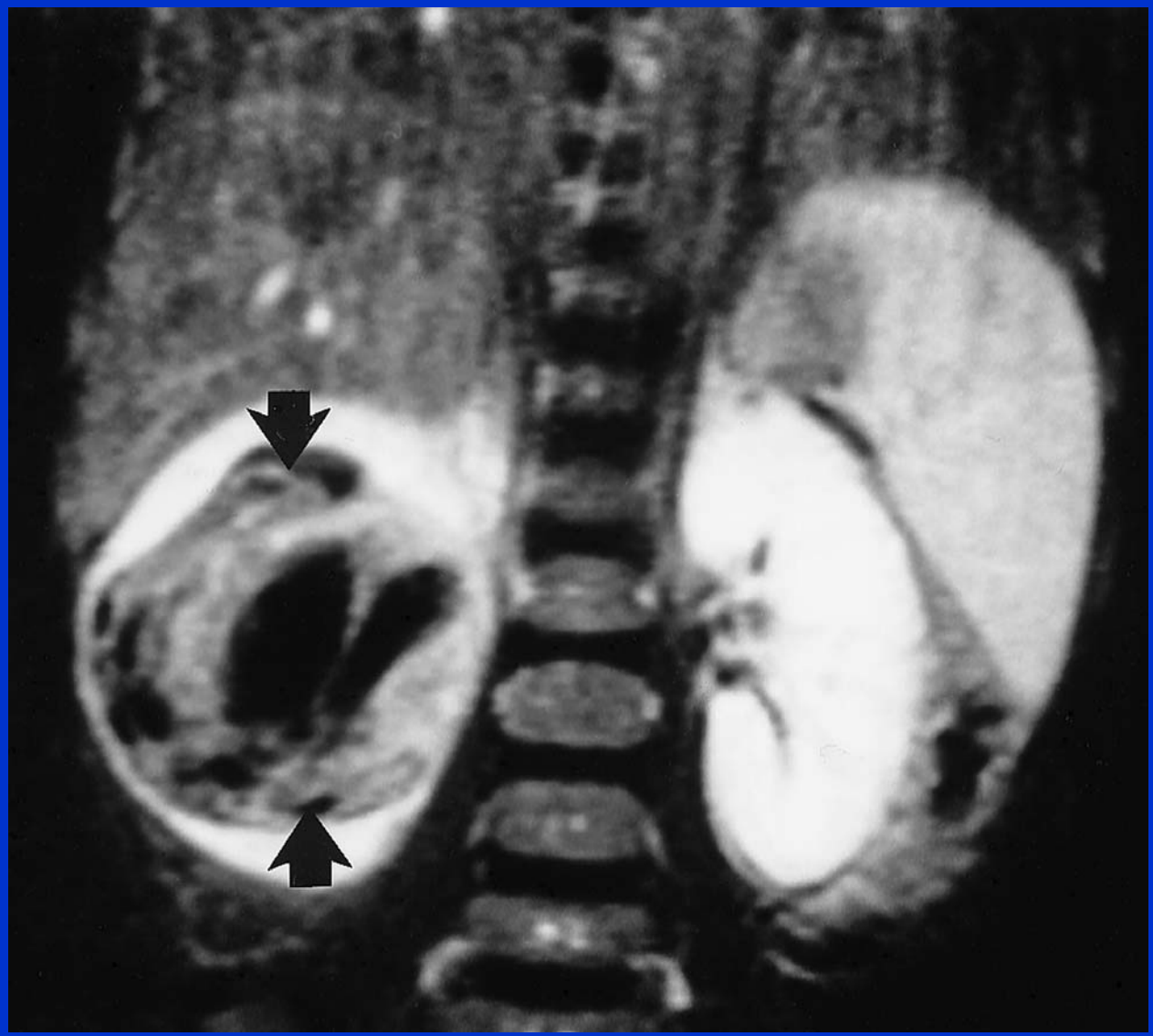
T1





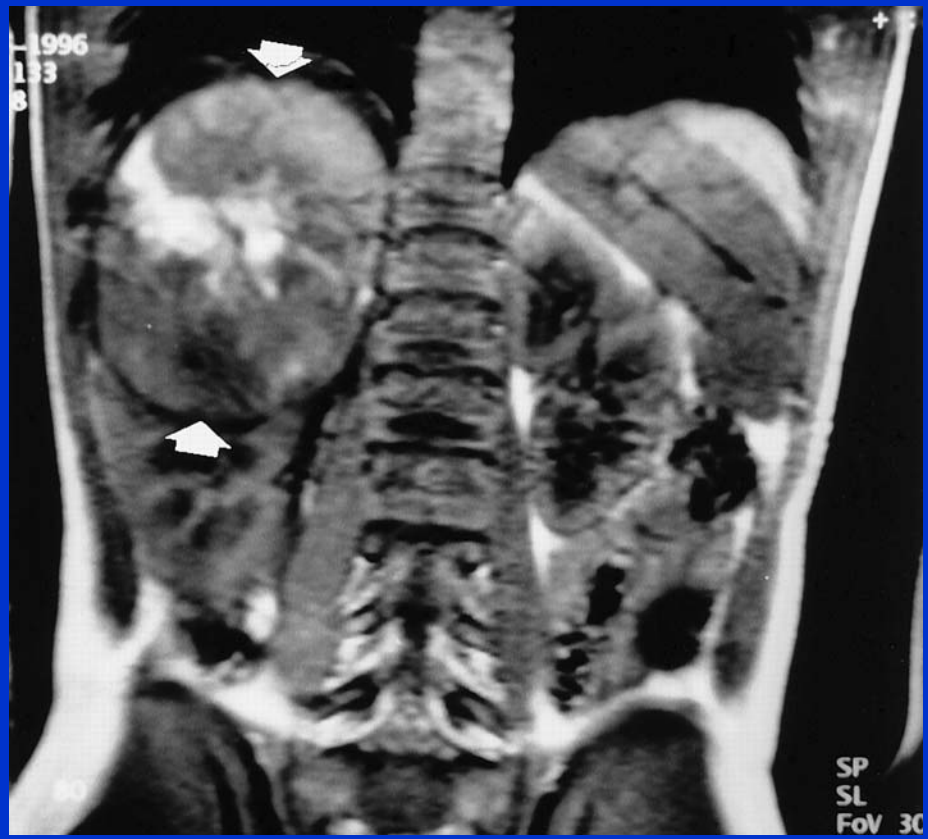
T2

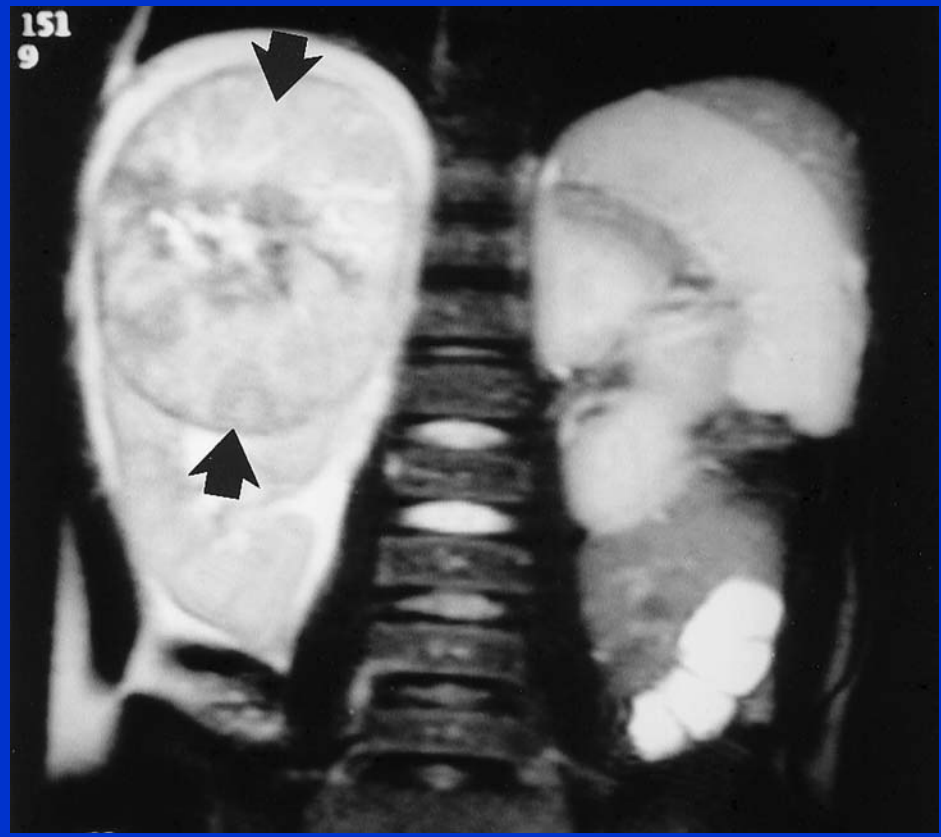
3 year old boy with RT sided mass: Wilm's tumor with hypointense hemorrhagic foci



Lowe et al, Radiographics 2000

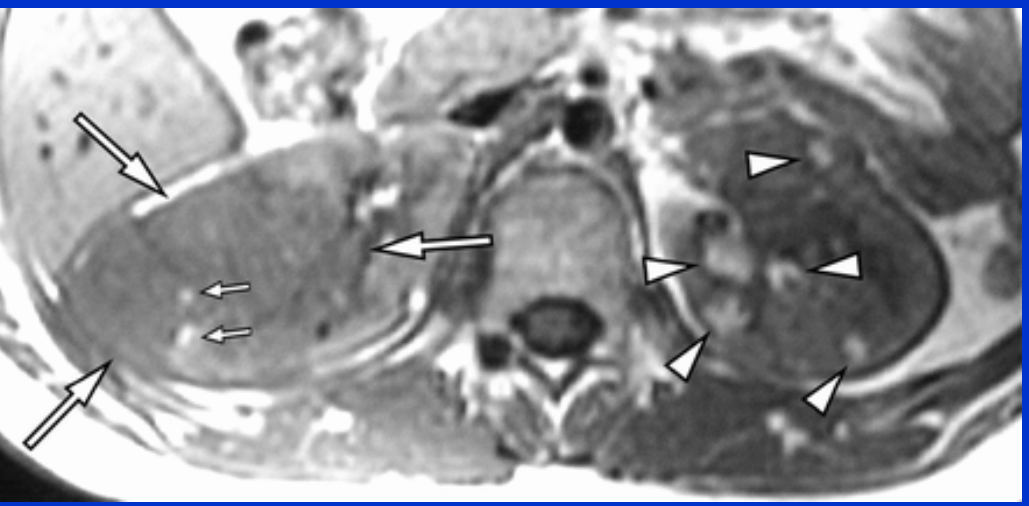
7 year old boy with RT renal tumor: Renal cell carcinoma





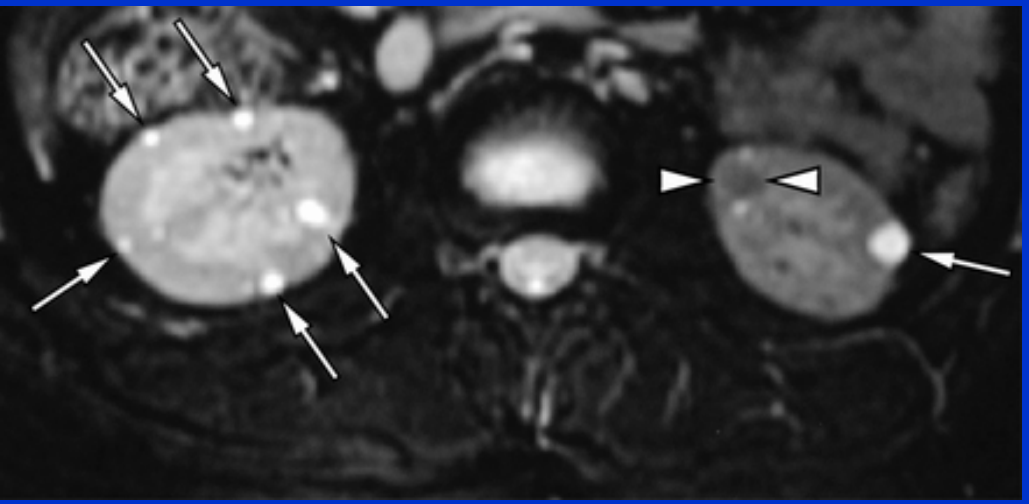
Lowe et al, Radiographics 2000

14-year-old boy with tuberous sclerosis



T1 axial

LT kidney--multiple high signal intensity fatty lesions: angiomyolipomas. Larger mass RT kidney that contains small areas of fat, also consistent with angiomyolipoma



T2 w/fatsat

LT kidney: cysts homogeneous high signal intensity. Angiomyolipoma: low signal intensity

Protocol for Acute Pyelonephritis

- **Pre-Gad:**
  - **Axial, coronal fast multiplanar inversion recovery (IR)**
  - **T2 fs axial, coronal**
- **Post-Gad:**
  - **Axial, coronal fast multiplanar inversion recovery (IR)**

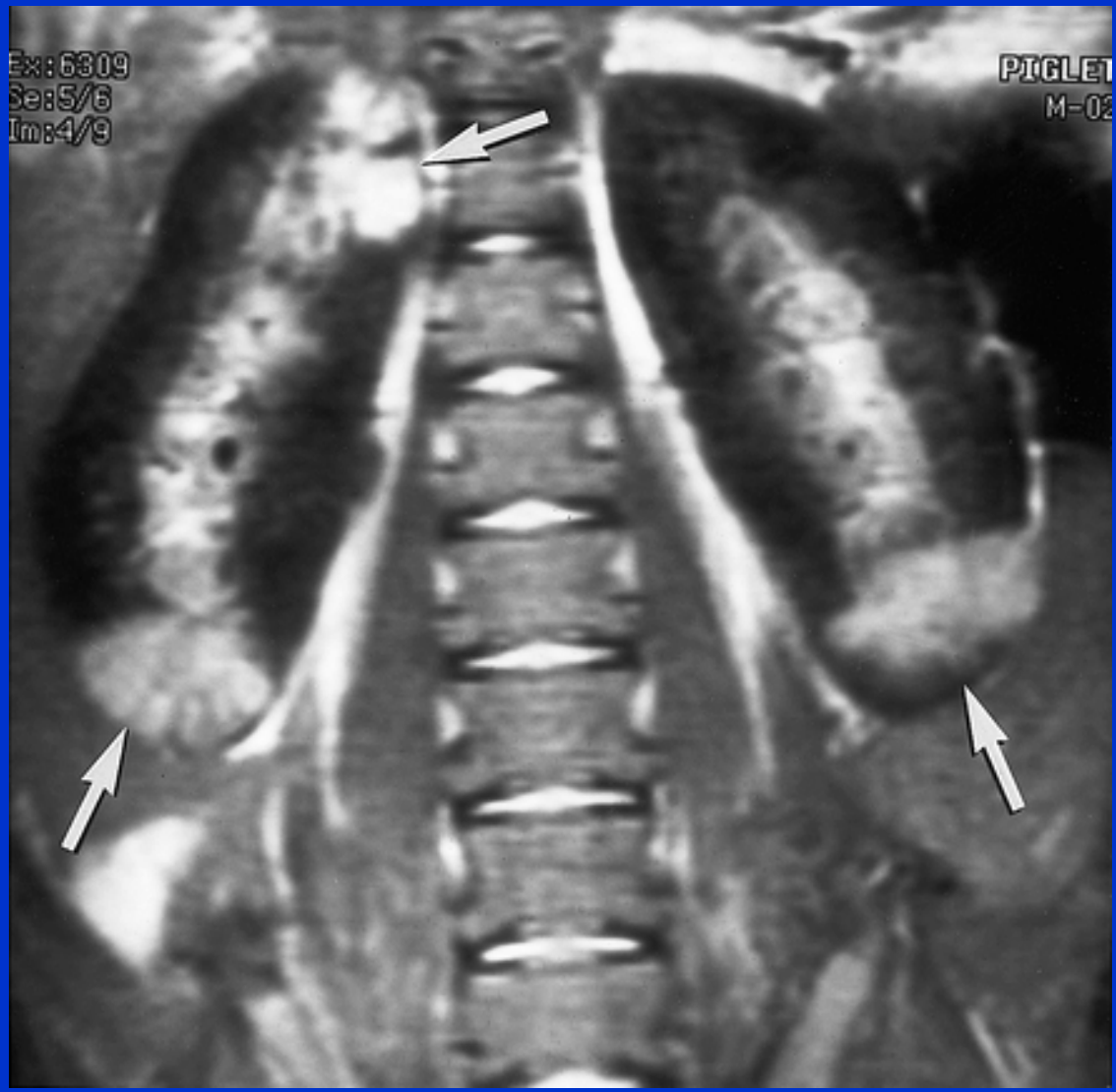
Fast Multiplanar Inversion Recovery (IR) Imaging

- Gadolinium has negative enhancement effect on IR image resulting in decreased signal in kidney (cortex looks black).

- Acute pyelonephritis is associated with edema and tubular obstruction causing decrease in delivery and concentration of gadolinium resulting in lesions that remain increased signal intensity against a black kidney.

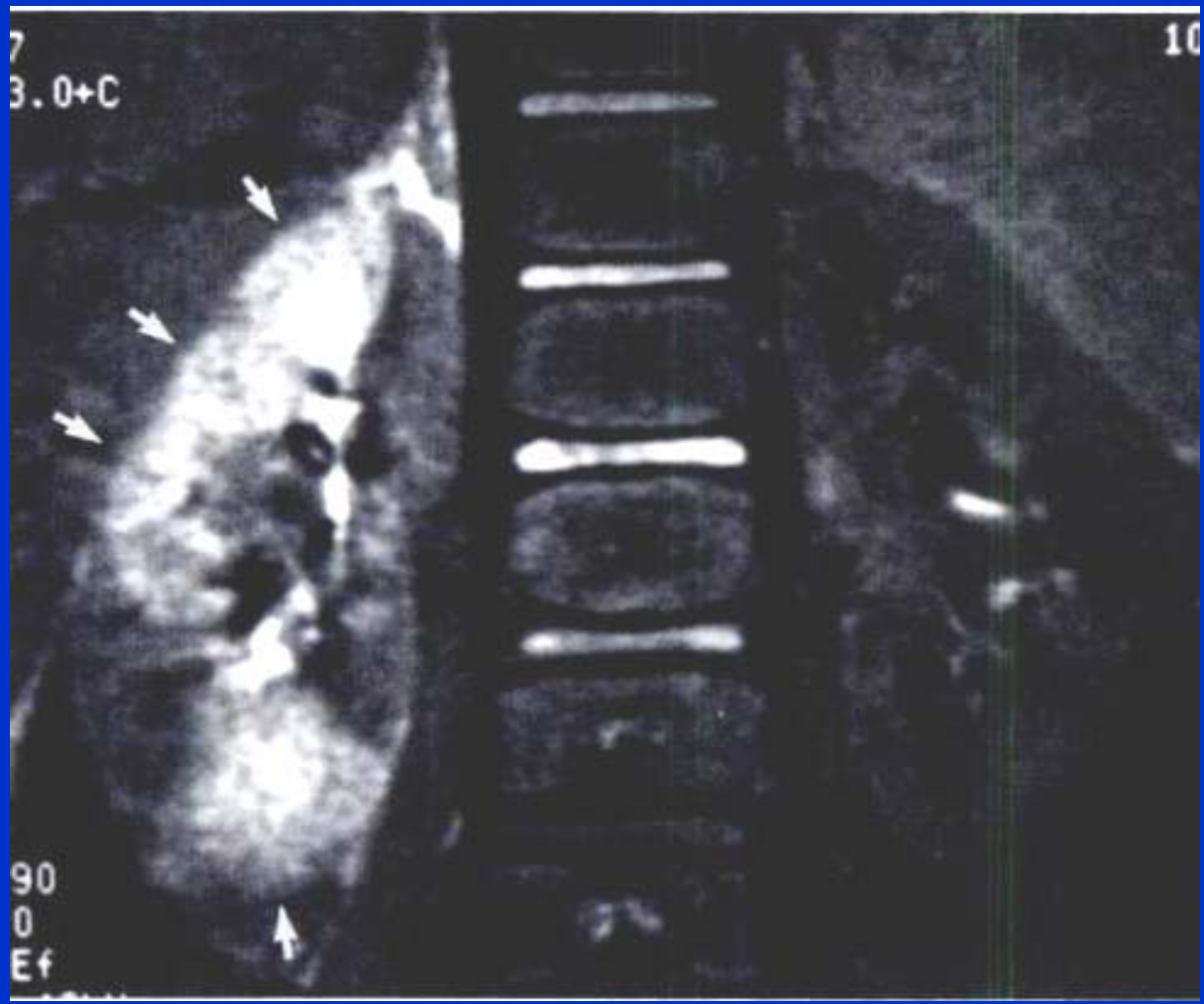
Coronal post-gad IR: Acute Pyelonephritis

RT upper and lower poles and LT lower pole



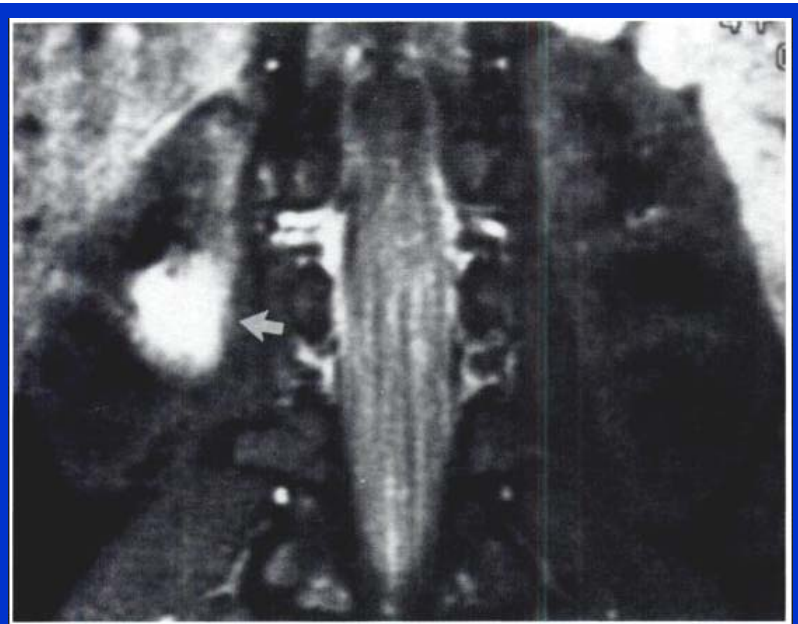
Majd et al, Radiology 2001

3.5 year old w/ febrile UTI: Acute pyelonephritis RT kidney. Note normal hypointense LT kidney.



Lonergan et al. Radiology, 1998

3 year old with febrile UTI: Multifocal acute pyelonephritis RT kidney



Lonergan et al.
Radiology, 1998

Protocol for Renal Artery Stenosis

- MR Angiography
  - 3-D spoiled gradient echo in coronal plane pre, during and after gadolinium
  - Should extend 2 cm above celiac trunk to bifurcation of common iliac arteries
  - Gadolinium: 0.2mmole/kg (double dose) gadopentate; may also use 0.1mmole/kg gadobenate *(Soulez et al, Radiology 2008)*
  - Use power injector, rate of 2cc/sec

MRA compared to Digital Subtraction Angiography

Soulez et al, Radiology 2008

- Compared MRA to DSA in patients (adults) with hypertension; multicenter study in 293 patients

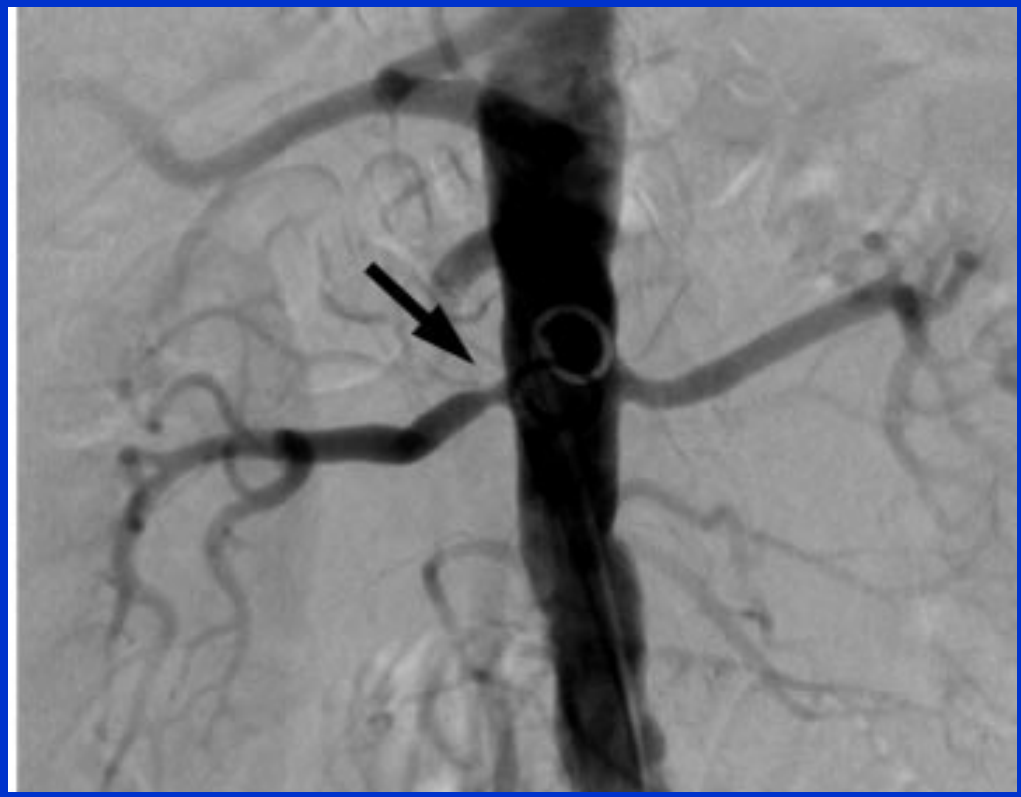
- For detection of renal artery stenosis of ≥51% or occlusion:
  - Sensitivity as high as 84%
  - Specificity as high as 95%
  - Accuracy as high as 87%

Choice of contrast agent

- **Gadobenate dimeglumine (MultiHance) --** mechanism based on weak protein binding in body fluid.
- Weak binding results in signal intensities from the vasculature higher than those obtained with **gadopentetate dimeglumine (Magnevist)**
- One study comparing gadobenate and gadopentetate at MR angiography (*Knopp MV, et al, International Society for Magnetic Resonance in Medicine, 1998*)
  - gadobenate dimeglumine produced a 29% higher vascular peak enhancement with longer duration than that produced with gadopentetate dimeglumine at the same dose and flow rate

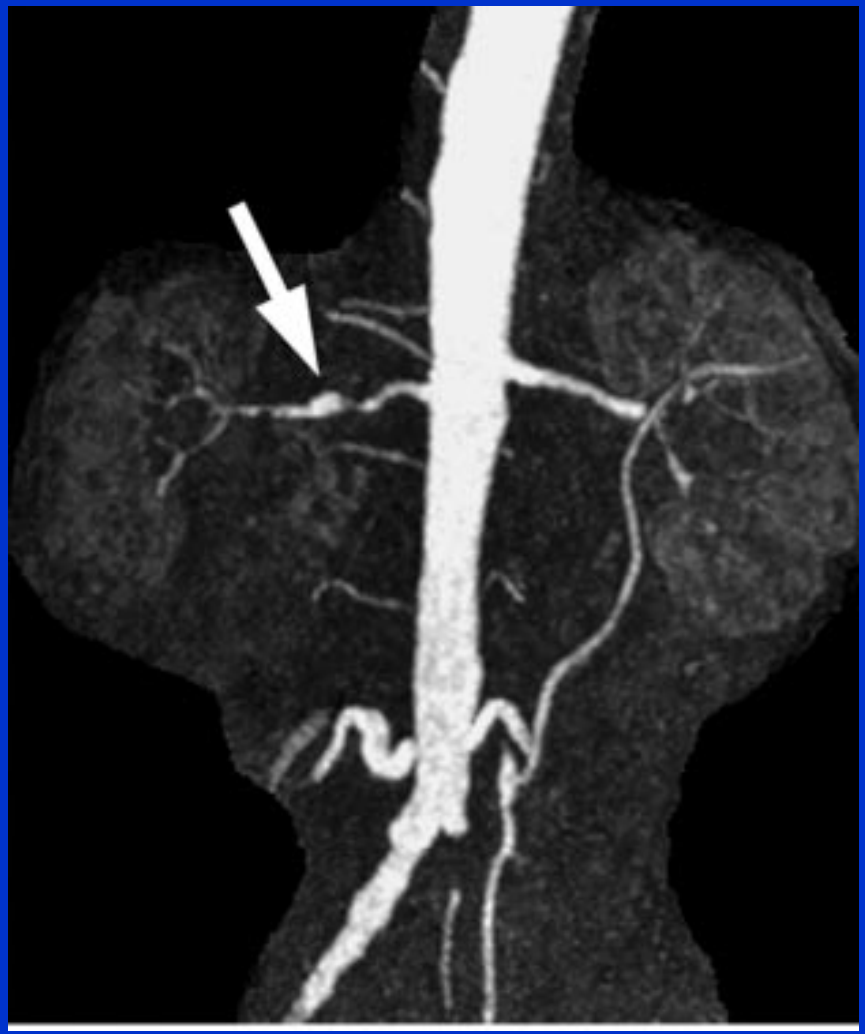
Patient with hypertension: RT main renal artery stenosis at orifice

MRA



DSA

Patient with hypertension: stenosis and focal dilatation of RT renal artery: fibromuscular dysplasia

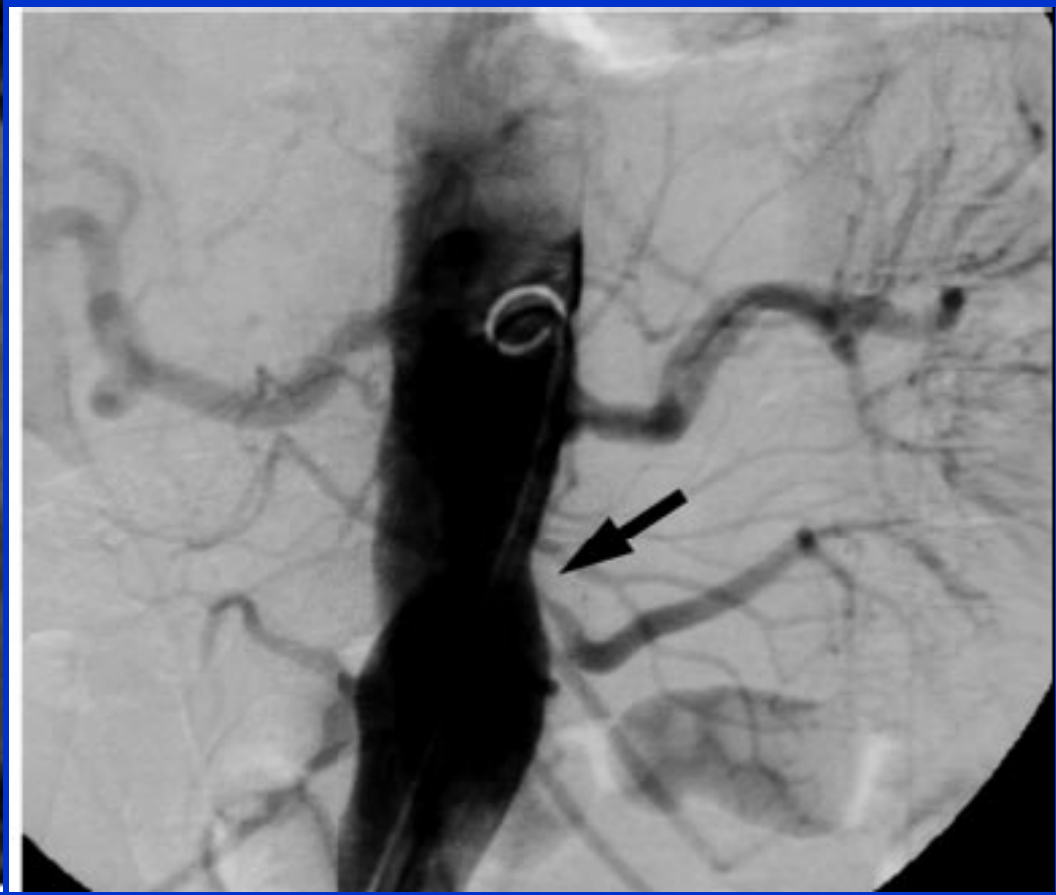


MRA

DSA

Patient with hypertension: stenosis in accessory inferior LT renal artery

MR MIP



DSA

MRA: Bilateral renal artery stenosis

Volk, M et al, Radiology 2008

MR Urography

- All obstruction is chronic and partial
- Evolving MR technique to evaluate hydronephrois and/or hydroureter
  - Kidney function
  - Kidney drainage
- Analogous to nuclear diuresis renography (MAG-3 renal scan with lasix)
- Main goal of management of obstruction is to preserve renal function

Grattan-Smith, D; Pediatric Radiology, 2008

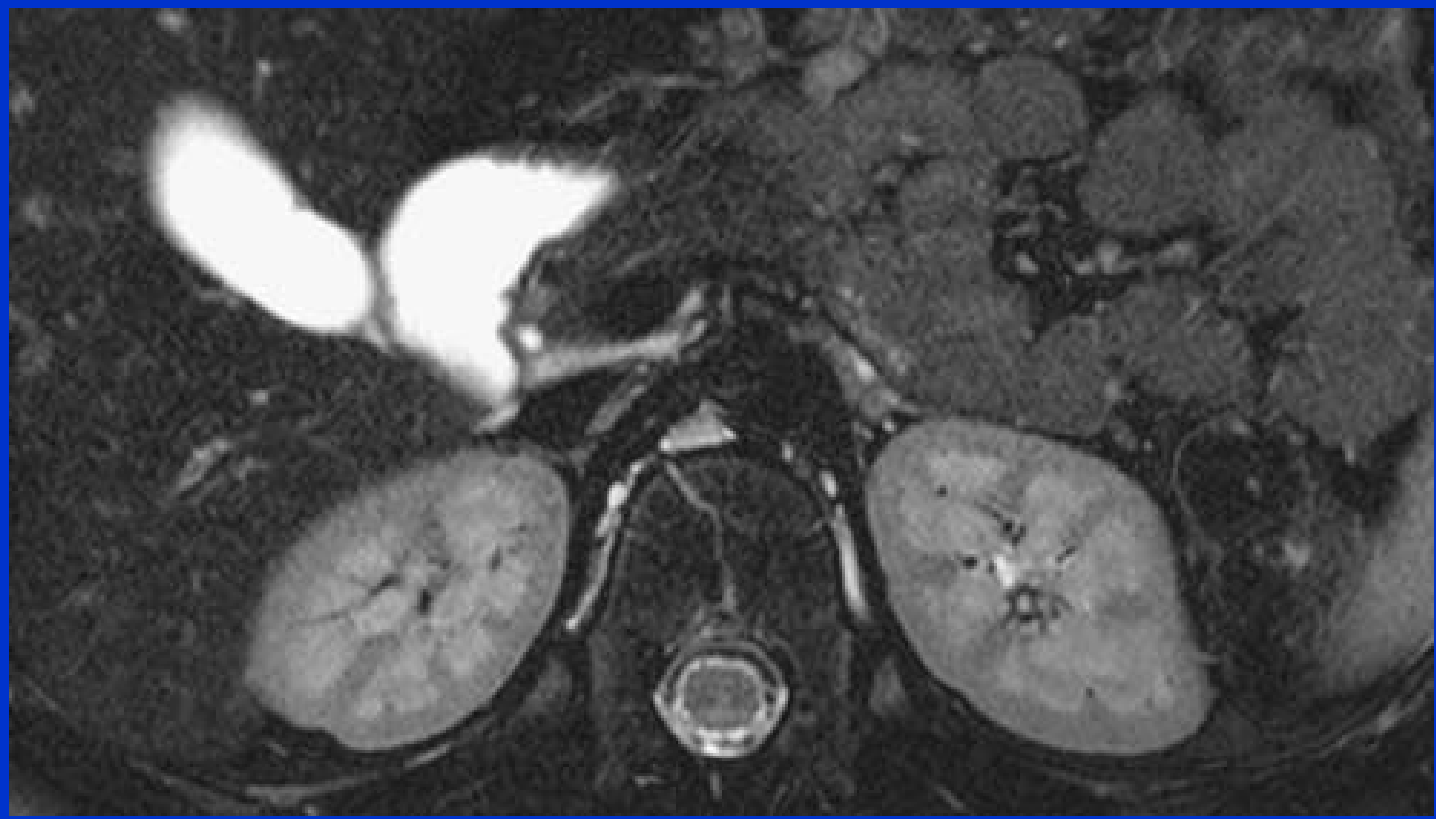
Technique of MR Urography

- Spine coil and anterior coils
- IV hydration
- Sedation
- Bladder catheterization
- IV furosemide 1 mg/kg, then do pre-gad images
- IV gadolinium 0.1mmole/kg via power injector at 0.1 cc/sec, do dynamic imaging
- Do post-gad imaging
- Processing:
  - differential renal function
  - Evaluate for drainage (renal transit time)

Imaging: Pre-Gad

- Do pre-gad images over 15 minutes
  - Ax T2 fatsat of kidneys (cysts, scars, parenchyma)
  - Ax T2 fatsat of bladder (ureterocele, bladder wall)
  - 2D Oblique coronal T1 and T2 gradient echo: kidneys and bladder

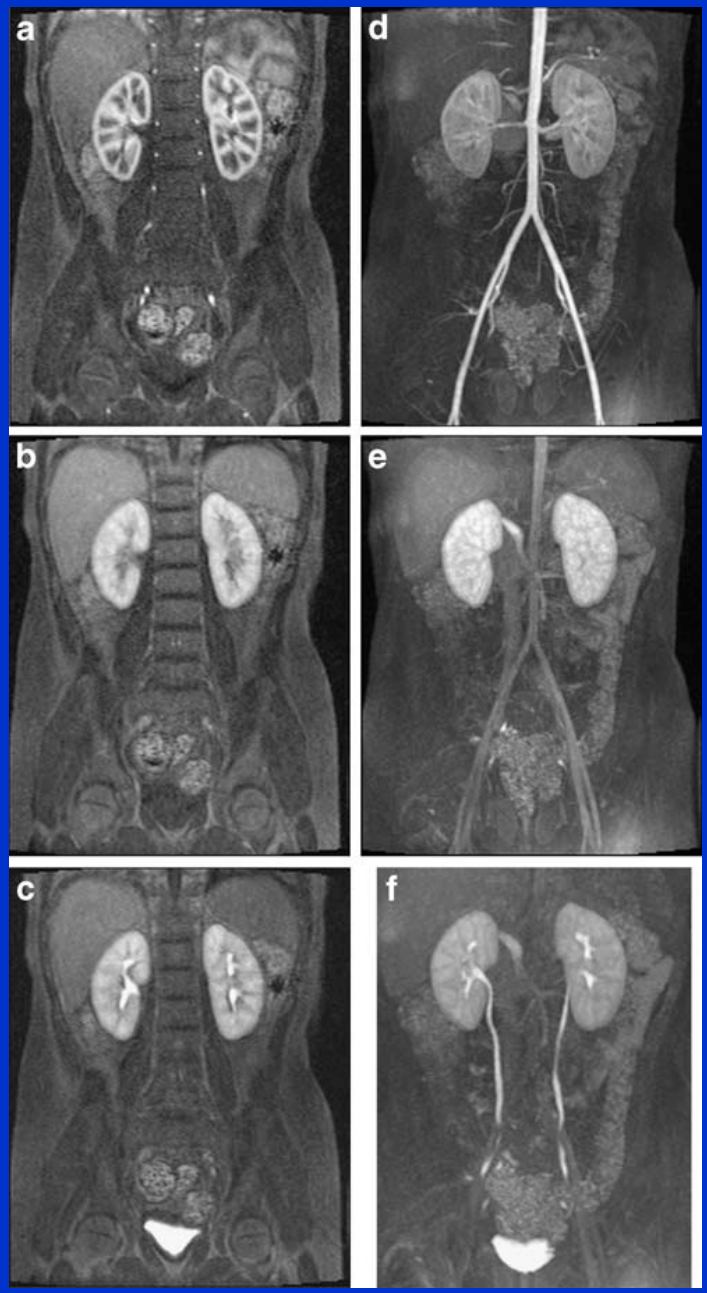
Pre-gad: Axial T2 w/fatsat--kidneys



Imaging: Dynamic during Gad injection

- Dynamic 3D oblique coronal T1: 50 volume acquisitions for 10 minutes
- A maximum intensity projection (MIP) automatically generated for each acquisition
- If no contrast in ureter, turn prone and repeat same acquisitions every 1 minute for 10 minutes

3 phases during/post gad injection



Cortical—immediate: for perfusion and glomerular filtration

Medullary—1 minute: concentration of contrast in renal tubules

Excretory—2 minutes: contrast in collecting system, ureter and bladder

Imaging: after completion of dynamic imaging

- Post-Gad: High spatial resolution imaging
  - 3D T1 oblique coronal kidneys and bladder

Post-processing

- Calyceal transit time: time taken for contrast to reach the calyces (qualitative only—symmetric, asymmetric)

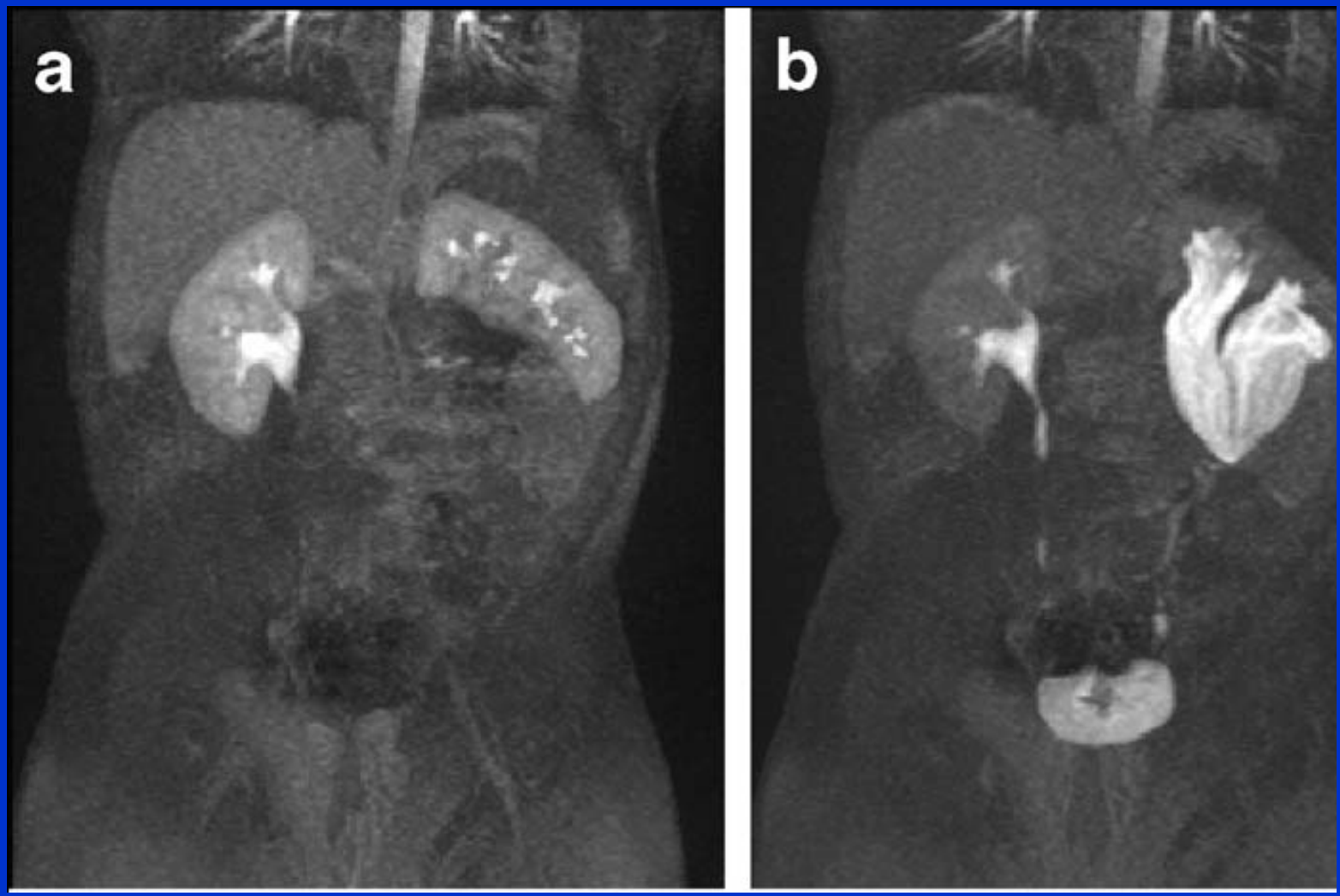
- Renal transit time: time taken for contrast to pass from cortex into ureter
  - < 4 minutes: non-obstructed
  - 4 to 8 minutes: equivocal
  - > 8 minutes: may be obstructed, depending on renal function & degree of hydronephrosis

Further Characterization of the Hydronephrosis (RTT in abnormal range)

- Compensated
  - Fluid challenge from the diuretic does not cause increased pressure in pelvicalyceal system
- Decompensated
  - Fluid challenge results in increased pressure in pelvicalyceal system, manifested by:
    - Parenchymal edema (increased T2 signal intensity)
    - Delayed CTT
    - Increased density of nephrogram (> 4% difference between vDRF and pDRF)
    - May indicate need for surgery

Pediatri Radiol 2008; 38 Suppl 1:S49-S69

Compensated Hydronephrosis



Symmetric excretion of contrast into collecting systems; symmetric washout of contrast

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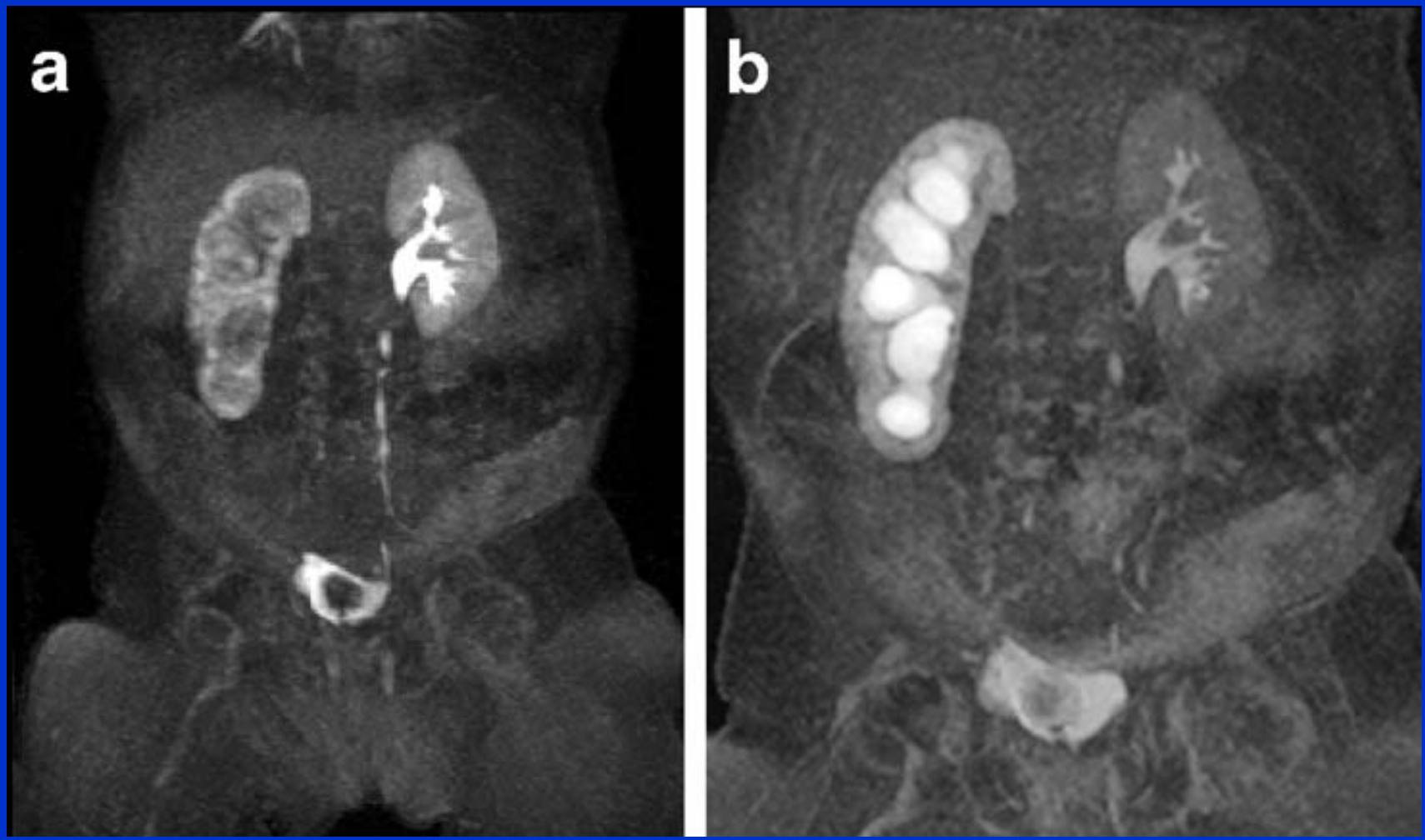
Decompensated Hydronephrosis



Asymmetric delayed excretion of contrast into collecting system on RT
Delayed dense nephrogram on the RT.

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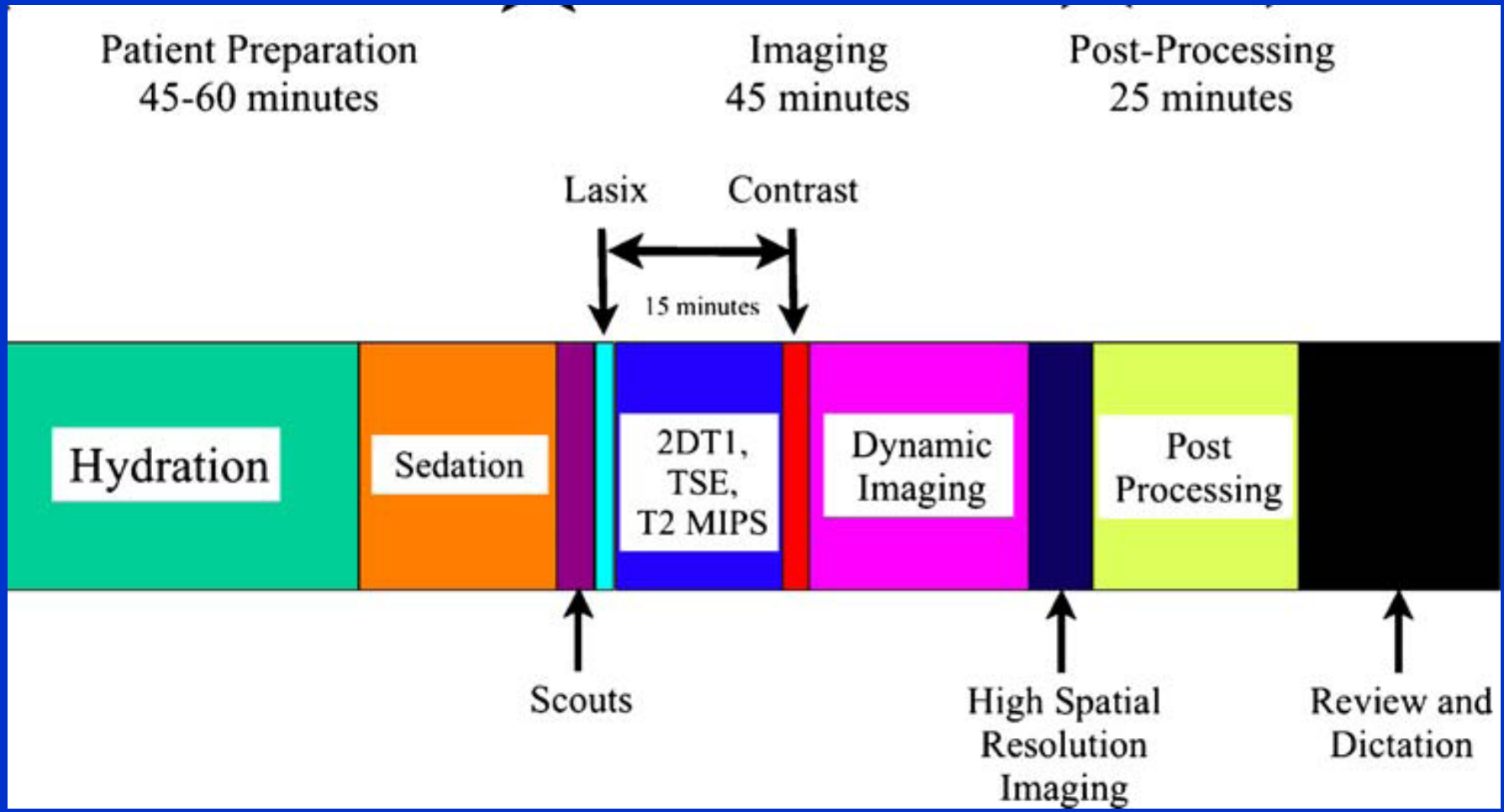
Post-processing

- Calculation of differential renal function, taken from the first minute acquisitions post-gad

Overview of MR Urography



Comparison of MR Urography with Nuclear Diuresis Renography

- MR Urography
  - Advantages
    - Excellent anatomic resolution
    - No radiation
  - Disadvantages
    - Need for sedation
    - Processing software not readily available
    - Evolving technique
- Diuresis Urography
  - Advantages
    - No sedation needed
    - Tried and true
    - Processing for function and obstruction easily done
    - Sedation not needed
  - Disadvantages
    - Radiation
    - Less anatomic resolution

Summary

- Multiple applications of MR in renal imaging including
  - Neoplasm
  - Acute pyelonephritis
  - Renal artery stenosis
  - MR urography

Use depends on availability of the magnet, expertise of the radiologists and preference of referring physicians