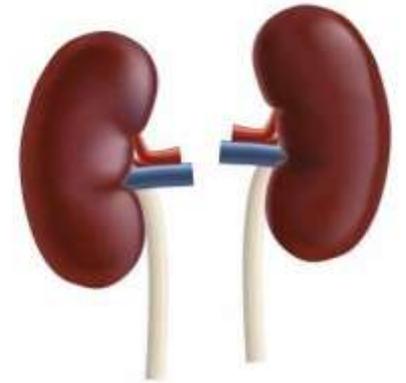




# Imaging in UTI



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**Pediatric nephrologist**  
**TUMS. Children's medical center**

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➤ To identify abnormalities of the genitourinary tract that require additional evaluation or management (eg, obstructive uropathies, VUR). Then modify the risk of subsequent renal damage (eg, surgical intervention or antibiotic prophylaxis to prevent recurrent UTI).

# Ultrasonography

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- The least invasive
- Relatively inexpensive
- Available
- Lack of exposure to radiation

- 
- Size and shape of the kidneys
  - Hydronephrosis, duplication and dilatation of the ureters, bladder wall abnormalities and the existence of gross anatomic abnormalities.
  - Acute complications of UTI (e.g. renal or perirenal abscess or pyonephrosis ) in children with acute UTI who fail to improve with antimicrobial therapy.

- 
- Limited sensitivity in detecting VUR
  - Highly observer-dependent.
  - Insensitive to the changes of acute pyelonephritis, with most patients having 'normal' scans. Abnormalities are identified in only 25% of cases .

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Possible features include:

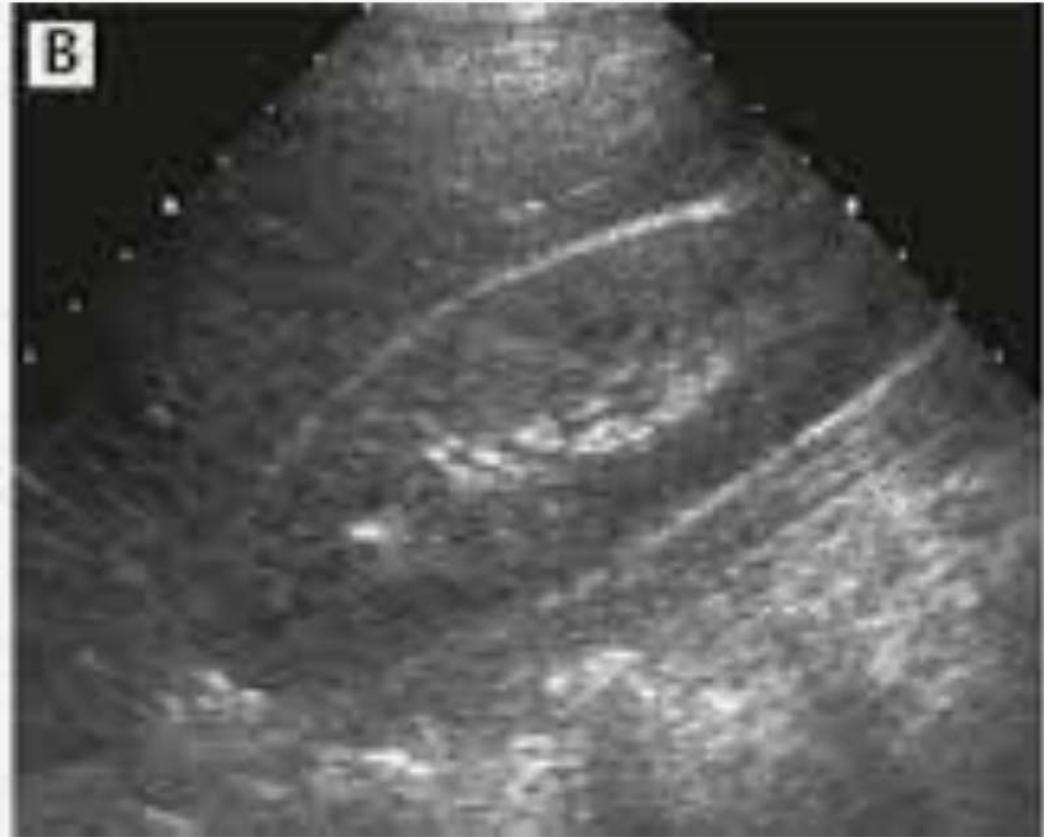
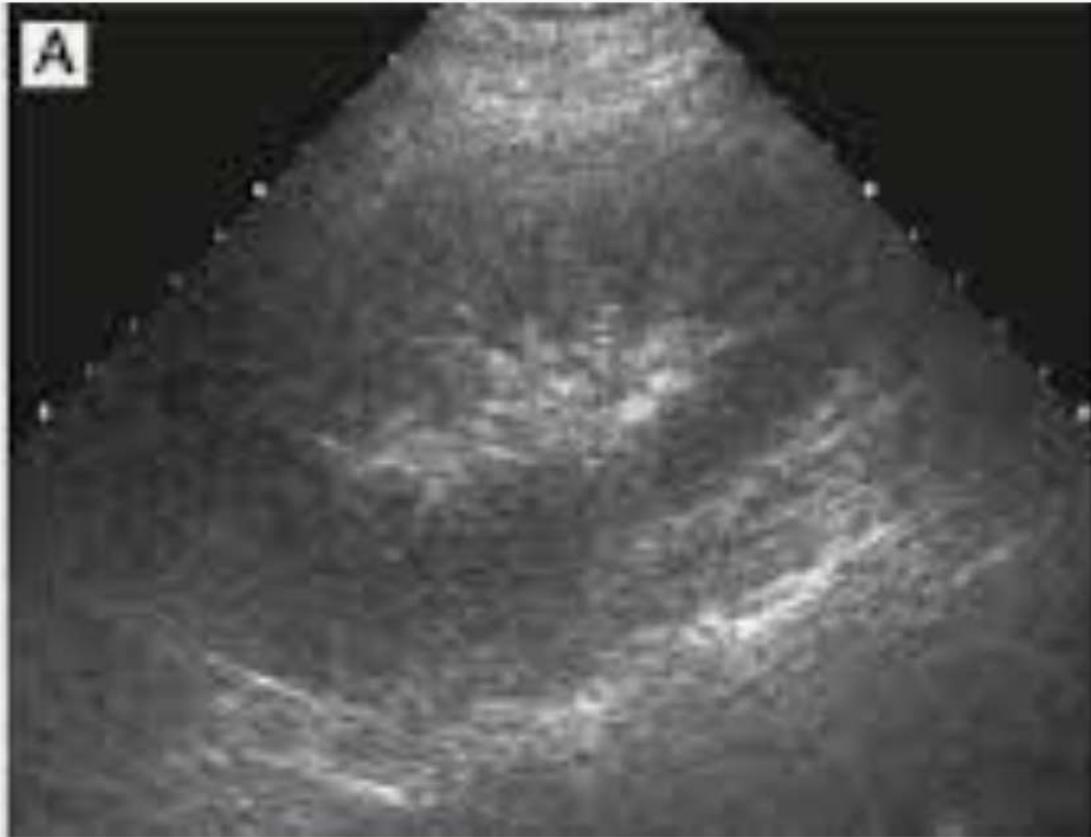
- Debris in the collecting system
- Renal enlargement
- abnormal echogenicity of the renal parenchyma
- reduced areas of cortical vascularity by using power Doppler

Diffuse renal enlargement

Decreased echogenicity

Loss of corticomedullary differentiation

Normal right kidney



# NICE Guideline

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US is indicated in all children with UTI and **aged <6 months**, whereas in older children responding well to therapy, routine US is not needed.

- Cost-effective but carries a risk of missing a significant number of patients who may benefit from CAKUT diagnosis

- 
- According to most of the remaining guidelines, US is indicated in those children with UTI who are **aged <2 years** or older children with CAKUT risk factors.

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**Atypical UTI :** serious illness, poor urine flow, abdominal or bladder mass, elevated creatinine, septicemia, infection with an organism other than *E. coli*, and failure to respond to antibiotics within 48 hours.

**Recurrence :**  $\geq 2$  episodes of upper UTI, one episode of upper UTI plus  $\geq 1$  episode of lower UTI, or  $\geq 3$  episodes of lower UTI.

	Age of patients	Ultrasound (US)
NICE	<6 months	All children
	6 months–3 years	Atypical/recurrent UTI
AAP	>3 years	Atypical/recurrent UTI
	≤24 months	All children
Italian CPS	≤36 months	All children
	<2 years	All children
Polish	>2 yrs.	Not specified
	<2 years	All children
	>2 years	Pyelonephritis, atypical/recurrent UTI or risk factors for recurrent UTI <sup>c</sup>
EAU/ESPU	All children	

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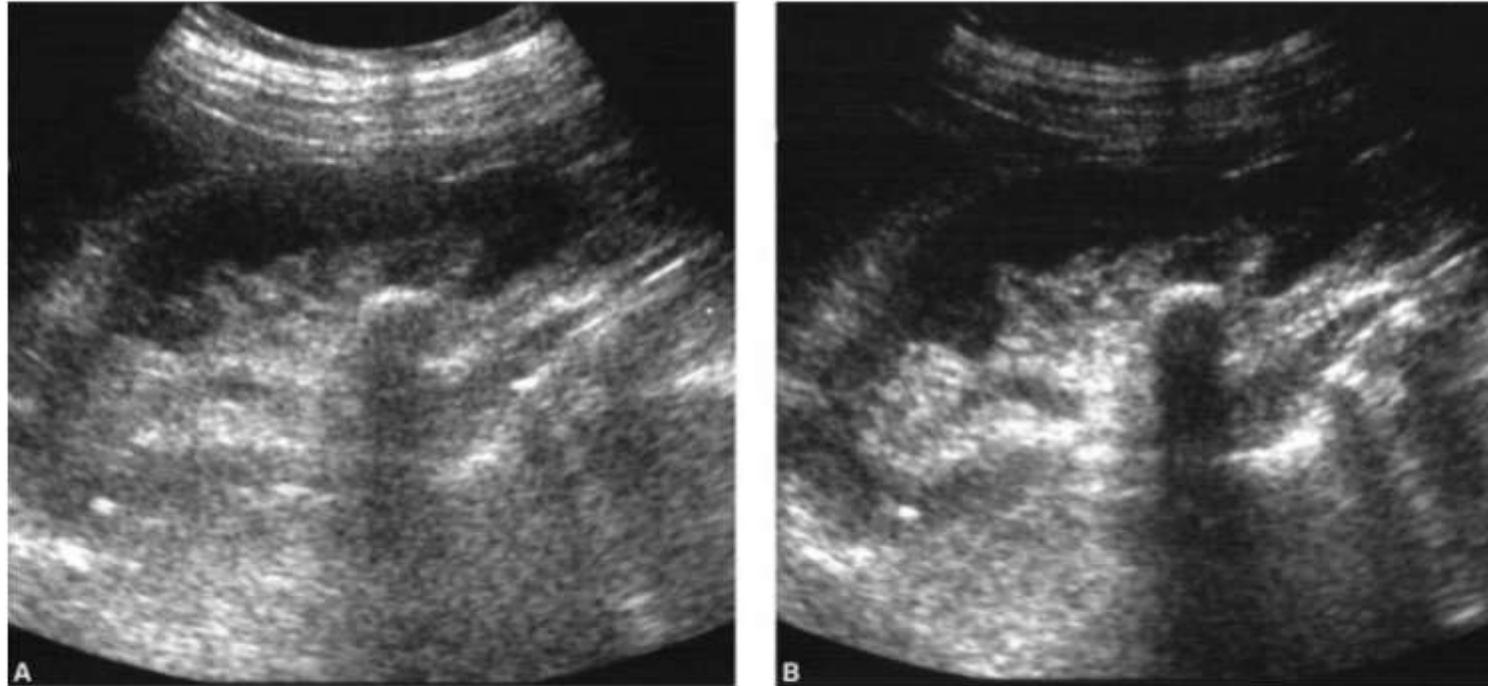
Advanced US techniques include the following:

- Harmonic imaging
- Three-dimensional (3D) US
- Voiding urosonography (VUS)

# Harmonic imaging

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- Clearer and sharper, particularly for larger patients,
- Superior to conventional gray-scale sonography for focal renal lesions, and fluid/solid differentiation.
- Improve detection of renal masses, subtle hydronephrosis, and deep abdominal and pelvic fluid collections, particularly in obese patients.



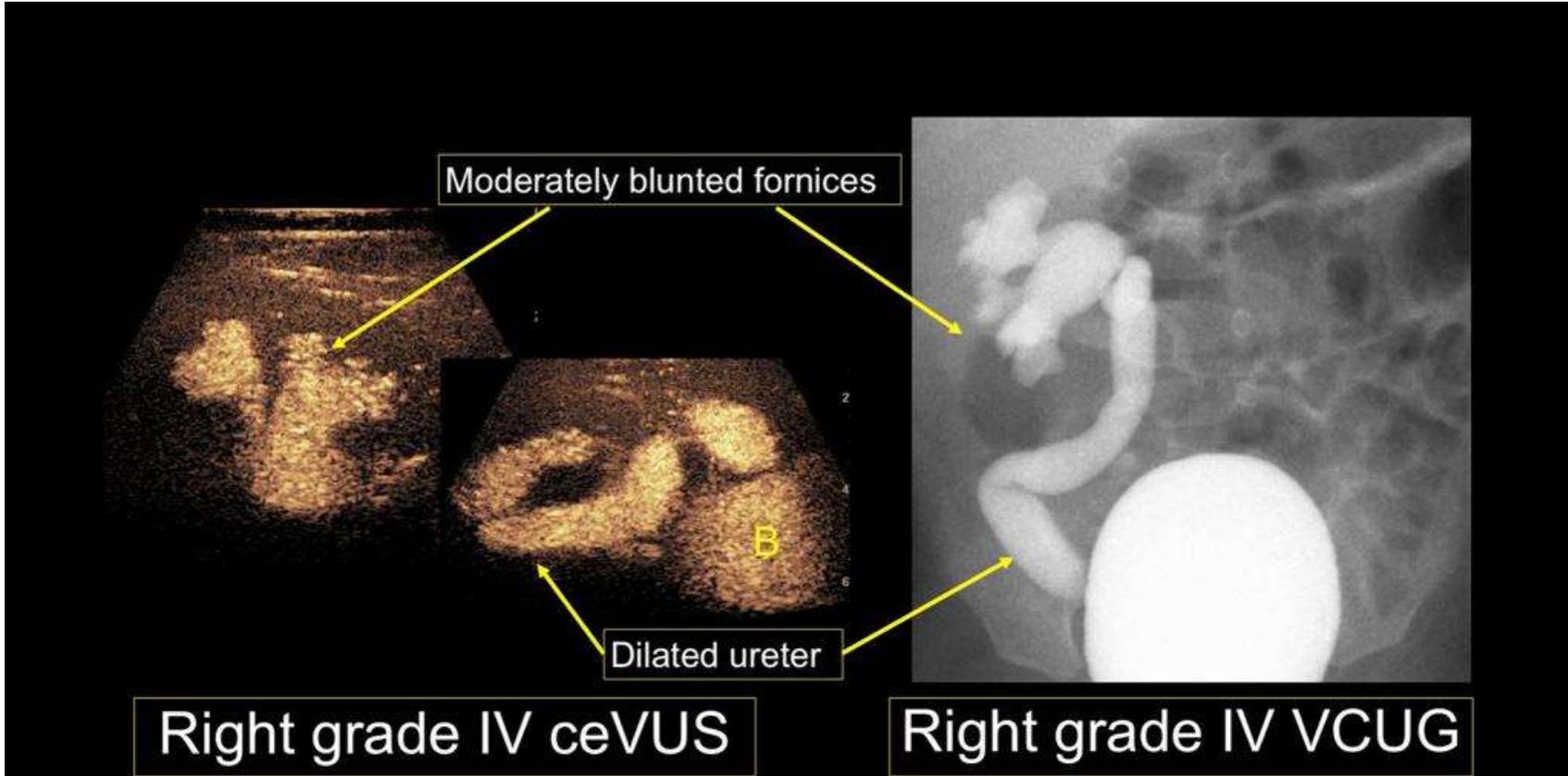
**FIGURE 1.** Renal calculus in an obese patient. **(A)** Fundamental gray-scale sonogram. **(B)** Phase inversion harmonic imaging scan. The overall renal conspicuity is superior and posterior shadowing is better defined with phase inversion harmonic imaging.

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**3D US** : multiplanar capabilities similar to CT and MRI.

**Contrast-enhanced VUS:** uses an intravesical US contrast agent, can be used in the evaluation of UTI and in the follow-up of known VUR.

Is used in Europe as a radiation-free alternative to fluoroscopic or nuclear VCUG.



# Timing

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Depends upon the clinical situation.

- In infants and young children with unusually **severe illness** or failure to improve after initiation of antimicrobial therapy, RBUS should be performed as soon as possible **during the acute phase** of illness to identify complications (eg, renal or perirenal abscess, pyonephrosis).

- 
- For infants and young children **who respond** as expected to appropriate antimicrobial therapy, RBUS should be performed **after the acute phase** (to reduce the risk of false positive results secondary to renal inflammation during the acute episode) .

# Doppler US

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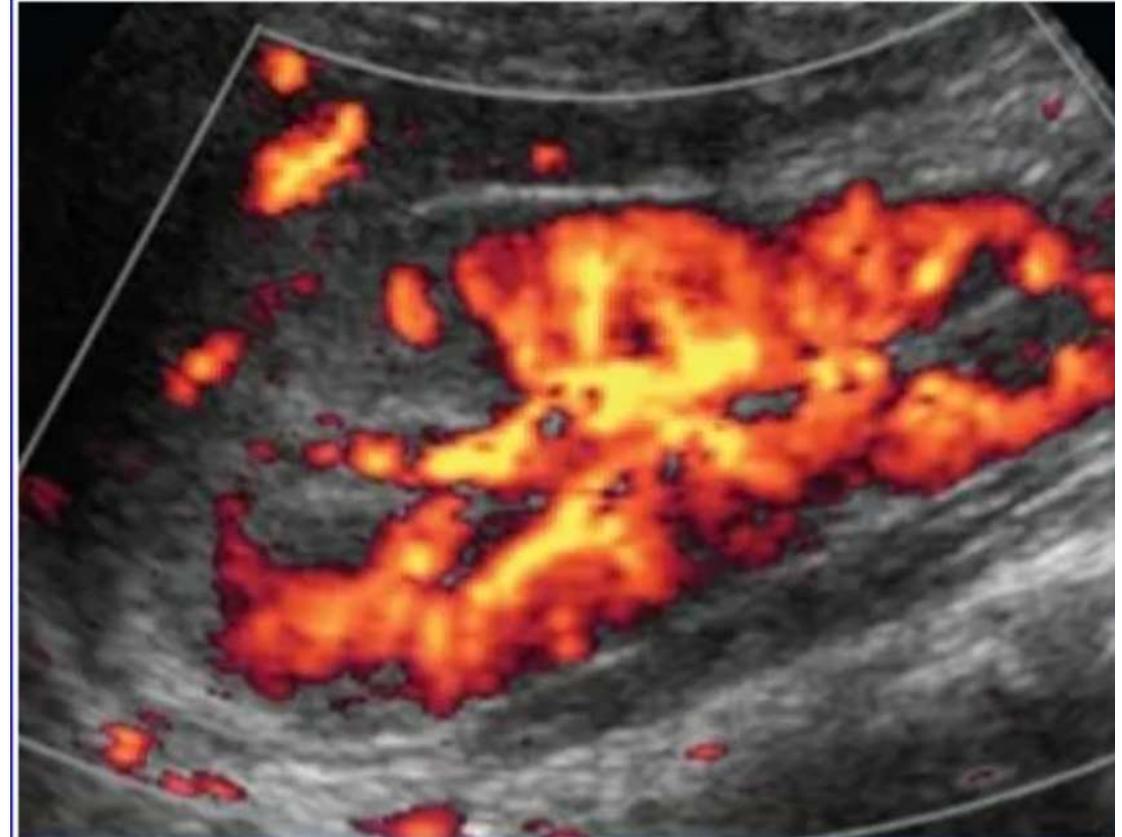
Doppler US provides additional information by showing renal perfusion and vascularity.

Areas of decreased blood flow with color-flow Doppler may indicate focal areas of acute pyelonephritis.

Wedge-shaped hyperechoic focus in upper pole of kidney



Diminished flow in involved area



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Doppler US is reliable in the acute phase.

However, the predictive values of Doppler US is relatively low, and it **cannot** yet be recommended as an accurate **predictor of scarring**.

# VCUG

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- Gold standard for the diagnosis and grading of VUR .
- Useful in visualizing the anatomy of the urethra and bladder, but allows upper urinary tract assessment only when VUR is present.

# Disadvantages

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- Radiation exposure
- The risk of inducing a UTI
- The high cost
- Discomfort for the patient.

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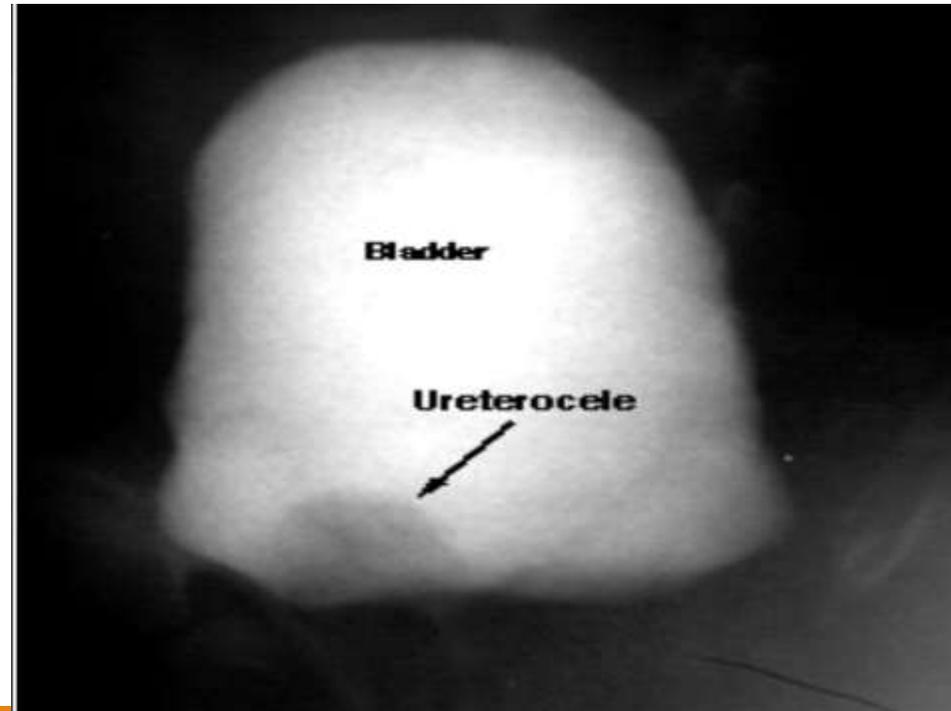
A small feeding tube (8 French for newborns, 10 French for infants) is passed via the urethra into the bladder.

Contrast material is then dripped into the bladder under gravity.

Serial radiographs of the pelvis and abdomen are then taken.

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The first film obtained is important for the diagnosis of ureterocele. It is observed as a round filling defect but may be compressed with further filling.



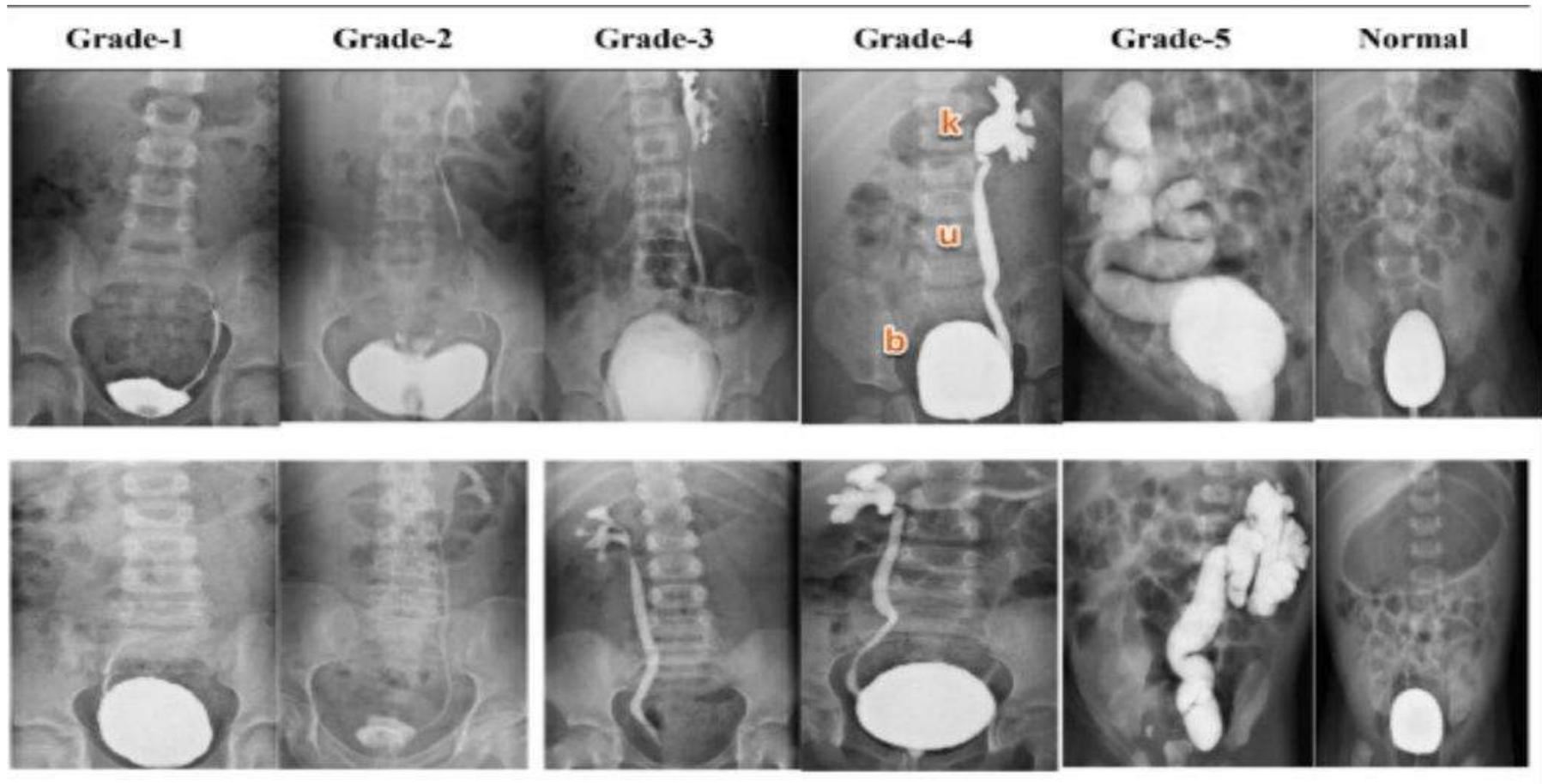
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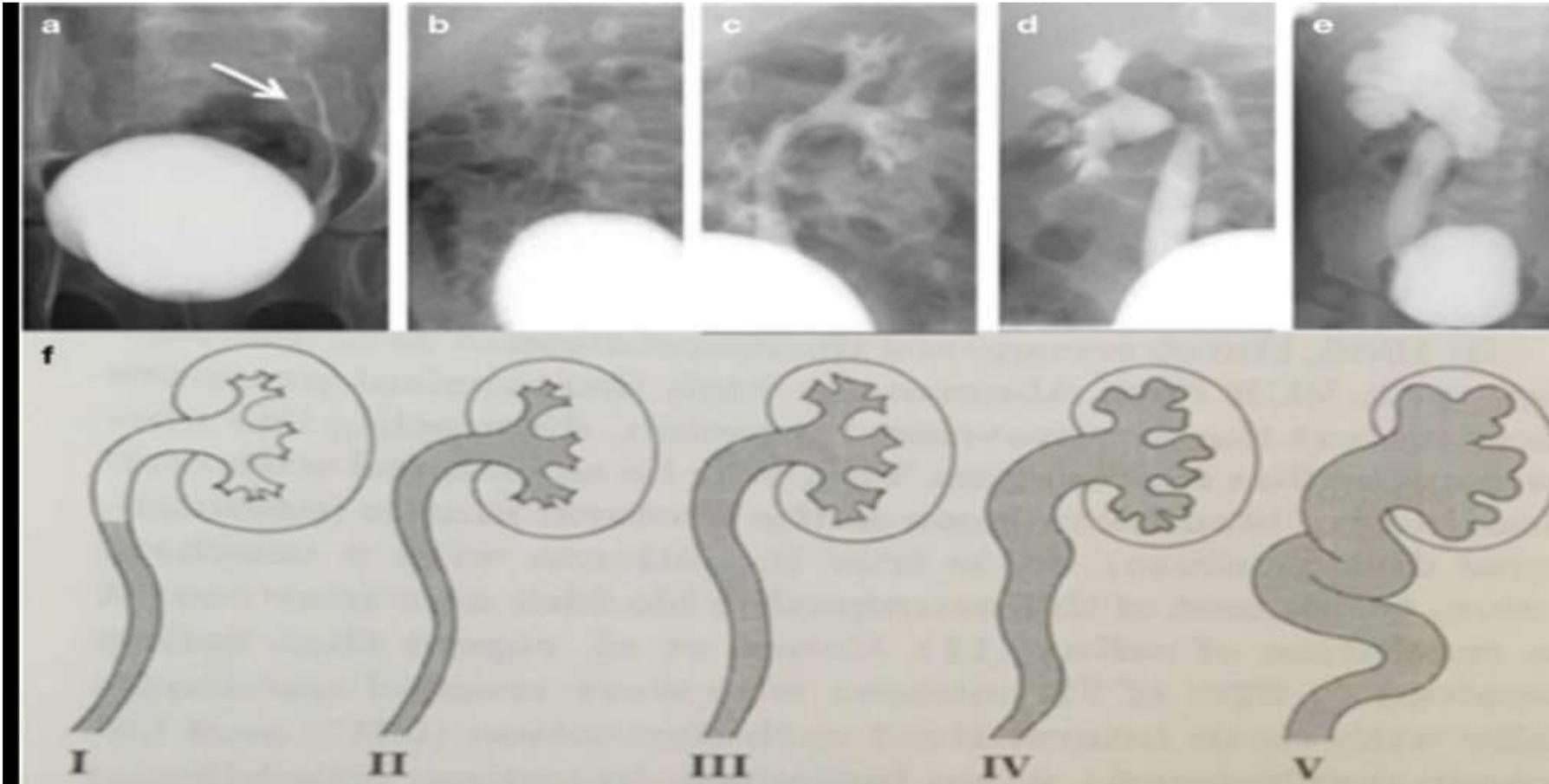
The bladder is then filled until the expected capacity is reached.

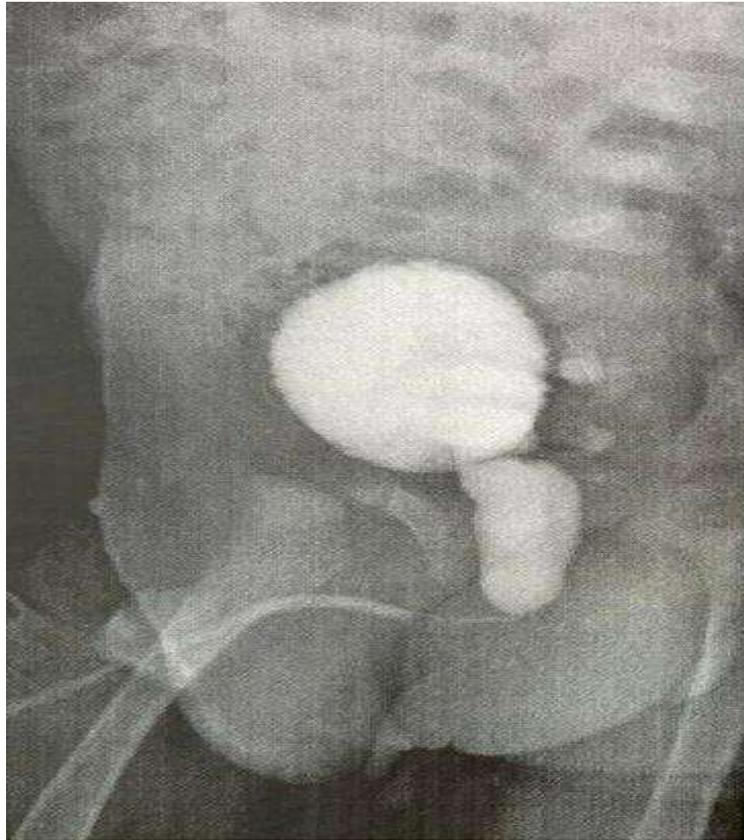
Tapping on the bladder or gentle massaging it is sometimes necessary to encourage the patient to void.

- 
- An oblique view of the male urethra is obtained once voiding has started.
  - 20% of reflux occurs only upon voiding.
  - Not routinely use sedation.

Sedation may render VCUG less reliable because it may affect the force with which the bladder contracts.







# Cyclic VCUG

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- Two or more cycles of filling and emptying
- Necessary to reveal reflux into an **obstructed** and refluxing system, such as an ectopic ureter draining into the bladder neck or urethra.
- During the first void, the urine in the pressurized obstructed system drains, and on the subsequent void, contrast may be observed to reflux.
- Cyclic VCUG also increase the sensitivity of the test.

# Nuclear VCUG

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Good choice for :

- Follow-up studies in patients with UTI
- Screening for siblings of patients with reflux, in that the radiation exposure is decreased

In patients with an abnormal anatomy (eg, duplication) that would influence a surgical approach, contrast VCUG is indicated.

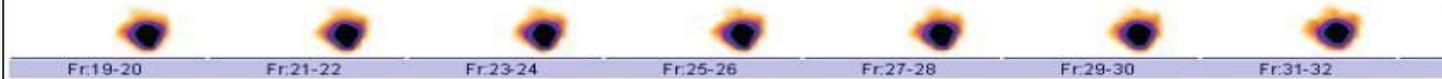
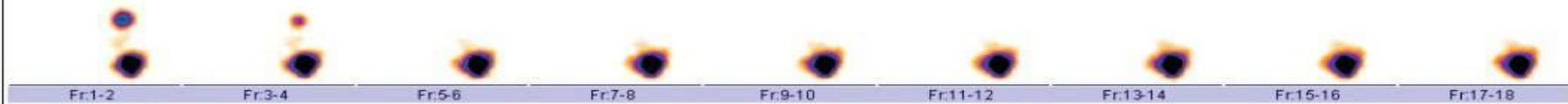


Nuclear Medicine Department  
CMC Hospital

### Filling Phase



### Voiding Phase



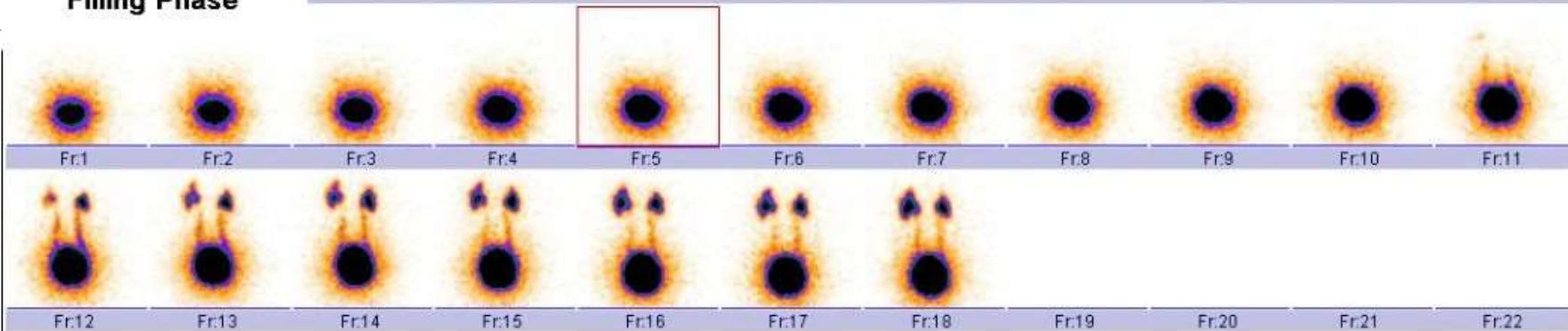
(B:3%,T:42%)

### Post Void(Static View)

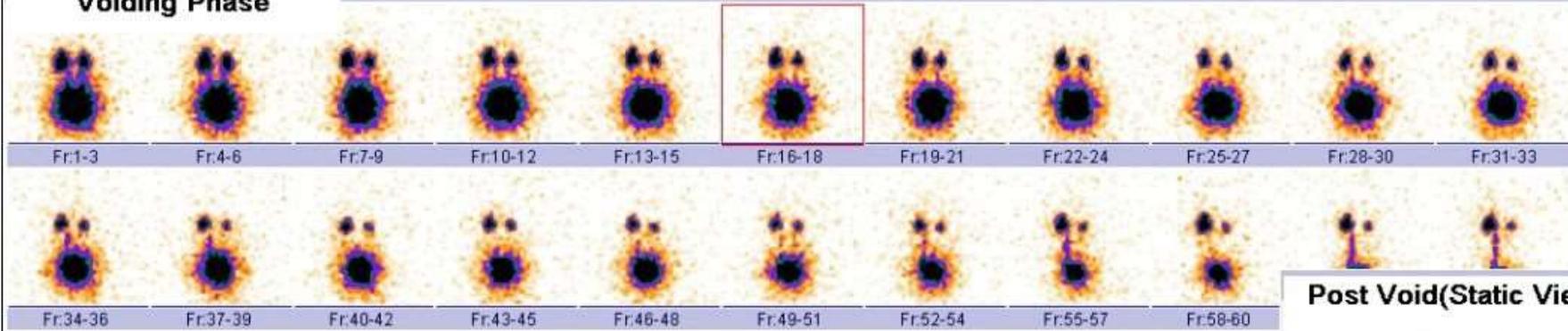




### Filling Phase



### Voiding Phase



### Post Void(Static View)



(B:0%,T:4%)

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According to most of the guidelines, VCUG is not routinely indicated and should only be performed if US reveals abnormalities suggesting CAKUT, or in other specific clinical circumstances .

# AAP

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Postponing VCUG until the second febrile UTI in children 2 to 24 months of age unless there are :

- Atypical or complex clinical circumstances
- RBUS reveals hydronephrosis, or other findings suggestive of high-grade (IV or V) VUR or obstructive uropathy .

# NICE guideline

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- For infants <6 months with atypical or recurrent UTI .
- For children six months to three years with atypical or recurrent UTI and dilation on ultrasonography, poor urine flow, non-*E. coli* infection, or family history of VUR.

# EAU/ESPU

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US alone misses 33% of patients at risk and thus recommends one of two further approaches in all patients with febrile UTI and aged <1 year :

- The bottom-up method (VCUG and, if positive, DMSA scan)
- The top-down method (DMSA scan and, if positive, VCUG).

In older children, exclusion of VUR is warranted in all girls, and in those boys who have recurrent UTI.

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## The Top-down method :

- higher cost
- lower sensitivity
- Fewer urethral catheterizations
- Fewer diagnoses of insignificant VUR

	Age of patients	Ultrasound (US)	VCUG
NICE	<6 months	All children	Atypical/recurrent UTI
	6 months–3 years	Atypical/recurrent UTI	Atypical/recurrent UTI AND specific features <sup>a</sup>
AAP	>3 years	Atypical/recurrent UTI	Not indicated
	≤24 months	All children	Abnormal US or other specific circumstances
Italian	≤36 months	All children	Abnormal US or risk factors <sup>b</sup>
CPS	<2 years	All children	Abnormal US; recurrent UTI in children <2 years
	>2 yrs.	Not specified	Atypical/recurrent febrile UTI; abnormal US; positive family history for VUR
Polish	<2 years	All children	
	>2 years	Pyelonephritis, atypical/recurrent UTI or risk factors for recurrent UTI <sup>c</sup>	
EAU/ESPU	All children		Either VCUG or DMSA is indicated in bottom-up or top-down approach

# Timing

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Although VCUG is often scheduled several weeks after UTI, it may be performed as soon as the patient is asymptomatic

Early imaging (as early as the first week) does not appear to falsely increase the detection of VUR

# DMSA

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DMSA is injected intravenously, and uptake by the kidney is measured two to four hours later. Areas of decreased uptake represent pyelonephritis or scarring.

DMSA scans are expensive, invasive, and expose children to radiation.

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A DMSA scan is reliable in

- Detecting both acute pyelonephritis and late renal parenchymal scarring,
- Search for ectopic renal tissue
- Determine differential renal function.

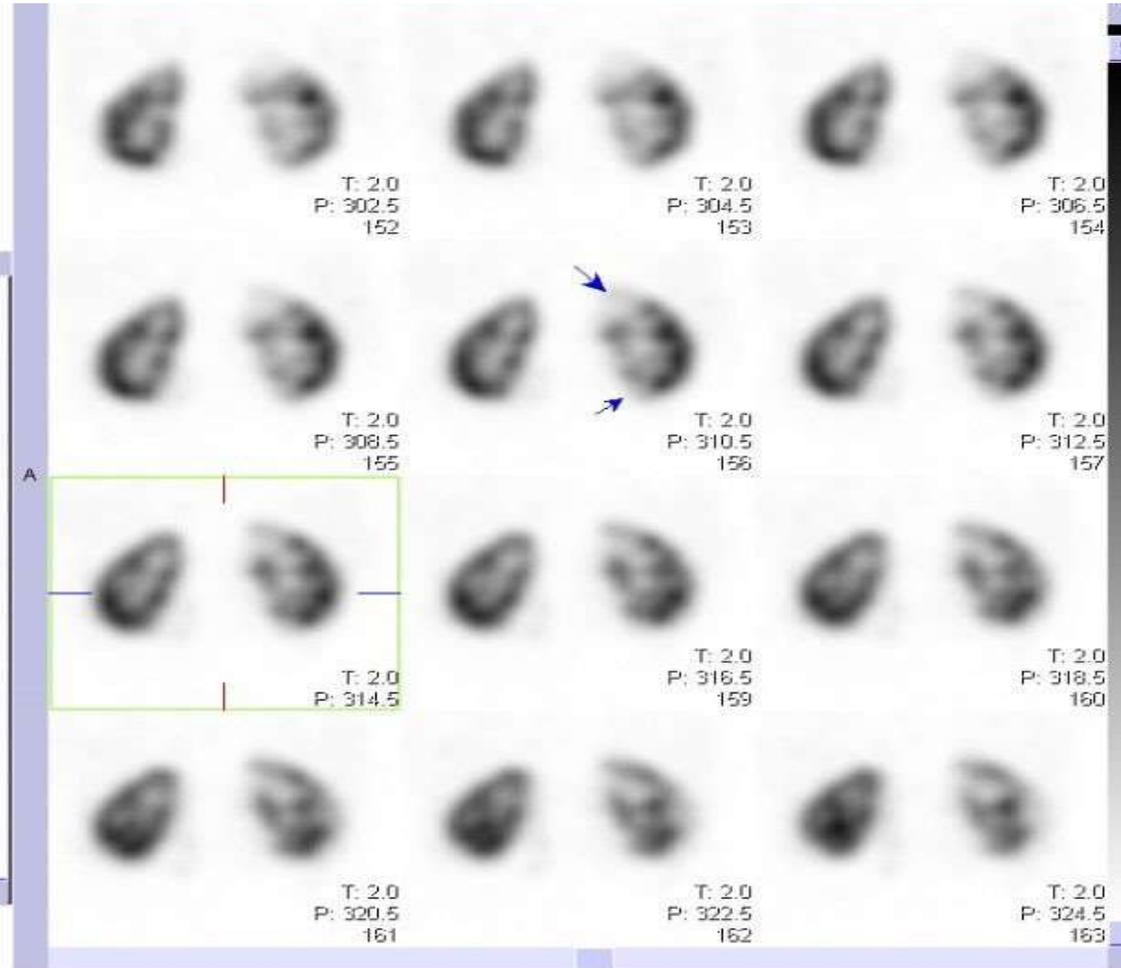
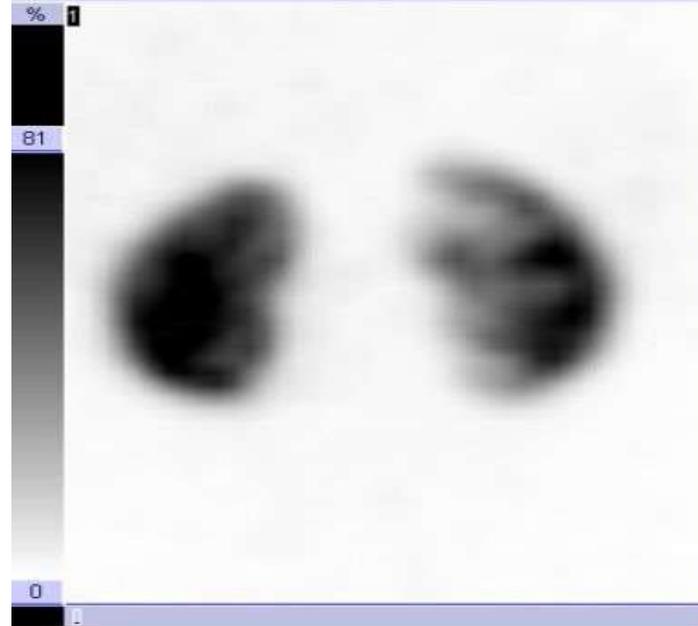
Often impossible to determine acute pyelonephritis or scarring, repeat imaging over several months may be required to distinguish the two .

# Acute pyelonephritis

5/9/2014, M, BY 

STUDY #  
**Children Medical Center Hospital**  
1000 N. **Nuclear Medicine Department**

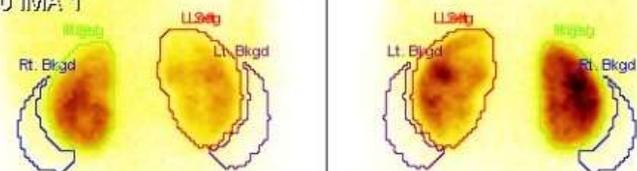
Tomographic [Isotope (A) - Recon - NoAC] 5/9/2022



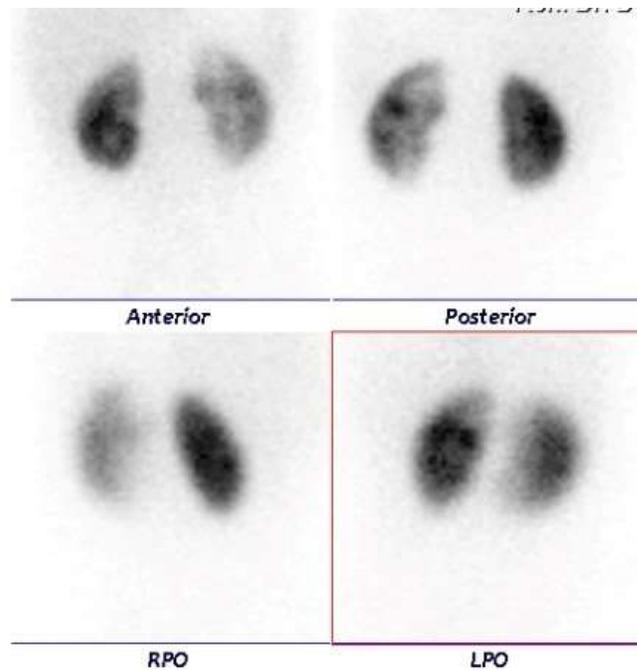
DMSA [Differential Function] 05/09/2022

STUDY 1

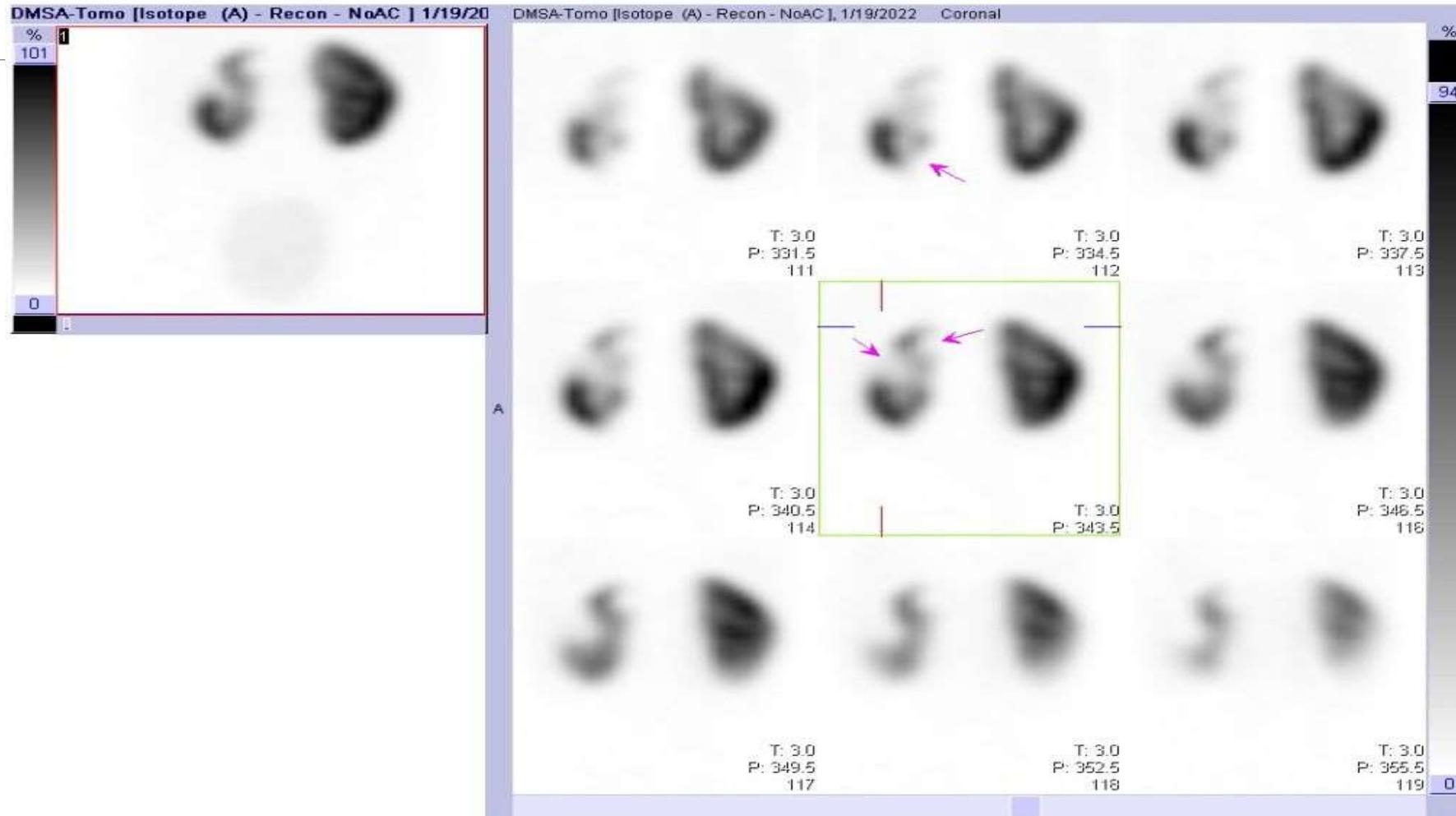
1000 IMA 1



(Counts)	Geometric Mean	
	Left	Right
Total	047K	058K
(% Ratios)	Left	Right
Total	44.68	55.32



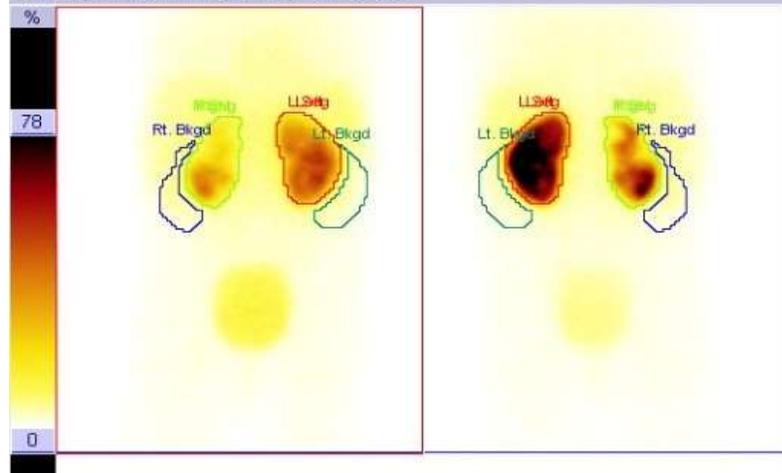
# Chronic pyelonephritis





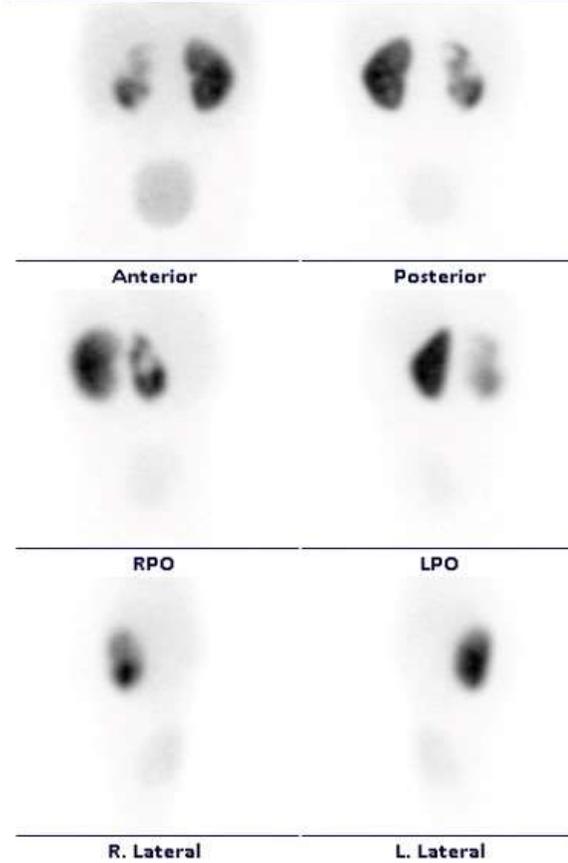
### CMC Hospital Nuclear Medicine Department

DMSA [Differential Function] 01/19/2022



Geometric Mean		
(Counts)	Left	Right
	251K	104K
Total	251K	104K
(% Ratios)	Left	Right
	70.60	29.40
Total	70.60	29.40

DMSA [Reformatted Series] 01/19/2022



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DMSA at the time of an acute UTI provides information about the extent of renal parenchymal involvement.

Some suggest that DMSA as the initial imaging to identify children at higher risk for renal scarring (the "top down" approach)

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**NICE guidelines** : DMSA 4 -6 months after acute infection

- for children younger than three years with atypical or recurrent UTI
- for children older than three years with recurrent UTI .

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DMSA 4-6 months after UTI in :

- Recurrent UTI,
- VUR grade III-V
- Those who have high risk of renal scarring (i.e. scarring visible on US or clinical symptoms: hypertension, albuminuria).

	Age of patients	Ultrasound (US)	VCUG	DMSA
NICE	<6 months	All children	Atypical/recurrent UTI	Atypical/recurrent UTI
	6 months–3 years	Atypical/recurrent UTI	Atypical/recurrent UTI <b>AND</b> specific features <sup>a</sup>	Atypical/recurrent UTI
AAP	>3 years	Atypical/recurrent UTI	Not indicated	Recurrent UTI
	≤24 months	All children	Abnormal US or other specific circumstances	–
Italian	≤36 months	All children	Abnormal US or risk factors <sup>b</sup>	Abnormal US or VUR
CPS	<2 years	All children	Abnormal US; recurrent	Only when diagnosis of
	>2 yrs.	Not specified	UTI in children <2 years	UTI is in doubt
Polish	<2 years	All children	Atypical/recurrent	RECURRENT pyelonephritis,
	>2 years	Pyelonephritis, atypical/recurrent UTI or risk factors for recurrent UTI <sup>c</sup>	febrile UTI; abnormal US; positive family history for VUR	VUR III-V
EAU/ESPU	All children		Either VCUG or DMSA is indicated in bottom-up or top-down approach	

# CT scan and MRI in UTI

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**CT** : important for detecting hydronephrotic changes, abscess and stones.

**MRI** : a problem-solving imaging if CT is not diagnostic.

CT and MRI are ideal for detection of complications related to UTIs such as renal abscess and also to follow up the response to medical treatment and percutaneous drainage

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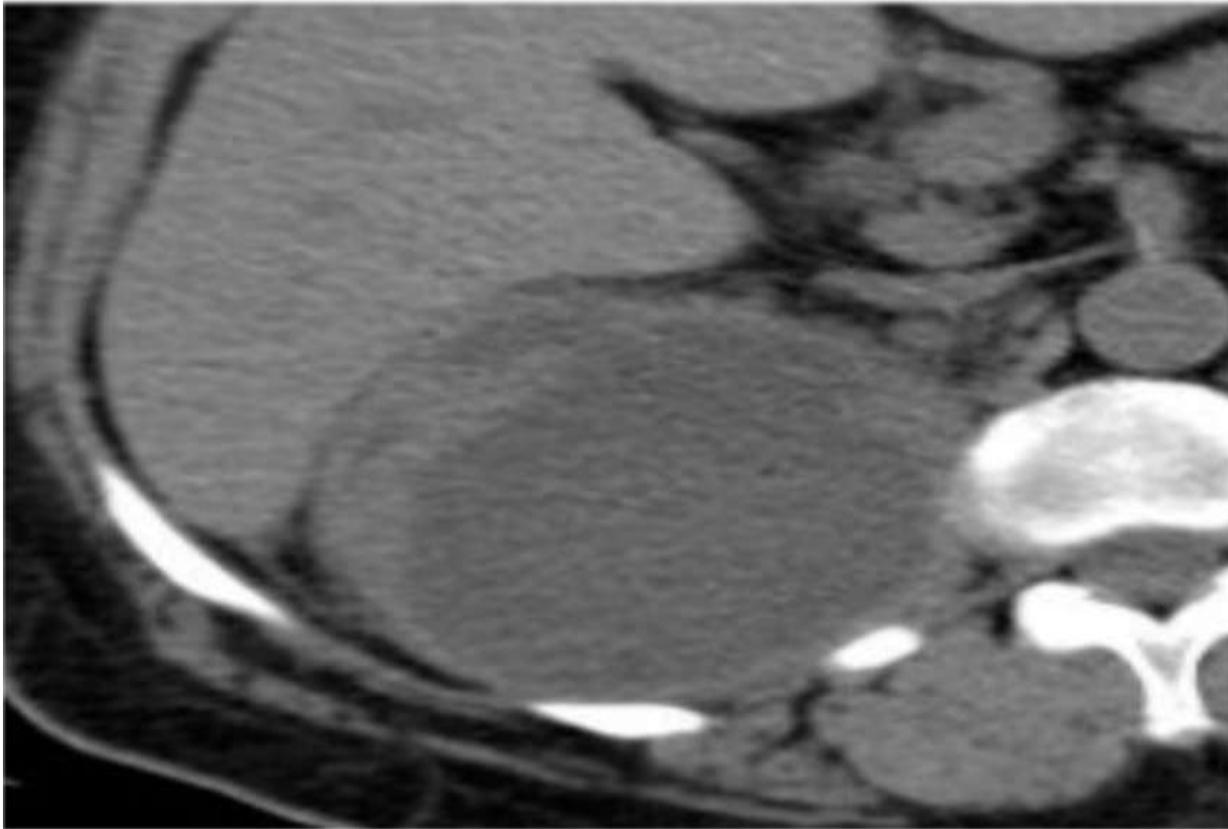
**Renal abscess** : hypodense geographic or rounded non-enhancing fluid collection at contrast-enhanced CT

CT can easily detect extrarenal extension of the abscess into the perinephric spaces and adjacent organs.

CT guided aspiration and tube drain is a preferable method for minimally invasive treatment of renal abscess in case of difficult ultrasound approach

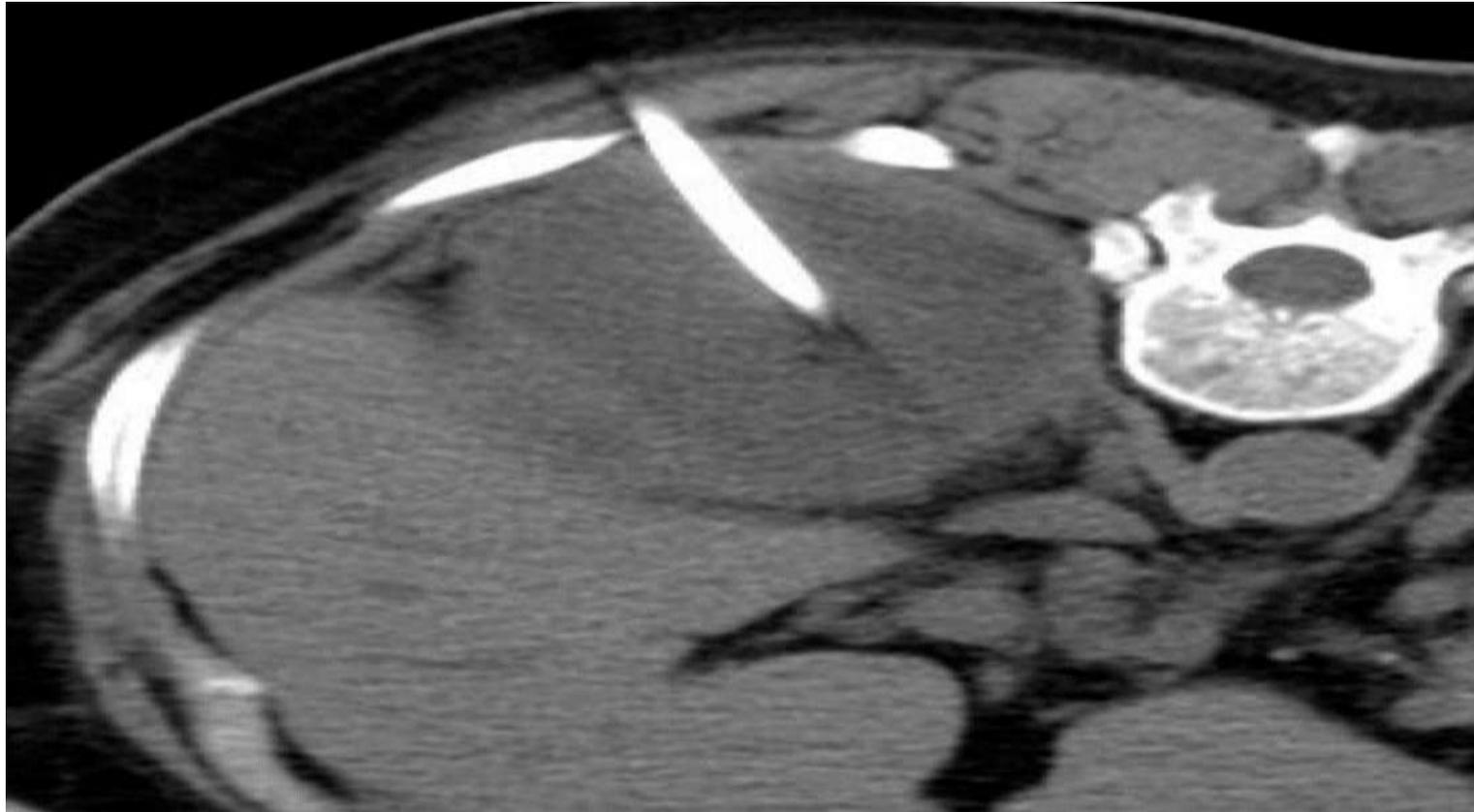
# Right renal abscess

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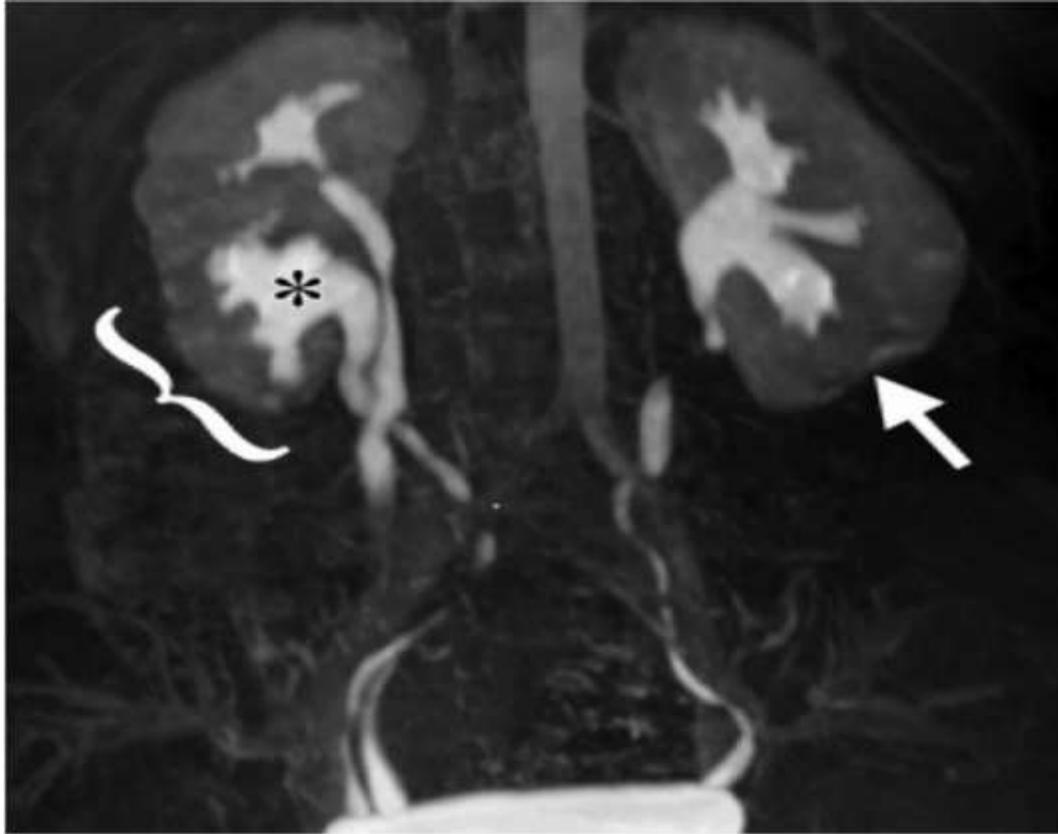
## CT guided tube drain of the right renal abscess

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MR urography (MRU) can detect hydronephrotic changes in cases of urinary tract obstruction and extension of perirenal inflammation.



MR urogram in a 6-year-old girl with right duplex kidney shows two right-sided collecting systems and ureters, right lower moiety mild pelvicaliectasis (\*) (“drooping lily” appearance) due to vesicoureteral reflux, and extensive scarring in the right kidney lower moiety parenchyma (bracket) and left kidney lower pole (arrow)





**THANK YOU**

**FOR LISTENING**