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## Radiographic Imaging

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*Lane S. Palmer*

**Abstract** The evaluation of children with urologic complaints or possible congenital anomalies cannot go forward without proper imaging. The mainstay of this imaging includes ultrasonography, voiding cystourethrography (VCUG), and nuclear scintigraphy. Each modality has its distinct indications and complements each other with the goal of defining the normal or anomalous genitourinary tract. Ultrasound allows for excellent screening of the kidneys and bladder in children presenting with various complaints, primarily urinary tract infections, or for various syndromes that affect the urinary tract; moreover, it serves to confirm prenatal ultrasound findings. VCUG, while invasive, is the gold standard for determining the presence of vesicoureteral reflux and is helpful in documenting other anomalies such as posterior urethral valves, ureteroceles, and diverticulae. Nuclear studies provide helpful information regarding differential function as well as drainage (MAG3) but can also help in determining parenchymal integrity (DMSA); i.e., scarring versus pyelonephritis. Finally, ultrasound and nuclear studies are vital adjunctive studies to help define scrotal pathology, both acute and chronic.

**Keywords** Radiology · Pediatric urology · Ultrasound · Children · Congenital

### INTRODUCTION

The mainstay of imaging the genitourinary tract of children remains the ultrasound, voiding cystourethrography (VCUG), and diuretic renography. Using these three modalities, the nature of the genitourinary tract remains ambiguous in very few children. In the few cases where there remains a question regarding the status of the urinary tract, improvements in CT and MRI now offer us superior adjunctive studies and may be the definitive study. Spiral CT offers considerable benefits for investigating stone disease, trauma, and tumor staging. MRI continues to mature as an imaging study for complex anomalies but also may have a role in evaluating obstruction and infection (1, 2). In this chapter, we will not go into significant depth into

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the anomalies of the genitor-urinary tract as they will be covered in other chapters but we will rather review the imaging findings associated with these anomalies.

## IMAGING MODALITIES

*Ultrasound:* Ultrasound is the most commonly performed study of the urinary tract. It is a quick study to perform, provides very good anatomic detail, and is non-invasive without the use of ionizing radiation. There are several indications for performing ultrasound in children (Tables 2.1 and 2.2), including detecting anatomic abnormalities that may explain the etiology of urinary tract infections (3), and the primary study of the acute scrotum in many institutions (4). It is routinely performed prenatally as a screening tool for congenital anomalies.

The evaluation of the urinary tract in children should routinely include the kidneys (Fig. 2.1) and the bladder. The images of the kidneys should be

Table 2.1  
Indications for performing renal and bladder ultrasound in children

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Urinary tract infection – febrile
Urinary tract infection – recurrent non-febrile
Voiding dysfunction
Prenatal renal abnormality
Renal colic
Palpable abdominal mass
Single umbilical artery
Hypertension
Hematuria
Proteinuria
Family history polycystic kidney disease
Hemihypertrophy
Azotemia
Urinary retention
Syndrome associated with renal involvement (e.g., Tuberous sclerosis, CHARGE, VACTERL, WAGR, Beckwith-Wiedeman, etc.)
Surveillance of
Vesicoureteral reflux
Nephrolithiasis
Hydronephrosis
Cystic renal disease
Neurogenic bladder dysfunction (e.g., myelodysplasia)
Obstructive uropathy (e.g., posterior urethral valves)

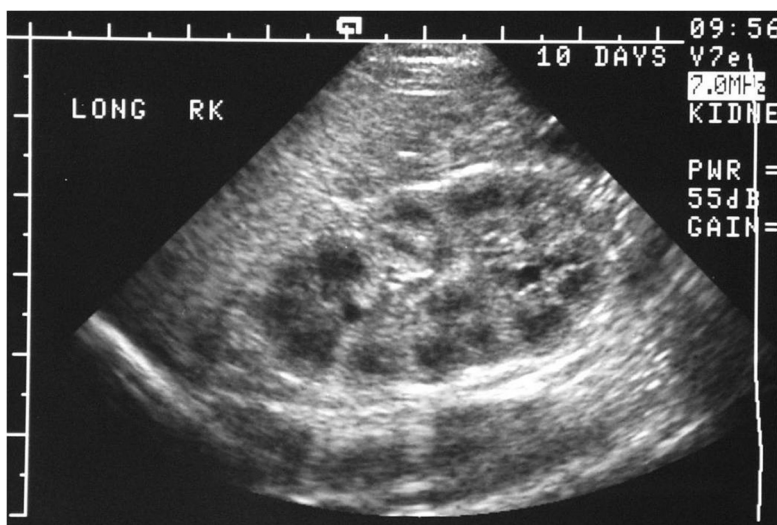
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Table 2.2  
Indications for performing  
scrotal ultrasound  
in children

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Palpable intrascrotal mass
Acute scrotal pain
Acute scrotal swelling
Chronic scrotal pain
Chronic scrotal swelling
Varicocele
Testicular asymmetry

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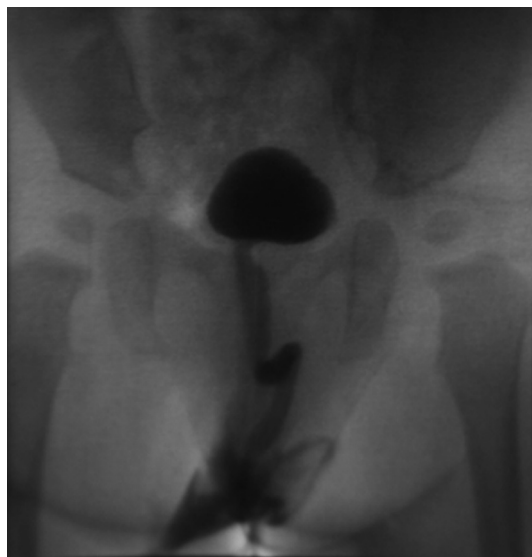
**Fig. 2.1.** Normal renal sonogram demonstrating reniform shape, parallel orientation to psoas major, central echogenic focus (correlates with pelvis, sinus fat, vasculature), surrounded by homogeneous parenchyma.

taken in both longitudinal and transverse views assessing renal length (compared against nomograms) (5), grade of hydronephrosis (using the Society for Fetal Urology grading system) (6), presence of any renal scarring, and the presence of duplication anomalies, cystic renal disease, and dilation of the proximal ureter. Bladder ultrasound should evaluate bladder volume and post-void residuals. It should also evaluate for such anomalies as ureteroceles, bladder masses, dilated distal ureters, or other pelvic abnormalities.

Scrotal ultrasound should include Doppler. In a child with scrotal pain, the study is limited by the fact that it is user-dependent and requires probe

placement over the painful area; however, it avoids radiation and is readily available. The study should be performed in the longitudinal and transverse plains to assess testicular symmetry and architecture. It will also evaluate the scrotum for extratesticular pathology.

**Contrast VCUG:** Contrast VCUG remains the preferred imaging study of the pediatric bladder. In most cases the VCUG (Fig. 2.2) provides excellent anatomic information as well as functional information on the bladder and urethra. The study starts with a plain film prior to catheterization that may detect sacral or bony abnormalities, spinal dysraphism, and abnormal bowel gas patterns and constipation. Following catheterization, contrast is instilled and an early anteroposterior film should be performed to assess for a ureterocele or bladder tumor. To evaluate for vesicoureteral reflux, steep oblique views of the bladder and renal fossae are taken just before and during voiding. Post-void images of the bladder will assess bladder emptying and urethral anomalies. The urethral catheter need not be removed during voiding (7).



**Fig. 2.2.** Normal VCUG in a boy with smooth bladder, absence of reflux, normal urethra.

### ***Nuclear Imaging***

**Kidney:** There are two types of nuclear imaging of the kidney. Static renal scans assess abnormalities of the cortex such as infection and scarring using  $^{99m}\text{Tc}$ -dimercaptosuccinyl acid (DMSA). Diuretic renography involves intravenous injection of a radiotracer that is reabsorbed by the tubules ( $\text{MAG}_3$  or DTPA), timely injection of a diuretic (furosemide,

1 mg/kg), and bladder catheterization. Hydration before the administration of the radiotracer prevents artificially poor tracer uptake. The split renal function is measured in the first 2 min.  $\text{MAG}_3$  produces less background activity than DTPA and therefore is currently favored. Furosemide is typically administered at the peak of tracer uptake or at 20 min post-injection of tracer. The time needed for drainage of 50% of the tracer ( $t_{1/2}$ ) correlates with the obstructive state of the kidney. Standardization of this study has been proposed to best avoid many of the confounders of accurate interpretation (8).

**Bladder:** Radionuclide cystography provides limited information regarding bladder anatomy or function. Catheterization of the bladder is required and the tracer is instilled. Reflux can only be graded as mild, moderate, and severe. The utility of radionuclide cystography is limited relative to the contrast VCUG.

**Scrotum:** The blood flow to the testicles can be assessed by injecting  $^{99\text{m}}\text{Tc}$ -pertechnetate intravenously and the testes evaluated in an immediate and delayed fashion.

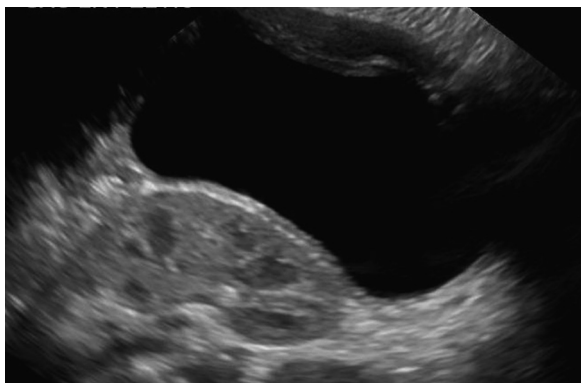
## ANOMALIES OF THE KIDNEY

### *Unilateral Renal Agenesis*

The absence of a kidney is often suspected on prenatal sonogram, during evaluation of the urinary tract after infection, or incidentally during evaluation of other organ systems for non-urologic complaints. On plain film, loops of bowel will occupy the renal fossa. On ultrasound, the renal fossa will be empty and the adrenal gland in the normal position. The absence of functioning renal tissue in the abdomen or pelvis on DMSA, MR, or CT confirms the diagnosis. VCUG, either contrast or radionuclide, should be performed as vesicoureteral reflux is commonly seen in these cases (9).

### *Renal Ectopia*

Kidneys develop in the bony pelvis and ascend during embryogenesis to their typical location in the flank. However, kidneys may be found in the pelvis (rarely the chest) or crossed to the contralateral side either fused or unfused. Ectopic kidneys can be detected on ultrasound (Fig. 2.3), IVU, CT, or MR. The horseshoe kidney, the most common fusion anomaly (Fig. 2.4), can be suspected when both kidneys are malrotated and caudally positioned on ultrasound, CT, or MR. Horseshoe kidneys are at risk for UPJ obstruction. The isthmus that separates the two kidneys may demonstrate function on nuclear scintigraphy (DMSA or  $\text{MAG}_3$ ). Ultrasound should be performed regularly to screen for Wilms' tumor and followed by CT or MR if suspected.



**Fig. 2.3.** Ectopic kidney located in the pelvis behind the bladder.



**Fig. 2.4.** Horseshoe kidney found in the pelvis with fusion of the lower poles.

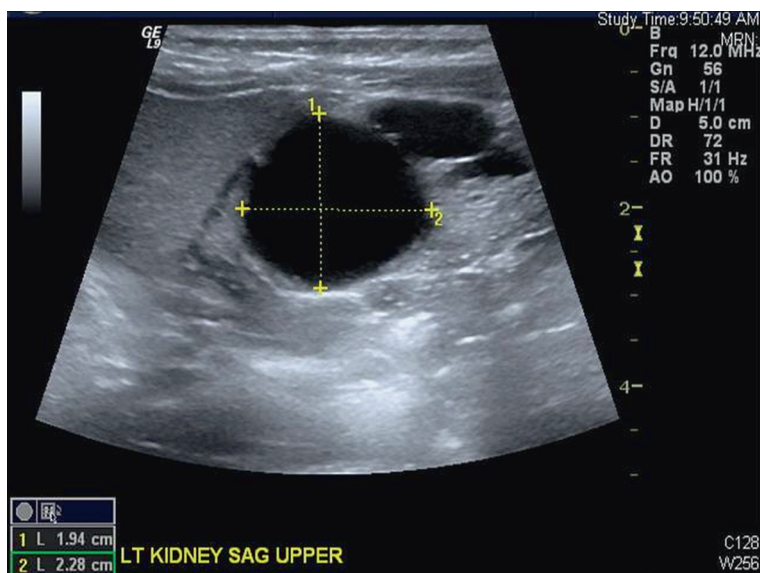
### *Renal Cystic Diseases*

Autosomal recessive polycystic kidney disease (ARPCD) – ultrasound is well suited to make the diagnosis of ARPCD. Both kidneys are reniform in shape but very large and hyperechoic. The ectatic dilated tubules create numerous interfaces that is responsible for the increased echogenicity.

Autosomal dominant polycystic kidney disease (ADPCK) – on ultrasound, ADPCK will demonstrate bilateral multiple renal cysts of variable size. In the early phase, the cysts are fewer in number and the parenchyma demonstrates normal corticomedullary differentiation and echogenicity. Later, the cysts grow and compress the renal parenchyma. Very large cysts

may distort the renal pelvis. MR or CT are best to assess hemorrhage into a cyst if there is suspicion on ultrasound.

**Multicystic dysplastic kidney (MCDK)** – The ultrasound findings in these cases include non-communicating multiple cysts of variable size and a paucity of renal parenchyma (Fig. 2.5). It can sometimes be challenging to distinguish MCDK from a severely hydronephrotic kidney. In MCDK, the largest cyst is not typically in the center and there will be no function on nuclear scintigraphy. Ultrasound can be used to follow children with MCDK as these cysts often involute and the renal unit contracts or disappears and to assess the contralateral kidney where abnormalities can be found in roughly 40%. VCUG is indicated to evaluate for vesicoureteral reflux into the stump of the MCDK or into the contralateral kidney (10).

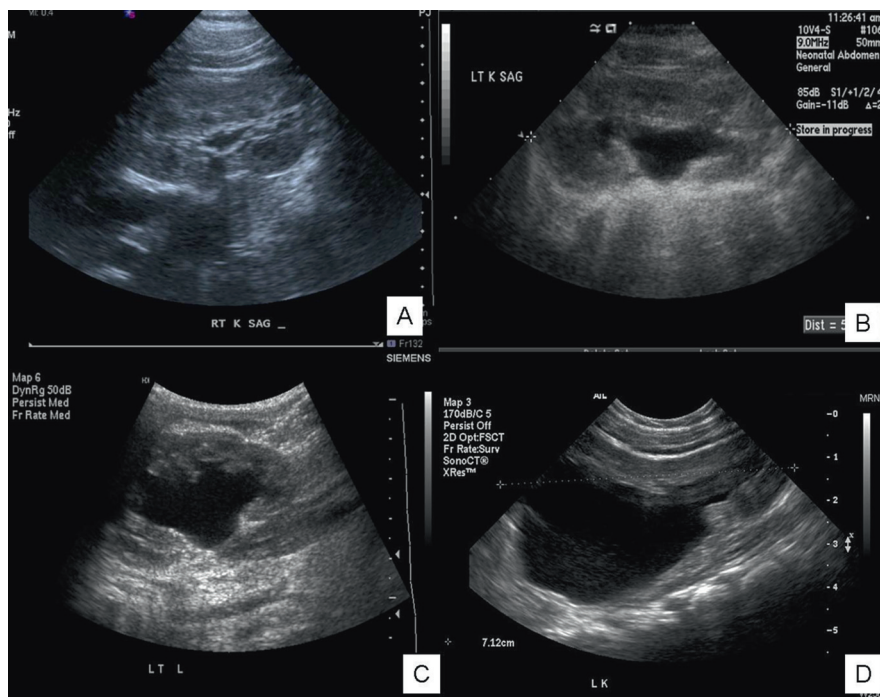


**Fig. 2.5.** Multicystic dysplastic kidney demonstrating multiple cystic structures that fail to communicate and the absence of normal parenchyma.

### *Hydronephrosis*

The most common ultrasound finding in the kidney is hydronephrosis (11). Prenatally, the renal pelvis is measured in the anteroposterior dimension to assess the risk of a uropathy (12, 13). Postnatally the presence of hydronephrosis is assessed using the Society for Fetal Urology Grading System (Fig. 2.6). By this system, the highest grade of hydronephrosis is associated with significant renal parenchymal thinning. It is important to distinguish hydronephrosis from the normal renal pyramids. Pyramids are small and ovoid or round hypoechoic areas that are radially distributed around the kidney.





**Fig. 2.6.** Hydronephrosis according to the Society for Fetal Urology grading system: (a) 1-mild pelvic dilation, (b) 2-moderate pelvic dilation, (c) 3-dilation including calyces, normal parenchyma; (d) 4-calyceal dilation and parenchymal thinning.

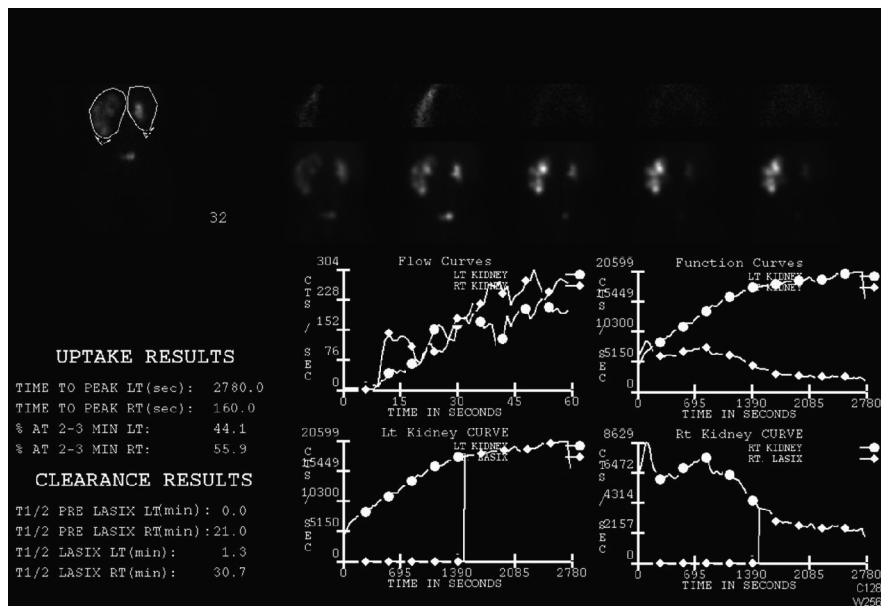
Hydronephrosis can be primary or secondary. Primary hydronephrosis may obstructive or non-obstructive. Secondary hydronephrosis may result from many of the processes described below. The presence of hydronephrosis will often indicate a need for VCUG to detect vesicoureteral reflux, posterior urethral valves, or other pathology. Diuretic renography can be performed to assess for obstruction and to determine the split renal function. It is possible that MR may serve this role in the future (2, 14).

### ***Ureteropelvic Junction (UPJ) Obstruction***

As mentioned earlier, hydronephrosis can be noted by several modalities such as US, CT, MR, and IVU. The Society of Fetal Urology Grading System (6) can be used to describe the extent of dilation. Pelvic dilation without extension into the calyces constitutes grades 1 and 2. Extension of hydronephrosis into the calyces defines grade 3 while thinning of parenchyma defines grade 4. When there is intermittent obstruction and flank pain, the grade of hydronephrosis may appear less impressive than expected (15).



The etiology of the hydronephrosis needs to be defined. VCUG will be performed to assess for vesicoureteral reflux. To determine if obstruction is present, the diuretic renogram using either  $\text{MAG}_3$  or  $\text{DTPA}$  remains the gold standard. Standardization of the technique of this study has reduced the confounding variables associated with its interpretation and determination of split renal function and radiotracer washout following furosemide administration. A  $t_{1/2}$  value of  $>20$  min and specific drainage curves establishes the presence of obstruction (Fig. 2.7).



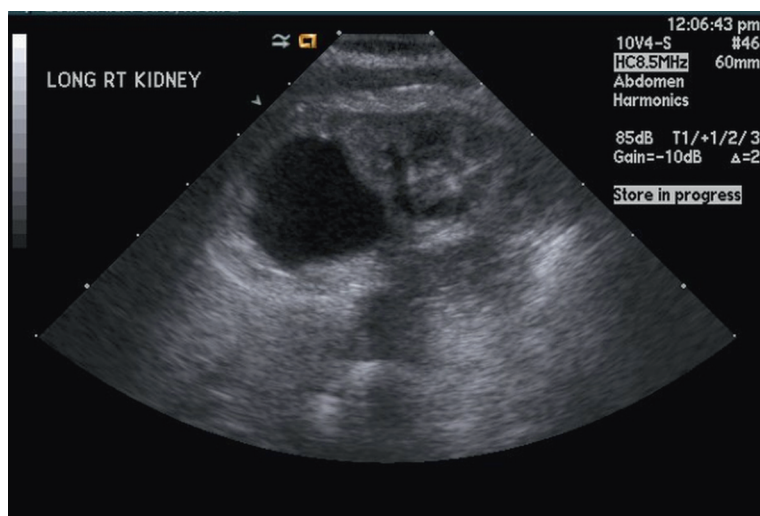
**Fig. 2.7.** Diuretic renogram with  $\text{MAG}_3$  demonstrating flat drainage after furosemide administration.

The etiology of obstruction differs in young children and older children. The younger children tend to be obstructed by an intrinsic narrowing of the ureter at the ureteropelvic junction. Older children and adults are often obstructed by vessels crossing anteriorly to the lower pole of the kidney causing impingement. Retrograde pyelography can establish the diagnosis as a linear filling defect. CT (16) with contrast or by MR may identify the vessels and their course.

### *Collecting System Duplication*

Duplication of the renal collecting system is common and may be incomplete or complete (17). Most cases are inconsequential while others are associated with clinically significant anomalies such as ureterocele, ectopic ureters, ureteropelvic junction obstruction, or reflux. Duplications may be detected on prenatal ultrasound or postnatally following a clinical event.

Renal and bladder ultrasound can help detail the nature of the duplication. The kidney may reveal two central echogenic foci separated by a bar of renal parenchyma. The renal parenchyma may have normal echotexture or it may be hyperechoic due to dysplasia from reflux or obstruction. Hydronephrosis may or may not be present in either of the two collecting systems (Fig. 2.8). The bladder is normal in thickness, distension, and contour. The ureters may not be visible or may be visible proximally and/or distally.



**Fig. 2.8.** Ultrasound of duplicated collecting system with hydronephrosis of the upper pole moiety.

The VCUG and diuretic renogram may be needed to provide additional diagnostic information. The lower pole system is more likely to be associated with vesicoureteral reflux (Fig. 2.9) that should be graded according to the International Grading System (18) as well as ureteropelvic junction obstruction. Obstruction at the level of the bladder from ureteral ectopia or ureterocele is more common in the upper pole system. The “drooping lily” is a classic finding on IVU, reflecting an obstructed upper pole duplication producing the downward and lateral displacement of the lower pole. VCUG should be performed using a non-ballooned catheter; dilute contrast and images during the early filling phase should detect a ureterocele or the location of an ectopic ureteral orifice and any associated reflux. Obstruction will be determined by the  $t_{1/2}$  and washout curve of a diuretic renogram.

### ***Stones***

The presence of renal or ureteral calculi is best seen on non-contrast CT or by ultrasound. Ultrasound is less useful in detecting small stones. Larger ones will appear as echogenic foci with posterior shadowing, which helps

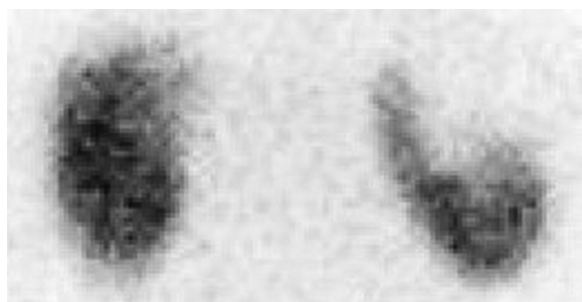


**Fig. 2.9.** VCUG demonstrates vesicoureteral reflux into the lower pole collecting system without contrast in the upper pole.

to distinguish the stone from fat or blood vessels. Hydronephrosis behind the stone can often be seen. Non-contrast thin slice (3–5 mm) CT is the best imaging study to define the presence of stones (19). In addition, CT will accurately define stone location, size, number, and associated hydronephrosis. The speed of spiral CT precludes the need for sedation in most children. CT is also superior to ultrasound in documenting bladder stones especially in augmented bladders.

### ***Pyelonephritis***

Signs of renal inflammation can be detected on renal scintigraphy, MR, CT, and ultrasound. Static renal scintigraphy using  $^{99m}\text{Tc}$ -dimercaptosuccinyl acid (DMSA) can detect cortical abnormalities such as infection and scarring. Images are acquired every 2–4 h in the anterior, posterior and oblique views (Fig. 2.10). The study needs to be repeated about



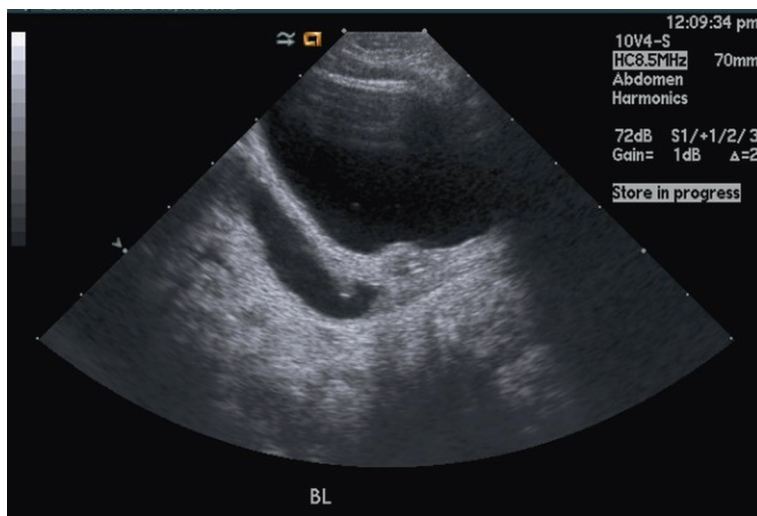
**Fig. 2.10.** DMSA scan of child with clinical pyelonephritis demonstrating poor uptake of tracer in the upper pole of the left kidney.

4 months later to differentiate cortical scarring from acute infection. MR may play a larger role in the future in making this distinction (*1*). On CT, there may be wedge-shaped segments of low attenuation radiating toward the surface from the collecting system, variable hydronephrosis, enlarged size, and delay in uptake of contrast. Similarly, ultrasound findings include enlarged size and heterogeneous echotexture from edema and pelvic dilation; these should resolve after treatment.

## ANOMALIES OF THE URETERS

### *Megaureter*

Megaureter is a wide ureter larger than 7 mm in diameter. The causes can be divided into refluxing, obstructive and non-refluxing, non-obstructive, or primary megaureter that corresponds to their radiographic findings. After ultrasound identifies the dilated ureter (Fig. 2.11), contrast VCUG will identify primary high-grade vesicoureteral reflux or secondary to posterior urethral valves, ureterocele, or neurogenic bladder dysfunction. When reflux is absent, obstruction will be evaluated by diuretic renogram ( $t_{1/2} > 20$  min). In equivocal cases, IVU or MRU (*20*) or CT may offer greater anatomical detail revealing a congenital stricture, ureteral valve, or the location of an ectopic ureteral orifice.

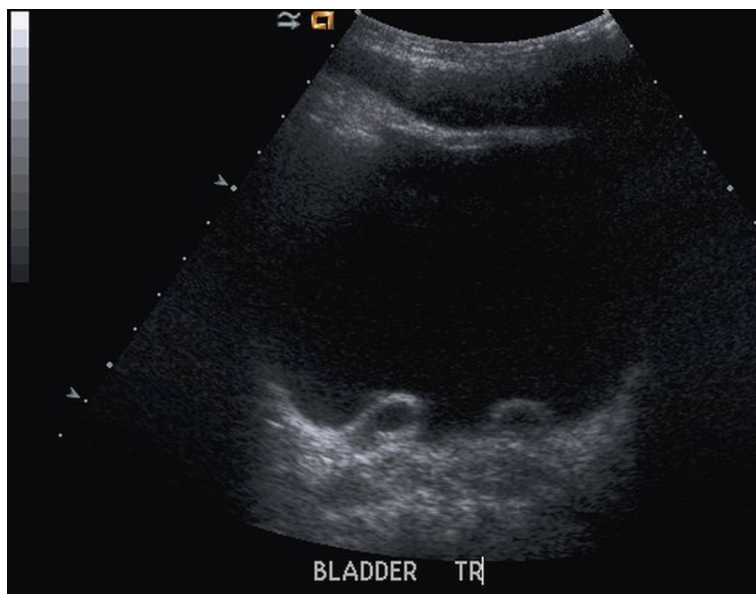


**Fig. 2.11.** Ultrasound of the bladder demonstrating elongated hypoechoic structure posteriorly consistent with dilated ureter.

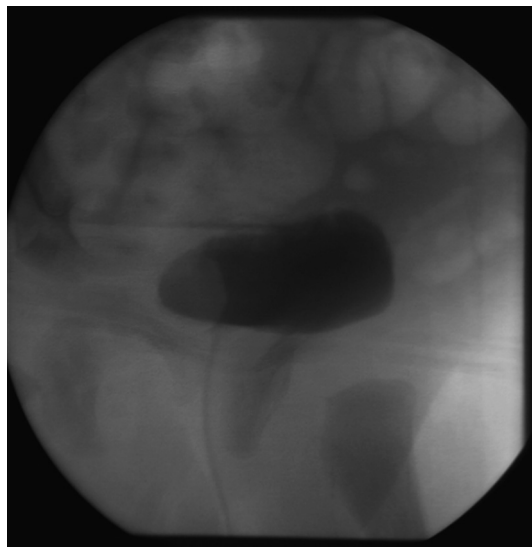
### *Ureterocele*

Proper imaging of the child with a ureterocele requires renal and bladder ultrasound, VCUG, and diuretic renography. This is true because ureteroceles may be associated with reflux, obstruction, and either single or duplicated collecting systems. Ultrasound (Fig. 2.12) is the most effective modality for identifying the presence of the ureterocele as a round thin-walled cystic structure at the base of the bladder; the size of the ureterocele is variable as is the amount of hydroureteronephrosis (21). The contralateral ureter may also be dilated if the ureterocele impinges on the contralateral orifice retarding urine passage or weakening the integrity of the antireflux mechanism, or obstructs the bladder outlet raising bladder pressures.

VCUG (Fig. 2.13) should be performed to better assess the ureterocele and its effect. Ureteroceles appears as filling defects, of variable size, within the bladder. The use of dilute contrast and early imaging are necessary to avoid obscuring the ureterocele with dense contrast or effacing the ureterocele by an over-distended bladder. The everted ureterocele is the one that appears to be outside of the bladder and may be misdiagnosed as a bladder diverticulum (22). Vesicoureteral reflux may be present in any ureter but is most likely to affect the ipsilateral lower pole system. Postoperative VCUG is important particularly following cystoscopic puncture where iatrogenic creation of reflux is the most common complication. Diuretic renography will determine the split renal function and the drainage patterns of all renal moieties. Each moiety should be considered a distinct region of interest.



**Fig. 2.12.** Small bilateral ureteroceles seen on ultrasound along floor of the bladder.



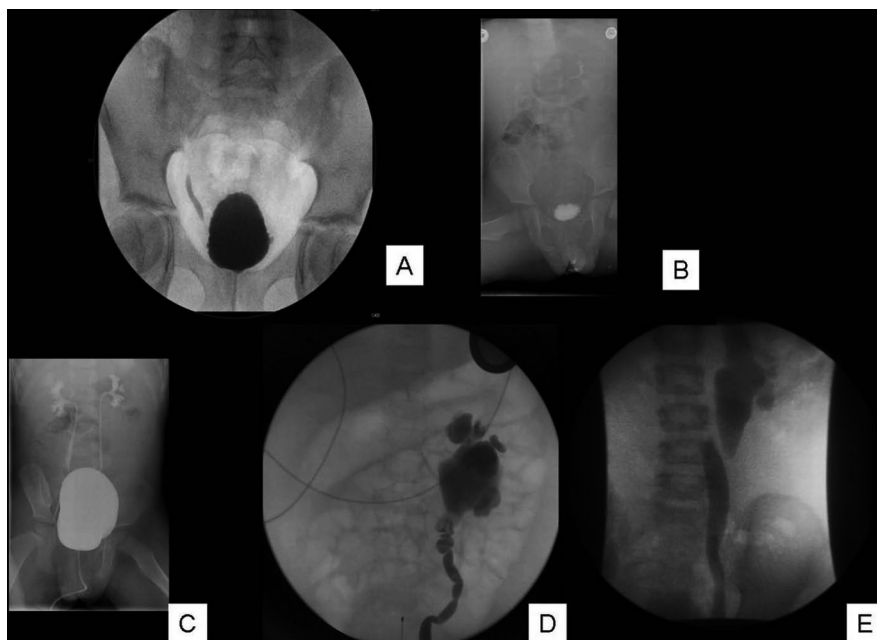
**Fig. 2.13.** VCUG demonstrating moderate sized filling defect on the right side of the bladder consistent with a ureterocele.

Although performing an IVU is not commonplace today, two classic findings of ureteroceles are worthy of mention. The “cobra head” or “spring onion” findings reflect the radiolucent ureterocele wall surrounding the contrast-filled ureterocele. The “drooping lily” represents downward and lateral lower pole displacement by the hydronephrotic obstructed poorly functioning upper pole system.

## ANOMALIES OF THE BLADDER

### *Vesicoureteral Reflux*

Vesicoureteral reflux is diagnosed most commonly after hydronephrosis is detected prenatally or during the work up of a urinary tract infection. Ultrasound may demonstrate normal kidneys and ureters or various degrees of hydronephrosis or hydroureteronephrosis. The degree of hydronephrosis does not necessarily correlate with the grade of vesicoureteral reflux (23). The single or duplicated nature of the collecting system will also be assessed. The presence of cortical scarring associated with reflux and urinary tract infections is not well detected by ultrasound. If scarring is extensive, there may be an irregular renal contour, loss of corticomedullary differentiation, or a contracted kidney may be seen. DMSA and MR are superior studies to detect the presence of the scars and dysplasia. Ultrasound of the bladder likely shows a smooth walled bladder unless the child has posterior urethral valves or myelodysplasia where the bladders are considerably thickened. Dilated distal ureters may also be seen.



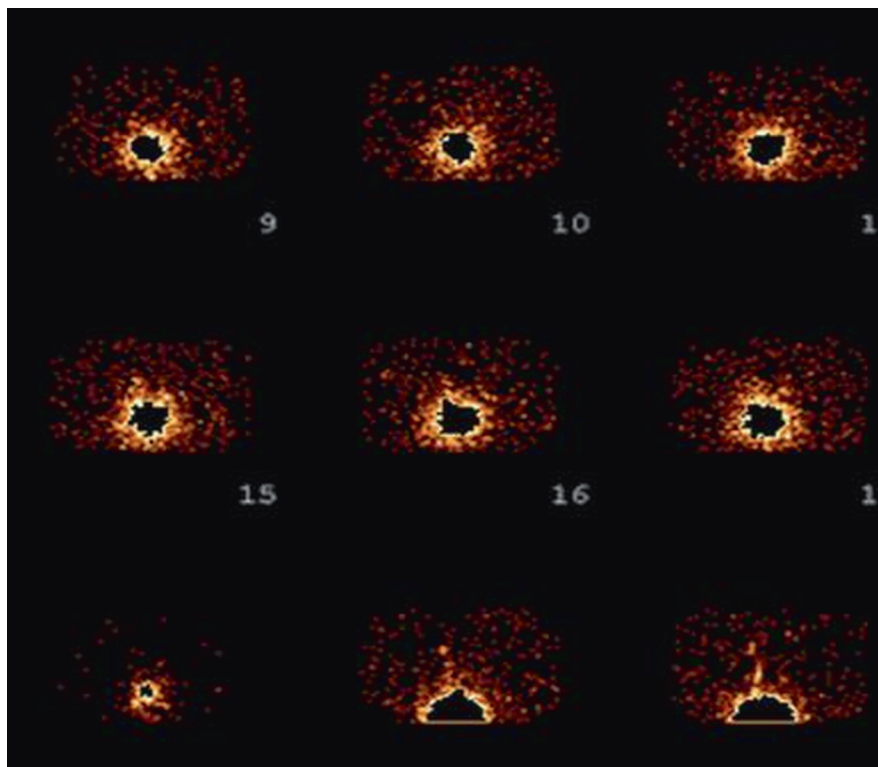
**Fig. 2.14.** Grades of vesicoureteral reflux according to the grading system of the International Reflux Study. (a) Grade 1 ureter only (b), Grade 2 into undilated pelvis (c), Grade 3 into mildly dilated pelvis, (d) Grade 4 into dilated calyces, and (e) Grade 5 into very dilated pelvis and blunting of all calyces.

Reflux should be graded after contrast VCUG (Fig. 2.14). Cyclical VCUG where the bladder is repeatedly filled and emptied may increase the sensitivity of the study to detect reflux. Grading is based on the International Reflux Study Grading System (I–V). Assessing the degree of ureteral dilation helps to plan for the need for ureteral tapering. The VCUG also evaluates the bladder for trabeculations, diverticulae, ureteroceles, and the urethral obstructive anomalies such as posterior urethral valves. Radionuclide VCUG (Fig. 2.15) is appropriate for use when the presence or absence of reflux is the only consideration, e.g., postoperatively, in follow-up of children on prophylactic antibiotics, and in screening of siblings without urologic complaints. The grading of reflux after radionuclide VCUG is less specific, i.e., mild, moderate, and severe.

### ***Neurogenic Bladder***

The neurogenic bladder is imaged by VCUG and ultrasound. The plain film taken at the beginning of a VCUG may demonstrate the spinal abnormality responsible for the neurogenic bladder. The infusion of contrast will fill the trabeculations, sacculations, and diverticulae. The “Christmas Tree” bladder (Fig. 2.16) from severe bladder hypertonicity is characterized by a vertical orientation and multiple diverticulae. Any associated reflux will





**Fig. 2.15.** Radionuclide cystogram demonstrates tracer only the bladder.



**Fig. 2.16.** VCUG from child with neurogenic bladder demonstrating elongation, diverticulae, and cellulules – “Christmas Tree bladder.”

be detected. An ultrasound will demonstrate bladder wall thickening, associated hydronephrosis or hydroureteronephrosis from reflux, or elevated bladder pressure. The ability of the bladder to empty can be assessed by identifying the extent of post-void residual.

### ***Bladder Diverticulum***

Bladder diverticulae occur in various settings and are best assessed by VCUG (24). Congenital out-pouching occurs posteriorly and are variable in size but may become larger than the bladder (Fig. 2.17). Paraureteral



**Fig. 2.17.** VCUG showing moderate sized diverticulum posterior to the bladder.



**Fig. 2.18.** Post-void image from a VCUG demonstrating bilateral Hutch, paraureteral bladder diverticulum in child with vesicoureteral.

(Hutch) diverticulae are also congenital and variable in size but may lead to reflux or prevent its spontaneous resolution (Fig. 2.18). As mentioned above, bladder outlet obstruction or neurogenic dysfunction may lead to multiple diverticulae reflecting high bladder pressures. Ultrasound may demonstrate bladder wall thickening but can miss identifying diverticulae unless they are substantially larger. There will be a hypoechoic area in the pelvis that may demonstrate its communication with the bladder. It may be difficult to distinguish very large diverticulae from the bladder itself. In the case of large diverticulae, anatomical considerations can be made as well as an assessment of the emptying of the diverticulum (Fig. 2.16).

## ANOMALIES OF THE URETHRA

### *Posterior Urethral Valves (PUV)*

Posterior urethral valves can lead to variable detriment to both the lower and upper urinary tracts. The point along the spectrum can be well-defined using the combination of renal and bladder ultrasound, VCUG, and nuclear scintigraphy. On ultrasound, hydronephrosis of all grades or hydroureteronephrosis may be seen. In the presence of severe renal damage, ultrasound may reveal parenchyma that is hypoechoic and sustained thinning as well as loss of corticomedullary differentiation, or cystic changes. The ureters will demonstrate variable amount of hydroureter. Bladder wall thickening from detrusor hypertrophy is commonly seen. On prenatal ultrasound, oligohydramnios can be seen in addition to hydronephrosis, normal to hyper-echoic renal echotexture, hydroureter, thick walled bladder, and a dilated prostatic urethra (25).

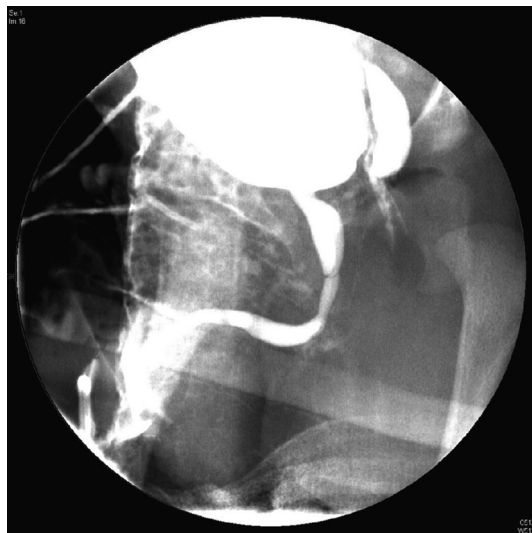
While posterior urethral valves may be suspected on ultrasound, the diagnosis is made by contrast VCUG (Fig. 2.19). The more common findings in the bladder and urethra includes trabeculations and saccules or diverticulae, a narrow bladder neck due to bladder neck muscular hypertrophy, a dilated and elongated posterior urethra, and an abrupt change in caliber at the external sphincter. Vesicoureteral reflux of any grade with possibly exaggerated dilation and tortuosity of the ureters may be present.

The role of diuretic renography is to provide information regarding differential renal function and urinary drainage. Of these bladders are associated with high bladder pressures and reflux that would cause considerable artifact such as retarded drainage; therefore, the insertion of a urethral catheter is crucial for this study.

When there are urine collections outside of the kidney secondary to forniceal rupture, ultrasound or CT are excellent imaging studies.

### *Other Urethral Anomalies*

*Anterior urethral valve:* Anterior urethral valves are not common but can cause obstruction of the urinary tract. In contrast to posterior urethral valves that are limited to the area of the prostaticmembranous portion of the urethra,



**Fig. 2.19.** VCUG in a neonate demonstrating irregular shaped bladder with dilated posterior urethra and sudden change in caliber at the location of the valve and vesicoureteral reflux into dilated ureters.

anterior urethral valves may be found in the penoscrotal, bulbar, or penile portion (anterior urethra). To best define the location and extent of obstruction and associated reflux, a VCUG is best performed. The anterior urethral valve typically appears as a linear filling defect ventrally with urethral dilation proximally and a narrowing distally or as an abrupt change in caliber. At times, the valve will appear as urethral dilation into a smooth bulge within the urethra. Ultrasound can be normal or demonstrate considerable hydroureteronephrosis depending on the obstructive nature of the valve.

*Megalourethra:* This uncommon anomaly may be divided into scaphoid or fusiform types. The scaphoid variant is more common and is due to deficiency of the corpora spongiosum. On VCUG, it appears as boat-like urethral dilation. The less common fusiform variant is due to deficiency of corpora cavernosum and it appears as a long floppy dilated urethra on VCUG.

*Prostatic utricle:* The utricle is a midline out-pouching arising in the area of the verumontanum and represent Mullerian system remnants. Infection may arise in either the urine or in the genital duct system. This will lead to imaging and detection of the utricle on VCUG. These are typically small but can be large and can be better defined using CT or MR.

## ANOMALIES OF THE TESTIS

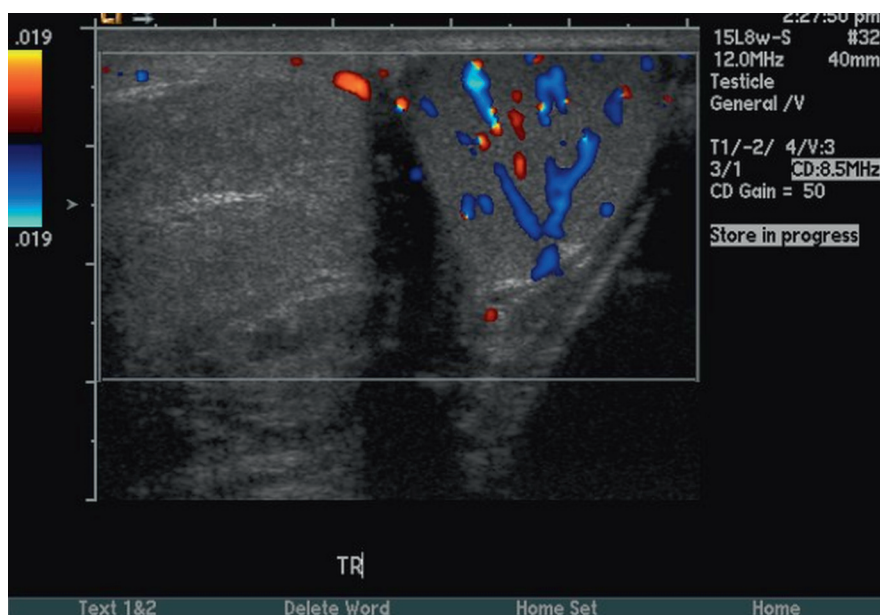
### *Acute Testicular Pain*

The general urologist is well acquainted with the most common causes of acute testicular or scrotal pain: testicular torsion, appendage torsion, and

epididymal inflammation. The mainstay of imaging children with pain in the scrotum is ultrasound with Doppler and nuclear scintigraphy.

Ultrasound (Fig. 2.20) is best at defining the combination of symmetry, architecture, and perfusion of the testicles. The technique was described early in this chapter. The study should start on the non-painful testis and then used to compare with the symptomatic side. The sonographic features of testicular torsion includes heterogeneity of the parenchyma associated with non-viability (26) (Fig. 2.21), echogenic parenchyma without detectable Doppler flow. The inflamed testis may also demonstrate a heterogeneous appearance but there will be ample flow or hyperperfusion of the testis and epididymis. Associated reactive hydroceles may be present with either diagnosis.

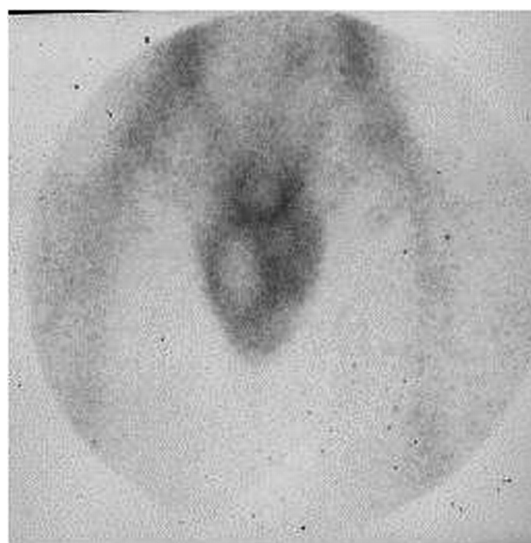
Nuclear scintigraphy using  $^{99m}\text{Tc}$ -pertechnetate cannot provide architectural information but effectively assesses testicular blood flow to both testes (Fig. 2.22). Symmetric activity reflects symmetric blood flow and excludes testicular torsion except in the case of intermittent torsion. When there is increased activity to the symptomatic testis, the diagnosis is likely epididymitis, orchitis, or inflammation secondary to torsion of an appendage. When there is acute testicular torsion, there will be absence of activity when compared with the unaffected side. The “donut sign” associated with missed torsion reflects a hyperemic rim of flow around a central area without tracer uptake.



**Fig. 2.20.** Transverse view of the scrotum showing both testes; the *left* has absent flow to the testis while the *right* one shows considerable Doppler signals.



**Fig. 2.21.** Ultrasound of the testis that has clinical history of acute pain from presumed torsion of 48 h duration. Heterogeneity of the parenchyma is clearly seen and is consistent with necrosis seen at the time of surgery.



**Fig. 2.22.** Nuclear scintigraphy of patient with acute onset of scrotal pain demonstrating absence of activity on the *right* side. The *left* side shows normal activity. Torsion of the testis was discovered at surgery.



## CONCLUSION

Any urologist treating children needs to have comfort with the proper imaging of the genitourinary tract. This comfort includes ordering the proper studies as well as their interpretation. The mainstay of imaging remains ultrasound, VCUG, and nuclear scintigraphy. With these three studies, the management of most congenital and acquired abnormalities of the genitourinary tract should be facilitated. While ultrasound is free of ionizing radiation, the other two studies are not without risk and are invasive in nature. However, advances in CT and MR may lead to future paradigm shifts that make imaging faster, more detailed, and free of radiation.

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