American College of Radiology
ACR Appropriateness Criteria®
Urinary Tract Infection–Child

Variant: 1 Child assigned male at birth (AMB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
Voiding urosonography	May Be Appropriate (Disagreement)	O
Fluoroscopy voiding cystourethrography	May Be Appropriate (Disagreement)	☢☢
MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
Nuclear medicine cystography	Usually Not Appropriate	☢☢
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
DMSA renal scan	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Variant: 2 Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
Voiding urosonography	May Be Appropriate	O
Fluoroscopy voiding cystourethrography	May Be Appropriate	☢☢
Nuclear medicine cystography	May Be Appropriate	☢☢
MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
DMSA renal scan	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Variant: 3 Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
Voiding urosonography	May Be Appropriate (Disagreement)	O
Fluoroscopy voiding cystourethrography	May Be Appropriate	☢☢
Nuclear medicine cystography	May Be Appropriate	☢☢

MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
DMSA renal scan	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Variant: 4 Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	May Be Appropriate (Disagreement)	O
Voiding urosonography	May Be Appropriate (Disagreement)	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
Nuclear medicine cystography	Usually Not Appropriate	☢☢
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
DMSA renal scan	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Variant: 5 Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
Voiding urosonography	Usually Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Appropriate	☢☢
Nuclear medicine cystography	May Be Appropriate	☢☢
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢☢
DMSA renal scan	May Be Appropriate (Disagreement)	☢☢☢
MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Variant: 6 Child. Established vesicoureteral reflux. Follow-up imaging.

Procedure	Appropriateness Category	Peds Relative Radiation Level
US kidneys and bladder	Usually Appropriate	O
Voiding urosonography	Usually Appropriate	O

Fluoroscopy voiding cystourethrography	Usually Appropriate	☢☢
Nuclear medicine cystography	Usually Appropriate	☢☢
MRU without and with IV contrast	May Be Appropriate (Disagreement)	O
DMSA renal scan	May Be Appropriate	☢☢☢
MRI abdomen and pelvis with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢☢

Panel Members

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Summary of Literature Review

Introduction/Background

Urinary tract infection (UTI) is a frequent bacterial infection during childhood, affecting approximately 2% of children assigned male at birth (AMAB) and 8% of children assigned female at birth (AFAB) by 7 years of age [1]. Diagnosis of UTI is made by history and physical examination findings and confirmed by urinalysis. UTI is defined by the presence of bacteria within the urine and is confirmed by a urine culture of at least 5×10^4 colony-forming units (cfu)/mL of the same bacterial species in a catheterized specimen or 10^5 cfu/mL in a voided specimen [2-5]. Approximately 75% of UTIs occur in the first 2 years of life [6]. The first incidence peak of UTI is in the first year of life, and the second peak of UTI occurs between the ages of 2 to 4 years during toilet training.

Cystitis is a UTI limited to the bladder. Cystitis typically presents with localized symptoms of frequency, urgency, fever, and dysuria. Cystitis in the absence of pyelonephritis is usually not associated with long-term sequelae [4]. Acute pyelonephritis is infection of one or both kidneys. Pyelonephritis typically presents with systemic symptoms such as high fever, malaise, vomiting, abdominal or flank pain, and tenderness [2-5]. Pyelonephritis is diagnosed in children on the basis of the presence of pyuria and/or bacteriuria, fever, flank pain, or tenderness. Between 50% and 64% of children who have a febrile UTI are found to have defects on renal cortical scintigraphy indicating acute pyelonephritis [7]. Pyelonephritis can cause renal scarring, which is the most severe long-term sequela of UTI and can lead to accelerated nephrosclerosis, leading to hypertension and chronic renal failure [2-5]. The reported incidence of scarring in children after pyelonephritis varies widely in the literature. A systematic review showed that 15% (95% confidence interval, 11%-18%) of children had evidence of renal scarring after the first episode of UTI [7]. With the increased use of prenatal ultrasound (US), it was determined that many of the scars that had been attributed to pyelonephritis actually occur in utero and represent renal

dysplasia [2-5]. Contrary to earlier studies suggesting that renal scarring secondary to pyelonephritis is the most common cause of chronic renal disease in children, it is now evident that the long-term risk is low [2-5]. The role of imaging is to guide treatment by identifying patients who are at high risk to develop recurrent UTIs or renal scarring. However, identification of children at risk is relevant only if there is effective treatment. Current management strategy to prevent UTIs and renal scarring is based on prophylactic antibiotics and selective surgical correction of vesicoureteral reflux (VUR).

UTI in a neonate or young infant requires special consideration. The prevalence of UTI in term neonates and young infants varies from 0.1% to 1%, with a predominance in the first 2 months of life in neonates and young infants AMAB [8-11]. The presentation of UTI is generally nonspecific, with symptoms similar to neonatal sepsis, and not all children will have fever. Concomitant bacteremia is common with UTI and was observed ranging from 4% to 36.4% [5,8-11]. Neonates with UTI have a high incidence of urinary anomalies; the most common is VUR [8,10-12].

Atypical UTI is considered if the patient is seriously ill or has poor urine flow, an abdominal or bladder mass, elevated creatinine, septicemia, failure to respond with suitable antibiotics within 48 hours, or infection with non–*Escherichia coli* organisms. Recurrent UTI is defined as 2 or more episodes of UTI with acute pyelonephritis/upper tract UTI, or 1 episode of UTI with acute pyelonephritis/upper tract UTI plus 1 or more episodes of UTI with cystitis/lower tract UTI, or 3 or more episodes of UTI with cystitis/lower tract UTI [13]. Upper tract refers to the kidneys and ureters, and lower tract is distal to the ureters.

Special Imaging Considerations

Voiding urosonography (VUS) is a safe and accurate method to evaluate for VUR. The bladder is filled with a solution containing microbubbles that appear echogenic by US.

CT urography (CTU) is an imaging study that is tailored to improve visualization of both the upper and lower urinary tracts. There is variability in the specific parameters, but it usually involves unenhanced images followed by intravenous (IV) contrast-enhanced images, including nephrographic and excretory phases acquired at least 5 minutes after contrast injection. Alternatively, a split-bolus technique uses an initial loading dose of IV contrast and then obtains a combined nephrographic-excretory phase after a second IV contrast dose; some sites include arterial phase. CTU should use thin-slice acquisition. Reconstruction methods commonly include maximum intensity projection or 3-D volume rendering. For the purposes of this document, we make a distinction between CTU and CT abdomen and pelvis without and with IV contrast. CT abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts and without both the nonenhanced and excretory phases.

MR urography (MRU) is also tailored to improve imaging of the urinary system. Unenhanced MRU relies upon heavily T2-weighted imaging of the intrinsic high signal intensity from urine for evaluation of the urinary tract. IV contrast is administered to provide additional information regarding obstruction, urothelial thickening, focal lesions, and stones. A contrast-enhanced T1-weighted series should include corticomedullary, nephrographic, and excretory phase. Thin-slice acquisition and multiplanar imaging should be obtained. For the purposes of this document, we make a distinction between MRU and MRI abdomen and pelvis without and with IV contrast. MRI

abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts, without both the precontrast and excretory phases, and without heavily T2-weighted images of the urinary tract.

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. A. CT abdomen and pelvis with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis with IV contrast in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. B. CT abdomen and pelvis without and with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without and with IV contrast in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. C. CT abdomen and pelvis without IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. D. CTU without and with IV contrast

There is no relevant literature to support the use of CTU in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

E. DMSA renal scan

A Tc-99m dimercaptosuccinic acid (DMSA) scan can be done for the initial imaging, close to the time of febrile UTI to evaluate for the presence of pyelonephritis. If the DMSA scan is normal, voiding cystourethrography (VCUG) may be avoided in >50% of individuals [14]. Tc-99m DMSA has a good image quality and is a desirable agent for renal cortical scintigraphy, especially in small infants, in patients with poorly functioning kidneys, and when other studies have identified dilated uropathy or high-grade VUR [15]. The UK National Institute for Health and Care Excellence (NICE) guidelines do not recommend DMSA for infants <6 months of age with first febrile UTI who respond well to treatment within 48 hours [16].

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. F. Fluoroscopy voiding cystourethrography

Literature on VCUG has mixed recommendations. Fluoroscopic VCUG has been shown to detect VUR in newborn children AMAB even if US is normal [8-11]. A finding of VUR, especially high-grade VUR, may lead to a change in management [9]. VUR is more commonly detected in children AMAB compared with children AFAB [17]. In addition, one of the primary concerns in young infants AMAB is diagnosing posterior urethral valves [9]. The NICE guidelines do not recommend VCUG for infants AMAB <6 months of age with first febrile UTI who respond well to treatment within 48 hours. If there is poor urine flow or if there is a family history of VUR, VCUG may be helpful if there is an abnormal kidney US study [16]. Others advocate performing routine VCUG studies in all newborns AMAB [9]. Furthermore, recent data have shown that in children <3 months of age with first febrile UTI, the presence of *E coli* in urine, and normal renal and bladder US, VCUG can be safely avoided [18].

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. G. MRI abdomen and pelvis with IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis with IV contrast in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. H. MRI abdomen and pelvis without IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis without IV contrast in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. I. MRU without and with IV contrast

There is no relevant literature to support the use of MRU in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. J. Nuclear medicine cystography

There is no relevant literature to support the use of nuclear medicine cystography in the evaluation of a child AMAB <2 months of age for the initial imaging of a first febrile UTI. There is good correlation between nuclear medicine cystography and VCUG for the detection of reflux [19]. The

nuclear cystogram does not allow for urethral assessment in a infant AMAB [20].

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. K. US kidneys and bladder

In a child AMAB <2 months of age, there is increased incidence of sepsis and renal anomalies associated with UTIs and increased rate of hospitalization. Therefore, the potential benefit of imaging in children <2 months of age is greater than in older children. However, there is less convincing evidence for the benefit of imaging based on outcome [8-11,21]. Hydronephrosis is the most frequent abnormality, found in 45% of neonates with UTI [9]. Postnatal US prior to 2 months of age is typically performed even if the prenatal US was normal. The NICE guidelines for UTI recommend US in evaluation of UTI in children <6 months of age within 6 weeks of the UTI if typical infection or during the acute infection if an atypical infection [16]. In the study by Goldman et al [9] on newborn AMAB with UTI, 8 of 12 children with abnormal postnatal US had a normal intrauterine US; 1 patient had posterior urethral valves, and 4 patients had grades III and IV VUR. The main limitations of US are the detection of pyelonephritis, scarring, and VUR. In a study by Chang et al [22] for evaluation of young infants (<3 months of age) with bacteremic UTI, US kidneys and bladder and fluoroscopic VCUG abnormalities were common, and the authors did not refer to any special imaging considerations for bacteremia in imaging decisions for otherwise well-appearing young infants with UTI. US has a high specificity (97.2%) for the detection of findings suggestive of VUR in children after the first UTI [23]. Sensitivity of US for the detection of findings suggestive of high-grade VUR is markedly improved when uroepithelial thickening is considered [24]. The main limitation of US is the low sensitivity (76.5%) for detecting VUR and renal scarring [25-31].

Variant 1: Child assigned male at birth (AMAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. L. Voiding urosonography

VUS is an alternative to VCUG for the evaluation of VUR in children, with a comparable sensitivity and specificity ranging from 80% to 100% and 77.5% to 98%, respectively [32-39]. The diagnostic accuracy of VUS compared with fluoroscopic VCUG has ranged from 78% to 96%, with most studies showing an accuracy of ≥90% [32,34,38]. Some studies suggest that VUS is more sensitive than fluoroscopic VCUG in the detection of dilated VUR [37,38]. Use of a transperineal approach for VUS enables improved evaluation of the bladder and urethra [36,38,39]. Furthermore, a study by Wozniak et al [40] showed that using 3-D and 4-D US techniques with VUS results in greater detection of reflux compared with VCUG. However, if the infection is atypical and/or the initial renal and bladder US is abnormal, VCUG may be performed, as recommended by American Academy of Pediatrics (AAP) guidelines [41].

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. A. CT abdomen and pelvis with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis with IV contrast in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile

urinary tract infection with appropriate response to medical management. Initial imaging. B. CT abdomen and pelvis without and with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without and with IV contrast in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. C. CT abdomen and pelvis without IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. D. CTU without and with IV contrast

There is no relevant literature to support the use of CTU in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. E. DMSA renal scan

A Tc-99m DMSA scan can be done for initial imaging, close to the time of febrile UTI, to evaluate for the presence of pyelonephritis. This top-down approach has been suggested in literature. If the DMSA scan is normal, VCUG may be avoided in more than 50% of individuals [14]. Tc-99m DMSA has a good image quality and is a desirable agent for renal cortical scintigraphy, especially in small infants, in patients with poorly functioning kidneys, and when other studies have identified dilated uropathy or high-grade VUR [15]. The NICE guidelines do not recommend DMSA for infants <6 months of age with first febrile UTI who respond well to treatment within 48 hours, but they do recommend DMSA for atypical or recurrent UTI [16].

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. F. Fluoroscopy voiding cystourethrography

A finding of VUR, especially high-grade VUR, may lead to a change in management [9]. The NICE guidelines do not recommend VCUG for infants AFAB <6 months of age with first febrile UTI who respond well to treatment within 48 hours. Furthermore, recent data has shown that in children <3 months of age with first febrile UTI, the presence of *E coli* in urine, and normal renal and bladder US, VCUG can be safely avoided [18]. In patients AFAB, there is usually less of a need for detailed anatomic evaluation of the urethra, and radionuclide cystography can be performed as an alternative to VCUG [42]. However, fluoroscopic VCUG may still be a useful study to perform based on consensus opinion derived from common practice.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. G. MRI abdomen and pelvis with IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis with IV contrast in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile

urinary tract infection with appropriate response to medical management. Initial imaging. H. MRI abdomen and pelvis without IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis without IV contrast in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. I. MRU without and with IV contrast

There is no relevant literature to support the use of MRU in the evaluation of a child AFAB <2 months of age for the initial imaging of a first febrile UTI.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. J. Nuclear medicine cystography

There is good correlation between nuclear medicine cystography and VCUG for the detection of reflux [19]. For more information, please see the fluoroscopic VCUG section. In patients AFAB, there is usually less of a need for detailed anatomic evaluation of the urethra, and radionuclide cystography can be performed instead of VCUG [42]. The literature in this patient population is evolving with a focus on other modalities such as VUS and fluoroscopy VCUG. It should be noted that the primary evidence supporting use of nuclear cystography is generally older than that of other modalities.

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. K. US kidneys and bladder

In patients AFAB <2 months of age, there is an increased incidence of sepsis and renal anomalies associated with UTIs and an increased rate of hospitalization. Therefore, the potential benefit in children <2 months of age is greater than in older children. However, there is less convincing evidence for the benefit of imaging based on outcome [8-11,21]. Hydronephrosis is the most frequent abnormality, found in 45% of neonates with UTI [9]. Postnatal US prior to 2 months of age is typically performed even if the prenatal US was normal. The NICE guidelines for UTI recommend US in evaluation of UTI in children <6 months of age within 6 weeks of the UTI if typical infection or during the acute infection if an atypical infection [16]. As discussed earlier, the main limitations of US are the detection of pyelonephritis, scarring, and VUR. In a study by Chang et al [22] for evaluation of young infants (<3 months of age) with bacteremic UTI, US kidneys and bladder and fluoroscopic VCUG abnormalities were common, and the authors did not refer to any special imaging considerations for bacteremia in imaging decisions for otherwise well-appearing young infants with UTI. Sensitivity of US for the detection of high-grade VUR is markedly improved when uroepithelial thickening is considered [24]. The main limitation of US is the low sensitivity (76.5%) for detecting VUR and renal scarring [25-31].

Variant 2: Child assigned female at birth (AFAB). Younger than 2 months of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging. L. Voiding urosonography

VUS is a useful alternative to VCUG for the evaluation of VUR in children with comparable sensitivity and specificity ranging from 80% to 100% and 77.5% to 98%, respectively [32-39]. The diagnostic accuracy of VUS compared with fluoroscopic VCUG has ranged from 78% to 96%, with most studies showing accuracy of ≥90% [32,34,38]. Some studies suggest that VUS is more

sensitive than fluoroscopic VCUG in the detection of dilated VUR [37,38]. Use of a transperineal approach for VUS enables improved evaluation of the bladder and urethra [36,38,39]. Furthermore, a study by Wozniak et al [40] showed that using 3-D and 4-D US techniques with VUS results in greater detection of reflux compared with VCUG. For more information, please see the fluoroscopic VCUG section.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

Prospective studies in children between the ages of 2 months and 6 years with UTIs were done to evaluate the effect of therapy [6,43,44]. There is limited evidence to support routine imaging of uncomplicated UTIs, and optimal imaging is controversial [2,5,43,45]. Currently there are 2 main methods for evaluating children with UTIs: the bottom-up approach [2], which focuses on detection of VUR, and the top-down approach [2,5,16], which focuses on the diagnosis of acute pyelonephritis and renal scarring [2,5]. DMSA followed by cystourethrography if DMSA renal scan suggests pyelonephritis is the top-down approach. The potential benefit of this approach is a decrease in the number of cystourethrography studies.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
A. CT abdomen and pelvis with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis with IV contrast in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
B. CT abdomen and pelvis without and with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without and with IV contrast in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
C. CT abdomen and pelvis without IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
D. CTU without and with IV contrast

There is no relevant literature to support the use of CTU in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
E. DMSA renal scan

Tc-99m DMSA is a sensitive (90%) and specific (95%) test for detecting pyelonephritis [46]. The NICE guidelines do not suggest DMSA renal scan if the patient responds well to treatment within 48 hours. A delayed DMSA renal scan (4-6 months) to evaluate for renal scarring in high-risk patients with atypical or recurrent UTI is recommended [16]. Evidence of acute pyelonephritis is

detected by DMSA in children with UTIs in approximately 50% to 80% of cases [47-52]. However, short-term studies have demonstrated that many of these abnormalities resolve over time, irrespective of whether a prophylactic antibiotic was used [53-55]. This suggests little benefit in using renal cortical scintigraphy after the first episode of UTI [5]. Furthermore, the high incidence of pyelonephritis identified on DMSA suggests that performing DMSA will not change the need to perform VCUG in many patients. There is conflicting evidence on the sensitivity of renal cortical scintigraphy and the top-down approach in the detection of sequela of VUR [45,56,57]. In a randomized controlled study comparing oral versus IV antibiotic administration, 308 patients who had Tc-99m DMSA were evaluated. The sensitivity of this top-down approach for VUR detection was 70%, with specificity of 42% [45]. A meta-analysis on the use of DMSA in acute UTI yielded a sensitivity and specificity of 79% and 53%, respectively, for grades 3 to 5 VUR. There was marked statistical heterogeneity between the studies. The authors concluded that acute-phase DMSA renal scanning is not useful as a replacement for VCUG in the evaluation of young children with a first febrile UTI [56].

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
F. Fluoroscopy voiding cystourethrography

The Randomized Intervention for Children With Vesicoureteral Reflux study, which enrolled 607 children, 2 months to 6 years of age with any grade of VUR, demonstrated that 2 years of prophylactic antibiotics in children with VUR decreased the incidence of recurrent UTIs by half (number needed to treat for 2 years was 8) [58]. Patients with high-grade VUR (grades III and IV) are more likely to have recurrent UTIs and scarring [7,43,50,58-61] and may benefit even more from prophylactic antibiotics. The Swedish study randomly assigned 203 children, 12 to 23 months of age, with dilated (grade III or IV) VUR and demonstrated benefit only in patients AFAB who received either prophylactic antibiotics or endoscopic treatment in decreasing recurrent UTI (number needed to treat for 2 years, 2.5 and 3, respectively) [62]. Patients AFAB who received antimicrobial prophylaxis had the lowest incidence of renal scarring (number needed to treat for 2 years was 5) [62].

The NICE guidelines do not recommend VCUG for patients from 6 months to 3 years of age with first febrile UTI who respond well to treatment within 48 hours and have a normal renal and bladder US study, normal urine flow, and no family history of VUR. However, VCUG is recommended for patients with a family history of VUR [16]. The NICE guidelines do not recommend VCUG for patients >3 years of age with first febrile UTI. The AAP guidelines suggest that VCUG should not be performed routinely after the first febrile UTI for patients 2 to 24 months of age but that VCUG is indicated if the renal and bladder US reveals hydronephrosis, scarring, or other findings that would suggest either high-grade VUR or obstructive uropathy. Furthermore, VCUG may be indicated in other atypical or complex clinical circumstances [41].

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
G. MRI abdomen and pelvis with IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis with IV contrast in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
H. MRI abdomen and pelvis without IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis without IV contrast in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
I. MRU without and with IV contrast

There is no relevant literature to support the use of MRU in the evaluation of a child 2 months to 6 years of age for the initial imaging of a first febrile UTI.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
J. Nuclear medicine cystography

Good correlation has been shown between nuclear medicine cystography and VCUG for the detection of VUR [19]. Unlike in children AMAB, detailed urethral assessment in children AFAB is less necessary, so radionuclide cystography can be performed as an alternative for VCUG in patients AFAB [42,48]. A finding of VUR, especially high-grade VUR, may lead to a change in management [9]. Nuclear medicine cystography may reveal VUR despite a normal VCUG in children with recurrent febrile UTI [63]. For more information, please see the fluoroscopic VCUG section.

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
K. US kidneys and bladder

The main benefit of US is for the detection of underlying congenital renal anomalies [1,16]. The potential harm of using US as the only imaging for UTI is the poor sensitivity for VUR and pyelonephritis/scarring [25-30,64]. There are limited data showing inconsistent results on the sensitivity of US in the detection of dilated VUR [65,66]. Grayscale US identifies approximately 25% of the patients with acute pyelonephritis and approximately 40% of the patients with chronic parenchymal scarring [29,31,67-72].

In a retrospective study of 2,259 children <5 years of age, sensitivity of US was related to criteria for the definition of a normal study. With the use of the most relaxed criteria (25% abnormal), US had a sensitivity of 28% (specificity of 77%), and with the most stringent criteria (4% abnormal), US had a sensitivity of 5% (specificity of 97%) [31]. Assuming a 40% prevalence of VUR and a 20% recurrent rate of UTIs in 100 children who have US, up to 11 children will have positive US studies that will be followed by a VCUG study, of which 8 will be positive for VUR. Two years of a prophylactic antibiotic will decrease recurrent UTIs from up to 2 children to 1 child. This means that 1 child will benefit from US and an additional 3 children that may benefit from prophylactic antibiotic will not be treated. In addition, with the increased use of prenatal US screening, the yield of detection of unknown renal abnormalities in children with UTIs has decreased [73].

A few studies with small series of children suggest good correlation between power Doppler and Tc-99m DMSA for pyelonephritis [74,75]. Other studies, however, demonstrated low sensitivity for pyelonephritis and low prediction for development of renal scarring [49,76,77]. Therefore, the use of power Doppler as a replacement for DMSA is not useful [26,49,76].

The NICE guidelines for UTI do not recommend US in evaluation of UTI in children >6 months of age if typical infection [16]. The AAP guidelines recommend US for children with a febrile UTI from

ages 2 to 24 months [41].

Variant 3: Child. 2 months to 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
L. Voiding urosonography

VUS is a useful alternative to VCUG for the evaluation of VUR in children with comparable sensitivity and specificity ranging from 80% to 100% and 77.5% to 98%, respectively [32-39]. The diagnostic accuracy of VUS compared with fluoroscopic VCUG has ranged from 78% to 96%, with most studies showing an accuracy of ≥90% [32,34,38]. Some studies suggest that VUS is more sensitive than fluoroscopic VCUG in the detection of dilated VUR [37,38]. Use of a transperineal approach for VUS enables improved evaluation of the bladder and urethra [36,38,39]. Furthermore, a study by Wozniak et al [40] showed that using 3-D and 4-D US techniques with VUS results in greater detection of reflux compared to VCUG. For more information, please see the fluoroscopic VCUG section.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.

The incidence of new-onset UTI in children >6 years of age is low and often associated with behavioral abnormalities, dysfunctional elimination syndrome, or initiation of sexual intercourse in adolescents [78,79]. Patients AFAB are affected more often than patients AMAB [78]. The likelihood of detection of a previously unknown underlying renal anomaly is low [79]. There is no evidence to support any routine imaging in the first UTI in this group of patients.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
A. CT abdomen and pelvis with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis with IV contrast in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
B. CT abdomen and pelvis without and with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without and with IV contrast in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
C. CT abdomen and pelvis without IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
D. CTU without and with IV contrast

There is no relevant literature to support the use of CTU in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
E. DMSA renal scan

The NICE guidelines do not recommend DMSA renal scan for patients >6 years of age with first febrile UTI [16].

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
F. Fluoroscopy voiding cystourethrography

The NICE guidelines do not recommend VCUG for patients >6 years of age with first febrile UTI [16].

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
G. MRI abdomen and pelvis with IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis with IV contrast in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
H. MRI abdomen and pelvis without IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis without IV contrast in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
I. MRU without and with IV contrast

There is no relevant literature to support the use of MRU in the evaluation of a child >6 years of age for the initial imaging of a first febrile UTI with appropriate response to medical management.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
J. Nuclear medicine cystography

The NICE guidelines do not recommend cystography for patients >6 years of age with first febrile UTI [16].

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
K. US kidneys and bladder

The NICE guidelines do not recommend US kidneys and bladder for patients >6 years of age with first febrile UTI [16], unless there is poor urine flow, abdominal or bladder mass, raised creatinine, septicemia, failure to respond to treatment with suitable antibiotics within 48 hours, or infection with non–*E coli* organisms. However, US kidneys and bladder may still be a useful study to perform based on consensus opinion derived from common practice.

Variant 4: Child. Older than 6 years of age. First febrile urinary tract infection with appropriate response to medical management. Initial imaging.
L. Voiding urosonography

The NICE guidelines do not recommend VUS for patients >6 years of age with first febrile UTI [16]. However, VUS may be a useful study to perform based on consensus opinion.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
A. CT abdomen and pelvis with IV contrast

An IV contrast-enhanced CT scan can be performed selectively when there is suspicion for complications, such as renal abscess or xanthogranulomatous pyelonephritis [80-83].

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
B. CT abdomen and pelvis without and with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without and with IV contrast in the evaluation of a child with atypical or recurrent febrile UTI for the initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
C. CT abdomen and pelvis without IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast in the evaluation of a child with atypical or recurrent febrile UTI for initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
D. CTU without and with IV contrast

There is no relevant literature to support the use of CTU in the evaluation of a child with atypical or recurrent febrile UTI for initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
E. DMSA renal scan

A DMSA renal scan may have limited benefit in patients with VUR and atypical, complicated, or recurrent UTIs. A normal DMSA scan in patients with recurrent infections may exclude high-grade reflux on VCUG and thus direct toward antibiotic treatment without the need for invasive VCUG. The NICE guidelines recommend DMSA renal scan 4 to 6 months after atypical or recurrent infection (<3 years) and for recurrent infection (>3 years) in children [83]. The literature in this patient population is evolving with a focus on other modalities such as VUS and fluoroscopy VCUG. It should be noted that the primary evidence supporting use of DMSA renal scan is generally older than that of other modalities.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
F. Fluoroscopy voiding cystourethrography

Children with recurrent UTIs have an increased prevalence of VUR [43]. Based on multiple studies in a pooled cohort of infants after first UTI and recurrent UTI, the frequency of VUR increases from 35% to 74%, with increased risk for renal scarring with each UTI [1]. A finding of VUR without dilatation of urinary tract may lead to antibiotic prevention treatment, and a finding of dilated VUR may lead to endoscopic or surgical treatment. VCUG is routinely performed for children <6 months of age with atypical UTI and from 6 months to 3 years of age with atypical UTI and abnormalities on renal and bladder US, poor urine flow, or family history of VUR as per the NICE guidelines [83]. VCUG is not recommended by NICE guidelines for children >3 years of age with UTI, even if atypical or recurrent UTI [16]. The AAP guidelines suggest VCUG for children 2 to 24 months of age after the second febrile UTI and after the first for patients with abnormalities on renal and bladder US [41].

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging. G. MRI abdomen and pelvis with IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis with IV contrast in the evaluation of a child with atypical or recurrent febrile UTI for initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging. H. MRI abdomen and pelvis without IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis without IV contrast in the evaluation of a child with atypical or recurrent febrile UTI for initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging. I. MRU without and with IV contrast

There is no relevant literature to support the use of MRU in the evaluation of a child with atypical or recurrent febrile UTI for initial imaging.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging. J. Nuclear medicine cystography

There is good correlation between nuclear medicine cystography and VCUG for the detection of reflux [19]. For more information, please see the fluoroscopic VCUG section. The literature in this patient population is evolving with a focus on other modalities such as VUS and fluoroscopy VCUG. It should be noted that the primary evidence supporting use of nuclear cystography is generally older than that of other modalities.

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging. K. US kidneys and bladder

In children with atypical, recurrent, or complicated UTI, the main benefit of US is the detection of underlying abnormalities, calculi, or complications such as a renal or perirenal abscess [82,84]. The potential harm of using US as the only imaging for UTI is the poor sensitivity for VUR and pyelonephritis/scarring [25-30,64]. There are limited data showing inconsistent results on the sensitivity of US in the detection of dilated VUR [65,66]. Grayscale US identifies approximately 25% of the patients with acute pyelonephritis and approximately 40% of the patients with chronic parenchymal scarring [29,31,67-72].

In a retrospective study of 2,259 children <5 years of age, sensitivity was related to criteria for the definition of a normal study. With the use of the most relaxed criteria (25% abnormal), US had a sensitivity of 28% (specificity of 77%), and with the most stringent criteria (4% abnormal), US had a sensitivity of 5% (specificity of 97%) [31]. Assuming a 40% prevalence of VUR and a 20% recurrent rate of UTIs in 100 children who have US, up to 11 children will have positive US studies that will be followed by a VCUG study, of which 8 will be positive for VUR. Two years of a prophylactic antibiotic will decrease recurrent UTIs from up to 2 children to 1 child. This means that 1 child will benefit from the US study and an additional 3 children that may benefit from prophylactic antibiotic will not be treated. In addition, with the increased use of prenatal US screening, the yield of detection of unknown renal abnormalities in children with UTIs has decreased [73].

Few studies with small series of children suggest good correlation between power Doppler US and Tc-99m DMSA findings of pyelonephritis [74,75]. Other studies; however, demonstrated a low sensitivity for pyelonephritis and a low prediction for development of renal scarring [49,76,77]. Therefore, the use of power Doppler US as a replacement for nuclear medicine cystography is not

useful [26,49,76].

The NICE guidelines for UTI recommend US if the infection is atypical for all ages or recurrent [16]. The AAP guidelines recommend US for children with a febrile UTI from ages 2 to 24 months [41].

Variant 5: Child. Atypical or recurrent febrile urinary tract infections. Initial imaging.
L. Voiding urosonography

VUS is a useful alternative to VCUG for the evaluation of VUR in children with comparable sensitivity and specificity ranging from 80% to 100% and 77.5% to 98%, respectively [32-39]. The diagnostic accuracy of VUS compared with fluoroscopic VCUG has ranged from 78% to 96%, with most studies showing accuracy of ≥90% [32,34,38]. Some studies suggest that VUS is more sensitive than fluoroscopic VCUG in the detection of dilated VUR [37,38]. Use of a transperineal approach for VUS enables improved evaluation of the bladder and urethra [36,38,39]. Furthermore, a study by Wozniak et al [40] showed that using 3-D and 4-D US techniques with VUS results in greater detection of reflux compared with VCUG. For more information, please see the fluoroscopic VCUG section.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
A. CT abdomen and pelvis with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis with IV contrast in the evaluation of a child with established VUR for follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
B. CT abdomen and pelvis without and with IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without and with IV contrast in the evaluation of a child with established VUR for follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
C. CT abdomen and pelvis without IV contrast

There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast in the evaluation of a child with established VUR for follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
D. CTU without and with IV contrast

There is no relevant literature to support the use of CTU in the evaluation of a child with established VUR for follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
E. DMSA renal scan

Approximately one-fifth of children may have renal damage after UTI, with significant risk for deterioration [85]. DMSA may be considered for follow-up of children with VUR to detect new renal scarring, especially after a febrile UTI or when renal US is abnormal [61].

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
F. Fluoroscopy voiding cystourethrography

VCUG is recommended by the American Urological Association between 12 and 24 months after UTI with longer intervals between follow-up studies in patients in whom evidence supports lower rates of spontaneous resolution (ie, those with higher grades of VUR [grades III-V], bladder/bowel

dysfunction, and older age) [61].

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
G. MRI abdomen and pelvis with IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis with IV contrast in the evaluation of a child with established VUR for follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
H. MRI abdomen and pelvis without IV contrast

There is no relevant literature to support the use of MRI abdomen and pelvis without IV contrast in the evaluation of a child with established VUR for follow-up imaging.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
I. MRU without and with IV contrast

MRU has been suggested as a safer alternative to scintigraphy in children with VUR, particularly those who require follow-up imaging [86,87]. This is pertinent for follow-up imaging of VUR causing renal scarring.

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
J. Nuclear medicine cystography

Nuclear medicine cystography is recommended by the American Urological Association between 12 and 24 months after UTI with longer intervals between follow-up studies in patients in whom evidence supports lower rates of spontaneous resolution (ie, those with higher grades of VUR [grades III-V], bladder/bowel dysfunction, and older age) [61].

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
K. US kidneys and bladder

US is recommended by The American Urological Association for the follow-up imaging in established VUR every 12 months to monitor renal growth and any parenchymal scarring [61]. Grayscale US identifies approximately 40% of patients with chronic parenchymal scarring [29,31,67-72].

Variant 6: Child. Established vesicoureteral reflux. Follow-up imaging.
L. Voiding urosonography

VUS is a useful alternative to VCUG for the evaluation of VUR in children with comparable sensitivity and specificity ranging from 80% to 100% and 77.5% to 98%, respectively [32-39]. The diagnostic accuracy of VUS compared with fluoroscopic VCUG has ranged from 78% to 96%, with most studies showing accuracy of ≥90% [32,34,38]. Some studies suggest that VUS is more sensitive than fluoroscopic VCUG in the detection of dilated VUR [37,38]. Use of a transperineal approach for VUS enables improved evaluation of the bladder and urethra [36,38,39]. Furthermore, a study by Wozniak et al [40] showed that using 3-D and 4-D US techniques with VUS results in greater detection of reflux compared to VCUG.

Summary of Highlights

- **Variant 1**: In the setting of a child AMAB <2 months of age presenting with a first episode of febrile UTI with appropriate response to medical imaging, US of kidneys and bladder is usually the appropriate imaging study to evaluate for renal anomalies and hydronephrosis.

- **Variant 2**: In the setting of a child AFAB <2 months of age presenting with a first episode of febrile UTI with appropriate response to medical imaging, US of kidneys and bladder is usually the appropriate imaging study to evaluate for renal anomalies and hydronephrosis. VUS, fluoroscopic VCUG, or nuclear medicine cystography may be appropriate to evaluate for VUR.
- **Variant 3**: In the setting of a 2 month to 6 year old child presenting with a first episode of febrile UTI with appropriate response to medical management, US of kidneys and bladder is usually the appropriate imaging study. Fluoroscopic VCUG or nuclear medicine cystography may be appropriate to evaluate for VUR.
- **Variant 4**: In the setting of a child >6 years of age presenting with a first episode of febrile UTI with appropriate response to medical management, the likelihood of detection of a previously unknown renal anomaly is low. There is no evidence to support any routine imaging. However, US kidneys and bladder may still be a useful study to perform based on consensus opinion derived from common practice.
- **Variant 5**: In the setting of atypical or recurrent febrile UTI in a child, US of kidneys and bladder, VUS, and fluoroscopic VCUG are usually appropriate for initial imaging. Nuclear medicine cystography may be appropriate, noting that the primary evidence supporting use of nuclear cystography is generally older than that of other modalities. CT abdomen and pelvis with IV contrast may be performed selectively when there is suspicion for complications such as renal abscess.
- **Variant 6**: In the setting of a child with established VUR presenting for follow-up imaging, US of kidneys and bladder, VUS, fluoroscopic VCUG, and nuclear medicine cystography are usually appropriate. DMSA may be appropriate for follow-up of children with VUR to detect new renal scarring, especially after a febrile UTI or when renal US is abnormal.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.

May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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