

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

**Variant 1: Age <2 months, first febrile urinary tract infection.**

| Radiologic Procedure  | Rating | Comments  | RRL*                             |
|---|--------|---|----------------------------------|
| US kidneys and bladder  | 9      |   | O                                |
| Voiding cystourethrography  | 6      | Consider this procedure in boys and in the presence of sonographic abnormality.                       | ☼☼                               |
| Tc-99m pertechnetate radionuclide cystography   | 5      | Consider this procedure in girls.   | ☼☼                               |
| Tc-99m DMSA renal cortical scintigraphy   | 3      | This procedure is not a first-line test. It could be used 4 to 6 months after UTI to detect scarring. | ☼☼☼                              |
| <b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate |        |   | <b>*Relative Radiation Level</b> |

**Variant 2: Age >2 months and ≤6 years, first febrile urinary tract infection with good response to treatment.**

| Radiologic Procedure  | Rating | Comments   | RRL*                             |
|---|--------|--|----------------------------------|
| US kidneys and bladder  | 7      | This procedure has a low yield, especially if US in the third trimester is normal. | O                                |
| Voiding cystourethrography  | 4      |  | ☼☼                               |
| Tc-99m pertechnetate radionuclide cystography   | 4      |  | ☼☼                               |
| Tc-99m DMSA renal cortical scintigraphy   | 3      |  | ☼☼☼                              |
| <b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate |        |  | <b>*Relative Radiation Level</b> |

**Variant 3: Age >6 years, first febrile urinary tract infection with good response to treatment.**

| Radiologic Procedure  | Rating | Comments  | RRL*                             |
|---|--------|---|----------------------------------|
| US kidneys and bladder  | 5      | This procedure may be appropriate but there was disagreement among panel members on the appropriateness rating as defined by the panel's median rating. | O                                |
| Voiding cystourethrography  | 3      |   | ☼☼                               |
| Tc-99m pertechnetate radionuclide cystography   | 3      |   | ☼☼                               |
| Tc-99m DMSA renal cortical scintigraphy   | 2      |   | ☼☼☼                              |
| <b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate |        |   | <b>*Relative Radiation Level</b> |

**Variant 4:****Child. Atypical (poor response to antibiotics within 48 hours, sepsis, poor urine stream, raised creatinine, or non-*E coli* UTI) or recurrent febrile urinary tract infection.**

| Radiologic Procedure  | Rating | Comments   | RRL*                             |
|---|--------|--|----------------------------------|
| US kidneys and bladder  | 9      | This is a complementary procedure.   | O                                |
| Voiding cystourethrography  | 7      | This is a complementary procedure.   | ☼☼                               |
| Tc-99m pertechnetate radionuclide cystography   | 7      | This procedure is an alternative for cystourethrography. Consider it in girls. | ☼☼                               |
| Tc-99m DMSA renal cortical scintigraphy   | 6      | This procedure could be used 4 to 6 months after UTI to detect scarring.       | ☼☼☼                              |
| CT abdomen and pelvis with IV contrast  | 4      | This procedure is indicated in patients with suspected abscess.                | ☼☼☼☼                             |
| CT abdomen and pelvis without IV contrast   | 2      | This procedure may be useful in rare cases when stone disease is suspected.    | ☼☼☼☼                             |
| CT abdomen and pelvis without and with IV contrast  | 1      |  | ☼☼☼☼                             |
| <b>Rating Scale:</b> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate |        |  | <b>*Relative Radiation Level</b> |

## URINARY TRACT INFECTION–CHILD

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### **Summary of Literature Review**

#### **Introduction/Background**

Urinary tract infection (UTI) is the most frequent serious bacterial infection during childhood, affecting approximately 2% of boys and 8% of girls by the age of 7 years [1,2]. UTI is defined by the presence of bacteria within the urine and is confirmed by a urine culture of at least  $5 \times 10^4$  colony-forming units (cfu)/mL of the same bacterial species in a catheterized specimen or  $10^5$  cfu/mL in a voided specimen [3-6]. Approximately 75% of UTIs occur in the first 2 years of life [7]. The first 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. After the age of 6 years, UTIs are infrequent and often associated with dysfunctional elimination [8].

Cystitis is a UTI limited to the bladder. Cystitis typically presents with localizing symptoms of frequency, urgency, and dysuria. Acute pyelonephritis is infection of the kidneys. Pyelonephritis typically presents with systemic symptoms such as high fever, malaise, vomiting, abdominal or flank pain, and tenderness [3-6]. Pyelonephritis can cause renal scarring, which is the most severe long-term sequela of UTI and can lead to hypertension and chronic renal failure [3-6]. With the increased use of prenatal ultrasound (US), it was realized that many of the scars that were attributed to pyelonephritis actually occur in utero and represent renal dysplasia [3-6]. 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 [3-6]. 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 valuable 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). Prospective studies failed to demonstrate significant decrease in renal scarring in patients with febrile UTI who were treated with prophylactic antibiotics [8-10], and surgical correction of VUR was not found to improve outcome [11]. Thus the effectiveness of current management of UTIs is put into question [3,4,8].

Pyelonephritis is diagnosed in children based on 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 (RCS) indicating acute pyelonephritis [12]. The relationship between childhood UTIs, VUR, and renal scarring is complex and not completely understood. Children with VUR are at an increased risk for pyelonephritis and parenchymal scarring, but pyelonephritis and renal scarring commonly occur without VUR [13-20]. The incidence of acute pyelonephritis in the absence of documented VUR is much too high to be explained only by intermittent VUR [21,22]. Previous episodes of pyelonephritis or VUR increase the risk for recurrent pyelonephritis [17]. Absence of fever does not exclude development of pyelonephritis [23].

Cystitis in the absence of pyelonephritis is usually not associated with long-term sequelae [5]. The incidence of scarring in children following pyelonephritis varies widely in the literature. A systemic review of the literature showed that 15% (95% CI, 11%-18%) of the children had evidence of renal scarring after the first episode of UTI [12]. Contrary to common belief, renal scarring after pyelonephritis does not decrease in older children [17,24].

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Reports from the 1960s and 1970s showed that scarring secondary to pyelonephritis is the etiology for 50% of hypertension and 30% of end-stage renal disease (ESRD) cases in children [1,25]. Many of the cases that were attributed to scarring from pyelonephritis actually represented congenital hypoplastic or dysplastic kidneys [1,5,25]. Scarring accounts for 5% of children with hypertension [25]. Retrospective studies demonstrated that mainly children with bilateral renal scarring are at risk for renal insufficiency [26]. According to the North American Pediatric Renal Trials and Collaborative Studies 2011 report, reflux nephropathy accounted for 3.5% of ESRD cases [25]. Worldwide, reflux nephropathy accounted for 7% to 17% of ESRD cases [25].

The main purposes of treating UTIs are to cure acute pyelonephritis and cystitis and to prevent recurrent UTIs and renal scarring. Acute UTIs are typically treated with oral antibiotics [6]. Prophylactic long-term oral antibiotics may decrease the incidence of recurrent UTIs and renal scarring. However, the benefit is small and should be weighed against the risk of microbial resistance [1,10,27,28].

Prospective studies in children between the ages of 2 months and 6 years with UTIs were done to evaluate the effect of therapy [1,6,8,27,29]. There is limited medical-based evidence to support routine imaging of uncomplicated UTIs, and optimal imaging is controversial [1,3,6,8,29,30]. Currently there are 2 main methods for evaluating children with UTIs: the bottom-up approach [3,31], which focuses on detection of VUR, and the top-down approach [3,6,32,33], which focuses on the diagnosis of acute pyelonephritis and renal scarring [3,6,33].

Until recently it was not clear if children with VUR benefit from treatment. A prospective Swedish reflux trial randomized treatment (antibiotic prophylaxis, endoscopic correction of reflux, or surveillance) in 203 children with grade III or IV reflux [34]. There was a significantly lower rate of recurrent febrile UTIs in girls receiving antibiotics and endoscopic treatment. No scar developed in children treated with antibiotics. However, the number of patients in this study was small [34]. The Randomized Intervention for Children with Vesicoureteral Reflux (RIVUR) trial in 607 children aged 2 months to 6 years with VUR grades of I to IV demonstrated decreased recurrent UTIs in half of the patients (n=305) who received prophylactic antibiotics as compared to those who received placebo (n=302). Incidence of recurrent UTIs increased with increased grade of VUR (14.3% in grades I-II and 22.9% in grades III-IV). The benefits of prophylactic antibiotics increased with the presence of fever (80%) and bowel and bladder dysfunction (60%) [29]. There was no significant change in the development of new renal scarring (about 8%) [29].

Surgery—open, laparoscopic, or endoscopic (injection of a bulking agent)—is usually reserved for high-grade VUR, recurrent UTI despite antibiotic prophylaxis, and noncompliance with prophylactic antibiotics [35].

Other nonsurgical treatment options are targeted to children with a variety of bladder functional abnormalities, including behavioral modification, biofeedback relaxation of the pelvic floor, and treatment of constipation [36].

UTI in a neonate requires special consideration. The prevalence of UTI in term neonates varies from 0.1% to 1%, with a male predominance in the first 2 months of life [19,37-40]. The presentation of UTI is generally nonspecific, with symptoms similar to those seen in neonatal sepsis, and not all children will have fever. Concomitant bacteremia with UTI is common and was observed in the range of 4% to 36.4% [6,37-40]. Neonates with UTI have a high incidence of urinary anomalies; the most common is VUR [19,37-40].

## **Overview of Imaging Modalities**

### *Ultrasonography*

Renal US is a noninvasive imaging method that avoids the risk of ionizing radiation and is readily available. It can detect urinary tract anomalies such as hydronephrosis, duplex renal system, hydroureter, and ureterocele. In older children, postvoid evaluation of bladder volume could be useful to assess for functional bladder abnormalities and retention syndrome [41]. The main limitation of US is the low sensitivity for detecting VUR and renal scarring [31,42-47].

### *Renal cortical scintigraphy*

RCS with Tc-99m dimercaptosuccinic acid (DMSA) or Tc-99m glucoheptonate is used for the detection of pyelonephritis [48]. Tc-99m DMSA has a higher image quality than Tc-99m glucoheptonate, which makes DMSA a more desirable agent for renal cortical imaging, especially in small infants, in those with poorly functioning kidneys, and when other studies have identified dilated uropathy or high-grade VUR [49]. Pinhole imaging or single-photon emission computed tomography should be considered to maximize the sensitivity of RCS without loss of specificity [50].

The likelihood of dilated VUR in children with normal RCS is low [51]. RCS is the gold-standard study for evaluation of renal scarring [25]. It is used as an important outcome finding in studying various treatment options for children with UTIs.

#### *Voiding cystourethrography, nuclear cystography, and voiding ultrasonography*

The main role of voiding cystourethrography (VCUG) is to detect VUR [3-6]. Radionuclide cystography (RNC) has a lower absorbed radiation dose than VCUG, but it does not have the spatial resolution needed to identify anatomic abnormalities of the urethra, bladder, and ureters. Voiding ultrasonography (VUS) is a nonionizing, safe, and accurate method to evaluate for VUR. The bladder is filled with a solution containing microbubbles that appear echogenic by US. This technique has been accepted in several European countries where US contrast agents are approved for this application. Using a first-generation contrast agent, the diagnostic accuracy of VUS as compared to VCUG has ranged from 78% to 96%, with most studies showing accuracy of 90% or above [52-54]. Some studies suggest that VUS is more sensitive than VCUG in the detection of dilated VUR [54,55]. Use of a second-generation contrast agent and transperineal approach enables improved evaluation of the bladder and urethra [54,56,57]. However, in the United States, US contrast for VUS is not approved by the Food and Drug Administration and can only be used as off-label. There is not yet any published experience with VUS in the United States.

#### *Computed tomography*

Postcontrast computed tomography (CT) scan is sensitive in diagnosing pyelonephritis [48]. It has a role in evaluation of renal abscess or unusual complications such as xanthogranulomatous pyelonephritis [58].

#### *Magnetic resonance imaging*

Small series demonstrated that magnetic resonance imaging (MRI) has high sensitivity for detecting pyelonephritis, comparable to DMSA scintigraphy [48,59,60]. Diffusion MR has comparable sensitivity to contrast-enhanced MRI in the detection of pyelonephritis [61,62]. There is no role of MRI in predicting the presence of VUR [63]. MRI is not routinely used in the evaluation of children with UTI because of its relatively high cost, low availability, and potential need for sedation in younger patients.

### **Variant 1: Age <2 months, first febrile urinary tract infection.**

#### *Ultrasonography*

In children <2 months there is increased incidence of sepsis and renal anomalies associated with UTIs and increased rate of hospitalization. Therefore, the potential benefit at that age is greater than in older children. However, there is low-quality evidence on the benefit of imaging on outcome [37-40,64]. Hydronephrosis is the most frequent abnormality, found in 45% of neonates with UTI [38]. US should be performed even if the intrauterine US was normal. In the study by Goldman et al [38] on newborn males with UTI, 8 of 12 children with abnormal US had a normal intrauterine US; 1 patient had a posterior urethral valve and 4 patients had dilated (grades III-IV) VUR. As discussed above, the main limitation of US is in the detection of parenchymal abnormalities and VUR.

#### *Voiding cystourethrography and nuclear cystography*

VCUG has been shown to detect VUR in newborn males even if US is normal [37-40]. A finding of VUR, especially high-grade VUR, may lead to a change in management [38]. VUR is more commonly detected in boys as compared to girls. In addition, one of the main concerns in boys is missing a case of posterior urethral valve [38]. The UK National Institute for Health and Clinical Excellence (NICE) guidelines for UTI do not recommend routine VCUG in evaluation of UTI in children younger than 6 months [32]. Others advocate performing routine VCUG studies in all male newborns [38]. In females there is no need for detailed anatomical evaluation of the urethra, and RNC can be performed instead of VCUG as it has lower radiation [65].

#### *Renal cortical scintigraphy*

RCS has a limited role in guiding management of newborns with febrile UTI as the main concern in this age is the presence of underlying renal anomalies.

### **Variant 2: Age >2 months and ≤6 years, first febrile urinary tract infection with good response to treatment.**

#### *Ultrasonography*

Routine US study after the first episode of UTI is suggested by several guidelines [2,32]. The main benefit of US is for the detection of underlying congenital renal anomalies [2,32].

The potential harm of using US as the only imaging for UTI is the poor sensitivity for VUR and parenchymal abnormalities. The sensitivity for detecting VUR and renal scarring is low [31,42-46]. There are limited data showing inconsistent results on the sensitivity of US in the detection of dilated VUR [66,67]. Grayscale US identifies about 25% of acute pyelonephritis and about 40% of chronic parenchymal scarring cases [45,47,68-73].

In a retrospective study of 2259 children younger than 5 years, 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%) [47]. Assuming 40% prevalence of VUR and 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 [74].

Few studies with small series of children suggest good correlation between power Doppler and Tc-99m DMSA findings of pyelonephritis [75,76]. Other studies, however, demonstrated low sensitivity for pyelonephritis and low prediction for development of renal scarring [77-79]. Therefore, the use of power Doppler as a replacement for RCS cannot be recommended [42,77,79].

#### *Renal cortical scintigraphy*

RCS, Tc-99m DMSA, and Tc-99m glucoheptonate are sensitive (90%) and specific (95%) tests for detecting pyelonephritis [48]. However, short-term studies have demonstrated that many of these abnormalities resolve over time, irrespective of whether a prophylactic antibiotic was used [9,10,23]. This suggests little benefit in using RCS after the first episode of UTI [6]. Persistent parenchymal abnormality in RCS or decreased uptake of tracer associated with loss of contour or cortical thinning are indications of renal scarring [25]. Most recurrent UTIs occur within 3 to 6 months after the first episode of UTI. The NICE guideline suggests a delayed RCS (4 to 6 months) to evaluate for renal scarring in high-risk patients [32].

RCS, followed by cystourethrography if the RCS suggests pyelonephritis, is the top-down approach. The benefit of this approach is the decrease in the number of cystourethrography studies. There are few deficiencies with the use of RCS as the primary imaging for UTI.

Evidence of acute pyelonephritis is detected by RCS in children with UTIs in about 50% to 80% of cases [24,50,79-82]. This means that RCS will not change the need to perform VCUG in most patients. There is conflicting evidence on the sensitivity of RCS in the detection of VUR [30,51,83]. In a randomized controlled study comparing oral versus intravenous antibiotic administration, 308 patients who had Tc-99m DMSA were evaluated. The sensitivity for VUR was 70%, with a specificity of 42% [30]. A meta-analysis study on the use of DMSA in acute UTI yielded a sensitivity and specificity of 79% and 53%, respectively, for dilated hydronephrosis. There was marked statistical heterogeneity between the studies. The authors concluded that acute-phase DMSA renal scanning cannot be recommended as a replacement for VCUG in the evaluation of young children with a first febrile UTI [83].

There are other limitations of using RCS as the primary imaging for UTI. RCS for children is not readily available and usually takes place in specialized medical centers. Studies are performed 3 to 4 hours after intravenous injection and may require sedation in young children [84]. The estimated effective dose of DMSA is approximately 1 mSv, which is about 100 times more than nuclear cystography and about 10 times more than current low-dose VCUG technique [85].

#### *Voiding cystourethrography and nuclear cystography*

The main role of VCUG is to detect VUR [3-6]. Studies that include only children with VUR suggest that this group of patients may benefit more from prophylactic antibiotics. The RIVUR study, which enrolled 607 children 2 months to 6 years old 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, 8) [18]. Patients with high-grade VUR (grades III-IV) are more likely to have recurrent UTIs and scarring [12,16-18,29,35,80] 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 girls who received either prophylactic antibiotics or endoscopic treatment in decreasing recurrent UTI (number needed to treat for 2 years,

2.5 and 3, respectively) [34]. Girls who received antimicrobial prophylaxis had the lowest incidence of renal scarring (number needed to treat for 2 years, 5) [34].

The potential harms of VCUG relate to exposing children that will not benefit from a prophylactic antibiotic to an unpleasant study associated with minimal ionizing radiation and additional costs. In addition, there was no evidence of a decrease in renal scarring with prophylactic antibiotics, and the proportion of *Escherichia coli* isolates that were resistant to trimethoprim-sulfamethoxazole increased (63% in the prophylaxis group and 19% in the placebo group) [29]. Minor adverse drug reactions from prophylactic antibiotics were reported in 7% of children in the Montini et al [9] trial and antibiotics were stopped for suspected adverse reactions in up to 3.5% of the children in other studies [18,28].

VUR is detected with equal sensitivity by fluoroscopic contrast VCUG and direct RNC [86,87]. A second filling of the bladder (cyclic cystography) increases overall detection of VUR and dilated VUR [21,22]. Cyclic VCUG may be appropriate in children older than 2 years who cannot control voiding and when there is a high suspicion of VUR [21,22].

RNC has a lower absorbed radiation dose than VCUG, but it does not have the spatial resolution needed to identify anatomic abnormalities of the urethra, bladder, and ureters. Initial evaluation of VUR in girls and follow-up studies can be done by RNC [65].

### **Variant 3: Age >6 years, first febrile urinary tract infection with good response to treatment.**

The incidence of new-onset UTI in children older than 6 years is infrequent and often associated with behavioral abnormalities, dysfunctional elimination syndrome, or, at the teenage period, initiation of sexual intercourse [8,88]. Girls are affected more often than males [8]. The likelihood of detection of unknown underlying renal anomaly is low [88]. There is no evidence to support any routine imaging in the first UTI in this group of patients.

### **Variant 4: Atypical (poor response to antibiotics within 48 hours, sepsis, poor urine stream, raised creatinine, or non-*E coli* UTI) or recurrent febrile urinary tract infection.**

#### *Ultrasonography*

In children with atypical, recurrent, or complicated UTI, the main benefit of US is the detection of underlying abnormalities, stones, or complications such as a renal or perirenal abscess [89,90]. US has low sensitivity in detection of parenchymal abnormalities or VUR [31,42-47].

#### *Renal cortical scintigraphy*

RCS may have limited benefit in patients with VUR and atypical, complicated, or recurrent UTIs. Demonstration of renal scarring may suggest increased long-term risk for renal injury from VUR and support endoscopic or surgical antireflux management. RCS may also be helpful in predicting the risk of breakthrough infection and renal damage in children with VUR [91].

#### *Voiding cystourethrography and nuclear cystography*

The prevalence of VUR increases in children with recurrent UTIs [29]. In a hypothetical cohort of infants after first UTI and recurrent UTI, VUR increases from 35% to 74%, with increased risk of renal scarring with each UTI [2]. A finding of VUR may lead to antibiotic prevention treatment, and a finding of dilated VUR may lead to endoscopic or surgical treatment. As discussed above, nuclear cystography can be used in follow-up studies and as a first study in females.

#### *Computed tomography*

Postcontrast CT scan is sensitive in diagnosing pyelonephritis [48]. However, because of its radiation it should be performed selectively when there is suspicion for complications such as renal abscess or xanthogranulomatous pyelonephritis [58,89,92].

### **Summary of Recommendations**

- Imaging of UTI in children younger than 2 months may need to be more conservative, as neonates with UTI have a higher incidence of renal anomalies and are more likely to be complicated with sepsis. US is usually appropriate and cystourethrography may be appropriate in boys and whenever there are any sonographic abnormalities.
- In children aged >2 months and ≤6 years with a first febrile UTI with good response to treatment, imaging typically does not have a role in guiding management. US is the only imaging that is usually appropriate.

- In children aged >6 years with a first febrile UTI with good response to treatment, there is lower prevalence of VUR and there is usually no need for imaging to guide treatment. The role of US in this age group is controversial.
- In complicated UTIs (not responding well to antibiotics within 48 hours, sepsis, decreased urine stream, raised creatinine, or non-*E coli* UTI) or recurrent UTIs, the child should be imaged with VCUG in addition to US to help select children who may benefit from prophylactic antibiotics or antireflux intervention.

### Summary of Evidence

Of the 92 references cited in the *ACR Appropriateness Criteria® Urinary Tract Infection – Child* document, 6 are categorized as therapeutic references including 5 well-designed studies and 1 good quality study. Additionally, 80 references are categorized as diagnostic references including 2 well-designed studies, 18 good quality study/studies, and 27 quality study/studies that may have design limitations. There are 33 references that may not be useful as primary evidence. There are 6 references that are meta-analysis studies.

The 92 references cited in the *ACR Appropriateness Criteria® Urinary Tract Infection – Child* document were published from 1987-2014.

While there are references that report on studies with design limitations, 26 well-designed or good quality studies provide good evidence.

### 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, both because of 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 to 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 |
| ○                                     | 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 (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies”.

### Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

### References

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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.