

**American College of Radiology
ACR Appropriateness Criteria®**

Clinical Condition: Hematuria — Child

Variant 1: Isolated hematuria.

Radiologic Procedure	Rating	Comments	RRL*
US kidneys and bladder	7		O
X-ray voiding cystourethrography	3	May be useful if abnormality found on US.	☼☼
CT abdomen and pelvis with or without contrast	3	May be useful if abnormality found on US.	☼☼☼☼
X-ray abdomen and pelvis	2		☼☼☼
MRI abdomen and pelvis with or without contrast	2		O
Arteriography kidneys	2		☼☼☼☼
X-ray intravenous urography	2		☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: Painful hematuria (nontraumatic).

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without contrast	8	To evaluate for stones.	☼☼☼☼
US kidneys and bladder	7		O
X-ray abdomen and pelvis	6		☼☼☼
X-ray intravenous urography	2		☼☼☼
X-ray voiding cystourethrography	2		☼☼
MRI abdomen and pelvis with or without contrast	2		O
Arteriography kidneys	2		☼☼☼☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition:**Hematuria — Child****Variant 3:****Traumatic hematuria — macroscopic.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast	9		☼☼☼☼
X-ray retrograde urography	6	If blood present at urethral meatus, or if associated with pelvic fractures.	☼☼☼
CT pelvis with bladder contrast (CT cystography)	5	If there is a possibility of bladder injury or pelvic fracture and bladder is not well opacified with contrast from routine study.	☼☼☼☼
Arteriography kidneys	3	May be appropriate for interventional therapy.	☼☼☼☼
US kidneys and bladder	2		O
X-ray abdomen and pelvis	2		☼☼☼
X-ray intravenous urography	2		☼☼☼
MRI abdomen and pelvis with or without contrast	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 4:**Traumatic hematuria — microscopic.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast	7	CT may be indicated in the presence of risk factors such as pelvic fractures, flank pain and tenderness, hypotension, or other injuries.	☼☼☼☼
US kidneys and bladder	4	US can exclude mass or anomaly.	O
Arteriography kidneys	2		☼☼☼☼
X-ray abdomen and pelvis	2		☼☼☼
X-ray voiding cystourethrography	2		☼☼
X-ray intravenous urography	2		☼☼☼
MRI abdomen and pelvis with or without contrast	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

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Summary of Literature Review

Hematuria is the presence of red blood cells in the urine, either visible or as viewed under the microscope. Detecting blood in the urine of a child causes great alarm to patients, parents, and physicians.

The clinical evaluation of children with any form of hematuria begins with a meticulous history. Topics covered in the history should include urinary tract infection, strenuous exertion, tropical exposure, recent strep throat, recent trauma, menstruation, bleeding tendency, bloody diarrhea, joint pains, rash, flank pain, frequency, and dysuria. Searching for occult forms of trauma, foreign body insertion, family history of sickle cell disease or hemophilia, stone disease, hearing loss, and familial renal disease, hematuria, and hypertension should be undertaken. Factitious causes of “hematuria,” such as food substances or medicines coloring the urine without actually having red blood cells in the urine, should also be investigated [1-3]. An assessment of the child’s height and weight should be followed by a thorough physical examination. Fevers, arthritis, rashes, edema, nephromegaly, abdominal masses, genital or anal bleeding suggesting sexual abuse, deafness, and costovertebral angle tenderness should be discerned.

The next step is a thorough evaluation of the urine. Tea-colored urine and hematuria accompanied by proteinuria (>2+ by dip stick), red blood cell casts, and deformed red blood cells (best seen with phase contrast microscopy) suggest a glomerular source of hematuria (ie, glomerulonephritis). As will be discussed, imaging is seldom required for glomerular sources of bleeding, whereas it may be useful in nonglomerular sources of hematuria. White cells and organisms clearly indicate the

possibility of a urinary tract infection, which will direct care and imaging by a different set of criteria. Evaluation for hypercalciuria (such as a spot urine calcium/creatinine ratio) and a urine culture may be indicated. Basic laboratory metabolic screening will indicate findings of chronic renal insufficiency or long-standing acidosis; initial evaluation should include a blood urea nitrogen (BUN) test, a creatinine test, complete blood count, and a platelet count. If suggested by the initial clinical workup, more advanced medical assessment for various causes of glomerulonephritis and vasculitis should be performed, and an audiogram should be performed if indicated [4-10].

The need for imaging evaluation depends on the clinical scenario in which hematuria presents. This review focuses on the following clinical variations of childhood hematuria:

- Isolated hematuria.
- Painful hematuria.
- Renal trauma with gross hematuria.
- Renal trauma with microscopic hematuria.

The literature on pediatric hematuria generally consists of cohort studies (most being retrospective), as well as literature reviews and reports of personal experience. There are few randomized controlled trials or comparison studies with control groups. Despite these limitations, however, there are good and reasonably consistent data in the more recent literature to provide guidance on whether and how to image children with hematuria.

Isolated Hematuria

When the child has a definite medical diagnosis suggested by clinical evaluation (such as postinfectious glomerulonephritis, Henoch-Schönlein purpura, coagulopathy, sickle cell disease, systemic lupus erythematosus, or infection), imaging may be necessary to assess the size of the kidneys as an indicator of the chronicity of the renal disease and also as an assessment before renal biopsy. In this situation, ultrasound (US) is the best modality to display the anatomy, size, and position of the kidneys (especially prior to biopsy) and to screen for other pre-existing structural lesions in a patient with glomerulonephritis. If the US findings are normal, renal biopsy can sometimes add to the diagnosis of the common renal parenchymal diseases causing hematuria, such as IgA nephropathy (Burger’s disease) or Alport’s syndrome. However, many patients are followed clinically at this point without more extensive workup [1,4,7,11,12].

While isolated asymptomatic gross hematuria is usually due to benign and self-limited processes [2,13,14], there is fair to good evidence supporting the performance of US on these patients. Renal and bladder tumors may present with gross hematuria and are likely to be found with US

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[2,11,15-17]. Since the incidence of transitional cell uroepithelial neoplasia is extremely rare in children, intravenous urography (IVU) is not indicated [11,18]. While computed tomography (CT) is an excellent modality for imaging the genitourinary tract, given its expense and radiation exposure it is not indicated as a first-line test. In the cases of a suspected vascular lesion, such as a distended left renal vein from the nutcracker phenomenon, or an intrarenal vascular malformation, US is still the best method of initial evaluation, although contrast-enhanced CT and even angiography may be necessary for further diagnosis [14-17,19-23].

Asymptomatic microscopic hematuria (usually defined as five or more red blood cells per high-powered field on at least two of three consecutive urine specimens) is a common entity, with an incidence estimated to be 0.25%-1.0% in children 6 to 15 years of age [1-6,8,11,12]. Patients without proteinuria or dysmorphic red blood cells (which indicate glomerular disease) are unlikely to have clinically significant renal disease, and there is good evidence that no imaging is indicated [1,2,4,11,12]. Feld et al [1] evaluated 325 patients with microscopic hematuria; 87% had renal US and 24% had voiding cystoscopy urethrograms (VCUGs), and no findings were deemed to be clinically significant. As with isolated gross hematuria, IVU is not indicated in evaluating microscopic hematuria [11,18,24]. Microscopic hematuria is sometimes associated with hypercalciuria and/or hyperuricosuria, and some authors advocate renal US to evaluate for renal calculi in these patients [11,25], although others have found little value [1]. In cases of persistent unexplained microhematuria, US may be useful to evaluate for occult anatomic abnormalities (cystic renal disease, vascular abnormalities, congenital malformations, etc), although the yield of these examinations is likely low [4-6,8,11,24]. When nonmedical pressures (such as parental anxiety over neoplasia) are an issue, US is the modality of choice due to its relatively lower cost and lack of patient risk [2,12], and in some cases it may be justified for the reassurance it provides [11]. However, it must be recognized that isolated microscopic hematuria is almost never the presenting scenario of Wilms tumor [1].

If no diagnosis has been made and further workup is deemed necessary, evaluation of children is different than it is for adults. Cystoscopy is rarely indicated in the workup of a child with hematuria, whereas adults would routinely have cystoscopy performed to evaluate for transitional cell carcinoma of the bladder. Examination of the urinary bladder in the child will be performed during the renal US to assess for the presence of bladder lesions not diagnosed by the medical workup, such as polyps, masses, or vascular lesions of the bladder [8]. A VCUG should be considered to evaluate for vesicoureteral reflux, posterior urethral valves in the male, or other urethral causes of hematuria such as polyps, meatal stenosis, Cowper's duct cyst, urethral stenosis, or an abnormality of the fossa navicularis. A renal or bladder mass that is detected by US should have further imaging with CT or

magnetic resonance imaging (MRI) to define the extent of disease or vascular invasion (in the case of Wilms tumor), and to detect any presence of metastases.

Painful Hematuria

In the patient with abdominal pain and hematuria, the principal differential diagnosis is urolithiasis, although tumor and ureteropelvic junction (UPJ) obstruction should also be included. In young patients with genitourinary tract stone disease, the presenting symptoms may not be as classic as in adults, which in turn leads to uncertainty about the best imaging approach. Pediatric stone disease has an incidence of less than 2% of that in adults but is still commonly seen in busy pediatric practices [26]. While the literature provides some general suggestions and guidelines, what imaging test to perform under what clinical scenario is not universally agreed upon.

There is good evidence in the adult and pediatric imaging literature that CT is the most accurate imaging modality in the identification of stones and the quantification of stone burden [26-31]. CT scanning of course exposes these children to ionizing radiation. While with proper techniques the CT dose can be lowered to less than that of a traditional IVU [26], it raises the question of whether other imaging modalities (specifically radiographs and US) still play a role in pediatric stone disease. Levine et al [27] in a study of 178 adult and pediatric patients found radiographs had a 59% sensitivity for stone detection. Palmer et al [29] reported that US found 75% of all urinary tract stones, although US found only 38% of stones within the ureter. Similarly, Oner et al [28] showed that US correctly found stones in 78% of patients, although it only found 25% of urethral stones. Ulsan et al [32] showed variations in US stone detection between the right and left kidney, with a maximum accuracy of 77% for the right kidney and 54% for the left kidney, as compared to CT. Limitations of both radiography and US in children include greater obscuration by bowel gas and contents, and smaller stone size than in adults, neither of which impairs CT evaluation. The addition of Doppler evaluation for "twinkle" artifact improves renal stone detection [33,34], but direct comparisons with CT are thus far lacking.

The evidence is very good for the use of CT to detect genitourinary tract stones in children [26-29]. However, given the often vague nature of symptoms in pediatric nephrolithiasis, there is fair evidence that radiographs may still have some use, especially in a patient with a personal or family history of stone disease [27-29]. Similarly, US is still recommended as an initial screening test and, if positive, can then direct patient management [28,29], with the caveat that a negative US does not exclude stone disease [29]. In this approach, dose-adjusted CT is reserved for problematic cases. However, a reasonable argument can be made for limited dose-adjusted CT as the initial study of choice (especially in patients without a prior history of stones), it has the advantage of providing information about other pathology. IVU is seldom indicated in children as an

initial examination, although a limited study may provide information about stone position and movement after initial diagnosis.

Traumatic Hematuria

Hematuria is frequently found in the pediatric patient with blunt abdominal trauma [35,36]. In children, the most commonly injured viscera are the spleen, liver, and kidney. The amount of hematuria that should trigger radiologic investigation of the urinary tract is somewhat controversial, but several facts are well accepted:

- Gross hematuria is a finding that necessitates a radiologic evaluation of the abdomen and pelvis [37-42].
- Isolated microscopic hematuria without any clinical or laboratory findings of visceral trauma does not need emergency investigation [37,38,40-44].
- The presence of blood in the urethral meatus in a patient with pelvic fractures should lead to an investigation of the urethra and bladder (50% incidence of genitourinary injury) [45].
- Minor trauma to an anomalous kidney can cause major clinical repercussions (renal anomalies occur in 1%-4% of the population) [38,46].
- All CT scans must be done with intravenous (IV) contrast (enhanced CT).
- Hypotension is an unreliable clinical indicator for prompting imaging in children [40,46].

Macroscopic Hematuria

There is good evidence from multiple adult and pediatric studies that contrast-enhanced CT scan is the best modality for evaluating renal trauma, and that such imaging is required in patients with gross hematuria [37,38,40-43,47]. While US has been advocated as a first-line imaging test in abdominal trauma, renal injuries are sometimes missed [48-50], and in the setting of gross hematuria these patients are better served with CT. While there is evidence that contrast-enhanced US may perform nearly as well as CT in detecting traumatic injuries [51,52], US contrast agents are not currently available for this use in the United States. If renal injury is detected on CT, then obtaining delayed scans to evaluate for collecting system disruption should be performed [53].

Patients with gross hematuria and pelvic fractures are at high risk for bladder rupture [54,55]. The conventional fluoroscopic cystogram requires moving the patient to another imaging suite. There is good evidence that CT cystography is an accurate method of evaluation, with the advantage that the patient need not be moved from the CT scanner [54-56]. In general, images are obtained with a contrast-filled bladder and then after drainage, although one study in adults suggests that postvoid images may be unnecessary [54]. Multiplanar reformatted images may help in diagnosis [57].

Patients with blood at the urethral meatus, especially if associated with pelvic fractures or straddle injuries, are at

risk for urethral injury and disruption. These patients should undergo retrograde urography (RUG) prior to bladder catheter placement [45] and may warrant a cystogram to exclude concomitant bladder injury.

The limited or “one-shot” IVU was once a mainstay of adult renal trauma imaging. In current practice in a hemodynamically stable pediatric patient, the IVU has little role in the evaluation of hematuria [53,54].

Microscopic Hematuria

Different threshold values have been used for evaluating post-traumatic microhematuria, but in general >50 RBC/hpf has been used as a threshold for imaging [46,58]. However, recent studies note at best a fair correlation between degree of microhematuria and risk or severity of renal injury [37,40-42], and the use of a cutoff value may not be appropriate.

For patients with isolated microscopic hematuria without coexistent injury, there is good evidence that renal imaging with CT is unlikely to disclose clinically significant findings [37,40-42]. While there have been advocates for US in this setting [48], it is unlikely to provide meaningful patient management information [41].

However, children with microhematuria can have significant renal trauma, almost always associated with coexistent injury or congenital abnormalities, and associated clinical findings. There is good evidence that patients with multiorgan injury, a history of deceleration injury, localized flank pain, and ecchymosis should undergo CT imaging to evaluate for renal injury. While hypotension is an unreliable clinical indicator in the child (unlike the adult), a child with a falling hemoglobin or a hemodynamic instability should be considered for imaging [40,42].

Summary

- Isolated nonpainful hematuria is best evaluated by US.
- To evaluate for renal calculi, CT without contrast is the most useful examination, although US can also be useful. Be sure to reduce radiation dose if possible.
- In the setting of trauma, CT with contrast is the most useful examination, especially with macroscopic hematuria.

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
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 (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as NS (not specified).

Supporting Document(s)

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Information](#)
- [Evidence Table](#)

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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.