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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Hematuria**

Variant 1: **Patients with vigorous exercise, presence of infection or viral illness, or present or recent menstruation.**

Radiologic Procedure	Rating	Comments	RRL*
US kidneys and bladder retroperitoneal	3		O
CT abdomen and pelvis without and with IV contrast	2		☢☢☢☢
CT abdomen and pelvis with IV contrast	2		☢☢☢☢
CT abdomen and pelvis without IV contrast	2		☢☢☢☢
X-ray intravenous urography	2		☢☢☢
MRI abdomen and pelvis without and with IV contrast	2		O
MRI abdomen and pelvis without IV contrast	2		O
X-ray retrograde pyelography	1		☢☢☢
Arteriography kidney	1		☢☢☢
X-ray abdomen and pelvis (KUB)	1		☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant2: **Patients with disease of renal parenchyma as the cause of hematuria.**

Radiologic Procedure	Rating	Comments	RRL*
US kidneys and bladder retroperitoneal	8		O
X-ray retrograde pyelography	2		☢☢☢
CT abdomen and pelvis without and with IV contrast	2		☢☢☢☢
CT abdomen and pelvis with IV contrast	2		☢☢☢☢
CT abdomen and pelvis without IV contrast	2		☢☢☢☢
MRI abdomen and pelvis without and with IV contrast	2		O
MRI abdomen and pelvis without IV contrast	2		O
Arteriography kidney	1		☢☢☢
X-ray abdomen and pelvis (KUB)	1		☢☢
X-ray intravenous urography	1		☢☢☢
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**

Variant3: **All patients except those described in variant 1 or 2.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without and with IV contrast	9	CT urography. Must include high-resolution imaging during excretory phase.	☢☢☢☢
CT abdomen and pelvis without IV contrast	6		☢☢☢☢
X-ray retrograde pyelography	6	For patient with contraindication to iodinated contrast or strong suspicion of urothelial lesion, to clarify abnormality suspected on CT or IVU.	☢☢☢
CT abdomen and pelvis with IV contrast	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.	☢☢☢☢
US kidneys and bladder retroperitoneal	5		O
MRI abdomen and pelvis without and with IV contrast	5	MR urography. For patients with contraindication to iodinated contrast.	O
MRI abdomen and pelvis without IV contrast	4		O
Arteriography kidney	2		☢☢☢
X-ray abdomen and pelvis (KUB)	2		☢☢
X-ray intravenous urography	1		☢☢☢
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

HEMATURIA

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Summary of Literature Review

Introduction/Background

Hematuria is one of the most common presentations of patients with urinary tract diseases and of patients referred for urinary imaging. This review summarizes practice for the radiologic approach to such patients. It is limited to adults and does not refer to patients whose hematuria coexists with other clinical situations reviewed in other ACR Appropriateness Criteria® topics, including acute trauma, infection, renal failure, symptoms of acute stone disease, known renal masses, and prostatism. It is also limited to initial tests; follow-up of normal or abnormal first tests is beyond its scope.

The initial decision to be made is whether all patients with any degree of hematuria need imaging evaluation. Hematuria can originate from any site in the urinary tract and be due to a wide range of causes, which can be roughly divided into renal, urothelial, or prostatic causes. Thorough evaluation of gross hematuria is recommended, and this is usually done with a combination of clinical examination, cystoscopic evaluation, and urinary tract imaging [1-3]. Patients on anticoagulants who present with gross or microscopic hematuria have a sufficiently high prevalence of important disease including tumors that workup cannot be forgone [2-4].

Microscopic Hematuria

In comparison to gross hematuria, the situation is somewhat different in patients with microscopic hematuria. The recommended definition of microscopic hematuria is three or more red blood cells per high-power field on microscopic evaluation of urinary sediment from two of three properly collected urinalysis specimens [3]. Patients with no detectable abnormalities in their urinary tracts may release small amounts of blood into the urine, so that several red cells per high-power field may be seen upon microscopic examination of the spun sediment.

The low prevalence of clinically detectable disease in some groups of patients with asymptomatic microscopic hematuria has led some investigators to suggest that minimal microhematuria in an asymptomatic young adult needs no evaluation. Unfortunately, no threshold number of red blood cells per high-power field has been found that separates patients with clinically important disease from those with no detectable urinary tract abnormalities [3].

As alluded to above, hematuria can be due to a wide variety of causes such as calculi, neoplasms, infection, trauma, coagulopathy etc. [1-3,5]. In patients with risk factors such as cigarette smoking, occupational exposure to chemicals, irritative voiding symptoms, a full urologic evaluation for urothelial carcinoma is recommended if even one urinalysis documents the presence of at least three red blood cells per high-power field [4].

There may be specific circumstances in which complete radiologic workup of microscopic hematuria is unnecessary [6]. Young women with a clinical picture of simple cystitis, and other patients whose hematuria completely and permanently resolves after successful therapy, are unlikely to benefit from any imaging [7]. Patients who have a disease of the renal parenchyma (which include glomerulonephritis, glomerulonephropathy, acute tubular necrosis, and acute kidney injury) also constitute a special group. A thorough urinary analysis

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should be the initial workup in this population. Although such patients should have renal ultrasound (US) to evaluate the kidneys for coexistent morphologic abnormalities, an extensive workup to exclude a mass that may be the cause of the hematuria is thought to be unnecessary [1,4]. In patients with recent history of infection or viral illness, vigorous exercise, or urological procedures such as catheterization, initial imaging workup is also not beneficial [3,4]. Chronic hematuria in the above populations of patients warrants further workup that probably should include imaging.

In situations of recent trauma, patients with minor blunt trauma may not need imaging initially, but penetrating or major trauma will definitely warrant some imaging early. In the setting of trauma, please see the ACR Appropriateness Criteria® "Suspected Lower Urinary Tract Trauma" [8].

Imaging Evaluation

Imaging evaluation is recommended for all other adult patients with hematuria [4] to detect urologic malignancies as well as the other possible causes of hematuria mentioned above. A complete history, physical examination, urine analysis, and appropriate serologic tests such as antinuclear antibody (ANA) and double-stranded DNA (dsDNA) should precede or accompany the imaging examinations. The imaging evaluation will almost always be accompanied by cystoscopy to evaluate the urinary bladder, since many bleeding urinary tract lesions arise in the urinary bladder [5], and imaging procedures are not yet conclusively proven to be as sensitive as cystoscopy in diagnosing most of them. Multi-detector-row computed tomography (CT) has been evaluated in detecting bladder cancers [9,10], and reports suggest a sensitivity and specificity of 95% and 92%, respectively [11]. One retrospective study reports that computed tomography urography (CTU) and cystoscopy had similar diagnostic accuracy for detection of bladder cancer in patients with hematuria alone; however, cystoscopy remains superior in patients with prior urothelial malignancy [12].

Computed Tomography

Until the mid-1990's, excretory urography (IVU) was the imaging study used in evaluating hematuria [2,5,9,13], but development of multidetector CT and the excretory phase CT urogram, also known as CTU, have supplanted IVU over the past 15 years [14,15]. Compared to CT and US, IVU has low sensitivity for detecting renal masses <2–3 cm in size, and even if a mass is visualized, further cross sectional studies such as US, CT, or magnetic resonance imaging (MRI) are then necessary to characterize the mass. In one prospective study that compared CT and IVU in the same patients with microhematuria [16], radiographic abnormalities were noted in 38 patients; sensitivity and accuracy of CT were 100% and 98.3% compared to 60.5% and 80.9% for IVU. Fewer additional radiographic studies were recommended after CT than after IVU in the experience of these authors. Another prospective study that compared CT and IVU in different patients with hematuria found that CTU had higher sensitivity than IVU for detecting upper tract pathology (94.1% versus 50%), but both imaging modalities had low sensitivities (40% or less) for detecting lower tract lesions [17].

Dual energy, split bolus CT protocol that provides virtual noncontrast, parenchymal and urographic phases in a single scan is being researched, but its benefits are unclear at this time [18,19].

Ultrasound

US still has a role in the initial workup of hematuria to search for bleeding urinary tract lesions [6,13,20-22]. It is especially useful in radiation-sensitive populations, such as children and pregnant or child-bearing age women, to detect renal calculi and renal masses. In patients in whom glomerular disease is the cause of hematuria, US can examine the renal parenchyma and follow disease progression. US can evaluate length, quantitative echogenicity, cortical thickness, and parenchymal thickness. One study showed that echogenicity correlated the strongest with histological parameters that include glomerular sclerosis, tubular atrophy, interstitial fibrosis, and interstitial inflammation [23]. In a prospective study, US had higher sensitivity (96% versus 25%) and negative predictive value (98% versus 91%) than IVU in detecting abnormalities of the upper urinary tract in patients present with hematuria [22]. Therefore, US should replace IVU for first-line screening of the upper tracts in radiation-sensitive populations and patients with glomerular disease as the cause of hematuria. However, in comparison to cross-sectional imaging modalities such as multidetector CTU or magnetic resonance urography (MRU), US has lower sensitivity in detecting urinary tract abnormalities [22]. Another prospective study of 841 hematuria patients who had CTU or MRU showed no significant upper urinary tract lesions in 86.1%. US was a significant predictor of the final CTU/MRU result [20]; that is, US can be used as an initial screening tool and can triage patients who need further cross-sectional urography. For the majority of patients with hematuria, multidetector CTU remains the best overall imaging modality due to its widespread availability, ability to detect a range of possible causes including small renal masses, calcifications and stones and ability to image the upper tract collecting system. MRU is a reasonable alternative for detection of small renal masses but is poor for detection of calcifications and small stones. In patients who have contraindications to CTU or are sensitive to radiation, or who have a very low-risk of having a malignant cause of hematuria, US is the first-line imaging modality [20,22]. One study has shown that 3D US improved accuracy of detecting bladder cancer compared to 2D US, especially for small lesions [24].

In patients with medullary sponge kidney disease and papillary necrosis, US can be used as an initial imaging study and subsequent follow-up study for progression.

Intravenous Urography and Retrograde Pyelography

The detection of urothelial lesions in the upper tracts was traditionally performed with IVU and/or ureteroscopy along with cystoscopy [3]. CTU has largely supplanted IVU for imaging the upper urinary tract [15,25,26]; images are acquired prior to contrast administration and then during nephrographic and excretory urographic phases of enhancement for a complete evaluation for urinary tract stones, neoplasms in the upper and lower urinary tracts, and other pathologies. Reconstructed 3D images can be used to produce IVU-like images in different projections.

Numerous studies have established that CTU is superior to IVU for detecting upper tract urothelial lesions in patients with hematuria [27-29]. In a meta-analysis, CTU proved to be a very sensitive and specific method for the detection of urothelial malignancy with pooled sensitivity of 96% and pooled specificity of 99%, and was superior in direct comparison to IVU in terms of sensitivity and specificity [27].

Retrograde pyelography does not rely on renal excretion of intravascular contrast. In patients with impaired renal function, or contraindications to CTU or MRU, or suboptimal CTU or MRU, a retrograde pyelography may be a reasonable adjunct to cystoscopy in patients with suspected upper tract lesions [4].

Magnetic Resonance Urography

MRU can be performed with or without contrast. MRU without contrast is an excellent technique to demonstrate the cause and level of urinary obstruction, particularly if it is not due to calculous disease [30,31]. The sensitivity of MRU in detecting urothelial lesions remains under investigation, and at present it is not believed to be the equivalent of either IVU or CTU [25,32]. However, in patients who cannot receive iodinated contrast material or are radiation sensitive, MRU can be useful [30]. Now there is research to study other sequences such as diffusion-weighted MR imaging in detecting bladder cancer [33].

MRI and CT have shown comparable accuracy in detection and characterization of most renal lesions. However, with indeterminate renal lesions on CT or complicated cysts, MRI can be useful for better characterization [34,35].

Cystoscopy

Although bladder neoplasms can be visualized on IVU, CT, and MRI, cystoscopy is still considered to be the optimal technique to detect the plaque-like lesions of early bladder cancers, although newer studies suggest that a properly performed CTU in an adequately distended bladder is quite sensitive in detecting bladder cancer [11]. CTU as the first study in patients with hematuria may help in the triage of such patients [9,10]. Patients with no bladder abnormality on CTU can proceed to office cystoscopy, while those with a suspected bladder neoplasm can undergo cystoscopy in the operating room with intent to biopsy.

Other Imaging Studies

Plain radiography of the abdomen and pelvis (KUB) and catheter arteriography of kidneys are not used as first line image modalities for initial evaluation of hematuria. KUB may be useful in patients with history of kidney stones for evaluation of stone size and position and for assessment of stone passage. Rarely, vascular disorders such as aneurysms, arterio-venous malformations or obstruction of a calyx from overlying artery (Fraley's syndrome) may result in hematuria. In these suspected situations, catheter angiography may be useful for diagnosis and for therapeutic interventions [36].

Summary of Recommendations

- Most adults with gross or persistent microhematuria require urinary tract imaging, with CTU replacing the traditional IVU for this indication.
- Although MRI is an excellent technique to evaluate the renal parenchyma for masses and other abnormalities, it is inferior to CTU and IVU in detection of small stones and urothelial lesions.

- In patients with microscopic hematuria with suspected renal parenchymal disease, renal US may be useful to exclude coexistent morphologic abnormalities. In a few carefully chosen patients with selected indications, no imaging may be necessary.

Summary of Evidence

Of the 36 references cited in the *ACR Appropriateness Criteria® Hematuria* document, 1 is categorized as a quality therapeutic study that may have design limitations. Additionally, 35 references are categorized as diagnostic references including 1 well-designed study, 6 good quality studies, and 10 quality studies that may have design limitations. There are 18 references that may not be useful as primary evidence.

The 36 references cited in the *ACR Appropriateness Criteria® Hematuria* document were published between 2002–2014.

While there are references that report on studies with design limitations, seven 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**
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 "Varies".

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

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