American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Hematuria**

Variant 1: **All patients except those with generalized renal parenchymal disease or young females with hemorrhagic cystitis.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis without and with contrast (CT urography)	9	Must include high-resolution imaging during excretory phase.	☢☢☢☢
X-ray intravenous urography	6	If CT urography unavailable.	☢☢☢
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.	☢☢☢
US kidneys and bladder retroperitoneal	5		O
MRI abdomen and pelvis without and with contrast (MR urography)	5	For patients with contraindication to iodinated contrast. See statement regarding contrast in text under "Anticipated Exceptions."	O
CT abdomen and pelvis without and with contrast	5		☢☢☢☢
MRI abdomen and pelvis without and with contrast	3		O
Arteriography kidney	2		☢☢☢
X-ray abdomen and pelvis (KUB)	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: **Due to generalized renal parenchymal disease.**

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

HEMATURIA

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Summary of Literature Review

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 nephrological and urological causes. Thorough evaluation of gross hematuria is usually recommended, and this is usually done with a combination of clinical examination, cystoscopic evaluation, and urinary tract imaging [1,2]. Patients on anticoagulants who present with gross hematuria have a sufficiently high prevalence of important disease that workup cannot be forgone; tumors were found in one quarter of patients and other treatable findings in half the patients in one series [3].

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 [2]. 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 [4]. 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 [5,6].

As alluded to above, hematuria can be due to a wide variety of causes such as calculi, neoplasms, infection, trauma, coagulopathy etc [7]. In patients with risk factors such as a history of smoking, occupational exposure to chemicals, irritative voiding symptoms, etc. a full urologic evaluation is recommended if even one urinalysis documents the presence of at least three red blood cells per high-power field [7].

There may be specific circumstances in which complete radiologic workup of microscopic hematuria is unnecessary [2]. Young women with a clinical picture of simple cystitis, and whose hematuria completely and permanently resolves after successful therapy, are unlikely to benefit from any imaging [8-10]. Patients who have clear-cut evidence of glomerular disease also constitute a special group; although such patients should probably have renal ultrasound (US) to evaluate the kidneys for coexistent morphologic abnormalities, an extensive workup to exclude a surgical lesion that may be the cause of the hematuria is probably unnecessary [10-13].

Imaging evaluation is recommended for all other adult patients with hematuria [9,10,14] 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 should precede or accompany the imaging

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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 [13,15], 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) is being evaluated in detecting bladder cancers [16], and reports suggest a sensitivity and specificity of 95% and 92%, respectively [17].

Historically, excretory urography (IVU) was the imaging study used in evaluating hematuria [2,9], but the availability of excretory phase CT, also known as CT urography (CTU), has supplanted the use of IVU in many institutions [18,19]. IVU has low sensitivity for detecting renal masses <2-3 cm in size [20,21], and even if a mass is visualized, other studies such as US, CT, or magnetic resonance imaging (MRI) are then necessary to characterize the mass. In one study that compared CT and IVU in patients with microhematuria [20], radiographic abnormalities were noted in 38 patients; CT accuracy was 98.3% compared to IVU accuracy which was 80.9%, with sensitivity of 100% for CT and 60.5% for IVU. Fewer additional radiographic studies were recommended after CT than after IVU in the experience of these authors. The performance of MRI is equivalent to CT in detecting and characterizing renal masses in clinical practice.

US still has a role in the initial workup of hematuria to search for bleeding urinary tract lesions [22-24]. It is especially useful in radiation-sensitive populations, such as pregnant women and children, to detect renal calculi and renal masses. In the general adult population, US has a more limited role in renal mass detection due to its lower sensitivity relative to other cross-sectional imaging modalities. For example, Amendola et al [25] found a sensitivity of 67% for IVU, 79% for sonography, and 94% for conventional nonmedical CT for renal masses. Warshauer et al [21] in a study of 201 patients found that US detected 60% of CT lesions between 1-2 cm in size and 82% of CT lesions 2-3 cm in size, and 85% of CT lesions >3 cm in size. Despite the improvements in US technology, the superiority of CT was further confirmed in a subsequent study of 205 surgically resected renal masses [26]. This study found that for masses <1 cm, CT detected 76% and US detected 20%, and for masses <2 cm, CT detected 95% and US detected 70%. For masses >3 cm, sensitivities were above 90% for both modalities.

US may be more useful for renal mass characterization than for detection, because it can reliably distinguish simple cysts, which occur in 50% of people older than age 50 and require no follow-up, from less common complex masses that warrant additional evaluation. The reported accuracy for distinguishing a cyst from a solid mass is 82% for lesions between 10-35 mm, with an accuracy of 100% for lesions ≥35 mm [26]. US has already been shown to be the most cost-effective approach for evaluating renal masses detected on urography, as 80% of those masses may be characterized as cysts sonographically [27]. US and urography tend to miss different sorts of lesions. US is not likely to detect nonobstructing ureteral stones or small urothelial abnormalities, and urography with nephrotomography may miss small exophytic anterior and posterior renal masses and small bladder lesions [25,28]. The choice of examination may be affected by clinical circumstances (a positive urinary cytologic analysis may make IVU or CTU crucial, whereas serious risk factors for contrast reactions may make US more appropriate).

The detection of urothelial lesions in the upper tracts was traditionally performed with IVU or cystoscopy followed by bilateral retrograde pyelography in patients who could not receive intravenous contrast [2]. CTU is now increasingly used for a complete evaluation of the urinary tract [19,29-32]; images are acquired in noncontrast, nephrographic, and 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 orientations and projections.

There is insufficient data in the literature to conclusively indicate whether CTU has sufficient sensitivity in detecting upper tract urothelial lesions to replace IVU, which has higher in-plane spatial resolution. A recent study indicated that CTU was the equivalent of retrograde pyelography in detecting upper tract urothelial tumors [33].

Magnetic resonance urography (MRU) is an excellent technique to demonstrate the cause and level of urinary obstruction, particularly if it is not due to calculous disease [34]. 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 [29,35].

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 CT is quite sensitive in detecting bladder cancer [17]. CT urography as the first study in patients with hematuria may help in the triage of such patients [16]. 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.

Virtual cystoscopy, the acquisition of high-resolution CT images reconstructed to allow virtual "fly-through" of the bladder, is being studied in evaluation of the bladder in patients with hematuria [32]. Its role remains yet to be defined.

Urinary tract scintigraphy [36] has insufficient spatial resolution to screen for renal parenchymal or nonobstructing urothelial lesions.

Summary

- Most adults with gross or persistent microhematuria require urinary tract imaging, with CTU supplanting the time-honored 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 urothelial evaluation at present.
- In patients with microscopic hematuria that is determined to be due to renal parenchymal disease, there is no defined role for imaging.
- In a few carefully chosen patients with selected indications, no imaging may be necessary.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m^2. For more information, please see the ACR *Manual on Contrast Media* [37].

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

- ACR Appropriateness Criteria® Overview
- Procedure Information
- Evidence table under review

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