Role of radiological imaging for the evaluation of haematuria

DHARUV PATEL AND UDAY PATEL

Haematuria is a sign that can arise from a constellation of disorders, ranging from urinary tract infection to invasive malignancy. The authors review imaging modalities for the investigation of haematuria and highlight how imaging is key to the exclusion of potentially serious causative aetiologies.

Dhruv Patel, MB ChB, BSc, MRCS, FRCR, Specialist Registrar in Radiology; Uday Patel, MB ChB, MRCP, FRCR, Consultant Radiologist, St George’s Hospital, London

Haematuria is the presence of blood in the urine and may be macroscopic or microscopic. It is more strictly defined as the presence of five or more red blood cells per high-powered field in three of three consecutive centrifuged specimens, obtained at least one week apart. In the clinical setting, a positive urine dipstick reaction for the presence of blood is usually the first indication of haematuria. It may be symptomatic or asymptomatic, transient or persistent, encountered as an isolated feature or in association with other urinary abnormalities.

Haematuria, especially when gross, can be a troubling sign for the patient, and prompt reassurance and investigation are required for diagnosis. The history and nature of the haematuria is of obvious importance in establishing the initial differential diagnosis.

Patients with macroscopic haematuria, symptomatic microscopic haematuria, and those aged over 40 years with asymptomatic microscopic haematuria, should be referred for urological investigation according to consensus guidelines provided by the British Association of Urological Surgeons.1

Urological investigation of haematuria depends upon local policy and practice; until recently, however, most centres would advocate ultrasound of the urinary tract and flexible cystoscopy, often as part of a ‘one-stop’ haematuria clinic.2,3 In certain circumstances, for example acute renal colic causing haematuria, plain film imaging may be of value. The most important diagnosis to exclude is malignancy: ultrasound (Figure 1) and computed tomography (CT) examinations are the most sensitive imaging modalities in this regard.

Figure 1. Ultrasound image demonstrating transitional cell carcinoma at the bladder base
Post-contrast techniques such as intravenous urography (IVU) or CT-urography (CT-U) are of great importance in detecting upper tract urothelial (transitional cell carcinoma) malignancies. It should be noted that imaging plays little role in the diagnosis of haematuria secondary to renal parenchymal disease, and is of only modest value for excluding bladder pathology.

**IMAGING MODALITIES**

The choice of imaging modality utilised in the investigation of haematuria depends on various surrounding factors such as the chronicity of the presentation, renal function, co-existent medical pathologies, previous/family history of urinary tract malignancy, negative or positive urine cytology and local availability/expertise.

**Plain radiograph**

The kidneys/ureters/bladder (KUB) radiograph is of limited value in the assessment of haematuria. However, it does play a role in the diagnosis of urinary stones, which may cause haematuria. Occasionally, less common causes of haematuria may be visible on a plain KUB radiograph, for example bladder wall calcification in a transitional cell carcinoma or air within the bladder lumen caused by an enterovesical fistula. Schistosomiasis is another cause of bladder wall calcification, and should be considered in travellers or recent migrants.

**Intravenous urography**

Intravenous urography was one of the first contrast-based radiological investigations (first performed in 1923) and was for many years the workhorse imaging modality for detection/surveillance of upper tract urothelial-based disease, including malignancy. It is, however, not sufficiently sensitive, and has now been been superseded by CT-U. In centres where CT-U is not routinely practised, IVU remains a useful tool in the detection of upper tract neoplasia. IVU may also detect other pathologies within the kidneys causing haematuria, such as papillary necrosis or renal cell carcinoma. The disadvantages of the IVU are that it is lengthy, taking 30–45 minutes, requires intravenous contrast injection and comes with an appreciable radiation load. However, its relative inaccuracy is the main shortcoming. It will soon be of historical interest only.

**Ultrasound**

Ultrasound plays a central role in the assessment of haematuria. It is a readily available, risk-free and inexpensive imaging technique. Its sensitivity is variable, depending on the experience and ability of the operator and the body habitus of the patient. It is a useful modality for the detection of urinary tract calculi. In addition, ultrasound has been shown to be more sensitive than IVU in diagnosing urological malignancy. Ultrasound is also considerably more sensitive for detection of bladder tumours than IVU (see Figure 1). The sensitivity of ultrasonography is, however, not sufficient to obviate the need for cystoscopy because of its lack of sensitivity in detecting small tumours <0.5cm in diameter. Ultrasound also has a useful role in detecting secondary signs of tumours, such as hydronephrosis resulting from a bladder tumour obstructing the vesicoureteric junction. In addition, ultrasound allows for interventional procedures such as renal biopsy.

**Computed tomography**

Contrast-enhanced CT is firmly established as the overall most sensitive modality for imaging causes of haematuria. It is more sensitive than ultrasound in diagnosing renal masses, with sensitivity in the range of >98 per cent compared to approximately 85 per cent for ultrasound. CT-U has a greater sensitivity in diagnosing upper tract urothelial malignancy than IVU, with sensitivities of up to 85 per cent compared with up to 60 per cent on IVU. In addition, CT has a potential role as a non-invasive means of diagnosing bladder malignancy, but this requires further evidential data (Figure 2).

Computed tomography can be used in a variety of methods and protocols depending upon the presentation of the patient. For example, if a urinary calculus is suspected as the cause of haematuria associated with renal colic, an unenhanced CT KUB can be performed, with an excellent sensitivity in the diagnosis of renal colic. Contrast-enhanced CT also allows for the evaluation of renal pathology, which may be contributing to haematuria, such as renal cell carcinoma. By utilising differing phases of contrast enhancement, abnormally enhancing tissue may be visible against the normal surrounding renal parenchyma (Figures 3 and 4).

Multiphasic post-contrast imaging is extremely useful in diagnosing upper tract urothelial malignancy. The principle of this
technique is based upon contrast medium being absorbed by normal renal parenchyma, excreted into the collecting system and subsequently into the ureters. If the correct timings are utilised following the administration of contrast, a CT-urogram can be obtained, equivalent to, but more detailed than an IVU. This technique can be performed using a split-bolus of contrast, allowing optimal enhancement of both the renal parenchyma and the collecting systems in one examination. This has the obvious advantage of localising pathology with high anatomical detail (Figure 5).

Computed tomography-urography is a non-invasive technique and allows for a thorough examination of the kidneys, collecting systems, ureters and urinary bladder, as well as allowing for the identification of any extra-urinary pathologies that may be causing haematuria.

Indeterminate renal masses may be analysed using multiphasic CT for further characterisation. For example, detection of fat within a renal mass can help distinguish an angiomylipoma from a renal malignancy. CT also allows for three-dimensional reconstruction of images, which is useful in guiding surgical intervention within the upper tract. In addition, renal masses can be biopsied under CT guidance. CT is also the first-line examination in the assessment of haematuria secondary to blunt or penetrating trauma. Computed tomography-urography does have its limitations. It requires the use of intravenous contrast medium and, because of the use of ionising radiation, it is not suitable for all patients. The radiation dose is estimated at 12mSv for a split-bolus technique13 and higher for multiphasic examination.25,26

Magnetic resonance imaging
Magnetic resonance imaging (MRI) is of limited value in the assessment of haematuria. It can be of use in helping to define the internal composition of some renal masses and can be useful in renal cystic disease by detecting signs of haemorrhage. In patients with tuberose sclerosis, surveillance of renal masses is often undertaken with abdominal MRI because of the need to avoid repeated radiation doses from CT. Its greatest use is when combined with a urographic (MRU) technique to ascertain the level and cause of urinary tract obstruction.27 The sensitivity of MRU in detecting urothelial lesions remains a topic of investigation, and at present it is not believed to be equivalent to either IVU or CT-U.28,29

Nuclear medicine
Conventional isotope imaging is also of limited use in haematuria because of its lack of spatial resolution, although CT-positron emission tomography is of increasing use in the detection and evaluation of renal masses.30 Mercaptuacetyltriglycine (MAG-III) examination is also of some use in evaluating differential renal function when surgical therapy is considered.

Angiography
Super-selective catheterisation of renal vessels allows for the assessment and treatment of renal arterial haemorrhage, which may be causing haematuria. This may occur as a result of bleeding from a

Figure 3. Computed tomography-urography axial image in a patient presenting with haematuria. A right renal pelvic transitional cell carcinoma is visible, outlined by the surrounding contrast

Figure 4. Computed tomography-urography coronal reformat in a patient presenting with haematuria. A left upper pole renal tumour is evident with a blood clot visible in the left renal pelvis inferior to this (arrow)

Figure 5. Computed tomography-urography coronal reformat in a normal subject demonstrating excellent opacification of the pelvicalyceal systems and ureters (arrows on ureters)
Haematuria is a common complaint, which places a significant burden on both community and hospital resources.

Accurate imaging in conjunction with urological evaluation plays a central role in the exclusion of serious pathologies.

Computed tomography-urography (CT-U) is the accepted gold standard for the appraisal of macroscopic haematuria and sustained microscopic haematuria.

Intravenous urography and ultrasound still play an important role in the first-line evaluation of haematuria and provide a rapid and safe means of excluding many pathologies.

The role of magnetic resonance imaging is increasing, although currently it remains inferior to CT-U in the detection of urothelial malignancy.

renal malignancy or haemorrhage from an angiomyolipoma, or may be the result of trauma. Angiography and subsequent embolisation is now the treatment of choice in the management of renal haemorrhage.

CONCLUSION
Multimodality imaging of patients with haematuria allows for rapid assessment and subsequent management. The traditional and cost-effective combination of ultrasound and IVU is being superseded by CT-U in many centres. CT allows for a thorough assessment of the urinary tract and is undoubtedly the current gold standard in the imaging evaluation of haematuria.

Declaration of interests: none declared.

REFERENCES


