Diagnosis and Management of Hematuria

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KEYWORDS

• Hematuria • Trauma • Malignancy • Infection • Urolithiasis • Workup
• Clot retention • CBI

KEY POINTS

- Hematuria can be caused by a variety of etiologies, found along the entire genitourinary tract, including urolithiasis, urinary tract infection, malignancy, iatrogenic causes and trauma.
- The most important aspects of triaging and initial management of a patient with hematuria are assessing hemodynamic stability, determining the underlying cause of hematuria, and ensuring urinary tract drainage.
- Hematuria workup should be pursued in all patients presenting with hematuria in whom benign causes of bleeding have been ruled out.

INTRODUCTION

Hematuria is a complex condition with a multitude of causes and treatments. It can be a daunting situation when an otherwise nonurologic surgical patient has this condition. This article provides an overview of the many aspects of this condition and provides guidelines for treatment. In general, collaboration with the urology, and occasionally nephrology, services is recommended in treating the general surgery patient with hematuria. After reading this article, the reader will gain knowledge on common etiologies, diagnosis, treatment, outcomes, and follow-up of the surgical patient with hematuria to provide the best possible patient care.

Hematuria is commonly encountered in the inpatient setting where it accounts for 4% to 20% of inpatient urology consults and hospitalizations.[1] *Hematuria* is the presence of blood cells in the urine. Gross hematuria is when blood is visible in the urine. Microscopic hematuria is defined as 3 or more red blood cells per high-powered field in a properly collected urine sample.

The initial evaluation of patients presenting with gross hematuria is 3-fold: assess hemodynamic stability, determine the underlying cause of hematuria, and ensure urinary drainage. The most important consideration in the initial evaluation of a patient

Disclosures: The authors have nothing to disclose.
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Surg Clin N Am 96 (2016) 503–515
http://dx.doi.org/10.1016/j.suc.2016.02.007 **surgical.theclinics.com**
0039-6109/16/$ – see front matter

with hematuria is hemodynamic stability with assessment of vital signs, physical examination, and hemoglobin/hematocrit, because an unstable patient must be treated emergently. Examples of etiologies of hematuria that may cause emergent bleeding include, but are not limited to, trauma such as intraperitoneal bladder rupture, ureteroarterial fistula, and hemorrhagic cystitis. By contrast, painless gross hematuria without hemodynamic compromise is a condition that is generally worked up on an outpatient basis. For this reason, it is extremely important to ensure that these patients have outpatient urologic follow-up scheduled.

The best approach to treating a patient with hematuria is to identify the underlying cause of hematuria, because the etiologies are diverse and often have very different treatments. Common etiologies of hematuria in the surgical inpatient include urinary tract infection (UTI), urolithiasis, malignancy, and trauma or iatrogenic causes (eg, traumatic urethral catheter placement or anticoagulation).

There are several medications (such as phenazopyridine, nitrofurantoin, phenytoin, and warfarin) that can cause or give the appearance of hematuria. Thus, inpatient medications should be evaluated. Additionally, patients may be anticoagulated, which may cause hematuria from a variety of sources such as benign prostatic hyperplasia (BPH) or undiagnosed urinary tract malignancies.

Gross hematuria should always be considered significant, because it is a sign of malignancy until proven otherwise. Roughly 4% of patients with microscopic hematuria and up to 40% of patients with gross hematuria could be harboring a malignancy.[2]

RELEVANT ANATOMY AND PATHOPHYSIOLOGY

The etiology of hematuria can originate from anywhere along the urinary tract, including the kidneys, ureters, bladder, prostate, and urethra (**Table 1**).

Kidney and Ureter

Specifically from the kidney, hematuria can be of glomerular origin, including medical renal disease, and nonglomerular origin, which includes urologic disorders. Urologic sources of hematuria from the kidney and ureter may include masses, both benign and malignant, infection, urolithiasis, arteriovenous malformation, and trauma.

Kidney masses may represent metastasis or be primary renal tumors. Although infrequent, the most common malignancies to metastasize to the kidneys include lung, colorectal, head and neck, breast, and gastrointestinal tumors.[3] Renal tumors can be intraparenchymal or urothelial. Upper tract urothelial tumors can be found anywhere along the ureters and in the renal pelvis.

Table 1
Relevant anatomy and anatomic contributors to hematuria

Kidney/Ureter	Bladder	Prostate	Urethra

• Glomerular
• Tumor
  ○ Parenchymal
  ○ Urothelial
• Infection
  ○ Pyelonephritis
  ○ Calculi
• Trauma
• Ureteraoarterial fistula
	• Uncomplicated cystitis
	• Radiation/hemorrhagic cystitis
	• Tumor
	• Trauma/rupture
		• BPH
		• Prostate cancer
		• Prostatitis
			• Urethritis
			• Trauma
			  ○ Disruption
			  ○ Traumatic Foley removal/placement
			• Urethral mass
			• Urethral caruncle
			• Urethral stricture

Abbreviation: BPH, benign prostatic hyperplasia.

Infection of the kidney, or pyelonephritis, may cause microscopic or gross hematuria. Pyelonephritis often results from ascending infection from the bladder (cystitis) and can lead to high fevers and lateralizing flank pain. These symptoms can also be present in patients with renal or ureteral calculi. Thus, if the suspicion is high (known history of nephrolithiasis, chronically bed bound patient, strong family history of kidney stone formation), there should be a low threshold to image the patient with noncontrast computed tomography (CT).

Blunt, penetrating, or iatrogenic trauma can lead to hematuria from anywhere along the urinary tract. The kidneys are the most frequently injured genitourinary organ, in up to 5% of civilian traumas and 24% of traumatic abdominal solid organ injuries. The kidneys are especially at risk of deceleration injuries owing to their relatively fixed position by the renal pelvis and vascular pedicles in the retroperitoneum.[4] Accounting for only 1% of urologic injuries, ureteral injuries are infrequent. Iatrogenic ureteral injury during gynecologic, urologic or colorectal surgeries accounts for 80% of ureteral injuries.[5]

Bladder

Bladder sources of hematuria include trauma, infection, hemorrhagic cystitis (from radiation and/or chemotherapy exposure), and tumors. Bladder ruptures are categorized as intraperitoneal, about 30% of the time, extraperitoneal 60%, and both in the remaining 10%.[6] Although more than 85% of blunt bladder injuries are associated with pelvic fractures, less than 10% of blunt pelvic fracture patients are found to have bladder injuries.[5] They occur rarely in blunt abdominal trauma owing to the location of the bladder in a relatively protected position in the pelvis. The typical site of intraperitoneal rupture is at the dome of the bladder, often in setting of a full bladder. Extraperitoneal bladder ruptures often occur at the bladder neck or the base of the bladder. Blood at meatus in the setting of trauma and pelvic fractures should make the clinician suspicious of urethral or bladder injury.

Cystitis refers to any inflammation of the bladder, whether infectious or noninfectious in origin. Infectious causes can be bacterial, viral, and fungal. Uropathogenic *Escherichia coli* is the most common cause of UTIs. These bacteria have unique properties that allow them to bind to the outermost layer of the urothelium, enter the cells, replicate, and eventually lead to cell lysis. Less common, viral cystitis is typically seen in immunosuppressed patients owing to adenovirus and BK virus.

Noninfectious etiologies of cystitis include radiation and chemical cystitis, which can lead to hemorrhagic cystitis. Radiation-induced cystitis can be seen at any time after treatment, and there are no known risk factors for who will develop this complication. Radiation cystitis leads to damage of urothelium via apoptosis initiated by DNA damage and can also affect the muscular layers of the bladder as well as the vasculature. Chemical cystitis can be from various medications, for example, cyclophosphamide and/or ifosfamide chemotherapy. These medications are metabolized by the liver, resulting in the formation of a harmful metabolite acrolein, which is filtered into the urine, inducing urothelial damage.[7]

Bladder tumors are a common cause of gross and microscopic hematuria; approximately 80% to 90% of patients with bladder cancer present with painless gross hematuria. Transitional cell carcinoma (or urothelial carcinoma) accounts for 90% of bladder cancers and develops in the inner layer (urothelium) of the bladder. It is described as a field change defect, meaning that it can affect the entire urothelium, with significant potential for recurrence owing to highly malignant tumor biology. The remaining 10% of bladder cancers include but are not limited to squamous cell, adenocarcinoma, and small cell. Risk factors for developing bladder cancer are outlined in **Box 1**.

Box 1
Risk factors for urologic malignancy

- Smoking history
- Advanced age
- Male gender
- History of pelvic irradiation or certain chemotherapeutics (eg, cyclophosphamide)
- Chronic bladder inflammation (indwelling catheter, chronic urinary tract infections)
- Occupational exposures (eg, aromatic amines, aniline dyes, benzene)

Prostate

Prostatic causes of hematuria can largely be attributed to prostatic hyperplasia. The prostatic hyperplastic process is owing to an imbalance between cell death and cell proliferation, which eventually leads to cell accumulation.[8] In this process, there is also expression of vascular endothelial growth factor, which makes the prostate an extremely vascular organ prone to bleeding. Prostatic malignancy and infection of the prostate, or prostatitis, are other contributors to hematuria of prostatic source. Bacterial prostatitis is the result of focal uropathogenic bacteria residing in the prostate gland. The most common cause of bacterial prostatitis, both acute and chronic, is the Enterobacteriaceae family of Gram-negative bacteria.[9] Locally advanced prostate cancer may also cause hematuria.

Urethra

Urethral causes of hematuria include infection (urethritis), urethral masses, and trauma. Urethritis is inflammation of the urethra, and is usually infectious in origin. As with any infection, a urinalysis and culture as well as testing for *Neisseria gonorrhea* and chlamydia are useful. An uncommon cause of emergent urethral bleeding is in the setting of traumatic Foley catheter manipulation or removal (eg, by a demented or delirious patient or during transfers). After traumatic catheter removal, reinsertion of the catheter is recommended.[1] If resistance is met on reinsertion, there should be further evaluation of urethral integrity, either with bedside cystoscopy or retrograde urethrogram.

CLINICAL PRESENTATION AND EXAMINATION

Patients with gross hematuria have a wide range of presentations (**Table 2**). As mentioned, the first and most important part of evaluation of a patient with hematuria is hemodynamic stability. Patients with hypotension, tachycardia, and low hemoglobin/hematocrit may require emergent intervention. This can involve surgical intervention (ie, fulguration of prostatic bleeding, angioembolization by interventional radiology) as well as resuscitation.

Obtaining a thorough history is essential in evaluating patients with hematuria because the history often provides clues for diagnosis of underlying etiology (eg, a strong family history of prostate cancer or a long history of smoking provides further evidence of likely urologic malignancy). Although patients with hematuria may be asymptomatic, common presenting symptoms include dysuria, urinary frequency and/or urgency, and abdominal and/or flank pain.

In the physical examination of the patient with hematuria, it is important to perform a focused examination of the abdomen, flanks, pelvic examination in women, digital

Table 2
Clinical presentations by etiology

Urinary Tract Infection	Urolithiasis	Malignancy	Prostate	Hemorrhagic Cystitis	Trauma
• Dysuria • Hematuria • Frequency/ urgency • Incontinence • Small volume voids • Foul-smelling, cloudy urine • Suprapubic pain	• Symptoms of urinary tract infection • Lateralizing flank pain • Fevers	• Often painless • Irritative voiding symptoms (frequency, urgency, dysuria)	• Enlarged prostate on digital rectal examination • Clot retention • Range of symptoms (frequency, urgency, decreased stream, nocturia)	• Persistent bleeding from bladder • Urgency • Frequency • Bladder pain	• Hematuria • Blood at meatus • Clinical correlation • Inability to void

rectal examination in men, and external genitourinary examination. Pain on digital rectal examination can clue the clinician into a diagnosis of prostatitis, and a nodule on digital rectal examination raises the concern for prostatic malignancy. Flank or costovertebral angle tenderness may signal a diagnosis of pyelonephritis or urolithiasis. Pain from obstructing ureteral calculi can often radiate to the lower abdomen or scrotum.

In addition to a focused physical examination, as discussed, the urine must also be examined. The color and viscosity of the urine often provides valuable clinical information. As with bleeding in other areas of the body, dark red/brown urine often signifies the presence of old blood, whereas bright red blood likely signifies active, new bleeding. Increased viscosity of urine as well as the presence of clots in voided urine is concerning because this may signal that a patient may develop clot retention. Clot retention is defined as blood clots within the bladder that obstruct the flow of urine causing symptomatic urinary retention.

Urinary Tract Infection

UTIs can occur in any part of the genitourinary tract (cystitis, urethritis, prostatitis, pyelonephritis, epididymitis). Although patients with a UTI can be asymptomatic, common symptoms associated with cystitis include dysuria, hematuria, urinary frequency and/or urgency, incontinence of urine, small volume voids, foul-smelling urine, and suprapubic pain. An indurated and tender epididymis in addition to the above symptoms is an easily localizable feature of epididymitis. Symptoms associated with upper UTIs, namely pyelonephritis, include these symptoms with the addition of fevers, rigors, flank pain, nausea, and vomiting. Although symptoms are very helpful in the diagnosis of UTI, they do not accurately localize the infection within the genitourinary tract.[10] UTI in the setting of obstructive uropathy or stones is a urologic emergency.

Patients with urolithiasis often present with dysuria and hematuria along with intense lateralizing flank pain. When the suspicion is high, CT abdomen/pelvis without contrast in the prone position is the modality that often diagnoses ureteral and renal stones. It is important to understand the indications for urgent intervention (ie, placement of ureteral stent or nephrostomy tube) for obstructing stones, which include fever, uncontrollable pain despite treatment with narcotics, solitary kidney, renal dysfunction, bilateral ureteral stones, and hemodynamic instability.

Urologic Malignancy

Patients with occult urologic malignancy often present with painless gross hematuria, which may be the only abnormality on presentation. Irritative voiding symptoms (frequency, urgency, dysuria) can also be symptoms of malignancy, particularly carcinoma in situ of the bladder. Roughly 80% of patients with bladder carcinoma in situ present with irritative voiding symptoms, and the presence of these symptoms doubles the risk of harboring carcinoma in situ in patients with hematuria (from 5% to 10%).[11] However, the symptom combination of hematuria and voiding dysfunction is quite common in a variety of urologic pathology including UTI, prostatic hypertrophy, and urolithiasis, which makes diagnosis quite complex.

Hemorrhagic Cystitis

A particularly difficult to manage etiology of gross hematuria is hemorrhagic cystitis. This condition is characterized by diffuse, persistent bleeding from the bladder mucosa. The severity of bleeding can range from mild bleeding managed conservatively to life-threatening bleeding requiring blood transfusion, bladder irrigation, and/or operative intervention. Hemorrhagic cystitis can be associated with irritative symptoms, including urinary urgency, frequency, and bladder pain.[12] Typically hemorrhagic cystitis is only seen in patients with known risk factors, such as prior pelvic radiation and cyclophosphamide chemotherapy. Reports indicate that up to 5% of patients who receive pelvic radiation will experience moderate or severe persistent gross hematuria.[13]

Trauma

Trauma patients often present with multiple injuries and hematuria as a result of urinary tract injury. Although patients with renal and bladder injuries often present with gross hematuria, a patient with urethral disruption/injury may present with inability to void and blood at urethral meatus. In ureteral trauma, gross hematuria is unfortunately not a reliable indicator of injury, and these injuries are often diagnosed in a delayed fashion. Suspicion for ureteral injury should arise in patients with bowel, bladder, or retroperitoneal injuries or in patients with high velocity pelvic or vertebral fractures.[14]

Prostatic Enlargement

Prostatic enlargement may cause hematuria in men in a variety of scenarios, including BPH, prostatitis, and advanced prostate cancer. The prostate can bleed owing to a variety of aggravators (including Foley catheterization, infection, and anticoagulation). Localization of hematuria to the prostate should be determined after a complete evaluation of the hematuria is completed; other etiologies for the hematuria must be excluded.[1] Hematuria from prostatic enlargement has a range of presentations from mild bleeding to recalcitrant bleeding with clots and thus has a variety of treatments.

Ureteroarterial Fistula

Ureteroarterial fistula is an infrequent but very serious cause of gross hematuria. It can be life threatening. This diagnosis requires a high degree of suspicion. Patients may present with gross hematuria, symptomatic anemia, and lateralizing flank pain. Risk factors include chronic indwelling stents, previous pelvic radiation, pelvic or vascular surgery, and vascular disease.[15]

DIAGNOSTIC PROCEDURES AND DIAGNOSIS

After excluding benign causes, the presence of hematuria should precipitate a urologic evaluation. The workup for hematuria includes history, examination, laboratory

studies, cystoscopy, and upper tract imaging (with CT urogram, which is the standard, or MR urogram vs renal ultrasound with retrograde pyelography for patients with renal dysfunction; **Table 3**). The initial step in diagnosis is to obtain a properly collected, midstream clean catch urinary specimen and identify 3 or more red blood cells per high-power field. A dipstick test is not adequate to identify microhematuria because it can result positive in the setting of oxidation or myoglobinuria. This must be confirmed by a microscopic urinalysis. This analysis will also allow the identification of red blood cell casts, proteins, and dysmorphic red blood cells, which can indicate a medical renal source for hematuria. A urine culture should also be sent to assess for infection. If the workup is unremarkable but microscopic hematuria persists, a urologic evaluation can be repeated in 3 to 5 years.

In the history, in addition to assessing risk factors for urologic malignancy, the provider should inquire about medical renal disease, UTI, trauma, and menstruation. Physical examination should include a thorough abdominal and genital examination and blood pressure reading.

Laboratory tests should include the estimated glomerular filtration rate, creatinine, and blood urea nitrogen to evaluate renal function. Renal function can determine eligibility for further diagnostic testing. Although once considered a mandatory part of the workup, urine cytology has limited use and should not be part of the initial workup for asymptomatic microscopic hematuria.[16]

Cystoscopy, which involves direct visualization of the urethra and bladder by camera, should be performed for all patients older than 35 years of age. Cystoscopy should be done at the discretion of the physician for any patients younger than 35 years, such as if there is concern for malignancy owing to exposures or irritative voiding symptoms. This can be done in the office setting for the appropriately selected patient. Cystoscopy allows identification of urethral lesions, strictures, and false passages, bladder lesions or masses, and lateralizing hematuria from a ureteral orifice. Additionally, retrograde radiographic studies can be done if fluoroscopy is available.

The gold standard for imaging in hematuria workup is multi-phasic CT urography. This includes 3 phases with and without contrast: a noncontrast phase for identification of stones, a nephrogenic phase for evaluation of renal masses, and an excretory phase for assessment of filling defects in the collecting system (ureters and bladder). Another option is MR urography. If CT or MRI are unavailable or patient is ineligible owing to pregnancy, iodinated contrast allergy, or renal insufficiency, renal and bladder ultrasound examination with retrograde pyelogram is an option.

In settings of traumatic hematuria, if stable enough for imaging, the patient should undergo intravenous contrast-enhanced CT of the abdomen and pelvis with delayed images to evaluate the collecting system. If the patient is too unstable and proceeds directly to operating room without imaging, an intravenous pyelogram can be obtained and should be performed if nephrectomy is being considered to confirm presence of contralateral kidney.

Table 3
Hematuria workup

Cystoscopy	Urine Cytology	Upper Tract Imaging
• Evaluates urethral and bladder mucosa for masses	• Examines urine for cancer cells • Not recommended in asymptomatic microhematuria • Consider in high-risk patients	• CT urogram gold standard • Renal ultrasound with retrograde pyelogram vs MR urogram in renal insufficiency

If bladder rupture is suspected, a CT or plain film cystogram can elucidate extravasation. A cystogram involves images captured after filling the bladder and then after emptying to identify any extravasated contrast concealed by the distended bladder.[5] Contrast outlining bowel supports an intraperitoneal rupture. Contrast localized in the pelvis supports an extraperitoneal rupture. If there is concern of urethral injury, a retrograde urethrogram should be done before Foley catheter placement and will show extravasation of contrast outside the urethra.

If the source of hematuria has not yet been clarified by imaging methods already mentioned or if the patient is hemodynamically unstable, percutaneous angioembolization can be diagnostic and therapeutic as an alternative to surgical exploration.[5]

INTERVENTIONS AND TREATMENT

Management and treatment can vary depending on the etiology of hematuria.

Urinary Tract Infections

Infections of the urinary tract (pyelonephritis, cystitis, prostatitis, epididymitis, and urethritis) are common and treatable causes of hematuria. In terms of management of these patients, all patients should have urine culture performed before initiation of antibiotics. Antibiotic selection should focus on coverage of uropathogens (Gram-negative and Gram-positive bacteria). Antibiotic coverage should be broad when initiated, and eventually narrowed based on culture data. A hospital's antibiograms should be used in antibiotic selection. Consider consultation with the infectious disease service in patients with complex infections to further aid in antibiotic selection and duration of therapy.

Urolithiasis

With kidney stone disease affecting 1 in 11 people in the United States, it is a very common and important entity for clinicians to learn to diagnose and manage.[17] Unlike cholelithiasis, appendicitis, and other surgical conditions, surgical treatment of stones is not the endpoint in stone therapy, because patients have a high incidence of recurrence of disease. In terms of stone management, it is important to recognize which patients can be managed non-operatively with medical expulsive therapy and which patients will require urgent surgical intervention with ureteral stenting or percutaneous nephrostomy tube placement.

There are several indications for the urgent surgical management of ureteral stones. These indications include intractable pain, solitary kidney, bilateral ureteral stones with obstruction, high-grade unilateral obstruction, renal dysfunction, abnormal ureteral anatomy, infection (which can manifest with fever, sepsis, and positive urinalysis and urine culture), hemodynamic compromise, and stones that are unlikely to pass spontaneously.[18]

If the patient is hemodynamically compromised or septic, it is prudent to proceed with percutaneous nephrostomy decompression, because this procedure requires less manipulation of the urinary tract. Although the general surgery patient may have nonurologic causes for being hemodynamically compromised, a concurrent obstructing stone must be addressed.

Medical expulsive therapy is a non-invasive and viable approach to managing the patient with uncomplicated urolithiasis (ie, in the absence of factors requiring urgent intervention). The ideal candidate for medical expulsive therapy is a patient with a stone but without signs of hemodynamic compromise, infection, or obstruction. It should be noted that the size and location of the ureteral stone are extremely important. The rate of spontaneous passage is much greater for distal ureteral stones (71%)

than for proximal ureteral stones (22%).[19] Medical expulsive therapy includes high-rate intravenous fluids, adequate pain control with narcotics, and alpha-1 antagonist therapy, most commonly tamsulosin, although there is a debate in current literature on the utility of tamsulosin.[20]

Urologic Malignancy

Gross hematuria should always be taken seriously as a "red flag" for urologic malignancy. Should painless gross hematuria be present in the general surgery patient in the absence of other etiologies of hematuria (trauma, infection, urolithiasis, etc), urologic malignancy should be high on the differential. In addition to referral to urology, the general surgeon can begin the process of working up gross hematuria by ordering laboratory and imaging studies. Urology completes the evaluation with cystoscopy, as an outpatient in the majority of cases, to rule out urethral and bladder mucosal pathology.

Clot Retention

The initial management of hematuria is resuscitation and bladder drainage. It is also important to identify risk factors and reversible causes for severe hematuria. In terms of catheter selection, large-bore catheters are preferable to ease passage of clots. Urinary catheters are sized in the French system, where 1 French equals 0.33 cm in circumference (not luminal diameter). In patients with severe hematuria and passage of clots, the best catheters to choose are large bore ($\geq$22 French) with 3 channels to allow for the possibility of manual and continuous bladder irrigation (CBI).[1] After the catheter is in place, manual irrigation with normal saline using catheter-tipped syringes should be performed to clear any clots from the bladder. Should the urine clear after adequate manual irrigation, the focus should be on conservative management with hydration and resuscitation. Should severe hematuria and clots persist despite adequate manual irrigation, then CBI may be used. In CBI, irrigation fluid continuously flows into a patient's bladder via a third port on the 3-way urethral catheter and is drained out via the exit port. Although CBI is an excellent treatment for severe hematuria, patients must be monitored for catheter obstruction during CBI, which raises the risk of bladder perforation. If bleeding persists despite this treatment, the clinician should consider intravesical therapy, cystoscopy with fulguration, or embolization (**Box 2**).

Box 2
Clot Retention

- Assess hemodynamic stability/resuscitate
- Identify etiology
- Place large catheter ($\geq$22 French), manually irrigate
- *Urine clears*
  - Hydration
  - Resuscitation
  - Hematuria workup
- *Urine does not clear*
  - Imaging to evaluate clot burden
  - Start continuous bladder irrigation
  - Assess for reversible causes of hematuria (such as anticoagulation status)
  - Consider operative intervention or intravesical therapy

Prostatic Hematuria

Prostate-related gross hematuria can be due to prostatitis, BPH, or advanced prostate cancer. The initial management of these patients is the same as with any patient with severe hematuria (bladder drainage, resuscitation, treatment of reversible causes).

In patients with acute prostatic bleeding owing to BPH, use of 5-alpha reductase inhibitor (finasteride) should be considered. Finasteride is associated with decreased prostatic blood flow by inhibition of vascular endothelial growth factor expression.[21] Finasteride is dosed 5 mg once daily and is associated with sexual side effects (decreased libido and trouble with erections and ejaculation).

Patients with advanced prostate cancer may also present with hematuria. If stable, the patient may be considered for surgical treatment (limited transurethral resection of prostate), radiation therapy, or androgen deprivation for control of hematuria. Androgen deprivation decreases prostate tissue vascularity and can control refractory bleeding from the prostate.[1] Should hematuria from BPH or prostate cancer persist despite conservative therapies, operative intervention should be considered (cystoscopy with fulguration and clot evacuation, embolization).

Hemorrhagic Cystitis

Hemorrhagic cystitis presents with severe hematuria due to diffuse bladder mucosal bleeding. The patient may even present with clot retention. Often the patient endorses a history of passing significant clot burden and has known risk factors (ie, history of pelvic radiation, cyclophosphamide chemotherapy). If a patient is scheduled to receive cyclophosphamide, the administration of 2-mercaptoethane sulfonate sodium (Mesna) can be bladder protective by neutralizing the harmful metabolite acrolein. These patients should also undergo a full hematuria workup to rule out other causes of hematuria, namely active urologic malignancy. The acute management of these patients remains the same as discussed. There are additional treatments that can be used for these patients such as intravesical agents (alum, aminocaproic acid, etc), fulguration with electrocautery, and hyperbaric oxygen. If still unable to control, urinary diversion (cystectomy, bilateral percutaneous nephrostomy) is an option.

Urotrauma

Traumatic injury to the urinary tract often results in gross hematuria. Patients with urinary tract trauma frequently present in the setting of multiple organ injuries. Trauma is the cause of 150,000 deaths per year in the United States and is the leading cause of death in adults under 45 years of age.[22] Treatment of urinary tract trauma is complex and is based on the organ that is injured. Intraperitoneal bladder rupture usually requires operative management, whereas extraperitoneal rupture can be managed nonoperatively with catheterization. Urethral injury may be managed with Foley catheter alone or may require urinary diversion, repair, or ureteral stenting. Urethral injury may require diversion with suprapubic tube and delayed repair.

Traumatic urethral catheterization and removal can also cause hematuria. Urethral catheter trauma may be remedied simply with replacement or manipulation of the catheter; however, about 30% may require prolonged catheterization, CBI, cystoscopy, or suprapubic tube placement. Urethral catheter placement can cause traumatic hematuria, especially in men with BPH or on anticoagulation.

Ureteroarterial Fistulae

Although it is an uncommon cause of hematuria, ureteroarterial fistula is a life-threatening condition. The general surgeon should have a high degree of suspicion

Box 3
Hematuria: pearls and pitfalls

- To limit urethral catheter trauma in men, inflate the Foley catheter balloon only if:
  - Catheter is completely hubbed at urethral meatus at junction with the balloon port.
  - There is return of urine.
- Make sure the patient's catheter is not obstructed while he or she is on continuous bladder irrigation, particularly if complaining of abdominal pain.
- A large-bore catheter (≥22 French) should be used for bladder lavage/continuous bladder irrigation
- All patients with gross hematuria warrant a hematuria workup.
- Obtain urinalysis and urine culture on all patients with hematuria.

of this condition in patients presenting with hematuria, lateralizing flank pain, downtrending blood counts, and risk factors (chronic indwelling ureteral stents, history of pelvic irradiation or pelvic and/or vascular surgery). Immediate involvement of vascular surgery or endovascular treatment by interventional radiology is essential.

SUMMARY

Hematuria in the general surgery patient is a unique and complex situation that warrants close investigation. After careful evaluation of history and physical examination, laboratory tests, and indicated imaging, the source may remain elusive. In a study screening patients with hematuria on initial microscopic urinalysis, 2% were found to have bladder cancer, 22% infection, 10% BPH, and 65% remained of unknown cause.[23]

The general surgeon should take into consideration the circumstances under which new-onset gross hematuria develops. For example, if in the postoperative period, consider the operation, anticoagulation status, and whether the patient had a urethral catheter placed. Iatrogenic hematuria can be owing to unidentified intraoperative complications, such as laceration or thermal injury to ureter or bladder, or inflation of urethral catheter balloon in urethra.[24] Certain medications can alter the urine color to give the appearance of hematuria; thus, the medication list should be reviewed.

Gross hematuria can occasionally lead to a symptomatic reduction in hematocrit requiring transfusion, which can occur in cases related to trauma, ureteroarterial fistula, and hemorrhagic cystitis. Thus, these etiologies should be dealt with emergently.

In this article, we have outlined some of the most common causes of hematuria that a general surgeon may encounter, such as UTIs, urolithiasis, urologic malignancy, urinary tract arterial fistulae, prostatic bleeding, hemorrhagic cystitis, and trauma, as well as the clinical scenario of clot retention. Pearls and pitfalls of addressing hematuria are provided to the reader in **Box 3**. We hope that reading this article provides the general surgeon with an armamentarium of knowledge to properly triage and initiate diagnosis and treatment of the complex general surgery patient with hematuria.

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