CHAPTER 40

Genitourinary System

Sanjay N. Shewakramani

PRINCIPLES

Background and Importance

Ten percent of trauma cases in the United States involve the genitourinary tract, and most of these injuries are not life-threatening. In fact, due to the anatomic protection of the kidneys, ureters, and bladder, as well as the mobile nature of the male external genitalia, isolated urologic injuries are uncommon in patients involved in major trauma. However, genitourinary trauma can cause significant, long-term morbidity, including renal insufficiency, chronic hypertension, incontinence, and sexual dysfunction. Additionally, traumatic renal injuries can be overlooked, due to the location of the kidneys and subtle presentation, with serious consequences for the patient.[1]

Almost three-quarters of all blunt injuries are caused by motor vehicle collisions, but seatbelts and air bags have been shown to result in substantially fewer high-grade renal injuries and, as a result, fewer nephrectomies.[2] Seatbelts and air bags can also cause injuries to the kidneys, although the benefits of these protective devices have been shown to outweigh the risks.[3] Forty percent of patients with renal trauma have a coexistent abdominal injury.

Blunt trauma is responsible for nearly all cases of pediatric renal trauma.[4] Kidney injuries are more common than injuries to the spleen, liver, pancreas, and bowel in this population. However, due to more conservative approaches in management, pediatric renal trauma now only rarely leads to nephrectomy.[3]

Due to the long, tubular nature of the ureter and its location in the retroperitoneum where it is well protected by the vertebrae and soft tissues, blunt traumatic injuries of the ureter are rare and virtually never occur in isolation. Most noniatrogenic ureteral injuries are due to penetrating mechanisms; the ureter is involved in up to 5% of penetrating injuries to the abdomen.[5]

After the kidney, the bladder is the most commonly injured genitourinary organ with blunt trauma; this happens most frequently from motor vehicle collisions, which are responsible for approximately 90% of cases.[6] Bladder injury most often occurs in the context of pelvic fractures or other intra-abdominal injuries, and the mortality rate in patients with blunt bladder trauma is therefore as high as 22%.[7] The bladder also is subject to penetrating injury through the abdomen, rectum, or buttocks. Up to 80% of patients with penetrating bladder injuries also suffer bowel injuries.[8]

Blunt trauma mechanisms, the majority of which are motor vehicle collisions, are responsible for approximately 90% of urethral injuries. Males are five times more likely than women to suffer urethral injuries due to the increased overall incidence of trauma in males, and the longer length and reduced mobility of the male urethra.[1] Similar to bladder injuries, significant blunt pelvic trauma is typically required to cause injuries to the urethra. As a result, concomitant injuries are often observed, with significant pelvic fractures or straddle-type injuries involved in the majority of cases.[9] Penetrating injuries to the urethra are rare and are suspected on the basis of the nature and trajectory of the penetrating object. Urethral trauma also can occur from misadventure during self-instrumentation, which is most often related to sexual activity. Urethral injury can cause significant morbidity, due to stricture formation, incontinence, impotence, and infertility, even if urethral injuries are appropriately diagnosed and treated.[10]

The external genitalia, particularly the scrotal contents, are subjected to direct injury, which happens most often in sports-related trauma. Minor external trauma may occur with consumer products (including zippers, sporting items, and furniture), and the large majority of these injuries are self-limited.[11] Severe injuries, including penile fractures and testicular rupture, are rare but generally require hospital admission. These injuries also can lead to long-term reproductive, physiologic, and psychological consequences.[1]

Although the overall rates are low in females, up to 8% of reported childhood trauma in girls involves the external genitalia.[12] Sexual abuse is much more commonly the cause than accidental trauma in this age group (see Chapter 177).[13]

Anatomy and Physiology

The genitourinary tract is divided into the upper tract (kidneys and ureters, including the renal pedicle), lower tract (bladder and urethra), and external genitalia (penis, scrotum, testicles, and vulva).

The kidneys are retroperitoneal organs that are encapsulated by fibrous tissue known as *Gerota's fascia.* They lie against the psoas muscles, are surrounded by the ribs and spinal column, and are well-cushioned by perinephric fat, leaving them fairly well-protected (Fig. 40.1). This explains why isolated renal injury is rare in trauma, because it often requires a significant mechanism to cause injury. However, the lower poles of the kidney do project inferior to the twelfth rib bilaterally, which makes them susceptible to trauma.[1] Due to their proportionately larger kidneys with less perirenal fat, weaker abdominal muscles, and a less rigid chest wall, children are at higher risk for renal injury.[14]

The renal pedicle—which includes the renal artery, renal vein, and the ureter—inserts into the kidney along the medial border, at the hilum. A longitudinal cross-section of the kidney reveals the outer renal cortex with inner medulla that compose the renal parenchyma (Fig. 40.2). These create and drain urine into the calyces, which flow into the renal pelvis, which then drains into the ureter.

The bladder is a muscular organ that lies in the abdomen at birth but descends into the pelvis at around 6 years old and is, thus, considered extraperitoneal. It is heavily protected by the bony pelvis, especially when it is not distended.[15] However, when distended, the dome of the bladder rises into the abdomen (as high as the umbilicus), making it more prone to both blunt and penetrating trauma. Posteriorly, the bladder connects to the ureters on the superior aspect, and in males, it is adjacent to the seminal vesicle and vas deferens on the inferior side. Loose connective tissue surrounds the bladder laterally.

The male urethra is approximately 22 cm in length when measured from the bladder to the urethral meatus (Fig. 40.3). The

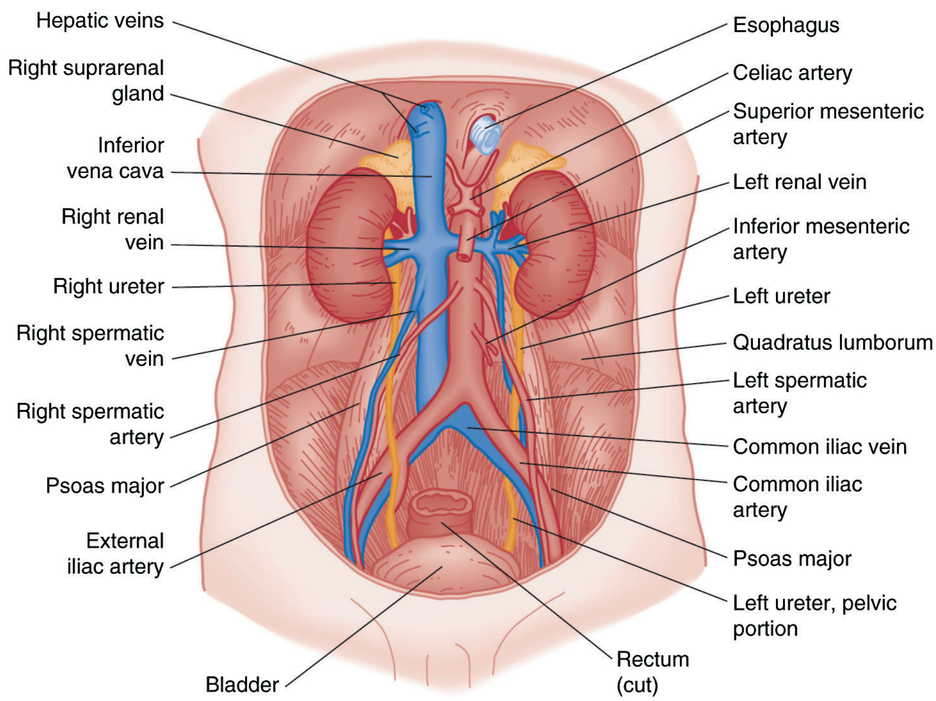

Fig. 40.1. Dissection of abdomen showing kidneys and ureters and their relationship to other anatomic features in the retroperitoneal space.

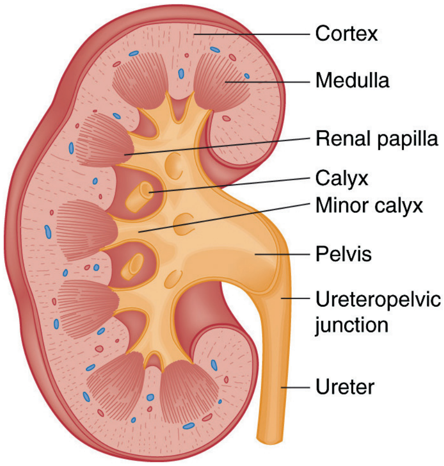

Fig. 40.2. Longitudinal section of kidney.

urogenital diaphragm divides the posterior urethra (comprised of the prostatic and membranous segments) from the anterior urethra (comprised of the bulbous and penile segments). The fossa navicularis is the slightly dilated segment of the penile urethra contained within the glans. Although the anterior urethra is more mobile, the posterior urethra is anchored to the anterior pubic arch by the puboprostatic ligaments. The female urethra is only approximately 5 cm long and is protected due to its close association with the vagina, which absorbs the majority of the force during trauma. In addition, the female urethra has no significant attachments, making it mobile, and reducing the likelihood of significant trauma.[16]

The testicles normally measure 5 × 3 × 2 cm each and are individually encapsulated by the fibrous tunica albuginea (Fig. 40.4). The encapsulated testicles are then surrounded by the tunica vaginalis, which has both a visceral and parietal surface. The potential space between these surfaces allows for hydroceles or even hematoceles to form. Each half of the scrotum contains a separate testicle, spermatic cord, and epididymis.

The penis is composed of two paired corpora cavernosa along the dorsal aspect and a corpus spongiosum along the ventral surface (Fig. 40.5). The corpora cavernosa are filled with venous sinusoids that surround a central artery and engorge with blood during an erection, whereas the corpus spongiosum surrounds the urethra and forms the glans penis on its distal aspect. Each of the three is surrounded by a separate fascial sheath, which also is referred to as the *tunica albuginea.* Buck's fascia, the deep fascia of the penis, immediately surrounds the three structures, and multiple other superficial fascial layers further surround Buck's fascia. The superficial and deep dorsal veins provide most of the venous drainage from the penis.

Pathophysiology

Because it is fixed in space only by the renal pelvis and pedicle, the kidney is prone to acceleration and deceleration injuries from blunt trauma. The American Association for the Surgery of Trauma (AAST) guidelines for grading blunt renal trauma are essentially unchanged since their creation in 1989, with grades III, IV, and V defined as "high grade" renal trauma (Table 40.1 and Fig. 40.6).[1] Lacerations and contusions typically occur from direct trauma, whereas renal artery avulsions can occur from deceleration mechanisms. Renal artery thrombosis can occur when the renal artery is compressed between the anterior abdominal wall and vertebral bodies.[17] Penetrating injuries, typically due to gunshot and stab wounds, can cause similar patterns of injury as blunt injuries.

Blunt injuries can cause trauma to the ureter either directly from compression against fractured bony structures (such as, transverse processes of lumbar vertebrae) or by deceleration mechanisms, which can cause a disruption at the ureteropelvic and ureterovesical junctions.[5] Due to their hyperextensible vertebral columns, children are more prone to deceleration mechanisms. Penetrating injuries are almost exclusively unilateral, and

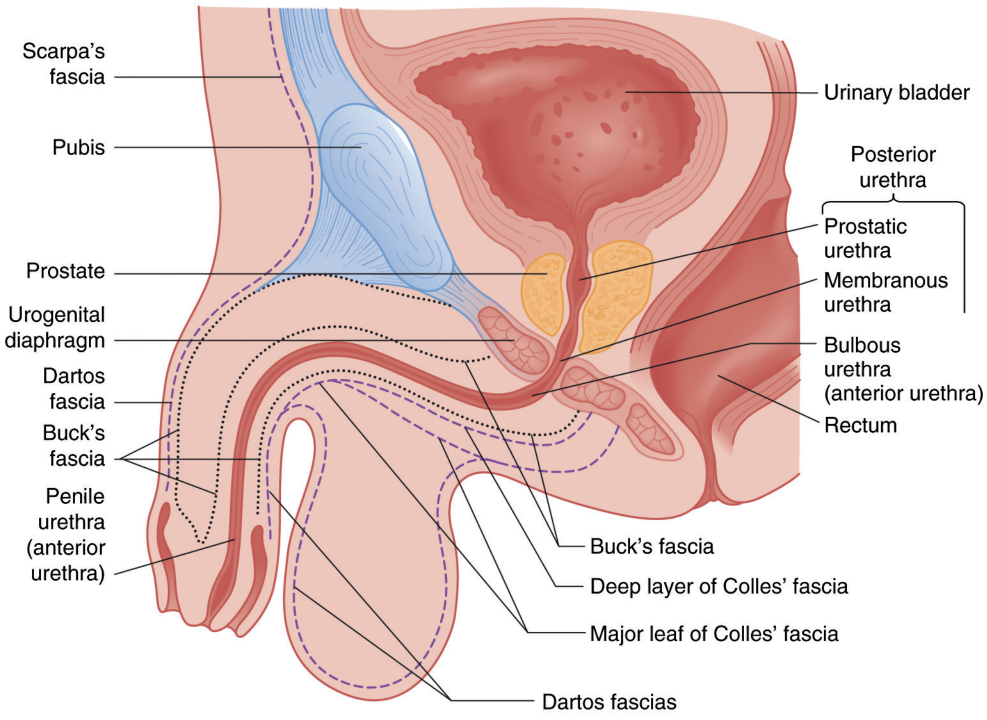

Fig. 40.3. Anatomy of male genitalia.

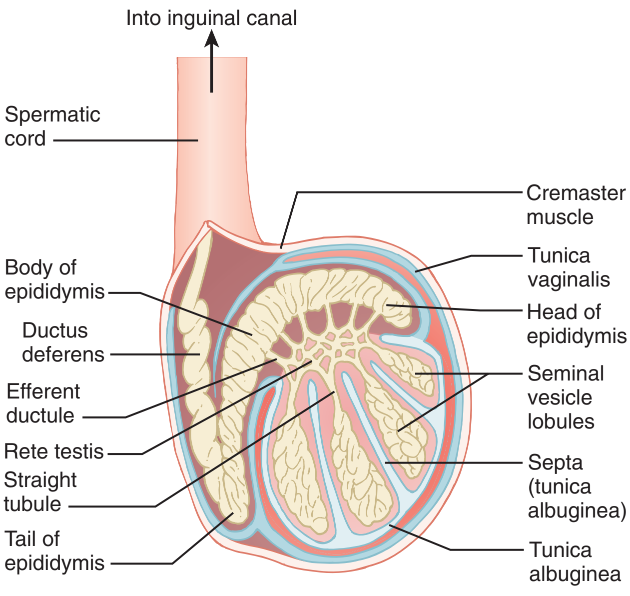

Fig. 40.4. Scrotal anatomy.

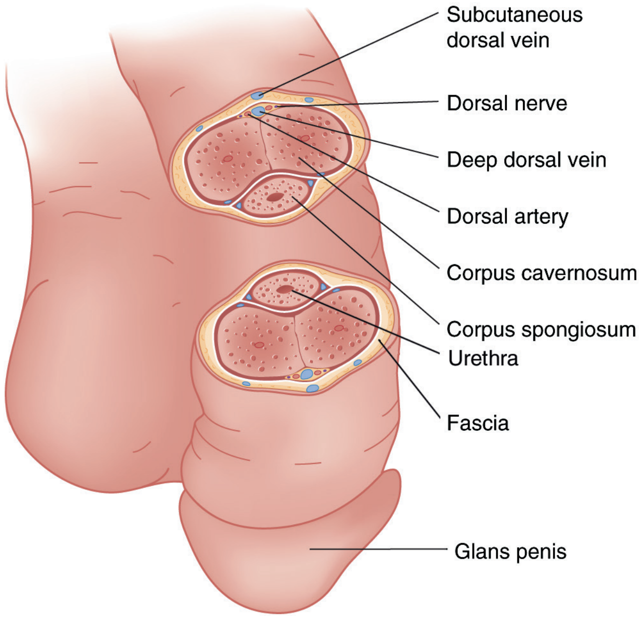

Fig. 40.5. Cross-sectional view of the penis.

gunshot wounds tend to cause more devascularization and potential ureteral necrosis than stab wounds, which usually involve only a short segment of the ureter.[8]

Bladder injuries range from mural contusions (representing 50% of injuries) to bladder ruptures, which are defined as lacerations through the entire wall of the bladder.[18] Ruptures are further classified into intraperitoneal bladder ruptures (IBRs) and extraperitoneal bladder ruptures (EBRs). Intraperitoneal injuries resulting from blunt trauma are typically caused by rupture of a distended bladder at its weakest point, which is the dome where it abuts the peritoneum. As a result, urine drains into the peritoneal cavity. EBRs, which account for the majority of bladder ruptures, occur as the result of direct compression, shear forces at the bladder base, or lacerations from bony spicules from pelvic fractures.[1,18] These ruptures result in urine draining into the pelvic cavity. Approximately 10% of bladder injuries are both intraperitoneal and extraperitoneal in nature.[1]

With blunt trauma to the pelvis, shearing forces transmitted through the urogenital diaphragm create tension along the urethra, most often between the anterior and posterior segments at the bulbomembranous junction. These forces occur commonly in unstable pelvic fractures, bilateral ischiopubic rami fractures, and symphysis pubis diastasis injuries. In fact, the combination of anterior pelvic ring fracture with sacroiliac joint disruptions posteriorly present with a concomitant posterior urethral injury in approximately 25% of cases. Injuries can range from stretching, to partial lacerations, to complete disruptions of the urethra; the latter of which accounts for approximately 50% to 65% of urethral injuries.[19] The majority of these injuries involve the posterior urethra, and the most severe injuries are complex posterior injuries involving the bladder neck or rectum.[1]

Anterior urethral injuries, which are four times less common than posterior injuries, are often caused by blunt straddle-type injuries, which result in crushing of the bulbar urethra against the inferior aspect of the pubic bone (Fig. 40.7). These injuries occur more commonly in children and can be easily missed, potentially resulting in future strictures.[16] Gunshot wounds and other penetrating injuries involve the anterior urethra more commonly than the posterior urethra.[1]

Besides testicular rupture, which is caused by disruption of the testicular tunica albuginea, blunt trauma can also lead to scrotal hematomas, testicular contusions, testicular fractures, testicular dislocation, or even traumatic testicular torsion and traumatic epididymitis.[20] In fact, significant injuries occur in up to 45% of all patients presenting with blunt trauma to the scrotum.[21] Testicular hematomas form within the testicle and may be associated with testicular rupture, whereas testicular fractures are defined as linear avascular areas within the testicular parenchyma without rupture of the tunica albuginea. Testicular dislocation occurs when blunt trauma forces the extra-scrotal migration of one or both testicles, although bilateral dislocations are rare. They migrate along the course of the spermatic cord and typically are found in the superficial inguinal area, but they can even be found in the suprapubic region.[22] Penetrating injuries often violate the tunica albuginea.[1]

Penile fractures, due to tears of the tunica albuginea, account for the majority of blunt penile injuries that present to the emergency department (ED). Blunt trauma can also lead to rupture of the dorsal veins or artery, resulting in local ecchymosis that can be easily mistaken for a penile fracture, and is therefore termed a *false penile fracture*.[23] Penetrating injuries to the penis involves the urethra in up to 29% of cases and can also result in penile amputation, which is more common in patients with a psychiatric history.[1,24]

Nonsexual genital injuries in females are most often due to straddle injuries in young girls, but other blunt and penetrating injuries do occur and are often more severe.[13] The labia are most frequently involved, as well as the perineum. Penetrating injuries can involve the rectum as well as urethra, and these deeper injuries

TABLE 40.1

The American Association for the Surgery of Trauma Grading Scale for Classification of Renal Trauma

GRADE	TYPE	DESCRIPTION
I	Contusion	Microscopic or gross hematuria
	Hematoma	Subcapsular, nonexpanding without parenchymal laceration
II	Hematoma	Nonexpanding perirenal hematoma confirmed to renal retroperitoneum
	Laceration	<1 cm parenchymal depth of renal cortex without urinary extravasation
III	Laceration	>1 cm parenchymal depth of renal cortex without collecting system rupture or urinary extravasation
IV	Laceration	Parenchymal laceration extending through the renal cortex, medulla, collecting system
	Vascular	Main renal artery or vein injury with contained hemorrhage
V	Laceration	Completely shattered kidney
	Vascular	Avulsion of renal hilum that devascularizes kidney

From Harper K, Shah KH: Renal trauma after blunt abdominal injury. J Emerg Med 45:400–404, 2013.

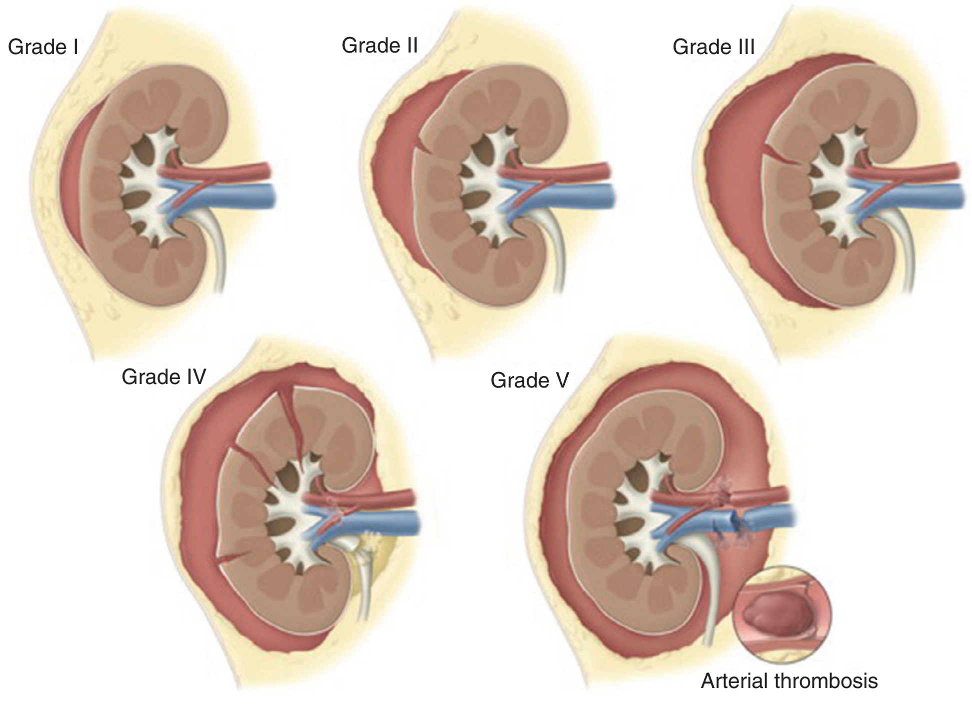

Fig. 40.6. Schematic of the American Association for the Surgery of Trauma (AAST) grading scale for renal trauma. (From Myers JB, Brant WO, Broghammer JA: High-grade renal injuries: radiographic findings correlated with intervention for renal hemorrhage. Urol Clin North Am 40:335–341, 2013.)

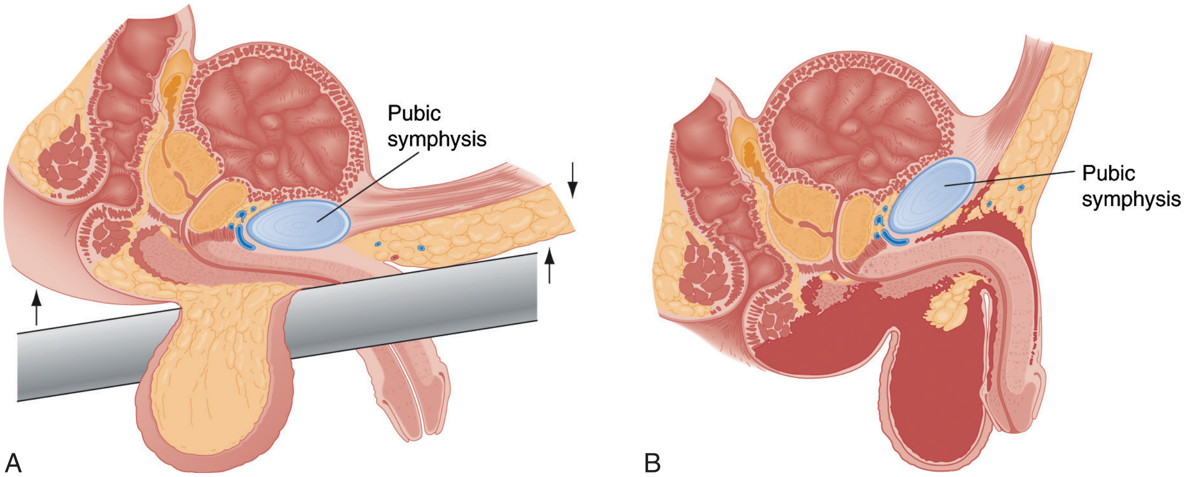

Fig. 40.7. Injury to the bulbous urethra due to straddle mechanism. **A,** Mechanism: Usually a perineal blow or fall astride an object, crushing the urethra against inferior edge of pubic symphysis. **B,** Extravasation of blood and urine enclosed within Colles' fascia. (From McAninch JW: Injuries to the genitourinary tract. In Tanagho EA, McAninch JW, editors: Smith's general urology, ed 14, Norwalk, CT, 1995, Appleton & Lange.)

can easily be missed in young girls if a thorough examination is not performed.[12]

The diagnostic and management approach to each organ varies, necessitating a basic understanding of the anatomy and traumatic pathophysiology of each individual organ. The majority of cases require early urologic consultation. The clinical features, diagnostic approach, and management guidelines for the specific organs are discussed in the following sections.

RENAL TRAUMA

Clinical Features

The history for patients with potential renal trauma includes the mechanism of injury for blunt trauma and the type of implement or weapon for penetrating injury. Significant genitourinary injury is rare in the absence of high energy blunt trauma, unless the trauma is localized to a full bladder or the external genitalia. Gross hematuria warrants careful evaluation for significant genitourinary injury, although the degree of hematuria does not necessarily correlate with the degree or grade of injury, and significant genitourinary trauma can occur without hematuria.[14] Renal injury requiring intervention is rare in the absence of gross hematuria or shock. Examination of the patient with multisystem trauma may reveal shock, flank tenderness, mass, or ecchymosis; loss of flank contour; obviously fractured ribs; abdominal tenderness; or an abdominal mass.[25]

Differential Diagnosis

Blunt or penetrating trauma can result in a range of injuries to the kidney and the vascular supply to the kidney, as shown in Table 40.1). Injuries to the renal parenchyma can cause contusions or lacerations within the kidney or hematomas surrounding the kidney. Vascular injuries can involve the renal artery or vein and vary in significance. Minor injuries to the vascular supply can lead to a contained hematoma, but hilar avulsion can result in complete devascularization of the kidney.[1]

Diagnostic Testing

Although significant renal injury can occur without causing hematuria, 95% of all patients with renal trauma have some hematuria on urinalysis, which is defined as more than five red blood cells per high power field. Patients with multisystem trauma, especially with evidence of blood loss, require a complete blood count and type and screen. Creatinine drawn within an hour of injury reflects renal function prior to the injury and, thus, serves as a baseline for future testing.[25]

Microscopic hematuria in a blunt trauma patient without shock is not an indication for renal imaging, even if there is evidence of local trauma (eg, costovertebral angle tenderness or localized ecchymosis). Although renal injury may uncommonly be identified on imaging for these patients, the injuries are mild and do not require intervention. Hemodynamic instability with evidence of intraperitoneal injury on abdominal examination, presence of pelvic fracture, a penetrating trauma mechanism, or presence of lower rib fractures, with or without hematuria, are indications for further investigation. Additionally, imaging is advisable for patients with gross hematuria, targeted to the entire urinary tract or localized to the lower tract (bladder and urethra), depending on the mechanism and location of the trauma.[1]

Computed tomography (CT) with intravenous (IV) contrast is the best modality to evaluate for renal injury with nearly 100% sensitivity and specificity. CT can evaluate for renal lacerations, hematomas, extravasation of contrast, devascularized renal segments, and urinary extravasation and thereby grade the severity of renal trauma (Fig. 40.8).[26] If there are concerns about collecting system injury (eg, ureteropelvic junction disruption, ureteral injury), delayed images should be performed 10 minutes after administration of contrast (Fig. 40.9).

Ultrasound can demonstrate renal injuries but has lower sensitivity and specificity than CT, and the quality of the study is operator dependent. It is also difficult to determine the depth and extent of renal lacerations, and it is often unclear if fluid seen surrounding the kidney on ultrasound represents urine or blood. However, unlike CT, ultrasound can be performed at the bedside if the patient is unstable. Management of the multisystem trauma patient and the patient with abdominal trauma is discussed in Chapters 33 and 39.

Management

Multisystem trauma is managed in collaboration with a general or trauma surgeon, and consultation with a urological surgeon often is indicated when there is injury to the urinary tract.

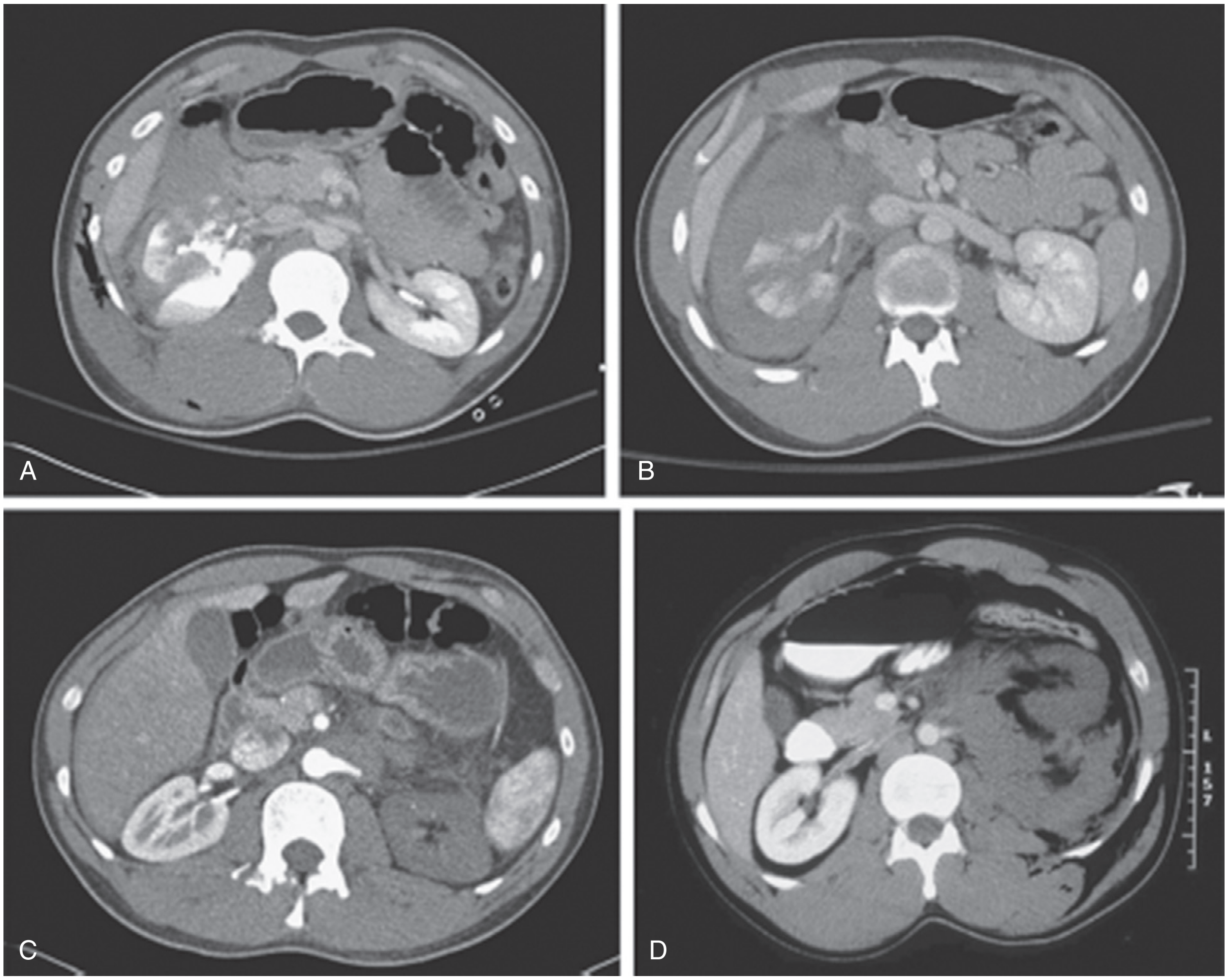

Fig. 40.8. High grade renal injuries. **A,** Grade IV injury with urinary extravasation. **B,** Severe grade IV laceration, also referred to as *shattered kidney.* **C** and **D,** Grade V injuries with devascularization of the affected kidney. (From Myers JB, Brant WO, Broghammer JA: High-grade renal injuries: radiographic findings correlated with intervention for renal hemorrhage. Urol Clin North Am 40:335–341, 2013.)

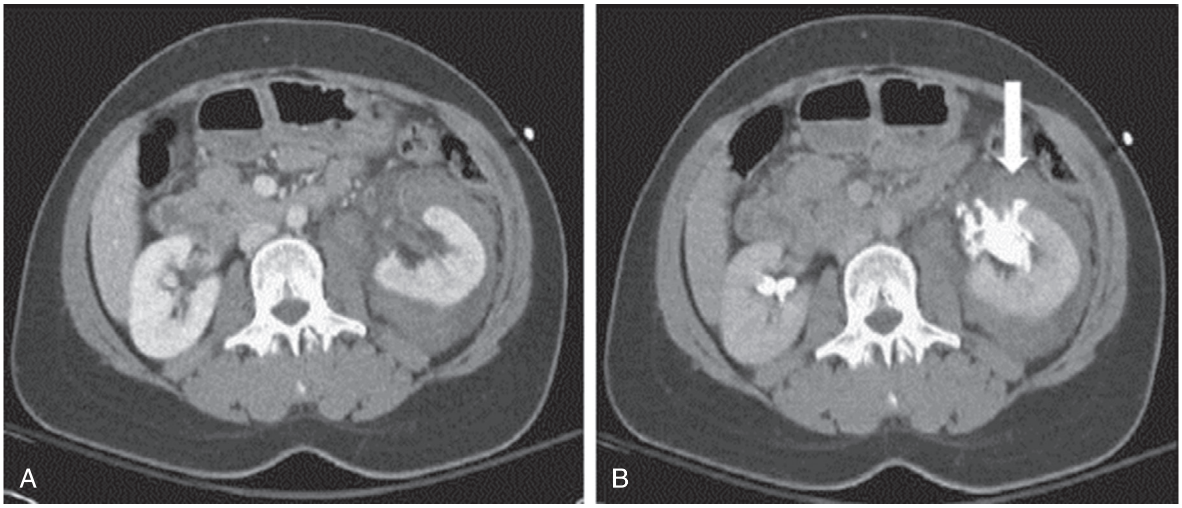

Fig. 40.9. **A,** Left-sided perinephric fluid collection suggests a collecting system injury on computed tomography (CT) images. **B,** Delayed images confirm a collecting system injury with contrast extravasation *(arrow)*. (From Hardee MJ, Lowrance W, Stevens MH, et al: Process improvement in trauma: compliance with recommended imaging evaluation in the diagnosis of high-grade renal injuries. J Trauma Acute Care Surg 74:558–562, 2013.)

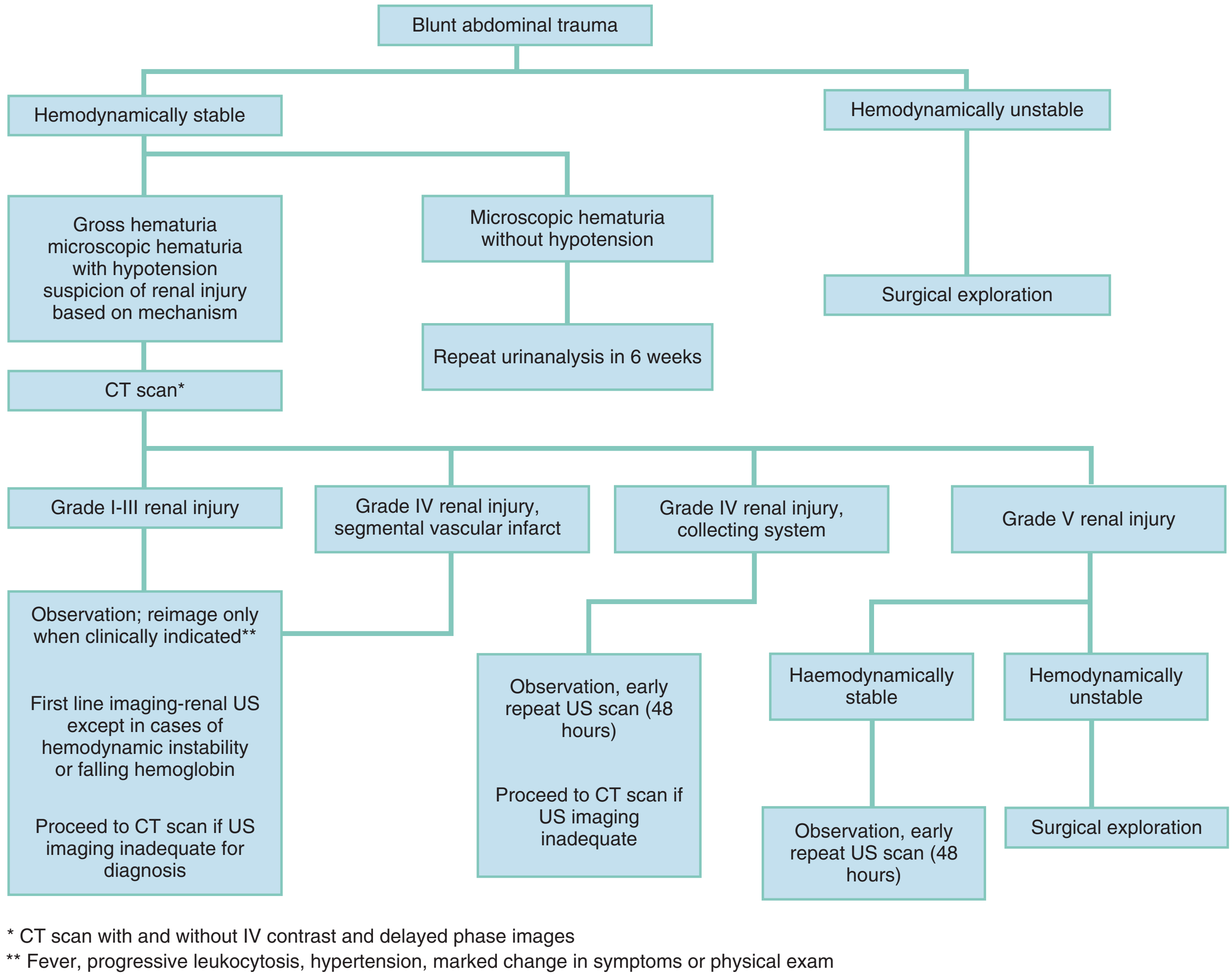

Fig. 40.10. Algorithm for imaging and management of renal trauma. *CT,* Computed tomography; *IV,* intravenous; *US,* ultrasound. (From Breen KJ, Sweeney P, Nicholson PJ, et al: Adult blunt renal trauma: routine follow-up imaging is excessive. Urology 84:62–67, 2014.)

Figure 40.10 represents an algorithm for the management of blunt trauma to the kidneys. After renal trauma is identified on imaging, hemodynamic instability determines the next step. If the patient is unstable despite fluid resuscitation, they should undergo surgical exploration. Patients found to have minor renal injuries (grade I to III) can be managed conservatively with observation and fluid resuscitation, whereas grade IV and V have a higher likelihood of needing operative intervention.[27]

Therapeutic options for blunt renal trauma include nephrectomy, ureteric stenting, percutaneous drainage, and arterial embolization.[28] Recent changes in management have focused on nonoperative therapy, leading to increased renal salvage. Surgical practice has shifted away from early exploration due to the high number of nephrectomies performed with early exploration. Thirty percent of patients with minor renal trauma undergoing exploration have nephrectomies, but if exploration is performed within 24 hours of arrival, over half undergo nephrectomy. Percutaneous transarterial embolization is being used with increased frequency even for high grade injuries to avoid nephrectomy.[27] This shift has been even more pronounced in the pediatric population, where the renal salvage rate now approaches 99%, and patients are treated with stent and nephrostomy if needed.[4] In contrast to blunt trauma, penetrating injuries to the kidney are often explored operatively. Approximately one-third of these patients will require a nephrectomy.[29]

Consideration has recently been given to further dividing grade IV injuries into IVa and IVb. The distinction is made because patients with grade IV injuries that have CT findings that reveal contrast extravasation, medial or complex lacerations, or hematomas larger than 3.5 cm require surgery more often than patients who do not.[30] In fact, patients with two or three of these criteria are 25 times more likely to require an intervention than those with zero or one of these findings.[31]

Patients with renal artery thrombosis are typically more stable and asymptomatic. Hypertension is often seen with thrombosis of the main renal artery but is rare with segmental artery thrombosis.[17] These injuries can result in devascularization of segments of the affected kidney but are also treated conservatively if possible.[32]

Complications of renal trauma include infection, urinary leak with resultant urinoma, loss of renal function, and hypertension. The most common complication is urinary tract infection.[33] In general, antibiotics should be considered for all patients with renal trauma to potentially avoid future urinary tract infections and perinephric abscess formation.[28] Grade III, IV, and V injuries are associated with a decrease in renal function of 15%, 30%, and 65%, respectively, after trauma.[34]

URETERAL TRAUMA

Clinical Features

Signs suggestive of ureteral injury include flank ecchymosis and occasionally gross hematuria with blunt trauma, and fractures of the transverse process of lumbar vertebrae are often seen. However, hematuria is seen in only half of patients and is usually microscopic. In addition, because over 20% of patients with ureteral injuries and blunt trauma have multisystem trauma with bony injuries (such as, pelvic and vertebral fractures) and hollow viscus injuries, they may not have complaints specific to the ureter, despite having a significant injury. Penetrating injuries of the ureter are often associated with injuries to the iliac vessels, which are often life-threatening. Given their subtle presentation, ureteral injuries do not declare themselves until later when patients present with sepsis (from urinary extravasation), hydronephrosis from obstruction, or a urinary fistula.[5]

Differential Diagnosis

Blunt trauma affecting the ureter can lead to stretching and resultant hematomas or, if more severe, partial or complete disruption of the ureteral wall. Penetrating injuries involving the ureter generally result in complete or partial transection.[5]

Diagnostic Testing

Hematuria is not a reliable indicator of ureteral trauma, because it is present in only 50% of patients. Blunt ureteral injury is rare, however, and further diagnostic evaluation for ureteral injury is reserved for patients with unexplained persistent hematuria or evidence of injury adjacent to the ureter, such as retroperitoneal vascular injury, vertebral fractures, or penetrating injuries near the flank. The best modality for diagnosing ureteral injury is IV contrast CT scan.[1]

IV pyelography/urography and retrograde pyelography were once used to diagnose ureteral injury, but they have been supplanted by CT scanning (Fig. 40.11). CT scan performed immediately after the administration of IV contrast can potentially miss ureteral injuries, and 10 minute delayed imaging (allowing for contrast to enter and pass through the ureter from the collecting system) is recommended. CT findings of ureteral injury include contrast extravasation, a delayed pyelogram, hydronephrosis, or lack of contrast distal to the ureteral injury.[1] Additionally, the presence of a transverse process fracture, perinephric stranding or hematomas, and low-density retroperitoneal fluid (representing urinary extravasation) should raise the concern for ureteral injury. If delayed CT imaging was not initially performed but ureteral injury is suggested by these findings, a plain film of the abdomen can be obtained 30 minutes after CT to assess for contrast extravasation into the pelvis. Alternatively, retrograde pyelography can be performed.[35]

Fig. 40.11. Intravenous (IV) urography revealing an injury to the left distal ureter, resulting in contrast extravasation. (From Cutinha P, Venugopal S, Salim F: Genitourinary trauma. Surgery [Oxford] 31:362–370, 2013.)

Management

With minor injuries including contusions and partial lacerations, ureteral stenting is typically sufficient. However, débridement with anastomosis may be necessary with loss of a segment.[5] Additional options include percutaneous nephrostomy for unstable patients and ureteral reimplantation into the bladder. Nephrectomy is rare but sometimes necessary with more proximal injuries.[35]

Almost one-quarter of all patients develop a complication after ureteral injury, which are rarely life threatening but can occasionally lead to the loss of the affected kidney. Urinary leaks leading to sepsis or fistulas, as well as strictures, are among the most common complications, and are frequently seen when diagnosis of the initial injury is delayed.[35]

BLADDER TRAUMA

Clinical Features

Unlike injuries to the ureter, hematuria is the hallmark of a bladder injury, with gross hematuria noted in 72% of patients with blunt trauma to the bladder, and up to 95% of patients with penetrating bladder trauma.[6] Other signs and symptoms include abdominal tenderness (approximately 60% of patients), blood at the urethral meatus, the inability to void, and ecchymosis in the perineum, thigh, or abdomen.[15]

Differential Diagnosis

Differentiating intraperitoneal from EBR is of utmost importance. Intraperitoneal injuries are most often caused by significant blunt force abdominal trauma in a patient with a distended bladder. Extraperitoneal injuries are usually associated with some form of pelvic trauma. Bladder injuries themselves can range from mural hematomas to through-and-through disruptions of the bladder wall, resulting in rupture.[15]

Diagnostic Testing

Other than urinalysis, laboratory evaluation is not useful in diagnosis of bladder injury.[1] Gross hematuria is present in the majority of cases; those without gross hematuria will have microscopic hematuria. High energy pelvic fractures, such as symphysis diastasis and displaced obturator ring fractures, should also raise the suspicion of bladder injury.[16]

All patients with gross hematuria and pelvic fracture should undergo cystographic imaging, due to the high likelihood of

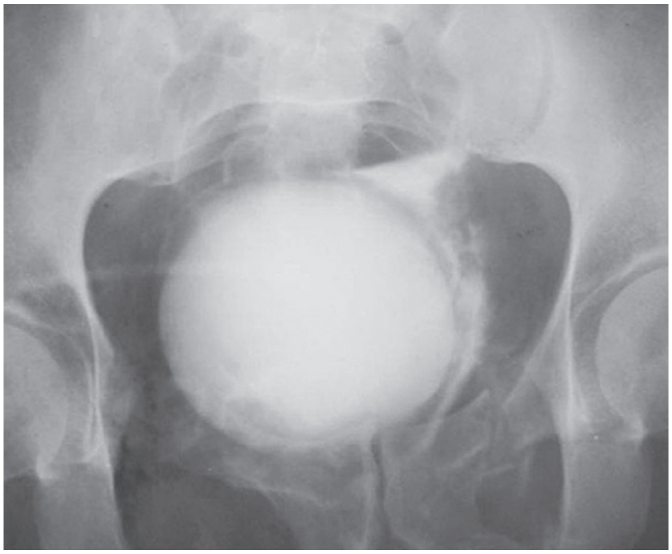

Fig. 40.12. Extraperitoneal bladder rupture (EBR) on retrograde cystography. Contrast extravasation is limited to the pelvis. (From Cutinha P, Venugopal S, Salim F: Genitourinary trauma. Surgery [Oxford] 31:362–370, 2013.)

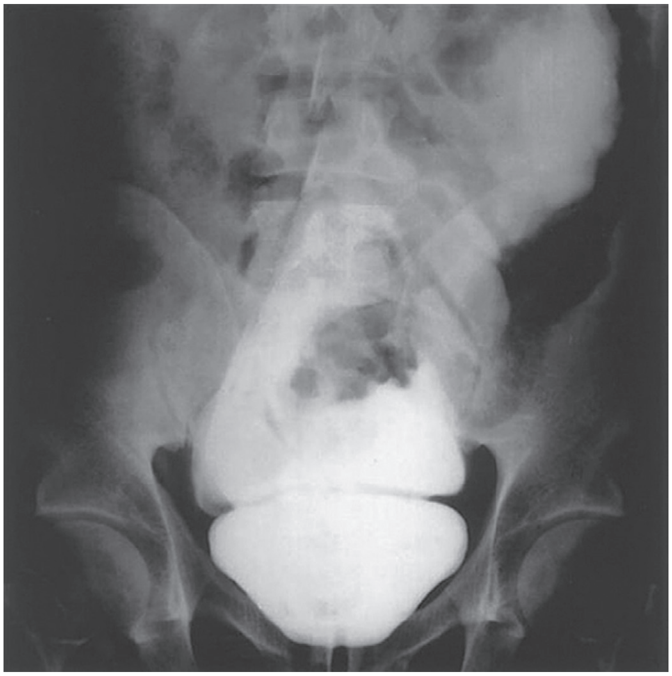

Fig. 40.13. Intraperitoneal bladder rupture (IBR) on retrograde cystography. Extravasating contrast can be seen outlining bowel. (From Cutinha P, Venugopal S, Salim F: Genitourinary trauma. Surgery [Oxford] 31:362–370, 2013.)

bladder injury.[1] Imaging is also indicated for patients with microscopic hematuria and either pelvic ring or obturator fractures, or with penetrating trauma to the pelvis.[18] CT scan performed with IV contrast alone does not sufficiently distend the bladder to evaluate for mural defects, leading to false negatives, and thus retrograde "stress" cystography must be performed.[6] This involves diluting 30 mL of water-soluble ionic contrast in a 500 mL bag of warmed saline. Approximately 300 to 400 mL of this solution is then introduced into the bladder via a Foley catheter using gravity.[18] Foley catheterization should not be performed unless the clinician is confident that urethral injury is not present (see discussion following). By distending the bladder, thrombi that may have formed along the bladder wall are dislodged, allowing for urinary extravasation. Images are then acquired to assess for rupture. Conventional cystography can assess for urinary extravasation (Figs. 40.12 and 40.13). However, CT is more sensitive (95%) and can evaluate for foreign body involvement from fractures or even bladder neck injuries. EBR may demonstrate a "molar tooth" appearance on cystography, which represents contrast tracking along the pelvic fascial planes (Fig. 40.14), whereas IBR reveals contrast material outlining the intraperitoneal structures (Fig. 40.15).[18]

Bedside ultrasonography has not been fully studied to assess for bladder rupture, although it does show promise (Fig. 40.16).[36] As with any evaluation using ultrasound, this technique is highly operator dependent, and findings are not necessarily specific.

Management

The distinction between EBR and IBR is important, because the management differs. Contusions and extraperitoneal injuries due to blunt trauma are typically managed conservatively with Foley catheterization, unless they are complicated by other intra-abdominal injuries, bladder neck injuries, bone fragments in the bladder wall, or if open reduction is performed on an associated pelvic fracture.[37] In contrast, given the extremely low likelihood of IBR and penetrating injuries healing with conservative therapy, almost all patients with these types of injuries are taken to the operating room for exploration and repair.[1] Without surgery, there is an extremely high likelihood of complications, which include infections and fistula formation.

Compared to patients with pelvic fracture alone, a concomitant bladder injury is associated with a 75% increase in mortality.[6] Due to the significant mechanism needed to cause an IBR, these injuries are associated with an approximate 20% mortality, which is twelve times more than is seen with isolated EBR.[6] Operative repair decreases the mortality risk by nearly 60%.[37] Additionally, intraperitoneal urinary extravasation can lead to delayed morbidity and mortality due to resultant infections, as well as ileus and chemical peritonitis. Extraperitoneal injuries can lead to fistula formation or infections as well but occur in the minority of cases. Penetrating rectal injuries leading to bladder involvement can result in abscess, bladder stones, urethral strictures, and fistulae.[38] The high likelihood of potential complications underscores the importance of performing retrograde cystography with an adequate amount of volume in order to diagnose all cases of bladder injury.

URETHRAL TRAUMA

Clinical Features

The "classic" presentation of posterior urethral injury includes blood at the urethral meatus, urinary retention, and a "high-riding" prostate on digital rectal examination (DRE). However, DRE is not a sensitive test, because the prostate can be obscured by a pelvic hematoma, which is common after pelvic fractures. Therefore, DRE should be focused on detecting rectal injuries, and it should not be used to diagnose urethral injury.[39] Other findings include swelling or ecchymosis of the perineum or penis (including "butterfly bruising" seen with anterior injuries that violate Buck's fascia; Fig. 40.17) and a distended bladder due to the inability to void.[35]

Blood at the urethral meatus is the most common sign, occurring in up to 90% of posterior injuries and 75% of anterior injuries. As a result, absence of blood at the meatus and the lack of a genital hematoma, bruising, or swelling decrease the likelihood of urethral injury. The degree of hematuria is not correlated with the

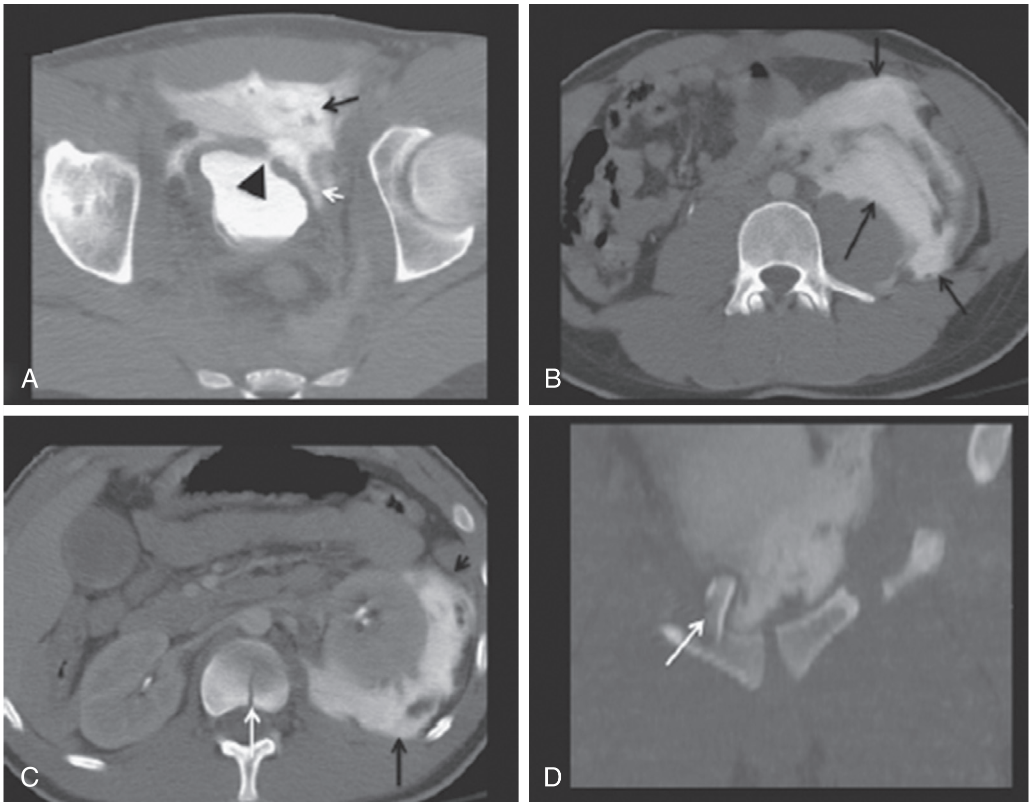

Fig. 40.14. Computed tomography (CT) cystography images from a complex extraperitoneal bladder rupture (EBR). **A,** The *arrowhead* overlying the bladder points to the location of extravasation into the perivesicular spaces. **B** and **C,** Contrast extravasation continues along the left retroperitoneum, extending into the perirenal space. **D,** The rupture was likely caused by the displaced ramus fracture fragment which is seen violating the bladder wall. There is an associated lumbar spine fracture noted in **C.** (From Avery LL, Scheinfeld MH: Imaging of male pelvic trauma. Radiol Clin North Am 50:1201–1217, 2012.)

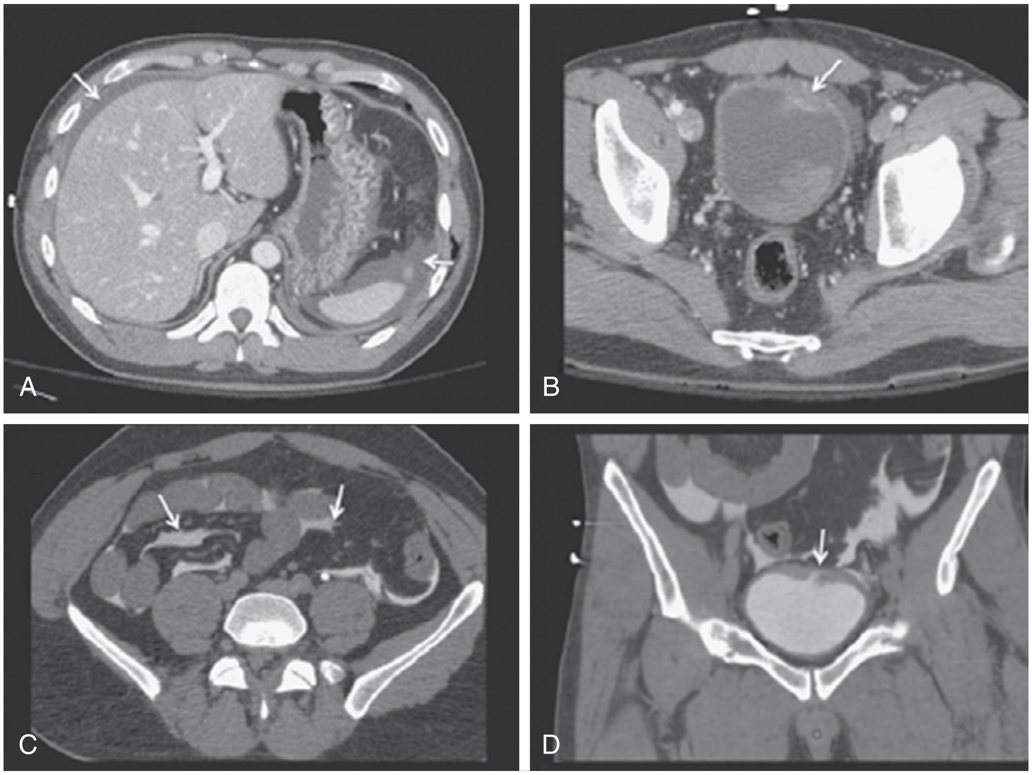

Fig. 40.15. Computed tomography (CT) images from a patient with intraperitoneal bladder rupture (IBR). **A** and **B,** Images acquired immediately after intravenous (IV) contrast administration reveal fluid around the liver and spleen, as well as clot within the bladder and left anterior bladder wall. CT cystography reveals intraperitoneal extravasation of contrast **(C)** with a disruption of the dome of the bladder **(D).** (From Avery LL, Scheinfeld MH: Imaging of male pelvic trauma. Radiol Clin North Am 50:1201–1217, 2012.)

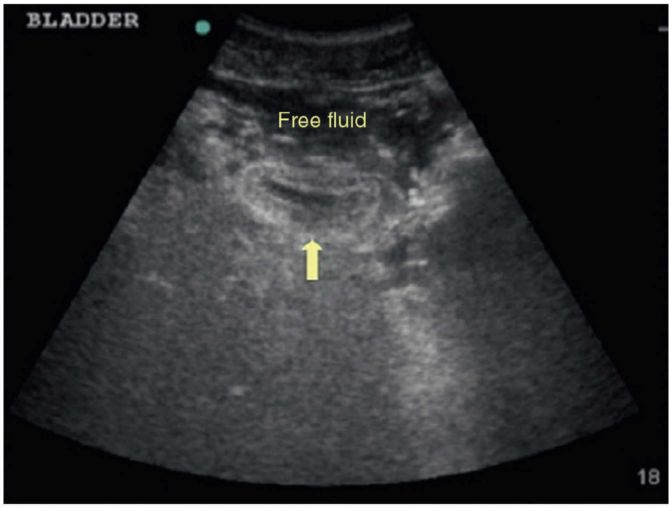

Fig. 40.16. Ultrasound image of bladder rupture. The bladder is contracted, with an irregular bladder wall posteriorly *(arrow),* and free fluid anteriorly. (From Wu TS, Pearson TC, Meiners S, et al: Bedside ultrasound diagnosis of a traumatic bladder rupture. J Emerg Med 41:520–523, 2011.)

Fig. 40.17. "Butterfly pattern" of ecchymosis of the scrotum and perineum. (From Mundy AR, Andrich DE: Urethral trauma. Part I: introduction, history, anatomy, pathology, assessment and emergency management. BJU Int 108:310–327, 2011.)

degree of injury; in fact, a transection can cause a minimal amount of microscopic hematuria, whereas a contusion can induce copious bleeding.[1]

Differential Diagnosis

Mild blunt-force injuries to the urethra can result in stretching of the urethra or a contusion of the wall. More severe injuries include partial or complete disruption of the wall. Penetrating injuries usually result in some sort of disruption of the lumen of the urethra. If complete disruption occurs, the amount of urethral separation is important, because more than 2 cm of disruption carries a worse prognosis.[1]

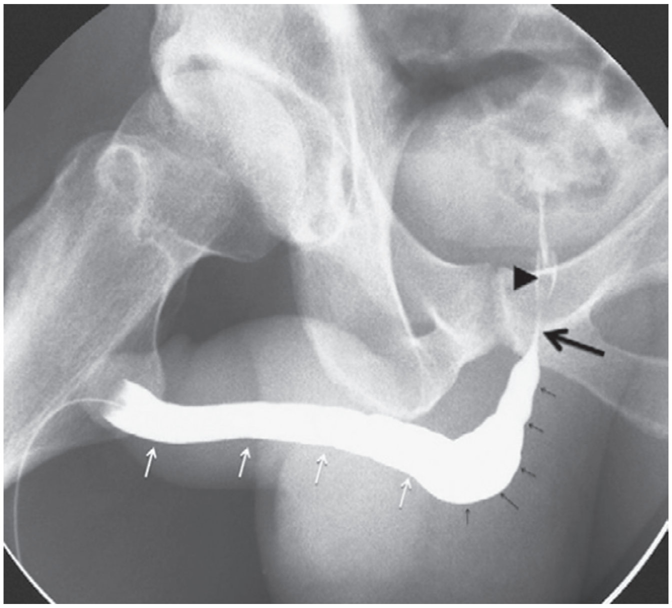

Fig. 40.18. Normal retro urethrogram. *White arrows* point to the penile urethra, and *black arrows* point to the bulbous urethra, which together form the anterior urethra. The posterior urethra is composed of the membranous urethra *(black arrow)* and the prostatic urethra *(black arrowhead).* (From Avery LL, Scheinfeld MH: Imaging of male pelvic trauma. Radiol Clin North Am 50:1201–1217, 2012.)

Diagnostic Testing

Retrograde urethrography (RUG) is the gold standard for diagnosing urethral injuries, and it should be performed if there is blood at the urethral meatus, or other findings consistent with urethral injury (eg, perineal or pelvic ecchymosis or swelling), prior to bladder catheterization (Fig. 40.18).[39] The technique for performing a RUG is detailed in Box 40.1 and depicted in Figure 40.19. A scout film that can demonstrate preexisting calcifications is important to avoid false positive diagnoses, and then it can be compared to post-contrast images.[39] Urethrography can determine the location (anterior and posterior) and extent (partial versus complete) of the injury, and it has excellent sensitivity and specificity. Figure 40.20 depicts a potential schematic of a urethral injury with the resultant RUG image. If a urinary catheter has already been placed, a pericatheter RUG can be performed by introducing a 3 Fr catheter into the fossa navicularis and then introducing a small amount of contrast.

CT scan with IV contrast only carries a sensitivity of 88% and specificity of 79%, confirming RUG as the gold standard. Ultrasonography and magnetic resonance imaging (MRI) also have limited utility in the diagnosis of urethral injury.[35]

Management

The immediate goal with urethral injury is to secure catheter drainage of the bladder.[1] Instrumenting a partially disrupted urethra with a Foley catheter can lead to complete disruption of the urethra. Additionally, continued extravasation of urine through a urethral laceration can lead to infection. Therefore, if a urethral injury is diagnosed, a suprapubic catheter should be placed as soon as possible.[39] Figure 40.21 details this procedure, which should be performed under ultrasound guidance, if possible, to avoid injury to the bowels.[40]

After suprapubic drainage is established, the surgical management of urethral injuries can be delayed in favor of treating other life-threatening injuries, except in the case of penetrating injuries or concomitant bladder neck injuries, which should be explored

BOX 40.1

Technique for Performing Retrograde Urethrography

1. A 16-Fr or 18-Fr Foley catheter or a hysterosalpingogram catheter is flushed with radiopaque contrast to avoid air bubbles.
2. The glans penis and urethral meatus are cleaned with antiseptic.
3. The catheter is inserted into the penis, and the balloon is partially inflated (1 to 2 mL) in the fossa navicularis.
4. The penis is then pulled laterally to straighten the urethra under moderate traction.
5. A precontrast "scout" image is obtained, because prostatic calcifications may be confused for extravasated contrast.
6. Under fluoroscopic visualization, 20 to 30 mL of contrast is injected with the goal of filling the entire urethra.
7. If spasm of the external sphincter prevents posterior urethral filling, slow, gentle pressure may allow opacification.
8. Static images are obtained to demonstrate the identified pathologic condition.

From Avery LL, Scheinfeld MH: Imaging of male pelvic trauma. Radiol Clin North Am 50:1201–1217, 2012.

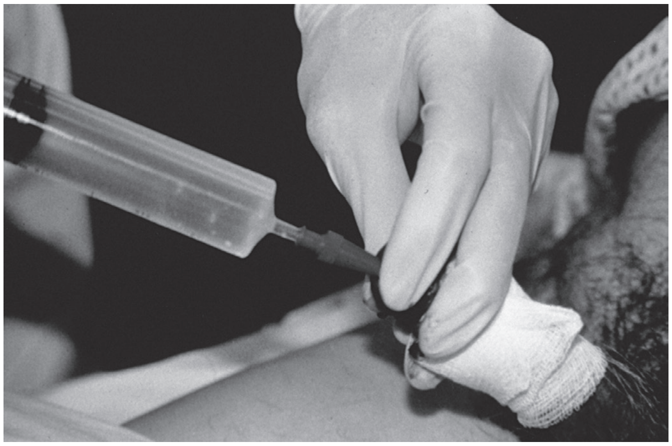

Fig. 40.19. Christmas tree adapter on the end of a 60-mL syringe has been gently placed inside the fossa navicularis in preparation for retrograde urethrography (RUG).

and débrided immediately. Delayed repair allows time for inflammation to decrease and is associated with lower rates of erectile dysfunction, urinary incontinence, and stricture formation.[9]

Complications of urethral injury include urethral stricture, urinary incontinence, and erectile dysfunction, which effects almost half of all men suffering urethral injuries.[9] Almost half of all children with pelvic fractures and associated urethral injury will exhibit erectile dysfunction at puberty. An even higher number is seen in patients with pubic diastasis.[41] The cause of erectile dysfunction is thought to be neurogenic in most cases, but it can be vasogenic or mixed in some cases.[42] In children, a higher risk is seen with urethral gap lengths more than 2.5 cm and lateral prostatic displacement.[41] A higher rate of future stress incontinence is seen in women with urethral trauma.[16]

GENITAL TRAUMA

Clinical Features

Patients with scrotal injuries may present immediately with swelling and pain, but note that patients with scrotal injuries often do not present acutely; in one study, patients had median presentation durations of 3 days.[20] Due to swelling, it is often difficult to distinguish between the different types of testicular injury on examination. Blunt force of at least 50 kg is needed to cause a rupture of the tunica albuginea with extrusion of the seminiferous tubules, resulting in testicular fracture.[20]

Penile injuries result in pain, swelling, and ecchymosis. In the setting of blunt or penetrating injuries, blood at the urethral meatus, gross hematuria, or the inability to void suggest a concomitant urethral injury.[1] False penile fractures present with the swelling and ecchymosis that is typically seen with penile fractures, but patients typically experience a more gradual detumescence and do not typically notice the popping sound that accompanies most cases of penile fracture (Fig. 40.22).[23] However, it is very difficult to make a clinical distinction between true and false penile fractures, and many of these cases still require exploration.

True penile fractures are relatively uncommon but are also likely underreported.[10] It is defined as a rupture of the tunica albuginea surrounding any of the three corpora of the penis.[43] The tunica albuginea stretches when the penis is erect, making it thin and inflexible, and thus more prone to rupture with lateral

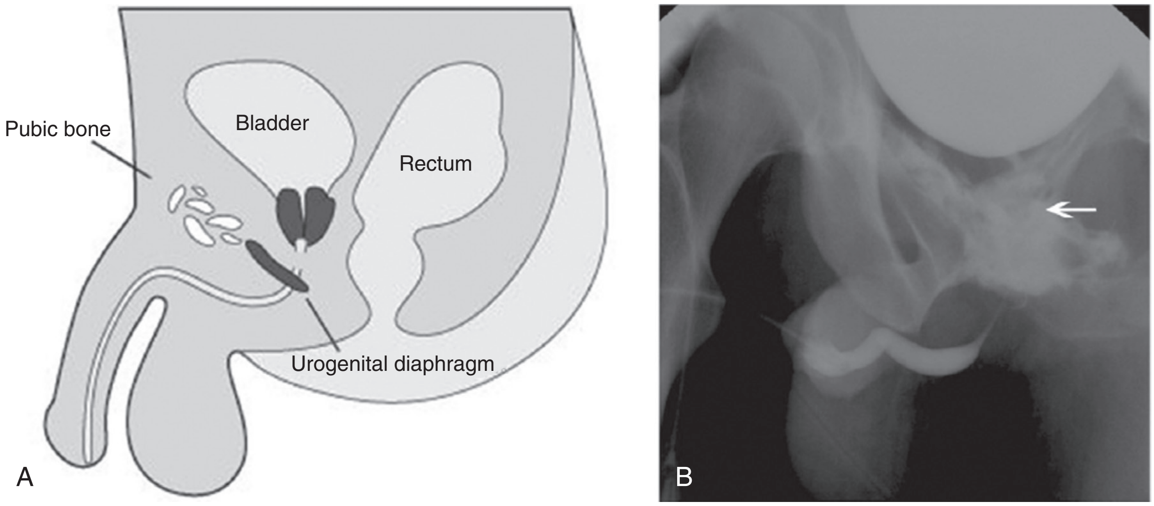

Fig. 40.20. Schematic representation of disruption of the membranous urethra **(A)** with retrograde urethrogram **(B)** revealing contrast extravasation above the urogenital diaphragm. (From Nicola R, Menias CO, Mellnick V, et al: Sports-related genitourinary trauma in the male athlete. Emerg Radiol 22[2]:157–168, 2015.)

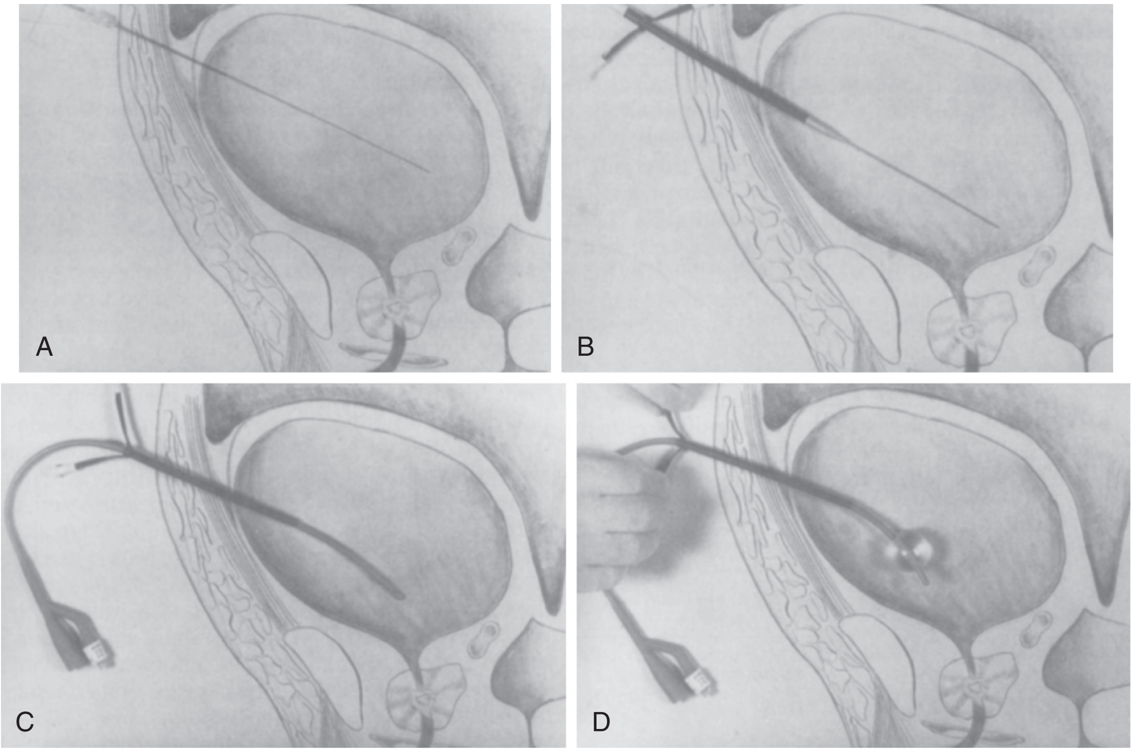

Fig. 40.21. Percutaneous placement of a suprapubic tube with peel-away sheath introducer. **A,** An 18-gauge needle is in the bladder. A guidewire is advanced through the needle. **B,** A dilator and peel-away sheath are advanced over the guidewire. **C,** The dilator and guidewire are removed. Through the peel-away sheath, an appropriately sized catheter can be introduced into the bladder. **D,** The balloon is inflated, and the sheath is pulled back and peeled away. (From O'Brien WM: Percutaneous placement of suprapubic with peel away sheath introducer. J Urol 145:1015, 1991.)

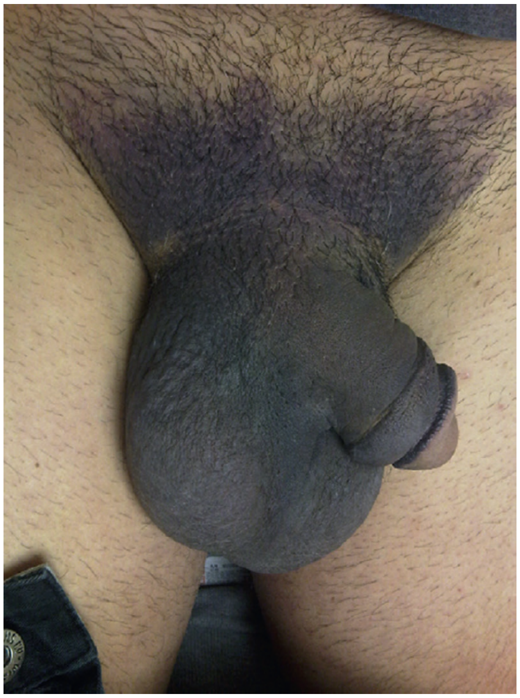

Fig. 40.22. Superficial dorsal vein rupture imitating penile fracture. (From Chang AJ, Brandes SB: Advances in diagnosis and management of genital injuries. Urol Clin North Am 40:427–438, 2013.)

Fig. 40.23. Penile fracture causing penile and scrotal ecchymosis and blood that has emanated from the urethral meatus, suggesting urethral injury. (From Hoag NA, Hennessey K, So A: Penile fracture with bilateral corporeal rupture and complete urethral disruption: case report and literature review. Can Urol Assoc J 5:E23–E26, 2011.)

bending.[44] In the Western hemisphere, penile fracture most often occurs when the penis slips out of the vagina during intercourse and is accidentally thrust against the perineum or pubic symphysis. However, in the Mediterranean and Middle-East, the most common cause is *taghaandan*—where the erect penis is forcibly pushed down to achieve detumescence.[45] Penile fractures are associated with urethral injuries in 10% to 20% of cases, and urethral injuries are more likely in cases of bilateral corporal fractures or when blood is noted at the urethral meatus (Fig. 40.23).[10] Patients with penile fracture experience immediate pain with

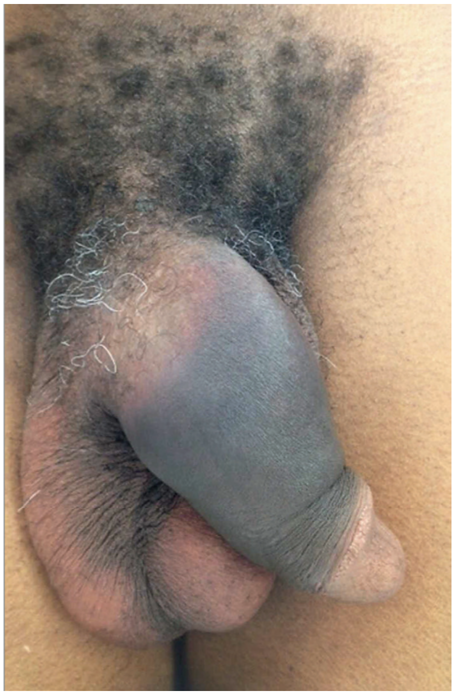

Fig. 40.24. Penile fracture and hematoma causing an "eggplant deformity." (From Mundy AR, Andrich DE: Urethral trauma. Part II: types of injury and their management. BJU Int 108:630–650, 2011.)

rapid detumescence and a resultant penile hematoma with swelling. An audible popping sound is often heard as well.[43] Ecchymosis typically is present along the entire shaft of the penis; however, if Buck's fascia is also torn, a "butterfly pattern" (see Fig. 40.17) of ecchymosis can be seen in the perineal region.[46] The swelling and color caused by penile fractures can result in an "eggplant deformity," and the penis tends to deviate away from the damaged side (Fig. 40.24).[47] A defect in the tunica albuginea may be palpated along the shaft of the penis, which is known as *Rolling sign*.[24]

Injuries to the female genitalia can result in labial swelling or ecchymosis, but consideration should be given to performing procedural sedation or even general anesthesia to allow for adequate examination to assess the entire extent of their injuries, especially in young girls.[13] An examination under anesthesia is suggested for female patients who are younger than 10 years old who present with perineal bleeding, hematoma, or swelling resulting from falls, assaults, or playground activities. Studies have shown that thorough examinations are underperformed in this population, resulting in missed diagnoses, which can lead to significant morbidity.[12]

Differential Diagnoses

Blunt trauma to the scrotum can lead to testicular rupture, testicular dislocation, testicular fracture (parenchymal injury contained within the tunica albuginea), intraparenchymal contusions, hematoceles, or scrotal hematomas. Blunt trauma to the penis can cause penile fractures or false penile fractures. Urethral injury can sometimes occur as a result of blunt penile trauma. Penetrating injuries to the male genitalia often cause a disruption to the tunica albuginea of the penis or scrotum, but they can lead to amputation as well. Blunt trauma in females can cause labial and vaginal contusions, hematomas, and lacerations. Severe vulvar trauma, either from blunt or penetrating mechanisms, can lead to rectal injuries as well.[1]

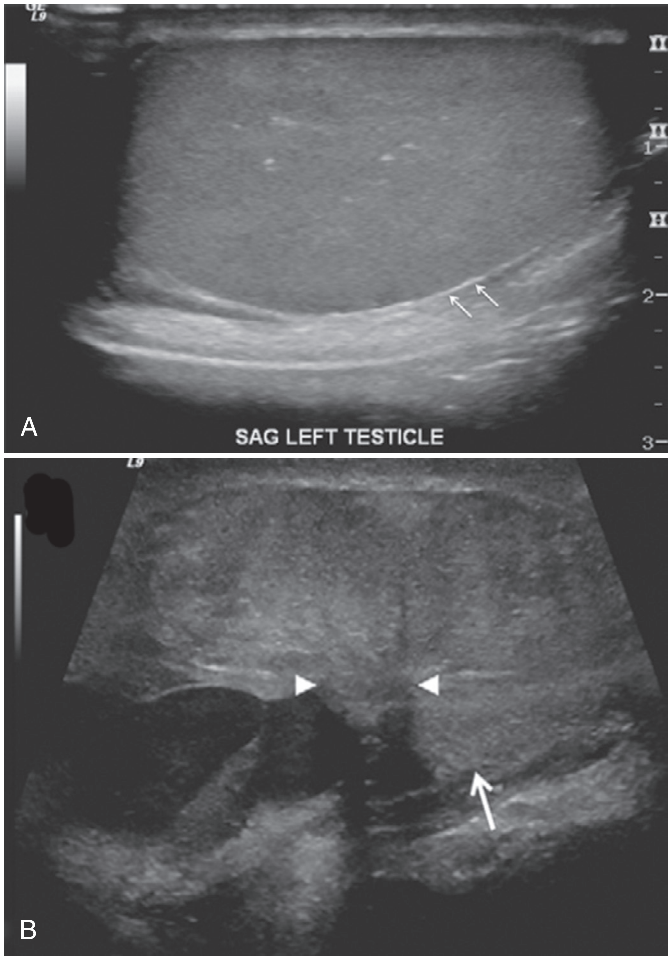

Fig. 40.25. **A,** Normal testicular ultrasound. *Arrows* define the thin tunica albuginea. **B,** Testicular rupture. *Arrowheads* point to a disruption in the tunica albuginea with extrusion of the seminiferous tubules. The *large arrow* indicates a hematocele. (From Avery LL, Scheinfeld MH: Imaging of male pelvic trauma. Radiol Clin North Am 50:1201–1217, 2012.)

Diagnostic Testing

Due to the external nature of the genitalia, diagnoses of genital trauma are usually made clinically, as opposed to other genitourinary trauma, which often require imaging studies. Scrotal injuries typically present with swelling, pain, bruising, lacerations, and/or skin loss. However, due to swelling, the examination can be limited.[48] Laboratory studies are not helpful, except for diagnosing concomitant injuries.

Imaging

Scrotal ultrasound is the imaging modality of choice when evaluating for testicular injury because of its accuracy, as well as its availability. The ability to evaluate flow using Doppler is extremely useful when determining viability and vulnerability of tissue. Along with testicular rupture, ultrasound can diagnose fractures, hematomas, hematoceles, and contusions. MRI can be used but is less practical given its long acquisition time and the limited availability. For testicular rupture, the sensitivity of ultrasonography approaches 100% and should focus on testicular echotexture, as well as the contour of the testicle. Irregularities of the contour or a discontinuity of the tunica albuginea suggest testicular rupture (Fig. 40.25).

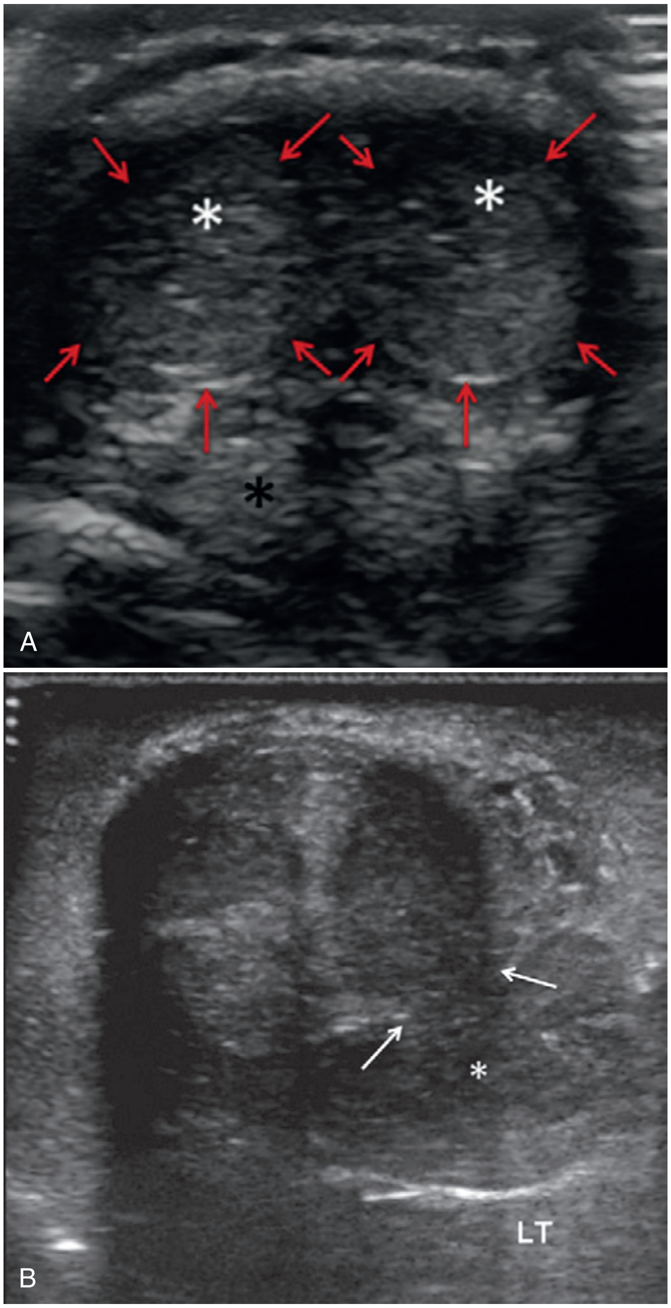

Fig. 40.26. **A,** Normal penile ultrasound. *Arrows* outline the tunica albuginea, asterisks overly the corpora cavernosa *(white asterisks)* and corpus spongiosum *(black asterisk)*. **B,** Disruption of the tunica albuginea *(arrows)* and extruded corpus cavernosum tissue *(asterisk)* suggest penile fracture. (From Avery LL, Scheinfeld MH: Imaging of male pelvic trauma. Radiol Clin North Am 50:1201–1217, 2012.)

Ultrasound is also the preferred modality for penile imaging. It can diagnose penile fracture, but can also be used to evaluate the blood flow in penile arteries and veins. Unlike scrotal ultrasound, however, penile ultrasound is used less often, as the diagnosis of penile fracture is usually made clinically. Due to the extensive exploration required to evaluate for penile fracture, however, ultrasound is gaining more popularity because it can reveal a defect in the tunica albuginea with extruding hematoma, as well as assess blood flow in the arteries and veins (Fig. 40.26).

RUG should be considered if there are concerns about concomitant urethral injury (Fig. 40.27).[44]

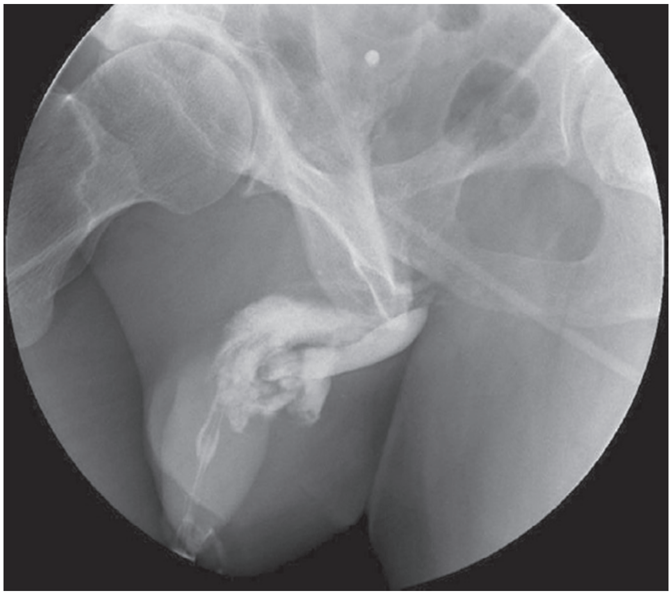

Fig. 40.27. Retrograde urethrogram revealing anterior urethral injury and contrast extravasation in the setting of a penile fracture. (From Cutinha P, Venugopal S, Salim F: Genitourinary trauma. Surgery [Oxford] 31:362–370, 2013.)

Management

Testicular and penile fractures require prompt urological consultation and surgery, and they are discussed in more detail later. With any type of penetrating injury to the scrotum or penis, surgical exploration is usually indicated to evaluate for injuries to deeper structures that could result in significant morbidity, unless the injury is extremely superficial.[49] Penile surgical exploration involves degloving the entire penis to allow for visualization of all structures. Prognosis after penile fractures is generally good, but cosmetic abnormalities can occur, even with prompt surgical repair.[50]

For testicular rupture, operative intervention focuses on débriding nonviable tissue and closing the tunica albuginea, although orchiectomy is performed if the testicle is deemed nonviable.[1] The rate of orchiectomy is low (10% to 20%) if exploration is performed within 72 hours, but if there is significant delay, the rate is significantly higher (45%).[20,21] The goal of surgery for testicular injuries is testicular salvage, although penetrating injuries still result in a 35% rate of orchiectomy due to testicular necrosis or unhealthy parenchyma.[49]

Typically, small scrotal hematomas respond well to rest and nonsteroidal antiinflammatory drug (NSAID) therapy. However, scrotal hematoceles and expanding or large scrotal hematomas may lead to testicular ischemia due to local pressure effects on blood vessels and, thus, may also require exploration.[48] Reduction of testicular dislocations should be attempted by applying gentle caudad pressure following the course of the spermatic cord. However, even if reduction is successful, ultrasound should be performed to evaluate for vascular compromise, and patients usually require future operative intervention in the form of orchiopexy to prevent testicular torsion.[22]

Amputations of either the testicles or penis require immediate surgical evaluation. In the interim, the amputated part should be wrapped in saline soaked gauze and then placed in a sealed bag, which can then be placed in another bag that is filled with ice.[1] The amputated part should never be placed directly on ice. Direct pressure is usually adequate to achieve hemostasis.

Injuries to the female genitalia may need the operating room for an examination (and repair) under anesthesia, or for extensive lacerations involving the labia, perineum, and posterior fourchette.[12] Again, the threshold for an examination under anesthesia should be extremely low, especially in the pediatric population.

Zipper injuries should be evaluated thoroughly for underlying trauma to the penis (or scrotum when involved). If the zipper is stuck, the cloth between the interlocked dentition of the zipper can be cut. However, if the penis is caught in the buckle of the fastener, unzipping can be attempted, and mineral oil may help with removal. However, if this proves unsuccessful, the medial bar of the zipper can be cut with bone or wire cutters to separate the face plates. Sometimes, however, circumcision or an elliptical incision of the penile skin must be performed to achieve release.[51]

Burns to the external genitalia are usually not seen in isolation, and the thin skin of the penis makes it quite vulnerable to full-thickness burns. Patients with burns that are not extremely superficial should be evaluated at a burn center as soon as possible.[47] More than 10% of these patients will need surgical débridement.[52] Superficial burns can be treated with topical therapies.[47]

Occasionally, patients will present with constricting rings that have created local ischemia and swelling, and attempts at removal should be made as quickly as possible to prevent tissue necrosis from ischemia.

Scrotal injuries leading to orchiectomy can be a source of infertility but can also alter hormonal function. Other complications include voiding dysfunction and erectile dysfunction.[49] Many of the complications of penile injury are cosmetic in nature, including penile curvature and plaque or nodule formation superficially after penile fracture, but the likelihood is significantly decreased with surgery.[43,50] Still, urethral injury can lead to stricture formation, penile abscess, permanent curvature, and painful erections, even if repair is successful.[53] A delay in diagnosing female genital injury can lead to urinary or fecal incontinence, chronic fissures, rectovaginal fistula, or even vaginal stenosis, highlighting the importance of a thorough physical examination.[12]

KEY CONCEPTS

- Microscopic or gross hematuria is suggestive of genitourinary trauma; however, the degree of hematuria does not correlate well with the severity of injury.
- The kidney is the most frequently injured genitourinary organ, and imaging should be considered in patients with gross hematuria or microscopic hematuria with hemodynamic instability.
- Delayed CT images after IV contrast should be obtained in patients with mechanism or findings suggestive of ureteral trauma. Blunt ureteral trauma is rare.
- CT scan with IV contrast is not sensitive for diagnosing bladder injury, and retrograde cystography should be obtained if there is any concern to allow proper distention of the bladder to allow for urinary extravasation.
- Pelvic fractures associated with hematuria strongly suggest urethral injury.
- Retrograde urethrography (RUG) should be performed in patients with pelvic fractures and hematuria, perineal ecchymosis or swelling, or those with blood at the urethral meatus, because passage of a Foley catheter blindly in these settings can worsen a preexisting urethral injury.
- Genital injury is rarely life threatening, but prompt diagnosis and evaluation is necessary to decrease the likelihood of future morbidity in these patients.

The references for this chapter can be found online by accessing the accompanying Expert Consult website.

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CHAPTER 40: QUESTIONS & ANSWERS

40.1. All of the following are associated with clinically significant blunt renal injuries in adult patients and would warrant further evaluation, except:

A. A sudden decelerating mechanism of injury in a patient without microhematuria
B. A sudden decelerating mechanism of injury in a patient without shock
C. Gross hematuria
D. Microscopic hematuria
E. Microscopic hematuria in a patient with shock

Answer: D. Renal injury requiring intervention is rare in the absence of gross hematuria or shock. Gross hematuria warrants careful evaluation for significant genitourinary injury, although the degree of hematuria does not necessarily correlate with the degree or grade of injury and significant genitourinary trauma can occur without hematuria. Microscopic hematuria in a blunt trauma patient without shock is not an indication for renal imaging, even if there is evidence of local trauma (eg, costovertebral angle tenderness or localized ecchymosis). Although renal injury may uncommonly be identified on imaging for these patients, the injuries are mild and do not require intervention. Hemodynamic instability with evidence of intraperitoneal injury on abdominal examination, presence of pelvic fracture, a penetrating trauma mechanism, or presence of lower rib fractures, with or without hematuria, are indications for further investigation. Additionally, imaging is advisable for patients with gross hematuria, targeted to the entire urinary tract or localized to the lower tract (bladder and urethra), depending on the mechanism and location of the trauma.

40.2. A 27-year-old male presents after a motor vehicle collision complaining of abdominal pain. He was the restrained driver of a car struck on the driver's side by a delivery truck. His vital signs are blood pressure 118/72, heart rate 70 beats per minute, and respiratory rate 16 breaths per minute. Physical examination reveals left upper quadrant abdominal tenderness without guarding or rebound tenderness. There is no blood at the urethral meatus or scrotal hematoma. A Foley catheter is placed without difficulty and drains gross blood. A radiograph of the pelvis reveals fractures of the left superior and inferior pubic rami, and a focused assessment with sonography in trauma (FAST) examination reveals free fluid in the splenorenal pouch. Which of the following diagnostic strategies is most appropriate?

- **A.** Intravenous (IV) contrast-enhanced computed tomography (CT) of the abdomen and pelvis with delayed images of the bladder after clamping the Foley catheter to allow the IV contrast to collect in the bladder
- **B.** IV contrast-enhanced CT of the abdomen and pelvis with delayed images of the renal collecting system
- **C.** IV contrast-enhanced CT of the abdomen and pelvis and retrograde CT cystogram
- **D.** IV contrast-enhanced CT of the abdomen and pelvis and retrograde urethrogram
- **E.** Retrograde cystogram followed by IV pyelogram

Answer: C. This patient has clinical features concerning for several possible injuries, including a splenic laceration, renal injury, and bladder rupture. Significant urethral injury is less likely, given the examination findings and ease of Foley catheter placement. Because the patient is stable without apparent indication for laparotomy, the most appropriate diagnostic evaluation would be IV contrast-enhanced CT of the abdomen and pelvis and retrograde CT cystogram. The former will evaluate for solid organ injury and the latter for bladder rupture. It is essential that cystography not be done in an antegrade fashion, because such studies (eg, injecting IV contrast material, clamping the Foley catheter, and allowing the examination to depend on antegrade filling of the bladder from renal excretion of progressively dilute contrast material) may produce incomplete and spurious findings because of inadequate distention of the bladder.

40.3. A 72-year-old male presents with flank and pelvis pain after he slipped and fell on an icy sidewalk. His examination reveals normal vital signs and abrasions over the left flank and left iliac crest and is otherwise unremarkable. He has grossly clear urine, but a urinalysis reveals 25 red blood cells per high-power field. Radiographs of the pelvis and hips reveal no fracture, and the patient is able to ambulate without difficulty. What is the most appropriate next step?

- **A.** Obtain a renal ultrasound scan.
- **B.** Obtain an IV contrast-enhanced CT of the abdomen and pelvis.
- **C.** Perform a retrograde cystogram.
- **D.** Perform a retrograde urethrogram.
- **E.** Treat the patient's pain and discharge him home with outpatient urology follow-up in 1 week.

Answer: E. A significant genitourinary injury is unlikely, given the patient's history, physical examination, and urine findings. However, outpatient urology follow-up until microhematuria has cleared is advisable to be certain that it does not represent another more serious underlying (nontraumatic) condition.

40.4. A 35-year-old female presents after being stabbed with an ice pick during a robbery. Her examination is normal except for a 0.5-cm, hemostatic wound to the right flank at the level of the second lumbar vertebrae. Bedside ultrasonography reveals no free intra-abdominal fluid. Her urinalysis does not contain blood. What is the most appropriate next step?

- **A.** Obtain a renal ultrasound scan.
- **B.** Obtain an IV contrast-enhanced CT of the abdomen and pelvis, with additional images of the renal collecting system 10 minutes after contrast injection.
- **C.** Perform a retrograde cystogram.
- **D.** Perform a retrograde urethrogram.
- **E.** Treat the patient's pain, counsel her on appropriate wound care, and discharge her home with outpatient urology follow-up in 1 week.

Answer: B. In cases of penetrating renal trauma, the presence or absence of hematuria is not a reliable predictor of upper urinary tract injury. The location of the penetrating injury in relation to the urinary tract is the most important determining factor in deciding the need for radiographic investigation. Therefore, the absence of hematuria in a patient with a gunshot or stab wound in proximity to the urinary tract does not eliminate the need for IV contrast-enhanced CT as the initial diagnostic examination. Significant injuries to the kidney and ureter may occur in penetrating trauma without hematuria. Additional images obtained at 10 minutes after contrast injection are indicated to evaluate for delayed contrast extravasation and to maximize the sensitivity of the study.

40.5. A 25-year-old male presents after an unfortunate incident resulting in a scrotal injury and a left testicle that was traumatically amputated (the patient brings the amputated testicle with him in a towel). All of the following would be indicated, except:

- **A.** Analgesics for the patient
- **B.** Emergent urological consultation
- **C.** Place the amputated testicle directly on ice
- **D.** Prepare the patient for possible operative exploration by the surgeon
- **E.** Wrap the amputated testicle in saline soaked gauze

Answer: C. Amputations of either the testicles or penis require immediate surgical evaluation. In the interim, the amputated part should be wrapped in saline-soaked gauze, and then placed in a sealed bag, which can then be placed in another bag that is filled with ice. The amputated part should never be placed directly on ice. Direct pressure is usually adequate to achieve hemostasis.

40.6. A 30-year-old female presents after blunt abdominal trauma after a motor vehicle collision, and an ultrasound demonstrates free fluid. You suspect a bladder rupture. A true statement about this entity includes which of the following:

- **A.** A bladder contusion may be successfully managed with Foley catheterization drainage.

B. Extraperitoneal bladder injuries are typically managed with surgical intervention.
C. It is unimportant to distinguish an intraperitoneal from an extraperitoneal bladder rupture (EBR).
D. Most patients with an intraperitoneal bladder rupture (IBR) will resolve with Foley catheter drainage.
E. Most penetrating bladder injuries will resolve with Foley catheter drainage.

Answer: A. The distinction between EBR and IBR is important, because the management differs. Contusions and extraperitoneal injuries due to blunt trauma are typically managed conservatively with Foley catheterization, unless they are complicated by other intra-abdominal injuries, bladder neck injuries, bone fragments in the bladder wall, or if open reduction is performed on an associated pelvic fracture. In contrast, given the extremely low likelihood of IBR and penetrating injuries healing with conservative therapy, almost all patients with these types of injuries are taken to the operating room for exploration and repair. Without surgery, there is an extremely high likelihood of complications, which include infections and fistula formation.