# Imaging of Male Pelvic Trauma

Laura L. Avery, MD[a,*], Meir H. Scheinfeld, MD, PhD[b]

**KEYWORDS**

• Bladder trauma • Testicular trauma • Testicular rupture • Penile trauma • Penile fracture

**KEY POINTS**

- Prompt imaging plays an important role in the evaluation of male pelvic soft tissue trauma, particularly in the evaluation of bladder, scrotal, and penile/urethral injuries. Using appropriate imaging modalities, with optimization of contrast administration when appropriate, is essential for accurate diagnosis.
- Traumatic bladder rupture, either extraperitoneal or intraperitoneal, is diagnosed with high accuracy using computed tomography cystography, thus allowing for either conservative or surgical repair, respectively.
- Suspicion of urethral injury warrants evaluation with retrograde urethrography to evaluate for the presence of injury and injury location (anterior versus posterior).
- Early identification of laceration of the testicular tunica albuginea, usually with ultrasound but occasionally with magnetic resonance imaging, is essential given the need for emergent surgical repair.
- Penile injuries require surgical exploration and repair when the tunica albuginea of the corpus cavernosum is ruptured. Understanding both normal penile anatomy and the imaging appearance of corpus rupture (as opposed to a hematoma) is imperative for proper diagnosis and management.

## INTRODUCTION

Male pelvic trauma, including bladder, urethral, penile, and scrotal injuries, are uncommon, but when they occur, prompt diagnosis and treatment are required. Many of these injuries occur in the context of multitraumatized patients in whom other injuries and potential hemodynamic instability may lead to clinical distraction from these injuries. Various imaging modalities have been developed to diagnose these injuries with a high diagnostic accuracy in a timely manner. Rapid recognition of pathologic conditions is essential for timely and appropriate intervention, with delay having the potential for development of complications and/or loss of function. Imaging and clinical aspects of bony and vascular pelvic injuries have been covered elsewhere.[1–5] This article will focus on the soft tissue organs with a review of the proper imaging techniques, regional anatomy, and common injury patterns encountered in the evaluation of the traumatized male pelvis.

## BLADDER TRAUMA

Bladder injuries can be caused by either blunt or penetrating trauma. The bladder's position deep within the bony pelvis provides moderate protection from injury. Bladder injury may be seen in multitraumatized patients, and in general, the probability of bladder injury increases with the degree of bladder distention.[6] In one study, there was a 22% mortality rate in trauma patients whose presentations include a ruptured bladder, with patient death usually related to the polytrauma.[7]

[a] Division of Emergency Radiology, Department of Radiology, Harvard Medical School, Massachusetts General Hospital, 55 Fruit Street, FHD-210, Boston, MA 02114, USA; [b] Division of Emergency Radiology, Montefiore Medical Center, Albert Einstein College of Medicine, 111 East 210 Street, Bronx, NY 10467, USA
* Corresponding author.
*E-mail address:* lavery@partners.org

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Blunt traumatic injury of the bladder frequently occurs with deceleration injuries such as occurs in motor vehicle collisions; 83% to 97% of patients with bladder rupture have associated pelvic fractures.[7,8] Conversely, only approximately 10% of patients with pelvic fractures sustain bladder injuries.[9,10] Traumatic bladder ruptures may be either extraperitoneal or intraperitoneal. Extraperitoneal rupture occurs in 54% to 56% of cases, whereas intraperitoneal rupture accounts for 38% to 40% of injuries.[11] Combined injuries are uncommon and range from 5% to 8% of cases.[11]

One analysis concluded that radiographic investigation of the bladder is necessary when both pelvic fracture and gross hematuria are present.[10] If only one is present, then other clinical factors should influence the decision of whether dedicated bladder imaging should be performed. This was confirmed in a recent consensus statement.[11]

Because of its high accuracy, computed tomography (CT) cystography is the test of choice to investigate bladder wall integrity.[12,13] After the trauma team determines urethral continuity based on clinical examination or retrograde urethrography (RUG), bladder catheterization is performed. CT cystography requires adequate distention of the bladder with retrograde filling using a minimum of 300 mL of iodinated contrast material (**Box 1**). Gadolinium-based contrast has also been used in patients with a known life-threatening reaction to iodinated contrast.[14] Although in the past, conventional cystography was performed,[15] CT cystography has a demonstrated accuracy approaching 100% and provides efficient and timely evaluation, particularly in the multitrauma patient in whom CT cystography can be performed following standard abdominal and pelvic trauma CT imaging.[12,16] Although CT cystography may expose the patient to a larger quantity of radiation than fluoroscopic imaging, CT imaging has the advantage of rapid acquisition, no need to transfer the patient to a different imaging room, and the potential to diagnose additional injuries.

**Box 1**
**CT cystogram**

1. Retrograde bladder catheterization is usually performed by the trauma team before imaging.
2. Trauma protocol CT of the abdomen and pelvis is performed to exclude vascular contrast extravasation.
3. Drain the bladder to eliminate urine and blood.
4. The bladder is filled retrograde using a minimum of 300 mL of sterile dilute contrast (20 mL Iothalamate Meglumine 60% (Conray) in 500 mL of saline) under gravity drip 40 cm above the patient.
5. Repeat CT of the pelvis, with multiplanar reconstructions.

Extraperitoneal bladder rupture is nearly always associated with pelvic fractures.[11] Classically, this was presumed to be caused by bony pelvic fragments directly lacerating the bladder wall. Currently, however, it is thought that injury is usually caused by a burst or shearing mechanism that results in rupture of the anterolateral aspect of the bladder during traumatic deformation of the bony pelvis.[11,17]

The classic CT finding of extraperitoneal bladder rupture is contrast extravasation around the base of the bladder, confined to the perivesicular and prevesicular space (of Retzius) (**Fig. 1**). On axial CT scans, the presence of irregular extraperitoneal areas of contrast extravasation anterior and lateral to the bladder is commonly described as having a “molar tooth” appearance (with the crown of the tooth anterior to the bladder and the roots of the tooth on either side of the bladder).[6] On coronal images, the contrast opacified bladder may assume a “teardrop”- or “pear”-shaped configuration, similar to its classic appearance using conventional cystography.[18] This shape is caused by a combination of compression by pelvic hematoma and extravasated urine.

In simple extraperitoneal ruptures, contrast extravasation is limited to the perivesical space. In complex ruptures, contrast may dissect into adjacent fascial planes and extraperitoneal spaces, including the thigh, penis, and anterior abdominal wall. Contrast may reach the scrotum if the urogenital diaphragm or it superior fascia is disrupted (**Fig. 2**).[19]

Historically, extraperitoneal bladder rupture was managed with good results with either urethral or suprapubic catheter drainage and follow-up cystography after 10 days.[20] Some series have described common complications using this approach.[21] Currently, catheter drainage is favored for low-grade injuries; however, in more complex injuries and in ones that involve the bladder neck, operative treatment is favored.[22] When the patient is going to surgery for operative orthopedic repair of the bony pelvis, bladder repair is commonly performed simultaneously.[23]

Intraperitoneal bladder rupture usually occurs when a full, already thinned, bladder sustains an abdominal and pelvic impact, causing a sudden large increase in intravesical pressure. In the adult, the bladder dome is covered by a thin layer of peritoneum, and it is the part of the bladder that is

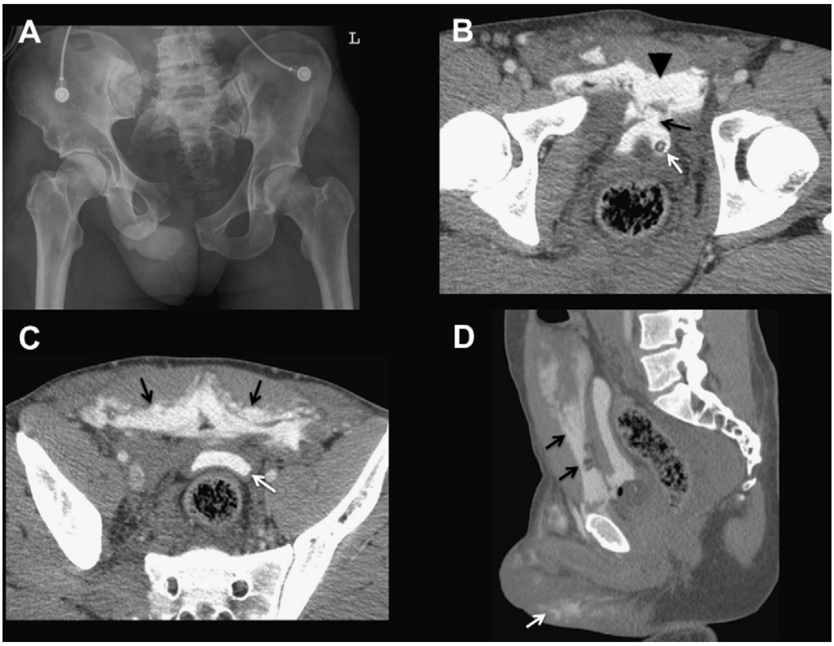


**Fig. 1.** Extraperitoneal bladder rupture. (*A*) Frontal pelvic portable radiograph from a trauma series demonstrates a displaced vertical shear fracture with elevation of the right hemipelvis and marked diastasis at the pubic symphysis. (*B*) Axial CT cystogram image demonstrates extravasation of contrast from the anterior base of the bladder (*black arrow*). Contrast extends into the prevesicular space (*black arrow head*). A Foley catheter is identified in the bladder lumen (*white arrow*). (*C*) Axial CT cystogram image more superior than in *B* demonstrates extraperitoneal contrast accumulation along the anterior pelvic wall (*black arrows*). Contrast material is identified in the bladder lumen (*white arrow*). (*D*) Sagittal CT scan demonstrates the extent of extraperitoneal contrast extravasation into the anterior abdominal/pelvic wall (*black arrows*). Contrast also extends inferiorly into the scrotum (*white arrow*), consistent with disruption of the urogenital diaphragm.

poorly protected from sudden increases in pressure. The bladder only fully descends into the pelvis by 20 years of age. Therefore, in children, more of the bladder is intraperitoneal and intraperitoneal rupture is more prevalent in children.[24] An enlarged prostate gland in an older man may increase the risk of intraperitoneal rupture as a result of the bladder being more distended at baseline in this population.

On CT cystography, contrast extravasation will be visualized as contrast entering into the peritoneal cavity (**Fig. 3**). Contrast is seen surrounding loops of bowel, separating leaves of mesentery and layering in the paracolic gutters.[6] Even when this is seen, an extraperitoneal component to rupture should be searched for to exclude a combined intraperitoneal-extraperitoneal injury.

Nearly all intraperitoneal bladder ruptures require surgical exploration and repair.[22,25] These injuries are usually large and do not heal with prolonged catheterization alone. Urine continues to leak into the abdominal cavity, leading to urinary ascites, abdominal distention, electrolyte disturbances, and possible chemical peritonitis.[22] With injury limited to the bladder such that laparotomy is not necessary, laparoscopic repair has been successfully performed in humans and cystoscopic repair has been performed in an animal model.[26]

## BLADDER HERNIA

Bladder hernia is an uncommon complication of pelvic trauma and occurs secondary to a traumatic abdominal wall hernia or pelvic ring disruption. Bladder hernia may be seen is the setting of pubic symphysis diastasis, such that the bladder is trapped between the pubic bones (**Fig. 4**). When this is discovered, it must be relayed promptly to the orthopedic team to prevent bladder entrapment or injury that may occur during pelvic reduction or surgery.[27–29] Rupture of the rectus abdominis muscle or avulsion of its tendon from the pubis may occur after a blunt or penetrating anteroposterior force to the pelvis. This defect may be an additional site of bladder herniation and entrapment (see **Fig. 4**).

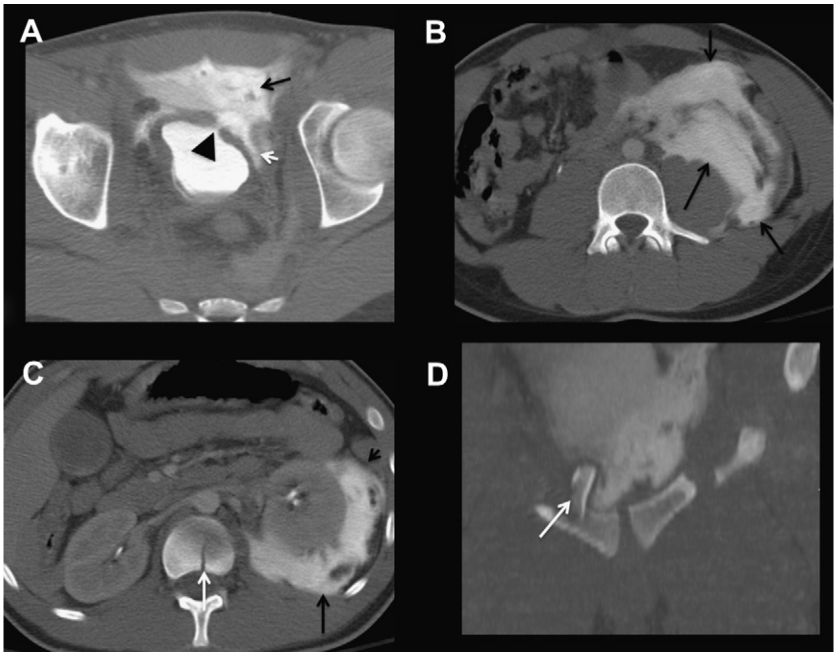


**Fig. 2.** Complex extraperitoneal bladder rupture. (*A*) Axial CT scan through the base of the bladder demonstrates extravasation of contrast into the prevesicular (*black arrow*) and perivesical spaces (*white arrow*). The location of bladder perforation is indicated (*black arrowhead*). (*B* and *C*) Axial CT scans at progressively more superior levels demonstrate contrast material dissecting through fascial planes in the left retroperitoneum and extending into the perirenal and posterior pararenal spaces (*black arrows*). Note the sagittal lumbar spine fracture (*white arrow in image C*). (*D*) Coronal CT scan of the pelvis demonstrates a displaced fracture fragment of the right pubic rami (*white arrow*) as a possible source for bladder perforation seen in *A*.

## URETHRAL INJURIES

A brief anatomic overview of the urethra is presented, as evaluation of urethral trauma requires understanding of male urethral anatomy (**Fig. 5**). The urethra is approximately 22 cm in length[30] and extends from the base of the bladder to the external urethral meatus. The posterior urethra is made up of the prostatic and membranous segments, with the membranous segment being the narrowest urethral segment.[31] The anterior urethra consists of the bulbous and penile (or pendulous) segments. The portion of the urethra within the glans penis is mildly dilated relative to the remainder of the penile urethra and is termed the fossa navicularis. The urogenital diaphragm separates the anterior and posterior segments. The membranous urethra and prostate are anchored to the anterior pubic arch by the puboprostatic ligaments.[32]

Male urethral injuries are rare, with less than one-tenth of a percent of noniatrogenic trauma cases resulting in urethral injuries.[33] Iatrogenic injury is believed to be more common.[34–36] Noniatrogenic urethral injuries are seen in the setting of significant pelvic trauma (eg, motor vehicle accidents and falls from a height) or straddle-type injuries. Classically, it was thought that the posterior urethra at the level of the membranous urethra was the most commonly injured portion of the urethra occurring in conjunction with pelvic fractures. Now it is thought that it is actually the proximalmost portion of the bulbous urethra, just distal to the urogenital diaphragm, that is injured.[33,37] Anterior urethral injuries are more common with straddle-type injuries caused by a crush mechanism. This occurs when the relatively immobile bulbous urethra is compressed against the inferior aspect of the pubis.[38]

Proper and prompt diagnosis is imperative to decrease the morbidity associated with urethral injuries. For example, in the acute setting, misdirection of a bladder catheter through an injured urethra may upgrade a partial injury into a complete injury. Additionally, unrecognized and incompletely treated lacerations may result in chronic urethral strictures because of the formation of fibrous scar tissue.

Clinical signs may be present that suggest urethral injury and warrant RUG before bladder catheter placement. These signs include blood at the urethral meatus, swelling or hematoma of the

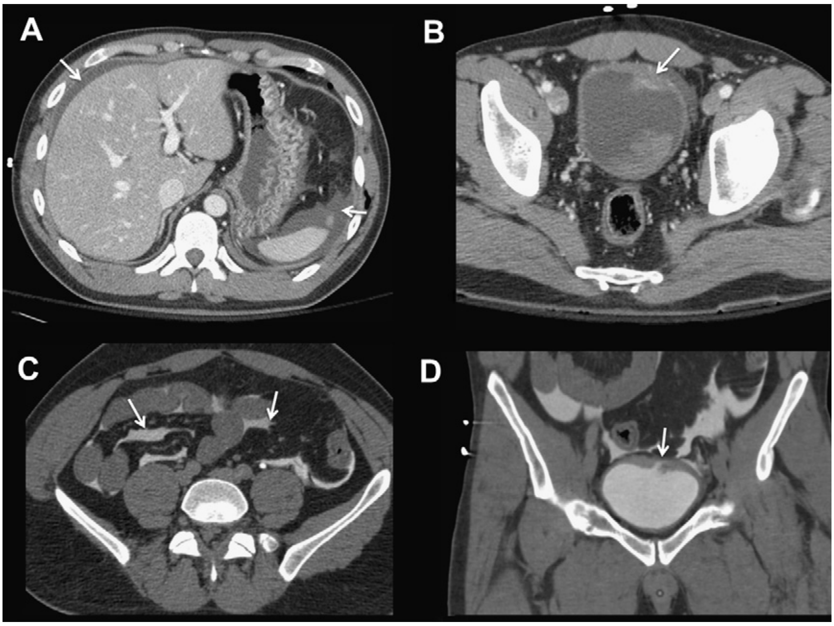


**Fig. 3.** Intraperitoneal bladder rupture. (*A*) Axial intravenous contrast-enhanced portal venous phase CT scan demonstrates low- to mixed-density fluid around the liver and spleen (*white arrows*). (*B*) Axial intravenous contrast-enhanced portal venous phase CT scan through the bladder demonstrates high-attenuation clot layering dependently in the bladder with thickening along the left anterolateral bladder wall (*white arrow*). (*C*) CT cystogram image demonstrates free contrast in the peritoneal cavity interdigitated among bowel loops and leaves of mesentery (*arrows*). (*D*) Coronal image demonstrates focal interuption of the dome of the bladder with extravasation of contrast into the peritoneal cavity (*arrow*).


**Fig. 4.** Bladder hernia. (*A*) Axial contrast-enhanced CT scan from a patient who sustained an open-book fracture of the pelvis demonstrates bladder herniation though the pubic symphysis (*black arrow*) following orthopedic reduction. (*B*) Coronal image demonstrates the bladder (*black arrow*) to be resting on the dorsum of the penis (*white arrows*). (*C* and *D*) Axial and sagittal CT scans from a different patient who also sustained an open-book pelvic fracture demonstrates herniation of the bladder (*white asterisk*) over the pubis secondary to avulsion of the inferior rectus abdominis tendon (*white arrow*) with adjacent hematoma (*black asterisk*).

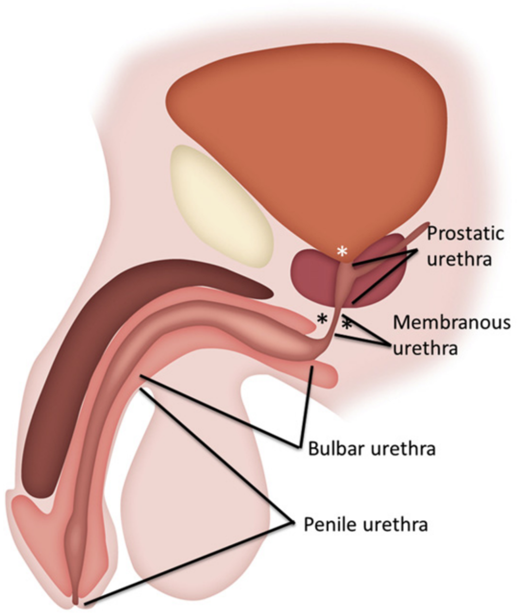


**Fig. 5.** Drawing of the male urethra in the sagittal plane. The various segments of the urethra including prostatic, membranous, bulbar, and penile portions are illustrated. The bladder neck (*white asterisk*) and level of the urogenital diaphragm (*black asterisks*) are key anatomic landmarks for the classification of urethral injuries when performing urethrography.

perineum or penis, inability to void, and a "high-riding" prostate gland on digital rectal examination.[33] Imaging of the male urethra is best performed using RUG (**Box 2**, **Fig. 6**). Retrograde contrast opacification of the urethra is performed via instillation of contrast material through a small catheter with its balloon inflated in the fossa navicularis. When the patient is stable, the examination is ideally performed under fluoroscopic visualization with real-time imaging. In an unstable patient, images can be obtained portably in the trauma bay after the injection of contrast. At the authors' institution, when urethral evaluation is essential, a more concentrated dilute contrast (40 mL Iothalamate Meglumine 60% (Conray) in 500 mL saline as opposed to 20 mL Iothalamate Meglumine 60% (Conray) in 500 mL saline for cystography) is injected into the urethra and a pelvic CT scan is performed (termed a CT-RUG) following standard CT. The increased density of the concentrated contrast helps distinguish the contrast from vascular or excreted bladder contrast.

Although the portable-RUG and CT-RUG techniques are generally able to determine only the presence or absences of urethral injury, with only limited information about the exact location of the injury, they are important time-saving screening examinations to be considered in specific

**Box 2**
**Retrograde urethrogram**

1. A 16-F or 18-F 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 (1–2 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, 20–30 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.

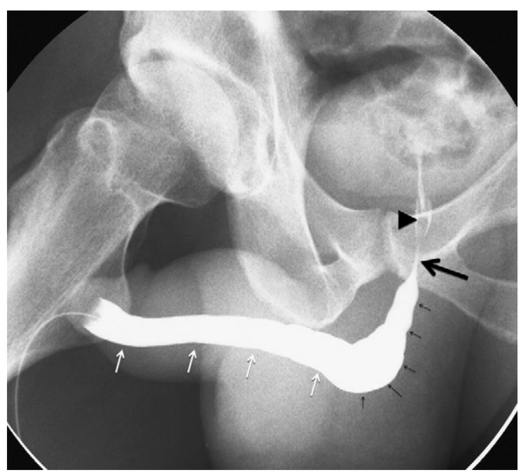

**Fig. 6.** Normal retrograde urethrogram with filling of the entire urethra. The prostatic urethra demonstrates the normal impression of the verumontanum (*black arrowhead*). The membranous urethra is the narrowest portion of the urethra on the normal urethrogram (*large black arrow*). Small black arrows denote the bulbar portion of the anterior urethra. The white arrows denote the penile portion of the anterior urethra.

situations. For example, in an unstable patient, this information may be sufficient to proceed to suprapubic catheter placement or cystoscopically guided Foley catheter placement.

Urethral injuries have been traditionally classified anatomically as either anterior or posterior. Additional classification systems have been proposed, with the Goldman classification based on anatomic location of injury being the most frequently used system (**Table 1**).[31,39] This system defines 5 types of urethral injuries. In type I injuries, the puboprostatic ligaments are ruptured, resulting in stretching of the prostatic urethra without urethral urothelial discontinuity (**Fig. 7**). In type II injuries, the membranous urethra is torn above an intact urogenital diaphragm; this causes contrast extravasation about the prostate but prevents contrast from extravasating inferiorly into the perineum (**Fig. 8**). Type III urethral injury is characterized by contrast material extravasation into the pelvic extraperitoneal space and also into the perineum as a result of interruption of the urogenital diaphragm (**Fig. 9**). Type IV injuries occur at the bladder base and are particularly concerning because of involvement of the internal sphincter, which is important for urinary continence (**Fig. 10**). Type V injuries are injuries that involve only the anterior urethra (**Fig. 11**).

Regarding treatment, all penetrating injuries are generally explored and debrided immediately.[40] In general, when retrograde drainage of the bladder via urethral catheterization is not possible, a suprapubic catheter is placed. Once urinary drainage is secure, reconstruction of blunt urethral injury may be delayed for weeks to months, thereby allowing time for other injuries to be managed and pelvic hematoma and inflammation to decrease. If there is another indication for immediate surgical exploration, such as penile fracture, bladder neck injury, or rectal tear, the urethra may be repaired concurrently.[36]

Although complete anterior urethral injuries are treated with suprapubic drainage and delayed repair, there are multiple opinions as to the optimal treatment of posterior urethral injuries, including primary realignment, immediate repair, and delayed repair.[22] Primary realignment of posterior urethral injuries, commonly endoscopically, has become increasingly popular[41,42]; however, other data suggest that this may lead to a higher rate of late complications.[36,43] Even in cases of incomplete injury, recent data indicate that stricture-free healing is more likely with suprapubic catheter placement alone.[44] The initially placed or a postrepair urethral catheter may still be in place when the patient presents for follow-up fluoroscopy, which is done to assess for persistent extravasation or possible stricture formation.

## SCROTAL TRAUMA

Scrotal trauma is relatively uncommon and accounts for less than 1% of all cases of trauma annually.[45] Frequently blunt testicular trauma is isolated to the scrotum instead of being associated with multitraumatic injuries. Scrotal injuries frequently are sports related and caused by projectiles such as baseballs or by a direct kick to the groin. As a result, younger men are most often injured with a peak age range between 10

**Table 1**
**Goldman system for classification of urethral injuries at urethrography**

| Injury Type | Injury Description | Urethrographic Appearance |
|---|---|---|
| I | Stretching or elongation of an intact posterior urethra resulting from ligament rupture | Intact but stretched urethra |
| II | Membranous urethral disruption above an intact urogenital diaphragm | Contrast extravasation above the urogenital diaphragm, no inferior contrast extravasation into the perineum |
| III | Disruption of the membranous urethra with injury of the urogenital diaphragm | Contrast extravasation above the urogenital diaphragm and below the urogenital diaphragm into the perineum |
| IV | Bladder neck injury extending into the proximal urethra | Extraperitoneal contrast extravasation around the bladder base |
| V | Isolated anterior urethral injury as from a straddle-type injury | Contrast extravasation below the urogenital diaphragm, confined to the anterior urethra |

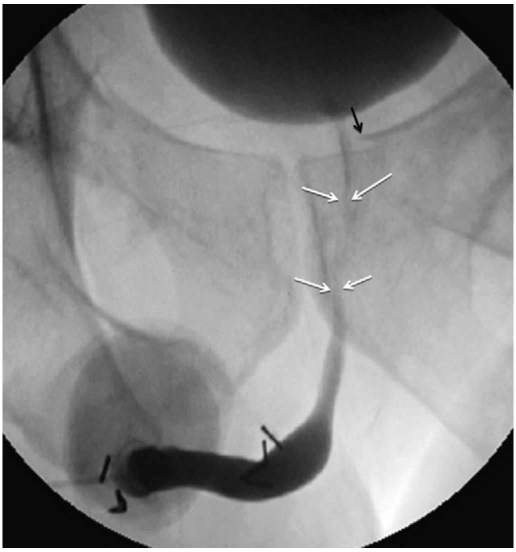

**Fig. 7.** Type I urethral injury. The posterior urethra is stretched (*white arrows*) but intact. Note the left superior pubic ramus fracture (*black arrow*).

and 30 years. A blunt force to the scrotum may result in testicular contusion, hematoma, or fracture/rupture. A testicular rupture is defined as a rupture of the tunica albuginea with extrusion of the seminiferous tubules. Approximately 50 kg of force is required to rupture a normal tunica albuginea.[46] The right testis is more prone to injury than the left testis, likely because of its superior location and greater propensity to be trapped against the pubis or inner thigh.[47] Testicular fracture/rupture is a surgical emergency, with immediate repair improving the preservation of fertility and hormonal function.

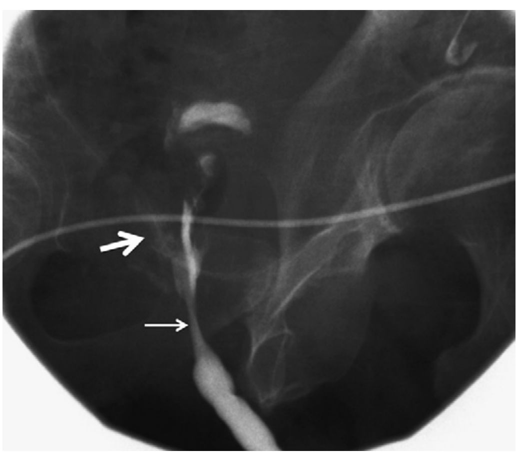

**Fig. 8.** Type II urethral injury. Contrast extravasation is seen adjacent to the prostatic urethra (*large white arrow*). Contrast does not extend below the intact urogenital diaphragm, indicated by the membranous urethra (*small white arrow*).

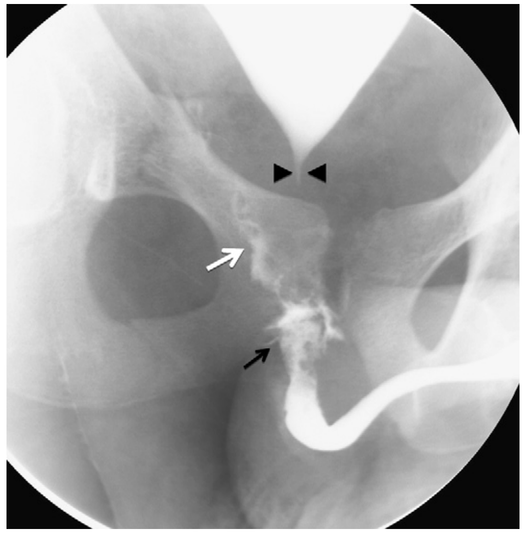

**Fig. 9.** Type III urethral injury. In this patient there is posterior urethral injury extending through the urogenital diaphragm to involve the bulbous urethra. Retrograde urethrogram reveals contrast material extravasation at and below the membranous urethra (*black arrow*) and a component above the urogenital diaphragm (*white arrow*). Complete disruption of the membranous urethra was diagnosed. Urethral transection results in dislocation of the bladder superiorly, which in this case is filled with excreted contrast from a prior contrast-enhanced CT scan. Note the narrowed and elevated bladder base (*arrowheads*) because of pelvic hematoma.

The normal adult testis measures approximately 5 cm in length and 2 to 3 cm in the transverse dimensions.[48] Many layers cover and protect the testis. Of these layers, the tunica vaginalis and tunica albuginea are import anatomic structures to be aware of when evaluating for traumatic injury. The tunica vaginalis is a double-layered serous membrane derived from the processus vaginalis of the peritoneum.[49] The tunica's inner visceral layer covers most of the testis and epididymis, and the outer parietal layer lines the internal spermatic fascia of the scrotal wall. Within the potential space between the layers, hydroceles or hematoceles may accumulate. The small physiologic volume of fluid normally found in this space allows mobility and provides cushioning to the testis, thus offering mild protection from injury.

The visceral layer of the tunica vaginalis is closely attached to the tunica albuginea of the testis. The tunica albuginea is a fibrous capsule that covers the testis and appears on ultrasound as an echogenic rim surrounding the testis (**Fig. 12**). Additionally, the fibrous nature of the

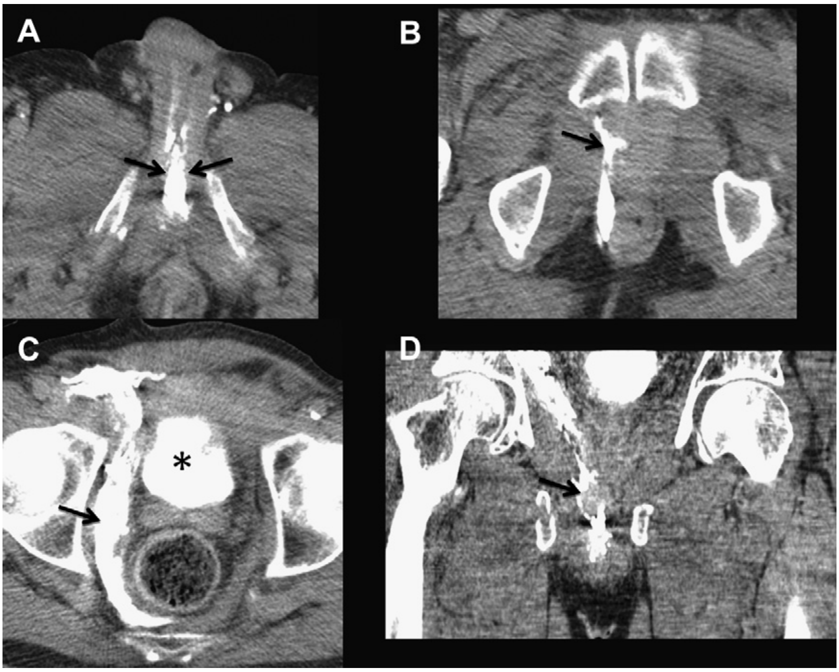


Fig. 10. Type IV urethral injury. A CT retrograde urethrogram was performed (*arrows*). (*A*) Axial CT scan at the level of the penis demonstrates contrast opacification of the bulbar urethra. (*B*) More superiorly, there is contrast extravasation above the urogenital diaphragm (*arrow*). (*C*) More superiorly, at the level of the superiorly displaced urinary bladder, excreted contrast from prior CT (*asterisk*) is seen within the bladder. Extraperitoneal contrast is noted along the right pelvic sidewall (*arrow*). (*D*) Coronal CT scan demonstrates urethral injury extending into the bladder base with extravasation of contrast and clot (*arrow*). This was confirmed at cystoscopy.

tunica gives it low signal on T1- and T2-weighted magnetic resonance (MR) images.[50] In cases of testicular fracture/rupture, the tunica albuginea is lacerated.

Ultrasonography is the most frequent modality used to evaluate the injured scrotum. Ultrasound has a high sensitivity for diagnosing testicular injury.[47,51] The sonographic features of an injured testis include focal areas of altered testicular echogenicity corresponding to areas of contusion or infarction, discrete intraparenchymal fracture plane, discontinuity of the tunica albuginea with irregular contour, and hematocele formation (**Figs. 13** and **14**).[45,47,51,52] The ultrasound findings of a heterogeneous testicular echotexture with a loss of normal testicular contour without directly demonstrating tunica albuginea discontinuity is sufficient to diagnose testicular rupture with a sensitivity of 100% and a specificity of 65% to 93.5% (**Fig. 15**).[51–53] Identifying the discontinuity

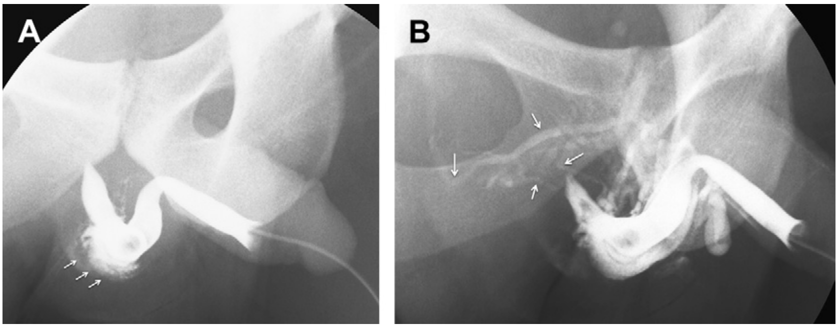


Fig. 11. Type V urethral injury, caused by straddle-type injury. Retrograde urethrogram demonstrates disruption of the bulbous urethra with extravasation inferior to the urethra. (*B*) Extensive venous intravasation of contrast is seen on later images (*arrows*).

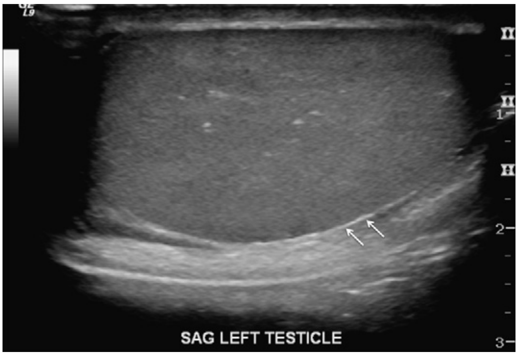


Fig. 12. Normal testicular ultrasound. The normal testicle has homogeneous intermediate echotexture. Arrows define the thin echogenic tunica albuginea, which surrounds the testicle.

within the tunica albuginea may increase confidence for the diagnosis of testicular rupture. The identification of testicular rupture is an indication for surgical exploration and repair.[53] Surgical exploration may also be warranted when a hematocele is present without other evidence of rupture.[53,54] Evolving treatment algorithms have favored exploration only in cases of large (>5 cm) or expanding scrotal hematomas. Thus, close follow-up with serial ultrasound measurements of the hematocele/hematoma may be needed in conservatively managed patients.

At times, MR imaging may be helpful to better define the pattern of testicular injury (**Fig. 16**). On T1-weighted images, the normal testes have homogeneous intermediate signal, whereas on T2-weighted images, the testes have homogeneous high signal.[50] High T2-weighted signal is expected given that the testes are composed of the fluid containing seminiferous tubules.[55] Heterogeneous low T2-weighted signal in the context of trauma should raise the possibility of testicular hematoma. Still interruption of the low signal tunica albuginea is diagnostic of rupture.[56,57] The relatively long acquisition time and limited availability for MR examinations make this modality imperfect for initial evaluation for traumatic injury.

## PENILE INJURIES

Penile injury may result from penetrating or blunt trauma.[58] Prompt surgical exploration without initial imaging is usually required for penetrating injuries.[59] Blunt traumatic injuries are often evaluated with imaging to determine clinical management. Similar to the scrotum, sonography is the preferred technique for penile imaging because it is well tolerated and widely available. Furthermore, penile blood flow is rapidly evaluated with color and spectral Doppler ultrasound. As MR imaging has become more accessible, this modality has gained acceptance for imaging of penile trauma. MR imaging is able to demonstrate the architecture of the fascial layers of the penis with high tissue conspicuity and sensitivity for injury. Given the dramatic degloving nature of surgical exploration, patients often refuse this mode of management. The MR imaging results can help counsel and persuade the patient toward surgical intervention when truly needed, while sparing others an unneeded exploration.

Anatomically, the penis[60] is composed of paired corpora cavernosa along the dorsal aspect of the penis and one midline corpus spongiosum along the ventral surface. The crura of the corpora cavernosa attach to the ischial rami proximally. The corpora cavernosa are composed of venous

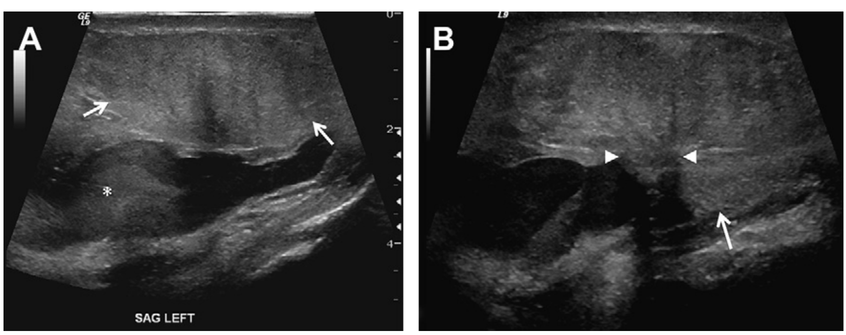


Fig. 13. Testicular fracture. (*A*) Sagittal image of the left testicle (*white arrows*) demonstrates a heterogeneous echotexture. Within the scrotum there is intermediate mixed echogenicity fluid (*asterisk*) consistent with a hematocele. (*B*) Sagittal image through a different portion of the testicle demonstrates rupture of the tunica albuginea visualized as discontinuity of the echogenic line surrounding the testicle with blood and testicular parenchyma seen extruding through the defect (*arrowheads*). Hematocele (*arrow*) is again noted. These findings were confirmed at surgery and a repair of the tunica albuginea was performed.

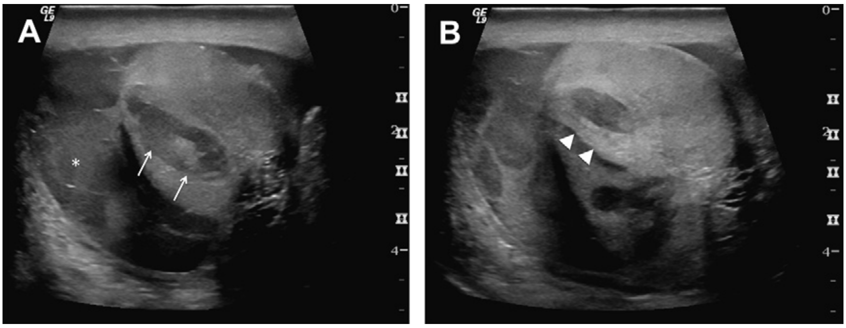


**Fig. 14.** Testicular fracture. (*A*) Transverse image of the left testicle demonstrates an oval defect extending into the testicular parenchyma consistent with a laceration with resultant hematoma (*arrows*). Within the scrotum there is intermediate mixed echogenic fluid (*asterisk*) consistent with a hematocele. (*B*) Transverse image more superiorly demonstrates the large volume of blood within the scrotum causing mass effect on the underlying testicle (*white arrowheads*). Immediate hematocele evacuation and tunica albuginea repair were performed.

sinusoids that engorge with blood during erection. The corpus spongiosum surrounds the urethra and forms the glans penis distally. The tunica albuginea is a strong fascial sheath that individually surrounds the 2 corpora cavernosa and forms a septum (the intercavernous septum) between them. A tunica albuginea also surrounds the corpus spongiosum. All 3 erectile bodies contribute to the firmness of erection; however, the corpora cavernosa becomes firmer than the corpus spongiosum.[61]

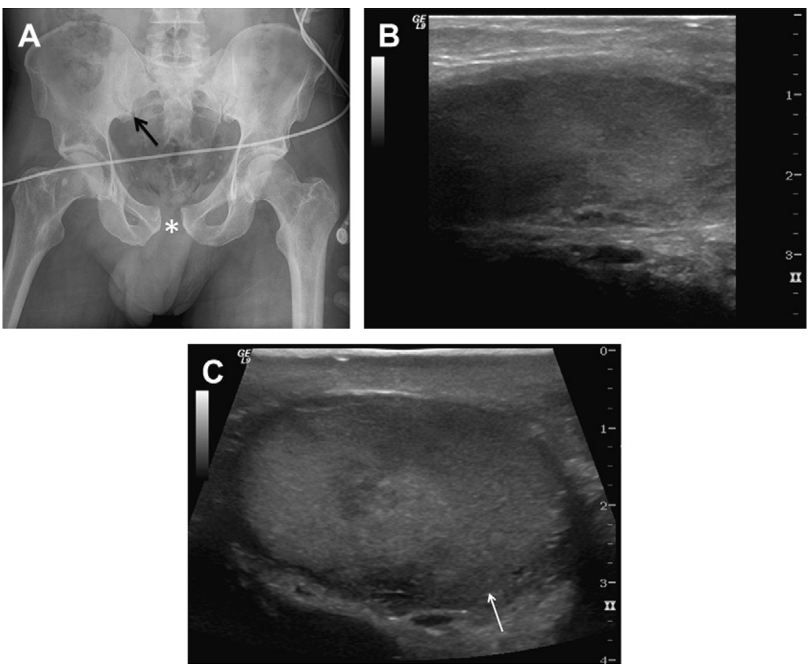


**Fig. 15.** Pelvic disruption with bilateral testicular injury. (*A*) Anteroposterior radiograph demonstrates an "open book" pelvic injury with diastasis of the symphysis pubis (*asterisk*) and widening of the right sacroiliac joint (*arrow*). (*B*) Sagittal image of the right testicle demonstrates heterogeneous echotexture filling the hemiscrotum without definable margins to indicate the tunica albuginea. Complete avulsion of the tunica albuginea was found at surgery with extrusion of the seminiferous tubules. The testicle was deemed nonviable and an orchiectomy was performed. (*C*) Sagittal image of the left testicle demonstrates heterogeneous echotexture consistent with intratesticular hematoma and poor tunica albuginea definition posteriorly (*arrow*). The testicular contour was grossly maintained. On surgical exploration, the left testicle was found to be "bruised with hematoma" but viable. Orchiopexy was performed.

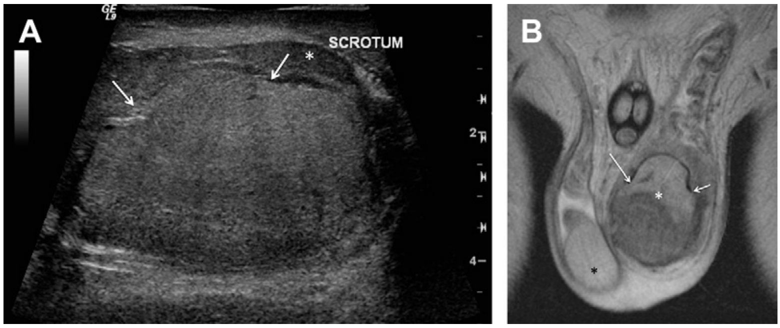


Fig. 16. Progressive avulsion of the tunica albuginea evaluated with ultrasound and subsequently with MR imaging. (*A*) Sagittal gray-scale ultrasound image of the left testicle demonstrates a mildly heterogeneous echotexture with a focal contour abnormality ventrally (*arrows*). A hematocele is also noted (*asterisk*). The patient refused immediate surgical exploration. (*B*) Two hours later, scrotal MR imaging was performed. T2-weighted coronal image demonstrates the normal right testis (*black asterisk*). Evaluation of the left testicle demonstrates retraction of the low-signal tunica albuginea (*edges are indicated with arrows*) and extrusion of the seminiferous tubules and blood into the inferior portion of the hemiscrotum (*white asterisk*). The progression of the avulsion and hemorrhage is attributed to the 2-hour delay.

Superficial to the tunica albuginea is a loose connective tissue called Buck fascia, also known as the deep fascia of the penis.

Ultrasound evaluation of the penis[62,63] is performed with a high-frequency (7.5- to 10-MHz) linear transducer (**Fig. 17**). Anatomic positioning and plentiful gel allow for high-quality images. Sonographically, the 3 corporal bodies are well demarcated. The corpus spongiosum generally appears mildly hypoechoic compared with the corpora cavernosa. The corpora cavernosa have a homogeneous mixed echogenicity appearance because of the innumerable interfaces created by its complex system of vascular sinusoids. There is commonly a region of shadowing between the corpora cavernosa that extends over the expected location of the urethra. Color and spectral Doppler examinations may be used to demonstrate patency and the character of flow within the penile arteries and veins.[64] The patent dorsal veins of the penis should be easily compressible by the transducer and color Doppler flow should be detectable.

MR imaging of the penis is best performed with the penis in anatomic position, lying on the abdomen (**Fig. 18**).[65,66] At our institution, the same protocol programmed for evaluation of the female pelvis is used. The protocol focuses on a small field of view with triplane high-resolution T2 non–fat-saturated sequences and T1-weighted

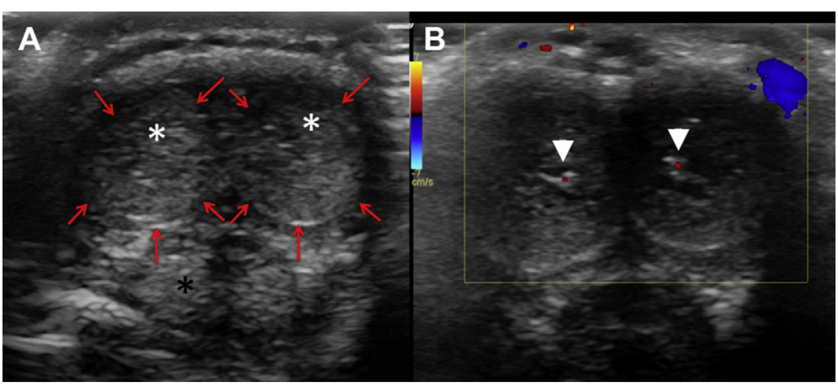


Fig. 17. Normal penile anatomy on ultrasound. (*A*) Gray-scale image demonstrates the corpora cavernosa (*white asterisks*) and corpora spongiosum (*black asterisk*). The tunica albuginea, best seen ventrally, is indicated with red arrows. (*B*) Color-scale image demonstrates small areas of color flow in the central arteries of each corpus cavernosum (*arrowheads*).

**Fig. 18.** Normal penile anatomy on MR imaging. Axial T2-weighted MR image through the penis demonstrates the paired high-signal corpora cavernosa (*asterisks*) surrounded by the dark-signal tunica albuginea (*straight arrows*). Flow voids from the central artery of each corpus cavernosum (*arrowheads*) and the flattened urethra (*curved arrow*) within the corpus spongiosum are indicated.

images in the sagittal and coronal planes. On T1-weighted images, the 3 corpora are of intermediate signal and there is poor tissue contrast. T1 hyperintense blood products may be well visualized. On T2-weighted images, the substance of the corpora is of high signal and is well differentiated from the enveloping low-signal tunica albuginea. Direct visualization of tunica discontinuity is best seen on T2-weighted images. The tunica albuginea and Buck fascia are indistinguishable from one another on T1- and T2-weighted images because of their similar low signal.

The penis is most vulnerable to injury when erect, frequently as a result of sudden lateral bending.[67] A penile fracture is a rupture of one or both corpora cavernosa because of a tear of the tunica albuginea, which is one of the strongest fascias in the human body.[68] One reason for the increased risk of penile fracture in the erect state is that the cavernosal tunica albuginea is markedly stretched and thinned during erection.[68] Clinically, penile fracture results in rapid loss of erection, pain, swelling, and penile hematoma. Concomitant injury to the penile urethra is estimated to occur in 10% to 20% of penile fractures and should be suspected if there is associated blood at the urethral meatus or in the setting of bilateral cavernosal injury.[69,70]

Ultrasound, if tolerated, can accurately depict the normal anatomy and delineate the nature and extent of penile injury.[71,72] Sonography can detect the exact site of the fracture as an interruption of the thin echogenic line of the tunica albuginea with extruding hematoma, which may be seen deep to the Buck fascia or the skin (**Fig. 19**).[63,71] Evaluation of the urethra with ultrasound is limited, and when there is concern for urethral injury, RUG is necessary.[31] The presence of echogenic air within the injured cavernosa suggests communication with the urethra and urethral injury.[72]

Where and when available, MR imaging may be used in the evaluation of a penile injury.[73,74] MR imaging offers superb soft tissue definition and directly demonstrates interruption of the cavernosal tunica albuginea (**Fig. 20**). Similar to ultrasound, foci of air, seen as susceptibility artifact, may indicate urethral injury. Fluid signal within the corpus spongiosum can indicate urine extravasation in the setting of urethral injury (**Fig. 21**).

Currently, the vast majority of authors favor immediate surgical repair of blunt penile injuries.[75] The "degloving" nature of the surgery is often unwelcomed by the patient; proper preoperative imaging diagnosis is therefore helpful in convincing the patient of the need for surgery. Complications of conservative management include plaque or nodule formation at the fracture site, missed urethral injury and subsequent stricture development, penile abscess, penile deformity, painful erection, and erectile dysfunction.[76]

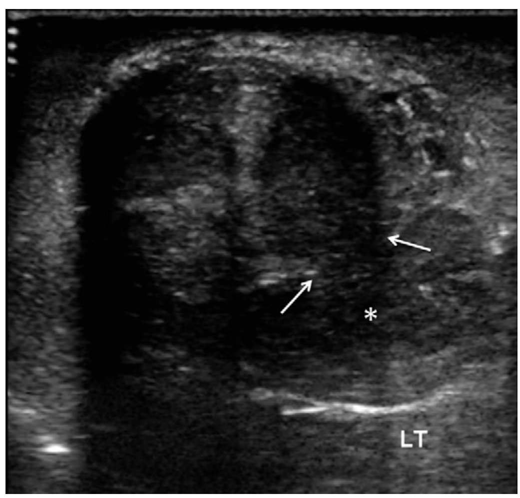


**Fig. 19.** Ultrasound demonstrating penile fracture. (*A*) Transverse gray-scale image of the penis demonstrates lack of definition of the ventral aspect of the left corpus cavernosum consistent with fracture (*arrows*). Blood products and extruded corpus cavernosal tissue is seen ventrolaterally (*white asterisk*).

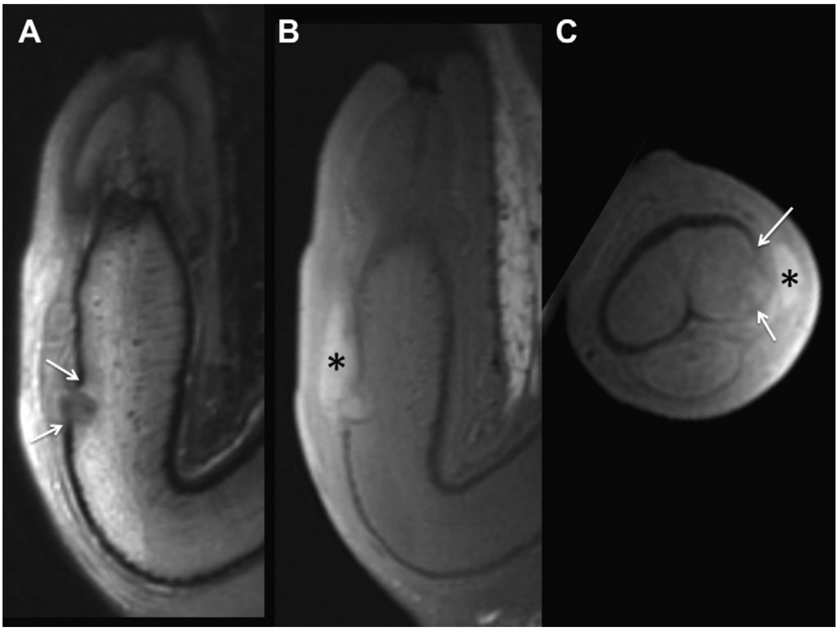


Fig. 20. MR imaging of penile fracture. (*A*) Sagittal T2-weighted image demonstrates focal interruption of the tunica albuginea consistent with tunica albuginea rupture (*arrows*). (*B*) T1-weighted image demonstrates high signal blood products in the overlying Buck fascia (*asterisk*). (*C*) Axial T1-weighted image demonstrates fracture of the cavernosum with discontinuity of the T1-weighted hypointense tunica albuginea on the left lateral side (*arrows*). High-signal overlying hematoma is again seen (*black asterisk*).

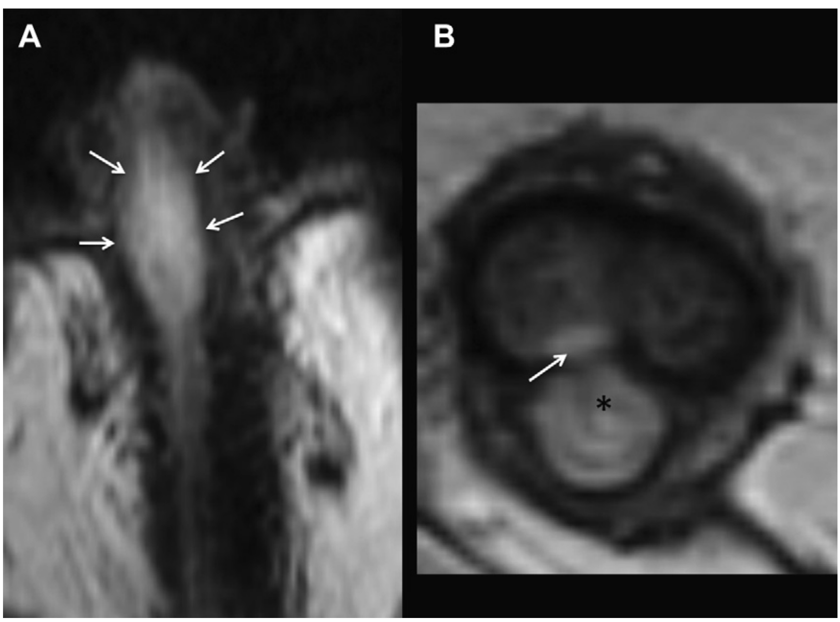


Fig. 21. MR imaging of penile fracture with injury of the urethra. (*A*) Long-axis T2-weighted image demonstrates expansion and increased T2 signal within the corpus spongiosum (*arrows*) concerning for urine extravasation and edema. (*B*) Axial image demonstrates fluid signal within the substance of the corpus spongiosum (*black asterisk*) extending into the right corpus cavernosum (*white arrow*). The tunica albuginea at this level is ill defined. A penile fracture with urethral injury was suspected. Surgical exploration and cystoscopic urethral visualization confirmed this diagnosis.

## SUMMARY

Male genital trauma is uncommon and therefore requires the radiologist and trauma team to recognize the clinical signs of injury. In the context of high clinical suspicion, the radiologist must be familiar with the role of imaging and the specific imaging findings found in these diagnoses. Ultrasound is frequently the first-line imaging tool for genital evaluation, with MR imaging, CT, and RUG playing important roles in troubleshooting. Confident identification of normal and abnormal imaging appearances of the bladder, urethra, scrotum, and penis will allow the radiologist to efficiently direct either prompt urologic repair or conservative management.

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