Imaging of Penile and Scrotal Emergencies[1]

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Penile and scrotal emergencies are uncommon, but when they do occur, urgent or emergent diagnosis and treatment are necessary. Emergent conditions of the male genitalia are primarily infectious, traumatic, or vascular. Infectious conditions, such as epididymitis and epididymo-orchitis, are well evaluated at ultrasonography (US), and their key findings include heterogeneity and hyperemia. Pyocele and abscess may also be seen at US. Fournier gangrene is best evaluated at computed tomography, which depicts subcutaneous gas. Vascular conditions, such as testicular torsion, infarction, penile Mondor disease, and priapism, are well evaluated at duplex Doppler US. The key imaging finding of testicular torsion and infarction is a lack of blood flow in the testicle or a portion of the testicle. Penile Mondor disease is characterized by a lack of flow to and noncompressibility of the superficial dorsal vein of the penis. Clinical examination and history are usually adequate for diagnosis of priapism, but Doppler US may help confirm the diagnosis. Traumatic injuries of the penis and scrotum are initially imaged with US, which depicts whether the penile corpora and testicular seminiferous tubules are contained by the tunicae albuginea; herniation of contents and discontinuity of the tunica albuginea indicate rupture. In some cases, magnetic resonance imaging may be performed because of its ability to directly depict discontinuity of the tunica albuginea. Radiologists must closely collaborate with emergency physicians, surgeons, and urologists to quickly and efficiently diagnose or rule out emergent conditions of the male genitalia to facilitate prompt and appropriate treatment.

Introduction

Male patients may present to the emergency department with penile and scrotal complaints, and a wide range of pathologic conditions, including infection, ischemia, and trauma, may affect the male genital region. Infectious scrotal conditions include epididymitis, orchitis, testicular abscess, pyocele, and Fournier gangrene. Ischemic events may occur in the setting of torsion, whereas ischemia of the penis may occur in patients with priapism or venous thrombosis. Traumatic injuries to the genitals vary and include blunt, penetrating, and degloving injuries. Many of these conditions are a surgical urologic emergency, and timely treatment is crucial to maintain fertility, hormonal activity, and erectile function. Because of this time factor, prompt imaging workup and rapid recognition of pathologic conditions are essential for appropriate intervention.

In this article, conditions that affect the testicles and scrotum are presented and followed by those that affect the penis. Infectious, ischemic, and primarily blunt traumatic injuries to the scrotum and penis are covered, and radiologic images and clinical photographs are presented, when available, to offer a complete imaging and clinicopathologic picture. The anatomy of male genitalia and optimal imaging techniques are also discussed.

The Scrotum

Acute scrotal pain is common among children and adults who present to the emergency department, often with vague symptoms and nonspecific clinical findings. Frequently, imaging is required to further pinpoint the causes of scrotal pain. Generally, ultrasonography (US) is well tolerated and widely available, making it ideal for scrotal evaluation. High-resolution gray-scale and color Doppler US enable prompt and accurate differentiation among possible causes of scrotal pain without the use of ionizing radiation (1–3). Magnetic resonance (MR) imaging is limited by its relatively long examination time, lack of portability, and frequent unavailability; however, it may have a role in equivocal cases for problem solving (4).

US is best performed with a linear high-frequency (7.5–12.0 MHz) transducer with the penis placed in an anatomic position over the abdomen. A towel may be used to elevate the scrotal sac. Images of each testicle and the epididymis are obtained in transverse and sagittal planes, with transverse images covering both testicles to allow for comparison. Color Doppler US is necessary to depict blood flow in patients with suspected torsion or hyperemia in the setting of infection. Appropriate color Doppler settings must be used to optimize depiction of slow flow (5,6). Because it is independent of the Doppler angle, power Doppler US is useful in imaging low-flow states, such as in the pediatric setting; however, power Doppler US also has increased sensitivity to motion ("flash") artifacts (7).

Anatomy and Imaging Appearance

The normal adult testis measures approximately 5 cm in length and 2–3 cm in its transverse dimensions (Figs 1, 2) (8). Each testicle is located within a hemiscrotum that is separated from the contralateral compartment by a septum (9). The scrotal sac is made up of multiple layers, including the skin; Dartos muscle and fascia; external spermatic fascia; cremaster muscle and fascia;
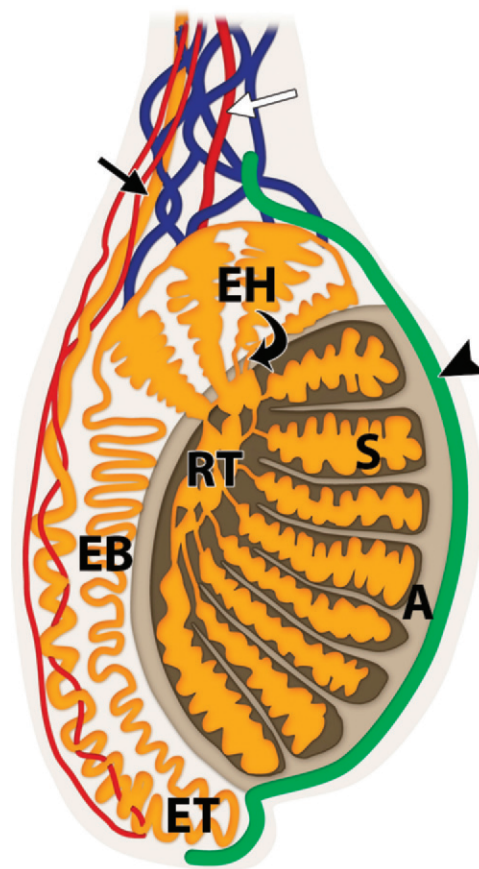

Figure 1. Scrotal anatomy. Illustration shows the main components of the testicles. The seminiferous tubules *(S),* in which sperm are produced, converge in the mediastinum testes as a network of tubules called the rete testes *(RT).* The efferent ductules (curved black arrow) bridge the testicle and epididymal head *(EH),* which leads to the epididymal body *(EB)* and tail *(ET).* Sperm eventually exit the scrotum through the vas deferens (straight black arrow). The tunica albuginea *(A)* surrounds the testicle. The tunica vaginalis (arrowhead) has two layers and also partially surrounds the testicle. The testicular (internal spermatic) artery (white arrow) supplies the testicle.

internal spermatic fascia; and tunica vaginalis, a two-layered serous membrane that derives from the process vaginalis of the peritoneum (9–12). The inner visceral layer of the tunica vaginalis envelopes most of the testis and epididymis, and the outer parietal layer lines the internal spermatic fascia of the scrotal wall. Hydroceles or other fluid collections (eg, blood or pus) may accumulate in the potential space between the layers of the vaginalis.

The visceral layer of the tunica vaginalis closely adheres to the tunica albuginea of the testis, a fibrous capsule that covers the testis and appears as
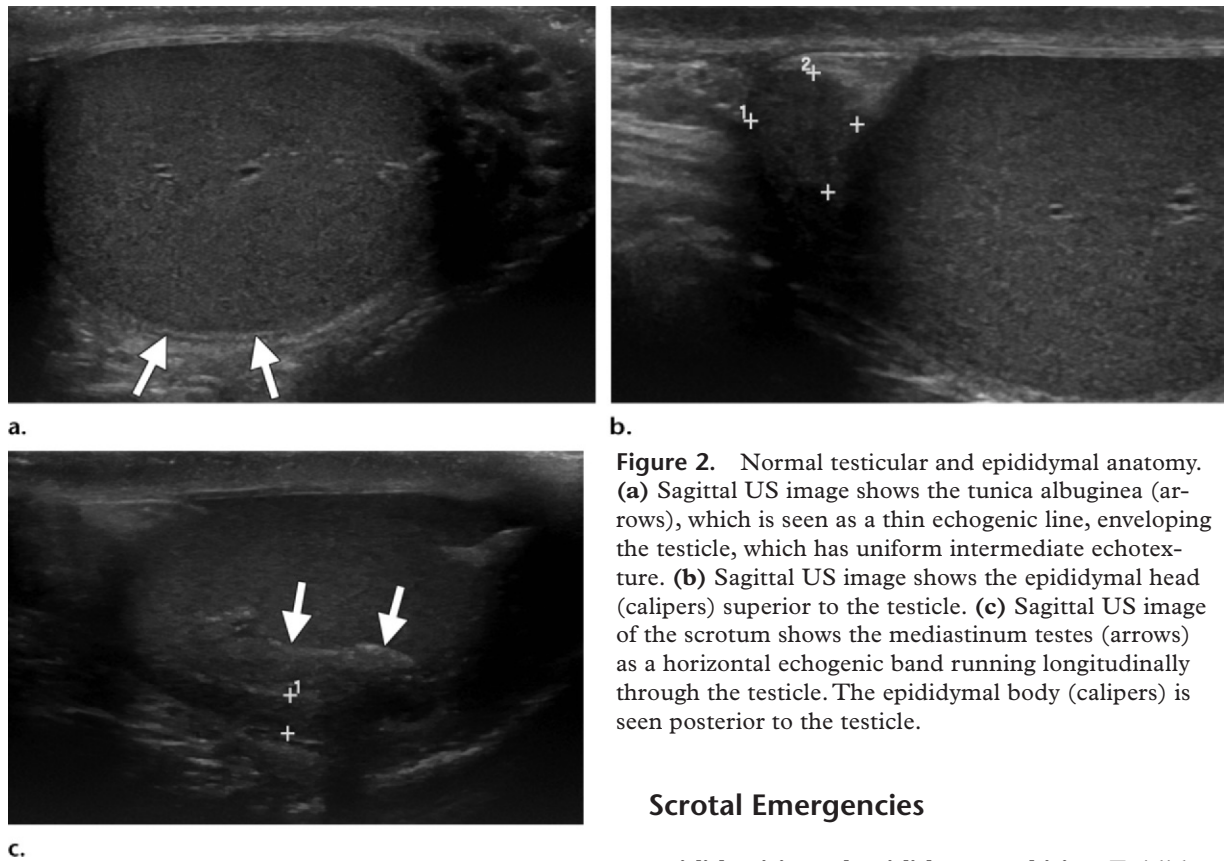
a.

b.

c.

Figure 2. Normal testicular and epididymal anatomy. **(a)** Sagittal US image shows the tunica albuginea (arrows), which is seen as a thin echogenic line, enveloping the testicle, which has uniform intermediate echotexture. **(b)** Sagittal US image shows the epididymal head (calipers) superior to the testicle. **(c)** Sagittal US image of the scrotum shows the mediastinum testes (arrows) as a horizontal echogenic band running longitudinally through the testicle. The epididymal body (calipers) is seen posterior to the testicle.

an echogenic rim surrounding the testis at US. It has low signal intensity at MR imaging, a result of its fibrous content (13). The tunica albuginea gives rise to septa that extend deep into the testicle and divide it into lobules. The posterior surface of the tunica albuginea reflects into the interior of the testicle and forms an incomplete vertical septum called the mediastinum testis, which appears as an echogenic band at US (8).

In general, the testicular parenchyma has a homogeneous echotexture at US despite the fact that it is divided into lobules that contain the seminiferous tubules, which converge in the mediastinum as the rete testes, which, in turn, empty into the efferent ductules, which lead to the epididymal head. The epididymis comprises a head, body, and tail, with the head located at the superior pole of the testes and the body and tail extending inferolaterally. In general, the epididymis appears iso- or hypoechoic relative to the testicular parenchyma. The epididymal tail continues as the vas deferens in the spermatic cord (14). Three arteries supply the scrotum: the external pudendal branches of the femoral artery, the scrotal branches of the internal pudendal artery, and the cremasteric branch of the inferior epigastric artery. Venous drainage follows the arterial supply (11).

Scrotal Emergencies

Epididymitis and Epididymo-orchitis.—Epididymitis and epididymo-orchitis are two of the most common causes of acute scrotal pain and, if left untreated, may be complicated by abscess formation and testicular infarction. In general, acute cases of epididymitis and epididymo-orchitis are caused by retrograde bacterial infection from a lower urinary tract infection. In men who are sexually active and younger than 35 years old, *Neisseria gonorrhoeae* and *Chlamydia trachomatis* are the most common pathogens, and in children and men who are older than 35 years old, urinary tract–contaminating organisms, such as *Escherichia coli,* are most common (15). In the literature, it is sometimes suggested that retrograde flow of urine into the epididymis may occur after heavy lifting or straining, causing "chemical epididymitis." (16,17)

Because infection and inflammation typically spread in a retrograde fashion, the epididymal tail is involved before the body and head are affected; thus, complete evaluation of the epididymis, especially the tail, is necessary to accurately diagnose an early infection. At gray-scale US, an inflamed epididymis appears enlarged and heterogeneous and is often hypoechoic relative to the testicle, a result of associated edema. The presence of hyperemia at color Doppler US may either corroborate gray-scale US findings or be
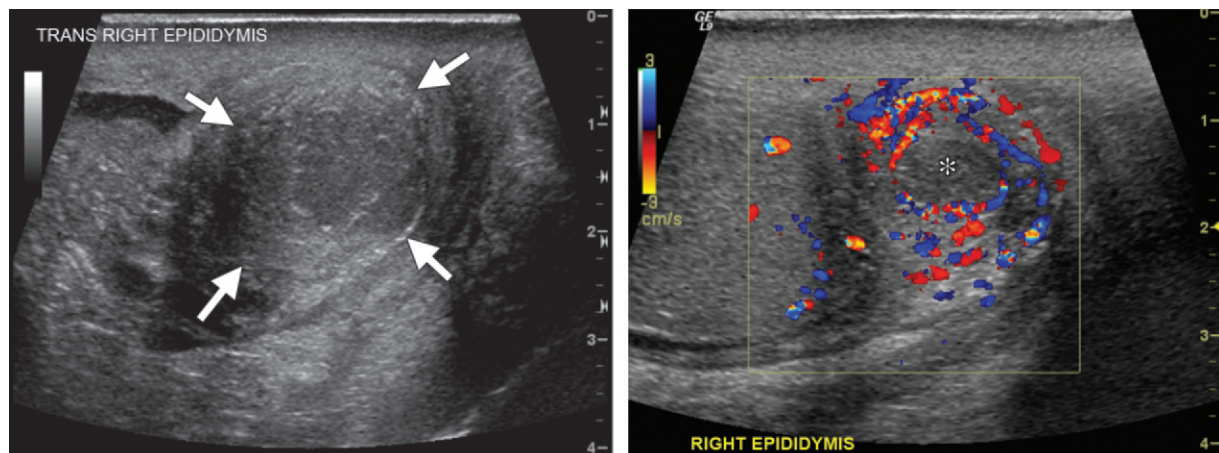
Teaching Point

Figure 3. Epididymitis and epididymal tail abscess in a 73-year-old man with right scrotal pain, an *E coli* urinary tract infection, and normal testicle and epididymal head at gray-scale US. **(a)** US image shows the epididymal tail (arrows), which is enlarged with a heterogeneous echotexture, in the inferior portion of the hemiscrotum. **(b)** Color Doppler US image shows increased blood flow in the epididymal tail and a lack of blood flow in the central region (∗), a finding consistent with abscess.
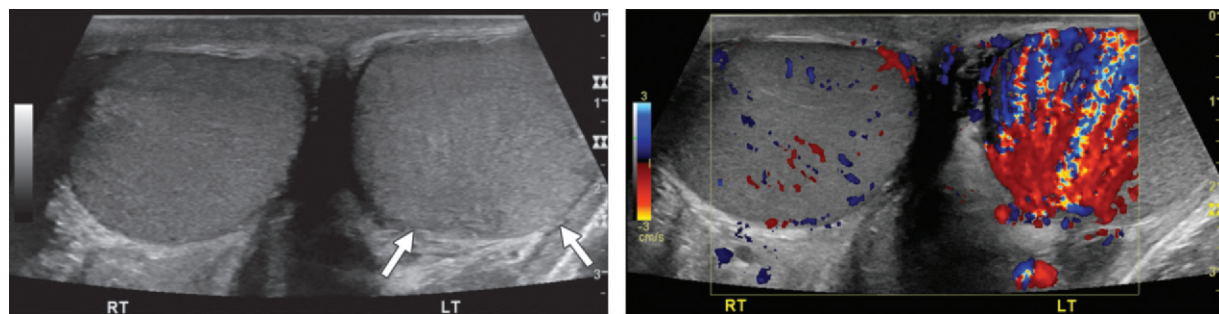

Figure 4. Epididymo-orchitis in a 31-year-old man with a 3-day history of scrotal pain. **(a)** Transverse US image of both testicles shows mild enlargement of the left testicle, which has a heterogeneous echotexture (arrows). **(b)** Transverse color Doppler US image shows dramatically increased hyperemia in the left testicle. **(c)** Color Doppler US images of both epididymal heads show a marked increase in blood flow in the left epididymis (arrows) in comparison with that in the right (arrowheads) and enlargement of the left epididymal head.
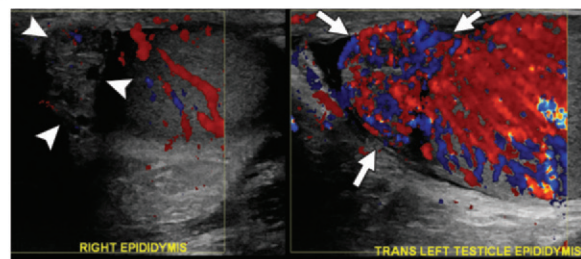
the only finding of acute epididymitis (18). Gray-scale US may depict a central region of liquefaction as a more hypoechoic focus, and color Doppler US may depict a lack of flow centrally (Fig 3). Both of these findings are indicative of abscess formation, which may require surgical drainage if trial antibiotic therapy is unsuccessful (19).

Epididymo-orchitis occurs in 20%–40% of patients with epididymitis and represents progression of the infection to the testicular parenchyma (Fig 4) (2). Typically, pain associated with epididymo-orchitis improves when the testicle is elevated

above the level of the pubic symphysis (the Prehn sign); such improvement does not occur in testicular torsion. Testicular edema may compromise testicular venous outflow, leading to necrosis (Fig 5) (20). Late or incomplete treatment of epididymo-orchitis may be complicated by pyocele or testicular abscess formation (Figs 5, 6) (21).

Fournier Gangrene.—Fournier gangrene is a necrotizing infection that involves both superficial and deep fascial planes and has a male predominance (male-to-female ratio, 10:1) (22–24). It constitutes a urologic emergency that must be recognized early because of its high mortality,

5a.

5b.

6a.

6b.

6c.

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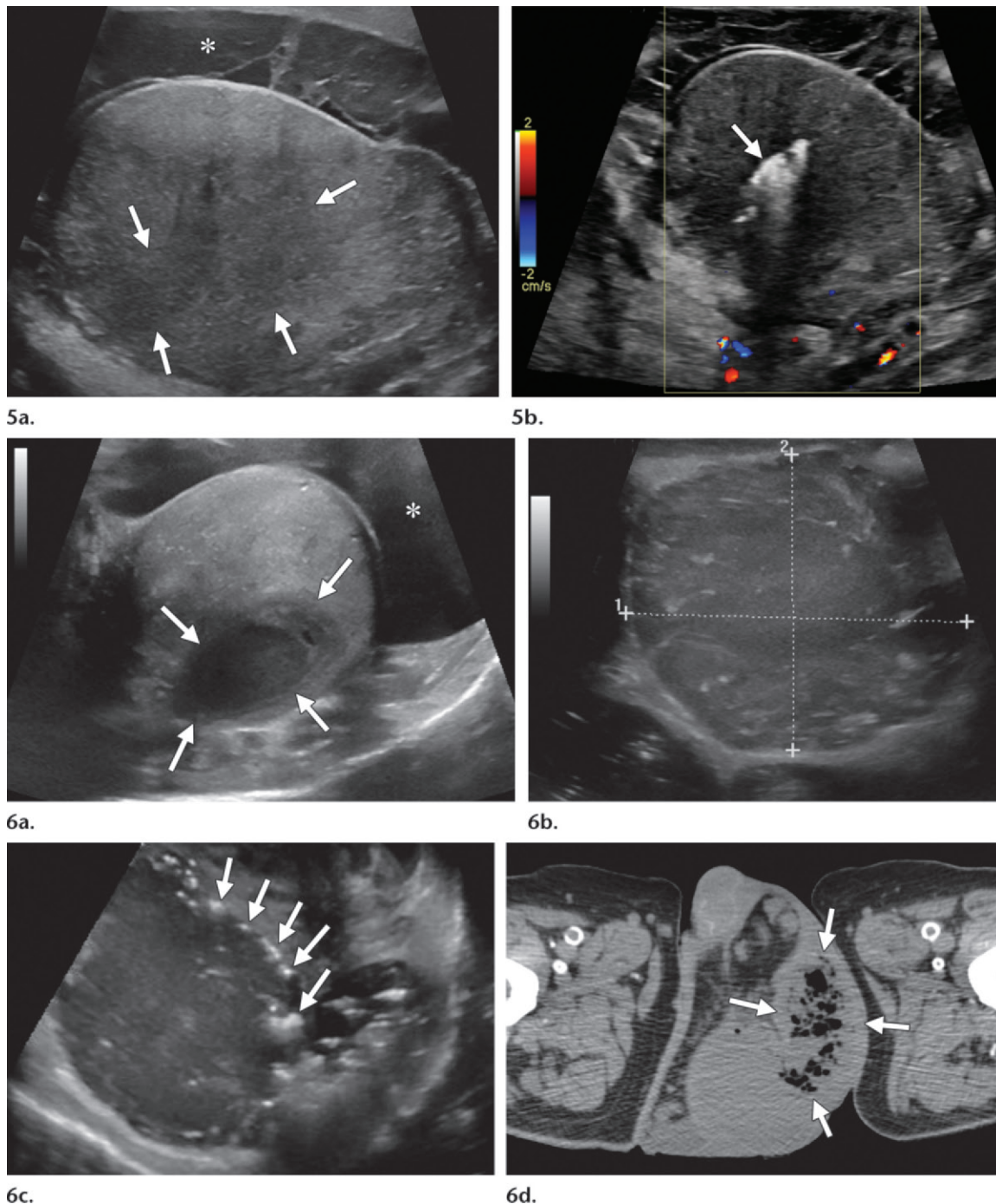
Figures 5, 6.   **(5)** Epididymo-orchitis with pyocele and testicular necrosis in a 64-year-old man with a 2-week history of symptoms. **(a)** Sagittal US image shows the testicle, which has a heterogeneous echotexture (arrows), a finding concerning for ischemia, and a complex pyocele (∗) with low-level echoes and echogenic septa around the testicle. **(b)** Oblique color Doppler US image of the right testicle shows no blood flow within the testicle, a finding consistent with ischemia, and intratesticular gas, which is seen as echogenic foci with "dirty shadowing" (arrow). **(6)** Orchitis complicated by testicular abscess, pyocele, and necrosis in a 65-year-old man with diabetes. **(a)** Transverse US image obtained at the level of the left testicle shows a well-circumscribed hypoechoic area in the testicular parenchyma (arrows) with internal low-level echoes and a simple hydrocele in the left hemiscrotum (∗). A diagnosis of testicular abscess was made, and conservative treatment with antibiotics was prescribed. **(b)** Transverse US image obtained 1 month later shows heterogeneous mixed-echogenicity material in the left hemiscrotum and no definable testicular tissue. The patient had not complied with antibiotic therapy. **(c)** Transverse US image shows multiple echogenic foci (arrows), a finding indicative of gas. **(d)** Axial unenhanced computed tomographic (CT) image obtained at the same time as **b** and **c** shows multiple foci of air in the left hemiscrotum centered in the left testicular parenchyma (arrows). Left orchiectomy was performed, and at pathologic analysis, the testicle was seen to be softball-sized and composed of necrotic and purulent material.

Figure 7. Fournier gangrene (from a cutaneous source) in a 68-year-old man with diabetes who presented with scrotal tenderness. He noticed a pimple on the scrotum 5 days earlier. **(a)** Photograph shows an erythematous scrotum and a necrotic eschar (arrows). **(b)** CT image (obtained at the same time as **a**) shows gas (arrows) in the posterior aspect of the scrotum. No gas is seen in the testicles (∗). **(c)** Photograph obtained after emergent surgical débridement of the perineum and scrotum shows that the underlying testicles and spermatic cord are intact. **(d)** Photograph obtained 8 weeks later shows that the scrotum was successfully reconstructed with skin grafting. (Photographs courtesy of Adam S. Feldman, MD, MPH, Massachusetts General Hospital, Boston, Mass.)
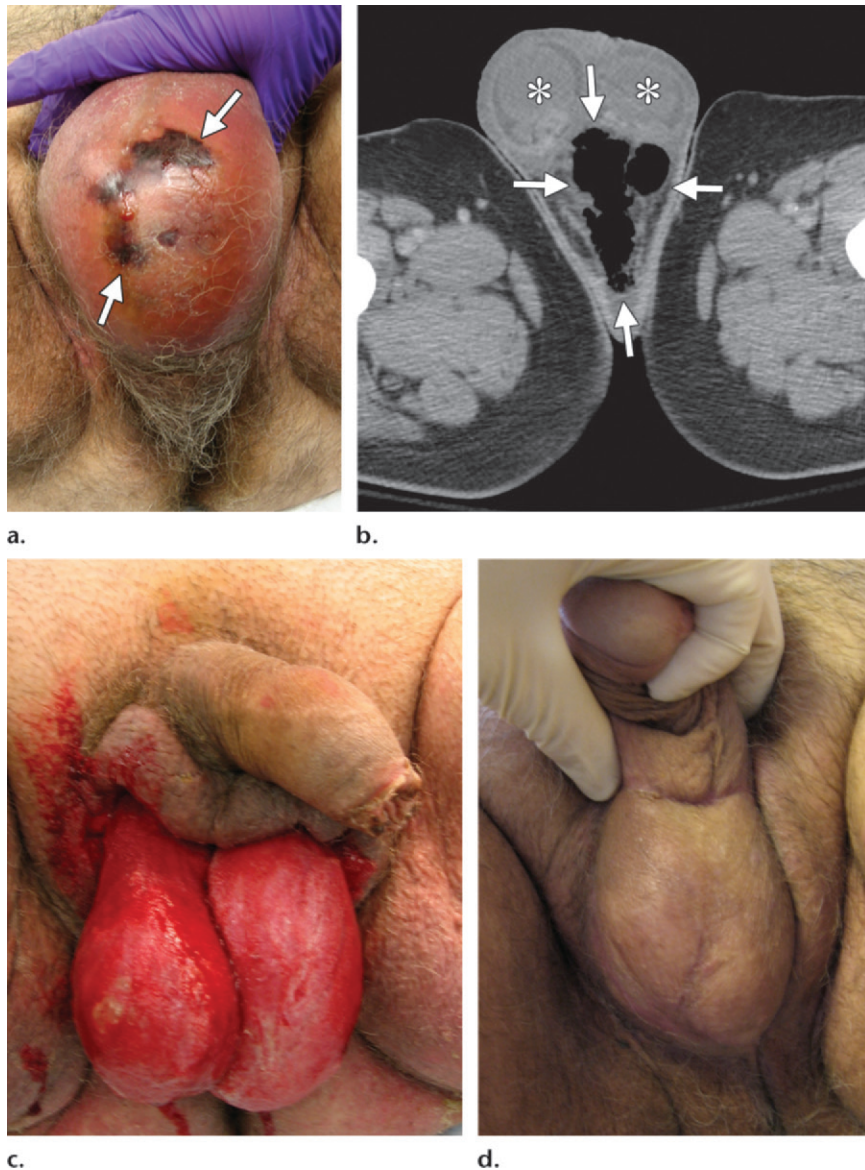
which ranges from 15% to 50% (25). Comorbid conditions that compromise the immune system have been implicated as predisposing factors for the development of Fournier gangrene and include diabetes mellitus and alcoholism (23). The cause of infection is commonly colorectal (eg, colorectal cancer, inflammatory bowel disease, and perirectal abscess), urologic (eg, epididymitis and urinary tract infection), or cutaneous (eg, pressure ulceration). The source of infection may be occult in 6%–45% of patients; however, more recent data indicate that the source is only occult in 10% of patients (23,24). Most Fournier gangrene infections are polymicrobial, with a synergy between aerobic and anaerobic bacteria (25).

CT is the modality of choice in patients with Fournier gangrene because it may depict the source of infection and its pathways of spread (25). Its wide availability and ability to rapidly acquire images are well suited to emergent imaging in this setting. CT may depict small amounts of gas in soft tissues and fluid collections in the deep fascial planes (Fig 7). Ideally, intravenous contrast material–enhanced CT of the entire abdomen and pelvis and extending through the entire scrotum and penis should be performed; limiting scanning to the pelvis may cause an abdominal source of infection to be missed and lead to inadequate treatment (Fig 8). US may depict fluid and gas in the subcutaneous tissues and may be of particular use in patients who cannot leave the emergency department or intensive care unit for CT scanning. Otherwise, US is usually suboptimal because direct pressure on the perineum is not well tolerated in patients with Fournier gangrene, and the extent of disease, such as gas deep
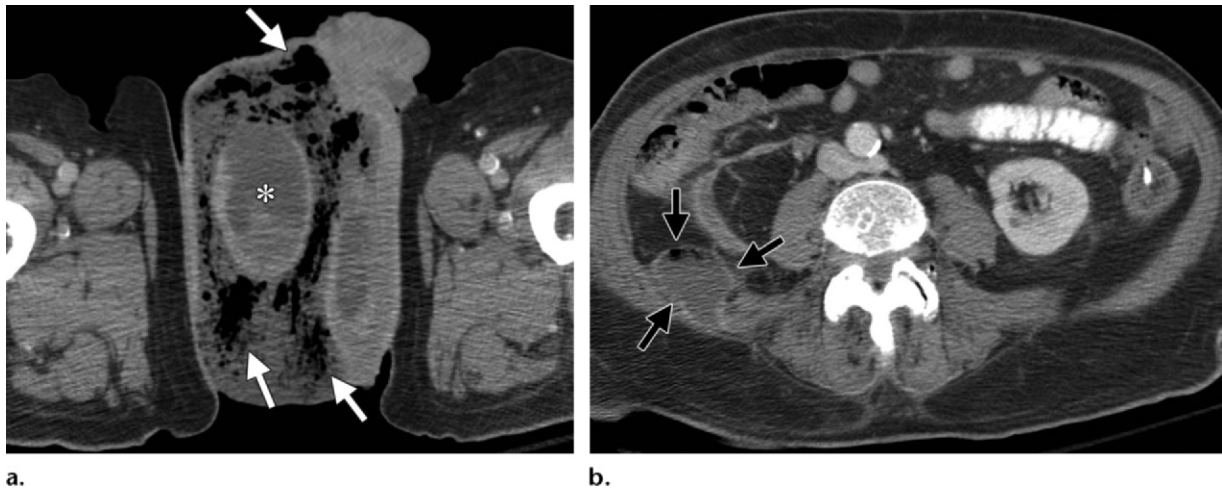
Figure 8. Fournier gangrene (from an intraabdominal source) in an 87-year-old man who presented with scrotal swelling, erythema, and crepitus. **(a)** Axial CT image shows air in the scrotum (arrows) circumferentially surrounding the right testicle (∗), a finding indicative of Fournier gangrene. **(b)** Axial CT image, obtained superiorly at the level of the right lower quadrant, shows a retroperitoneal diverticular abscess (arrows), the nidus for the scrotal infection, whose microbiologic characteristics were consistent with a polymicrobial infection caused by bowel flora.
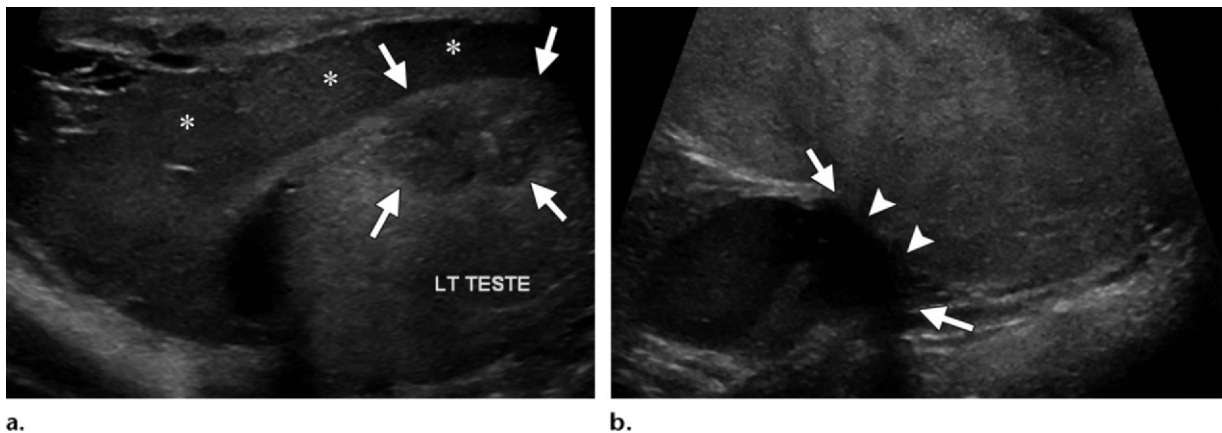

Figure 9. Left testicular fracture in a 24-year-old man who sustained a blunt trauma to the groin. **(a)** Sagittal US image shows a heterogeneous echotexture with a focal hypoechoic region in the left testicle (arrows), a finding consistent with contusion. Intermediate-echogenicity fluid (∗) is seen in the scrotum, a finding consistent with a hematocele. **(b)** Sagittal US image obtained at a different level shows discontinuity of the echogenic line surrounding the testicle (arrows), a finding indicative of dehiscence of the tunica albuginea, and extrusion of blood and testicular parenchyma through the defect (arrowheads). These findings were confirmed at surgery, where the tunica albuginea was repaired.

in the ischioanal fossa, may not be appreciated at US.

Scrotal Trauma.—Scrotal trauma is relatively uncommon and accounts for less than 1% of all traumas annually (10). Blunt testicular trauma is often sports related (eg, from a projectile in baseball or a direct kick to the groin in martial arts). The peak age range for scrotal trauma is 10–30 years of age. Blunt force on the testis may cause contusion, hematoma, fracture, or rupture, which is defined as rupture of the tunica albuginea with protrusion of the seminiferous tubules; approximately 50 kg of force is required to rupture a normal tunica albuginea (26). The right testis is injured more frequently than the left because of

its superior location and propensity to be trapped against the pubis or inner thigh (27). Given the young population at risk for blunt testicular trauma and the goals of preserving fertility and hormonal function, immediate surgical repair is necessary to reduce the risk for testicular ischemia and loss of spermatogenesis.

US has high sensitivity for depicting testicular injury (27,28). Features of an injured testis at US include focal areas of altered testicular echogenicity that correspond to areas of contusion or infarction, hematocele formation, a discrete fracture plane, and an irregular contour or discontinuity of the tunica albuginea (Figs 9–11) (10,27–29).
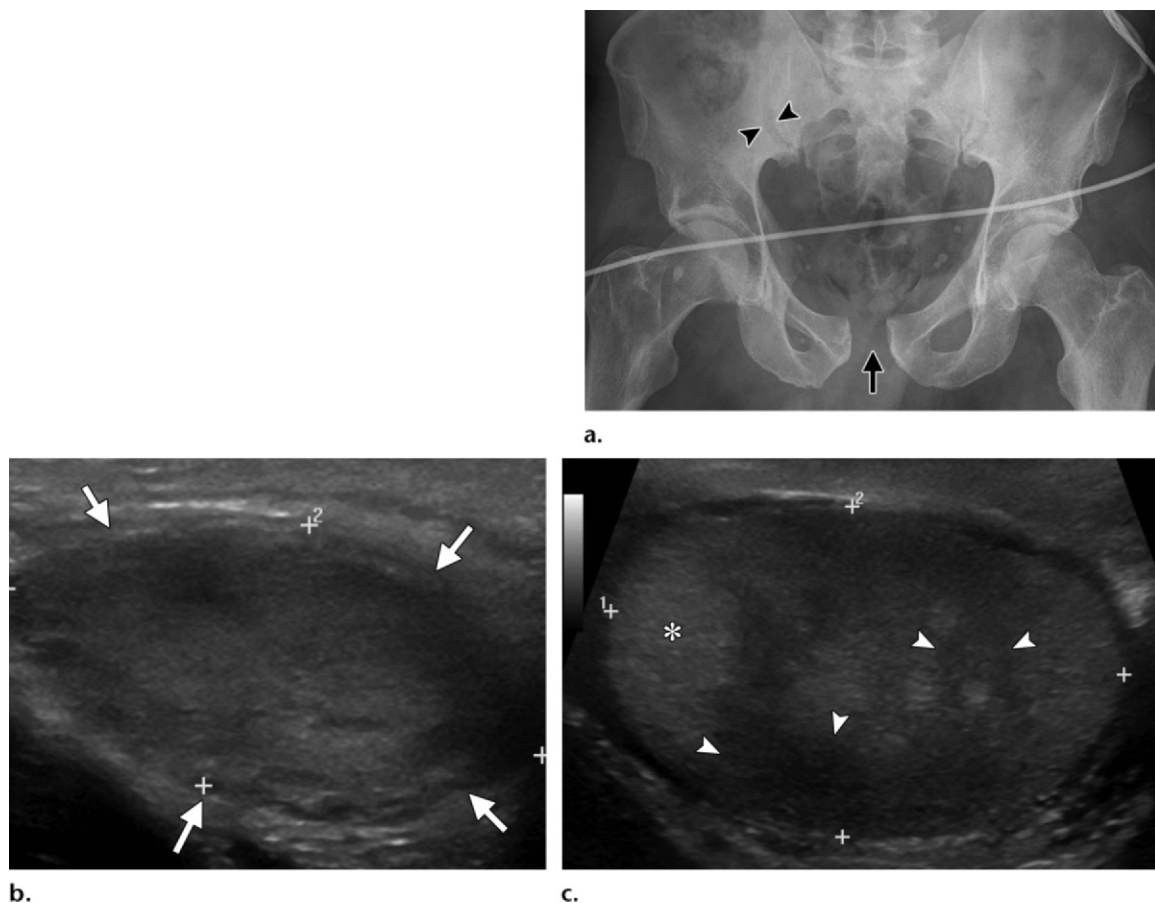
Teaching Point

Figure 10.   Rupture of the right tunica albuginea and left testicular hematoma in a 52-year-old man who was thrown from a motorcycle. **(a)** Anteroposterior radiograph of the pelvis shows widening of the symphysis pubis (arrow) and right sacroiliac joint (arrowheads), findings consistent with an anteroposterior compression fracture. **(b)** Sagittal US image of the right testicle shows that the testicular contour lacks definition (arrows) and that the thin echogenic rim of the tunica albuginea is absent, findings consistent with testicular rupture and complete avulsion of the tunica albuginea. **(c)** Sagittal US image shows the left testicle, which has a heterogeneous echotexture with ill-defined hypoechoic areas (arrowheads), a finding consistent with contusion. Testicular tissue at the upper pole (∗) appears more normal. At surgical exploration, complete avulsion of the right tunica albuginea with extravasation of the seminiferous tubules was seen, and right orchiectomy was performed. The left testicle was visibly contused but viable.

According to one study, the presence of a heterogeneous echotexture and a loss of normal contour (without direct depiction of discontinuity of the tunica albuginea) are sufficient to diagnose testicular rupture, with 100% sensitivity and 65.0%–93.5% specificity (28–30). Still, identifying discontinuity of the tunica albuginea may increase confidence in the diagnosis of testicular rupture, which is an indication for surgical exploration and repair (30). The presence of a hematocele with no other evidence of rupture may also be an indication for exploration (30,31). Evolving treatment algorithms favor exploration only in patients with a large (>5 cm) or expanding scrotal hematoma; thus, measurement of the hematocele or hematoma and close follow-up with US may be warranted in patients who undergo conservative treatment.

In equivocal cases, MR imaging may help define the pattern of injury. Normal testes have a homogeneous appearance at both T1- and T2-weighted imaging, with intermediate signal intensity at T1-weighted imaging and high signal intensity at T2-weighted imaging (32). In the context of trauma, an area of heterogeneous low signal intensity at T2-weighted imaging should raise the possibility of testicular injury (33,34). Furthermore, the testicles are surrounded by the tunica albuginea, which is fibrous with low signal intensity; interruption of this low-signal-intensity line is the key diagnostic finding of testicular rupture (Fig 11) (35). Thus, it is important to evaluate the tunica albuginea in all three planes. Despite directly depicting discontinuity of the tunica albuginea, its relatively long examination times make MR imaging unsatisfactory as an initial evaluation tool.
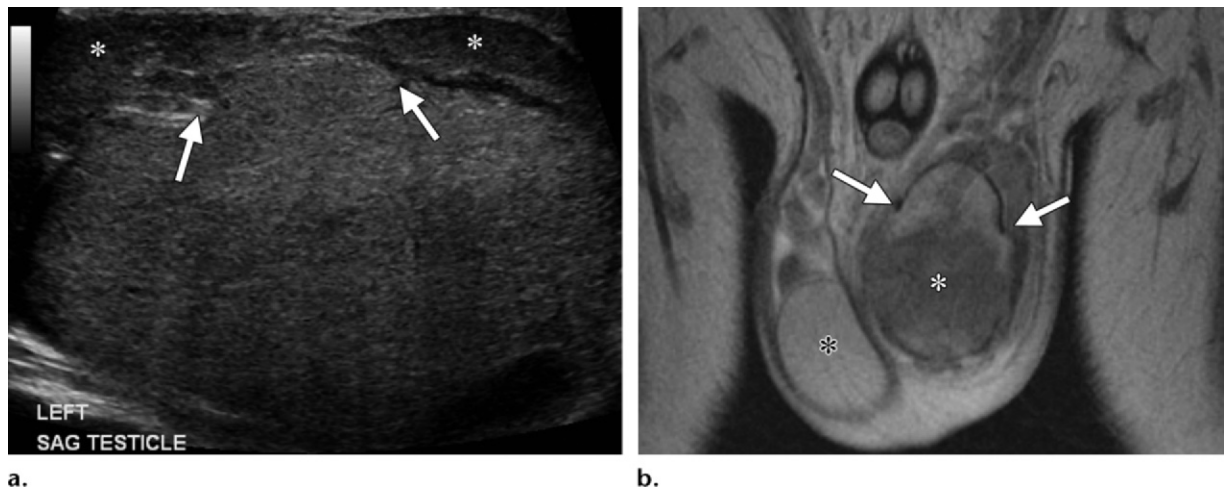
a.   b.

Figure 11. Evolving testicular hematoma and avulsion of the tunica albuginea in a 31-year-old man who was kicked in the groin while practicing karate. **(a)** Sagittal US image of the left testicle shows a mildly heterogeneous echotexture with an anterior focal contour abnormality (arrows) and a hematocele (∗). The patient declined immediate surgical exploration. **(b)** Coronal T2-weighted MR image of the scrotum obtained 2 hours later shows the normal right testis (black ∗); retraction of the left tunica albuginea (arrows), which has low signal intensity; and extrusion of the left seminiferous tubules into the inferior portion of the hemiscrotum (white ∗). The progression of avulsion and hemorrhage is attributed to the delay while performing MR imaging, which nicely depicts the injury. Such a delay may compromise salvageable testicular tissue; however, the contour abnormality seen at US was sufficient for a diagnosis.
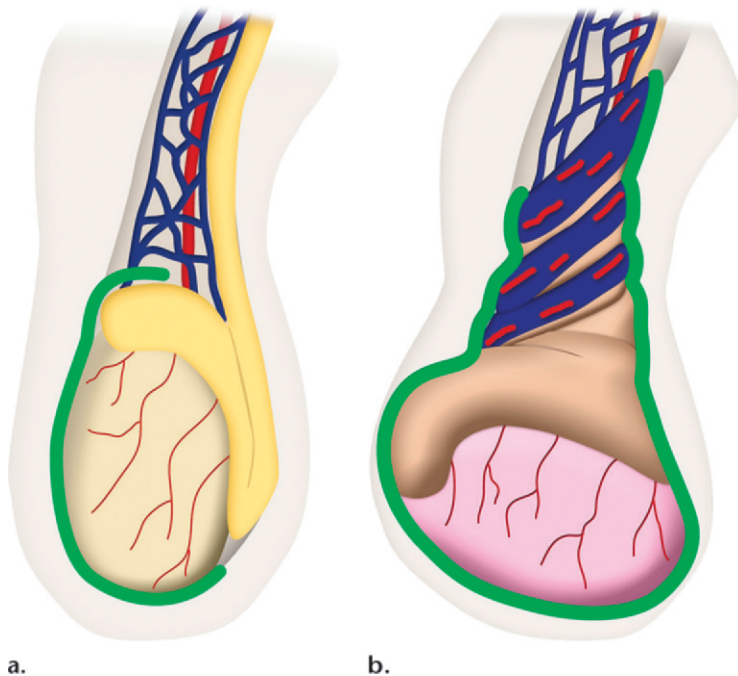

a.   b.

Figure 12. The bell-clapper deformity. **(a)** Illustration shows a normal tunica vaginalis (green line), which does not extend over the posterior aspect of the testicle and epididymis, thereby preventing free rotation of the testicle and making torsion unlikely. **(b)** Illustration shows the bell-clapper deformity, an anatomic variant in which the tunica vaginalis (green line) completely envelops the distal spermatic cord, epididymis, and testicle, allowing the spermatic cord to twist, which cuts off the blood supply to the testis.

Testicular Torsion.—Testicular torsion is a true surgical emergency, with testicular viability directly related to the duration of ischemia (2). Torsion may occur at any age; however, it is most common in adolescent boys (2). A predisposing anatomic scrotal variant known as the "bell-clapper" deformity occurs when the tunica vaginalis completely encircles the epididymis, distal spermatic cord, and testis rather than attaching to the posterolat-

eral aspect of the testis (Fig 12) (36). The bell-clapper deformity is present in 12% of men and boys and is bilateral in 80% of cases (37). Clinical history may be nonspecific in patients with torsion, and physical examination is difficult because of associated testicular tenderness.
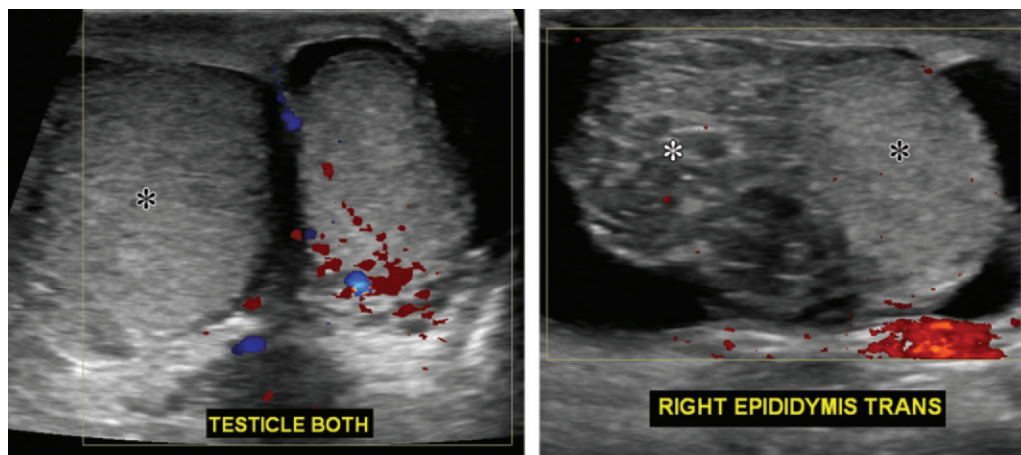
Figure 13. Testicular torsion in a viable testicle in a 14-year-old boy with a 2-hour history of sudden right scrotal pain. **(a)** Transverse color Doppler US image obtained at the level of the superior portion of the scrotum shows a lack of blood flow in the right testicle (∗), a finding consistent with torsion. The echotexture in both testicles is symmetric, indicating early torsion. The right testicle has a longitudinal appearance and demonstrates retraction superiorly, findings that may be seen in testicular torsion. **(b)** Power Doppler US image shows a lack of blood flow in the lower pole of the right testicle (black ∗) and epididymal tail (white ∗) and edema or venous congestion in the epididymal tail. Immediate manual detorsion was successful and relieved symptoms. At surgical exploration, a viable testicle and bilateral bell-clapper deformities were seen. Bilateral orchiopexy was performed.
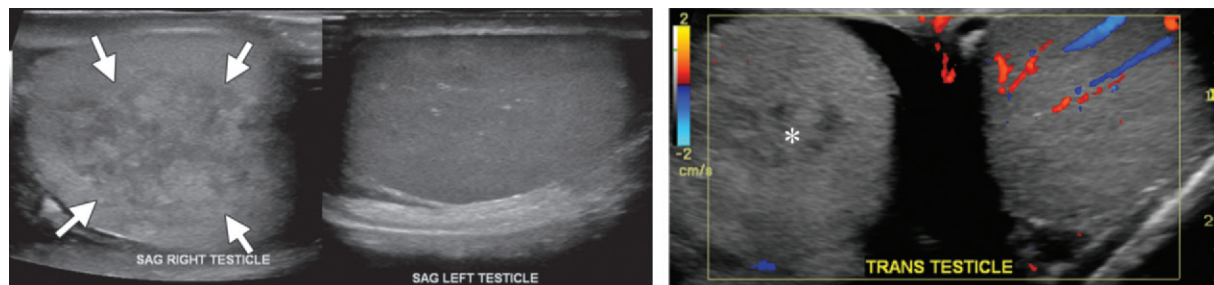

Figure 14. Testicular torsion in a nonviable testicle in a 10-year-old boy with a 15-hour history of right scrotal pain and swelling. **(a)** Sagittal US images show enlargement and central heterogeneity of the right testis (arrows) and a normal homogeneous echotexture in the left testis. **(b)** Transverse color Doppler US image shows a lack of blood flow in the right testicle (∗). The patient underwent emergent surgery, where a necrotic testicle and 360° torsion were found. Orchiopexy was performed to repair a contralateral bell-clapper deformity.

Color Doppler US is essential to confirm or exclude testicular torsion, which is recognized by an absence of detectable blood flow in the testis. The contralateral testis is used as an internal normal control. In early torsion, the testicle may appear normal at gray-scale US (Fig 13). As ischemia progresses, the testicle may become heterogeneous, enlarged, and hypoechoic, findings that suggest nonviability (Fig 14) (38).

If torsion is confirmed, prompt urologic consultation is necessary for definitive detorsion and orchiopexy or, possibly, orchiectomy if the testicle is nonviable. If a patient must be transferred for urologic care, manual detorsion
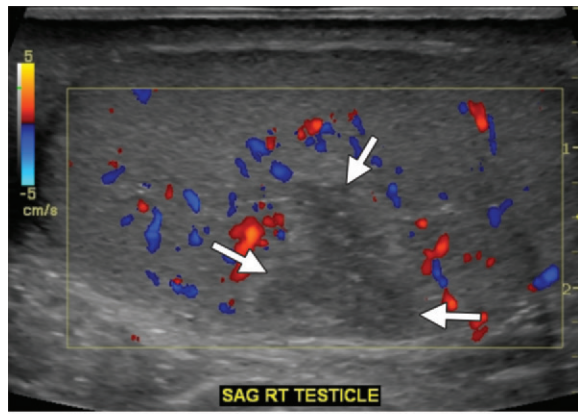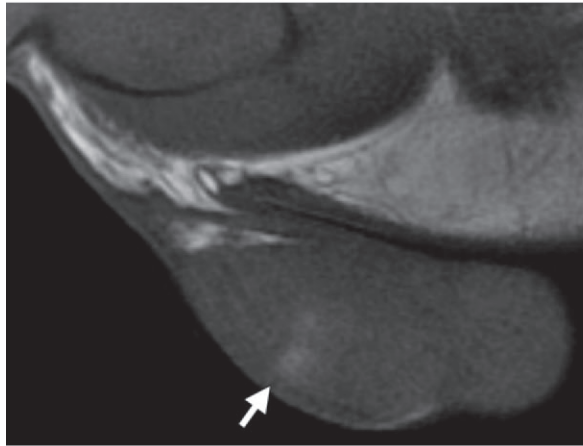
Figure 15.   Focal testicular infarction in a 22-year-old man who presented to the emergency department with right testicular pain. **(a)** Sagittal color Doppler US image of the right testicle shows a peripheral hypoechoic lesion with ill-defined borders (arrows) and a lack of blood flow. **(b)** Sagittal T1-weighted MR image shows an area of abnormal high signal intensity in the right testicle that corresponds to the region of concern and is consistent with hemorrhage (arrow). **(c)** Sagittal contrast-enhanced T1-weighted MR image shows a well-defined, wedge-shaped, none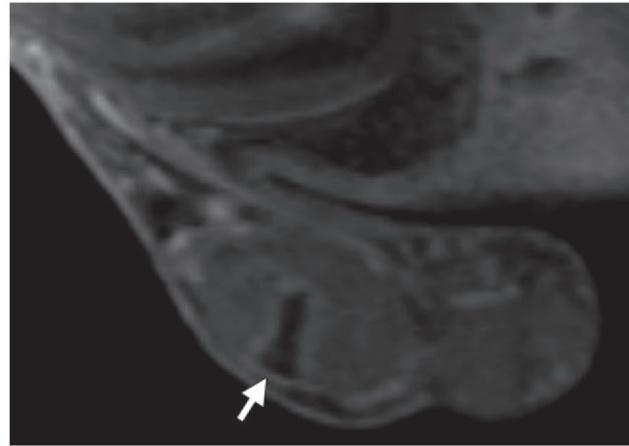nhancing area surrounded by a hyperenhancing rim (arrow). The lesion was managed conservatively, and the diagnosis of focal infarction was confirmed at follow-up imaging.

may be attempted, often by the radiologist, to accomplish rapid reperfusion. The procedure for manual detorsion of the testis is similar to that of opening a book, with the physician standing at the patient's feet while he lies supine (39). Two-thirds of twisted testes twist medially and toward the midline; thus, manual detorsion of the testicle most commonly involves twisting outward and laterally by approximately 180° (40). This procedure may need to be repeated if the initial torsion was greater than 180°, and it may not work in those with a lateral torsion, which occurs in one-third of patients. The true goal of manual detorsion should be relief of pain as a surrogate for reperfusion or color Doppler US (41). Regardless of the initial success of manual detorsion, definitive surgical intervention is necessary to relieve possible residual torsion and perform bilateral orchiopexy.

Segmental Testicular Infarction.—Segmental testicular infarction is extremely rare, and patients most often present with an acutely painful scrotum (42,43). Several causes of segmental testicular infarction have been established, including trauma; acute epididymo-orchitis; and hematologic disorders, such as sickle cell disease and vasculitis (42,43). The imaging modality of choice is color Doppler US; imaging may be further improved with the use of contrast material (where it is approved for use) (42,44,45). US most frequently depicts a wedge-shaped area in the testicle, with the vertex at the testicular mediastinum, which demonstrates no flow. The remaining, unaffected testicular parenchyma demonstrates normal blood flow (Fig 15).

A more rounded and less well-defined area may be confused with an intratesticular tumor because small tumors may be hypovascular at US and appear similar to infarction. In these cases, contrast-enhanced MR imaging has an emerging role in diagnosing segmental testicular infarction (44,46). The area of infarction may have high signal intensity on T1-weighted images, a finding consistent with hemorrhage. On contrast-enhanced T1-weighted images, the area of infarction is typically seen as an avascular area surrounded by an enhancing rim (Fig 15).

Performing short-interval follow-up US to substantiate this uncommon diagnosis and exclude a non- or hypovascular tumor is prudent. Evolution of infarction may lead to fibrosis and palpable abnormalities at physical examination. A general approach to evaluating a suspected segmental testicular infarction is to first perform US (eg, to rule out torsion), followed by MR imaging in equivocal cases. Conservative management with short-term follow-up US may help avoid unnecessary orchiectomy (47).

The Penis

Acute penile complaints are uncommon and often related to traumatic or vascular causes. Penile trauma may be blunt or penetrating, with imaging most often performed in the setting of blunt trauma and surgical exploration performed in patients with penetrating trauma. Symptoms such as penile pain and priapism are also often evaluated at imaging. Similar to the scrotum, US is the preferred modality because it is well tolerated and widely available. Furthermore, vascularity is rapidly evaluated with color and spectral Doppler US. The role of MR imaging in patients with blunt penile trauma is increasing, and its depiction of the fascial layers of the penis makes it an excellent choice for confirming or excluding fascial lacerations and directing surgical repair.

Anatomy and Imaging Appearance

The penis is composed of a pair of corpora cavernosa along its dorsal aspect and a midline corpus spongiosum along its ventral surface (Fig 16) (48). Proximally, the crura of the corpora caver-
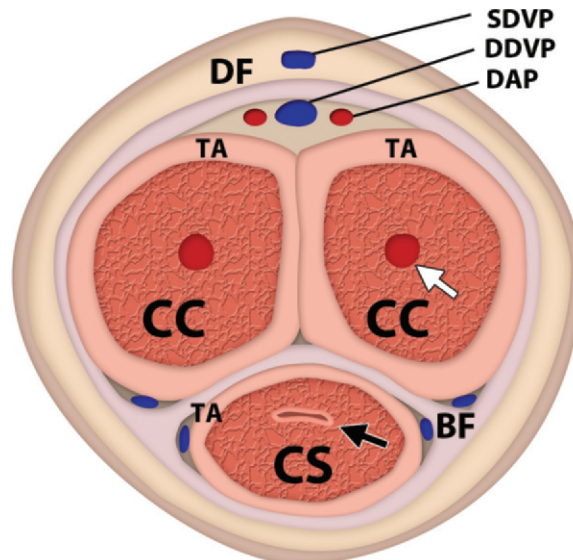

Figure 16.   Cross-sectional illustration shows the penile anatomy. The core of the penis consists of two dorsal corpora cavernosa *(CC)* and a ventral midline corpus spongiosum *(CS)*. A cavernosal artery (white arrow) is located in the center of each corpus cavernosum, and the urethra (black arrow) is located in the center of the corpus spongiosum. Each corpus is surrounded by a tunica albuginea *(TA)* and the Buck fascia *(BF)*, also known as the deep fascia of the penis. Venous drainage is provided by the deep dorsal vein of the penis *(DDVP)*, located deep to the Buck fascia and flanked by the dorsal arteries of the penis *(DAP)*, and the superficial dorsal vein of the penis *(SDVP)*, located within the Dartos fascia *(DF)*, which is also known as the superficial fascia of the penis.

nosa are attached to the ischial tuberosities. The corpora cavernosa consist of venous sinusoids that fill with blood during erection, and they are surrounded by the tunica albuginea, a strong fascial sheath. The corpus spongiosum surrounds the urethra and expands anteriorly to form the glans penis. The corpus spongiosum is also surrounded by a tunica albuginea; however, the corpus spongiosum does not become as firm as the corpora cavernosa during erection (49). The Buck fascia, also known as the deep fascia of the penis, is superficial to the tunica albuginea.

The venous drainage is through the dorsal veins: the superficial dorsal vein, which is superficial to the Buck fascia, and the deep dorsal vein, which is deep to the Buck fascia. There are three
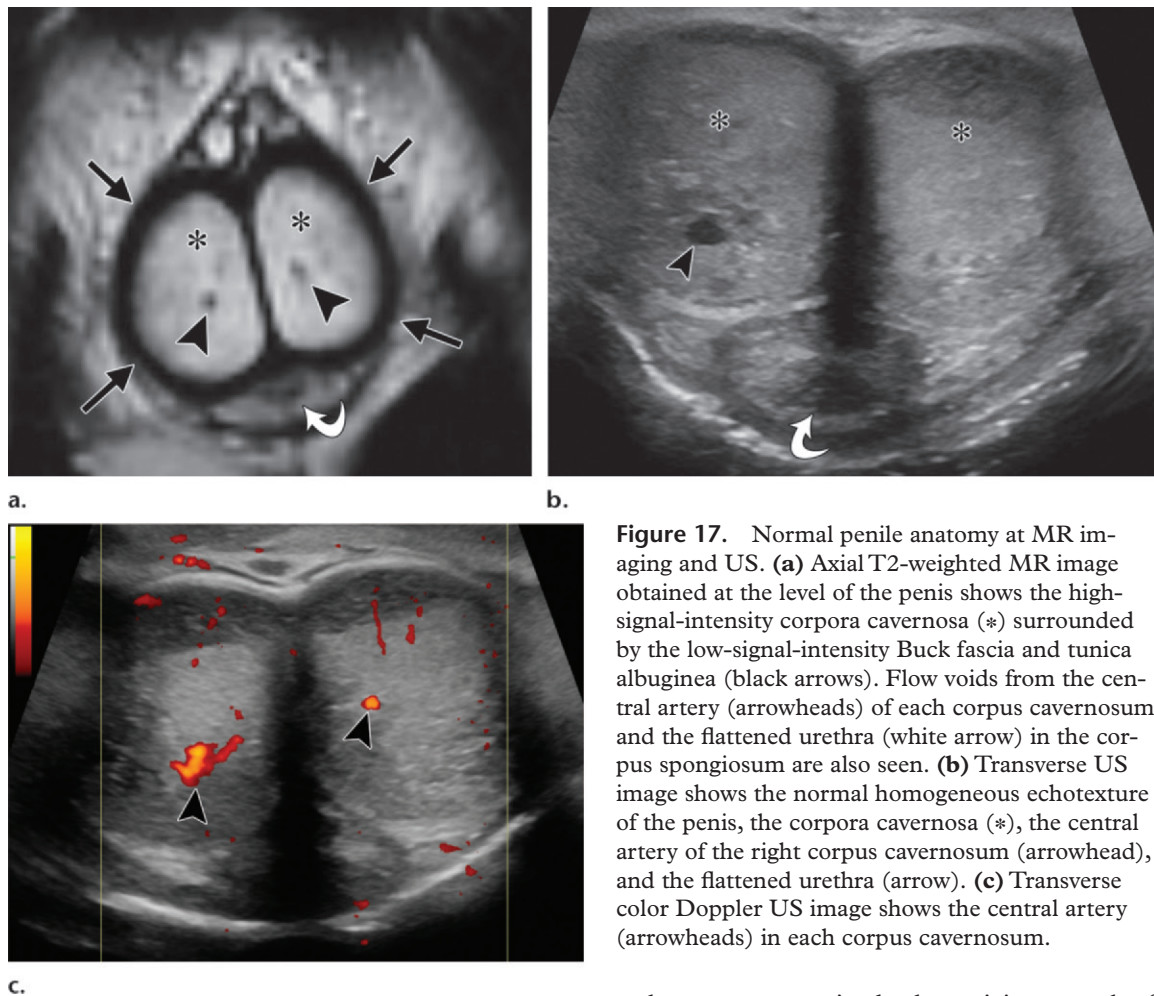
a.

b.

c.

Figure 17.   Normal penile anatomy at MR imaging and US. **(a)** Axial T2-weighted MR image obtained at the level of the penis shows the high-signal-intensity corpora cavernosa (∗) surrounded by the low-signal-intensity Buck fascia and tunica albuginea (black arrows). Flow voids from the central artery (arrowheads) of each corpus cavernosum and the flattened urethra (white arrow) in the corpus spongiosum are also seen. **(b)** Transverse US image shows the normal homogeneous echotexture of the penis, the corpora cavernosa (∗), the central artery of the right corpus cavernosum (arrowhead), and the flattened urethra (arrow). **(c)** Transverse color Doppler US image shows the central artery (arrowheads) in each corpus cavernosum.

main paired sources of arterial inflow in the penis: the dorsal artery, which is lateral to the deep dorsal vein and supplies the glans penis and skin; the cavernosal artery (also known as the deep artery), a terminal branch of the internal pudendal artery that is located in the center of each corpus cavernosum and provides arterial inflow to the corpus cavernosum during erection; and the bulbourethral artery (also known as the artery of the urethral bulb), which supplies the urethral bulb and posterior corpus spongiosum (48–51).

Ideally, US of the penis is performed with a high-frequency (7.5–10.0 MHz) linear transducer, anatomic positioning, and ample gel to provide high-quality images (Fig 17) (52,53). The three corporal bodies are well demarcated at US. The corpus spongiosum is mildly hypoechoic compared with the corpora cavernosa, which have

homogeneous mixed echogenicity, a result of the innumerable interfaces created by their complex system of vascular sinusoids. A region of shadowing is often seen between the corpora cavernosa and is caused by the fibrous tunica albuginea, which forms the intercavernous septum. Color and spectral Doppler US may depict patency and blood flow in penile arteries and veins (54). The patent dorsal veins should be easily compressible by the transducer, making blood flow detectable at color Doppler US.

MR imaging of the penis is best performed with the penis in an anatomic position (ie, lying on the abdomen) (Fig 17) (51,55). The protocol should focus on a small field of view, with T2-weighted images obtained in all three planes and T1-weighted images obtained in the sagittal
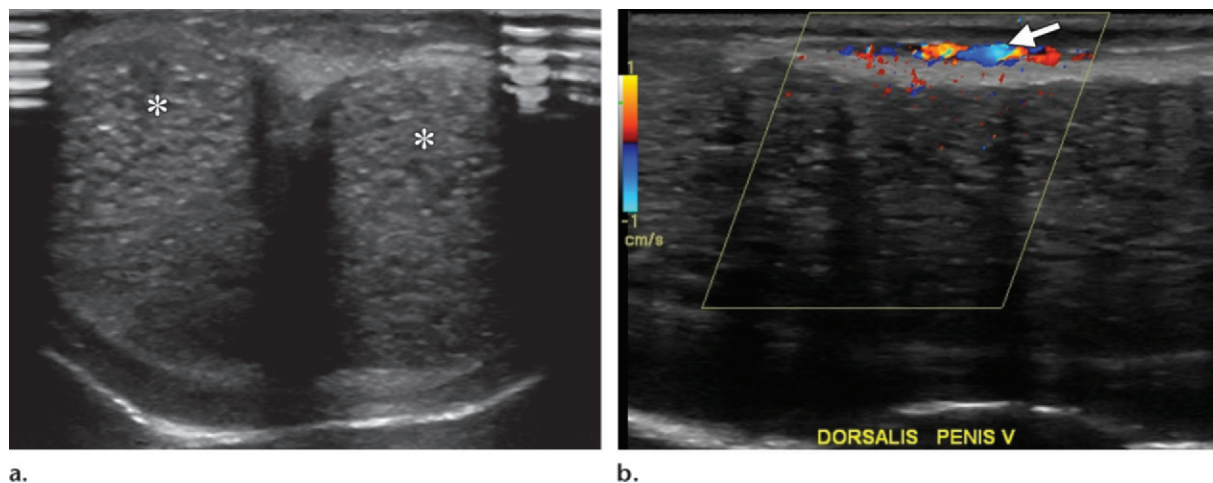
Figure 18. Low-flow priapism lasting 24 hours in a 7-year-old boy with sickle cell disease. **(a)** Transverse US image of the penis shows that the corpora cavernosa (∗) have a coarsened heterogeneous echotexture, a finding consistent with edema. **(b)** Transverse power Doppler US image shows blood flow in the superficial dorsal vein of the penis (arrow) but not in the substance of the corpora. Low-flow priapism was diagnosed on the basis of these findings. Because it did not resolve with intravenous hydration, exchange transfusion, and intracavernous phenylephrine injection, a surgical shunt was placed.

and coronal planes. On T1-weighted images, the three corpora have intermediate signal intensity and poor contrast between tissue planes. On T2-weighted images, they have high signal intensity and are well differentiated from the adherent low-signal-intensity tunica albuginea. The tunica albuginea and Buck fascia are indistinguishable from one another on T1- and T2-weighted images because of their similarly low signal intensity.

Penile Emergencies

Priapism.—Priapism is a prolonged penile erection not associated with sexual desire (56,57). The term *priapism* is derived from Priapus, the god of fertility in Greek mythology who possessed a large phallus (57). Priapism is broadly classified as low-flow (ischemic) or high-flow (arterial or nonischemic) (53,57,58). Low-flow priapism, the more common type, results from malfunction of normal penile outflow, and its causes include malignancy; hypercoagulable and thrombophilic states, such as sickle cell disease; spinal cord disorders; and medications (57,59).

Prolonged obstruction of venous outflow leads to sustained high cavernous pressures, which may lead to irreversible ischemic changes and permanent erectile dysfunction. Low-flow priapism is a true emergency.

High-flow priapism involves unregulated penile arterial inflow, typically from some form of arterial trauma, is far less common, and is not considered an emergency (60). Typically, patients with high-flow priapism present with a painless partial erection after a genitoperineal trauma (61). Because vascular trauma is often secondary to a pelvic bone fracture or straddle injury, full vascular evaluation of the perineum and penile base is warranted to identify an arterial-lacunar fistula or pseudoaneurysm. Unlike the ischemic, low-flow variant, high-flow priapism is not considered an emergency because it is not associated with pain, and permanent erectile dysfunction is unusual.

Usually, the cause of priapism is well-evaluated clinically: Whereas low-flow priapism is painful, rigid, and acute, high-flow priapism is painless, with an incomplete erection and a more prolonged manifestation after a trauma (57). Cavernosal blood gas levels may help confirm the diagnosis, with low oxygen tension seen in low-flow priapism and high oxygen tension seen in high-flow priapism. Doppler US may be used as an alternative to measuring blood gas levels (Fig 18) (60). In low-flow priapism, the goal of therapy
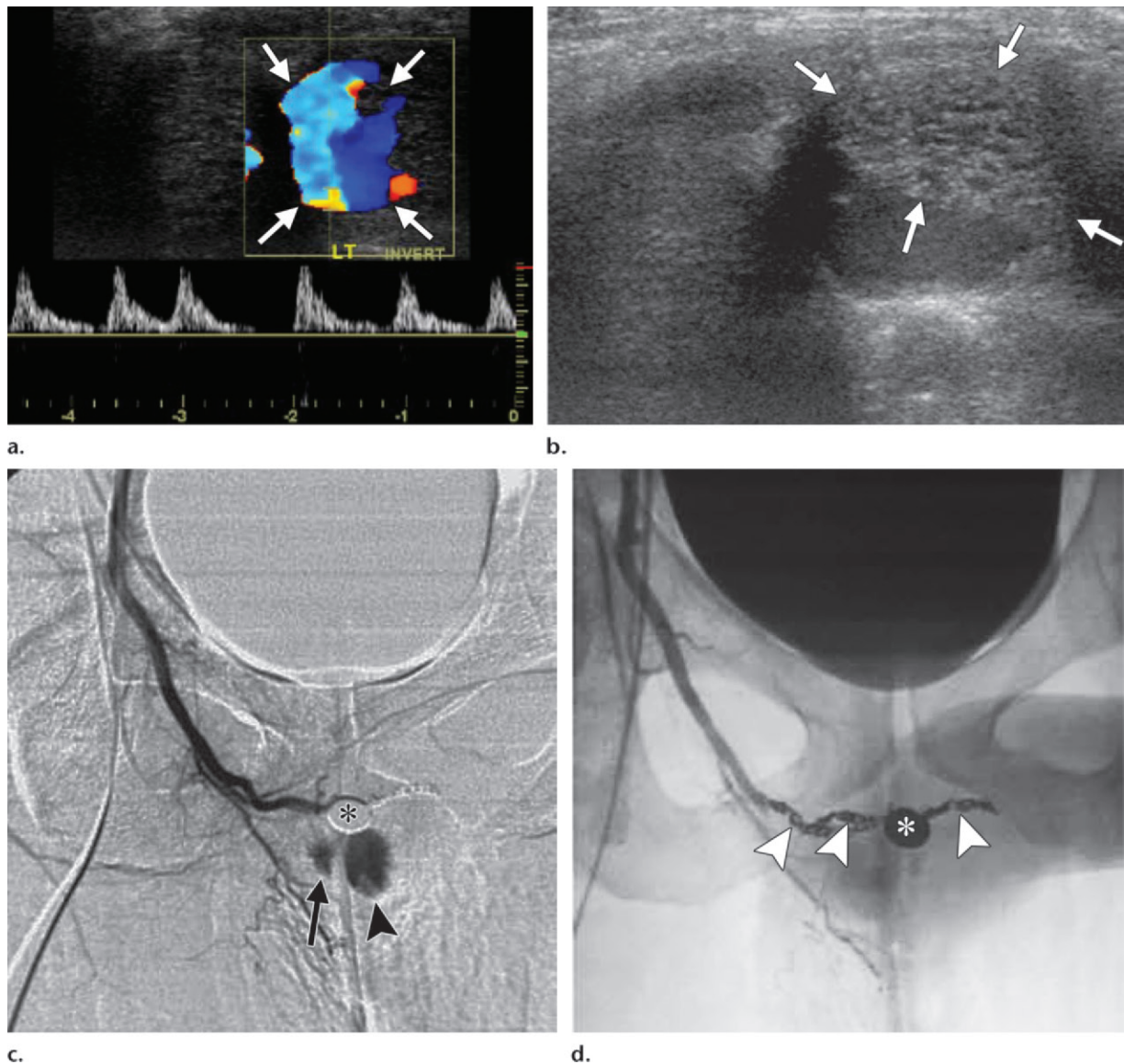
Teaching Point

Figure 19. High-flow priapism lasting 3 days in a 27-year-old man who was shot in the left hip 10 days earlier. **(a)** Color Doppler transperineal US image obtained near the base of the corpora cavernosa shows a 1.5-cm pseudoaneurysm (arrows) and an arteriocavernosal fistula at the base of the left medial corpora cavernosa. **(b)** US image shows heterogeneity of the left corpus cavernosum, a result of innumerable tiny cystic spaces (arrows) that correspond to dilated sinusoids. **(c)** Digital subtraction angiogram shows an area of abnormal blush at the penile base that corresponds to right (arrow) and left (arrowhead) pseudoaneurysms and a subtraction artifact (∗), which indicates a bullet projecting just inferior to the symphysis pubis. **(d)** Digital angiogram obtained after bilateral microcoil embolization of the pudendal branches of the internal iliac arteries (arrowheads), which promptly resolved the priapism, shows a bullet (∗) projecting just inferior to the symphysis pubis. (Reprinted, with permission, from reference 61.)

is to rapidly relieve the ischemic state (eg, with direct corporal blood aspiration, administering phenylephrine, or placing a surgical shunt), and there is a limited role for imaging evaluation (62). In high-flow priapism, color and spectral Doppler US may depict high blood flow in the cavernosal artery, a pseudoaneurysm, or an arterial-lacunar (arterial cavernous) fistula, and it may be used to direct definitive treatment, which usually involves angiography-directed embolization (Fig 19)

(61,63–65). Noninvasive methods of US-based treatment have also been reported (66,67).

Mondor Disease.—In penile Mondor disease, thrombosis or thrombophlebitis is present in the superficial dorsal vein of the penis (68). Patients with penile Mondor disease normally present with a palpable cordlike lesion along the dorsum in the location of the dorsal vein. Classically, penile Mondor disease affects young men who are sexually active, and many patients experience pain or discomfort, especially with erection. Its cause is poorly understood, but vigorous sexual activity, trauma, surgery of the pelvis or external genitalia, and a hypercoagulable state have been suggested (69). Color Doppler US remains an important tool in diagnosing the condition and monitoring patients (69). Similar to other locations, a lack of blood flow and noncompressibility of the dorsal vein indicate thrombosis (Fig 20). There is a report of Mondor disease at MR imaging, but this modality is usually not necessary (70). Mondor disease is self-limited, and its treatment is similar to that for superficial venous thrombosis elsewhere in the body, including applying local warm dressing and administering oral nonsteroidal anti-inflammatory drugs (56).

Fracture.—Penile injury may result from penetrating or blunt trauma (71). Patients with a penetrating trauma rarely undergo imaging because surgical exploration is usually required. Most blunt traumatic injuries are to the erect penis from sudden lateral bending (72,73). Penile fracture occurs when one or both corpora cavernosa rupture, a result of a tear in the tunica albuginea, which is one of the strongest fascias in the human body (73,74). Erect penises are at increased risk for fracture because the cavernosal tunica albuginea substantially stretches and thins during erection (74). Clinically, penile fracture results in rapid detumescence, pain, swelling, and hematoma. Concomitant injury to the penile urethra is estimated to occur in 10%–20% of patients and should be suspected if associated blood is seen at the urethral meatus or a bilateral cavernosal injury is present (75,76).

US is easily accessible, and it may accurately depict normal anatomy and delineate the nature and extent of injury (Fig 21) (52,53,77,78). It
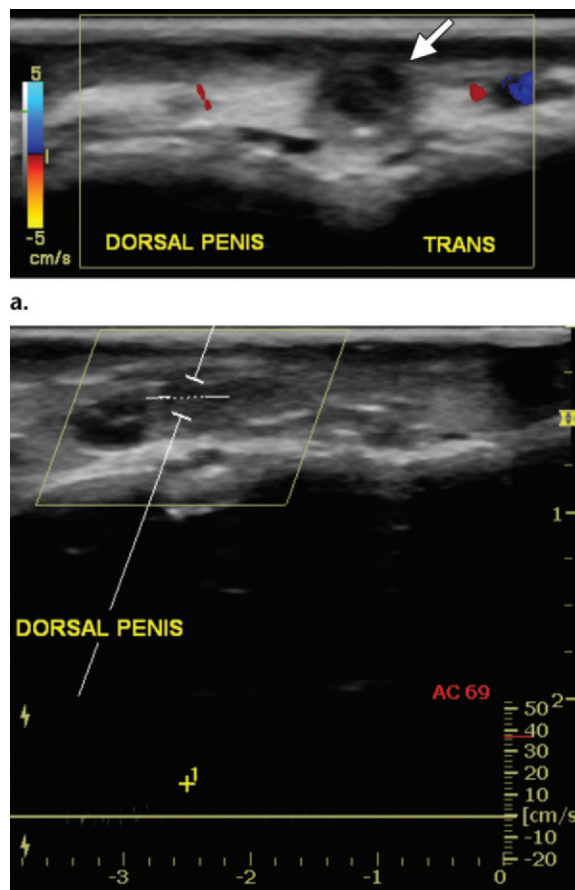
a.

b.

Figure 20. Penile Mondor disease in a 38-year-old man with a foreign-body sensation along the dorsum of the penis. **(a)** Magnified transverse color Doppler US image shows an absence of blood flow in the superficial dorsal vein of the penis (arrow). **(b)** Sagittal duplex Doppler US image obtained with the Doppler gate on the superficial dorsal vein of the penis shows a lack of blood flow in the dorsal vein.

may also depict the exact location of the tear, which is seen as an interruption of the tunica albuginea (which is seen as a thin echogenic line), and a hematoma may be seen deep to the Buck fascia or the skin (53,77). Evaluation of the urethra with US is limited; when there is concern, retrograde urethrography may be necessary (78,79). At US, the presence of echogenic air in the cavernosa is suggestive of urethral injury
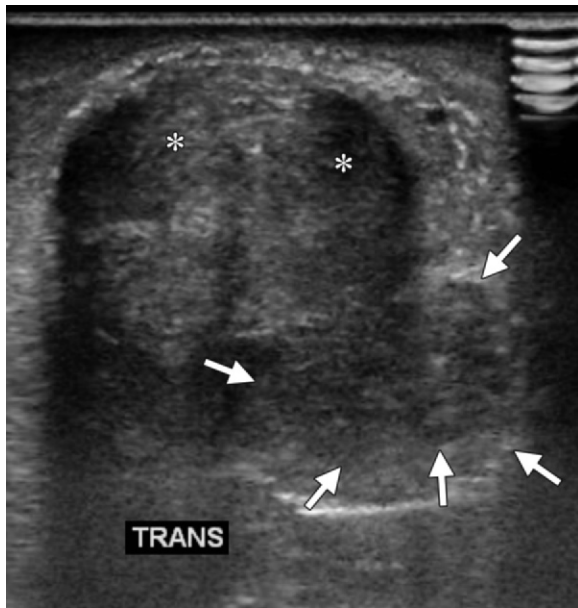
Figure 21. Penile fracture in a 36-year-old man with sudden pain, swelling, and ecchymosis during intercourse. Transverse US image shows both corpora cavernosa (∗) and a focal outpouching (arrows) from the left lateral aspect of the left corpus cavernosum. Penile fracture was confirmed at surgical exploration and repaired with four stay sutures.
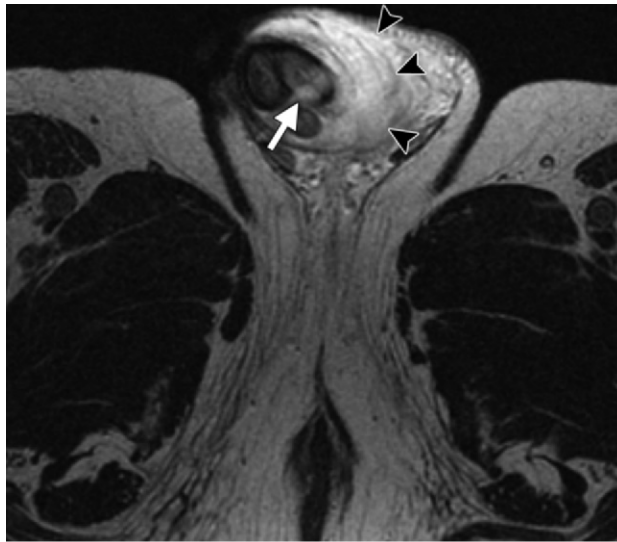

a.   b.

Figure 22. Penile fracture in a 50-year-old man with swelling and acute flaccidity after hitting his erect penis against his partner's pelvis. **(a)** Axial T2-weighted MR image shows focal interruption of the left lateral aspect of the low-signal-intensity tunica albuginea (arrow) and an overlying hematoma (arrowheads). **(b)** Coronal T2-weighted MR image shows focal interruption of the tunica albuginea (arrows) and the overlying hematoma (arrowheads). These findings were confirmed at exploratory surgery, and the fracture was repaired.

Teaching Point

and should be further evaluated (78). Where and when available, MR imaging may be used to evaluate patients with a penile injury and provides superb soft-tissue definition, depicting interruption of the cavernosal low-signal-intensity tunica albuginea (Fig 22) (51,80,81). Typically, hematomas have high signal intensity on T2-weighted images.

Currently, most authors favor immediate surgical repair of penetrating or blunt penile injuries (82). Although imaging is not usually neces-

sary, because of the degloving nature of the surgery, making an imaging diagnosis before performing surgical exploration may help convince patients of the need for surgery (83). Complications of conservative management include plaque

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or nodule formation at the fracture site, missed urethral injury and subsequent stricture, penile abscess, penile deformity (eg, chordee), painful erection, and erectile dysfunction (84).

Conclusion

Genital emergencies in men and boys are uncommon and, therefore, require radiologists to have a high level of suspicion and be familiar with the role of imaging and the specific imaging findings of these injuries. US is often the first-line imaging tool used to evaluate the genitals, and MR imaging, CT, and retrograde urethrography play an important supplementary role. Confident identification of normal and abnormal imaging appearances of the scrotum and penis allow radiologists to efficiently direct either prompt urologic repair or conservative management.

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RadioGraphics

Imaging of Penile and Scrotal Emergencies

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Because infection and inflammation typically spread in a retrograde fashion, the epididymal tail is involved before the body and head are affected; thus, complete evaluation of the epididymis, especially the tail, is necessary to accurately diagnose an early infection.

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US has high sensitivity for depicting testicular injury (27,28). Features of an injured testis at US include focal areas of altered testicular echogenicity that correspond to areas of contusion or infarction, hematocele formation, a discrete fracture plane, and an irregular contour or discontinuity of the tunica albuginea.

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Color Doppler US is essential to confirm or exclude testicular torsion, which is recognized by an absence of detectable blood flow in the testis.

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Prolonged obstruction of venous outflow leads to sustained high cavernous pressures, which may lead to irreversible ischemic changes and permanent erectile dysfunction. Low-flow priapism is a true emergency.

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Where and when available, MR imaging may be used to evaluate patients with a penile injury and provides superb soft-tissue definition, depicting interruption of the cavernosal low-signal-intensity tunica albuginea. Typically, hematomas have high signal intensity on T2-weighted images.