Seminars in
ULTRASOUND
CT and MRI

Ultrasound Emergencies of the Male Pelvis

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Male pelvic emergencies are uncommon, and symptoms typically include scrotal pain, scrotal enlargement, or a palpable scrotal mass or all of these. Ultrasound is often the first-line modality for evaluation of male pelvic emergencies, which may be stratified into vascular, infectious, or traumatic causes. Entities such as testicular torsion, Fournier gangrene, and testicular dislocation are surgical emergencies and should not be missed or misdiagnosed, as this may cause a significant delay in urgently necessary treatment. Radiologists need to be familiar with the role of imaging as well as the key characteristic imaging findings of these injuries to direct the appropriate management.
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Introduction

Male pelvic emergencies are uncommon. However, diagnostic pelvic ultrasound is routinely performed on an emergent basis in male patients presenting with acute scrotal or penile symptoms.[1–3] These symptoms typically include scrotal pain, scrotal enlargement, or a palpable scrotal mass, or all of these.[4] Emergent male pelvic conditions may be stratified into vascular, infectious, or traumatic causes.[3] Vascular etiologies include testicular ischemia and infarction in the setting of testicular torsion. Infectious scrotal entities include epididymitis, epididymo-orchitis, testicular abscess, pyocele, and Fournier gangrene. Traumatic injuries include blunt and penetrating scrotal injuries, as well as degloving pelvic injuries due to scrotal sac avulsion.[3,5]

Prior to the introduction of ultrasonography and cross-sectional imaging, the scrotum and its contents were examined predominately by palpation on physical examination and with transillumination. However, ultrasound is now the ideal imaging modality to use in the emergent setting, because it is portable, readily available, uses no radiation, allows for real-time imaging and is extremely useful in clearly delineating testicular torsion from other acute scrotal pathologies, including complications of epididymitis.[6,7] Although pelvic magnetic resonance imaging (MRI) can also diagnose and more thoroughly characterize a wide plethora of scrotal pathology, it is usually much more time consuming and not as readily available. Additionally, although pelvic MRI does have a role in more clearly delineating scrotal pathologies in ambiguous cases, it is impractical in the emergent setting.[8]

Anatomy

The anatomical structure most commonly evaluated emergently by pelvic ultrasonography in the male pelvis is the scrotum and its contents. The scrotum is a pouch divided by the median raphe, a midline structure, and contains a testicle in each hemiscrotum[2,9] (Fig. 1). The tunica vaginalis surrounds the anterior, medial, and lateral margins of the testes. The scrotum is separated from the testicle by the tunica vaginalis that consists of 2 serous membranous layers, the visceral and parietal layers, arising from the processus peritoneum.[2,7] The parietal layer lines the fascial wall of the scrotum, whereas the innermost visceral layer is closely adherent to a similar sounding structure, the tunica albuginea.[3,9,10] The tunica albuginea, however, is composed of fibrous tissues covering the testicle, which helps the testis maintain its shape and integrity. Typically, the tunica albuginea looks like a hyperechoic line surrounding and outlining the testis (Fig. 2). Discontinuity of the tunica albuginea suggests testicular rupture.

The testis, epididymis, and spermatic cord contents including the vas deferens and the internal spermatic vessels, reside in each hemiscrotum, contained within the tunica vaginalis.[2,3,9]

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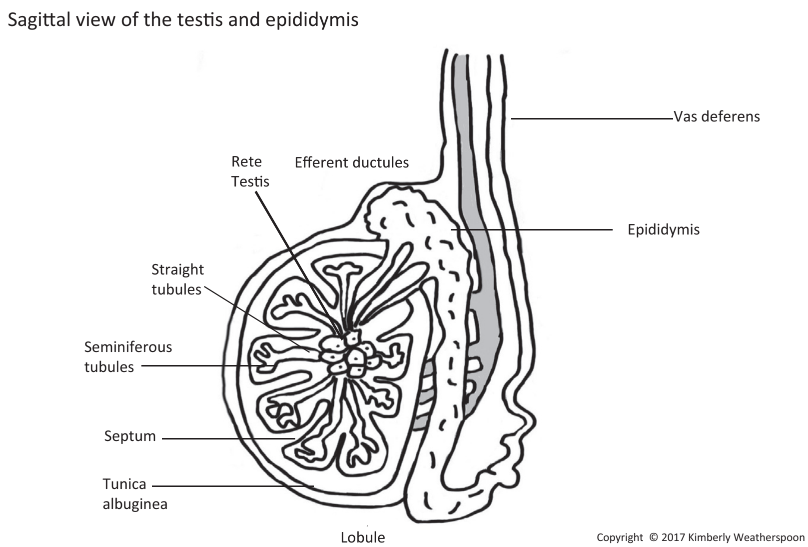

Figure 1 Diagram of scrotal anatomy.

The testis is a mobile, ovoid structure, which typically measures between 3 and 5 cm[10,11] (Fig. 3). The testicular parenchyma is homogenous, made up of multiple lobules, composed of seminiferous tubules, leading to the rete testis located deep within the testicular hilum. The rete testes are a fine network of tubules that function to carry sperm from the seminiferous tubules to the vas deferens and concentrate sperm[12] (Fig. 4). Tissues with fibrous septa radiating out toward the testicular periphery, known as the mediastinum testis, provide the structural support of the rete testis.

The spermatic cord suspends the testes in place and is located in the scrotum. The epididymis is located superior and lateral to the testis, containing an epididymal head, body, and tail that carry sperm away from the testicle. The epididymal tail drains downward as the vas deferens[12] (Fig. 5). Furthermore, the testis and the epididymis demonstrate a homogenous echotexture. Generally, the epididymis is hypoechoic relative to the testicle and demonstrates slightly less blood flow.[2,3,12] Cases of relatively increased epididymal blood flow may indicate epididymitis in the correct clinical setting. Within the substance of the epididymis, the epididymal body and tail are more echo-poor than the epididymal head, which is usually similar in echogenicity to the testis and contains converging tubules.[2]

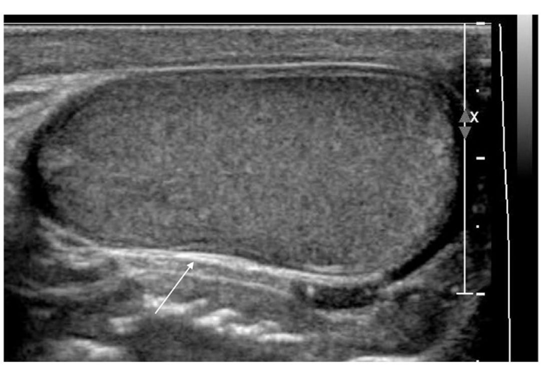

Figure 2 Tunica albuginea. The echogenic structure surrounding the testicle (arrow) is the tunica albuginea.

The testicular artery arises from the abdominal aorta and serves as the main arterial supply to the testis. Additionally, the cremasteric artery, a branch of the inferior epigastric artery, supplies the scrotal wall.[10] The deferential artery arises from the inferior visceral artery to supply the epididymis. The pampiniform venous plexus, a complex of veins in the scrotum wrapped around the testicular artery, drains the testis via the testicular veins. In the abdominal cavity, the right testicular vein drains into the inferior vena cava, and venous drainage from the left testicular vein is via the left renal vein. The cremasteric plexus drains the epididymis and the scrotal wall.

A very small amount of anechoic physiological fluid may be found in the scrotum normally, surrounding the testicle in the potential space between the vaginalis layers. However, excessive fluid in the scrotum surrounding the testicle raises concern for a significant hydrocele (Fig. 6A). When present, many small hydroceles are asymptomatic. However, large hydroceles may present clinically as an enlarging scrotal mass. Hydroceles may also be complex with interweaving septations (Fig. 6B). A congenital hydrocele is usually caused by a patent processus vaginalis. Normally, the processus vaginalis closes perinatally. However, a persistent, patent connection between the scrotum and the parietal peritoneum may result in a hydrocele.[4] Other causes of hydroceles may be postinflammatory or even idiopathic. Nonetheless, regardless of a hydrocele's etiology, fluid is not ever present in the "bare area" at the testicular attachment to the tunica vaginalis.[13]

Technical Considerations

When examining the scrotum and its contents sonographically, a high-frequency transducer should be used to yield high

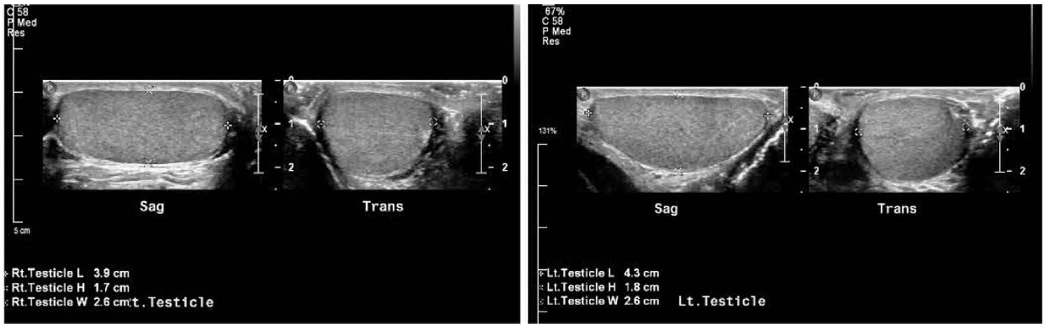

Figure 3 Normal bilateral testicular ultrasound. Note the homogenous testicular echotexture.

signal quality without undue attenuation. A high-frequency linear transducer, approximately 7-15 MHz, is most commonly used.[2,9] For optimal imaging, the scrotum may be elevated on a towel for added support, while the sonographer scans the scrotum in direct contact between the transducer and the scrotal tissues. Additionally, for optimal imaging, preset mode selection should be set to small parts and may use multiple focal zones.[14]

Scanning usually begins on the nonaffected side so that adequate imaging can be obtained, as the patient may not tolerate the entire examination if the affected side is imaged first.[15] Sonographic images are taken in both transverse and sagittal orientation. On ultrasonography, the testis appears round on transverse images and more ovoid on sagittal images (Fig. 7). On both transverse and sagittal images, the scrotal layers appear as echogenic stripes around the homogenous testicular parenchyma. Color Doppler ultrasound is critical when assessing acute conditions[9]. Flow settings should be optimized to detect low velocities in the testis. In the setting of minimal testicular blood flow, Power Doppler may be used to evaluate flow with greater sensitivity in patients presenting with acute testicular pain.[16-18] Spectral Doppler is necessary to show arterial and venous waveforms (Fig. 8). In the acute setting, evaluation of the testes, as well as the extratesticular sac structures, should be undertaken to look for extratesticular injuries, collections, and hematomas.

Scrotal Emergencies—Vascular

Testicular Torsion

Testicular torsion refers to twisting of the testicle around the spermatic cord or testicular twisting on its vascular pedicle attachments. Testicular torsion typically presents with acute, persistent scrotal pain and is a surgical emergency due to obstructed blood flow in the spermatic cord and adjacent testicular artery leading to testicular ischemia.[7] The degree of ischemia demonstrated is relative to the amount of twisting, beginning with venous compromise, and progressing to arterial occlusion. Therefore, arterial flow in a threatened, enlarged, and painful testis does not completely exclude the diagnosis of testicular torsion.[19] Careful evaluation of the testes, including ultrasonography with low pulse frequency and high Doppler gain, may be necessary to definitively demonstrate slow flow within the affected testicle.[20]

Testicular torsion is a surgical emergency because if the affected testicle is not detorsed within a few hours of testicular torsion, irreversible testicular infarction may ensue. Progressive ischemia leading to a heterogeneously enlarged, hypoechoic testis suggests nonviability.[21] Detorsion within 6 hours has a very good prognosis for testicular salvageability, whereas detorsion after 24 hours has a poorer prognosis for preserving testicular viability.[3] On gray-scale ultrasonography, the contralateral testis can be used as an internal normal control.

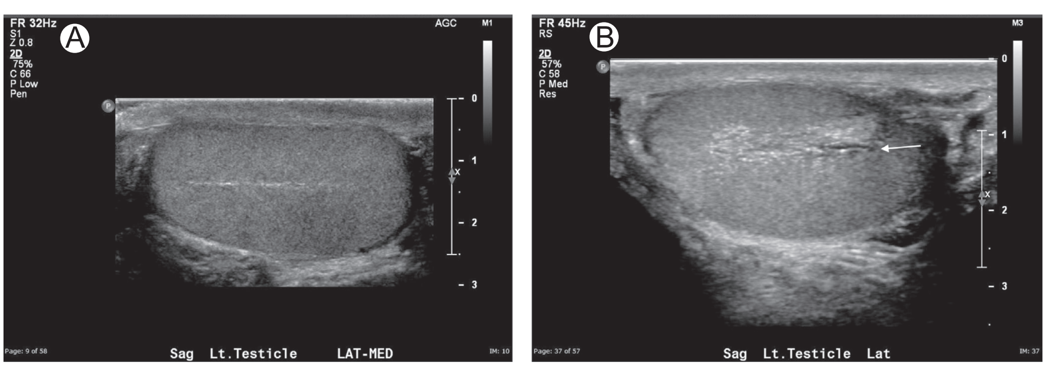

Figure 4 (A) Echogenic linear area in the central testicle, as seen on this sagittal image, is the mediastinum testis, an area where the blood vessels and nerves enter the testis. (B) Hypoechoic area at the arrow appears to have a septated appearance, characteristic of the rete testis.

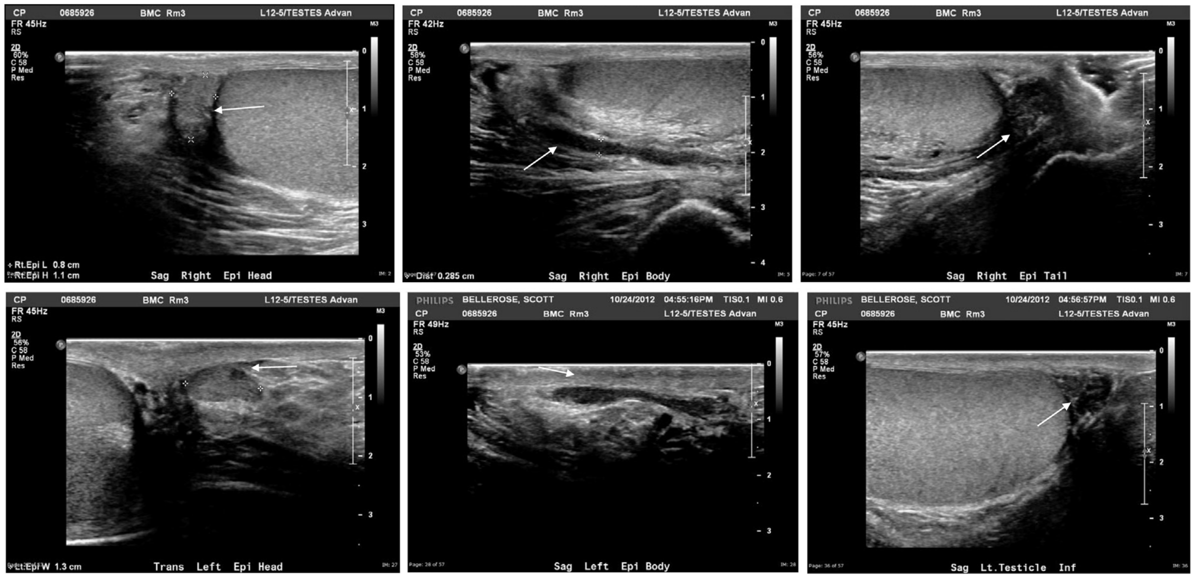

Figure 5 The normal epididymis is hypoechoic compared to the adjacent testicle. It is composed of an epididymal head, body, and tail (arrows).

The affected testis may be larger than the contralateral testis (Fig. 9). Findings may be subtle, and therefore side-by-side comparison is important.

An important point to remember when imaging the scrotum is that normal gray-scale ultrasound findings, as well as the presence of flow, does not exclude early, partial, or incomplete torsion, nor does it exclude torsion-detorsion phenomenon.[22] In partial torsion or torsion-detorsion, blood flow may be absent or even compensatorily hyperemic.[19] Distinguishable from epididymitis clinically, testicular torsion demonstrates absence of the cremasteric reflex, and no pain relief with scrotal elevation.[23] Early recognition of the imaging characteristics and clinical presentation of testicular torsion are imperative owing to the limited time-window of testicular salvageability from the time of onset to permanent infarction of the affected testis. Usually, diagnosis within the first 6 hours determines whether the testes will regain viability postoperatively. Time from onset of symptoms to surgery as related to salvage rate is 5-6 hours (80%-100%), 6-12 hours (70%), and only 20% after 12 hours.[24] If the testis is nonsalvageable, the necrotic testis should be surgically removed.[18]

As mentioned, undiagnosed testicular torsion leads to infarction of the testis, illustrated as a hypoechoic testis with a heterogeneous echotexture. Again, sonographic findings of testicular torsion are dependent on the time elapsed since the onset of the torsion. Testicular torsion, occurring within a few hours of presentation, may show a hyperechoic knot of the twisted epididymis and spermatic cord with absent or diminished blood flow in the affected testicle. Use of a high-resolution, high-frequency transducer assists in localization of the exact point of torsion via direct visualization of the twisted spermatic cord (whirlpool sign)[25,26] (Fig. 10). Testicular torsion that has occurred between a few hours and up to 24 hours of presentation may show an enlarged and heterogeneous testicle on the affected side. Missed torsion, greater than 24 hours before presentation, may demonstrate an enlarged and mottled testicle on the affected side with thickening of the scrotal skin and increased flow in the scrotal wall. An associated reactive hydrocele may also be present. Chronic testicular torsion that has been chronically devoid of perfusion may appear atrophied.[27]

On color or power Doppler, absent or diminished color flow is characteristic. It has been reported that absence of color Doppler flow in the testicle has a sensitivity of 86%, and accuracy of 97% for testicular torsion.[28] Furthermore, despite color Doppler flow being absent in the affected testis, the epididymis will remain perfused owing to its alternate blood supply. This is a common finding that should not deter the interpreting radiologist from suspecting testicular torsion. On spectral Doppler, absent or high-resistance waveforms are most likely to be observed. Additionally, increased resistive indices with decreased, absent, or reversed diastolic flow may be seen, suggesting vascular occlusion.[7,29]

Anatomical Variant That Predisposes to Testicular Torsion

Testicular torsion can be stratified into either intravaginal or extravaginal forms. The intravaginal form is usually secondary to an anatomical scrotal variant known as the bell clapper deformity. The bell clapper deformity predisposes to torsion due to a small testicular bare area. The bare testicular area is the testicular attachment site that normally stabilizes the testicle and prevents rotation. However, in bell clapper deformity, there is a failure of fusion of the visceral and parietal layers to the scrotal wall in the proper position. The tunica vaginalis does not attach to the posterolateral aspect of the testis as is normally the case, but instead, it completely encircles the epididymis, distal spermatic cord, and testis joining the spermatic cord in a higher than normal position.[3,10,30]

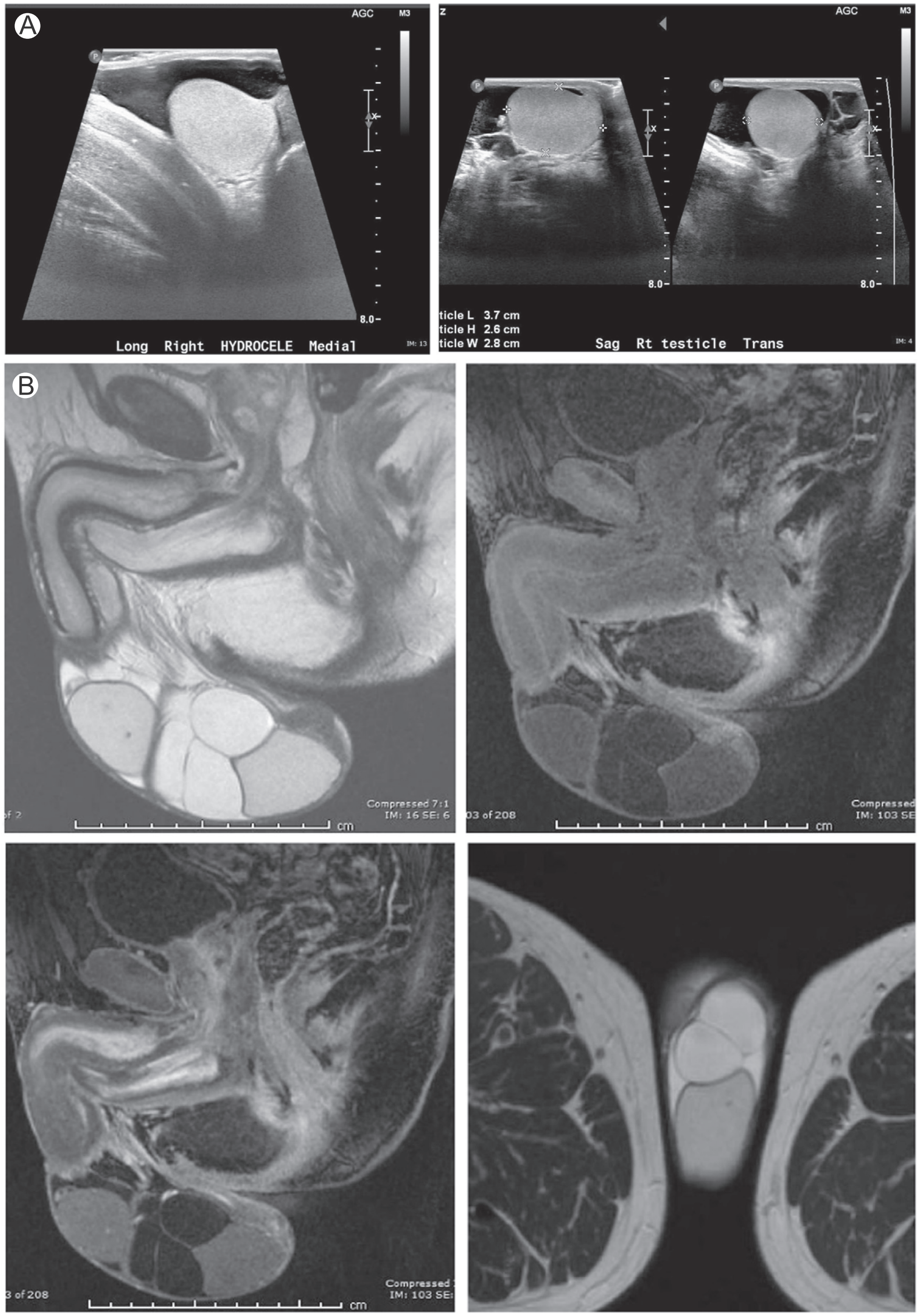

Figure 6 (A) *Hydrocele*: fluid in between the layers of the tunica vaginalis due to a patent processes vaginalis. (B) *Complex hydroceles*: Sag T2, T1C−, T1C+, and Ax T2. Bilateral lobular cystic abnormalities with fine internal septations, but no significant nodularity or other solid components.

This abnormal anatomical configuration allows the testes to rotate freely, predisposing to intravaginal testicular torsion.[31,32] This variant is bilateral in most cases.[30]

The extravaginal form of testicular torsion more commonly occurs perinatally, before fixation of the testis, with testicular torsion occurring in the region of the inguinal canal or just

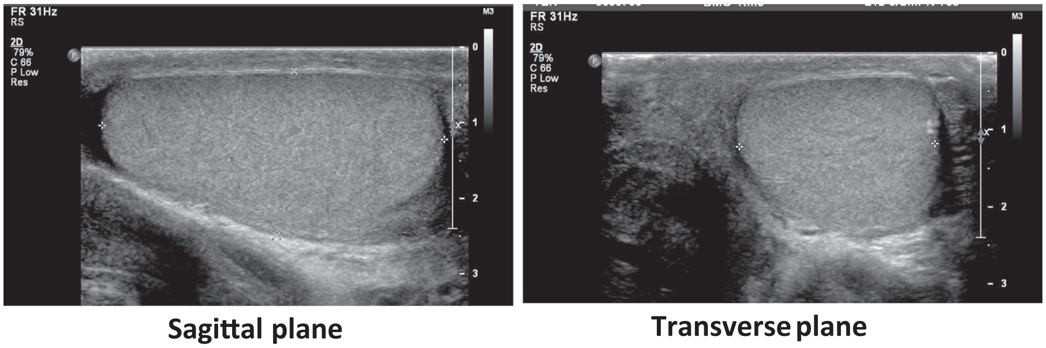

Figure 7 Sagittal and transverse images of a normal homogenous testis.

inferior to it, proximal to the tunica vaginalis attachment.[31] Extravaginal testicular torsion is testicular rotation within the scrotum due to mobility and lack of testicular fusion to the scrotal wall.[33,34] The extravaginal form is seen almost exclusively in neonates and children that have not yet experienced complete testicular descent and fusion of the scrotal wall.

Testicular Torsion-Detorsion Phenomenoma

Testicular torsion-detorsion or incomplete testicular torsion describes a phenomenon where the spermatic cord twists less than 360°.[35] In these cases, the testis may retain normal flow but with diminished velocities. Clinical history is key in these situations; classically, the patient relays a history of intermittent acute and sharp pain with long symptom-free intervals. The sonographer should be alerted to the symptomatic side and whether or not the symptoms dissipate during the examination to make this diagnosis accurately. Increased blood flow may be seen in the affected testis if sonographic imaging is performed immediately after detorsion.[36]

Testicular torsion-detorsion may demonstrate focal areas of hypoechogenicity in the testicular parenchyma on gray-scale ultrasonography, the typical appearance of focal infarcts. Focal infarcts associated with normal or increased flow raise the alarm for the possibility of intermittent torsion. Frequently, the epididymis appears enlarged and hyperemic in torsion-detorsion and can be mistaken for epididymitis. However, careful surveillance of the testis for focal infarction may lead to the correct diagnosis. Testicular tumors greater than 1 cm may also mimic infarcts with focal areas of avascularity and no flow.

Other Scrotal Vascular Emergencies: Segmental Infarction

Segmental infarction is a focal testicular infarction caused by microvascular thrombosis from acute trauma, infectious

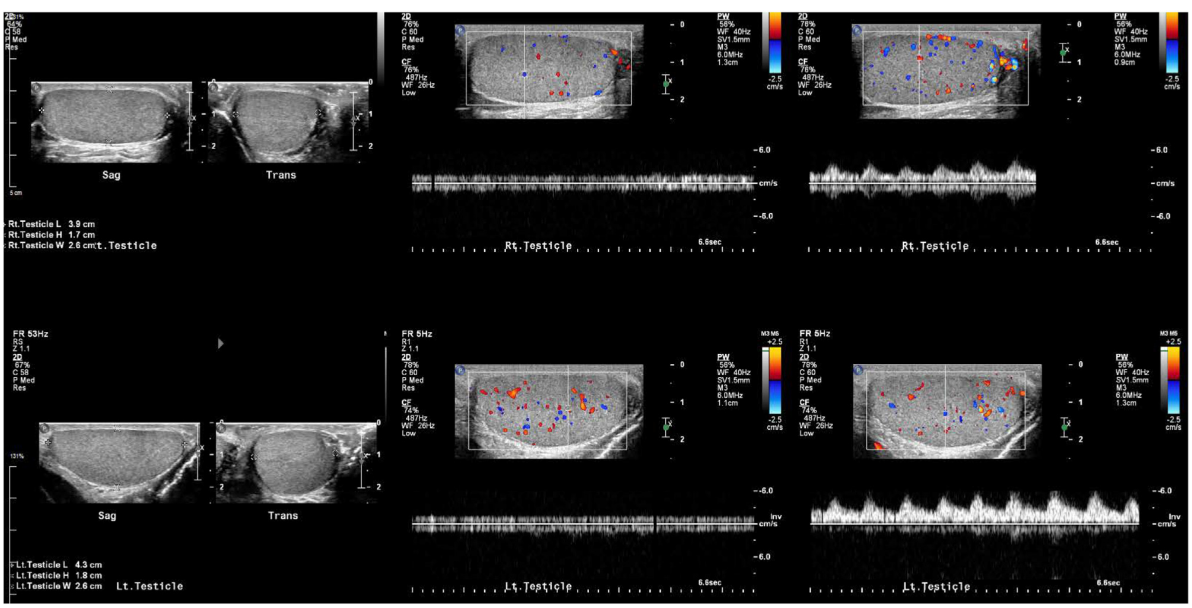

Figure 8 The testicles should be evaluated by both gray-scale and color Doppler ultrasound. Spectral Doppler assessment is necessary to demonstrate a rterial a nd venous flow. Color and spectral Doppler is necessary to demonstrate vascularity as well as arterial and venous flow. (Color version of figure is available online.)

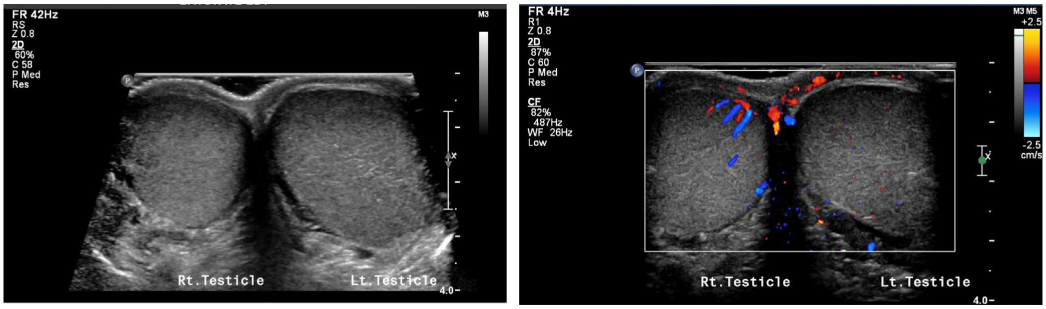

Figure 9 Testicular torsion: asymmetric enlargement of the left testicle on gray scale. No internal color flow is seen in the left testicular parenchyma on color Doppler interrogation. (Color version of figure is available online.)

processes such as epididymo-orchitis, inflammation, or hematologic processes such as vasculitis or sickle cell disease.[37,38] Patients affected by testicular infarction are typically in their thirties and present clinically with acute pain mimicking conventional testicular torsion or epididymitis. Although segmental testicular infarction is a rare entity, patients commonly present with acute scrotal pain just as in conventional, fulminant testicular torsion. On gray-scale ultrasound, the focal area of infarction is wedge-shaped with no flow seen on color Doppler ultrasound in the region, while the remaining unaffected testicular parenchyma shows normal blood flow.[3] Overlapping clinical symptoms lead to a differential diagnosis that includes not only conventional testicular torsion and epididymitis but also hypovascular tumors. Chronically infarcted testicular tissues may become necrotic leading to focal areas of tissue loss or scarring, thus confounding the diagnosis even further and making differentiation from a testicular tumor even more challenging.[3] In these cases, contrast-enhanced MRI or short-interval follow-up ultrasound may be helpful to distinguish chronic infarction from a tumor in ambiguous cases. Pelvic MRI may solidify the diagnosis, exclude a hypovascular tumor, and potentially spare the patient from orchiectomy.

Testicular Torsion Mimic: Torsion of the Appendix Testis

Another cause of acute scrotal pain that may mimic testicular torsion is a torsed testicular appendage. The testicular appendages are extratesticular structures prone to torsion owing to their pedunculated anatomical configuration (Fig. 11). Although acute scrotal pain is germane to both testicular

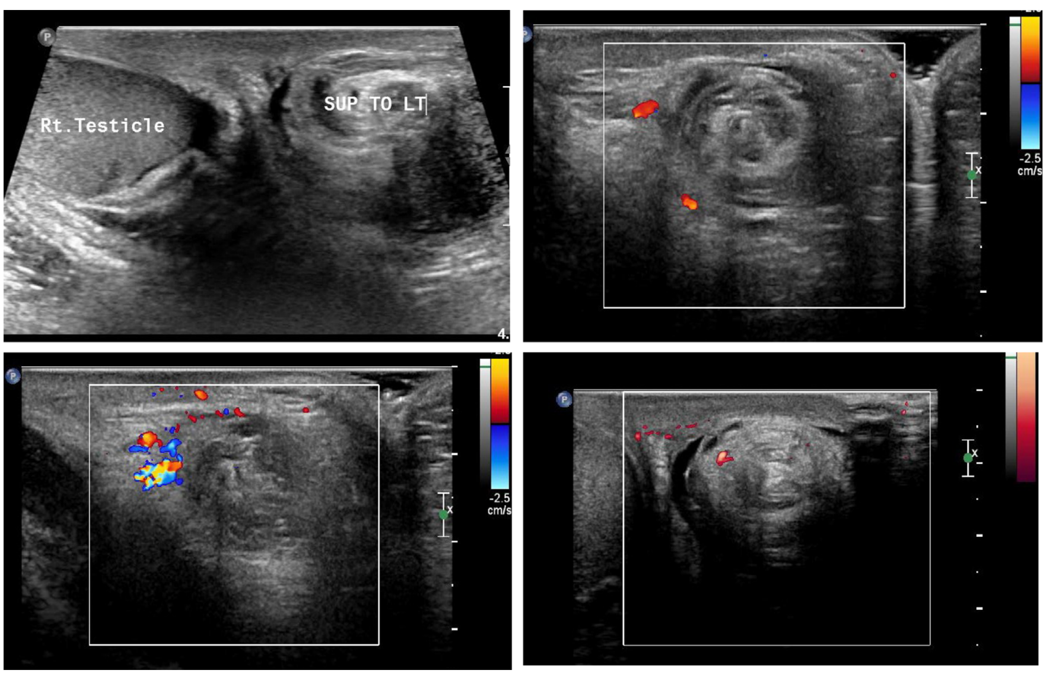

Figure 10 *Testicular torsion*: Gray-scale, color, and power Doppler assessment of the testes. The right testicle is homogeneous in echotexture and morphologically normal in appearance. There is an abnormal lie of the left testis with swirling of the spermatic cord (whirlpool sign) and diminished flow seen on color and even on power Doppler interrogation. (Color version of figure is available online.)

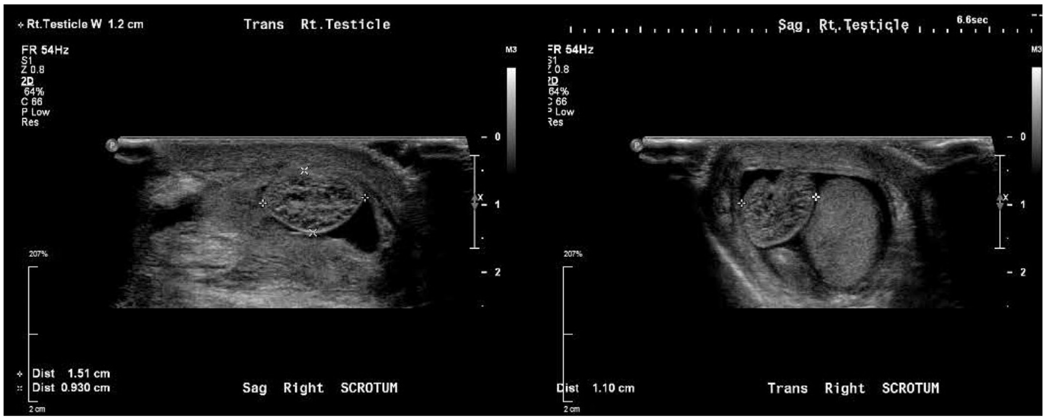

Figure 11 Torsion of the testicular appendages. Heterogeneous extratesticular mass with the appearance of a torsed appendage. This patient experienced pain following trauma that eventually subsided after 2 days. The presence of small, adjacent hydrocele renders the testicular appendage visible normally.

torsion and torsion of the testicular appendages, the latter often portends a more gradual onset of pain. Furthermore, pain may often be localized to the superior testicular pole in torsion of the appendix testis, and a characteristic blue-dot seen on clinical examination is pathognomonic. However, the blue-dot sign is not commonly present clinically on visual examination. On imaging, an enlarged appendix testis with absence of flow and a reactive hydrocele is characteristically seen.[3] This testicular pathology is seen more commonly in the pediatric population with a mean age of 9 years. Torsion of the appendix testis is self-limiting and does not require surgery.[19]

Miscellaneous Scrotal Processes Presenting in the Emergency Setting

Other miscellaneous scrotal pathologies presenting in the emergent setting include cases of testicular ischemia. Uncommon causes for testicular ischemia other than testicular torsion include vasculitides such as systemic lupus erythematosum, sickle cell disease, polyarteritis nodosa, patients in hypercoagulable states, those with uncontrolled or unresponsive epididymo-orchitis, and venous thrombosis. These causes are much less common and often seen in the setting of known underlying systemic processes.

Scrotal Emergencies—Infectious

Although testicular torsion is one of the most important acute male pelvic conditions, inflammatory processes, such as epididymitis or epididymo-orchitis, are significantly more likely to be the cause of acute scrotal pain. In cases of these infectious entities, Doppler ultrasound is usually well tolerated and extremely useful to clearly delineate testicular or epididymal pathology from other scrotal pathology.

As previously mentioned, epididymitis and epididymo-orchitis are the 2 most common causes of acute scrotal pain. Epididymitis is simply an infection of the epididymis. The cause is felt to be secondary to an ascending bacterial infection from the lower urinary tract with infection spreading in a retrograde fashion.[39] The characteristic clinical presentation of epididymitis is acute unilateral scrotal pain. Involvement of the epididymal tail may be present before involvement of the epididymal head or body, and therefore the epididymal tail should be evaluated carefully (Fig. 12). Epididymo-orchitis, on

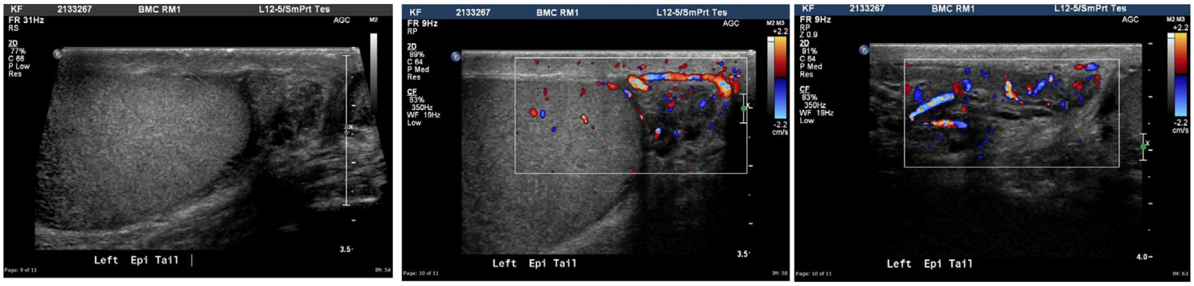

Figure 12 Epididymitis isolated to the epididymal tail, and normal appearance of the epididymal head and body (not shown). Enlarged, edematous epididymal tail that is heterogeneous on gray-scale analysis and demonstrates increased vascularity on color Doppler assessment. (Color version of figure is available online.)

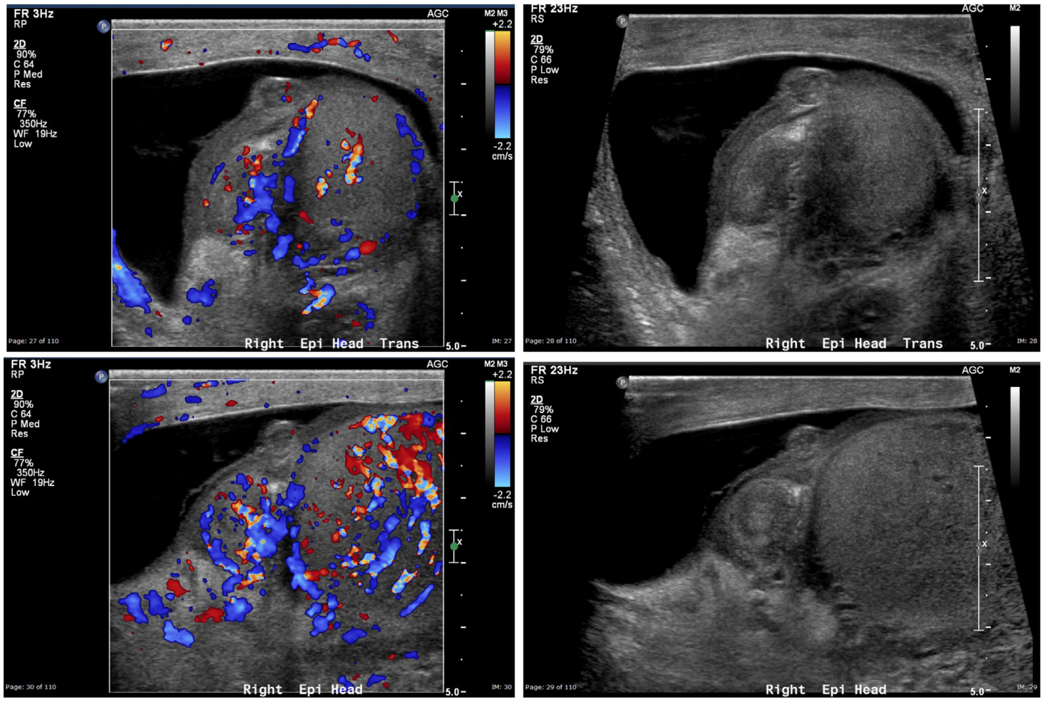

Figure 13 Epididymo-orchitis: markedly edematous and hyperemic epididymis with extension into the testicle, pathognomonic for epididymo-orchitis. A minimally complex hydocele containing a few thin line echoes is also present. (Color version of figure is available online.)

the contrary, refers to infection that has spread from the epididymis to also include the testicle (orchitis). Although avascular hypoechoic areas in the testicular parenchyma may represent orchitis, completely absent or minimal flow throughout the testis is much more suspicious for testicular torsion.

A key sonographic finding in acute epididymitis is an inflamed, enlarged, and heterogeneous-appearing epididymis, with increased color Doppler flow compared to the testicular parenchyma. In the case of acute epididymitis, the epididymis may appear markedly hypoechoic relative to the adjacent testicle because of associated edema.[3] The epididymal infection may progress to include the testis with resultant epididymo-orchitis (Fig. 13). Testicular echogenicity may appear normal early on and become more heterogeneous with spread of infection from the epididymis into the testicular parenchyma (Fig. 14). With epididymo-orchitis, color Doppler flow to the epididymis and the testicle will also be increased, which indicates the presence of hyperemia. A reactive hydrocele, often containing low-level echoes, and adjacent scrotal skin thickening may also be present. Characteristically, the Prehn sign is present when pain that is associated with epididymo-orchitis is relieved with testicular elevation above the pubic symphysis.[23]

Testicular and extratesticular infections and secondary inflammation can cause venous hypertension, a risk factor for focal testicular ischemia.[3] Furthermore, if the diagnosis of epididymitis is missed or delayed, and the entity is left untreated, this infectious process may lead to abscess formation and testicular infarction.[7] Incomplete or late treatment of epididymo-orchitis may also be complicated by the development of a pyocele or testicular abscess.

Complications of Infectious Scrotal Processes

An epididymal abscess may result from untreated epididymitis. On gray-scale ultrasound, an enlarged epididymis with internal cystic components and layering echogenic fluid or debris or both may be present. The infectious process may furthermore cause a reactive complex hydrocele. A testicular abscess represents a walled off infection in the testis from prior untreated or undertreated orchitis, most commonly from epididymo-orchitis. Gray-scale ultrasound may demonstrate a central hypoechoic region of liquefaction.[40] Color Doppler ultrasound may depict a lack of flow centrally. Both the gray-scale and color Doppler findings are indicative of abscess formation, and although not a surgical emergency, this process may require surgical drainage if antibiotic treatment is unsuccessful. Surgical drainage is indicated in untreated or undertreated orchitis mainly because it can result in vascular compromise, leading to testicular infarction and atrophy.[7]

A scrotal pyocele is a collection of purulent material in the scrotum, generally occurring in the setting of epididymo-orchitis (Fig. 15). This purulent scrotal fluid collection may result from an acutely infected testicle across the tunica vaginalis into a preexisting hydrocele (Fig. 16). Characteristic features of a scrotal pyocele on ultrasound are complex, septated, and heterogeneous fluid collection in the scrotal sac. Pyoceles may eventually organize into scrotal abscesses (Fig. 17). Rarely, an intrascrotal

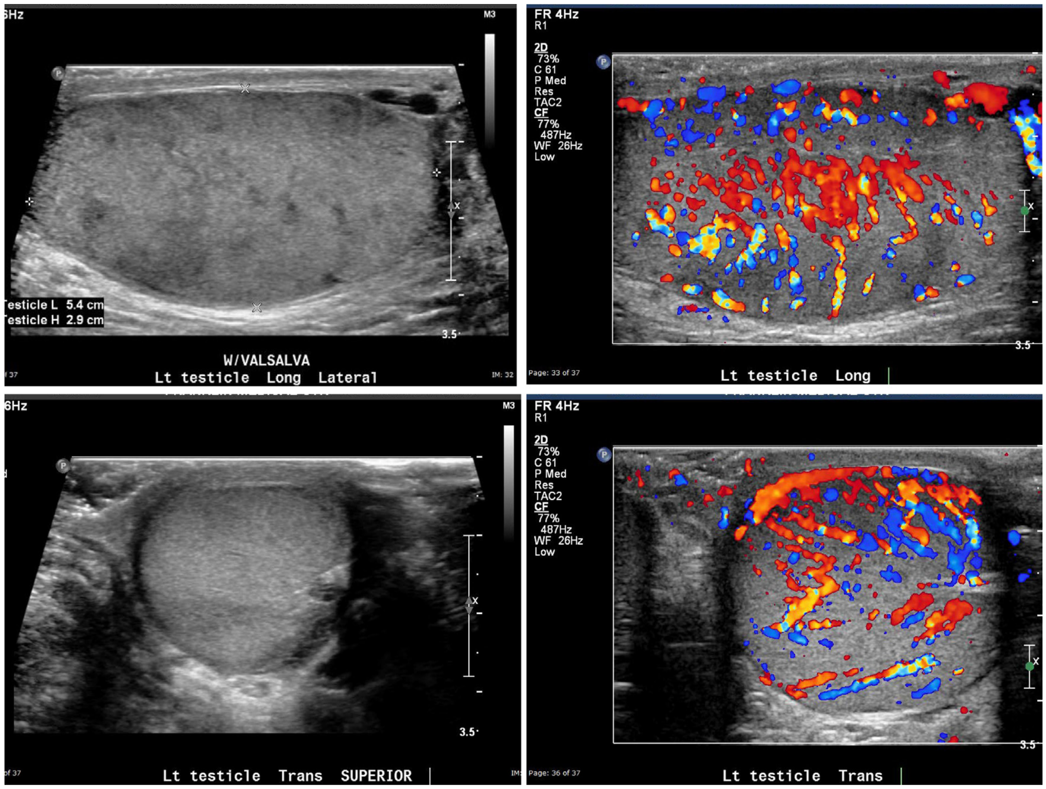

Fig. 14 *Orchitis*: hyperemic, mottled testicular echotexture with hypoechoic regions. Color doppler images show testicular hyperemia. This is often the result of spread from pre-existing epididymitis (not shown), rarely when isolated to the testicular parenchyma without associated epididymitis. This entity is known as orchitis and may be secondary to mumps. (Color version of figure is available online.)

abscess may arise as a complication of bacterial epididymitis.[33] Alternatively, an intrascrotal abscess may also arise because of a testicular abscess that ruptured through the tunica albuginea, or purulent drainage from appendicitis into the scrotum in the setting of a patent processus vaginalis. On ultrasonography, an intrascrotal abscess will appear as a complex fluid collection in the scrotum with thickening of the scrotal soft tissues.

Other less common infectious sources of pelvic pain not confined to the scrotum may be from acute prostatitis. Although acute prostatitis is less commonly an indication for imaging in the acute emergent setting, this infectious process may represent a source of acute pain in the male pelvis. Standard scrotal or pelvic ultrasound is not adequate to image the prostate gland, which is a deep pelvic structure inferior to the bladder, surrounding the prostatic segment of the urethra. Transrectal ultrasound may be performed in the nonemergent setting but is generally not well tolerated in the setting of active prostatitis due to exquisite pain in the area. Although acute prostatitis is typically a clinical diagnosis characterized by elevated prostate-specific antigen levels, prostatic imaging is useful to assess for complications of acute prostatitis such as prostatic abscesses. An alternative imaging approach available in the diagnostic armamentarium that is often useful in the setting of acute prostatitis is pelvic MRI, as it is better tolerated than transrectal ultrasound and yields superb tissue characterization in the assessment of prostatic abscess formation.

Additional Infectious Pelvic Surgical Emergencies

Fournier gangrene is a necrotizing infectious fasciitis of the scrotum and perineum that involves both superficial and deep fascial planes, allowing rapid spread of infection via deep tissue planes. Infection is usually polymicrobial, and common organisms responsible for this serious infection are mixed aerobic and anaerobic bacteria.[41] Although visualization of gas within the soft tissues is pathognomonic, the diagnosis of Fournier gangrene is a clinical diagnosis and absence of visualized gas in the soft tissues does not exclude its presence. The modality of choice to depict Fournier gangrene is computed tomography (CT). Predisposing factors for the development of Fournier gangrene include comorbid conditions that compromise the immune system such as diabetes mellitus and alcoholism.[42] There are significant clinical implications involved in the diagnosis of Fournier gangrene because rapid spread of infection along fascial planes may quickly lead to tissue necrosis, devascularization, or eventual loss of the involved limb.[43] Treatment involves aggressive surgical debridement, broad-spectrum antibiotic therapy, and hemodynamic stabilization.

As previously alluded to, the characteristic imaging finding associated with Fournier gangrene is subcutaneous gas, which on ultrasound appears as multiple echogenic reflectors in the

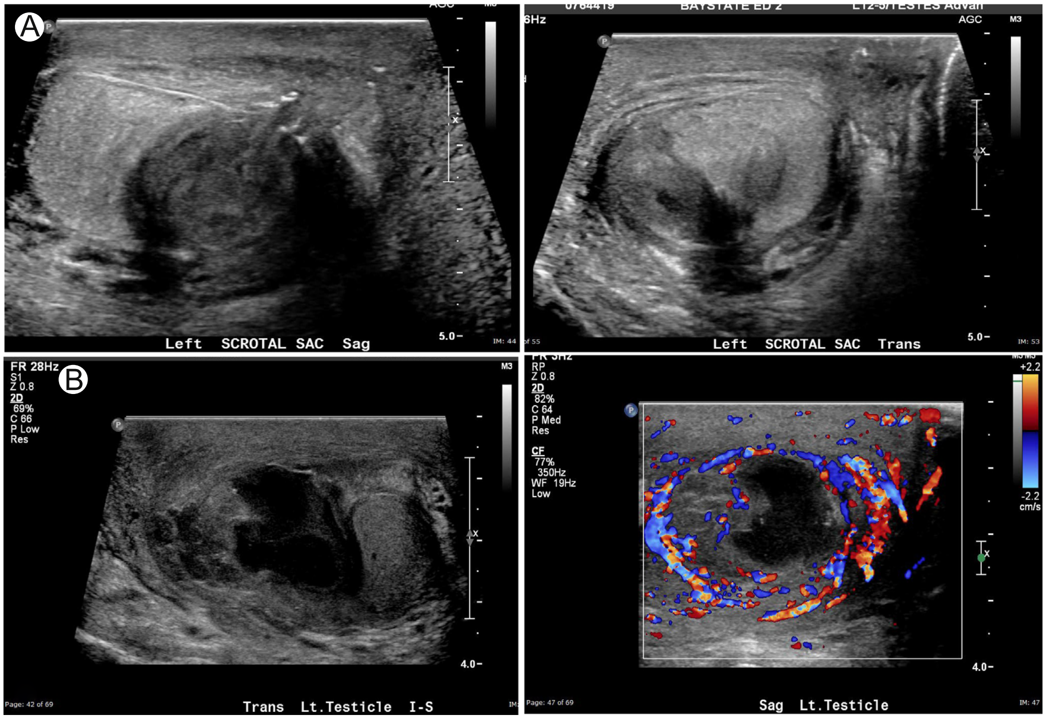

Figure 15 (A) Pyocele following testicular surgery. The patient experienced scrotal pain, swelling, and purulent scrotal discharge after testicular surgery. Abnormal appearance of the left hemiscrotum with significant skin thickening and echogenic debris within the left hemiscrotum. (B) Left pyocele in a patient with epididymitis (not shown). Diffuse hyperemia and reactive complex fluid collection in the left hemiscrotum with thick septations. (Color version of figure is available online.)

subcutaneous tissues with dirty shadowing (Fig. 18). A small amount of fluid may also be present. Ultrasonography may be helpful for those who are unable to be transported to the CT scanner. However, ultrasound alone is usually suboptimal to assess the full extent of the disease, especially in the deep recesses of the ischioanal fossa, owing to its anatomical depth.[3] Furthermore, because direct pressure on the perineum is not well tolerated in patients with Fournier gangrene, ultrasonography in these patients may not be a practical examination to undertake. Instead, CT is the modality of choice, because it is readily available, has a reasonably quick acquisition time, and may illustrate the source of infection as well as the pathway of spread of even small areas of gas and fluid within the deep fascial planes (Fig. 19). CT is additionally used to map the extent of involvement for surgical debridement planning.

Scrotal Emergencies—Scrotal Trauma

Other indications for pelvic ultrasound imaging in the emergent setting may be the result of scrotal trauma including blunt scrotal trauma and penetrating scrotal trauma, as well as scrotal avulsion and degloving injuries. In the setting of trauma, the goal of ultrasonography is to evaluate the testicular blood supply and integrity of the tunica albuginea because disruption of the tunica albuginea warrants surgical exploration and repair. Scrotal trauma comprises less than 1% of all annual traumas in the United States with peak age between 10 and 30 years.[15] The right testis is more commonly injured compared to the left because of its higher riding anatomical

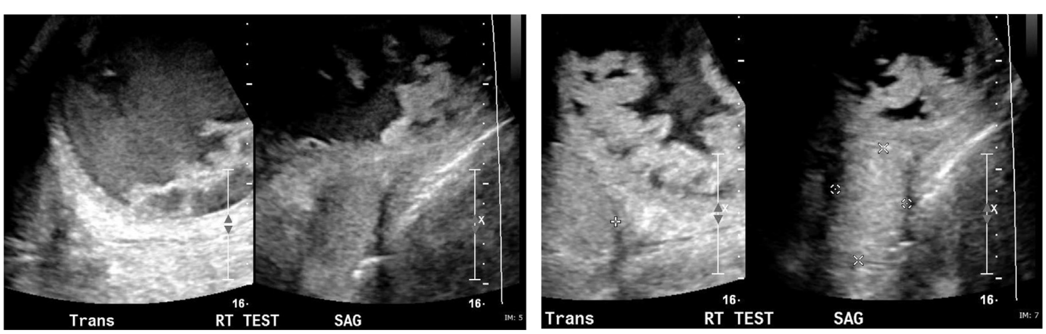

Figure 16 Complex right scrotal hydrocele. Large heterogeneous complex fluid collection with echogenic debris.

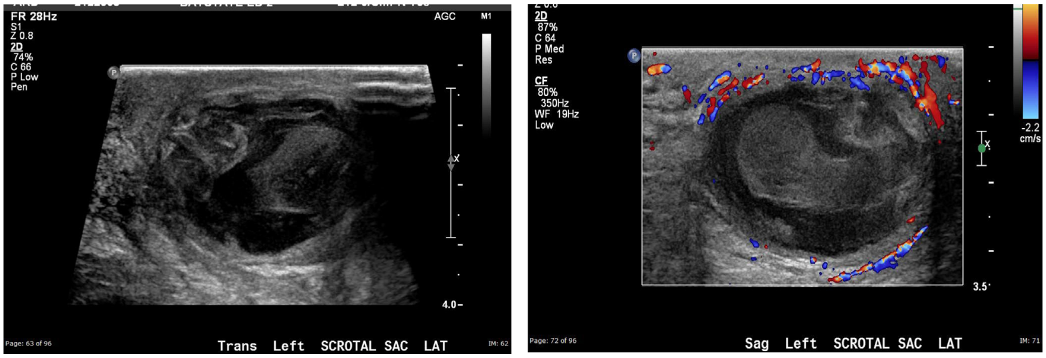

Figure 17 Scrotal abscess: large heterogeneous scrotal collection, with no internal flow on color Doppler assessment. (Color version of figure is available online.)

position and increased chance of becoming trapped against the pubis.[44] Blunt trauma to the scrotum and testis may cause a testicular contusion, hematoma, fracture, laceration, or rupture. Blunt scrotal trauma is most common due to sports injury in young males, but may also be seen secondary to motorcycle collisions.[7] Penetrating scrotal injuries may result from an assault, gunshot wound, animal attack, or even be self-inflicted.[2] Avulsion and degloving injuries are less common and result in shearing off of the scrotal skin[15] Under certain circumstance, acute scrotal trauma may require emergency surgical repair. Patients presenting with testicular rupture and extratesticular hematoma may mimic one another or may be concomitant presenting with immediate scrotal swelling after trauma. Ultrasound can differentiate intratesticular and extratesticular injuries from one another to promptly identify those that need emergent surgical management. Often, an extratesticular hematocele secondary to scrotal trauma can be managed conservatively.[5,45]

Clinical Findings

Clinically, acute scrotal pain, swelling, bruising, and even associated skin losses may result from direct injury to the scrotum. Unfortunately, embarrassment associated with the site of injury, the mechanism of injury, or even the circumstance in which the injury occurred often result in delayed presentation and an even more complicated diagnostic assessment.[46]

Sonographic Findings in Scrotal Trauma

Scrotal imaging in the setting of trauma may include interruption of the tunica albuginea with protrusion of the seminiferous tubules. Testicular heterogeneity with testicular contour abnormalities and areas of tunica albuginea disruption is pathognomonic for testicular rupture,[47,50] and recognizing this discontinuity increases confidence in the diagnosis of testicular rupture[47,48] (Fig. 20). Testicular rupture often is seen simultaneously with an associated testicular contusion or hematoma (Fig. 21).

Gray-scale ultrasound features of an injured heterogeneous testis with irregular borders and focal areas of altered testicular echogenicity may correspond to areas of testicular contusion, infarction, and hematocele formation. Avascular hypoechoic regions may be present, which represent intratesticular hematomas, whereas more linear hypoechoic areas may represent testicular fracture, indicating a defect in the testicular parenchyma, although rarely seen[49,51] (Fig. 22). Direct visualization of a discrete fracture line is only present in 17% of cases of testicular fracture.[7,49] However, there is an 80%-90% salvage rate if surgical repair is performed within 72 hours vs only a 45%

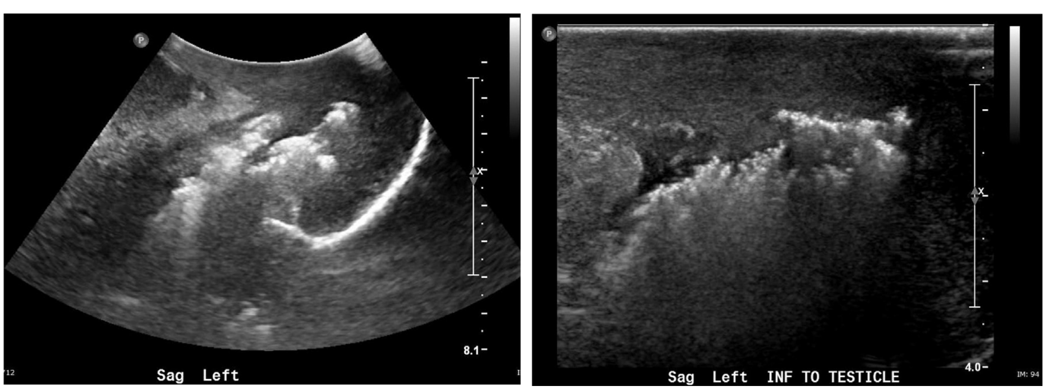

Figure 18 Fournier gangrene: scattered areas of increased echogenicity in the scrotal sac inferiorly with dirty shadowing, which most likely represents gas within the soft tissues.

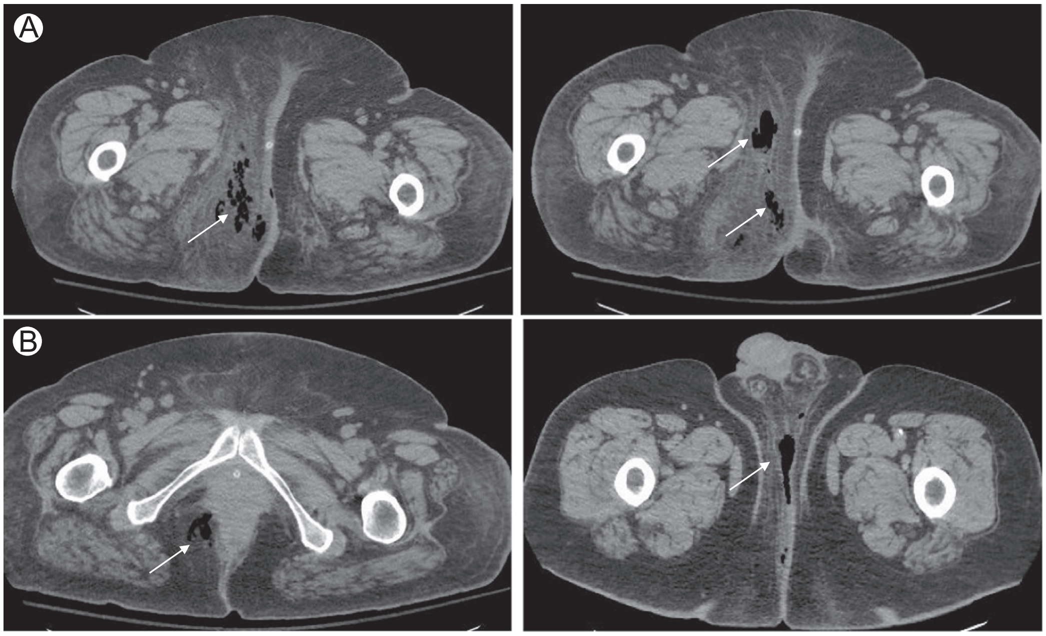

Figure 19 (A) *Fournier gangrene*: pelvic CT shows soft tissue gas seen in the perineum (arrows). (B) Pelvic CT in a different patient shows soft tissue gas along the the ischiorectal fossa on the right as well as in perineum and base of the scrotum at midline (arrows).

salvage rate thereafter.[5] Testicular fracture with an intact tunica albuginea can be managed conservatively if normal perfusion is preserved and confirmed on color Doppler ultrasound.[15]

Complex fluid surrounding the ruptured or fractured testicle may represent a hematocele. Extratesticular hematoceles are collections of blood within the tunica vaginalis, typically seen after blunt trauma.[52] In actual cases of scrotal hematoceles caused by direct injuries to the scrotum and its contents, an echogenic, extratesticular mass with no color Doppler flow is typically present sonographically. Although hematomas lack internal color Doppler flow, surrounding tissues may appear mildly hyperemic.[33,53] Acute hematoceles appear more echogenic, whereas chronic hematoceles are more anechoic, often lobulated with septations. Large hematoceles may cause extrinsic compression on nearby vessels, and surgical evacuation may be necessary to restore blood flow to save the testis. Therefore, limited evaluation for tunica rupture must be done in the setting of a large hematoma.[54] An important potential mimic to testicular injury with resultant hematocele in the setting of trauma is a painless hematocele found, especially in the pediatric population, which can occur in conjunction with abdominal trauma and abdominal solid organ injury such as splenic laceration due to a persistent processus vaginalis.[55]

Scrotal hematomas can evolve into complex, multiseptated mass-like lesions that make a discrete distinction between the testicle and the extratesticular hematoma difficult. Intratesticular hematomas are common sequelae of blunt trauma, and their appearance depends on the time interval that has elapsed since the trauma. More hypoechoic or anechoic collections are seen with more time lapse. Small hematomas with preserved testicular integrity may be treated conservatively. However, follow-up imaging is required owing to the high incidence of superimposed infection and necrosis.[5]

This proper distinction is necessary to avoid mistaking a hematoma for a testicular mass and resultant inappropriate orchiectomy. Scrotal hematomas may also lead to testicular compression when large enough. Large intratesticular hematomas require surgical exploration to avoid pressure necrosis.[56] Changing management algorithms suggest surgical exploration when intratesticular hematomas are greater than 5 cm. Therefore, image measurements of hematoceles and hematomas as well as close ultrasound follow-up are preferred in those undergoing conservative treatment.[3]

In cases of testicular contusion, sonographic imaging frequently demonstrates a peripheral, hypoechoic lesion that may mimic tumor. Despite a history of recent trauma, a suspicious testicular lesion requires further evaluation to exclude malignancy. Typically, this is achieved with a short-term follow-up. On MRI, the tunica albuginea, a fibrous structure, appears as a hypointense line around the testicle on T1- and T2-weighted images. Disruption of this line suggests testicular rupture.[57] Heterogeneously low T2 testicular signal suggests testicular injury.[58,59]

Scrotal Injuries in the Setting of Significant Trauma

In the setting of life-threatening trauma, scrotal injuries may be treated in a delayed fashion with general wound care and saline dressings, while associated injuries set the priority for timing for surgical interventions.[60] Traumatic injuries, such as burn victims, resulting in extensive skin losses or total scrotal avulsion may require delayed grafting. In such cases,

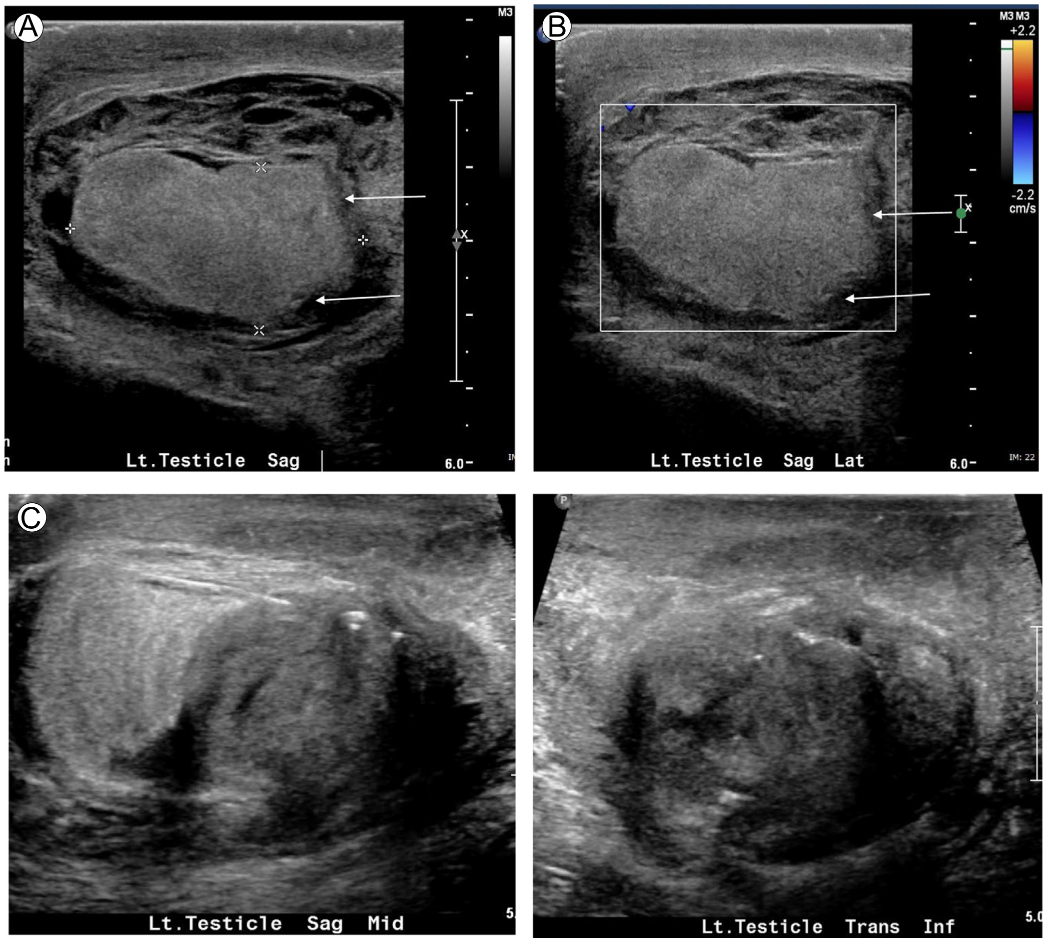

Figure 20 Testicular rupture with resultant hematocele. (A) Heterogeneous echotexture of the left testis with contour deformity most pronounced along the inferolateral margin (arrows) compatible with interruption of the tunica albuginea, and indicating testicular rupture. (B) Global absence of normal vascularity. A resultant moderate-sized heterogeneous hematocele is seen on both images. (C). Ruptured left testis. This patient was struck in the scrotum by a lacrosse ball. Abnormally hypoechoic testicular tissue with irregularity and contour defect of the tunica albigunea. A small amount of normal testicular parenchyma remains preserved. (Color version of figure is available online.)

there may be an indication for placing testes within a thigh pouch until coverage has been addressed for more vital structures.[60]

Testicular dislocation is a less common consequence of scrotal trauma, which is usually unilateral when present.[61] Testicular dislocation occurs when an upward force is directly applied to the scrotum, which forces either one or both testicles into the surrounding tissues.[62-64] Testicular dislocation is typically into the inguinal canal, often associated with an acetabular fracture and compression injury to the pelvic ring.[65] Testicular dislocation is a rare finding, most frequently associated with motorcycle collisions; this includes the spectrum with anterior-posterior compression.[63,64,66]

Although testicular dislocation is most commonly present in the setting of a motorcycle collision, it may also present following a wide variety of traumatic injuries that result in significant pelvic trauma. Owing to the severity of concomitant injuries, this entity may easily be overlooked.[5] Testicular dislocation can occur anywhere along the spermatic cord pathway, but it most commonly dislocates into the superficial inguinal region.[63,67] Clinically, testicular dislocation presents as a scrotal ecchymosis, an empty hemiscrotum, and an ipsilateral inguinal mass. Manual reduction of the testicle back into the scrotum may be attempted, but surgical reduction is required if the maneuver fails.[68] Those with pre-existing indirect hernias, atrophic testes, and wide external inguinal ring are at increased risk for testicular dislocation in the setting of trauma.[69,70] Testicular dislocations into the deep inguinal canal and the abdominal cavity have also been reported but are extremely rare.[63,71] Therefore, patients presenting after motorcycle collisions with acetabular fractures or pelvic ring should be assessed for possible testicular dislocation on scrotal examination. Once the diagnosis of testicular dislocation is made, surgical reduction and orchiopexy are necessary to prevent urologic and sexual issues including problems with spermatogenesis and fertility.[63,66] If any doubt exists as to the integrity of the testicle or spermatic cord, an open testicular reduction is warranted.[66]

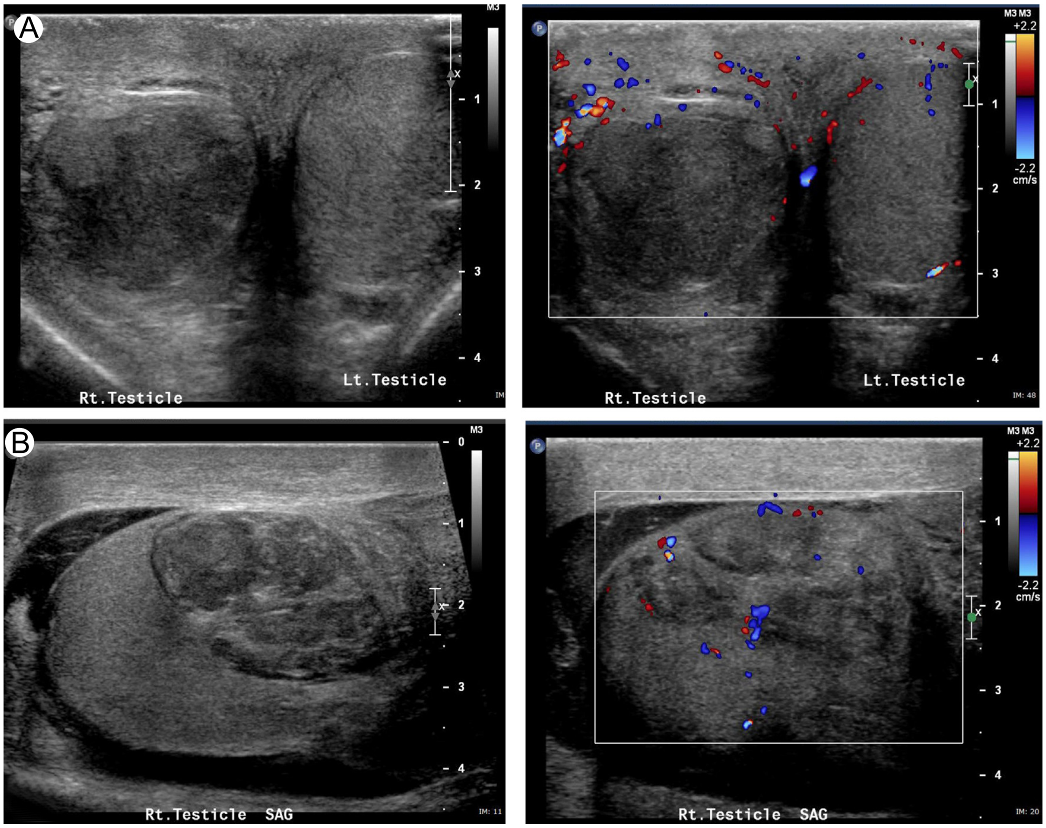

Figure 21 (A) Heterogeneity and expansion of the testicular parenchyma due to a large intratesticular hematoma. Additional intratesticular edema results in decreased blood flow when compared to the contralateral left testicle. Reactive scrotal wall thickening and hyperemia is also present from related trauma. (B) Intratesticular hematoma and resultant hematocele. Complex-appearing heterogeneous region within the substance of the right testicle representing an intratesticular hematoma. Moderate-sized complex right hydrocele, likely containing blood products suggestive of a hematocele. (Color version of figure is available online.)

Pelvic Ultrasound for Bladder Injury

Pelvic ultrasound is not the primary modality for suspected bladder injury in the setting of acute trauma. CT cystography is currently the most appropriate test to evaluate suspected bladder rupture. This is due to the ready availability of CT cystography and its ability to delineate associated or causative injuries (i.e., pelvic fractures).[72]

Delayed imaging from a standard intravenous contrast study is not sensitive enough, and full bladder distension is typically

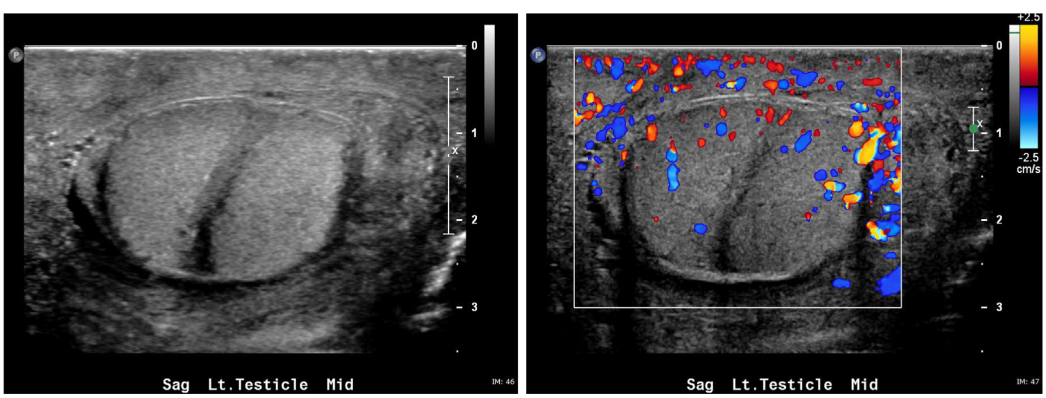

Figure 22 Old intratesticular fracture with subsequent linear hypoechogencity traversing the left testis. Preservation of flow in the remaining testicular parenchyma. (Color version of figure is available online.)

necessary. To perform a CT cystogram with a high level of accuracy, the urinary bladder should be distended with dilute water-soluble contrast (approximately 40-50 mL of IV contrast mixed in warm saline) for a total volume of at least 350 mL to be instilled into the urinary bladder by gravity, or as much as the patient can tolerate.[72] Bladder injuries are stratified into intraperitoneal (least common), extraperitoneal (most common), or combined intraperitoneal and extraperitoneal bladder injuries. Of clinical importance, pelvic fractures in male patients with suspected bladder injury may have associated urethral injury. Blood present at the urethral meatus suggests a urethral injury, which requires a retrograde urethrogram for diagnosis.

Penile Emergencies

Penile Anatomy

The penile shaft is composed of 3 columns: 2 corpora cavernosa and 1 corpus spongiosum. The tunica albuginea surrounds the paired corpora cavernosa and contains erectile tissue. The corpus spongiosum lies in a ventrally oriented groove between the paired corpora cavernosa, and the urethra passes through the center of the corpus spongiousum (Fig. 23). Corpus spongiosum continues anteriorly as the glans penis.[73] The combined corpora have 2 associated fascial layers. The superficial fascial layer is Colles layer. The deep penile fascia is referred to as Buck fascia, which splits to surround the corpus spongiosum and contains the deep dorsal vein and paired dorsal arteries as well as branches of the dorsal nerves on the dorsal aspect of the corpora cavernosa.[2] Buck fascia is a strong, deep fascial layer located immediately superficial to the tunica albuginea.

Deep arteries of the penis supply blood flow to the corpora cavernosa via the cavernosal arteries, a terminal branch of internal pudendal artery.[2] Each cavernosal artery is found within the central corpus cavernosum and provides inflow for erection. The bulbourethral artery supplies the posterior corpus spongiosum and urethral bulb.[73] The deep dorsal vein is venous drainage to Buck fascia and superficial dorsal vein supplies venous drainage to the superficial fascia. Color Doppler ultrasound is used to demonstrate patency of the penile arteries and veins.

Although somewhat less common, male pelvic emergencies may include penile trauma due to blunt or penetrating injuries. Of these causes, imaging is most often used in the setting of blunt trauma, while those victims of penetrating trauma often prompt surgical exploration. Vascularity is rapidly evaluated with color and spectral Doppler ultrasound. Traumatic complications such as penile fracture may occur when one or both corpora cavernosa rupture due to a tear in the tunica albuginea.[74] An erect penis is at increased risk for fracture because the cavernosal tunica albuginea is stretched and thinned during erection.[75] Therefore, most penile fractures are related to sexual activity.[76] Simultaneous penile urethral injury occurs in 10%-20%.[77] Ultrasonography is used to assess the extent of the tear in the tunica albuginea and has limited use for evaluation of the urethra sonographically. Retrograde urethrography is necessary for evaluation of clinically suspected urethral injury.[78]

Penile fracture usually occurs along the mid-shaft and is a urologically urgent situation typically requiring surgical exploration to prevent long-term complications. The consequences of conservative treatment in the setting of penile fracture are missed urethral injuries, stricturing, penile deformity, painful erection, and erectile dysfunction.[79] Ultrasound evaluation allows for assessment of normal anatomy as well as the extent of the injury and precise location of the tear in the tunica albuginea.[44]

A concomitant finding in the setting of penile trauma may be an intracavernosal hematoma. This entity results from injury to the cavernosal tissue when the penis is crushed against the bony pelvis.[44] Imaging features of an intercavernosal hematoma are similar to hematomas seen elsewhere in the body, heterogeneous on gray-scale ultrasound, and avascular on color Doppler with or without adjacent areas of reactive hyperemia in the surrounding tissues.

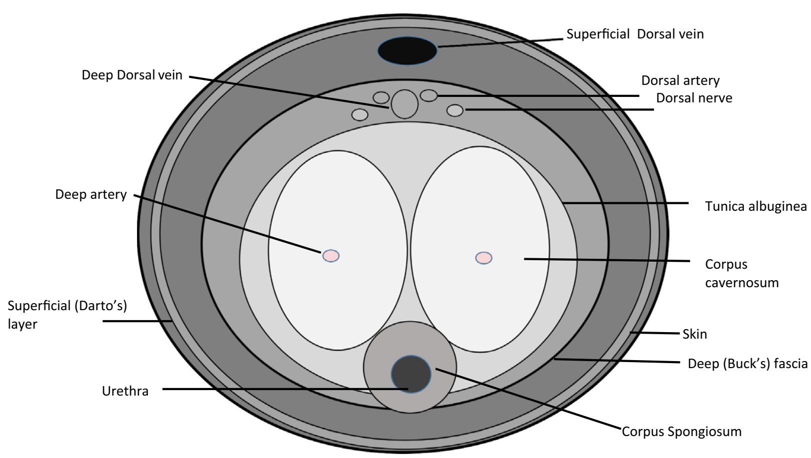

Figure 23 Cross-sectional view of normal penile anatomy. (Color version of figure is available online.)

Other Nontraumatic Vascular Penile Emergencies

Priapism is characterized by prolonged penile erection not associated with sexual desire.[80,81] Priapism can be categorized into low-flow and high-flow states. The most common type of priapism is the low-flow state and is caused by a malfunction of normal penile outflow. Low-flow priapism is often secondary to hypercoagulable states, malignancy, and thrombophilic states such as sickle cell disease, medications leading to high cavernous pressure, and resulting in irreversible ischemic changes.[80,82] This is a surgical emergency because prolonged obstruction of venous outflow leads to persistently high cavernous pressures, and possibly irreversible ischemic changes and permanent erectile dysfunction. High-flow priapism, on the contrary, is due to unregulated arterial inflow from genitourinary trauma, and is less common. High-flow priapism typically presents as painless, partial erection not associated with sexual desire.[62,83] This entity is not a surgical emergency and is not associated with permanent erectile dysfunction. Ultrasound is used to evaluate penile pain and priapism to distinguish between ischemic low-flow and nonischemic high-flow priapism.[80] In high-flow priapism, color and spectral Doppler ultrasound may demonstrate a cavernosal artery pseudoaneurysm or fistula that may require angiographic embolization.[84]

Another vascular etiology affecting the penis that may result in acute pain is Mondor disease, a thrombophlebitis of the superficial dorsal penile vein. Multiple etiologies including vigorous sexual activity, trauma, pelvic surgery, and hypercoagulable states have been suggested as causal factors leading to this condition. Venous thrombosis is indicated by lack of blood flow and noncompressibility of the dorsal vein on ultrasound.[3] Mondor disease is self-limited, like thrombophlebitis anywhere else in the body, and thus may be treated conservatively.[81]

Conclusion

Pelvic emergencies in a male patient may be associated with significant morbidity and mortality.

Entities such as testicular torsion, Fournier gangrene, and testicular dislocation are surgical emergencies that should not be missed, or misdiagnosed, as urgent treatment may be necessary. Delayed diagnoses may lead to significant morbidity or mortality or both, and radiologists need to have adequate knowledge of the role of the appropriate imaging, as well as the characteristic imaging findings of these entities. Diagnosis of acute scrotal pain often requires gray-scale, color, and spectral Doppler assessment. Although ultrasound is typically the first-line imaging tool used to evaluate the male pelvis, CT, MRI, and retrograde urethrography also play supplementary roles in certain clinical scenarios. Familiarity with both normal and abnormal male pelvic imaging allows radiologists to distinguish entities that are true emergencies and warrant prompt urologic intervention vs those processes that deserve conservative management. Ultrasound assessment is the modality of choice to quickly direct the most appropriate treatment. Color and spectral Doppler assessment are also an essential component of the ultrasound examination to make accurate assessments regarding scrotal integrity and viability.

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