



ULTRASOUND EVALUATION OF ACUTE SCROTAL PAIN

INTRODUCTION

Ultrasound is the preferred imaging modality for evaluating the patient with acute scrotal pain. Over the past decades, ultrasound has continuously evolved to allow high resolution imaging of the testicular parenchyma, scrotal soft tissues and the surrounding structures. Additionally, use of Doppler analysis allows detection and diagnosis of abnormalities affecting the vasculature. Ultrasound plays a key role in triage, as the patient presenting with acute scrotal pain can often produce a diagnostic dilemma for the evaluating clinician. Significant pain and non-specific laboratory and physical examination findings create overlap between several acute scrotal conditions. The portability, speed, accessibility and lack of ionizing radiation make ultrasound the most attractive imaging modality in the evaluation of acute scrotal pain.

SCANNING TECHNIQUE

The scrotum is effectively scanned using a high-frequency (8-15 MHz), linear-array transducer with the patient in the supine position. While use of a high-frequency probe optimizes visualization of anatomic detail, lower frequencies may be required to provide adequate penetration in some situations. Images of each testis and epididymis are obtained in the transverse and longitudinal planes and compared. In cases of a unilateral abnormality, the gray scale gain and Doppler parameters should be optimized on the contralateral, normal side before scanning the abnormal side. Application of color Doppler provides exquisite evaluation of blood flow to the testis and epididymis. In cases where vascular compromise is suspected, it is paramount that Doppler parameters be optimized to detect slow flow. The initial Doppler settings that enable detection of low velocities include use of a low wall filter, low pulse repetition frequency and high Doppler gain setting. Additionally, use of power Doppler provides increased detection of slow flow compared to color Doppler evaluation. Power Doppler employs integration of the Doppler signal to detect flow and allows higher gain settings. In addition to its ability to demonstrate slow velocity flow, Power Doppler is independent of Doppler angle correction. In addition to optimizing parameters and scanning the scrotum, a thorough US evaluation should include a survey of the inguinal canals and perineal soft tissues, as acute conditions affecting these structures can result in pain referred to the scrotum. Evaluation of these regions may require the technologist to reposition the patient so that the relevant anatomy is exposed and can be properly insonated.

ULTRASOUND ANATOMY

The scrotum is divided in the midline by the median raphe, which can be seen as a thin echogenic fibrous band on gray scale evaluation. The scrotal wall consists of skin and several layers of muscle and fascia. Normal scrotal wall thickness varies with the contractile state of the cremasteric muscle but ranges between approximately 2-8mm. Each hemiscrotum consists of a testis, epididymis, connective tissue and muscle. The normal testis appears as an ovoid, homogenous structure with intermediate echogenicity. The mediastinum of the testis consists of a thin echogenic band which extends along the longitudinal axis of the testis for a variable length. The mediastinum testis arises as a reflection of a thin fibrous

covering which surrounds each testis referred to as the tunica albuginea. The tunica albuginea can be identified at US as a thin echogenic interface along the surface of each testis. The tunica vaginalis covers the tunica albuginea and contains a small volume of anechoic fluid between its leaves. In the minority of patients, the rete testis, a series of dilated spaces draining into the epididymis, appears as an adjacent hypoechoic area with variable striation. The epididymis sits at the superior aspect of the testis and appears as an elongated hypoechoic tubular structure consisting of a head, body and tail. The epididymal head appears as a hypoechoic pyramidal structure measuring approximately 1cm. The epididymal head is typically isoechoic to the testis, but is slightly less homogeneous. Testicular appendages appear as subcentimeter ovoid structures which are isoechoic to the testis. The blood supply to the testes is primarily derived from the testicular arteries which originate from the abdominal aorta. The deferential artery arises from the superior vesicle artery while the cremasteric artery arises from the inferior epigastric artery; these arteries supply the epididymis, vas deferens and the scrotal soft tissues. Spectral flow within the testes typically consists of a low-resistance waveform in the adult.

TORSION

One of the most feared etiologies of acute scrotal pain is testicular torsion. While torsion can affect patients of all ages, most cases involve the young and are associated with high morbidity if not diagnosed early. The severity of ischemia depends on the degree and length of torsion. If torsion is diagnosed and treated within the first 6 hours after onset, the surgical salvage rate approaches 100%. If treatment is delayed to 12 to 24 hours, the salvage rate plummets to approximately 20%. US plays a critical role in the evaluation of patients with suspected torsion, since differentiation from epididymo-orchitis can be extremely difficult by physical examination and clinical history alone.

There are several etiologies of torsion including traumatic, post-herniorrhaphy and congenital. In most cases, torsion occurs due to congenital lack of attachment of the tunica vaginalis to the posterolateral wall of the testis (the 'Bell-clapper' deformity) which allows the testis to rotate freely in the scrotum. Regardless of the etiology, common US findings of torsion include lack of color and Power Doppler flow, reactive hydrocele and parenchymal heterogeneity, depending on the duration of the ischemia; in some cases, a 'twist' of the spermatic cord can be demonstrated. However, the presence of vascular perfusion on Doppler analysis does not exclude the possibility of torsion, since cases of incomplete or intermittent torsion may show flow during the time of Doppler interrogation. The gray scale findings of torsion are also variable, depending on the duration of the ischemic insult. In the first few hours of acute torsion, the testicular parenchyma will typically appear normal at gray scale evaluation (Figure 1). However, by approximately 6 hours of ischemia, the testicular parenchyma begins to become hypoechoic due to edema. By approximately 24 hours, parenchymal heterogeneity results from vascular congestion, internal hemorrhage and potential areas of infarction (Figure 2). The importance of gray scale analysis lies in the finding of a homogeneous testicular parenchyma, which indicates that the testis has not undergone irreversible ischemic damage and can typically be salvaged surgically. The end result of untreated, complete torsion is testicular infarction, manifested on US by absence of Power Doppler flow, reactive hydrocele and heterogeneous or hypoechoic parenchyma (Figure 3). In some cases, a segmental infarction may occur due to an embolic source; in such cases, a geographic region of parenchymal hypoechoicogenicity with lack of Doppler flow can be seen (Figure 4).

Torsion of a testicular or epididymal appendage can also result in acute scrotal pain. Clinically, some patients will develop focal discoloration in the superior aspect of the scrotal wall ('blue dot' sign) corresponding to the site of appendigeal torsion. The key US finding consists of a circular mass adjacent

to the superior aspect of the testis or epididymis with a variable amount of adjacent reactive hyperemia. As with other types of acute scrotal pathology, reactive hydrocele and skin thickening can also be observed.



Figure 1a: Acute testicular torsion with normal-appearing parenchyma. a) Transverse color Doppler image of both testes shows lack of flow in the left testis due to torsion. The left testis was salvaged and a 'Bell-clapper' deformity was repaired at surgery.

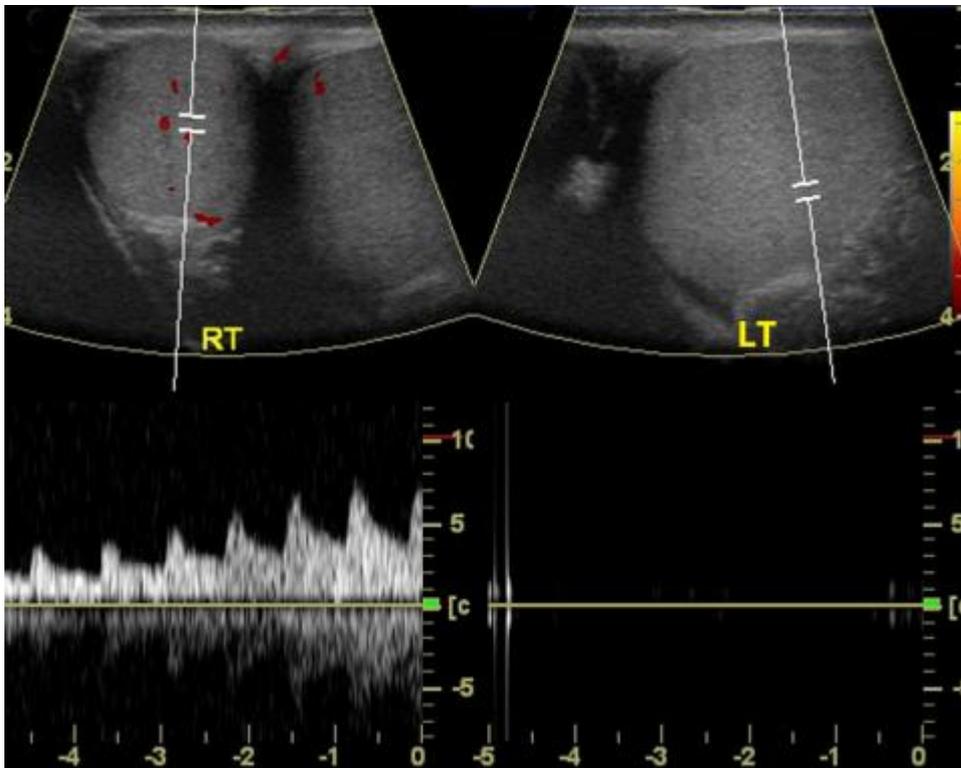


Figure 1b: Acute testicular torsion with normal-appearing parenchyma. b) Transverse spectral Doppler image shows normal arterial waveforms in the right testis and no detectable flow in the left testis. The left testis was salvaged and a 'Bell-clapper' deformity was repaired at surgery.

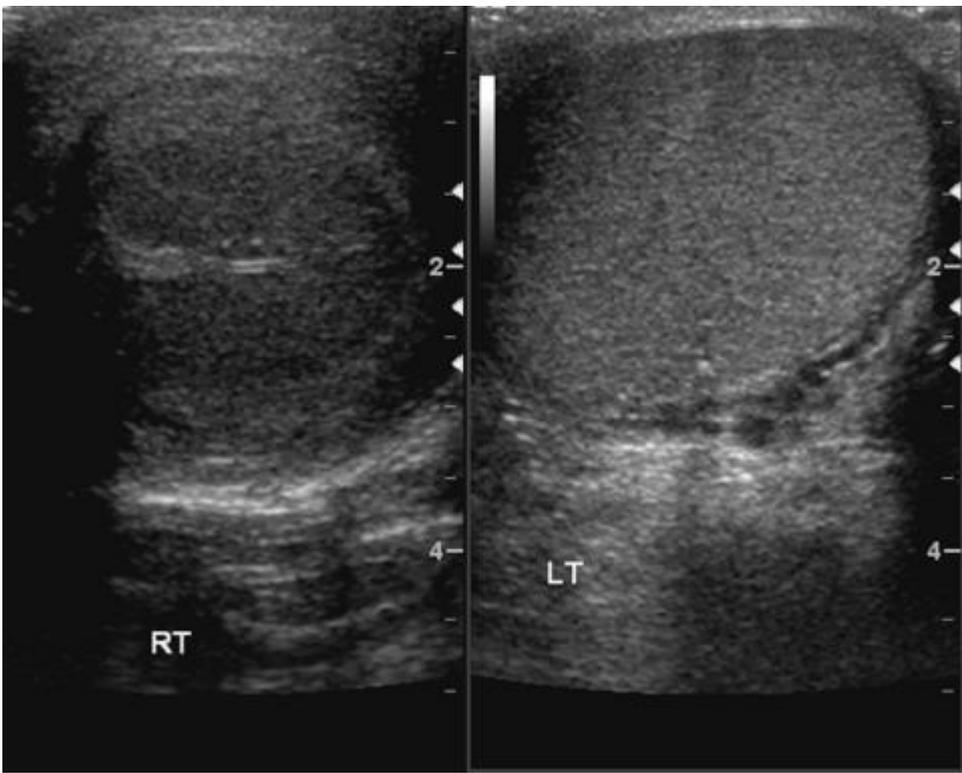


Figure 2a: Testicular torsion with abnormal parenchyma. a) Transverse gray scale image of both testes demonstrates hypoechogenicity of the right testis due to torsion for approximately 22 hours. No Power or spectral Doppler flow was shown either. The right testis was infarcted at the time of surgery and was removed.

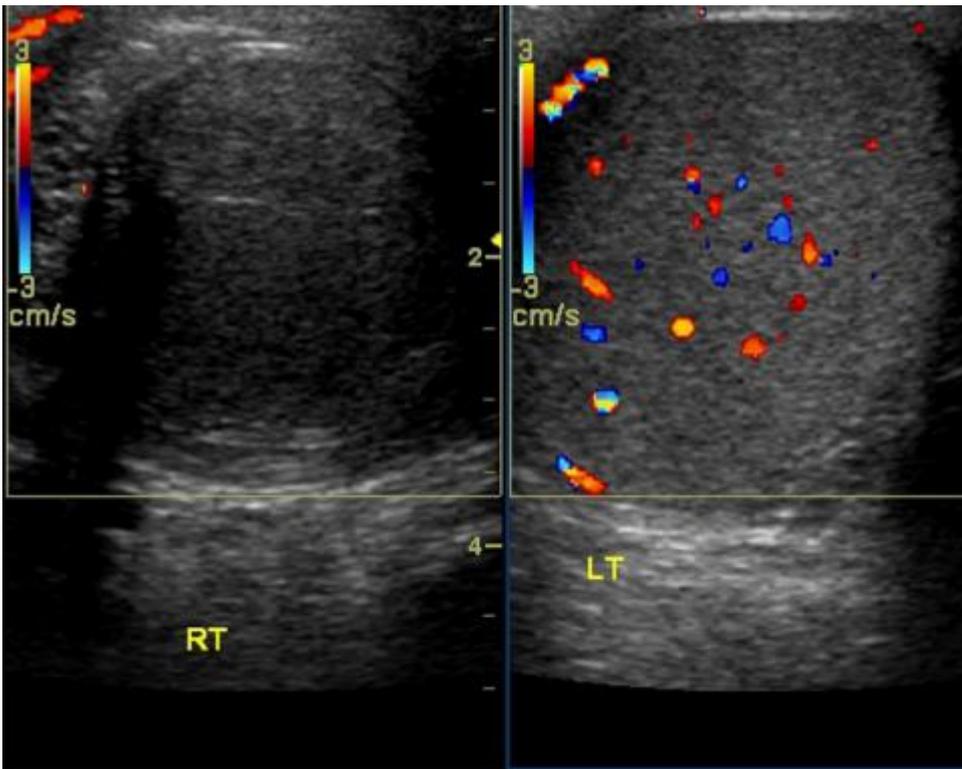


Figure 2b: Testicular torsion with abnormal parenchyma. b) Transverse color Doppler image of both testes shows lack of flow in the right testis. No Power or spectral Doppler flow was shown either. The right testis was infarcted at the time of surgery and was removed.

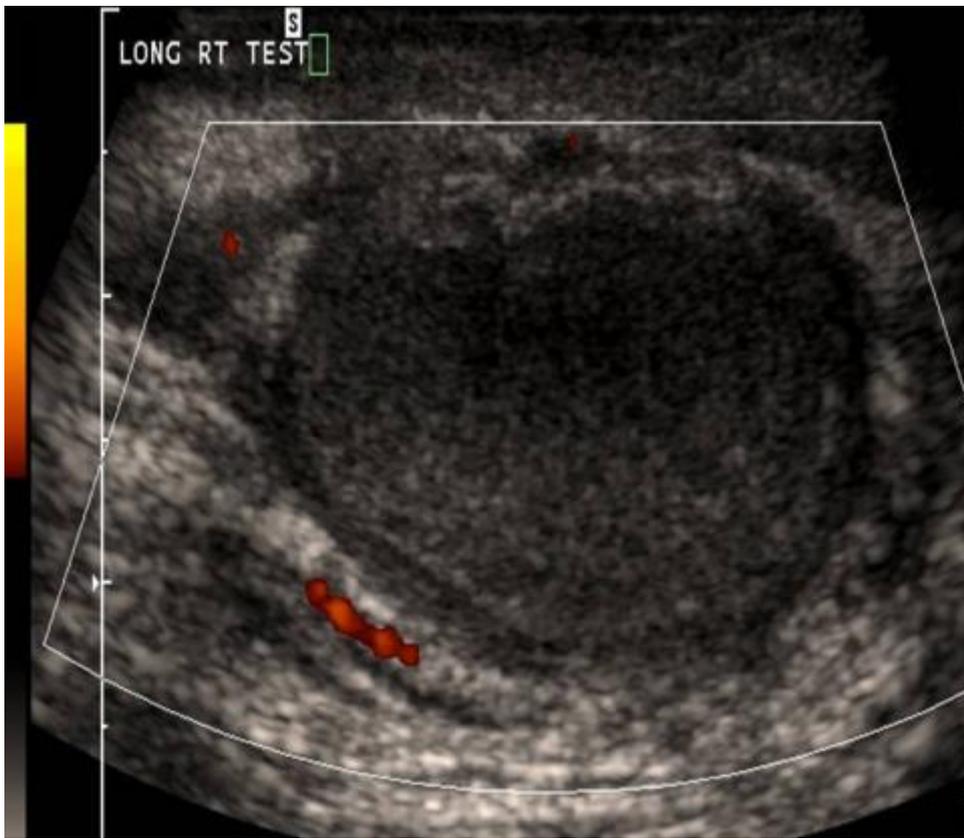


Figure 3a: Testicular infarct post herniorraphy. a) Longitudinal color Doppler image of the right testis shows absence of Power Doppler flow and parenchymal hypoechoogenicity due to infarction. Findings were confirmed at surgery and a right orchiectomy was performed.

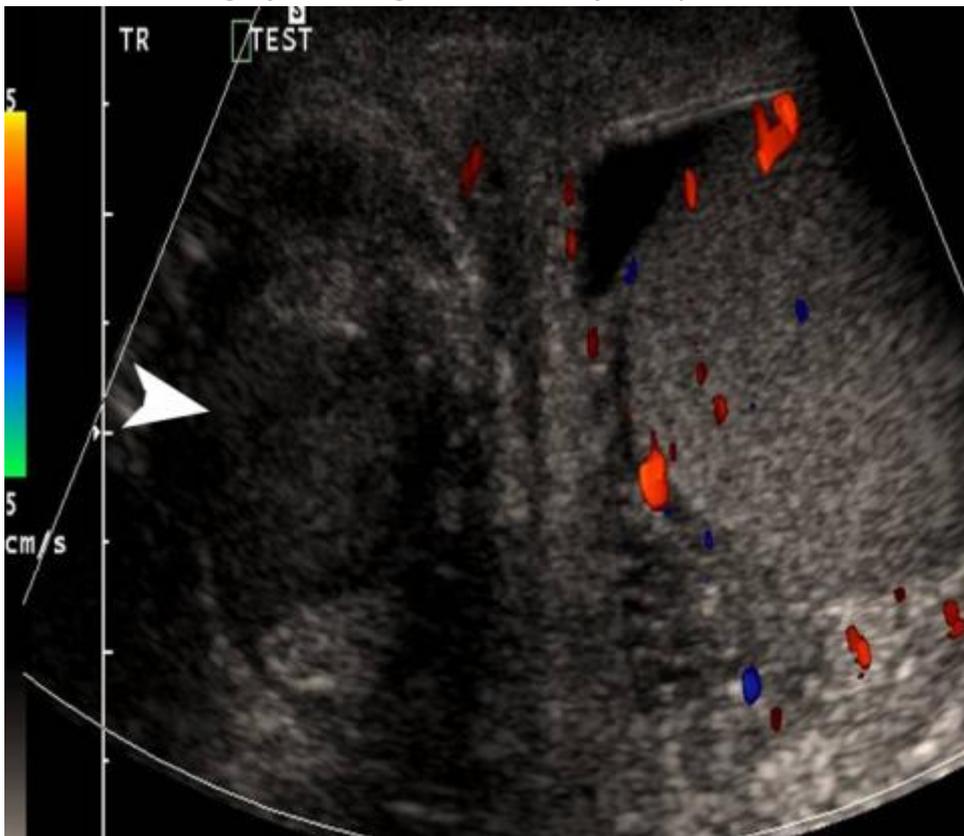


Figure 3b: Testicular infarct post herniorraphy. b) Transverse color Doppler image of both testes shows absence of flow in the hypoechoic right testis (arrowhead) and normal flow in the left testis. Findings were confirmed at surgery and a right orchiectomy was performed.

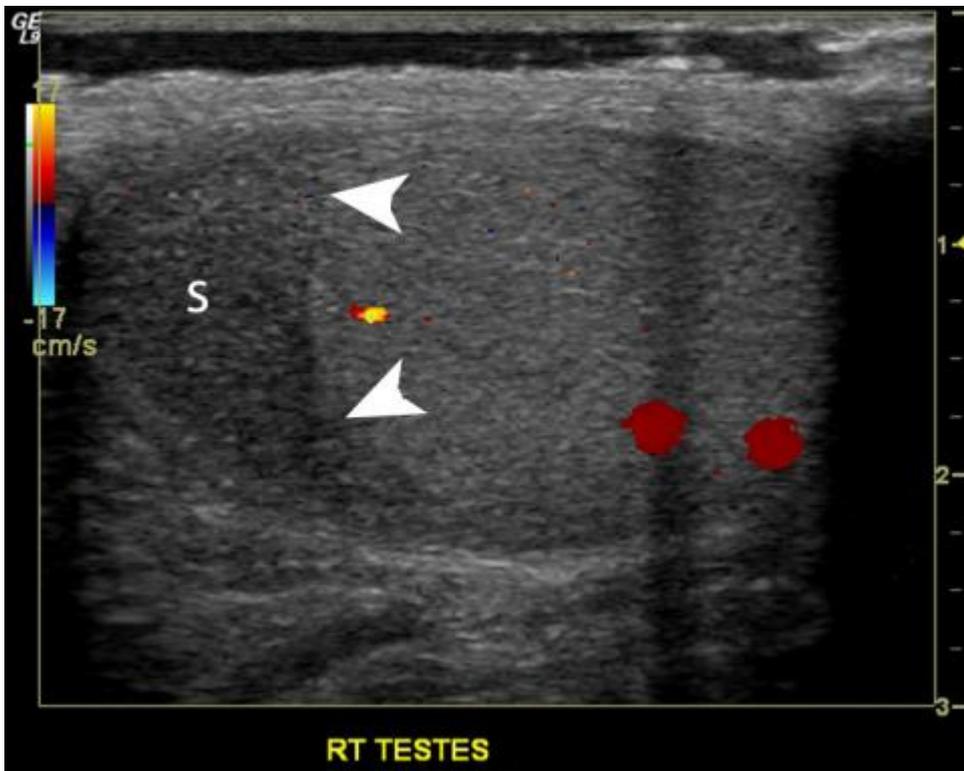


Figure 4a: Segmental testicular infarct due to embolus. Longitudinal color Doppler image of the right testis shows an avascular geographic region (arrowheads) at the superior pole of the testis. The patient was managed conservatively. Follow-up US (not shown) revealed progressive atrophy of the infarcted superior pole.

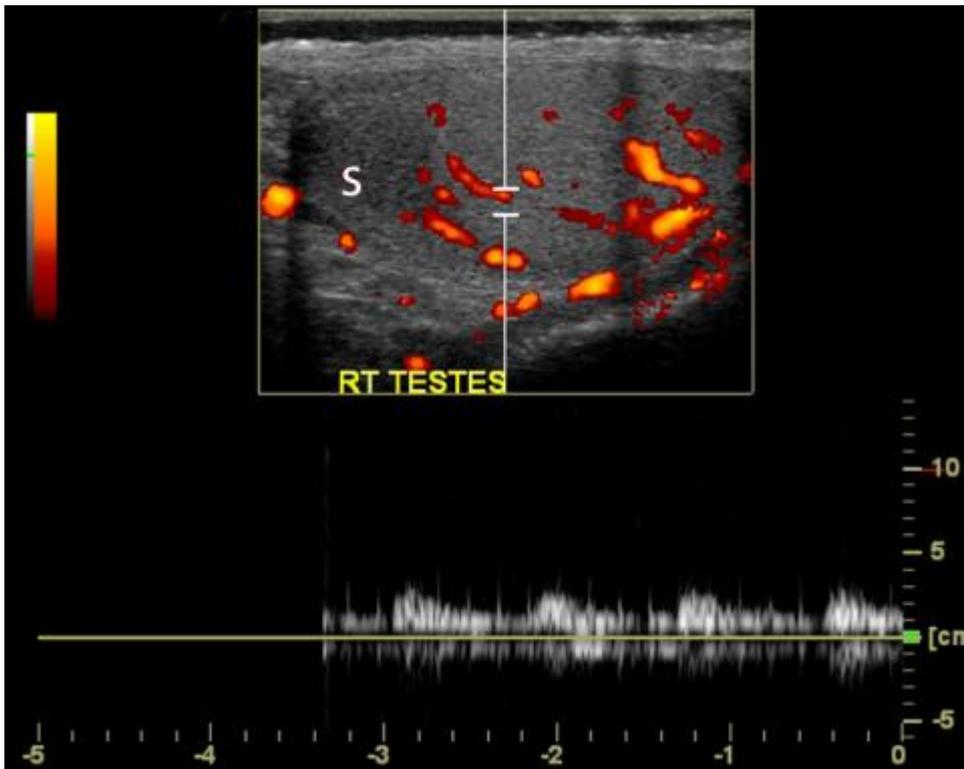


Figure 4b: Segmental testicular infarct due to embolus. Longitudinal color Doppler image of the right testis shows an avascular geographic region (arrowheads) at the superior pole of the testis. b) Power Doppler interrogation confirms lack of flow in the geographic region at the superior pole of the right testis. The patient was managed conservatively. Follow-up US (not shown) revealed progressive atrophy of the infarcted superior pole.

INFLAMMATION AND INFECTION

Inflammation and infection of the scrotum can be generally divided into conditions affecting the superficial soft tissues and conditions affecting the internal contents (scrotum and epididymis). Inflammation or infection affecting the superficial tissues (scrotal cellulitis) is often a clinical diagnosis due to the observation of skin erythema, induration and tenderness. However, intense pain may preclude a meaningful physical examination. Therefore, US is often obtained to exclude abscess and pathology within the testis and epididymis. Scrotal cellulitis is more prone to occur in individuals with malnutrition, diabetes and immunosuppression. US findings of scrotal cellulitis are similar to cellulitis occurring elsewhere on the body and consist of skin or scrotal wall thickening, hyperemia and edema (Figure 5). A differential consideration for scrotal cellulitis is diffuse scrotal wall edema due to retention and third spacing of fluid. Differentiation of scrotal cellulitis from generalized edema can be made by noting that hyperemia is usually present in cases of scrotal wall inflammation/infection and is typically absent in cases of generalized edema. Of note, generalized scrotal wall edema is a non-specific finding which may be due to a myriad of causes.

Epididymitis and orchitis are common etiologies for acute scrotal pain, especially in teenagers and young adults. At physical examination, pain can be diffuse but often localizes along the posterior aspect of the scrotum, mirroring the extent of the epididymis. Differentiation of epididymitis from acute torsion can be difficult during physical examination alone. However symptoms of urinary tract infection and relief of pain with elevation of the testis (Prehn sign) make the diagnosis of epididymitis more likely. In cases of epididymitis, orchitis coexists in up to approximately 40% of patients due to contiguous spread of infection (Figure 6). Common bacterial pathogens include *Chlamydia trachomatis*, *N. gonorrhoeae* and several urinary tract pathogens such as *E. coli*. US findings of epididymo-orchitis consist of an enlarged, edematous, predominantly hypoechoic but heterogeneous epididymis and testis. It should be noted that testicular heterogeneity at gray-scale evaluation is non-specific and can also result from malignancy and infarction. Therefore, follow-up examinations should be obtained until the testis homogenizes to exclude other pathologies. Ancillary findings of acute epididymo-orchitis consist of reactive skin thickening and hydrocele. Application of color and Power Doppler readily demonstrate hyperemia of the inflamed structures. In some cases of mild inflammation, gray scale findings may be unimpressive or normal; however, the exquisite sensitivity of Power Doppler will usually show reactive hyperemia even in very mild or early cases of epididymo-orchitis. During spectral Doppler analysis, epididymo-orchitis has been associated with a low resistance waveform.

Extension of inflammation from epididymo-orchitis can affect the vas deferens and result in vasitis or deferentitis. This inflammation can result in vague pelvic or inguinal region pain. At physical examination, a thickened, tender cord-like structure can be palpated lateral to the testis extending through the inguinal region. Similarly, US will show the inflamed vas deferens as a thickened, hyperemic cord-like structure running along the lateral aspect of the testis and through the inguinal canal (Figure 7).

Treatment for epididymo-orchitis and/or vasitis consists of antibiotics and pain control.

If untreated, epididymo-orchitis can progress to abscess formation or pyocele (Figure 8). Clinically, patients present with fever, leukocytosis and focal scrotal tenderness or palpable abnormality. US examination demonstrates a well-defined fluid collection within the scrotum in cases of abscess. The internal echogenicity varies due to the amount of reactive fluid, pus, gas and cellular debris. At Doppler interrogation, the fluid collection is avascular except for potential peripheral hyperemia. A pyocele can also result from untreated epididymo-orchitis or rupture of an abscess into the potential space between

the leaves of the tunica vaginalis. A pyocele appears as complex fluid often with numerous internal septations and loculations. Follow-up US should be considered to assure resolution after surgical drainage or medical therapy.

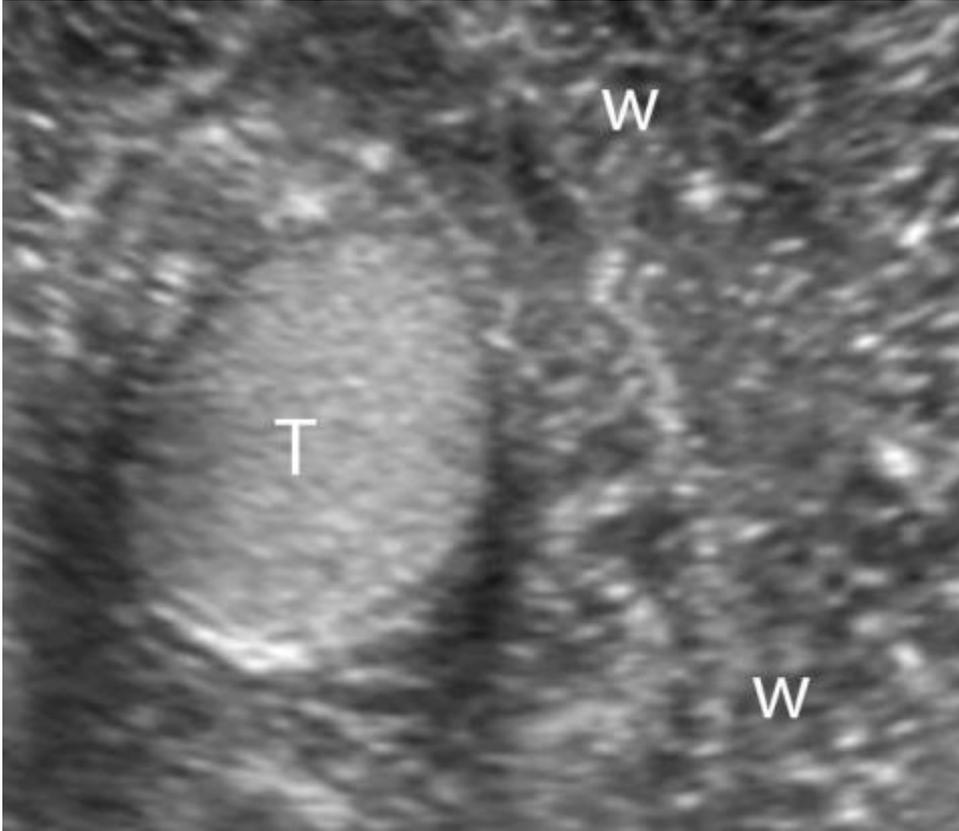


Figure 5: Scrotal cellulitis. Transverse gray scale image of the right testis (T) shows massive thickening of the scrotal wall (w) due to extensive cellulitis. There was profound hyperemia at color Doppler analysis (not shown). The patient was treated conservatively and the cellulitis eventually resolved.

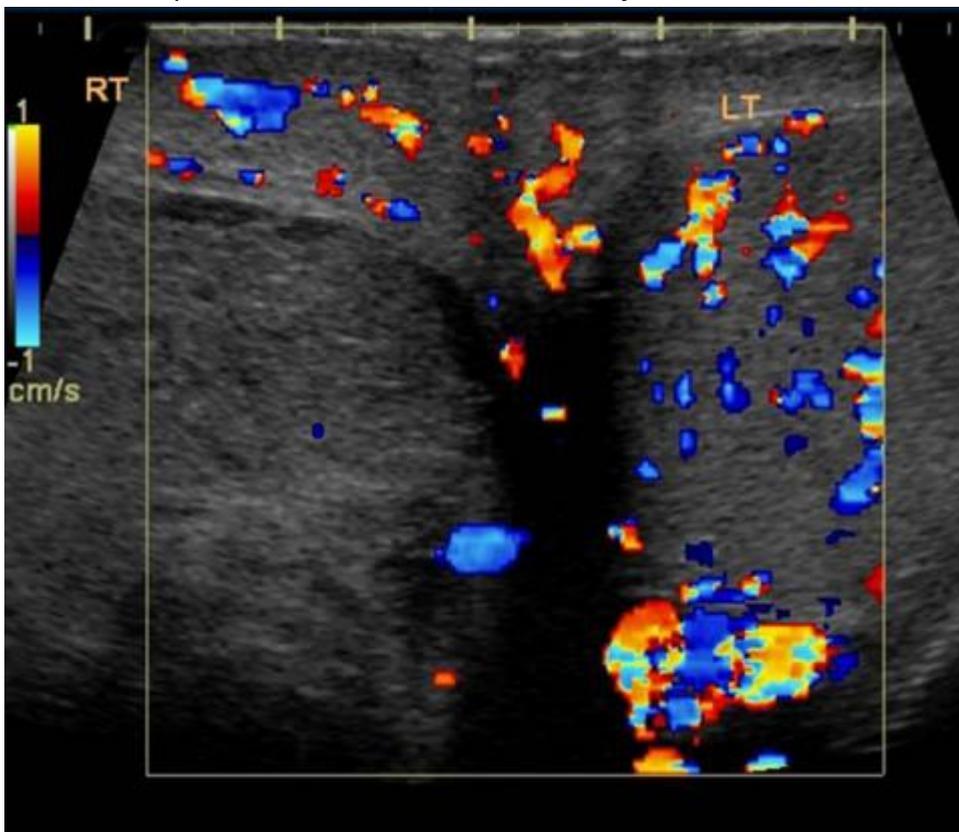


Figure 6: Orchitis. Transverse color Doppler image of both testes shows relative hyperemia of the left testis due to orchitis. Symptoms resolved after treatment with antibiotics.

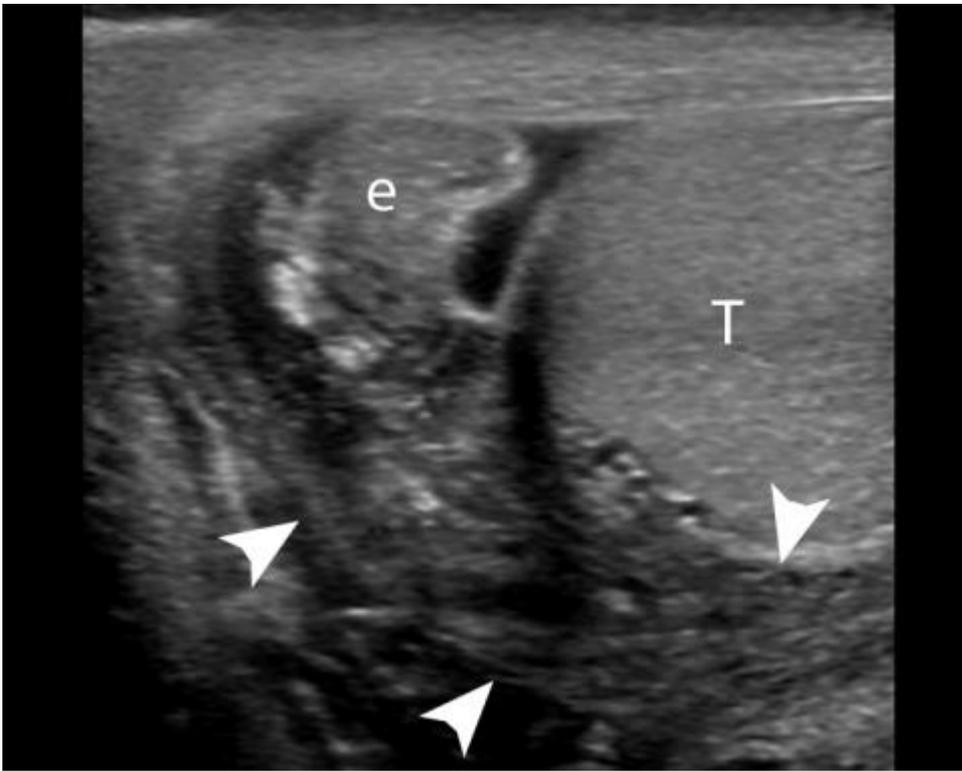


Figure 7a: Vasitis. a) Longitudinal gray scale image of the superior aspect of the right scrotum shows an enlarged epididymal head (e) and a thickened spermatic cord (arrowheads). The testis (T) was normal. The spermatic cord was hyperemic at color Doppler interrogation (not shown).

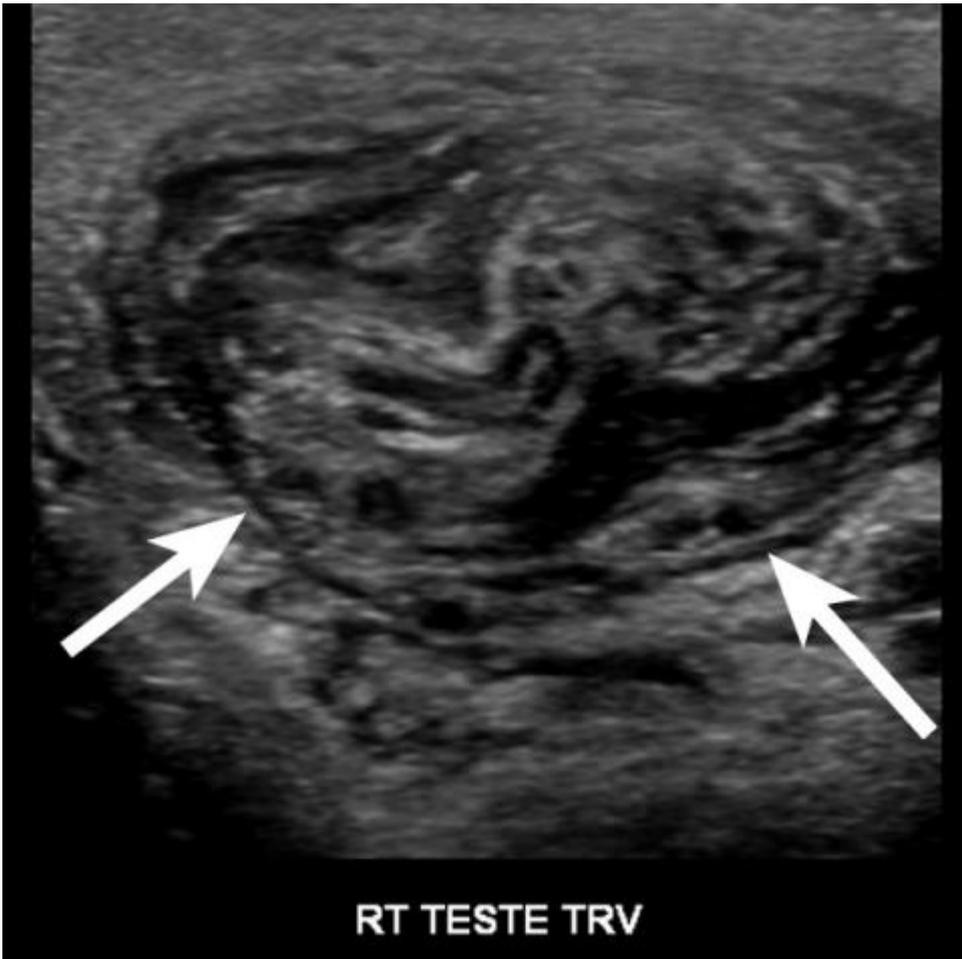


Figure 7b: Vasitis. The testis (T) was normal. b) Transverse gray scale image of the mid-portion of the right inguinal canal shows extensive thickening of the spermatic cord due to inflammation of the vas deferens. The spermatic cord was hyperemic at color Doppler interrogation (not shown).

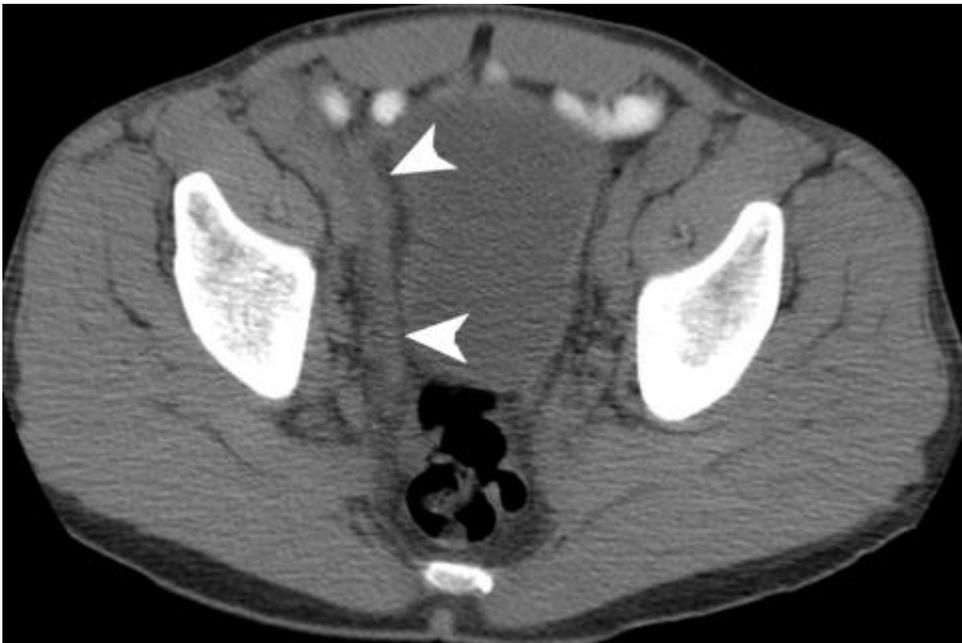


Figure 7c: Vasitis. The testis (T) was normal. The spermatic cord was hyperemic at color Doppler interrogation (not shown). c) Non-contrast CT image through the pelvis shows the thickened vas deferens (arrowheads) on the right side.

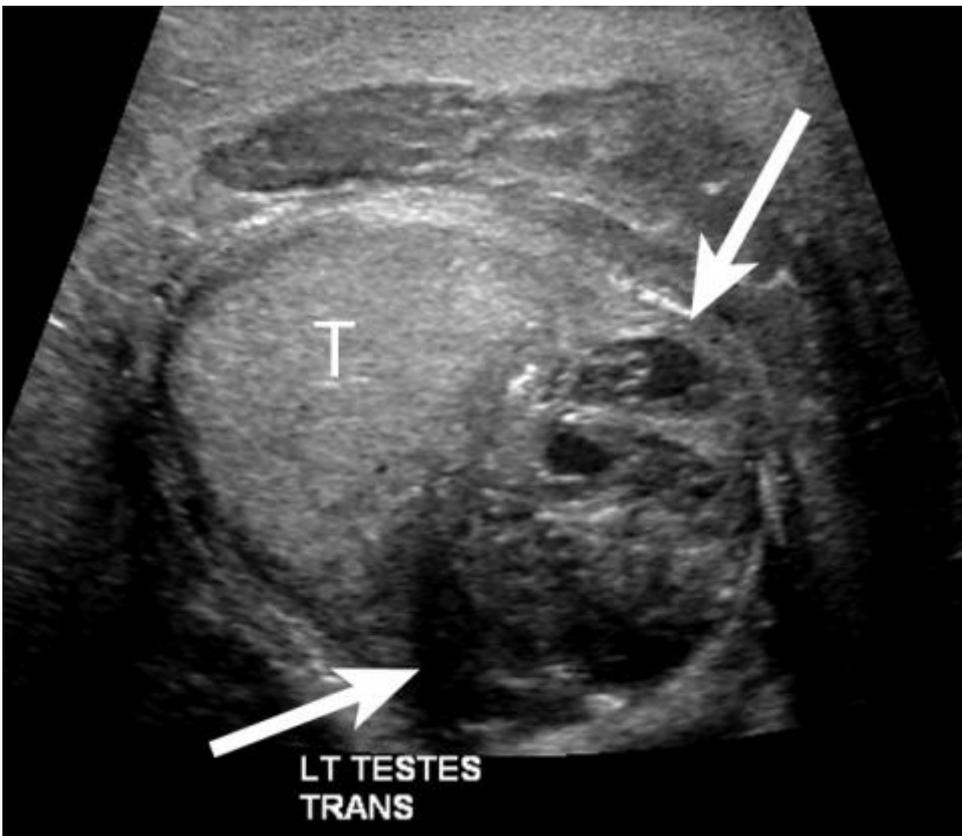


Figure 8: Scrotal abscess. Transverse gray scale image of the left hemiscrotum shows a heterogeneous fluid collection (arrows) abutting the left testis (T).

TRAUMA

Blunt scrotal trauma can result in intra/extratesticular hematoma, hematocele, parenchymal contusion, fracture and testicular rupture. US findings of hematoma vary depending on its age and size. Generally, acute hematomas are relatively hyperechoic and gradually become hypoechoic as they liquefy and are absorbed. The main US finding of a parenchymal contusion is a focal region of decreased echogenicity (Figure 9). Disruption of the tunica albuginea is diagnostic of testicular rupture. In many cases, extensive

associated edema and hematoma may obscure the actual site of tunica disruption. However, the findings of focal irregularity of the tunica, contour abnormality of the testis, extrusion of testicular contents into the scrotal sac, heterogeneous echotexture of the testicular parenchyma, and a large hematocele support the diagnosis of testicular rupture (Figure 10). When there is rupture of the tunica albuginea, there is often co-existing injury of the tunica vasculosa which can result in compromised flow to portions of the testis and possible infarction. Surgical exploration is advocated in cases of disruption of the tunica albuginea, nonperfusion of the testis, and in cases of equivocal US findings but high clinical suspicion for rupture. Delayed diagnosis and treatment can result in atrophy, ischemia, infarction, abscess or decreased spermatogenesis.

Testicular fracture without extrusion can result from blunt trauma. In cases of an intact tunica albuginea and Doppler signal, treatment can be conservative although debridement along the fracture line is sometimes undertaken. US findings of testicular fracture include a linear hypoechoic, avascular band. In cases of penetrating trauma, foreign bodies, gas and shrapnel fragments can be shown as echogenic foci within the scrotum. Metallic fragments and foreign bodies will typically produce strong posterior shadowing while intrascrotal gas will produce punctate, echogenic foci associated with incomplete, 'dirty shadowing' and reverberation artifacts. (Figure 11) The management of penetrating deep scrotal injuries typically includes surgical exploration. Penetrating injuries involving the spermatic cord can often be implied by the combination of inguinal hematoma and findings of testicular ischemia.

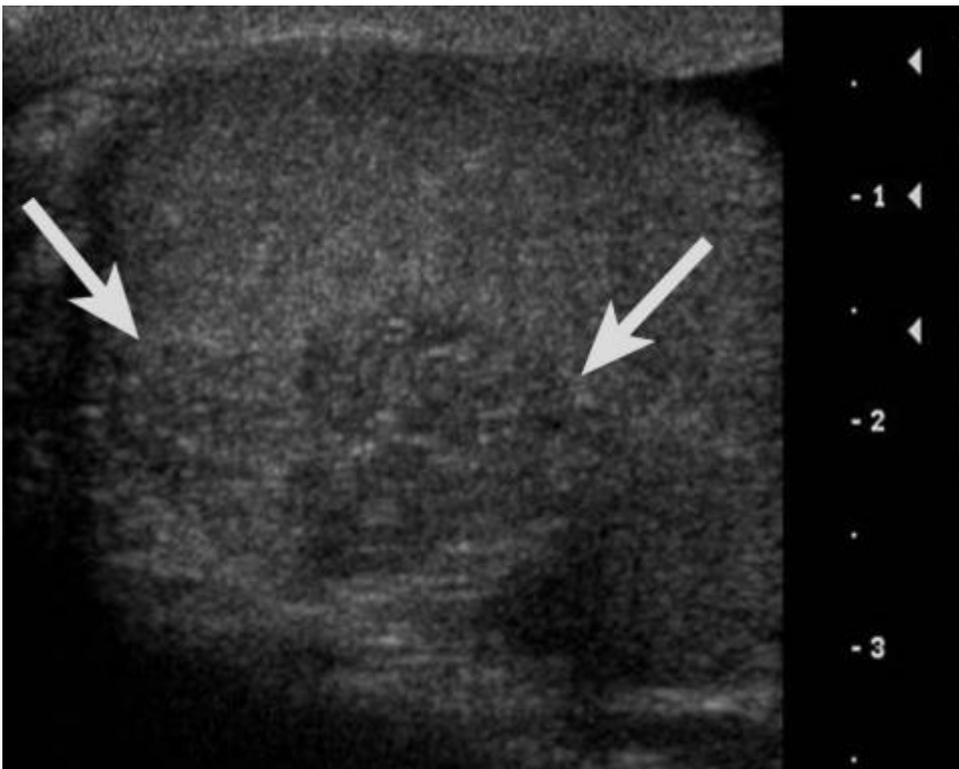


Figure 9: Testicular contusion. Transverse gray scale image of the right testis show a region of decreased echogenicity due to focal contusion following blunt trauma. The right testis eventually homogenized on follow-up US examinations (not shown).

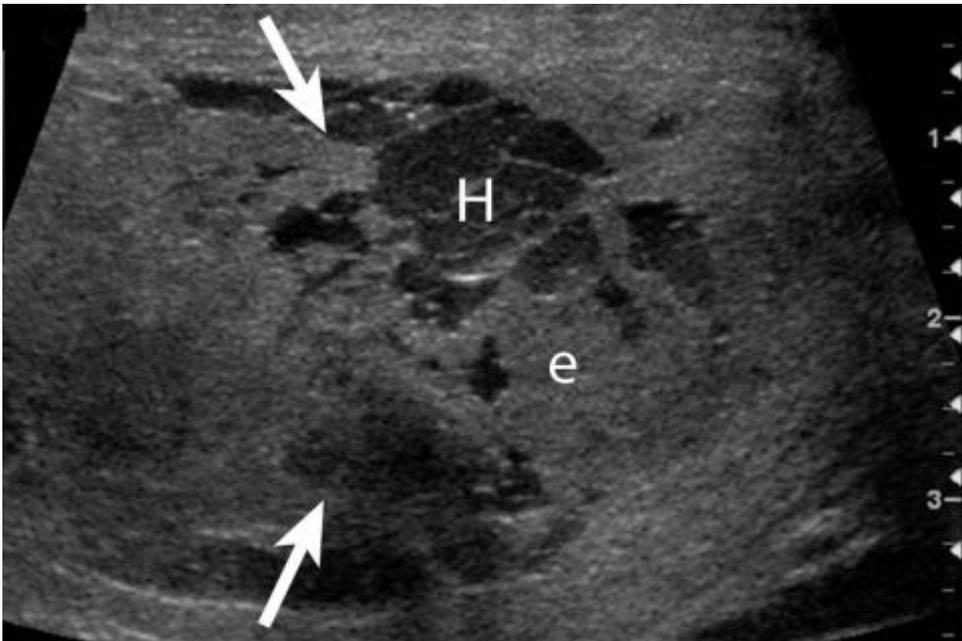


Figure 10a: Testicular rupture due to blunt trauma. a) Transverse gray scale image of the left testis shows extensive irregularity (arrows) along the lateral margin with extrusion (e) of testicular parenchyma into the scrotum and adjacent hematoma (H). There is also a geographic avascular band (arrowheads) at the superior margin of the testis due to a traumatic segmental infarction.

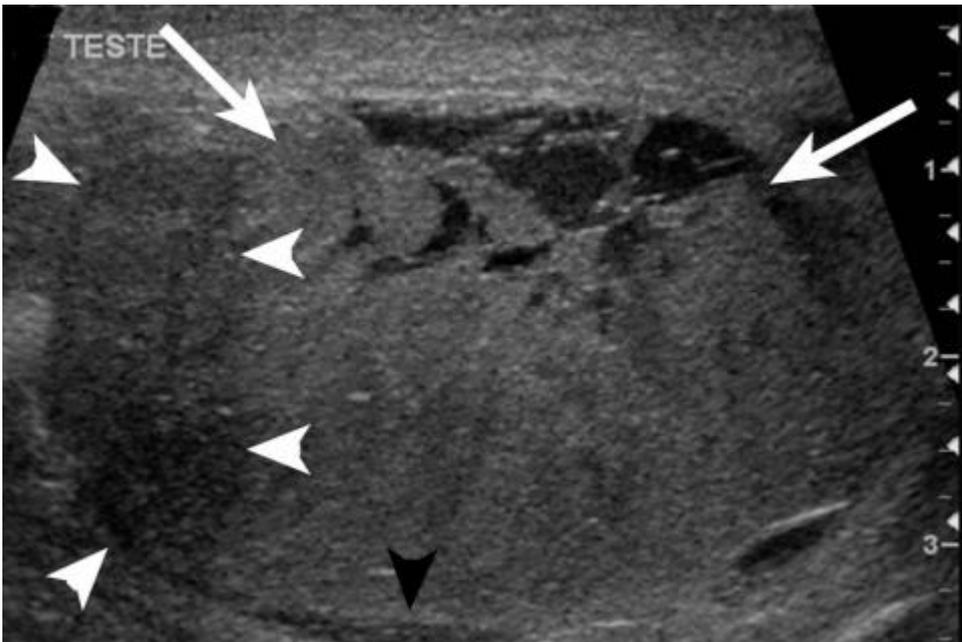


Figure 10b: Testicular rupture due to blunt trauma. b) Corresponding longitudinal image shows similar testicular contour irregularity (arrows) along the ventral margin at the site of disruption of the tunica albuginea. For reference a normal segment of tunica albuginea (black arrow) is annotated along the posterior margin of the testis. There is also a geographic avascular band (arrowheads) at the superior margin of the testis due to a traumatic segmental infarction.

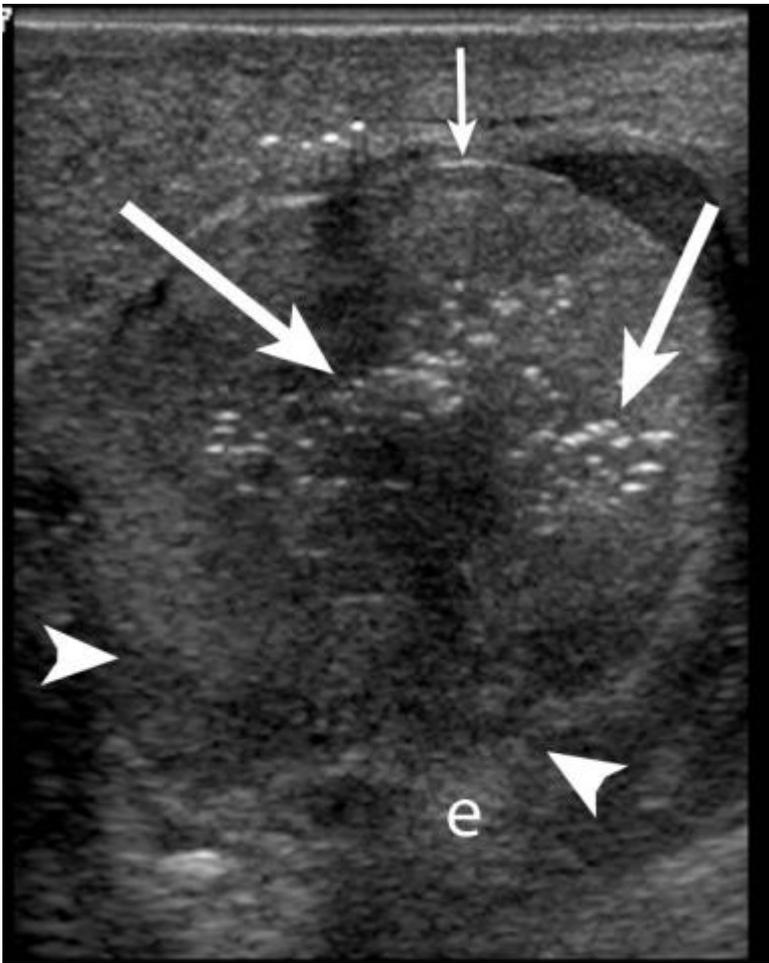


Figure 11: Testicular rupture and intraparenchymal gas due to gunshot wound. Transverse gray scale image of the right testis shows multiple, punctate echogenic foci (thick arrows) within the testicular parenchyma due to gas locules. There is a contour irregularity along the posterior margin (arrowheads) of the testis at the site of disruption of the tunica albuginea due to rupture and extrusion (e) of testicular parenchyma into the scrotum. A normal segment of tunica albuginea (thin arrow) is annotated along the ventral margin of the testis.

MISCELLANEOUS

Spermatic cord

Since acute conditions affecting the contents of the inguinal canal can result in pain referred to the scrotum, a thorough scrotal US examination includes insonation of the inguinal canal and its contents. Fat, vessels, small bowel and colon can enter the inguinal canal via persistent patency of the processus vaginalis. These contents pass through the canal lateral to the inferior epigastric vessels and constitute an indirect inguinal hernia. While inguinal hernias can be asymptomatic, they can also result in pain due to exerting mass effect upon the spermatic cord or acting as a nidus for bowel obstruction. Observation of peristalsing bowel within the inguinal canal is a key US finding in diagnosing herniated small bowel. (Figure 12) Identification of peristalsis requires that the US probe be held still for several seconds to provide enough time for the peristaltic waves to become evident. In cases of herniated small bowel which is obstructed in the inguinal canal, peristalsis will be significantly diminished or absent. In these cases, and cases of colon herniated into the inguinal canal, recognition of the laminated bowel wall and potential 'dirty shadowing' and reverberation artifact from air in its lumen help to make the diagnosis. In cases of fat herniated into the inguinal canal, US findings consist of amorphous, echogenic material filling and associated vessels filling the canal. Ultimately, further evaluation with CT may be needed to better

assess potential inguinal hernias and potential bowel obstruction.

In the setting of trauma, a hematoma of the spermatic cord can exert mass effect and result in acute pain. The hematoma can have a variable appearance on US depending on its age; acute hematomas will appear echogenic but eventually evolve and become more heterogeneous and hypoechoic as they begin to liquefy and regress. Demonstration of Doppler signal within a suspected hematoma raises concern for either active hemorrhage or an occult neoplasm. Similar to the mass effect exerted by a hematoma, a sufficiently large neoplasm in the inguinal canal, such as a metastasis or sarcoma, can result in pain due to mass effect. Metastases will have a variable appearance but generally appear as a solid lesion which is hypoechoic to the adjacent fat. Differentiation of a metastasis from a hematoma can be usually made by clinical correlation and by identifying internal flow within metastases. Additional uncommon differential considerations for acute scrotal pain include vasculitis, hemorrhage within a tumor, varicocele and acute hydrocele.

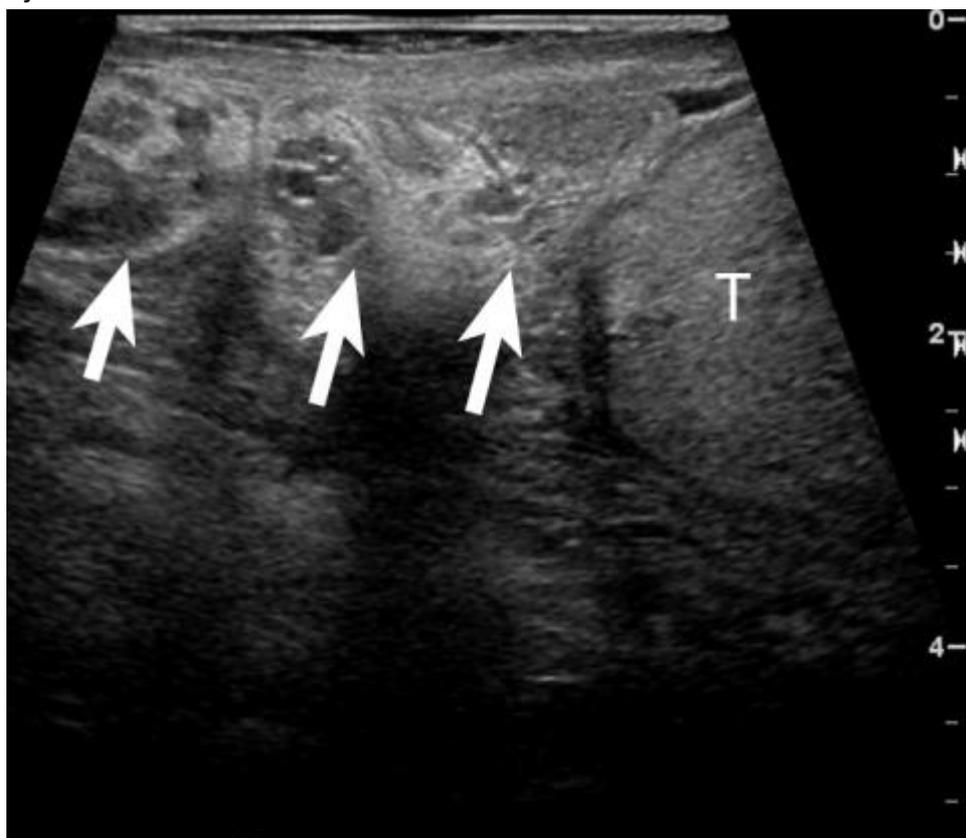


Figure 12: Inguinal hernia containing small bowel. Longitudinal gray scale image of the superior aspect of the right scrotum and inguinal canal shows an elongated, heterogeneous structure (arrows) extending through the inguinal canal and abutting the upper pole of the testis (T). The elongated structure was diagnosed as small bowel after observing peristalsis during real time imaging.

Perineum

The perineal soft tissues may also harbor pathology which results in pain referred to the scrotum. The perineal soft tissues can be subject to cellulitis, abscess or trauma. The US findings of cellulitis are similar to those described earlier. An abscess appears as well-defined fluid collection consisting of a variable degree of internal echogenicity depending on the constituents of its content. The identification of 'dirty shadowing' within the soft tissues raises concern for a gas-forming infection and Fournier's gangrene. Fournier's gangrene is an emergent condition characterized by a polymicrobial necrotizing infection which is diagnosed with increased frequency in patients suffering from chronic diabetes, advanced age, alcoholism and immunocompromise. Evaluation for Fournier's gangrene should also be carried out in

patients who have vague scrotal region pain and who are experiencing mental status changes or who were obtunded, as they may not be able to properly communicate their discomfort. Perineal trauma is usually better assessed by CT examination. A laceration may be detected on US as a focal soft tissue disruption or area of heterogeneous echogenicity while a hematoma appears as an ill-defined collection of increased echogenicity.

SUMMARY

US plays a critical role in the evaluation of numerous pathologic conditions causing scrotal pain. The combination of a high-frequency transducer and application of Doppler analysis allow for detailed evaluation of the scrotal soft tissues, internal contents, adjacent tissues and the degree of vascular perfusion. Correlation to physical examination and clinical history are key supplements to the US evaluation. A thorough US examination will often yield a specific diagnosis and facilitate management of patients presenting with acute scrotal pain.

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