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Sonographic Evaluation of Testicular Torsion

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Broadband high-frequency transducer sonography has become the gold standard for the evaluation of patients who have acute scrotal pain. High-frequency transducer sonography can not only help delineate the anatomic details of the testes but also aids in evaluating testicular perfusion. Testicular perfusion can be studied with the help of color or power Doppler sonography. Evaluation of testicular perfusion aids in the diagnosis of testicular torsion. This article reviews the gray-scale and color flow Doppler features of testicular torsion, including the partial torsion and torsion-detorsion syndrome.

Sonographic anatomy

The postnatal human testis is intraperitoneal. The adult human testis is also intraperitoneal but may appear extraperitoneal. The apparent discrepancy between the adult testis being intraperitoneal or extraperitoneal is likely to result from differences in the relative size of the tunica vaginalis between infant boys and elderly men [1]. Testes are bilaterally symmetrical and housed within the scrotum. Testes are ovoid in shape with medium-level echoes and measure 5×3×2 cm each. Tunica albuginea is the fibrous covering of the testicle and is covered by the tunica vaginalis. The tunica albuginea can be seen with a high-frequency transducer as an echogenic line [Fig. 1]. Septa extend from the tunica albuginea into the testicle, dividing the testis into 250 to 400 lobules. The posterior surface of the tunica albuginea is reflected into the interior of the testis, forming the incomplete septum known as the mediastinum testis. Sonographically, the mediastinum testis is seen as an echogenic band running in a cephalocaudal direction [Fig. 2]. Each lobule consists of one to three seminiferous tubules supporting the Sertoli cells and the spermatocytes that give rise to sperm. The seminiferous tubules open through the tubuli recti into dilated spaces called the rete testis within the mediastinum [Fig. 3]. The rete testis drains into the epididymis through 10 to 15 efferent ductules. The epididymis, consisting of a head, body, and tail, is located superior to and is contiguous with the posterior aspect of the testis. The tail of the epididymis continues as the vas deferens.

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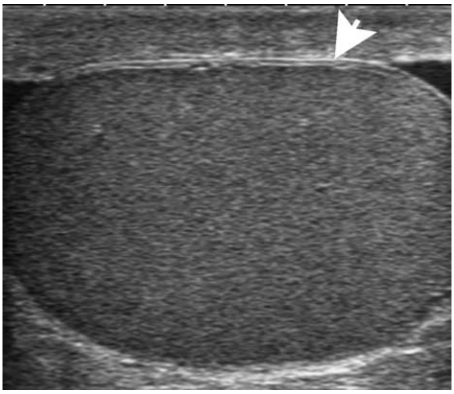


Fig. 1. Longitudinal sonogram of the testis reveals homogeneous medium-level echoes. The arrow points to the tunica albuginea.

Arterial blood supply to the testes is derived from the testicular artery, a branch of the abdominal aorta. The superior epididymal artery, a branch of the testicular artery, predominantly supplies the epididymis. The cremasteric artery, which is a branch of the inferior epigastric artery, predominantly supplies the peritesticular tissue and anastomoses with the deferential artery. The deferential artery, a branch of the superior vesicle artery, supplies the vas deferens [Fig. 4]. There are variable anastomoses between the posterior epididymal, deferential, and cremasteric arteries. A transmediastinal arterial branch of the testicular artery is present in approximately half of normal testes; it courses through the mediastinum to supply the capsular arteries and is usually accompanied by a large vein [Fig. 5] [2].

Sonographic technique

Scrotal US is performed with the patient in the supine position and the scrotum supported by a towel placed between the thighs. Optimal results are obtained with a 10 to 14-MHz, high-frequency, linear-array transducer. Scanning is performed with the transducer in direct contact with the skin; however, a stand-off pad can be used for evaluation of superficial lesions if necessary.

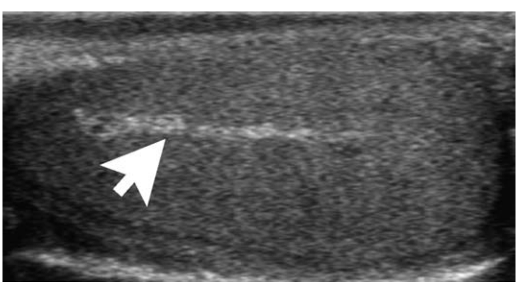


Fig. 2. Longitudinal sonogram of the testis reveals an echogenic band (*arrow*) consistent with mediastinum testis.

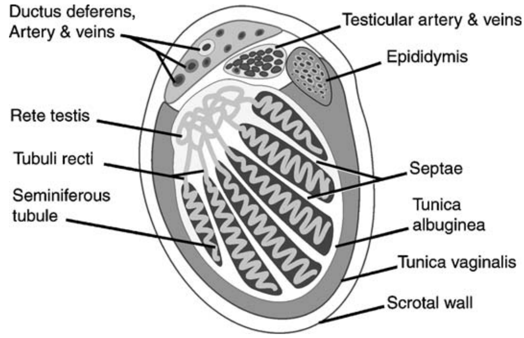


Fig. 3. Diagrammatic representation of the testis in cross-section.

The testes are examined in at least two planes: the longitudinal and transverse axes. The size and echogenicity of each testis and of the epididymis are compared with those on the opposite side. Scrotal skin thickness is evaluated. Color Doppler and pulsed Doppler parameters are optimized to display low-flow velocities and to demonstrate blood flow in the testes and surrounding scrotal structures. Bilateral testicular spectral Doppler tracings must be recorded. Power Doppler US may also be used to demonstrate intratesticular blood flow in patients who have an acute scrotum. In patients being evaluated for an acute scrotum, the asymptomatic side should be scanned initially to set the gray-scale and color Doppler gain settings to allow comparison with the affected side, remembering that testicular torsion can be a bilateral process in 2% of patients [3]. Transverse images with portions of each testis on the same image should be acquired in gray-scale and color Doppler modes. Additional techniques, such as use of the Valsalva maneuver or upright positioning, can be used as needed for venous evaluation.

Normal spectral Doppler

The proper interpretation of velocity waveforms requires an understanding of the normal waveform characteristics of a given vessel, and of the physiologic status of the circulation subtended by the vessel. The normal spectral waveform of the testicular artery and artery supplying the epididymis is a low-resistance, high-flow pattern [Fig. 6] [4], whereas that of the cremasteric artery supplying the scrotal wall has a high-resistance, low-flow pattern [Fig. 7] [4].

Quantification of outflow resistance may be achieved by determining the resistive index (RI). In the testes of a normal healthy volunteer, the RI is

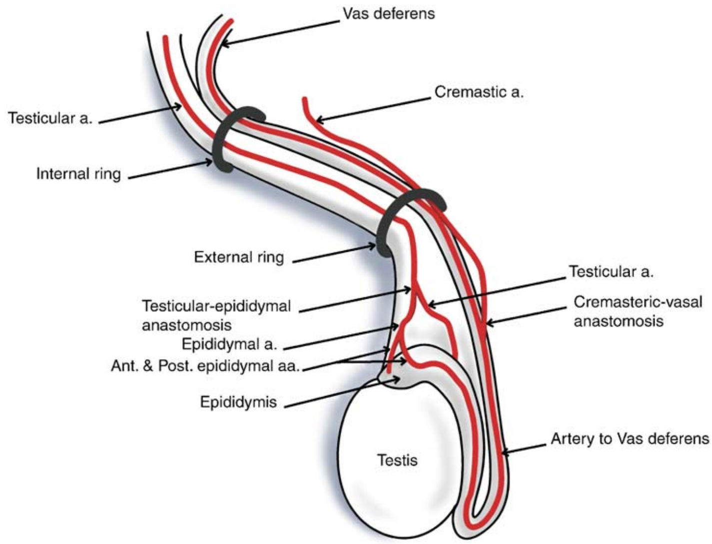


Fig. 4. Diagrammatic representation of the testicular blood supply.

rarely less than 0.5 [2]. It is the most widely used parameter and is defined as the peak systolic velocity minus the end diastolic velocity, divided by the peak systolic velocity.

Clinical presentation

In 1776, Hunter provided the first description of testicular torsion [5]. The chances of torsion of the testis or its appendage developing by the age of 25 years is about 1 in 160 [6]. Testicular torsion can occur at any age; however, it is most frequent in adolescent boys. Most testicular torsion occurs in young patients, with 66% occurring between 12 and 18 years of age and peak incidence occurring at 14 years [7].

Patients who have acute testicular torsion present after a sudden onset of pain followed by nausea, vomiting, and a low-grade fever. Physical examination reveals a swollen, tender, and inflamed hemiscrotum. It is difficult to distinguish the testis from the epididymis because of localized swelling. For this reason, the condition is frequently misdiagnosed as epididymitis. The cremasteric reflex is usually absent [8,9], and the pain cannot be relieved by elevating the scrotum [5]. In an adult in a standing position, the normal testis hangs in a near-vertical position, whereas the torsed testis will tend to hang in a near-horizontal position [10].

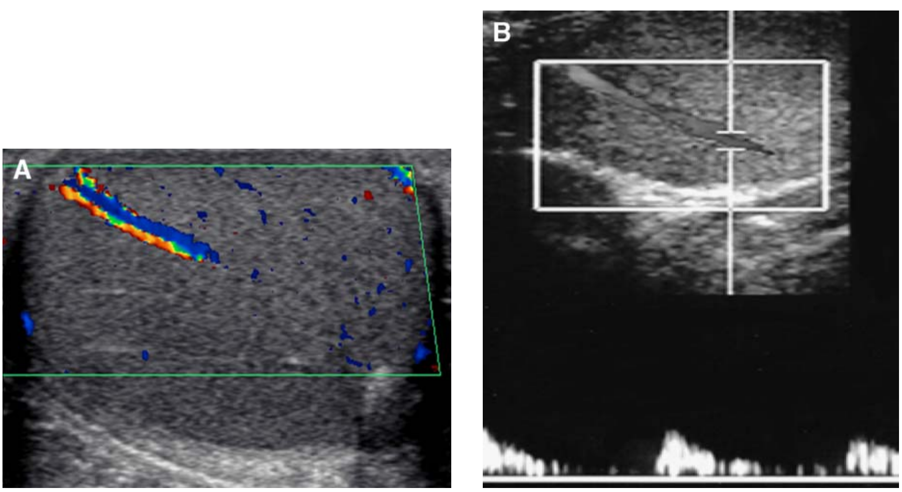


Fig. 5. (*A*) Transverse oblique sonogram reveals a transmediastinal artery. (*B*) Demonstrates the arterial waveform of the low-resistance pattern.

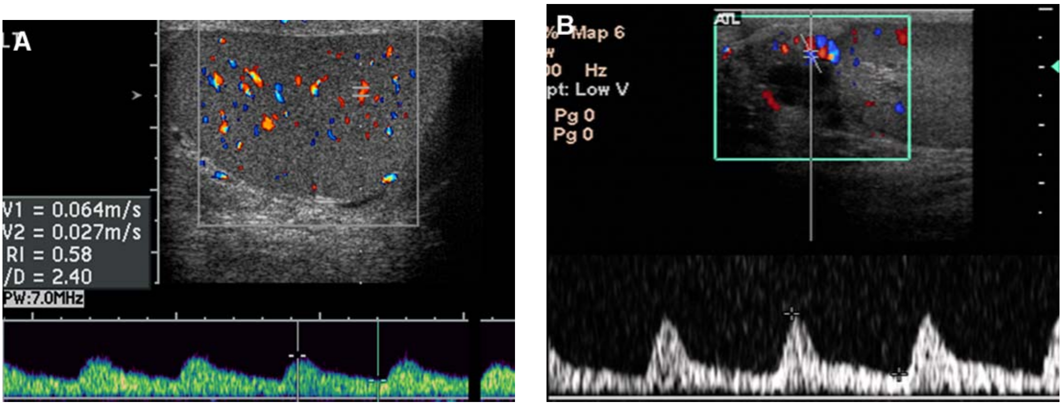


Fig. 6. Longitudinal sonogram: (*A*) demonstrates the low-resistance, high-flow pattern of the intratesticular artery, (*B*) demonstrates a similar pattern obtained from within the epididymis because anterior and posterior epididymal arteries originate from the testicular artery.

Elevation and transverse location of the testis with an anteriorly rotated epididymis associated with loss of the ipsilateral cremasteric reflex strongly suggests testicular torsion [11].

Testicular torsion

Extravaginal torsion

Two types of torsion have been described: extravaginal and intravaginal. Extravaginal testicular torsion occurs exclusively in newborns. Torsion occurs outside the tunica vaginalis when the testes and gubernacula are not fixed and are free to rotate [12]. The affected neonate presents with swelling, discoloration of the scrotum on the affected side, and a firm, painless mass in the scrotum [13]. The testis is typically infarcted and necrotic at birth. US findings include an enlarged heterogeneous testis, ipsilateral hydrocele, skin thickening, and no color Doppler flow signal in the testis or spermatic cord [Fig. 8] [14]. In children, power Doppler US is more sensitive than color Doppler US for detection of intratesticular blood flow. In one study [15], power Doppler US demonstrated intratesticular blood flow in 66 (97%) of 68 testes, whereas color Doppler US demonstrated intratesticular blood flow in 60 (88%) of the testes. Both techniques combined depicted blood flow in all 68 (100%) testes. Color Doppler US and scintigraphy are comparable with regard to the diagnosis of torsion in adolescent and adult populations [16]. Scintigraphy remains a reasonable alternative to color flow Doppler for evaluation of acute scrotal pain and should be used when color Doppler US sensitivity for low-velocity, low-volume testicular blood flow is inadequate and the diagnosis of torsion remains in question.

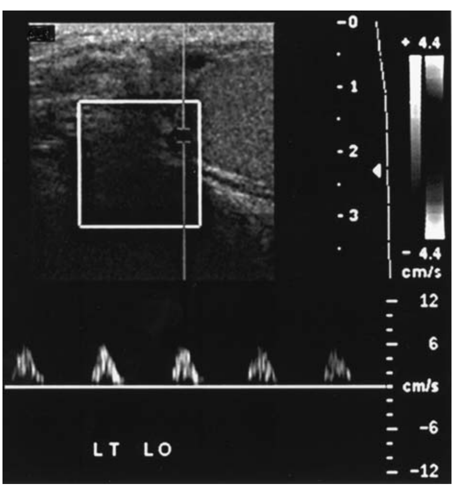


Fig. 7. Cremasteric artery at the periphery of the epididymis reveals a high-resistance, low-flow pattern of spectral waveform.

Intravaginal torsion

Intravaginal torsion occurs within the tunica vaginalis and is the most frequent type of testicular torsion seen in 80% of the population [17]. The predisposing factors include a long mesorchium or a bell-clapper deformity in which the tunica vaginalis completely encircles the epididymis, distal spermatic cord, and testis rather than attaching to the posterolateral aspect of the testis. This deformity leaves the testis free to swing and rotate within the tunica vaginalis, much like a clapper inside a bell [18]. The bell-clapper deformity can be diagnosed by US in the presence of moderate hydrocele [Fig. 9]. In most cases, the bell-clapper deformity is bilateral. A 12% prevalence of bell-clapper deformity was found in one autopsy series [19], thereby suggesting that it is a more common deformity than intravaginal testicular torsion. Testicular torsion, caused by long mesorchium, is associated

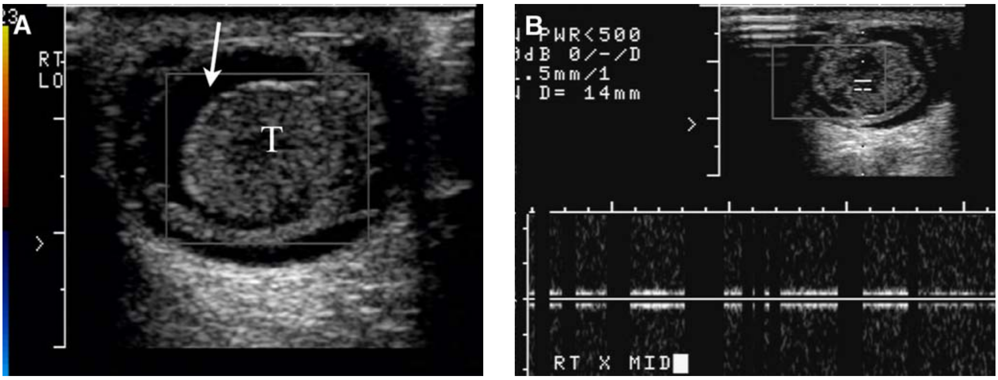


Fig. 8. (*A*) Sonogram of the testis in a newborn reveals the absence of blood flow within the testis (T) and the presence of a small hydrocele (*arrow*). (*B*) Corresponding spectral Doppler tracing further demonstrates the absence of blood flow (only noise is observed).

with cryptorchism [Fig. 10]. The most frequently found anatomical relation between the testis and the epididymis in patients who have testicular torsion is type I (epididymis united to the testis by its head and tail) [17].

Gray-scale features

In testicular torsion, venous obstruction occurs first, followed by obstruction of arterial flow, and ultimately by testicular ischemia. The extent of testicular ischemia depends on the degree of torsion, which ranges from 180° to 720° or greater. The testicular salvage rate depends on the degree of torsion and the duration of ischemia. A nearly 100% salvage rate exists within the first 6 hours after the onset of symptoms, a 70% rate within 6 to 12 hours, and a 20% rate within 12 to 24 hours [20].

US findings vary with the duration and degree of rotation of the spermatic cord. Gray-scale images are nonspecific for testicular torsion [21] and often appear normal if the torsion has just occurred [Fig. 11]. Testicular swelling and decreased echogenicity are the most commonly encountered findings 4 to 6 hours after the onset of torsion. At 24 hours after the onset, the testis has a heterogeneous echotexture secondary to vascular congestion, hemorrhage, and infarction. This condition is referred to as late or missed torsion [Fig. 12]. The gray-scale features are summarized in Box 1. An enlarged hypoechoic epididymal head may be visible because the artery supplying the epididymis is often involved in the torsion [22]. In a recent prospective study [23], a spiral twisting of the spermatic cord at the external inguinal ring was seen in 14 of 23 cases of torsion. The twisting induced an abrupt change in the course, size, and shape of the spermatic cord below the point of torsion and appeared as a round or oval homogeneous extratesticular mass with or without blood flow that could be traced cephalad to the normal spermatic cord. In the setting of testicular torsion, normal testicular echogenicity is a strong predictor of testicular viability [24]. Other indicators of testicular torsion include the presence of scrotal wall thickening and reactive hydrocele.

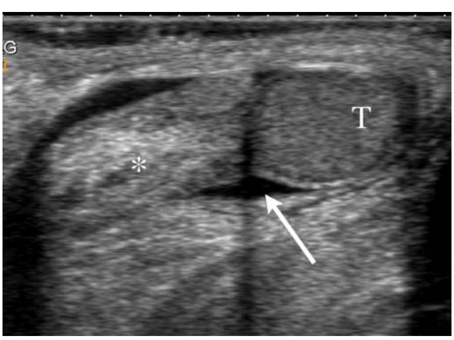


Fig. 9. Bell-Clapper Deformity in a 10-year-old male. Sonogram reveals hydrocele (*arrow*) encircling the distal third of the spermatic cord (*asterisk*). The child underwent a bilateral orchiopexy. T, Testis.

Color flow Doppler

Testicular perfusion can be evaluated by color Doppler, power Doppler, or spectral Doppler sonography. Color Doppler sonography can reliably demonstrate intratesticular flow [25]. Power Doppler sonography uses the integrated power of the Doppler signal to depict the presence of blood flow. Higher power gains are more likely with power Doppler sonography than with standard color Doppler sonography, thereby resulting in increased sensitivity for detecting blood flow. Power Doppler sonography is valuable in scrotal sonography because of its increased sensitivity to low-flow states and its independence from the Doppler angle correction [26]. Pulsed Doppler sonography is a useful method to

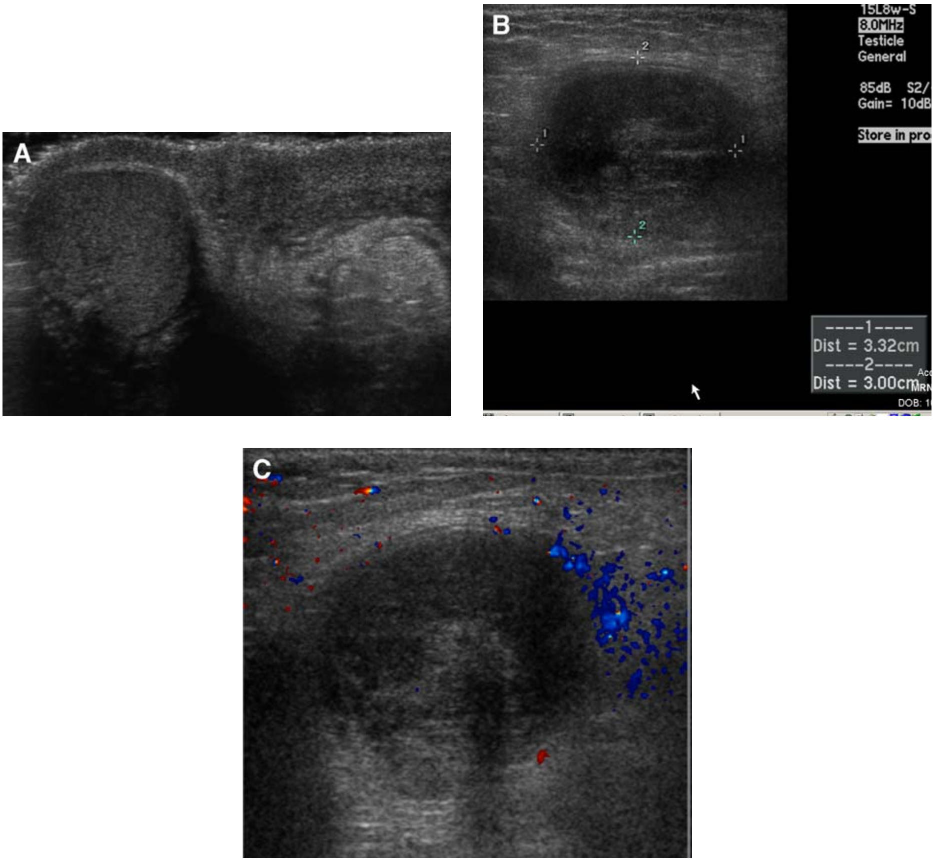


Fig. 10. Testicular torsion in a cryptorchid testis. (*A*) Transverse gray-scale sonogram demonstrates the right testis and empty left scrotal sac. (*B*) Transverse sonogram in the left inguinal region reveals a hypoechoic testis (within calipers) with no color flow (*C*).

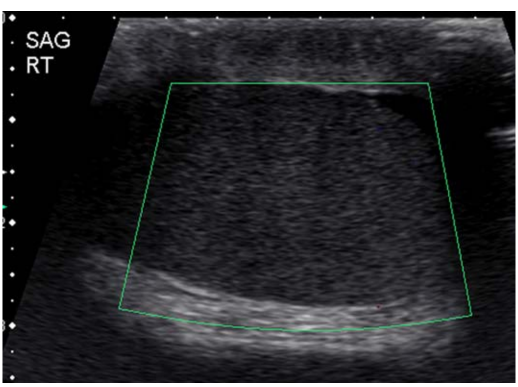


Fig. 11. Color flow Doppler of the right testis in the longitudinal plane reveals absent color flow with normal gray-scale echotexture, suggestive of early testicular torsion.

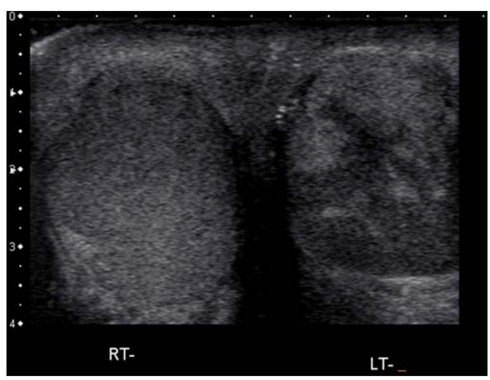


Fig. 12. Gray-scale sonogram of both testes in the transverse plane demonstrates a normal gray-scale appearance of the right testis. Left testis has heterogeneous echotexture with areas of increased echogenicity representing hemorrhage. This type of appearance favors testicular torsion of more than at least 6 hours.

Box 1: Gray-scale patterns of testicular torsion

- Normal gray-scale appearance of testis; testis may be enlarged
- Hypoechoic pattern that may be total or partial in the case of a partial infarct
- Hyperechoic and heterogeneous echo patterns; hemorrhagic infarct
- Hypoechoic with small testis (chronic torsion as end result)

identify flow in the testis using the time–velocity spectrum to quantify blood flow [27]. The spectral waveform of the intratesticular arteries characteristically has a low-resistance pattern [28] with a mean RI of 0.62 (range, 0.48–0.75) [25]; however, this is not true for testicular volumes less than 4 cm^3 as are often found in prepubertal boys when diastolic arterial flow may not be detectable [29].

Because gray-scale US findings are often normal in the early phases of torsion, the Doppler component of the examination is essential. The absence of testicular flow on color and power Doppler US is considered diagnostic of ischemia, provided that the scanner is optimized for detection of slow flow, is limited to the use of a small color-sampling box, and is adjusted for the lowest repetition frequency and the lowest possible threshold setting [30]. The threshold should be set just above the level for detection of color noise.

The role of color Doppler and power Doppler US in the diagnosis of acute testicular torsion is well established [31–33]. Using the absence of identifiable intratesticular flow as the only criterion for detecting testicular torsion, color Doppler US was 86% sensitive, 100% specific, and 97% accurate in the diagnosis of torsion and ischemia in painful scrotum [Fig. 13] [16]. As it is sometimes possible to record a small arterial signal in one part of the testis [Fig. 14] [34,35] in the appropriate clinical setting and age group, this should not dissuade one from making the diagnosis of testicular torsion. The presence of hypervascularity in paratesticular tissue is a characteristic finding of an infarcted testis [Fig. 15] [36]. Color flow Doppler features of testicular torsion are summarized in Box 2.

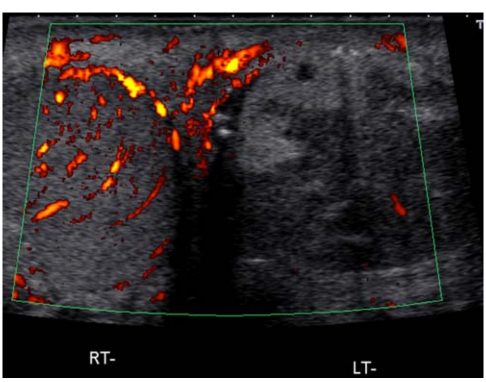


Fig. 13. Testicular torsion. Power Doppler reveals absent flow in the left testis and a normal power Doppler appearance in the right testis.

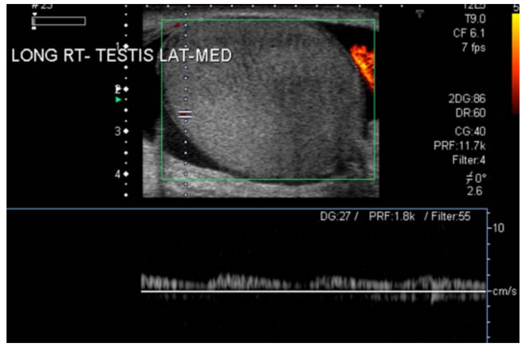


Fig. 14. Testicular torsion. A 28-year-old man presented with sudden onset of scrotal pain of 5-hours duration. Power Doppler examination revealed absent blood flow in the right testis except for a tiny arterial signal at the periphery. Please note the decreased echogenicity of the right testis. Despite the presence of minimal peripheral arterial flow, a diagnosis of testicular torsion was advanced. The patient underwent surgical exploration and was found to have bell-clapper deformity. Untwisting of the testis did not result in return of normal blood flow to the testis. Patient had to undergo orchiectomy.

Unilateral testicular torsion has bilateral effects and is a form of ischemia-reperfusion injury. Treatment of torsion by detorsion alone does not prevent testicular damage and may result in infertility [37]. If nonsalvagable, the necrotic testis is removed to decrease the risk for an autoimmune reaction to the residual testis [38].

Partial testicular torsion

Torsion is not an all-or-nothing phenomenon but may be complete, incomplete, or transient. Cases of partial or transient torsion present a diagnostic challenge. The ability of color and power Doppler sonography to definitively diagnose partial testicular torsion remains uncertain. The role of spectral Doppler US analysis is not well established with regard to the diagnosis of partial torsion, but the findings may be useful [39]. There are no studies that validate the role of spectral Doppler US in partial torsion; however, there are findings from sporadic case reports [19,40] that suggest its usefulness. Asymmetry in resistive indices with decreased diastolic flow or diastolic flow reversal may be seen [Fig. 16]. The presence of color or power Doppler

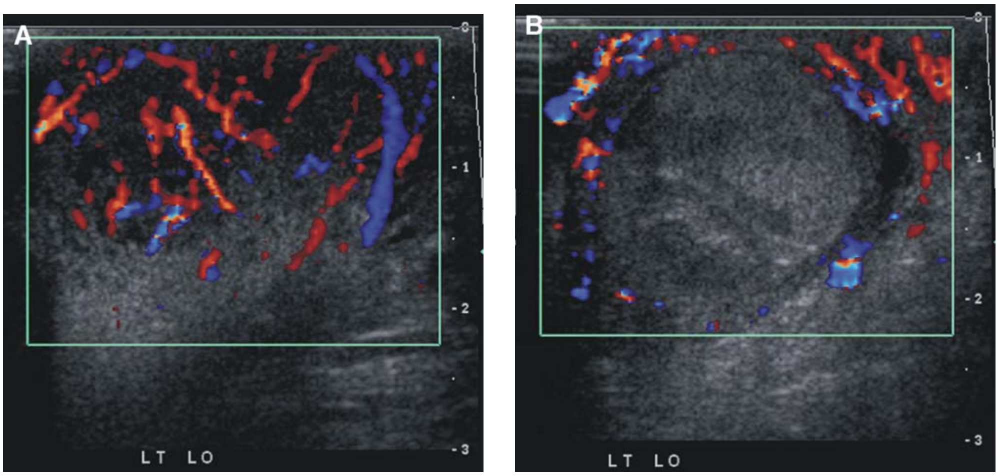


Fig. 15. Increased paratesticular blood flow. Color flow Doppler of the left testis demonstrates increased paratesticular blood flow (*A*) with absent blood flow within the left testis (*B*), consistent with testicular infarction.

signal in a patient who has the clinical manifestation of torsion does not exclude torsion [19,40].

Torsion-detorsion syndrome

Acute and intermittent sharp testicular pain and scrotal swelling, interspersed with long intervals without symptoms, are characteristic of torsion-detorsion. This type of presentation should arouse the suspicion of torsion-detorsion syndrome [41]. Physical findings may include horizontal or very mobile testes; an anteriorly located epididymis; or bulkiness of the spermatic cord from partial twisting [41,42]. Horizontal testicular position, even in the absence of pain at the time of physical examination, is a strong indication for exploration and bilateral testicular fixation [43]. If scanned when asymptomatic or immediately after detorsion, the affected testis may demonstrate increased blood flow [Fig. 17]. The testis may be enlarged, and focal infarcts may or may not be present.

If the suspicion for torsion-detorsion is high, a bell-clapper deformity can be expected on exploration and prophylactic orchiopexy should be performed bilaterally [44,45].

Box 2: Color flow Doppler patterns in testicular torsion

- Absent arterial and venous flow
- Increased RI on affected side (diminished or reversed diastolic flow)
- Decreased flow velocity difficult to measure because of small vessels/angle correction, but may be subjectively inferred by the relative difficulty in finding small, low-amplitude flow on the symptomatic side

Mimics of testicular torsion

Testicular infarction without torsion of the spermatic cord is a rare lesion, generally idiopathic and spontaneous. Absence or decrease of color flow within the testis is not always because of testicular torsion and can result from vasculitis, protein S, or antithrombin III deficiency [46]. Patients who have polyarteritis nodosa can present with acute scrotum [47,48]. Other causes of decreased testicular perfusion include large hydroceles [Fig. 18] and extratesticular hematomas [49].

Idiopathic testicular infarcts also present with acute pain, and testicular torsion is the main suspect [50]. These patients have a focal area of decreased echogenicity, usually anteriorly near the upper pole. The conditions resulting in decreased blood flow to the testis are listed in Box 3.

Testicular appendigeal torsion

Five testicular appendages are formed during the development of the male genitourinary tract; these are the remnants of the degenerating mesonephric and paramesonephric ducts. The testicular and epididymal appendages, found at the upper pole of the testis and at the head of the epididymis, respectively, are the most common [Fig. 19] [51]. Approximately 91% to 95% of twisted testicular appendices involve the appendix testis and occur most often in boys 7 to 14 years old. Patients who have torsion of the appendix testis and appendix epididymis present with acute scrotal pain, but there are usually no other physical symptoms and the cremasteric reflex can still be elicited. The classic finding on physical examination is a small, firm, palpable nodule on the superior aspect of the

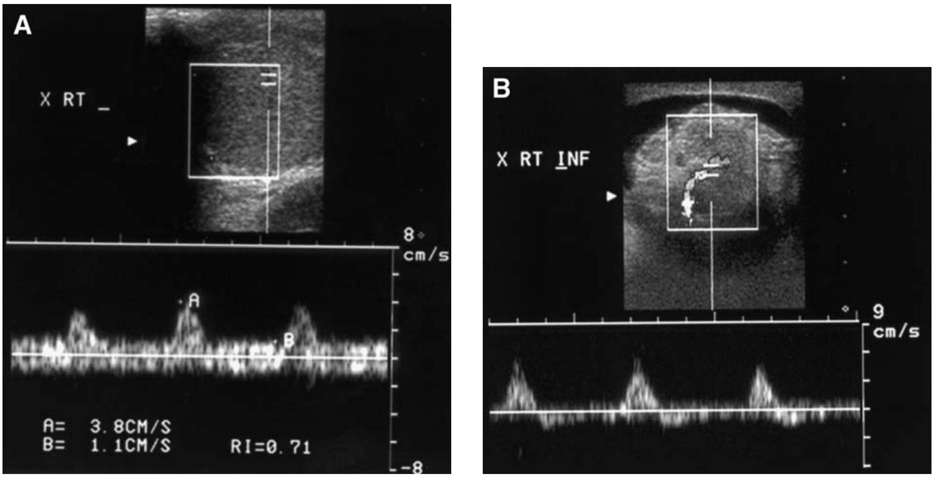


Fig. 16. Partial testicular torsion. (*A*) Right testis spectral Doppler evaluation reveals decreased diastolic blood flow. (*B*) In the same testis, the diastolic waveform can be seen below the baseline. This appearance is suggestive of increased resistance to the inflow of arterial blood. The patient underwent surgical exploration and partial torsion was confirmed. (*From* Dogra VS, Sessions A, Mevorach RA, et al. Reversal of diastolic plateau in partial testicular torsion. J Clin Ultrasound 2001;29:105–8; with permission.)

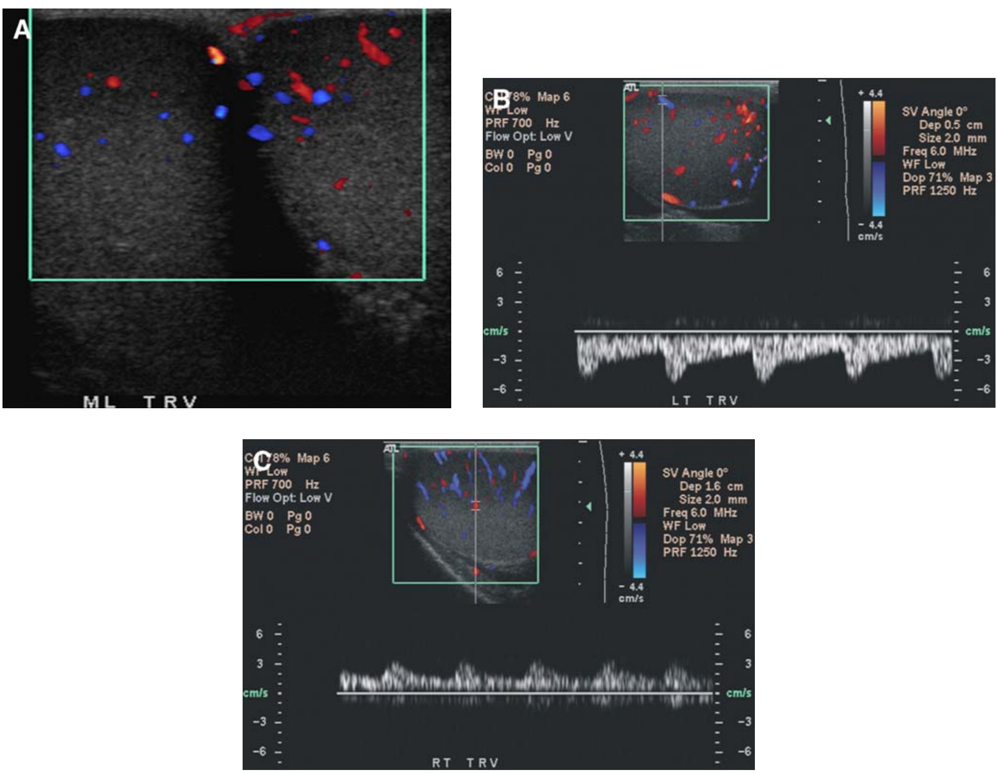
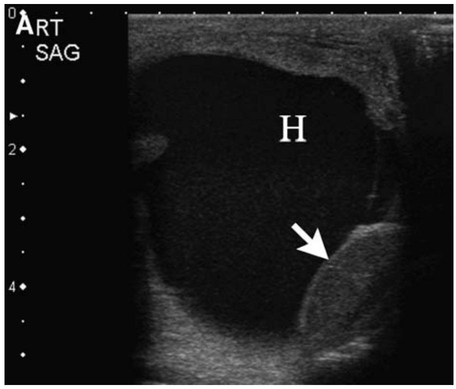


Fig. 17. Torsion-detorsion syndrome. The patient presented with a history of intermittent left testicular pain. He was asymptomatic at the time of examination. (*A*) Color flow Doppler in the transverse plane demonstrates increased blood flow to the left testis. Comparing spectral Doppler waveform of the left testis (*B*) with that of the right testis (*C*), it is evident that there is increased blood flow to the left testis.



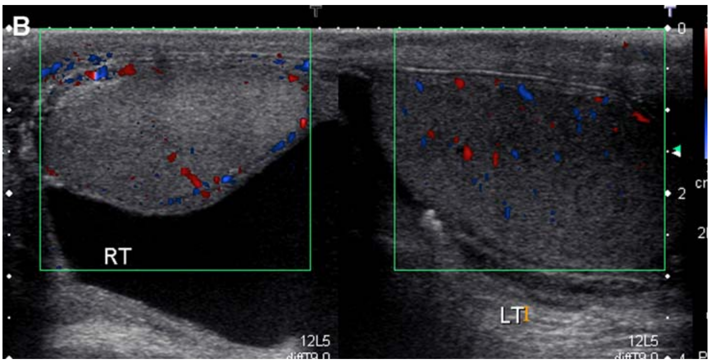


Fig. 18. Testicular torsion mimic. Patient who has right scrotal pain. (*A*) Gray-scale sonogram of the right testis demonstrates a large hydrocele (H) pushing and causing pressure on the testis (*arrow*). (*B*) Color Doppler evaluation of both testes side-by-side reveals decreased blood flow to the right testis. Blood flow returned to normal after hydrocelectomy.

testis; it exhibits a bluish discoloration through the overlying skin which is called the "blue dot" sign [52].

US appearance of torsion of the appendages of the testes is variable and may be isoechoic, hypoechoic, or hyperechoic to the testis or epididymis [Fig. 20] [53,54]. Reactive hydrocele and skin thickening are common in these cases. An appendix testis size of 5 mm or larger, spherical shape, and increased periappendiceal blood flow are suggestive of a torsed appendix testis [54]. The identification of a testicular appendage larger than 5.6 mm is suggestive of torsion. Therefore, depending on a patient's clinical condition, such cases can be treated conservatively when an appendage larger than 5.6 mm is identified [55]. The role of US examination in tor-

Box 3: Conditions that may result in decreased blood flow in the testes

- Poor technical parameters
- Pediatric population (small testicular volume)
- Hydrocele/hematoma
- Vasculitis, such as polyarteritis nodosa and lupus
- Marked scrotal edema, resulting in poor penetration of US beam
- Epididymo-orchitis, resulting in testicular infarction (a rare complication)
- Protein S and antithrombin III deficiency

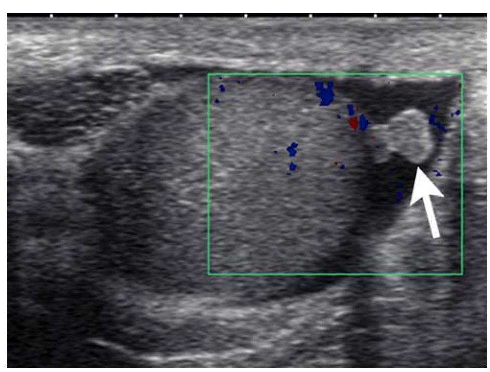


Fig. 19. Appendix testis. Sonogram demonstrates appendix of the testis (*arrow*). The presence of fluid facilitates this visualization.

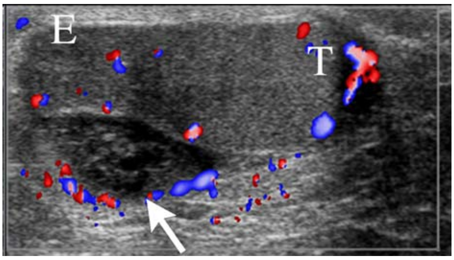


Fig. 20. Testicular appendigeal torsion. A 10-year-old man presented with testicular pain. Color flow Doppler demonstrates a hypoechoic mass with peripheral hyperemia (*arrow*) separate from epididymis (E). This hypoechoic mass resolved on follow-up. T, Testis.

sion of testicular appendages is to exclude testicular torsion and acute epididymo-orchitis.

Summary

As US is considered as the first step in evaluation of acute painful scrotum, it is important to optimize the scan parameters. Testicular torsion is a urologic emergency that can be accurately diagnosed by high-frequency transducer sonography in conjunction with appropriate clinical history and physical examination. Absence of color flow Doppler does not always signify testicular torsion as this could be secondary to vasculitis. Similarly, the presence of color flow does not exclude partial testicular torsion.

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