Scrotal Imaging

17

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Introduction

Imaging of the scrotum is the mainstay of the workup of a patient who presents with scrotal pathology. The different imaging modalities that are utilized include ultrasound, MRI, and nuclear scintigraphy, each with different advantages and limitations. Ultrasonography is the most commonly used modality due to its noninvasive nature, high degree of accuracy, low cost, and simplicity [1, 2]. Avoiding the need for ionizing radiation and contrast material is an added benefit when there is a need to image the testes, which are exquisitely sensitive to toxins. The study is interactive, and an experienced radiologist can tailor the study to the patient's history and clinical findings. More recently, the combination of color and power Doppler ultrasound has become the most prevalent method of sonographic evaluation of the testes. It is more sensitive to low-flow states and low velocities, but lacks directionality and has poor temporal resolution [3]. This is of special importance in the pediatric population as the preadolescent testes have low blood flow, which may be easily missed on routine Doppler ultrasound.

Nuclear scintigraphy with technetium 99 is used in the evaluation of the acute scrotum in cases that are equivocal on ultrasound. It may be used to differentiate between cases of testicular torsion, requiring emergent surgical intervention, versus a nonsurgical pathology such as epididymitis or orchitis. The benefits of this study must be weighed against the possible delay in treatment in a case of testicular torsion. In equivocal cases, when blood flow is undetectable by color Doppler ultrasound, nuclear scintigraphy may be a powerful tool as it may detect testicular perfusion in age-appropriate low-flow states [4].

Magnetic resonance imaging is another radiographic modality to help elucidate cases that are diagnostically equivocal on ultrasound. Although ultrasound is indispensible in the evaluation of the scrotum, the MRI is an excellent second-line modality when the diagnosis is inconclusive after sonogram [5]. There are characteristics of scrotal solid masses on MRI that may assist in planning surgery and in deciding whether a scrotal mass is malignant or benign and amenable to a partial orchiectomy or nonsurgical management [6].

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Technique

Scrotal ultrasonography is performed with the patient positioned supine and with a support, such as a warm folded towel underneath the scrotal sac for support. The penis should be displaced superiorly or superolaterally and a towel may be draped over it. A scrotal ultrasound scan is performed with a high-frequency (7.5–15-MHz) transducer for optimal resolution. Imaging should be conducted in sequential sagittal and transverse planes, proceeding in a systematic fashion. The first images should be transverse and include both testes side by side to allow comparison of echotexture, echogenicity, size, and flow, as well as documenting the presence of two testicles. The patient should be warm and as comfortable as possible, otherwise the scrotal contents retract and the scrotal skin thickens, making evaluation challenging. Color flow and duplex Doppler are pertinent when assessing testicular perfusion and viability as well as in identifying vascular injuries. It is also important to identify infection and the vascularity of a mass. Pinggera et al. have suggested the use of resistive index as a predictor of testicular dysfunction. They found that RI >0.6 correlates with an abnormal semen analysis or subfertility [7].

Nuclear scanning of the testicle is usually reserved for cases of indeterminate findings on ultrasound performed when testicular torsion is suspected but is not diagnostic. Details regarding performance of the study were described in a previous chapter. Briefly, scrotal scintigraphy is generally performed using technetium 99 for detection of blood flow. Images are typically taken every 3–5 s for 1–2 min.

MRI of the scrotum and testes is used as a second-line radiologic modality to aid in the diagnosis of masses in the scrotum that are indeterminate on ultrasound. A 1.5T magnet is used with a 5-in. (13 cm) coil. Imaging includes a large field of view frame to include the renal vessels to assess for hernias and allow evaluation of the lymph node drainage of the testicles in the retroperitoneum. A high-resolution T2-weighted fast spin echo sequence is used in the axial, sagittal, and coronal planes to image the scrotum. A high-resolution axial T1-weighted spoiled gradient echo sequence is also used to identify hemorrhage. Gadolinium can aid in differentiating between a benign cystic lesion and a cystic neoplasm and can be used to assess for areas of absent or reduced testicular perfusion, such as in segmental testicular infarct [8].

Anatomy

The scrotum is divided into two compartments by a fibromuscular septum. The main components of each scrotal compartment are the testicle and the epididymis, which is located on the posterolateral aspect of the testicle. The epididymis is comprised of a cauda, body, and caput, with the appendix attached to the caput. The average size of the epididymis in an adult is 6–7 cm in length and the epididymal head is 1–1.2 cm in cross section. The body of the epididymis should be less than 4 mm in cross section and the 1–2 mm on average. The appendix testis is a Müllerian remnant, also known as the hydatid of Morgagni, which may be found on the upper pole of the testis. The appendix epididymis (pedunculated hydatid) is found on the caput (head) of the epididymis and is a Wolffian duct remnant.

The arterial supply to the testicle and the venous drainage from the testicle are important components of the scrotal sac, and evaluation of those is a key factor on imaging. Changes to the skin and to the layers surrounding the testicle can also be noted. The potential space between the visceral and parietal layers of the tunica vaginalis, which are a continuation of the visceral and parietal peritoneum, may be commented upon.

Testicular arterial supply includes the testicular (gonadal) artery, the vasal artery, and the cremasteric artery. The vasal artery is a branch of the internal iliac artery, the gonadal artery is a branch off of the aorta, and the cremasteric artery is a branch off of the inferior epigastric. The majority of the blood supply to the testicle is derived from the gonadal artery [9]. The venous drainage is mainly a function of the pampiniform plexus, which may be dilated and result in a finding of a varicocele. This plexus drains into the internal iliac vein bilaterally as well as the gonadal vein which empties into the renal vein on the left and the aorta on the right [10].

The adult testicle is an elliptical structure which measures on average 25 ml by orchidometer and14 ml by ultrasound. Its dimensions are 4–5 cm longitudinally and 2.5 cm across. The size of the testicle in the pediatric population according to the patient's age was measured sonographically and reported in several studies. The size of the testicle increases significantly in the first 5 months of life, from 0.27 ml to 0.44 ml. By 9 months of age the testicle is 0.31 ml on average and remains stable in size until puberty [11]. Goede et al. collected data from 932 patients age 6 months to 18 years and found that the mean testicle volume at age 1 was 0.48 ml, at age 10 it was 0.97 ml, and at age 18 it was 13.73 ml. The greatest variability was found at age 14, where the range was 1.69–19.98 [12].

The spermatic cord is also evaluated sonographically, as it may harbor pathologies such as a mass, hydrocele, hernia, or varicocele. Normally the cord is comprised of the testicular vasculature, the vas deference, as well as nerves and lymphatics that drain the testicle directly into the retroperitoneal lymph nodes.

Ultrasound is the primary imaging study of the scrotum and its contents (Fig. 17.1). The testes should have a homogenous echotexture surrounded by the tunica vaginalis which is not visible in the absence of a hydrocele. A hyperechoic stripe that is parallel to the epididymis represents the mediastinum testis. The epididymis sits superior to the testis and is normally iso- or hypoechoic to the adjacent testicle. The individual components of the spermatic cord are not discernible by ultrasound, but bidirectional flow may be discerned by Doppler. This can be challenging in the prepubertal child.

Normal testes are homogeneous in appearance on MR imaging. There is intermediate signal intensity on T1-weighted images and high signal intensity on T2-weighted images relative to skeletal muscle (Fig. 17.2). The epididymis is similar to testicular parenchyma on T1-weighted images, but low signal intensity on T2-weighted images. The tunica albuginea is low signal intensity on both T1- and T2-weighted images. The mediastinum testis will be a low-signal band posterior in the testicle on T2-weighted images. Normal testis parenchyma is

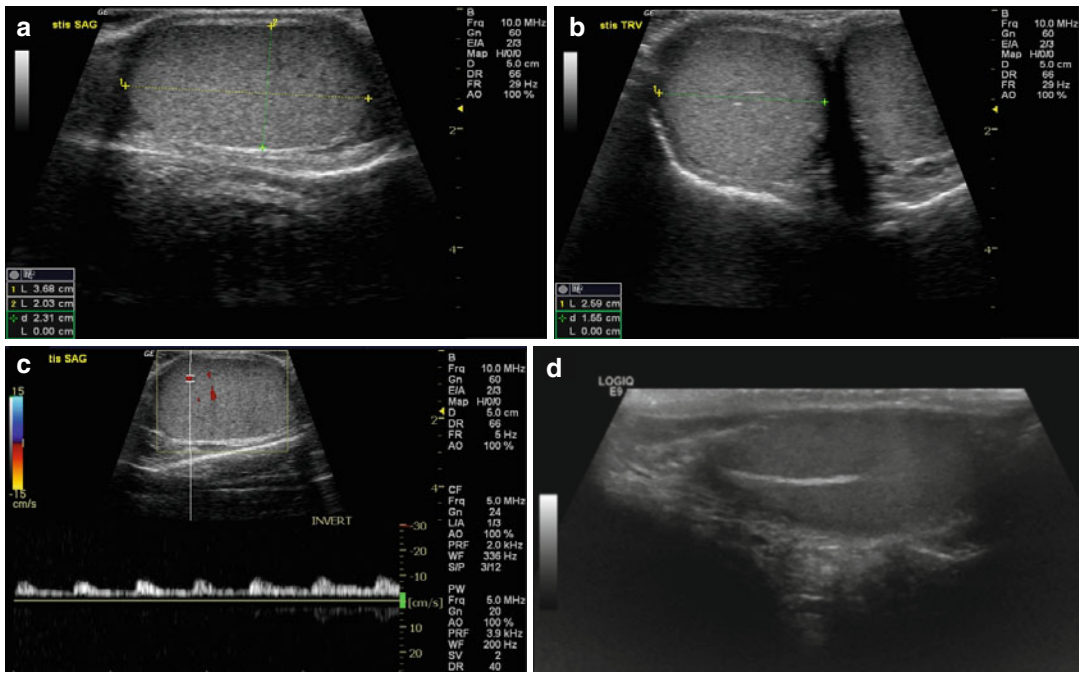

Fig. 17.1 Normal testis. Sagittal (**a**) and transverse (**b**) views of normal testes demonstrating homogeneous parenchyma. The markers take measurements of testicular size in both dimensions. Spectral Doppler tracing of a normal testis measured from a vessel noted in color Doppler (**c**). The mediastinum testis is seen as a hyperechoic stripe in the mid-testis (**d**)

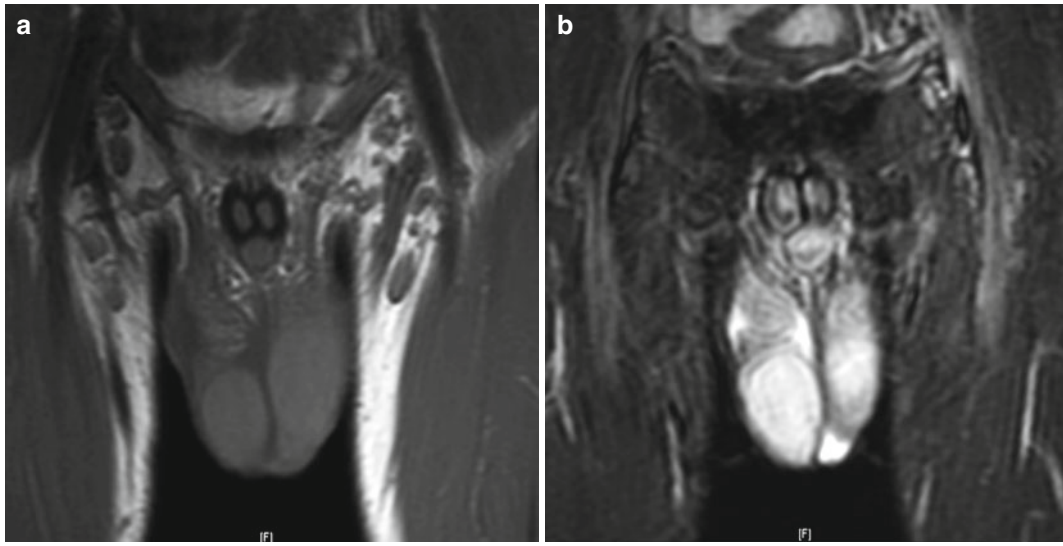

Fig. 17.2 Normal testis. MR images demonstrating the normal testes from a young teen imaged for osteomyelitis of the hip. The T1 images (**a**) demonstrate the hypointense testes in the scrotum. The T2 image (**b**) demonstrates the hyperintense ovoid structures in the scrotum. The size discrepancy reflects their position within the scrotum

homogenous in attenuation and enhancement on CT examinations. CT is not typically used to image testicle pathology, but rather to image the chest, abdomen, and pelvis for testicular cancer staging.

Acute Scrotum

The acute scrotum provides a unique radiological dilemma as interpretation of ultrasound findings relies on the clinical history. A detorsion event may present with similar findings as an epididymitis or epididymal torsion. This underscores the importance of obtaining a good history and maintaining open communication between the radiologist and the clinician.

Testicular Torsion

Testicular torsion is the single most common emergency within the realm of pediatric urology. Torsion can occur at any age but is most common in 12–18-year-old adolescents. Recovery of the testicle is most likely within the first 6 h after the event, after which testicular salvage rates drop precipitously. The etiology in the adolescent population is due to a bell-clapper deformity in which the tunica vaginalis encircles the epididymis, distal spermatic cord, and the testis rather than attaching to the posterolateral aspect of the testis. The deformity leaves the testis free to swing and rotate within the tunica vaginalis, as a clapper inside a bell.

The diagnosis of testicular torsion is primarily reliant on the clinical presentation. A typical history is a sudden onset of extreme and unremitting testicular pain that may or may not be associated with physical activity. Clinically, the patient is in severe pain, has difficulty ambulating, and may experience nausea and vomiting. The testicle is tender and in an abnormal transverse, high-riding lie, while the scrotum is erythematous. The cremasteric reflex is typically absent on the affected side and the Prehn's maneuver is negative, i.e., there is no pain relief with elevation of the testicle. Attempts at scoring systems have been made but are not yet widely used [13].

Ultrasonography has been shown as highly reliable in diagnosis of the acute scrotum in the emergency department, with a sensitivity of 94 %, specificity of 96 %, and accuracy of 95.5 % [2]. Radiographically, the appearance of the testicle changes according to the degree of torsion and the time since the onset of the event. In complete torsion (540–720° twisting), the testis may

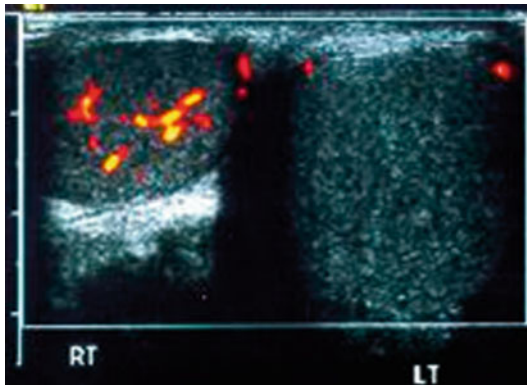

Fig. 17.3 Left testicular torsion for 5 h. Transverse images of the scrotum demonstrate the absence of flow and enlargement consistent with engorgement and edema

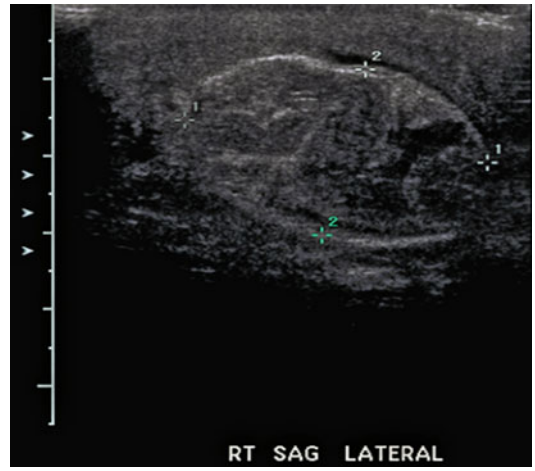

Fig. 17.4 Missed torsion. Sagittal view of the right testis on a 16-year-old male 18 h after the onset of testicular pain demonstrating heterogeneity of the parenchyma. Doppler flow was not demonstrable on the left. The left testis was normal

have normal echotexture with absent blood flow very early in the process. After 4–6 h, the testis is enlarged, the parenchyma may appear normal or have some patchy hypoechoic areas present, and the blood flow is still absent (Fig. 17.3). Additional findings include enlargement of the epididymis, thickening of the scrotal skin, as well as the presence of a reactive hydrocele. Sonographic examination of the cord may demonstrate a whirlpool sign, representing the twisted congested vessels of the cord [14]. Kalfa et al. determined that sonography of the spermatic cord is highly sensitive and specific for the diagnosis of acute torsion [15]. Decreased blood flow may be seen with a partial torsion of 180–360°, where there is a longer window of viability to the testicle.

Torsion longer than 24 h may clinically present with diminished pain due to the presence of a completely infarcted and unsalvageable testicle. Sonographically the testicle appears to have heterogeneous echotexture and absent blood flow, and it is surrounded by reactive hyperemia [16]. It may be enlarged in size and contain areas of decreased echogenicity (Fig. 17.4).

Flow velocity is evaluated by Doppler ultrasound. In the prepubertal patient, it may be challenging to detect blood flow. The addition of power Doppler increases blood flow detection rate from 80 to 90 % in that age group. The velocity scale should be set to the lowest setting in order to increase the sensitivity to flow detection. Spectral Doppler sonography allows for comparison between the two testicles and findings of asymmetry in blood flow. The diagnostic accuracy of ultrasound is equivalent to that of nuclear scanning; however, the two modalities may be complementary in cases of uncertain diagnosis.

Scintigraphy and sonography show similar high sensitivity for the diagnosis of testicular torsion; however, in equivocal cases these modalities can complement one another to further increase the diagnostic accuracy [17, 18] (Fig. 17.5). In a multi-institutional review of 130 pediatric patients with acute scrotal pain, Baker et al. demonstrated 89 % sensitivity and 99 % specificity for color Doppler ultrasonography for differentiating testicular torsion from other nonsurgical etiologies. The mean age at the time of ultrasonography was 11 years. Seventeen patients were suspected to have testicular torsion and were emergently explored. The remainder of outcomes was obtained by clinical follow-up with outpatient sonograms. The mean length of follow-up was 1.3 years, but 23 % of patients were lost to follow-up and could not be evaluated. There were two cases of missed testicular torsion which resulted in delayed testis atrophy and one case that underwent surgical exploration for a torsed epididymal appendage [17].

These limitations were addressed by Lam et al. in a large single institution review of 626 patients

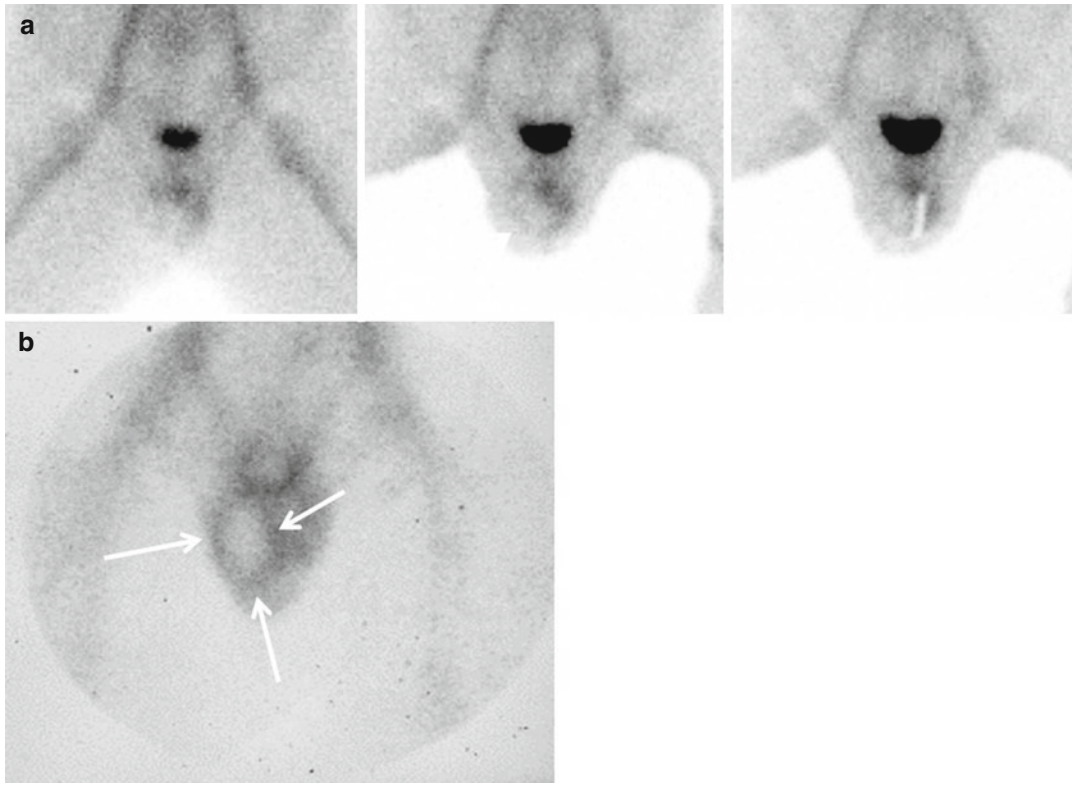

Fig. 17.5 Nuclear scintigraphy of two boys with acute onset of testicular pain. (**a**) There is a paucity of uptake of tracer in the right hemiscrotum after pain of 5 h duration (*arrow*). (**b**) There is absence of flow but surrounding hyperemia (*arrows*) on the right hemiscrotum after 24 h of pain consistent with a missed torsion

who presented with acute scrotal pain. Forty-seven percent were explored immediately, leaving 332 (53 %) who underwent initial color Doppler US at time of presentation. Mean age was 8 years, and all patients had at least 2 weeks follow-up. Nine patients showed no flow on color Doppler US, and all were confirmed as testicular torsion upon exploration. Four of 323 patients who were found to have normal or increased flow on sonogram and explored based on clinical suspicion were found to have testicular torsion. Overall, color Doppler US yielded nine true-positive results and 319 true-negative results out of 332 which computes to a sensitivity of 69 %, specificity of 100 %, and an accuracy of 98.8 % [18].

Other authors have demonstrated better sensitivity for Doppler US in older patients. Yagil et al. report their results using Doppler US as a screening tool in the ED for triage of patients with acute scrotum. The patients studied were slightly older than in prior series, with a mean age of 16 years. In this review of over 620 patients, testicular torsion was suspected by Doppler US in 20 patients and confirmed via surgical exploration in 18. There were two false positives and one false negative. The reported study sensitivity, specificity, and accuracy were 94, 96, and 95.5 %. The only false-negative exam occurred in a 3-year-old boy who had present, but slightly diminished flow in the affected testicle. Surgical exploration due to a high index of clinical suspicion revealed torsion. This outstanding diagnostic accuracy may be due in part to an older study population which may have improved the performance of Doppler US in detecting arterial flow [19].

Other authors have noted that Doppler US is often user dependent and that documenting flow in the prepubertal testis can be unreliable [20–23]. An oft-quoted report by Ingram et al. showed that in 50 normal boys ranging in age from 2 months to 13 years, blood flow could be detected by color Doppler in both testes in only 58 % of boys and 34 % had no detectable flow [21]. Albrecht et al. report similar abilities of

color and power Doppler to detect testicular blood flow in normal prepubertal boys (69 % vs. 65 %), with the combination of the two marginally better at 79 % [20]. This was confirmed in a prospective comparison by Blask et al. of scintigraphy and Doppler ultrasonography in 46 children who presented with an acute scrotum in which flow was demonstrated in the asymptomatic testis in only 60 % [24].

Appendix Testis/Epididymis Torsion

Torsion of an appendix is most common in 6–12-year-old patients. The clinical presentation is acute onset of pain, limited to the superior pole of the testicle at the level of the appendix. The occasional finding of a blue dot seen through the scrotal skin is due to ischemia and necrosis of the appendage. Sonographically the epididymis and sometimes the entire testicle are inflamed, and on occasion the enlarged and avascular appendix can be seen and palpated due to swelling and hyperemia. Treatment is symptomatic relief with nonsteroidal anti-inflammatory agents and scrotal elevation.

Epididymitis/Orchitis

These entities are common causes of an acute scrotum in the pediatric population. The onset is more gradual than that of testicular or appendix torsion, and it may be accompanied by fevers. In prepubertal patients the cause is usually nonbacterial and may be related to dysfunctional voiding. In the postpubescent patient this is usually related to retrograde spread of infection or to chemical irritation of the epididymis secondary to reflux of urine. In sexually active patients, this may be associated with the spread of a sexually transmitted disease. Sonographically, the epididymis and/or testis appear hyperemic and hypervascular, enlarged, and hypoechoic (Fig. 17.6). Reactive hydroceles and scrotal edema are also

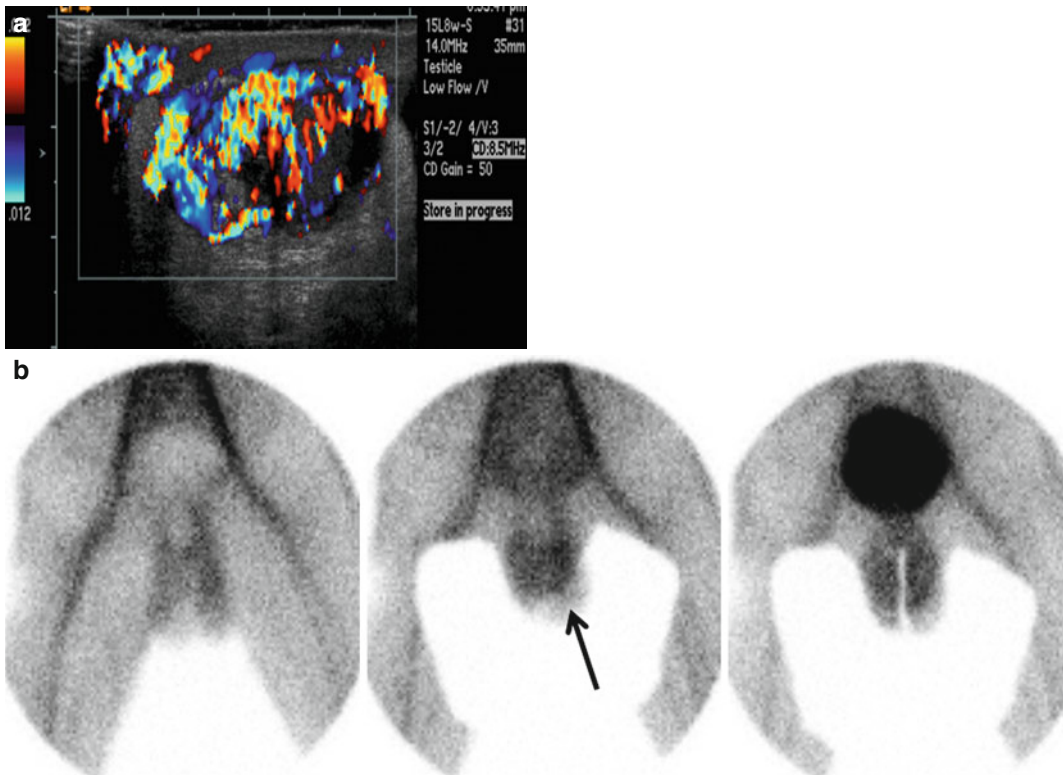

Fig. 17.6 Ultrasound (**a**) and nuclear scintigraphy (**b**) demonstrating the features of epididymo-orchitis. Increased Doppler flow is noted on ultrasound to both the testicle and epididymis when compared to the asymptomatic side. There is increased uptake of nuclear tracer to the left hemiscrotum (arrow)

common findings. Nuclear perfusion scintigraphy studies using technetium 99 rely on flow images showing abnormal increased testicular perfusion, as well as static pictures showing a "cold" defect in the area of hydrocele (Fig. 17.6). Inflammatory conditions are characterized by diffusely increased uptake of radiotracer into the affected testicle. A study by Mueller et al. found that when supplementing scintigraphy with sonography, the interpretation was changed in 14 % of cases, which spared 31 % of patients from a surgical procedure [18].

Trauma

The main objective of a sonographic evaluation is to assess whether there is presence of blood flow to the testicle and to identify whether the tunica albuginea surrounding the testicle is intact, as absence of flow or the presence of testicular rupture are indications for scrotal exploration. Indeterminate findings or high clinical suspicion is also an indication for exploration.

In testicular rupture there is extrusion of seminiferous tubules out of the testicle, and the tunica appears discontinuous. Salvage rate of testicular rupture is upwards of 90 % even after 72 h post-trauma. Buckley and McAninch reported that the finding of heterogeneous parenchyma and irregular contour had 100 % sensitivity and 93.5 % specificity for the diagnosis of testicular rupture [19] (Fig. 17.7).

Contusions can be seen as a hypoechoic area, but are not indications for scrotal exploration if the tunica albuginea is intact. A testicular fracture is a break in the parenchyma of the testis without a tear in the tunica albuginea. It will appear as a linear hypoechoic band and may be managed nonoperatively if there are no abnormalities in Doppler flow imaging.

Hematomas may occur anywhere within the scrotum following trauma. Acute injury is represented by a hyperechoic dense fluid collection whereas an older bleed will be hypoechoic and without vascularity. The fluid collection of a hematoma is usually complex and heterogeneous.

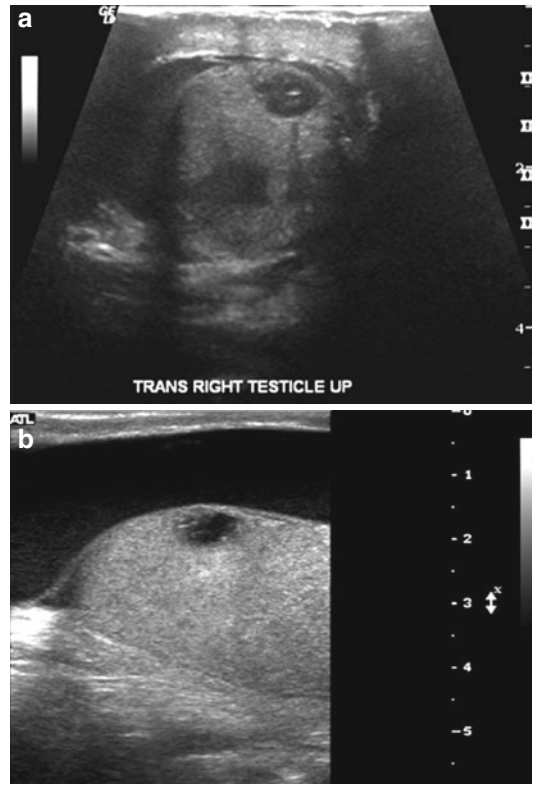

Fig. 17.7 Trauma. Transverse view of the right testis demonstrating several hematomas within the testis, a surrounding hematocele and thickening of the overlying skin following blunt trauma (**a**). The same testis several weeks later demonstrating an isolated remnant hypoechoic area and a large hydrocele (**b**)

Hematoceles are complex fluid collections that separate the visceral and parietal layers of the tunica vaginalis. In the acute setting they appear hyperechoic and become hypoechoic with time [20].

Pyocele/Abscess

Pyoceles are rare in the pediatric population [21]. Its presence is suggested by the clinical history, which usually includes prior surgery or a scrotal or perineal skin infection. Acute pain, fevers, and an elevated white blood cell count are present. The physical findings may include a tender and swollen scrotum, erythema, edema, and a tense hydrocele, which may be confused with an acute

torsion of the testicle. An abscess may be suggested radiographically by the presence of complex multiloculated scrotal fluid collection containing debris, thickened tunica vaginalis, and heterogeneous echogenic areas. Color Doppler will demonstrate peripheral hypervascularity without internal blood flow [22]; however, blood flow to the testicle should appear preserved.

Vasculitis

Systemic processes such as Henoch-Schonlein purpura (HSP) may affect the testicle in approximately 15 % of cases. In some patients, scrotal symptoms are the initial clinical manifestation of this disease process. The patient with HSP usually has cutaneous symptoms such as lower extremity petechiae, as well as renal and rheumatologic symptoms. The scrotum is painful and enlarged [23]. Ultrasound examination will reveal enlarged epididymis and thickened scrotal skin, as well as reactive hydroceles. Testicular blood flow is usually maintained or increased (Fig. 17.8). Nuclear scintigraphy is also diagnostic in such cases for epididymo-orchitis, which demonstrate increased perfusion to the testis [23, 24].

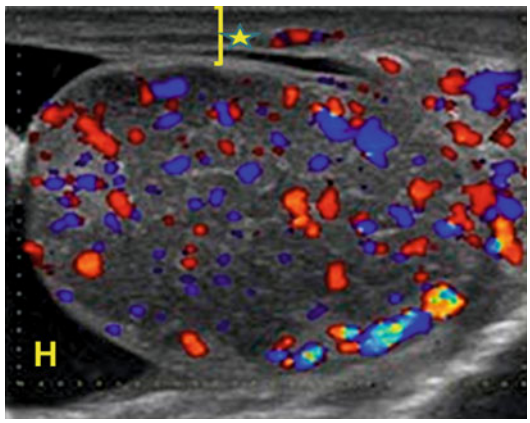

Fig. 17.8 Vasculitis. An 8-year-old boy presented with scrotal pain and a papular rash on the legs. While the diagnosis of Henoch-Schonlein purpura was made, concurrent testicular torsion could not be excluded by history and physical examination. The constellation of ultrasound findings of thickened scrotal skin (*bracket-star*) maintained or increased color Doppler flow, and the presence of a hydrocele (*H*) is all consistent with the diagnosis of HSP

Hydrocele/Hernia

The processus vaginalis is an extension of the parietal peritoneum, which envelops the testicle in two layers as it descends into the scrotum during embryogenesis. The processus vaginalis is normally obliterated in the 7–9 months of gestation, but in approximately 20 % of males the processus vaginalis is patent at birth, resulting in a potential space. In most cases this will resolve by 1 year of age, and many males with a patent processus vaginalis are asymptomatic. Sonographically, the two layers of the tunica vaginalis can appear as isoechoic to hyperechoic linear bands extending from the internal inguinal ring to the scrotum. Pediatric hydroceles are commonly due to an indirect hernia, which is a consequence of a patent processus vaginalis that allows for free communication of peritoneal fluid with the scrotum, and fluid accumulation. Those hydroceles are reducible, and the scrotal sac contents are seen to change in size throughout the day and with different activities. In the noncommunicating variant, the hydrocele sac size is fixed, as it is not in communication with the peritoneal fluid [25]. Hernias may not communicate with the tunica vaginalis, and the fluid may be able to be tracked distally from the groin and seen to end proximal to the testis (Fig. 17.9).

Hydroceles are usually diagnosed clinically, and imaging is not indicated. If imaging is obtained for inconclusive cases, the hernia is sonographically represented by hypoechoic fluid collection within the tunica vaginalis, and the scrotal hydrocele is the peritoneal fluid surrounding the testicle (Fig. 17.10). In the pediatric population these are usually simple fluid collections without septations unless there is a history of infection or trauma. Herniation of bowel via a patent processus vaginalis is more common in the premature infant, in which the inguinal canal is very short as the internal and external rings are almost overlying each other at birth, and the patency of the processus vaginalis is large relative to the abdominal contents. In cases of suspected bowel incarceration, plain radiographs can be use to augment ultrasound findings by detecting bowel gas in the scrotum. Echogenic bowel mucosa or bowel motility can be detected sonographically [26].

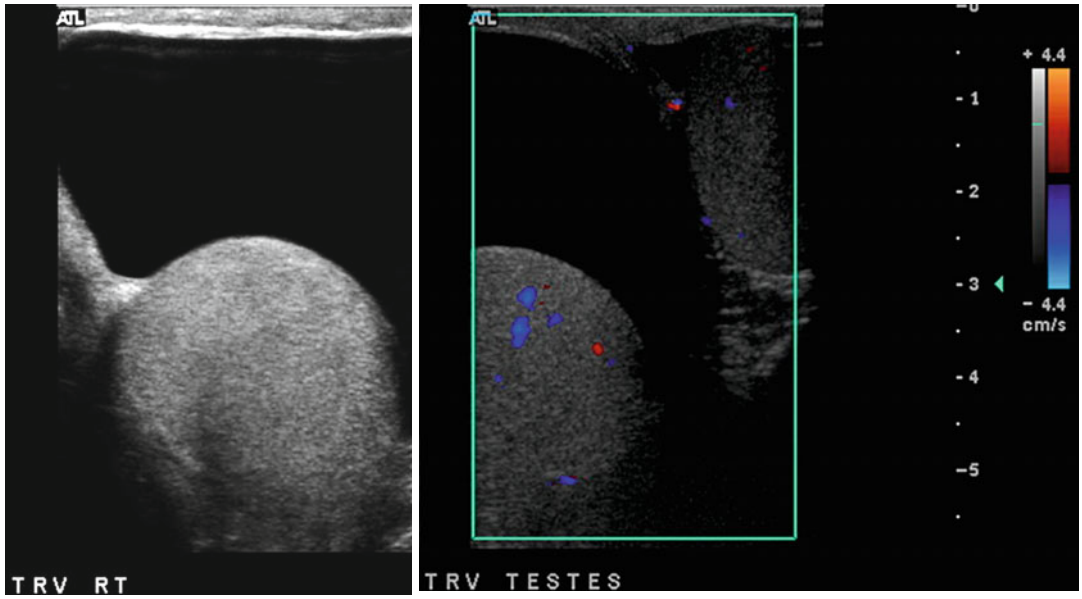

Fig. 17.9 Hydrocele. Anechoic space is seen in the right hemiscrotum that surrounds the testis. The superior margin of this collection was noted

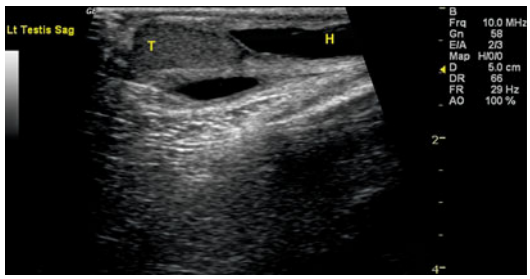

Fig. 17.10 Hernia. Sagittal view of an ultrasound performed in a 6-year-old boy with an inguinal swelling. A longitudinal hypoechoic area (*H*) is noted in the inguinal area superior to the testis (*T*). This was consistent with a left inguinal hernia which was confirmed at surgery

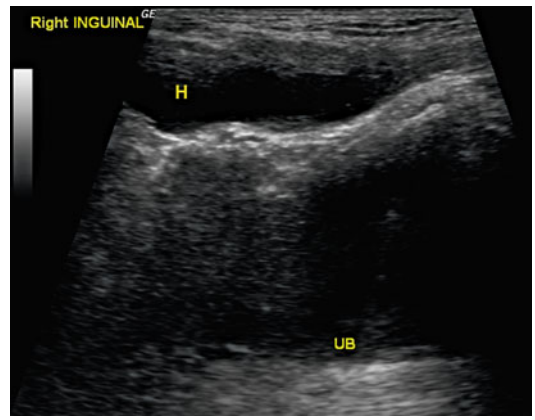

Fig. 17.11 Hydrocele of the spermatic cord. Sagittal view of the inguinal canal in a child who felt a "lump" in the inguinal canal. This area was limited to the spermatic cord on physical examination. The hypoechoic area (*H*) was well defined with normal cord superior and inferior to this area. Bladder (*UB*)

Hydrocele of the spermatic cord may present as an inguinal swelling, with or without pain (Fig. 17.11). It is a rare finding, present is about 1–5 % of cases with inguinal symptoms. Similar to the scrotal hydrocele, the spermatic cord hydrocele emanates from a patent processus vaginalis. This finding may have several variants: the encysted hydrocele, the reducible or funicular hydrocele, and the mixed variety. The encysted hydrocele does not communicate with the peritoneal cavity and therefore cannot be reduced. The funicular hydrocele appears as a peritoneal diverticulum into the inguinal canal that terminates above the scrotum. Occasionally there may be multiple cysts along the spermatic cord, which may appear as beads along the spermatic cord when studied sonographically [25]. In a study assessing the utility of scrotal ultrasound in the diagnosis of a hydrocele of the cord, 3,486

sonograms in 1,743 pediatric patients were reviewed. All patients presented with a mass or swelling of the inguinal region. Of those, 27 patients were diagnosed sonographically with a hydrocele of the cord after finding of an anechoic, avascular mass along the spermatic cord. Only one of these patients was clinically diagnosed with this entity, reflecting the lack of awareness of this diagnosis as well as its rarity [27, 28].

Varicocele

Dilated testicular veins are found in 10–13 % of adolescents and are more common on the left side. Isolated right varicocele or one that does not decompress in the supine position should prompt a workup of an abdominal or pelvic pathology. The association of varicoceles with testicular failure and with infertility is well established; however, the mechanism by which unilateral varicoceles have this bilateral effect remains controversial. This pathology is usually treated in adolescents when hypotrophy of the affected testicle is greater than 20 % as compared to the contralateral testicle. Varicoceles are rarely associated with pain or discomfort, and if severe they may be visible and deform the scrotum. Grade 1 is palpated only on Valsalva; grade 2 is easily palpable, but not visible; grade 3 is visible.

Sonographic evaluation of a varicocele is done both in the supine and standing positions, while performing Valsalva maneuvers. On ultrasound the varicocele appears as an anechoic serpiginous vein greater than 3 mm at rest and retrograde flow with increased vein diameter on Valsalva maneuver (Fig. 17.12). Grading of varicocele depends on sonographic evaluation. Grade 0, subclinical varicocele, is found only on sonogram, but not clinically detectable. High flow rates (>38 cm/s) were strongly associated with testicular volume asymmetry [29].

Ultrasound classification of varicocele grade 1 is characterized by the detection of a prolonged reflux in vessels in the inguinal channel only during Valsalva, while scrotal varicosity is not

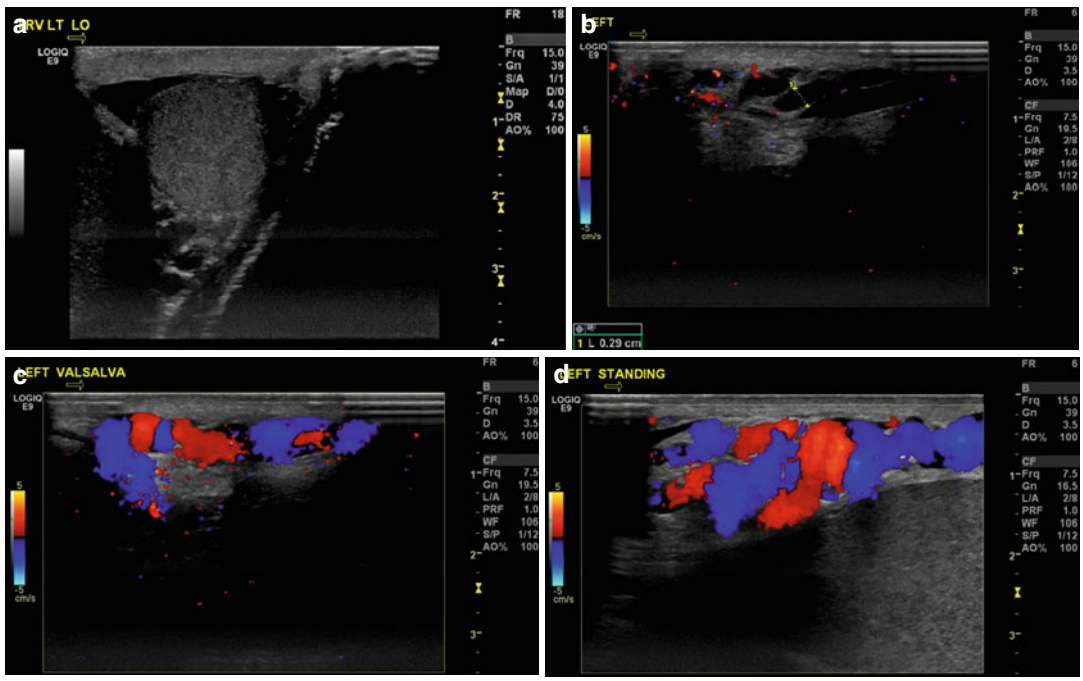

Fig. 17.12 Varicocele. Transverse (**a**) and sagittal (**b**) ultrasound images of the left testis demonstrate hypoechoic spaces inferior and superior to the testis. Color Doppler flow increases considerably with the patent moves from the supine (**c**) to the standing (**d**) position consistent with a varicocele

evident in the previous grayscale study. Grade 2 is characterized by a small posterior varicosity that reaches the superior pole of the testis and whose diameter increases after Valsalva. The ultrasound evaluation clearly demonstrates the presence of a venous reflux in the supratesticular region only during Valsalva. Vessels that appear enlarged at the inferior pole of the testis only when the patient is evaluated in a standing position characterize grade 3. Ultrasound demonstrates a clear reflux only under Valsalva. Grade 4 is diagnosed if vessels appear enlarged, even if the patient is studied in a supine position; dilatation increases in an upright position and during Valsalva. Enhancement of the venous reflux after Valsalva is the criterion that allows the distinction between this grade from the previous and the next one. Hypotrophy of the testis is common at this stage. Grade 5 is characterized by an evident venous dilation even in an upright position. Ultrasound demonstrates the presence of an important basal venous reflux that does not increase after Valsalva [30].

Microlithiasis

Microlithiasis are small (2–3 mm) calcified intratesticular lesions that may be found within the testicular parenchyma. These microcalcifications represent incompletely phagocytized degenerated cellular remnants within the seminiferous tubules. They are usually discovered incidentally when an ultrasound of the scrotum is performed for other reasons including scrotal pain; however, they do not appear to be associated with the etiology of the pain. Furthermore, most likely do not have an association with future testicular malignancy [31]. There is a suggested association with certain pathologies such as Down's syndrome and Klinefelter's syndrome, as well as with infertility and testicular germ cell tumors [32]. Sonographically, they appear as multiple, small (2–3 mm), non-shadowing, echogenic foci found within the testicular parenchyma, defined as the presence of ≥5 echogenic foci per transducer field in one testicle. There occasionally may be a comet tail artifact, which is a form of reverberation artifact seen on grayscale ultrasound of the highly reflective object characteristic of microlithiasis (Fig. 17.13).

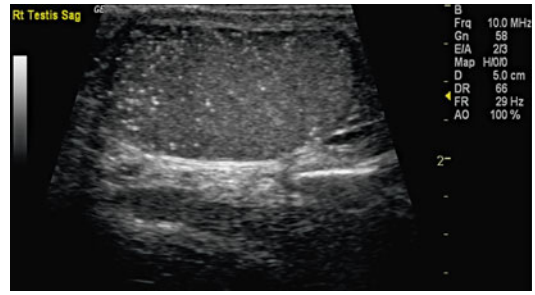

Fig. 17.13 Microlithiasis. Punctate hyperechoic areas are noted primarily in the superior portion of this right testis. Microlithiasis may be present diffusely in the testis or more localized as in this case

Cryptorchidism

The incidence of cryptorchidism is about 3 % at birth and is more common in premature infants and males with Down's syndrome. But by age 1 year, approximately 2/3 of these testes will descend leaving 0.8–1 % of boys requiring management, typically surgical. The incidence of infertility increases when both testes are undescended, when either or both testes are intra-abdominal, and when there is delay in providing descent. After age 2 years, degenerative changes can be seen histologically. In addition, the risk of malignancy is also noted to be higher in cryptorchid testes, and this may improve when early orchidopexy is performed. The undescended testicle is usually smaller from the descended one found in the inguinal canal or pelvis adjacent to the urinary bladder. The judicious use of imaging for localization should be employed as most testes that are beyond the internal inguinal ring should be palpable, except, perhaps the use of ultrasound in the obese child. MR is expensive and does not carry 100 % accuracy thus not precluding subsequent surgical management. If

the undescended testis is detected, it is smaller than expected and hypoechoic compared to its partner (Fig. 17.14). An image of the mediastinum testis can serve to distinguish it from the surrounding lymph nodes. Ultrasound is only indicated in cases of ambiguous genitalia [33]. On MR coronal T1-weighted images may reveal the ovoid structure with low signal intensity of the gubernaculum or spermatic cord which can lead to the testes. T2-weighted images will reveal a hyperintense testis located in the abdomen or pelvis (Fig. 17.15)

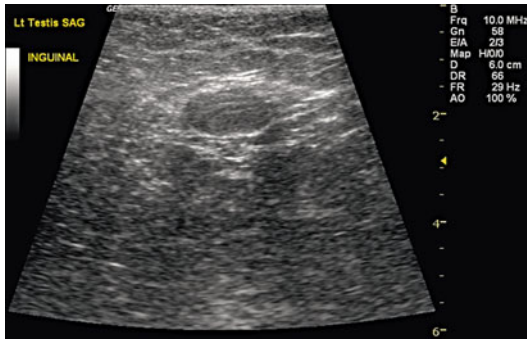

Fig. 17.14 Cryptorchidism. Imaging for an undescended testis may be effective in select cases. Ultrasound may identify (*left*) a testis in the inguinal canal in obese children as an oval homogenous structure that appears very different from the surrounding muscle and fat. MR may be useful in the case of a non-palpable testis

Lymphoma/Leukemia

Infiltrative malignancies such as lymphoma or leukemia may show enhanced vascularity that is similar in pattern to that of orchitis, and therefore the clinical history is of utmost importance in these cases. Leukemic infiltration of the testicle appears as gross enlargement and diffuse hypervascularity. These pathologies can rarely present initially with testicular finding, and therefore a high index of suspicion must be maintained. Sonography will show a diffusely hypoechoic enlarged testis or one with multifocal hypoechoic regions (Fig. 17.16). The process may be bilateral. The testicles are notably a privileged site due to the testis-blood barrier, and therefore recurrence of leukemia is possible posttreatment as chemotherapeutic agents do not cross the barrier effectively [34]. On MRI, one may see similar findings of diffuse replacement of the testicle by infiltrate by tumor, with iso- to hyperintensity on T1-weighted and hypointensity on T2-weighted images [6].

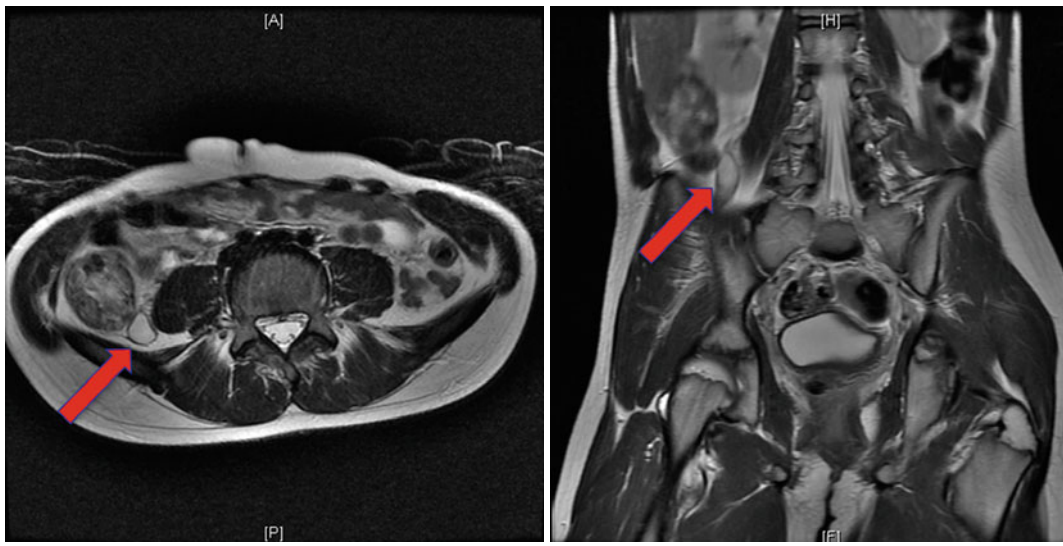

Fig. 17.15 Cryptorchidism. MR may be helpful in identifying an intra-abdominal testis. On these T2-weighted axial (*left*) and coronal (*right*) images, the hyperintense ovoid structure is an undescended testis (*red arrow*) located lateral to the right psoas muscle and adjacent to the mid-ascending colon within the mid-retroperitoneal abdomen

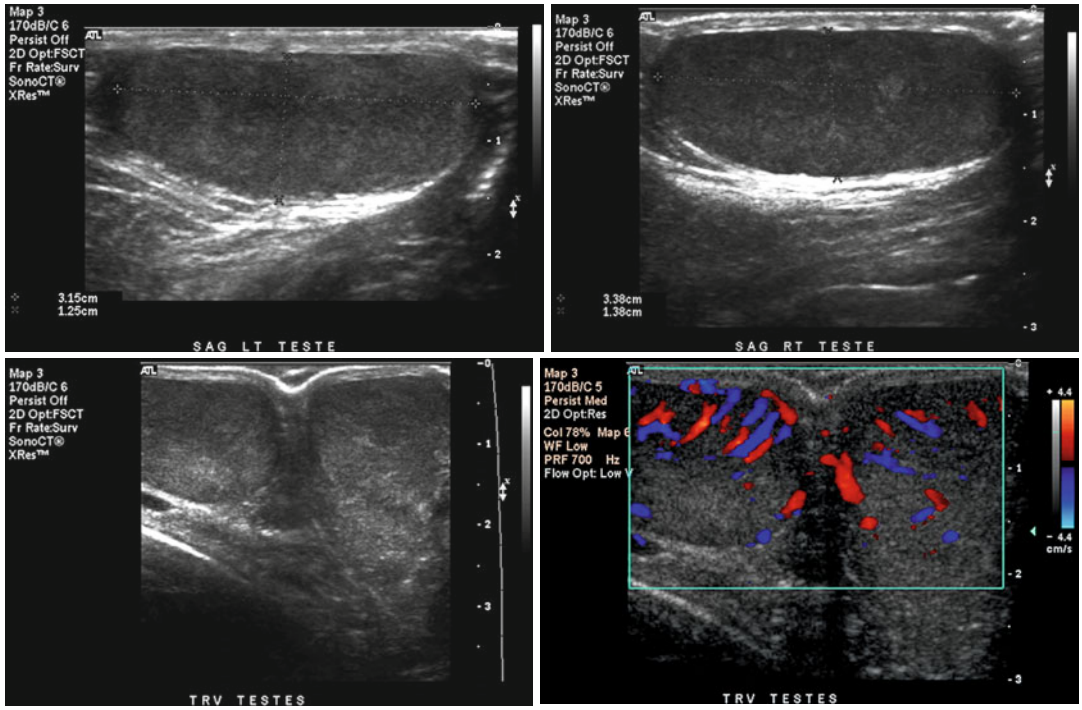

Fig. 17.16 Transverse and sagittal images of the scrotum in a child with acute lymphoblastic leukemia. In this case there is enlargement of both testes with patchy areas of decreased echogenicity and increased color Doppler flow

Masses

Sonograms are commonly used to characterize a testicular mass suspected on physical exam due to the high sensitivity of the test, its availability, and low cost. However, imaging is rarely diagnostic as to the type of tumor and the associated prognosis, which is usually obtained after orchiectomy and pathological analysis. Some patients with certain risk factors such as contralateral testis cancer will have periodical testicular scans to detect masses early, even before the mass is palpable, as sonography can detect masses 3–5 mm in size. Patients with a history of an undescended testicle are at increased risk of developing a malignancy later in life, and some patients may elect to undergo annual sonography for early detection of a tumor, particularly if the position of the testicle was not corrected or corrected after infancy. The incidental finding of microlithiasis in an otherwise normal testis may prompt some practitioners to initiate yearly surveillance for the development of testicular germ cell neoplasia, although this association is controversial.

A testicular mass in a prepubescent child is more likely to be benign, where as a postpubescent child with a testicular mass is highly suspicious for a malignant tumor. Therefore, the clinical history is very important in establishing a diagnosis, as many tumors may appear similar on imaging. In general, the larger the mass, the more vascularized it appears on color Doppler imaging. It is important to note that sonography is not diagnostic for the type of malignancy, and therefore an excisional biopsy or orchiectomy is warranted.

Malignant Germ Cell Tumors

Seminoma

Seminomas are the primary testicular malignancy in the postpubertal population and are not found in the prepubescent population. Sonography may

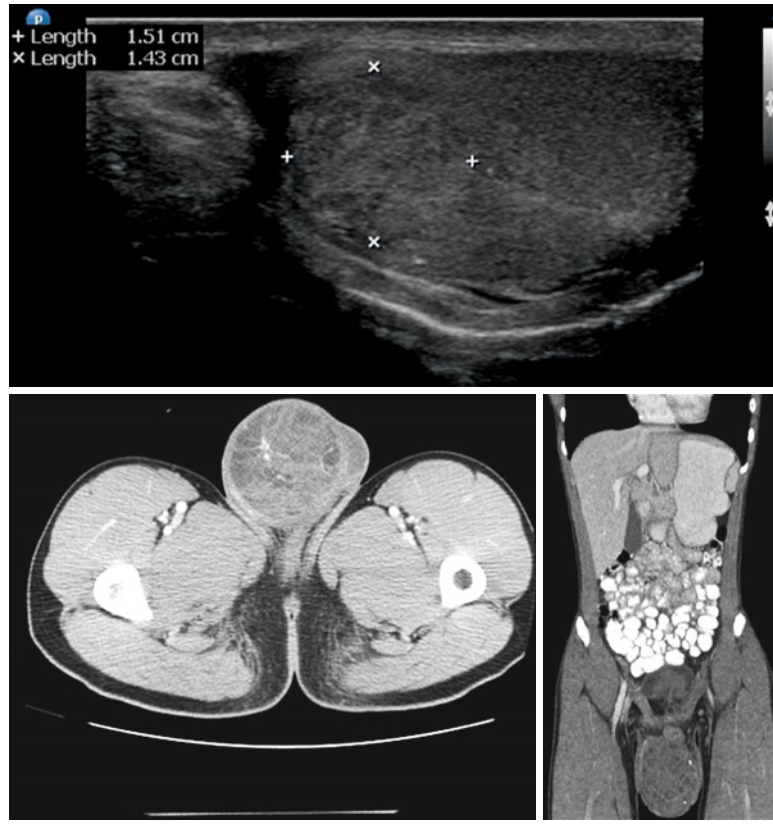

Fig. 17.17 Germ cell tumor found in the right testis. The ultrasound showed a relatively homogeneous and well-circumscribed mass causing enlargement of the testis. Similar findings are seen on the axial and coronal images of the T1-weighted MR

show single or multiple solid hypoechoic masses with homogeneous echotexture. They are usually well circumscribed with lobular margins and are highly vascular. Large masses may cause diffuse testicular enlargement [35]. On MR, seminomas are also homogeneous and usually hypointense to the normal testicular parenchyma on T2-weighted imaging and isointense on T1 [6, 8] (Fig. 17.17).

Nonseminomatous Germ Cell Tumor

In the prepubescent population, yolk sac (endodermal sinus) tumors are the predominant malignant finding. The mean age of diagnosis is 18 months. AFP is elevated in these tumors, which assists with diagnosis as well as response to treatment and long-term follow-up. These lesions are characterized by central necrosis and high degree of vascularity. They may simply enlarge the testicle without a discrete mass. Benign teratomas are probably equally as prevalent as yolk sac tumors (Fig. 17.18). They appear as heterogeneously hypoechoic masses with internal calcifications on US. In the postpubescent population, malignant testicular tumors can include choriocarcinoma, malignant teratoma, and embryonal carcinoma and appear as hypoechoic heterogeneous solid masses (Fig. 17.19). They may contain cystic spaces or densely echogenic foci that result from internal scarring, calcification, or cartilage [32]. On MR, nonseminomatous tumors are usually heterogeneous due to their mixed histology. Areas of increased signal intensity can indicate necrosis or hemorrhage which is often seen in this type of malignancy [6]. They are usually hypointense on T2 and iso- or hyperintense on T1 [8].

Sex Cord-Stromal Tumors

These are rare tumors that have low malignant potential, including Sertoli and Leydig cell tumors. Recently there have been increasing

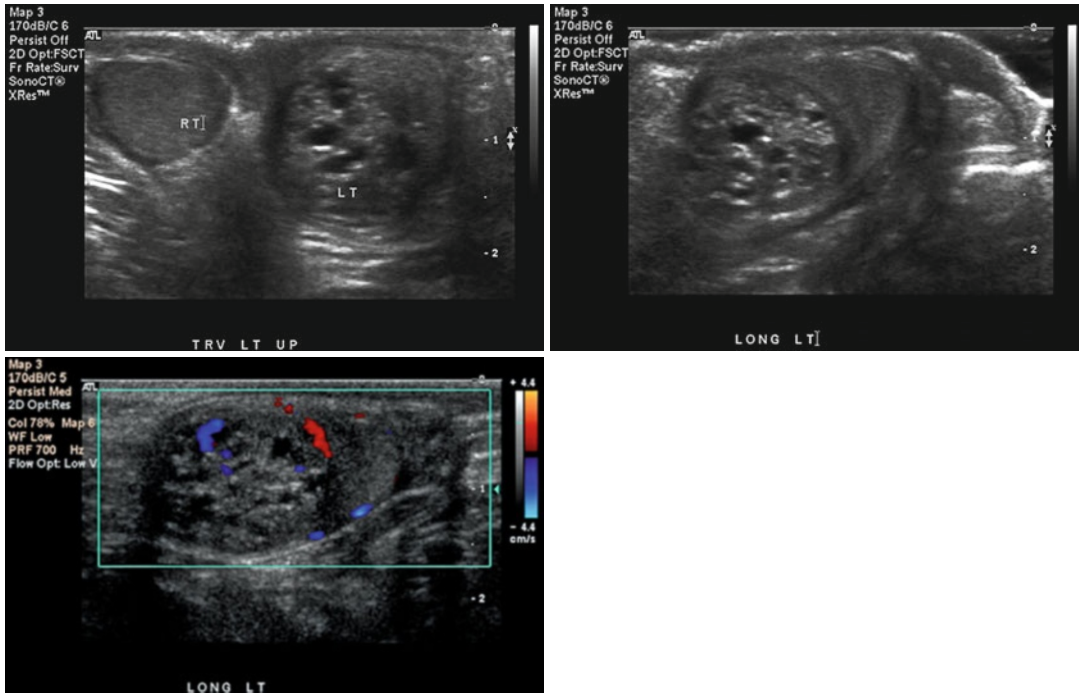

Fig. 17.18 Ultrasound of the testes demonstrates the mass in the right testis with large hypoechoic areas of necrosis and vascularity. The pathologic diagnosis was a benign teratoma

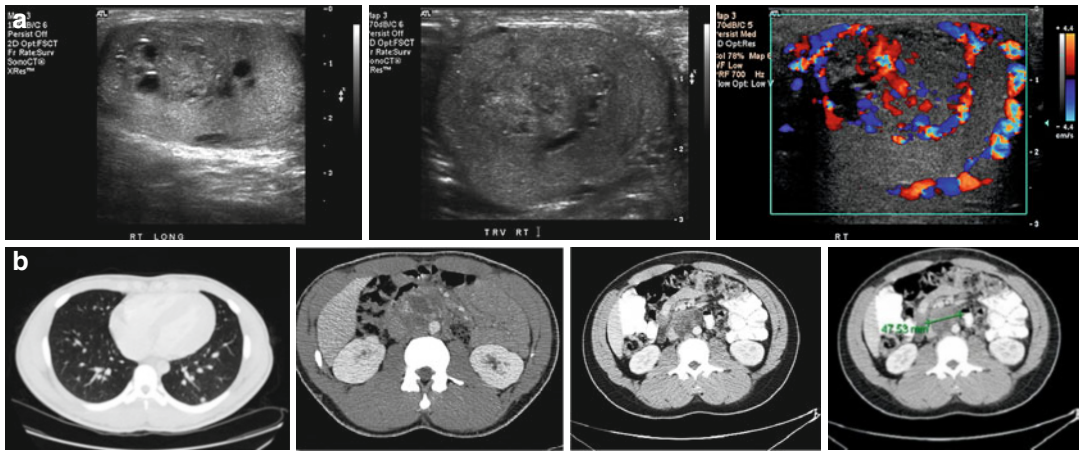

Fig. 17.19 Imaging studies of a palpable testicular mass are useful to characterize the testis tumor and for staging purposes. The pathologic type requires histologic analysis. (**a**) Choriocarcinoma seen on ultrasound as a mainly solid mass with hypoechoic areas (possible necrosis) and hypervascularity on Doppler. (**b**) CT demonstrates metastatic disease to the lung and retroperitoneal lymph nodes

reports of incidentally detected benign tumors, a phenomenon which could be explained by improved imaging techniques and the increase in their use [36, 37]. Approximately 25 % of Leydig cell tumors occur before puberty and may be found on workup for precocious puberty or gynecomastia. Sonographically they appear as a small, hypoechoic, nonhomogeneous nodule with vascularity. Since they are benign in 90 % of cases, partial orchiectomy is advocated (Fig. 17.20).

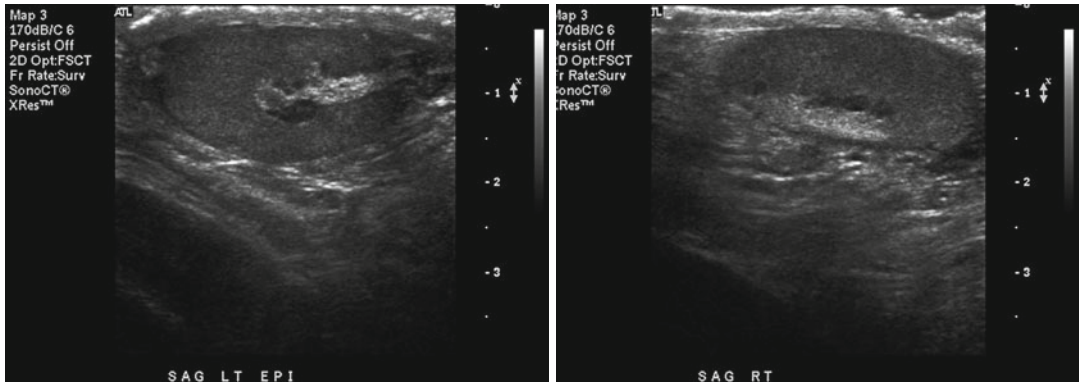

Fig. 17.20 An intratesticular cyst is noted on this transverse ultrasound image. There classic features of a simple cyst are present: imperceptible wall, absence of septations, smooth contour, and through transmission. These are benign

Sertoli cell tumors are found in young men and are usually benign. Sonographically they have increased echogenicity and a characteristic "spoke-wheel" multicystic appearance. Occasionally they contain calcified areas. Sertoli cell tumors have rarely been characterized on MRI; they are described as having a variable appearance and therefore not a recommended diagnostic modality [6].

Benign Intratesticular Tumors

Simple Cysts

As elsewhere, cysts are benign, anechoic, well-circumscribed lesions that may be found arising from the tunica albuginea around the testicle or from within the testicle (Fig. 17.21). These cysts appear as most of these cysts are not palpable and are encountered on ultrasound performed for other reasons. In the absence of symptoms, these cysts do not require treatment.

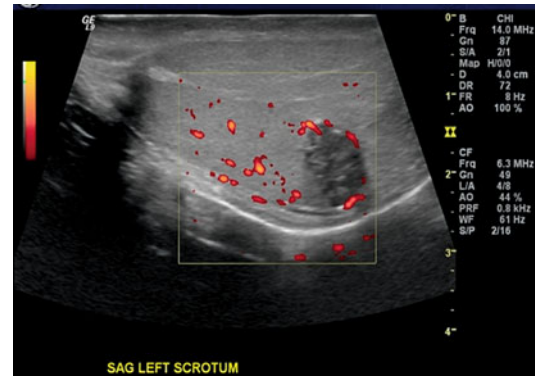

Fig. 17.21 Adrenal rests. Hypoechoic lesions are seen bilaterally in the rete testes of this child with 21-hydroxylase deficiency

Adrenal Rests

Testicular adrenal rests tumors (TART) are found in patients with congenital adrenal hyperplasia with 21-hydroxylase deficiency. These are benign lesions that may be implicated in infertility either due to a paracrine effect or due to compression of seminiferous tubules. Sonographically these are hypoechoic lesions located in the rete testis (near the mediastinum) (Fig. 17.22). A study by Cakir et al. attempted to assess the prevalence of TARTs in males with CAH. Sonography of 14 CAH patients detected 2 (14 %) with TART [38]. Another study by Poyrazoglu et al. detected TART in 9/41 (22 %) patients with CAH [39].

Epidermoid Cysts

These are benign intratesticular lesions, with a variable appearance that is related to the ratio of keratin versus calcium. They are associated with the sonographic finding of laminated "onion skin" appearance, surrounded by a hypoechoic or echogenic rim; however, this classic finding is

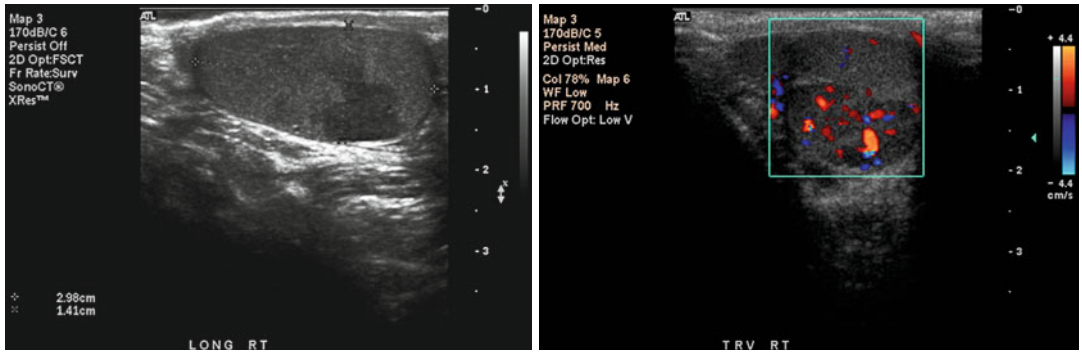

Fig. 17.22 Epidermoid cyst. There is a well-circumscribed lesion in the left testis with "onion skin" appearance of the layers of keratin associated with epidermoid cysts. These benign lesions are amenable to testis-sparing surgery with enucleation of the lesion

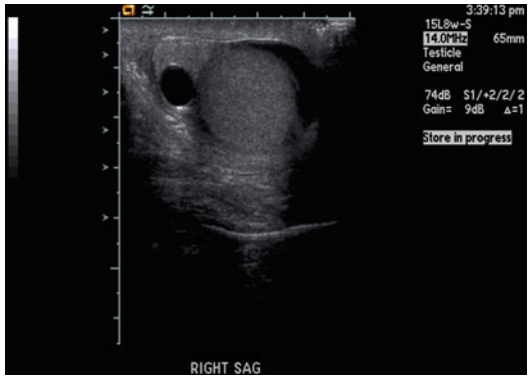

Fig. 17.23 Leydig cell tumor in a prepubertal male with gynecomastia. The ultrasound features include its small size, hypervascularity, and hypoechoic

present only in a minority of cases. Epidermoid cysts uniformly lack color flow on Doppler ultrasound (Fig. 17.23). Real-time elastography shows that these cysts are hard (blue) [40]. On MR imaging, the T2-weighted sequence demonstrates a lesion with increased signal intensity with or without low-intensity signal and surrounded by a low-signal rim. On T1 sequence, there is lack of enhancement [41].

Leydig Cell Hyperplasia

This condition may be the underlying cause for a child presenting with precocious puberty. The testicular parenchyma contains hyperplastic subcentimeter nodules that are usually multiple and bilateral. They are reported to have a variable sonographic appearance, and therefore a scrotal ultrasound is nondiagnostic when the clinical suspicion of Leydig cell hyperplasia is present. MRI is the preferred radiological modality for this entity. On T2 MR imaging these are small hypointense nodules that are contrast enhancing [42].

Paratesticular Masses

The paratesticular space includes the epididymis and the spermatic cord, as well as the investing tunica vaginalis. Pathological conditions in the paratesticular are rare and can be benign or malignant, where the benign conditions are more common. Paratesticular masses are further divided into solid and cystic lesions, all of which can be evaluated sonographically. Benign masses are usually slow growing and may not generate symptoms.

Benign Lesions

Spermatoceles and epididymal cysts are benign lesions that represent the most common causes of paratesticular pathology. Clinically, the patient may be completely asymptomatic or can present with a scrotal mass or induration, which is generally painless (Fig. 17.24).

The epididymal cyst is usually a simple cyst without internal echoes that contains serous fluid. Rarely, they are found to contain septations and calcifications. Some patients present with

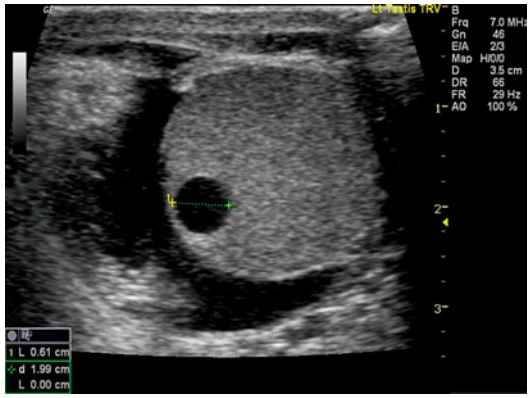

Fig. 17.24 Epididymal cyst. Well-circumscribed hypoechoic lesions in the epididymis or superior to the testis may represent a spermatocele or an epididymal cyst. Both lesions are benign and surgery is rarely indicated

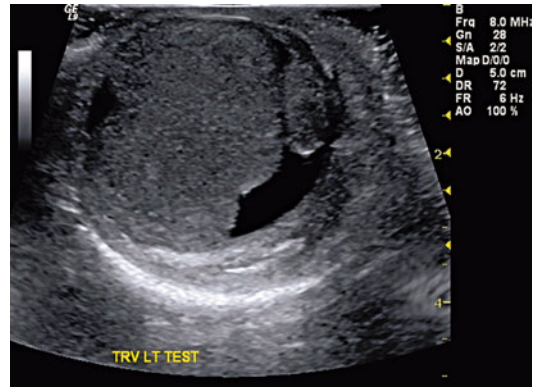

Fig. 17.25 Paratesticular rhabdomyosarcoma. Ultrasound images from a boy presenting with a hard scrotal mass. The mass is heterogeneous with indistinct borders which makes it difficult to determine if it arises from the testis. The pathology demonstrated a paratesticular rhabdomyosarcoma

a multiplicity of cysts and may be found in the appendix testis or appendix epididymis. The spermatocele is a sperm containing outpouching of the epididymis, usually at the level of the epididymal head. It can be differentiated from the epididymal cysts by the low level of internal echoes. Furthermore, it has a thin wall and is generally less taut appearing relative to the epididymal cyst [43, 44]. In a review of all scrotal sonograms done over an 8-year period, 14.4 % of patients had epididymal cysts, questioning the prevailing notion that this is a rare condition. Those were more common in the older pediatric population (35 % in children over age 15) and more common in children with larger testicles [44].

Paratesticular lipomas, which are found along the spermatic cord, and adenomatoid tumors, which arise from the epididymis, are benign masses that may be found in the scrotum. They are homogeneous and lack internal echoes or vascularity on ultrasound. MR imaging of a lipoma demonstrates the presence of fat. Fat suppression sequences can differentiate this entity from hematomas or a proteinaceous cyst. Adenomatoid tumors are the most common benign lesion in young adults, comprising about 30 % of all paratesticular tumors [45]. Sonographically, they are homogeneous round or oval lesions, without increased vascularity. They may have a rim of granulation tissue that is better defined on MR imaging with avid enhancement.

Epididymal cystadenomas are prevalent in patients with von-Hippel-Lindau, as syndrome in which patients are mainly affected by multiple bilateral clear cell renal tumors. The spectrum of clinical manifestations of the disease is broad and includes retinal and central nervous system hemangioblastomas, endolymphatic sac tumors, renal cysts and tumors, pancreatic cysts and tumors, pheochromocytomas, and epididymal cystadenomas.

Malignant Lesions

Malignant extratesticular tumors are very rare. They appear as solid, heterogeneous, hypoechoic masses sonographically due to internal hemorrhage and necrosis [35]. Frequently, they have significantly increased Doppler flow [43]. A malignancy is suspected in cases of a poorly defined solid mass with indistinct borders (Fig. 17.25). Sarcomas of the spermatic cord are the most common malignant extratesticular scrotal tumor. In the pediatric population a rapidly growing extratesticular tumor is suspicious for a rhabdomyosarcoma, while leiomyosarcoma and liposarcoma are usually found in the older population. Mesothelioma and lymphoma are other possible extratesticular malignancies. MR imaging helps in staging as it defines the location and extent of these tumors and their content [8].

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