Sonography of scrotal abnormalities in adults: an update

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ABSTRACT
The purpose of this pictorial review is both to demonstrate newly described conditions such as whirlpool sign, fibrosis, benign testicular lobulation, and effect of hydrocele on the testis, and to scrutinize usual and unusual scrotal abnormalities to bring the reader up to date. The use of ultrasonography will give the correct diagnosis in most conditions providing that it is used appropriately. Familiarity with the ultrasonography features of both common and newly described entities is important for the management of scrotal abnormalities.

Key words: • scrotum • testis • ultrasonography, Doppler

Ultrasoundography (US) is the imaging modality of choice for evaluating scrotal abnormalities. Familiarity with US pitfalls, tips, and tricks are essential for establishing the correct diagnosis. The first objective of this pictorial review is to demonstrate newly described conditions such as whirlpool sign, fibrosis, benign testicular lobulation, and effect of hydrocele on the testis; and the second objective is to provide current information on common and unusual scrotal abnormalities. In addition, normal anatomy and examination technique of the scrotum with tips are briefly summarized.

Normal anatomy and technique

In adults, the normal testes are paired organs with a symmetrical fine echotexture; each testis has a volume of 12–20 cm³ (Fig. 1a). The epididymis is mostly isoechoic to the testis. The ductus deferens, with a luminal diameter of 0.1 mm, is a continuum of the tail of the epididymis. The key feature to identify the ductus deferens is its typical thick smooth muscle wall. Of the appendages, the appendix testis and the appendix epididymis (Fig. 1b) are well seen at US. In contrast to the appendix testis, which is located in the groove between the testis and the epididymis, appendix epididymis is found mostly on top of the epididymal head (1).

Motion and maladjusted imaging parameters are pitfalls to color Doppler imaging of blood flow. To optimize color flow, imaging should be performed with a low wall filter, a low pulse repetition frequency, and a relatively high color gain output setting (Figs. 1c, d). Color priority with some equipments and a small color sampling box may also contribute to the optimization of the color flow image. Power and/or pulsed Doppler imaging as well as comparison with the contralateral testis are especially useful in cases of epididymoorchitis and incomplete testicular torsion. Pulsed Doppler provides a great deal of information about blood flow that is simply not available with color Doppler, particularly in a still image. During pulsed Doppler evaluation, changing transducer position is advised whenever beam steering is a problem. In addition, wider sample volume improves the spectral waveform.

Normally in the cord, the testicular artery has low resistance and a mean resistive index (RI) of 0.62, whereas deferens and cremasteric arteries have higher resistance (mean RI >0.75). Intratesticular arterial vascular trees also have low resistance, as in the cord.

Acute scrotal pain

Causes of acute scrotal pain include epididymoorchitis or focal orchitis (Fig. 2a), torsed appendix or torsion of testis (Fig. 2b), infarction (Fig. 2c), trauma (Fig. 2d), incarcerated inguinal hernia (Fig. 2e), neoplasm (in 10% of cases) (Fig. 2f), and scrotal wall inflammation (Fig. 2g). The
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moved down along the cord, and a rotation of the cord structures is looked for. If an acute rotation is seen, it is taken as a positive whirlpool sign. On pulsed Doppler, peak systolic velocity in intratesticular arteries increase 1.7–2.0 fold on symptomatic side in epididymoorchitis (3). The RIs in the testicular artery (<0.5) and epididymal artery (<0.7) decrease. High resistance in the testicular arteries is a clue for developing infarction in epididymoorchitis or incomplete torsion.

Trauma may increase the risk of torsion, lead to epididymoorchitis, or may result in fracture of the testis with or without large hematocele. Paratesticular coagulum may mimic testicular fracture in trauma patients. An important question in trauma is the status of tunica albuginea. If it is ruptured, surgery is required to maintain testicular viability and to prevent development of antibodies (4). Testicular rupture is a surgical emergency; more than 80% of ruptured testes can be saved if surgery is performed within 72 hours after injury. But, in some cases, orchiectomy is the treatment of choice. Other indications for US are assessment of the integrity of the epididymis, vascular status, and follow-up of patients undergoing conservative therapy.

Complications of acute epididymoorchitis include chronic pain, infarction, abscess (Fig. 2h), pyocele (Fig. 2l), gangrene, infertility, and atrophy.
Figure 2. a–e. Causes of acute scrotal pain. US image of a 22-year-old man with acute left scrotal pain caused by focal orchitis (a). Longitudinal color Doppler US image shows decreased echogenicity and increased vascularity in the lower two-thirds of the testis. Sharp transition is seen between normal and abnormal areas (arrow heads). This appearance is caused by focal orchitis, usually resulting from mumps. Even with no mass effect and regular distribution of the vessels in the abnormal area, this type of lesion should be followed until it resolves, to ensure that it is not a neoplasm, such as lymphoma. Inflammatory hyperemia is a positive finding, as opposed to torsion induced oligemia, which is a negative finding. The presence of hyperemia is predictive that the testis is not torsed. US image of a 28-year-old man with torsion and sudden onset of scrotal pain without history of previous episodes (b). Trapezoid transverse US image of the left hemiscrotum displays spiral twist of the spermatic cord at the external inguinal ring, which is diagnostic for torsion, regardless of color Doppler findings in the testis. On this image, the spermatic cord resembles a snail shell, with enlargement and increased echogenicity. On a 28-year-old man with infarcted left testis due to torsion, longitudinal power Doppler US image (c) shows markedly hypoechoic, enlarged testis without detectable blood flow, but peripheral blood flow is seen. Increased blood flow in the wall of the scrotum, tunica vasculosa, is a sign of late period torsion. Most adults with acute scrotal pain have infection, which can also complicate with infarction, rather than torsion that can be intravaginal or extravaginal. Intravaginal torsion, the most common type, is generally associated with a preexisting anomaly of fixation of the testsis, termed bell and clapper testsis. A 34-year-old man with testicular fracture and acute pain after a ball hit on the scrotum (d). Gray-scale transverse US image of the right testis shows hypoechoic heterogenous areas with anterior surface irregularities (arrow heads). All findings are consistent with testicular fracture with intratesticular hematoma needing surgical emergency. Also notice dilatation (>2 mm) of the paratesticular plexus pampiniformis veins on the left side (arrow). This shows retrograde flow during deep inspiration (not shown), consistent with varicocele. A 42-year-old man with inguinal hernia and acute scrotal pain (e). Split transverse (left) and longitudinal (right) gray-scale US images of the left hemiscrotum show bowel with fluid-fluid level next to the medial side of the testis, which is distorted by compression but otherwise normal. No peristalsis was seen during real-time examination, which supported the diagnosis of incarcerated hernia (T, testis; I, intestine). Inguinal hernia can be divided into indirect hernia, which is lateral to the inferior epigastric vessels and seen in the scrotum through the inguinal canal, and direct hernia, which is medial to the inferior epigastric vessels. (Continued on next page.)
Scrotal masses

The primary function of US in the diagnosis of a testicular mass is to distinguish intratesticular from extratesticular location because the majority of extratesticular masses are benign, but intratesticular ones are malignant (5). US does not offer the histologic diagnosis. Gray-scale US is extremely sensitive for detection of testicular masses.

Figure 2 (continued). f–i. A 32-year-old man with a testicular neoplasm who presented with scrotal pain without fever (f). Color Doppler longitudinal US image of the left testis shows a relatively small hypoechoic area with a large feeding vessel (arrowhead) in the lower third of the testis. Also notice limited microlithiasis (arrow). The lesion was identified by histopathology as a seminoma, the most frequent testicular germ cell tumor. Ten percent of testicular neoplasms present with acute symptoms caused by hemorrhage into the lesion. A 30-year-old man with scrotal wall cellulitis (g). Transverse gray-scale US image of the scrotum. On this trapezoid image, which shows larger areas than can be seen on a linear image, the anterior portion of the scrotal septum shows markedly hypoechoic areas with wall thickness and increased blood flow (increased blood flow not shown). Scrotal wall cellulitis may lead to scrotal abscess. Otherwise both testes and paratesticular areas are normal (RT, right testis; LT, left testis). A 36-year-old man with a palpable mass and persistent pain in the right hemiscrotum (h). Trapezoid gray-scale longitudinal image reveals an ectophytic bilobed markedly hypoechoic lesion in the tail of the epididymis in addition to enlargement and hypoechogenicity of the other parts of the epididymis (epididymitis). The patient had a history of acute scrotal pain. But persistent pain with palpable lesion suggests epididymal abscess formation as a complication of epididymitis. Patients with predominant involvement of the tail are diagnosed clinically, therefore, less frequently require imaging studies for definitive diagnosis. Otherwise, infection is routinely spread in the order of deferentitis, epididymitis (tail through body via head) and orchitis if untreated. A 34-year-old man with pyocele as a complication of epididymoorchitis (i). Trapezoid gray-scale longitudinal US image of the left hemiscrotum displays multiseptated fluid collections between parietal and visceral layers of the tunica vaginalis. Fluid is relatively hypoechoic because of pus accumulation. Chronic hydrocele can mimic pyocele.
Cysts and cyst-like lesions

Tubular ectasia of the rete testis is a benign condition and seen as fluid-filled tubular structures at the level of the mediastinum. Intratesticular retention cysts are also situated near the mediastinum (Fig. 3a). Although intratesticular retention cysts and intratesticular spermatoceles cannot be differentiated on US, intratesticular spermatocele communicates with the seminiferous tubules; this is unlike other cysts or ectasia of the rete testis, which do not communicate directly with the seminiferous tubule on histopathology (6). Spermatocele and simple cysts in the epididymis are encountered in most adults (Fig. 3b). Spermatocele is similar to cysts elsewhere, but it contains low-level echoes or can be septated. Clinically, differentiation of these two entities is not important. In typical cases, epidermoid cysts show a characteristic pattern of concentric layers of rings. The center is totally avascular, and any vascularity within the lesion excludes the diagnosis. But this is not always observed. Furthermore, most epidermoid cysts are intratesticular lesions in young men. The true reason for recognizing the lesion preoperatively is that in such cases, testis-sparing surgery (employing intraoperative ultrasound assistance) should be considered as a treatment option. Cysts of the tunica albuginea may bulge into the testis or out into the paratesticular space (Fig. 3c).

Intratesticular neoplasms

Most palpable intratesticular lesions are neoplasms, and most nonpalpable lesions (>1 cm) are not neoplasms. Lesions smaller than 1 cm may be nonpalpable neoplasms or benign lesions (Fig. 4). The presence of abnormally increased flow within testicular neoplasms depends on their size rather than their cell type. Masses larger than 1.5 cm are more likely to have demonstrable flow (7). In general, color or
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• Pulsed Doppler is not necessary for detection of intratesticular tumors. Distortion of the normal vessel course is more likely found in neoplasms than in inflammation. Intratesticular neoplasms can be divided into primary germ cell tumors, other primary tumors, and secondary tumors. Malignant germ cell tumors constitute 90% to 95% of intratesticular primary neoplasms. Germ cell tumors are divided into seminomas (Fig. 2f) and nonseminomatous tumors, including burned-out germ cell tumors (Fig. 5a). Burned-out germ cell tumors occur secondary to rapid tumor growth, resulting in occlusion of blood supply and subsequent tumor regression. When present, nodal metastases help confirm the presence and stage of a tumor. Whenever retroperitoneal adenopathy is detected in an adult male, occult testicular tumors should be considered; a scan of the testes should be performed to look for an occult tumor. Other intratesticular neoplasms are lymphoma, leukemia, sex cord-stromal tumors, mesenchymal tumors, adenocarcinoma of the rete testis, carcinoid, plasmacytoma, metastases (mostly from the prostate), and benign fibrous proliferation. Ten percent of testicular neoplasms present with acute symptoms (e.g., pain) usually caused by hemorrhage into the lesion; 10% of neoplasms present after scrotal trauma; and 10% of neoplasms present with metastases (8).

Extratesticular neoplasms

If the lesion is limited to the epididymis, the differentiation can easily be made. But, if the lesion originates from the tunica of the testis, differentiation can be difficult (Fig. 5b). Most extratesticular neoplasms are benign adenomatoid tumors (9). Other rare extratesticular masses are lipoma/liposarcoma, fibrous pseudotumor, papillary benign mesothelioma, and sperm granuloma.

Hydrocele

A hydrocele is an abnormally large collection of fluid between layers of tunica vaginalis and is the most common cause of painless scrotal swelling.

Figure 4. A 54-year-old man with a lipoma in the left testis. Transverse gray-scale US image reveals an incidentally found, 4-mm, markedly hyperechoic, well-demarcated solid lesion in the parenchyma (arrow). It was not palpable, and tumor markers were negative. Color Doppler examination (not shown) revealed little vascular coding at the periphery of the lesion (RT, right testis; LT, left testis).

Figure 5. a, b. Testicular tumors. US image of a 28-year-old man with biopsy-proven retroperitoneal extragonadal germ cell nodal metastases and burned-out tumor in the left testis; scrotum felt normal on physical examination (a). Trapezoid, gray-scale US image reveals small calcific clusters with hypoechogenic rim in the testis (arrows). Notice also minimal hydrocele. Burned-out germ cell tumor occurs secondary to rapid tumor growth and results in the occlusion of blood supply itself and subsequent tumor regression. US image of a 45-year-old man with a one-month history of a right scrotal mass (b). Transverse gray-scale US image reveals a homogeneous, hypoechogenic, 7.9 × 5.3 mm solid lesion on the anterior surface of the testis (between calipers) (RT, right testis). The lesion was surgically proven to be an adenomatoid tumor of the tunica vaginalis. Association of the mass with the testis can be determined by pushing the testis during real-time examination. In this situation, the mass will remain at its original location while the testis is displaced.
Until recently, the effect of hydrocele on the testis was poorly understood; it was thought that hydrocele needed no treatment except for cosmetic reasons or patient request. But idiopathic hydrocele may cause testicular enlargement and increased vascular resistance in the intratesticular arteries (Fig. 6). Hence, it may be associated with infertility by interfering with spermatogenesis. Increase in testicular volume and increased vascular resistance are explained by an increase in impedance to venous and lymphatic flow (10).

Infertility

Ultrasonography is used to evaluate testicular location (Fig. 7a), size and appearance of testicular parenchyma, contour abnormalities (Fig. 7b) and epididymis (Figs. 7c, d), presence of initial varicocele (intra- or extratesticular) (Figs. 7e, f), and any postoperative complications (Fig. 7g). Agenesis or partial agenesis of the epididymis and ductus deferens can be evaluated by ultrasound. In such cases, additional imaging of the seminal vesicles, prostate, bladder, ureterovesical junctions, and kidneys is essential for full evaluation of developmental abnormalities.

Approximately 80% of undescended testes are located within the inguinal canal. Sonography is especially useful for identifying testes in the inguinal canal. Evaluation of mediastinum is sometimes important to differentiate testes from lymph nodes. Intraabdominal testes occur in the retroperitoneum from the level of the kidneys to the internal inguinal ring (11). Magnetic resonance imaging can be helpful in detection of intraabdominal testes. If orchiopexy is not performed in childhood (possibly before 5 years of age, and certainly before puberty), the undescended testis is usually sterile or hypospermic and atrophic (12). The incidence of malignancy, mostly seminoma, is 2.5 to 8 times as great in the undescended testis as in the general population (greater increase with increased distance from the scrotum) (12). Because of the increased risk of malignancy in the undescended testis, even after orchiopexy and in the contralateral testis, it would be reasonable to use US as a screening test, although detection of tumors can sometimes be difficult in hypoplastic testis due to isoechogenicity (hypoechoic lesion in hypoechoic testis).

Benign testicular lobulation may be an idiopathic embryologic variant (13) or may develop after orchiopexy as a consequence of fibrosis (14). A contour abnormality on physical examination is not always indicative of malignancy. In this situation, sonography is helpful for excluding testicular lesions.

Varicocele may be extratesticular or intratesticular; intratesticular varicocele is rare and is usually found with extratesticular varicocele (15, 16). The size of the veins in varicocele is measured at rest and during Valsalva maneuver. US criteria for diagnosis of varicocele are
the largest plexus pampiniformis vein measured more than 2 mm in diameter in supine position or more than 3 mm in diameter in standing/semierrct position and/or more than 1 mm increase in size of the largest vein during Valsalva maneuver on color Doppler US (7). A combination of the first and the second or the first and the third criteria are used. However, the presence of venous reflux should be determined by color Doppler US (reflux in seconds). Varicocele can also be graded as follows: grade 1, slight reflux (<2 s) during Valsalva; grade 2, reflux (>2 s) during Valsalva, but no continuous reflux during the maneuver; and grade 3, reflux in rest during normal respiration or continuously during the entire Valsalva maneuver (7). Recurrence of varicocele is diagnosed with presence of reflux on color Doppler US. In the...
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Figure 7 (continued). f–g. Trapezoid color Doppler US image (f) displays these as intratesticular vessels, confirming varicocele rather than tubular ectasia of the rete testis. Pulsed Doppler confirmed the diagnosis (not shown). A 34-year-old man with left scrotal pain and focal infarct in the testis after varicocelectomy (g). Longitudinal trapezoid power Doppler US shows an infarcted area in the anterosuperior portion of the testis that is hypoechoic with no perfusion (arrows). Focal infarct is not a frequent cause of acute scrotal pain, but it is not uncommon after inguinal surgery, especially hernia operation. It can also occur after a varicocele operation, as in this case.

Figure 8. a, b. Microlithiasis. A 26-year-old man with microlithiasis, seeking treatment for infertility after 1.5 years of normal sexual intercourse (a). Trapezoid longitudinal color Doppler US shows classic microlithiasis with numerous fine (<2 mm), bright, nonshadowing hyperechoic foci that are uniform in size and are distributed in a diffuse pattern on this single slice. Notice also twinkle artifact (arrow) behind a microlith. A 27-year-old man with limited testicular microlithiasis (b). Trapezoid, longitudinal gray-scale US image shows fewer than 5 microliths in the testis (arrows), classified as limited microlithiasis. Microliths can also be clustered at the periphery of the testis. Limited microlithiasis is regarded as a benign condition.

testicular microlithiasis

Testicular microlithiasis (TM) may be described as classic (Fig. 8a) or limited (Fig. 8b) based on the presence of five or more microliths on one or more images of the testes (17). Its association with tumor development is controversial.

The etiology of TM is unknown, though an association with Sertoli cell dysfunction and an anomaly in the LKB1 gene, which maps the 19p13.3 chromosome, have been hypothesized to be responsible for TM (18). TM can be associated with several conditions, such as undescended testis, alveolar microlithiasis, congenital urethroperineal fistula, and Klinefelter syndrome. They are more common in patients with oligospermia. Men with TM, especially classical form, are at increased risk of developing germ cell tumors, particularly seminoma (7); the risk is small but not clearly quantified. Yearly
US screening or regular self-examination is recommended.

In conclusion, the use of gray-scale, color, power, and pulsed Doppler US will provide the correct diagnosis in most conditions when used appropriately. Knowledge of the US features of both common and newly described entities is important for the management of scrotal abnormalities.

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References