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Scrotal ultrasound

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Technique

The scrotum is examined with a linear high-resolution, high-frequency (7.5–13 MHz) dedicated high-resolution small-parts transducer (1.2). Although many problems can be solved with gray-scale imaging alone, color Doppler is extremely helpful in selected patients. Color Doppler settings are optimized to detect slow flow: the highest color gain setting allowing an acceptable signal-to-noise ratio, the lowest wall filter, and the lowest velocity scale.

Ultrasound of the scrotum is usually performed in the supine position. Sometimes it is helpful to support the scrotum by a towel to achieve an easier access for comparative views. The patient may be asked to hold the penis suprapubically. Occasionally, additional scanning in the upright position is helpful. If there is a palpable abnormality on physical examination, it is often helpful to perform targeted scanning during palpation to correlate potential US abnormalities with physical examination.

Normal anatomy

Testis, epididymis, and appendages

The testes are paired organs with smooth surface and fine granular and homogeneous echo texture (Fig. 1). The dimensions of the testes are 35–50 mm in length (L), 25–35 mm in width (W), and 15–25 mm in height (H). The volume (V) of the testis is best calculated as a rotational ellipsoid: $V=L\times W\times H\times 0.52$ (±15%) [1, 2]. The testis is enveloped by the tunica albuginea that is displayed as a hyperechoic line. Sometimes two layers can be seen (Fig. 2). At the posterior and superior aspect of the testis the gonadal hilum is seen as an echogenic area. It represents a focal thickening of the tunica albuginea (the body of Highmore). This includes efferent ducts of the rete testis (also known as Haller's organ). Sometimes, the rete testis is visible as an ill-marginated hypoechoic area. Septations may be seen merging out from the area of the rete testis.

The epididymis is situated on the upper and posterior–lateral aspect of the testis. The epididymal head is homogeneous and almost isoechoic compared with the testis (Fig. 1). Its maximal size is less than 10–12 mm. The body can be seen in many cases and has a diameter of 2–5 mm and is less echogenic than the head. The epididymal tail is situated at the inferior and posterior aspect of the testis and measures less than 5 mm.

In many cases the deferent duct is seen as a thick-walled muscular tube with narrow lumen (0.1 mm; Fig. 3).

The testis and epididymis are surrounded by the cavity of the tunica vaginalis which contains a small amount of serous fluid.

Appendages are recognized especially when the amount of fluid in the tunica vaginalis is increased [2]. The appendix epididymis (stalked or pedunculated hydatid of Morgagni) is a remnant of the Wolffian duct. It is recognized as a cystic lesion on top of the epididymal head (3–5 mm in diameter). The appendix of the testis is

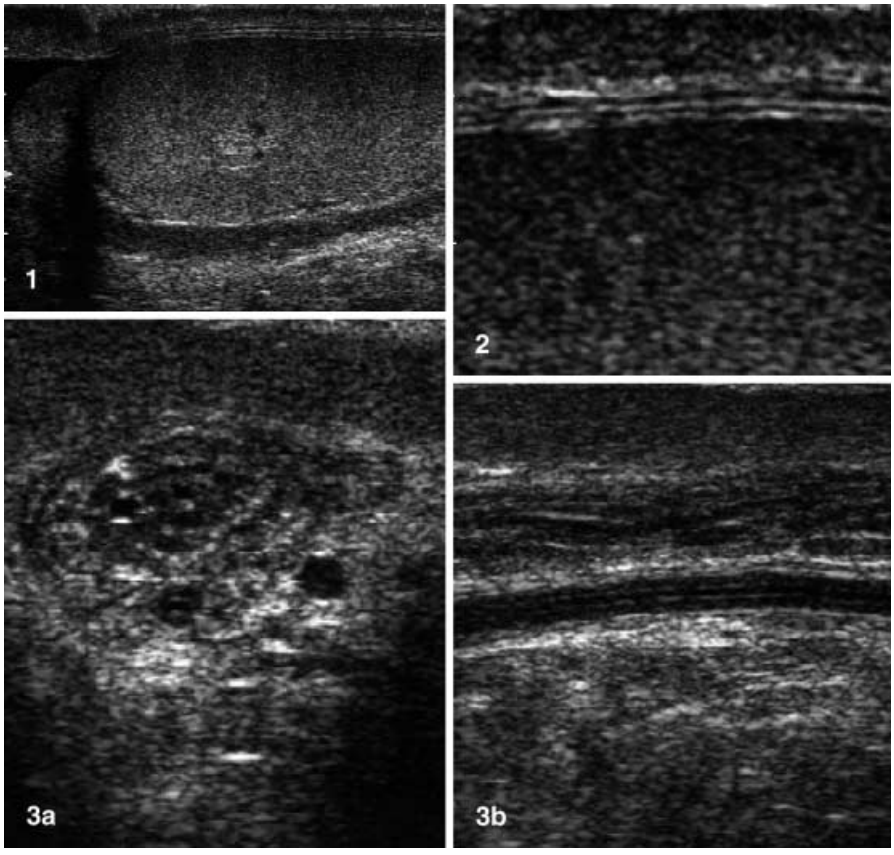


Fig. 1 Normal anatomy. Longitudinal view: normal testis and epididymis with homogeneous granular echo pattern. The epididymal head is isoechoic compared with the testis. The body (and tail) is slightly hypoechoic

Fig. 2 Tunica albuginea. Detail of the surface of a testis showing a hyperechoic line enveloping the testis. Two layers are recognized

Fig. 3a, b Normal deferent duct. **a** Transverse and **b** longitudinal scan showing the thick-walled deferent duct as part of the spermatic cord

a remnant of the Müllerian duct and is seen as an echogenic structure of a few millimeters diameter at the angle between the epididymal head and the testis. Other appendages may be present, at the surface of the epididymal body (organ of Giraldes and of Haller) or at the surface of the testis.

Vascular supply

The spermatic artery originates at the anterior aspect of the aorta at the level of the renal hilum and divides in two branches near the testis. The testicular artery follows the testis and penetrates the tunica albuginea at the lower pole, proceeding as the capsular artery. A transmediastinal artery in the upper third of the testis is visible in 50%; it is bilateral in 25% [3]. Branches from the capsular artery course through the parenchyma in the testicular septations as centripetal arteries and are directed to the gonadal hilum. Recurrent branches (centrifugal arteries) flow in the opposite direction from the vicinity of the hilum. The epididymal artery divides in an anterior branch for the head and a posterior branch for the body and tail. The deferential artery originates from the hypogastric artery, vascularizes the deferent duct, and anatomizes with the epididymal artery [4]. The cremasteric artery branches from the epigastric artery, supplies the soft tissues, and further anatomizes with the deferential artery and posterior epididymal artery.

With Doppler, the flow in the spermatic artery and testicular artery and its branches is of low resistance (mean 0.6, range 0.5–0.7), with a relative broad systolic part and holodiastolic flow. Asymmetry may be found (range 0.15–0.2). The peak systolic velocity in the intratesticular centripetal arteries is <15 cm/s (usually 4–12 cm/s). The flow in the cremasteric and deferent artery shows high-resistance flow pattern. In general, there is almost no flow detectable in the epididymis.

The testicular veins and the veins from the anterior aspect of the epididymis form the anterior spermatic plexus. Testicular veins are not consistently visible at color Doppler, except for the transmediastinal vein accompanying the transmediastinal artery, which is visible in 25% of patients. These veins join to form the internal spermatic vein ending in the inferior vena cava at the right side and in the renal vein at the left side. Venous drainage of the body and tail of the epididymis is by the posterior spermatic plexus or cremasteric plexus. The veins drain in the external spermatic vein ending directly in the external iliac veins or via the deep inferior epigastric vein.

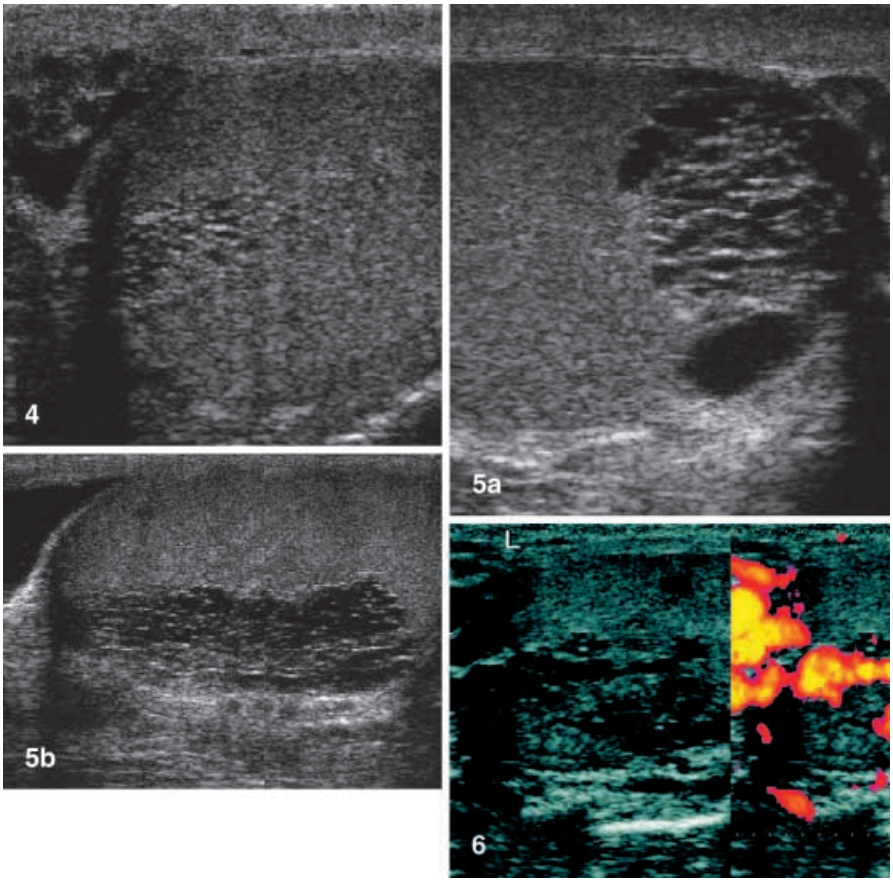


Fig. 4 Dilatation of the rete testis. Transverse scan of the right testis. Slight dilatation of the efferent ducts in the mediastinal testis

Fig. 5a, b Dilatation of the rete testis. **a** Transverse and **b** longitudinal scan. Grapefruit-like cystic dilatation of the rete testis. This should not erroneously be interpreted as tumor

Fig. 6 Intratesticular varicocele. Sagittal view. Cyst-like lesions in the upper pole of the left testis. During the Valsalva maneuver retrograde flow is demonstrated in the lumen

Cysts and cyst-like lesions

Dilatation of the rete testis

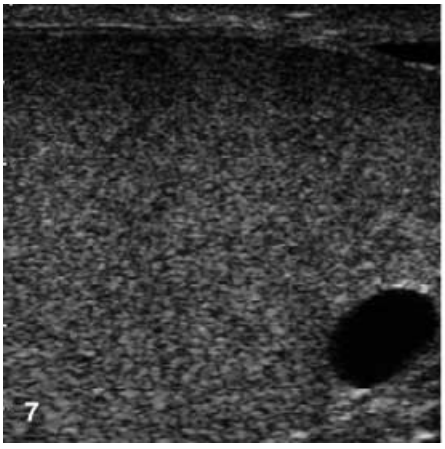
Ectasia of the seminiferous tubules at the level of the mediastinum is a recognized benign condition of the testis and should not erroneously be interpreted as a tumor [5, 6, 7, 8, 9]. It is postulated that tubular ectasia or cysts of the rete testis result from obstruction of the spermatic ductal system after infection or trauma. They are bilateral in approximately 45% of cases and associated with an ipsilateral spermatocele in approximately 74% of cases. At presentation, most men are in their sixth decade. Many patients have a clinically palpable spermatocele. Theoretically, in any patient with obstruction distal to the rete testis, dilatation can be expected. On US the process involves the mediastinum testis, begins at the periphery adjacent to the spermatocele, and extends for a variable distance within the testis (Figs. 4, 5). Although it may have typical features at US, the condition can at times be difficult to distinguish from tumors, inflammation, or infarction [7, 9]. Rarely the ducts resemble dilated intratesticular veins (intratesticular varicocele) [10]. Color Doppler then is required to differentiate between cysts and dilated veins (Fig. 6).

Testicular cysts

Intratesticular retention cysts are most commonly incidentally found during US. The incidence increases with age (>60 years an incidence of 8–10% is reported). Their appearance is similar to cysts elsewhere (Fig. 7). It is postulated that cysts result from obstruction of the spermatic ductal system. Cysts may be found in the tunica albuginea and then may be palpated as a firm mass of pinhead size (Fig. 8) [11]. The origin is unclear (congenital or acquired infection or trauma).

Cystic dysplasia of the testis is a very rare congenital disorder. Typically it occurs in combination with ipsilateral renal agenesis of dysplasia of both kidneys [12]. The cystic changes usually involve the rete testis and adjacent seminiferous tubules; atrophy of the remaining parenchyma may occur.

Epidermoid cysts of the testis are very rare and account for approximately 1% of all testicular tumors. Epidermoid cysts of the testis are usually found during the third decade. Typical testicular epidermoid cysts present as a unilateral, single, or multiple intratesticular hypoechoic mass with a characteristic lamellar swirling configuration or concentric rings similar to the cross section of an onion (Fig. 9). Sometimes the lesion has a target-



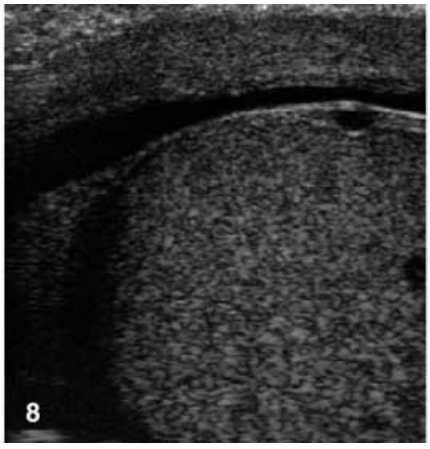
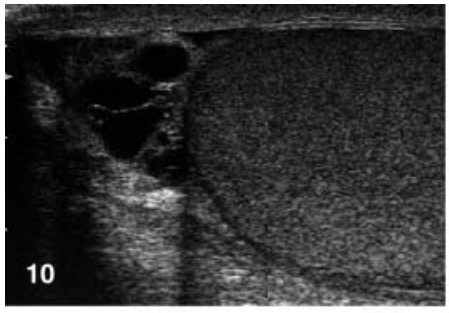


Fig. 7 Testicular cyst. Detail of the lower pole of the testis showing a typical cyst in parenchyma

Fig. 8 Tunica albuginea cyst. Longitudinal scan: tiny cyst between the layers of the tunica albuginea

Fig. 9 Epidermoid cyst. Hyperechoic mass lesion in a small testis, treated for cryptorchidism, in a patient with varicocele. Histologically proven epidermoid cyst; carcinoma in situ throughout the testicular parenchyma



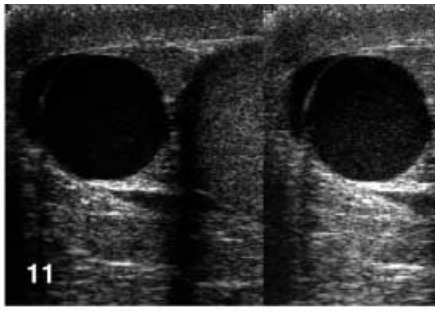


Fig. 10 Epididymal cysts. Tiny cysts in the epididymal head. Incidental finding

Fig. 11 Spermatocele. Longitudinal scan; detail of the upper pole of the testis and the epididymal head. Cyst in the epididymal head filled with reflections, more easily visualized at higher gain settings

Fig. 12 Spermatocele. Longitudinal scan of the left scrotum. Large cystic lesions with thin wall and internal reflections and displacing the testicle to the lower part of the scrotum. At times it can be difficult to distinguish between a large spermatocele and a hydrocele

like appearance [13, 14, 15, 16, 17]. Calcification of the wall or within the mass may also be present.

Epididymal cysts

Cysts and spermatoceles of the epididymis are more commonly found in the head. They have been reported in as many as 70% of men who undergo US. They are painless but may cause anxiety because of abnormal palpation. Epididymal cysts can be single or multiple, very tiny, or large (Fig. 10); the latter may be difficult to differentiate from hydrocele. Spermatoceles are relatively tense lesions, whereas hydroceles have a relatively flaccid consistency. Furthermore, a wall may be seen completely enveloping a spermatocele. Sometimes the epi-

didymal head is completely cystically deformed. With appropriate gain settings internal echoes are seen in spermatoceles (Figs. 11, 12). These are assumed to represent dead sperm. Also, when the fluid collection is larger than 4 cm in diameter, it is more likely to be a spermatocele. Thickening of the cystic wall is almost exclusively seen in cases of inflammation. This may occur after transcutaneous puncture.

Hydrocele

Hydrocele is the most common cause of painless scrotal swelling. It is the accumulation of an abnormal amount of fluid in the tunica vaginalis. In communicating hydrocele resulting from a patent processus vaginalis, fluid can be moved during clinical examination and increases with elevation of intra-abdominal pressure. A non-communicating hydrocele is not affected by palpation or positional change. Chronic hydrocele is enveloped by a thick wall and thick septa. In funiculocele ("cyst of the spermatic cord") a spherical tense-elastic cystic lesion is seen near the inguinal ring.

A limited hydrocele is found in as many as 65% of men. It may be primary (idiopathic) or secondary to virtually every underlying scrotal disease process. Hydrocele is bilateral in 10% of patients. Internal echoes are explained by cholesterol crystals, blood (hematocele), pus (pyocele), fibrin strands, or hernia. In many cases freely movable calcifications (scrotal phleboliths, scrotal pearls, or hydrocele concretion) are seen (Fig. 13). Some of them may have a bull's-eye appearance, with a central calcification surrounded by a hypoechoic border. It is thought that exfoliated cells or appendages form the core around which calcifications settle. A large, thick-walled hydrocele is almost always caused by (non-specific) epididymo-orchitis.

An intrascrotal lymphocele has the same US appearance as a hydrocele. It is usually seen within weeks or months after ipsilateral renal transplantation.

Fig. 13 Scrotal pearl. Freely movable nodule in de tunica vaginalis with central calcifications and peripheral soft tissue rim

Torsion

Testicular torsion

Testicular torsion is a medical emergency. When treatment is initiated within 4–6 h after the onset of symptoms almost every testis can be saved. Between 4 (6) and 10 (12) h, 75% of testis still can be saved; after 10–12 h, only 10–20% of testis can be saved. It has been shown in animal experiments that a normal testis at US more than 6 h after the onset of the symptoms virtually excludes the diagnosis of torsion. In the acute phase, the testis enlarges and becomes diffusely hypoechoic; the epididymis enlarges and becomes heterogeneous [18]. Twisting of the spermatic cord and abnormal position of the testis may be seen. Thickening of the scrotal wall (>5 mm) due to edema may be seen. A reactive hydrocele may develop. A heterogeneous testis with hypoechoic areas indicates irreversible damage of the testicular parenchyma due to ischemia.

The absence of flow at the symptomatic side at color Doppler US, compared with the normal side has a sensitivity of 80–100% and a specificity of 90–100%. When intratesticular vessels are still visible, increased resistive indexes may be measurable. Severe epididymo-orchitis may result in testicular ischemia due to edema and venous thrombosis [19]. Inversely, hyperemia may occur in partial torsion as after spontaneous detorsion [19]. In these cases a low-resistance spectral flow curve is obtained from intratesticular vessels.

In the subacute phase (missed torsion), from 1–10 days after the onset of symptoms, the testis and epididymis are enlarged and the testis is heterogeneous due to hemorrhagic infarction. Gradually the testis gets a coarse architecture and decreases in size. After this period, the testis becomes smaller and hypoechoic with a relatively large epididymis.

Torsion of the appendages

In children, appendiceal torsion is nearly as common as testicular torsion, accounting for 20–40% of cases of acute scrotum in the pediatric age group, with a peak incidence between 7 and 14 years of age. In these cases of acute scrotal pain, US may be normal. Occasionally,

swelling of the epididymal head and slight hyperemia adjacent to the appendix may be seen. The epididymal tail is normal (unlike in epididymitis). Visualization of the appendix surrounded by a small amount of fluid is almost impossible.

Inflammatory conditions

Acute epididymitis

Epididymitis is the most common cause of painful scrotal swelling over 18 years of age and represents at least 75% of all scrotal inflammatory disease processes. Twenty-five percent of cases are associated with orchitis. The inflammation is bilateral in 10%. Epididymitis is usually caused by retrograde infection (through urethra or deferent duct) or by hematogeneous spread.

At US, swelling of the epididymal tail and spermatic cord is seen, usually diffusely hypoechoic or at least with focal or multifocal hypoechoic areas (Fig. 14) [20]. The inflamed part is hypervascular at color Doppler. Hypervascularity of the epididymis (tail) has a sensitivity of 91–100% for epididymitis [20]. The scrotal wall is often thickened (>5 mm) by reactive edema. A reactive hydrocele may be present. Focal hypoechoic areas surrounded by hyperemia indicate abscess formation (10%; Fig. 15). The epididymal head is frequently normal as is the testis. When the testis is involved, it enlarges and becomes hypoechoic, either diffusely or focally. Frequently, however, the testis is normal at gray-scale imaging but hypervascular at color Doppler. The peak systolic velocity in intratesticular arteries increases 1.7–2 fold or even higher. The resistive indexes in the testicular artery (<0.5) and epididymal artery (<0.7) decrease.

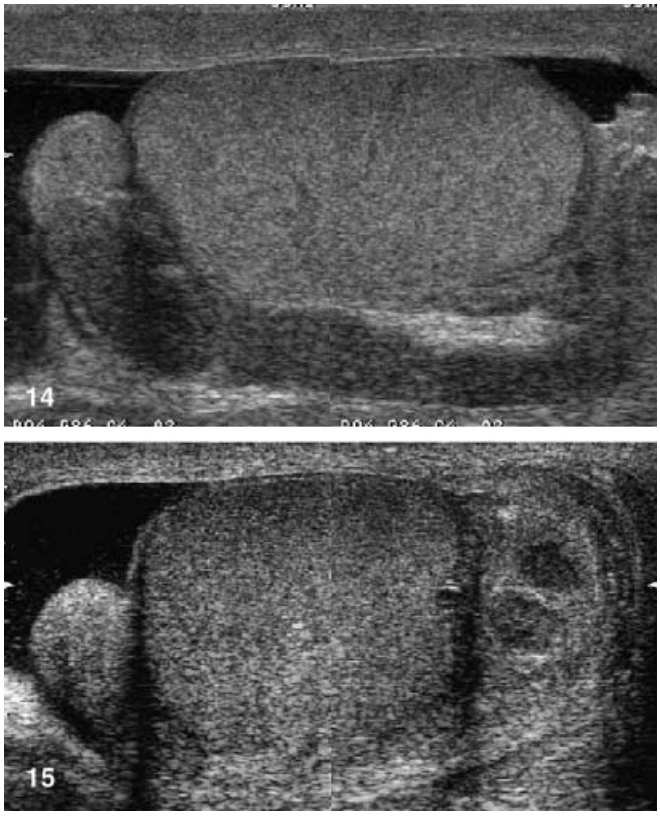


Fig. 14 Epididymitis. Longitudinal view. Hypoechoic swollen epididymis, body and tail, with normal epididymal head in a patient with acute scrotum and clinical epididymitis

Fig. 15 Epididymal abscess. Detail of the epididymal tail. Hypoechoic lesions the epididymal tail in a patient with epididymitis: small abscesses

Acute orchitis

Isolated orchitis is rare and may be due to viral infection (mumps) or acquired immunodeficiency syndrome. In general, orchitis occurs in association with epididymitis. The testis is enlarged and shows diffuse, focal, or multifocal hypoechoic areas. The testis, or parts of it, become hypervascular at color Doppler.

Chronic inflammation

Chronic epididymitis may result from recurrent episodes of inappropriately treated acute epididymitis. Rarely, tuberculosis or parasitic diseases cause chronic inflammation [21]. At US, the involved area is heterogeneously hyperechoic, very often with calcified areas.

Chronic orchitis is very rare. Granulomatous orchitis may present as focal or diffuse hypoechoic lesions in the testis occasionally with calcifications [22, 23, 24]. This may be indistinguishable from tumor. It predominantly affects men during the fifth and sixth decades. Approximately 150 cases have been reported worldwide.

Likewise, granulomatous epididymo-orchitis may develop as a (late) complication following use of Tice strain bacillus Calmette-Guerin for treatment of superficial bladder carcinoma. Lesions are asymptomatic and appear as complex scrotal masses or a diffusely hypoechoic mass lesions [24].

Sarcoidosis with extrapulmonary manifestations in the testis, epididymis, and spermatic cord has been reported, but is rare, affecting fewer than 1% of patients with systemic sarcoidosis. The patients usually present with an intrascrotal mass of unknown origin that suggests a testicular tumor both clinically and on imaging. Ultrasound shows a hypoechoic mass in the epididymis or, more commonly, in the testis. Differentiation from a testicular neoplasm may not be possible with US [25].

Pachyvaginalitis results from inflammation or (major) trauma and causes diffuse or focal thickening of the tuni-

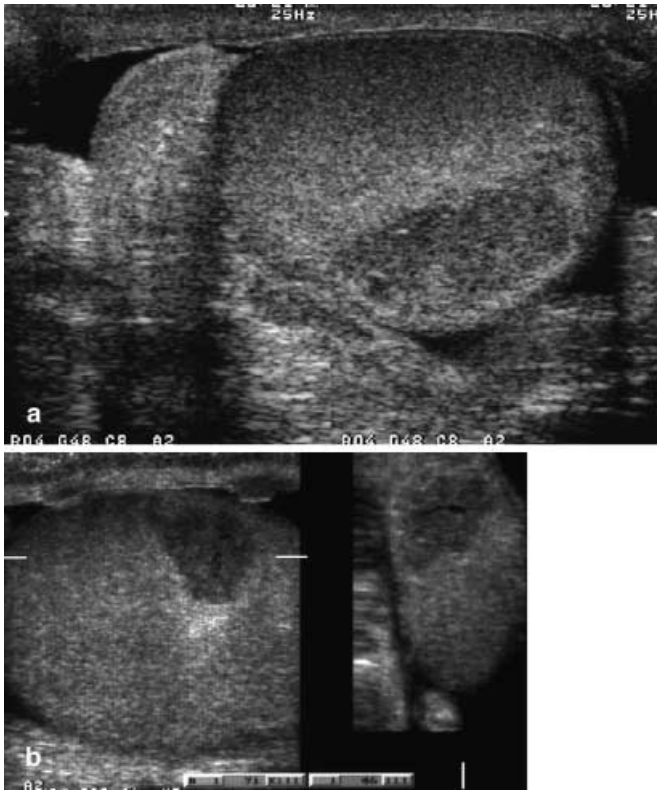


Fig. 16a, b Testicular infarction. Two patients with acute scrotum and hypoechoic mass lesion. In the patient shown in **b** there is a wedge-shaped pattern. In patient shown in **a** histologically proven infarction (polyarteritis nodosa without systemic involvement). In patient shown in **b** the lesion completely disappeared at follow-up sonograms

ca, sometimes with shadowing by calcifications. At palpation pachyvaginalitis may resemble a testicular tumor.

Testicular infarction

Acute infarction of the testis or sequelae of partial infarction of the testis may atypically present as a testicular mass that may mimic a testicular neoplasm since the age of presentation is similar. On US, an ill-defined hypoechoic mass can be expected, usually peripheral in location, septal in distribution, and without mass effect. At times a wedge-shaped area may be seen (Fig. 16) [26, 27, 28, 29]. This area is avascular on color Doppler US. Close clinical correlation is essential to differentiate it from tumor.

Necrotizing vasculitis affecting the testis is seen in patients with polyarteritis nodosa in as many as 86% of patients with systemic polyarteritis nodosa. Testicular involvement is only rarely the presenting manifestation of this entity. Testicular involvement includes arteritis, infarctions of various duration, hematoma, hemorrhage, and aneurysm formation in a painful testis.

Trauma

In patients with scrotal trauma, US is indicated to assess intratesticular hemorrhage, integrity of the tunica albuginea, integrity of the epididymis, hematocele, vascular status, and follow-up patients undergoing conservative therapy. Irregularities of testicular contour and heterogeneous hypo- or hyperechoic areas are characteristic of testicular injury. The presence of internal echoes distinguishes a hematocele from a simple serous hydrocele. Thick septa and wall thickening are demonstrated in chronic hematocele. Calcified areas may be seen occasionally. Chronic hematocele may resemble a chronic hydrocele or pyocele.

The rate of orchiectomies increases from 7.4 to 55.5% when surgical repair is delayed until more than 72 h after the trauma. Intratesticular hemorrhage may mimic testicular neoplasm, and often, patients with testicular neoplasms present after (minor) scrotal trauma (Fig. 17).

According to some reports, 1–31% of testicular fractures are missed at US. Delicate tears in the tunica albuginea without intratesticular hemorrhages and without extrusion of testicular tissue may escape US detection. The absence of hematocele does not exclude the diagnosis of testicular rupture; therefore, the sensitivity of US is as low as 64% and the specificity 75%.

Cryptorchidism

In cryptorchidism one or both testes are not located in the scrotal sac but (most often) in the normal course of testicular descent between the lower pole of the kidney and the external inguinal ring. In 75–80% of cases the testis is located in the inguinal canal between the internal and external inguinal ring. Ultrasound is suited to locate the testicle in the inguinal canal, to evaluate its size, and to some extent only, the testicular parenchyma [30]; the latter indeed may be difficult since a hypotrophic testis is usually hypoechoic and therefore it may become impossible to detect focal hypoechoic malignancies within the testis. Evaluation of the testicular parenchyma is important in view of fertility and increased incidence of testicular malignancies (germ cell origin) [31, 32, 33]. Although volume may be of interest after treatment of cryptorchidism (as in patients with varicocele), conclusive date are not available. The pars infravaginalis of the gubernaculum testis is hypoechoic and nodular at US and may mimic an atrophic testis. Demonstration of the hyperechoic intratesticular mediastinum is helpful in distinguishing the testis from the gubernaculum.

Carcinoma is far more common in an undescended testis than in a normally positioned testis [30, 31, 32, 33]. It is reported that 10% of all testicular neoplasms occur in undescended testes or in testis treated for cryptorchidism. Seminoma and embryonal cell carcinoma are

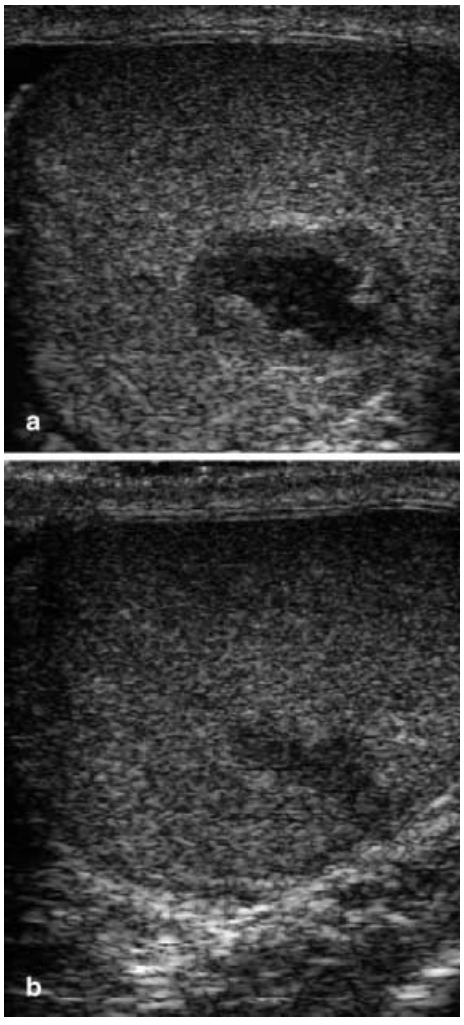


Fig. 17a, b Testicular hematoma. **a** Intratesticular hematoma a few days after a mild scrotal trauma and **b** confirmed at MRI almost completely resolved 6 weeks later

the most frequent neoplasms. The highest incidence is observed when the testis is located in an intra-abdominal position. The reported incidence of malignancy is variable, and it is generally believed that there is a 50 times higher frequency in an undescended testis. Animal experiments have shown that orchiopexy does not necessarily protect against malignancy. With bilateral cryptorchidism there is a 15% chance of developing a tumor in the opposite testis if one testis becomes involved with a tumor. In cases of bilateral intra-abdominal testes, if one testis becomes malignant, there is a 30% chance of malignancy in the contralateral testis. Generally, the malignancy rate correlates with increasing distance of the testis from the scrotum; thus, malignant change is six times more common in the abdominal testis than in the inguinal testis.

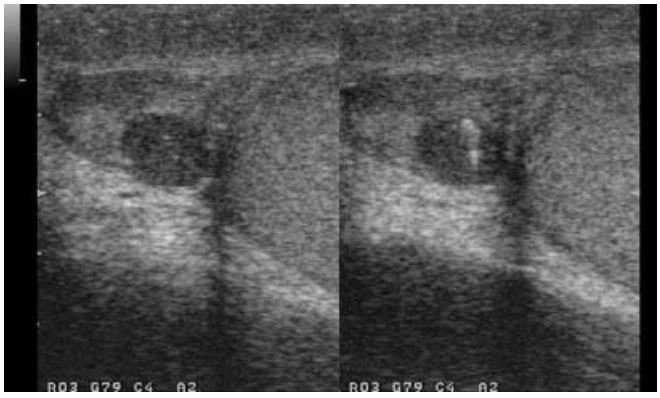


Fig. 18 Adenomatoid tumor in the epididymal head. Hypoechoic nodule in the epididymal head, with focal calcifications

Congenital inguinal hernias (persistent processus vaginalis peritonei) are also associated with undescended testis. This occurs when the narrow connection of the processus vaginalis to the peritoneal cavity fails to obliterate. Since testicular descent is closely related to obliteration of the processus vaginalis, more than 90% of patients with undescended testes have hernia sacs.

Tumoral pathology

Epididymal tumoral pathology

Solid tumors of the epididymis are very rare. The most common (75%) is the benign adenomatoid tumor originating in the tail (less frequently in the head) [34, 35]. The lesion is somewhat more echogenic than the testis but may be hypoechoic as well (Fig. 18). Very rarely a malignant variant has been reported.

Occasionally, sperm granulomas may be found in patients after vasectomy. It presents as a (palpable) hypoechoic nodule, sometimes with focal calcifications.

Other solid tumors are even more rare. They include papillary cystadenoma, sperm granuloma, fibrosarcoma, malignant histiocytoma, lymphoma, primary carcinoid tumor and metastases (stomach, kidney, prostate, colon, lung) [36, 37]. There is nothing specific about these lesions at US.

Testicular tumoral pathology

Testicular tumors represent 4–6% of all tumors of the male urogenital tract. Germ cell tumors account for 95% of the malignant tumors; 5% are of non-germ cell origin, i.e., stromal origin. The peak incidence is in the third and fourth decades (i.e., 25–35 years). In 4–14% of patients metastases are the presenting symptom. There is nothing specific about US of testicular tumors [38].

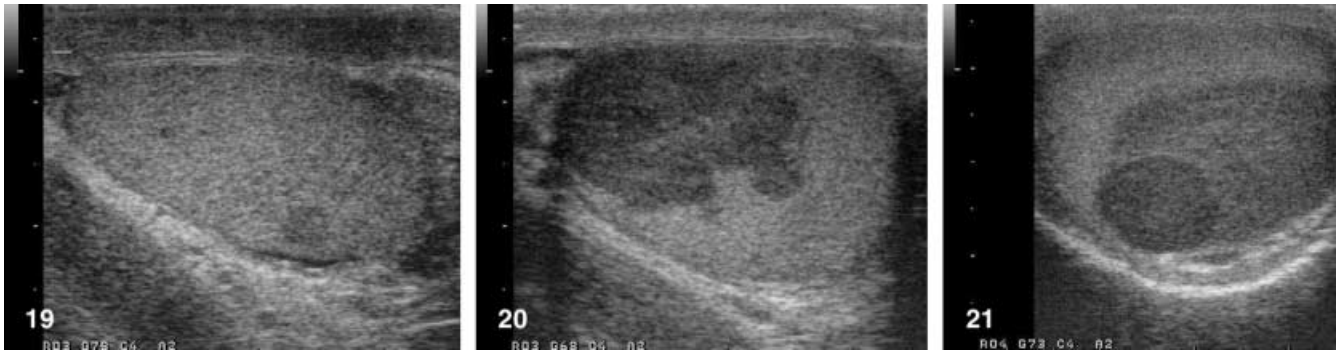


Fig. 19 Seminoma. Incidental finding. Hypoechoic lesion (4 mm) near the lower pole of the testis in a patient referred for subfertility. Histologically proven seminoma at orchiectomy

Fig. 20 Seminoma. Longitudinal scan. Homogeneous hypoechoic mass lesion, multinodular

Fig. 21 Seminoma. Transverse scan. Multinodular seminoma showing different echogenicity of the nodules

Germ cell tumors

Seminoma. Forty to 50% of the germ cell tumors are seminomas, 2–5% being bilateral. In approximately 10% of cases, metastases are detected in the retroperitoneal lymph nodes at the time of presentation. At US seminoma presents as a focal nodular or multinodular, well-circumscribed hypoechoic mass in the majority of cases (Figs. 19, 20, 21). Multifocal hypoechoic areas may be seen as well. Occasionally, diffuse involvement of the entire testis and heterogeneous echo texture is seen. Occasionally, cyst-like areas are seen due to necrosis or hemorrhage. Calcifications are seen in approximately one-third of cases. There is usually increased vascularity on color Doppler US when the mass is larger than 1.0 cm in diameter.

Non-seminomatous germ cell tumors. Non-seminomatous germ cell tumors include embryonal cell carcinoma (20–25%), teratoma (5–10%), choriocarcinoma (1–3%), and mixed tumors (20–40%; a mixture of virtually all histogical types).

Embryonal cell carcinoma occurs most commonly during the third decade. With the majority of embryonal cell carcinomas there are already metastases at the time of presentation. On US, these tumors may be hypoechoic but often are more heterogeneous than seminomas due to the presence of cystic degeneration and calcifications (Fig. 22). Because the tumors are usually large, the tunica albuginea may be irregular. Focal areas of hemorrhage may contribute to increased echogenicity.

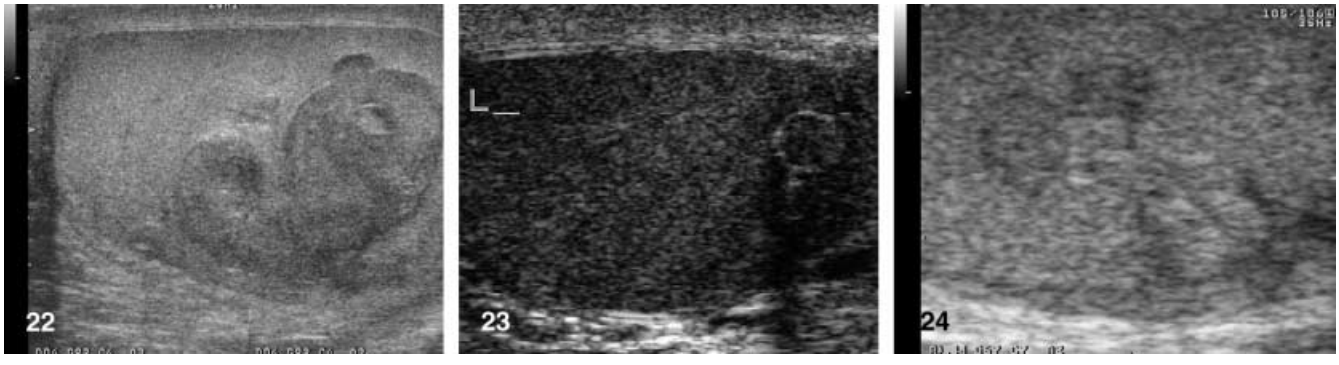
Teratomas most commonly occur in children [39]. In this age group, their biologic behavior is that of a benign neoplasm. In adults, however, they usually contain immature elements and behave as a malignant neoplasm. Indeed, despite its histologically benign appearance, primary pure teratoma of the testis is believed to have metastatic potential and behave similarly to other nonseminomatous germ cell tumors [40, 41]. They present as small lesions (<2 cm) with the US findings depending on the histologic tissue elements present in the lesion (Fig. 23). Most are composed of areas with cystic and solid components.

Bone or cartilage present as hyperechoic areas with acoustic shadow.

Fig. 22 Embryonal cell carcinoma. Large tumoral mass in the testis in a patient with retroperitoneal lymph node metastases

Fig. 23 Teratocarcinoma. Heterogeneous lesion in the lower pole of the testis

Fig. 24 Mixed germ cell tumor. Detail of the testis showing an ill-defined heterogeneous mass lesion in the testis, firm at palpation



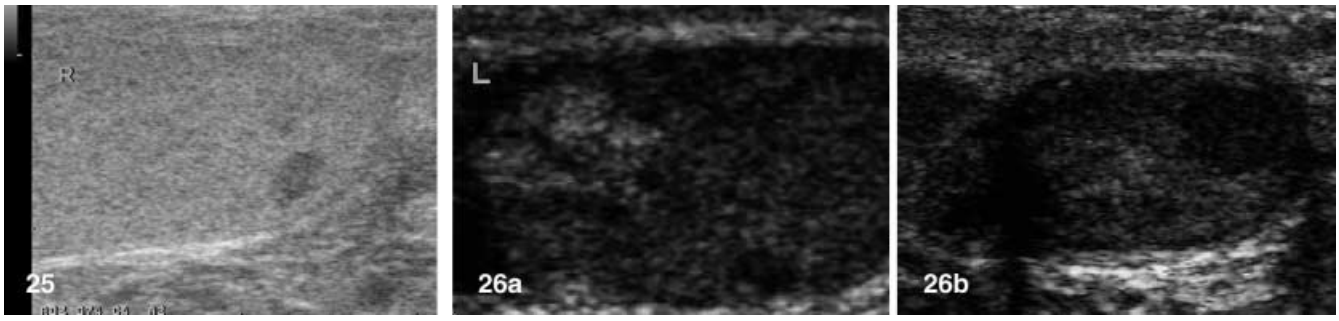


Fig. 25 Leydig cell tumor. Small hypoechoic lesion in the lower pole of the left testis in a patient referred for infertility. Histologically proven Leydig cell tumor (US-guided tumorectomy)

Fig. 26a, b Leydig cell hyperplasia/tumors. Patient with Klinefelter's syndrome. Bilateral (**a** right; **b** left) small testis with several hypoechoic lesions

Choriocarcinoma is the least common of all germ cell tumors and occurs most commonly during the second and third decades of life. Ultrasound is non-specific and may demonstrate heterogeneous solid masses with areas of hemorrhage, necrosis, and calcifications.

Any tumor that contains more than one histologic element is considered as a mixed germ cell tumor. They actually account for 40% of primary testicular tumors and may present in many possible combinations; therefore, the findings at US are variable with areas of cysts, hemorrhage, necrosis, and calcifications (Fig. 24) [42].

The pure form of yolk sac tumor is almost exclusively found in young children where it is the most common malignant germ cell tumor; it is rare in postpubertal males. The tumor presents as a predominantly solid mass with heterogeneous echogenicity and anechoic spaces [43, 44].

The majority of patients with germ cell tumors present with abnormal palpation of one of the testicles (painless testicular swelling). In some patients metastases or symptoms related to metastatic disease are the presenting symptom and the tumor is an incidental finding during scrotal US (occult tumor) [45, 46, 47]. Management should include inguinal exploration, eventually with frozen section diagnosis [45, 46, 47]. Ultrasound follow-up should be used only if there is a strong clinical suspicion of a benign lesion, such as a recent trauma or infection. Non-palpable tumors discovered in patients with metastatic germ cell tumor should be treated as malignant.

Stromal tumors

Stromal tumors represent approximately 5% of all testicular neoplasms. Gonadal stromal tumors generally are benign and hormonally silent. In adults, however, these tumors have a malignant potential and may produce distant metastases. When hormonally active, they may cause virilization or feminization.

Leydig cell tumors (3%) are usually benign; malignant variants are to be expected in 10% of cases. Leydig cell tumors are bilateral in 4–10% of cases (Figs. 25, 26). Such patients usually present with symptoms related to the hormonal activity: pseudo-pubertas precox, gynecomastia, obesity, or azoospermia [48, 49]. Sometimes they are incidental findings during scrotal US.

Sertoli cell tumors (1%) likewise may become obvious because of hormonal activity (gynecomasty in 30% of cases). There are two clear-cut types of large cell calcifying Sertoli cell tumor: (a) those associated with complex dysplastic syndromes and which are bilateral and multifocal; and (b) those which are not associated and are unilateral and focal [50].

It is considered that conservative resection of the tumor is the treatment of choice in cases not associated with complex dysplastic syndromes, since the malignancy rate is low.

With gonadal stromal tumors, a palpable mass is not always present, and ultrasonography may be required to identify such neoplasms. Single or multiple masses may be present, either hypo- or hyperechoic, rarely with calcifications (Figs. 25, 26). A diffusely heterogeneous pattern with increased echogenicity may be expected in large-cell calcifying Sertoli cell tumor [50].

Primary carcinoid tumor of the testis is extremely rare (<<1%) and has been described more commonly in older patients. Again, the imaging findings are not specific. Hypoechoic lesions with well-defined borders and focal areas of necrosis have been described [51, 52].

Bilateral testicular adrenal rests may occur in untreated or poorly controlled congenital adrenal hyperplasia in children. These lesions are always hypoechoic multifocal nodules on US, and in most cases bilateral [53, 54]. Areas of fibrosis cause acoustic shadowing.

Other testicular tumors

Malignant lymphoma (virtually limited to non-Hodgkin's lymphoma) of the testis is one of the most common neoplasms in men over age 50 years (25% of testicular malignancies); lymphoma represents 2% of testicular malig-

nancies under the age of 50 years. Patients with testicular lymphoma usually present with testicular enlargement. Ultrasound usually shows either homogeneously hypoechoic testes in patients with diffuse infiltration or multifocal hypoechoic lesions of various sizes (mean lesion size 16 mm, range 8–26 mm) [55, 56]. In some cases, paralleling hyperechoic lines radiating peripherally from the mediastinum testis are seen, probably representing blood vessels crossing through the lesion.

In necropsy series, involvement of the testicular parenchyma by leukemia is found in 27–92%; it is clinically evident in less than 10% only. At US, leukemia is seen as an infiltrating, slightly hypoechoic mass lesion. The testis may be completely involved and in these particular cases it may be very hard to recognize the involvement at US [56].

Color Doppler US reveals increased intralesional flow in all areas of lymphomatous or leukemic involvement irrespective of lesion size. Differentiation from inflammatory processes of the testis remains difficult. The clinical symptoms are often helpful.

Metastases to the testis from virtually every primary tumor have been reported. The common primary sites include prostate, lung, gastrointestinal tract, skin (melanoma), and kidney, but other primaries have been reported as well (including pancreas, urinary bladder, thyroid, neuroblastoma, schwannoma, retinoblastoma). There is nothing specific about the appearance at US.

Adenocarcinoma of the rete testis is a rare but aggressive tumor. Nearly two-thirds of patients present with metastases or develop metastases within a year after presentation. Ultrasound shows a solid mass consistent with a testicular tumor or a multicystic septated lesion with intracystic solid echogenic nodules [57, 58, 59]. Metastases occur in retroperitoneal lymph nodes, lung, liver, and elsewhere.

Macro-orchidism is a very rare entity and is characterized by asymptomatic, benign testicular enlargement. Sporadic cases have been reported in prepubertal boys. It is usually seen in mentally retarded boys, especially those with a fragile X chromosome. The enlarged testis is smooth, symmetric, and with homogeneous normal echo texture.

“Burned-out” tumors

Occasionally, a testicular scar is discovered in a patient with a presumed extragonadal germ cell tumor. Most patients are originally diagnosed with retroperitoneal germ cell tumors [60, 61]. Scrotal US reveals an echogenic focus or foci. In a few cases the hypoechogenic core may be surrounded by a hypoechoic rim. Very rarely, a homogeneous hypoechoic lesion is seen. These lesions may correspond to intratubular hematoxyphilic bodies or to intratubular psammoma bodies close to a fibrous scar with hemosiderin deposition. These foci may contain foci of intratubular germ cell neoplasia. The hematoxyphilic bodies and fibrosis with hemosiderin deposits are believed to represent remnants of testicular carcinoma. With a presumed retroperitoneal germ cell tumor and palpably normal testes, US demonstration of an echogenic lesion in the absence of a hypoechoic mass probably represents a burned-out primary neoplasm [61].

Miscellaneous extratesticular and extraepididymal tumors

Most spermatic cord tumors are benign and are primarily lipomas. Liposarcomas of the spermatic cord and paratesticular liposarcomas are uncommon. Ultrasound reveals findings suggestive of either inguinal hernia (containing fat) or lipoma [62, 63]. Liposarcomas usually roll up the ipsilateral spermatic cord and testicular vessels.

Occasionally, adenomatoid tumors originate at the tunica albuginea as an oval mass lesion. Tunica albuginea granuloma (fibrous pseudotumor) is a palpable benign, focal thickening of the tunica albuginea, hypo- or hyperechoic, with acoustic shadowing (Fig. 27) [34]. It may occur following inflammatory conditions of the scrotum. On physical examination, the lesion may be difficult to distinguish from a testicular or an extratesticular neoplasm.

Tumors of the tunica vaginalis testis (fibrous pseudotumor, non-papillary benign mesothelioma) are usually incidentally discovered during hydrocelectomy or present as a painless mass of the hemiscrotum. Non-papillary benign mesothelioma is the most common benign tumor arising from the epididymal tail, although it can also arise from the tunica albuginea, the spermatic cord, or they can even have an intratesticular origin. Sometimes, US reveals a nodular mass on the epididymis and papillary projections on the surface of the tunica vaginalis (Fig. 28) [64, 65]. The mass may be heterogeneous with acoustic shadowing. These tumors do not compromise the gonad and can be treated by a simple excision of the hydrocele. The clinical course of these tumors is benign, without local recurrence after local excision. On imaging, sperm granulomas exhibit similar appearances (Fig. 29).

Primary testicular sarcoma is a rare indolent tumor with potential for distant metastases. Testicular sarcomas include rhabdomyosarcoma (Fig. 30), spindle cell sarcoma, osteosarcoma, leiomyosarcoma, fibrosarcoma, granulocystic sarcoma, and chondrosarcoma [66]. Malignant fibrous histiocytoma rarely affects the spermatic cord [67, 68].

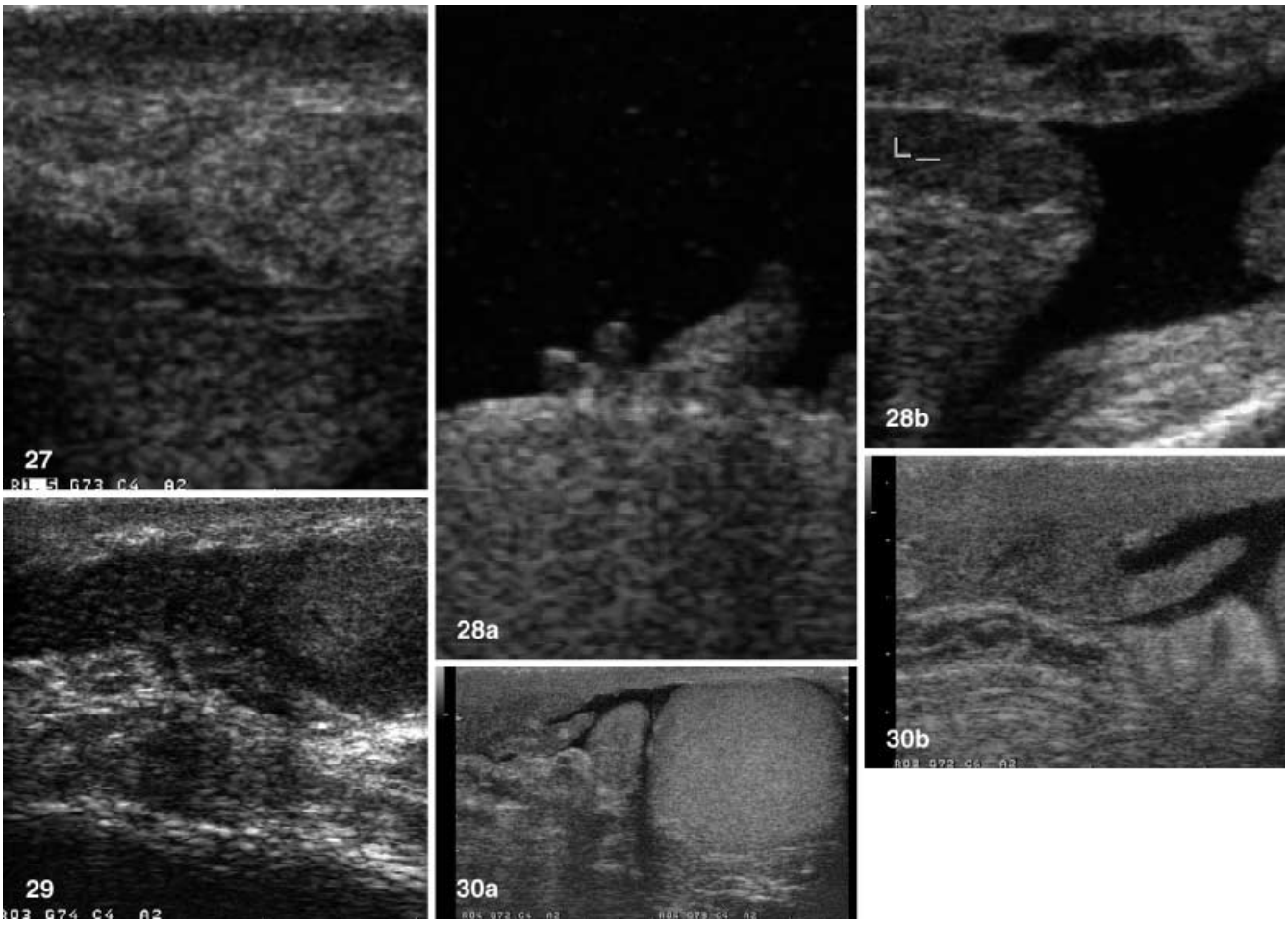


Fig. 27 Adenomatoid tumor. Palpable, painless, hyperechoic nodule at the surface of the testis

Fig. 28a, b Fibroma. Two different patients, **a** with finger-like protrusions at the surface of the testis, and **b** originating from the tunica vaginalis at the lower end of the scrotum

Fig. 29 Sperm granuloma. Detail of the transition between the epididymal body and tail. Palpable extratesticular soft tissue lesion, consistent with a sperm granuloma in a patient who underwent a vasectomy several years previously

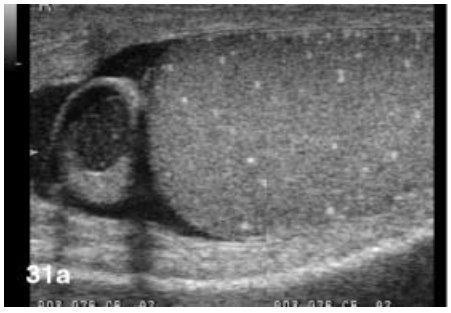
Fig. 30a, b Embryonal rhabdomyosarcoma. **a** Sagittal view (overview). **b** Detail of the upper part of the scrotum showing a finger-like protrusion originating at the tunica vaginalis near the external inguinal ring

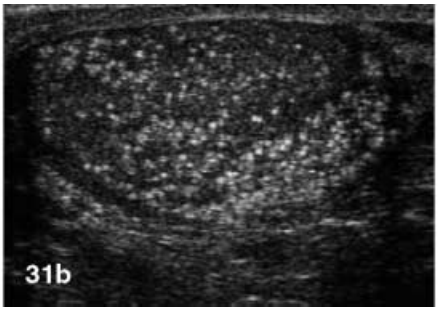
Color Doppler and testicular mass lesions

Demonstration of vascularity not only depends on equipment sensitivity, but on lesion size as well. In lesions >1.6 cm (1 cm) diameter, vascularity is almost always seen; in lesions <1.6 cm diameter, vascularity is not consistently seen. Color Doppler is not useful for differentiation of different histologic subtypes of testicular neoplasms. Distortion of the normal vessel course is more likely found in neoplasms, contrary to inflammation.

Testicular microlithiasis

The incidence of testicular microliths, focal or diffuse, unilateral or bilateral, is estimated at 0.05–0.6% [69, 70, 71]. The pathogenesis is still poorly understood, although it is thought that it is a primary process of the testicles, rather than a sequel of an underlying process. The etiology is uncertain. An association with other diseases or syndromes has been reported including cryptorchidism, Klinefelter, pseudo-hermaphroditism, infertility, and after orchiopexy [69, 72, 73, 74]. Since a higher incidence of (germ) cell tumors has been reported by several authors, testicular microlithiasis can no longer be considered as a benign disease and careful follow-up seems mandatory (4% of cases may harbor a testicular neoplasm). It is known that a high percentage of contralateral testes in men with unilateral testicular cancer have such an abnormal echo texture and that carcinoma in situ is most likely to be found in these testes [74]. Testicular microlithiasis is seen at US as multiple echogenic spots in an otherwise normal testicular parenchyma (Figs. 31, 32) [75, 76, 77, 78]. Nevertheless, considerable variation is found in the number and distribution of occurrences of





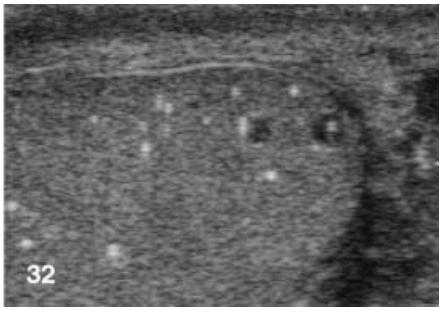


Fig. 31a, b Testicular microlithiasis. Typical "snow-storm" image of the testicular parenchyma due to the presence of numerous calcifications, **a** mild and **b** diffuse without (hypoechoic) mass lesion. Bilateral incidental finding in a patient with infertility and treated for cryptorchidism in childhood

Fig. 32 Testicular microlithiasis. Longitudinal view showing multiple calcifications and two small hypoechoic lesions near the lower pole of the testis. At follow-up scans the lesions remain stable

testicular microlithiasis (5–60 echogenic foci per transducer field). In some patients peripheral clustering is seen. Most patients demonstrate side-to-side symmetry, but asymmetric distribution and unifocality may be seen as well.

Infertility

Patients with fertility problems may be referred for scrotal US to evaluate testicular size and parenchyma, to evaluate epididymal integrity (partial or complete agenesis? obstruction?; Figs. 33, 34), and to evaluate the presence of (subclinical) varicocele [79]. Care must be taken not to compress the testis during measurement to avoid undersizing the anteroposterior diameter and oversizing the sagittal diameter.

The incidence of varicocele in the population is estimated at 13.4%; in patients with hypofertility 37% [80]. Varicoceles are bilateral in 30% of patients. Most large varicoceles are easily palpated and require no diagnostic evaluation other than physical examinations. Small varicoceles almost always require diagnostic procedures in addition to physical examination. To evaluate varicocele with US, examination in supine position is sufficient; in selected patients, additional scanning in the erect position is required [81]. The procedure is performed at rest and during Valsalva maneuver. The size of the veins is measured at rest and during Valsalva maneuver, and the absence or presence of venous reflux is determined by color Doppler (reflux in seconds). Ultrasound criteria for diagnosis of varicocele are: (a) diameter of the veins multiplied by 3 mm; (b) increase in size of the veins during Valsalva and/or in the upright position; and (c) retrograde flow during Valsalva and/or in the upright position. Combination of (a) and (b) is diagnostic; criteria (c) in itself is diagnostic as well. Varicoceles can be graded as follows: grade I, slight reflux (<2 s) during Valsalva; grade II, reflux (>2 s) during Valsalva, but no continuous reflux during the maneuver; or grade III, reflux in rest during normal respiration or continuously during the entire Valsalva maneuver.

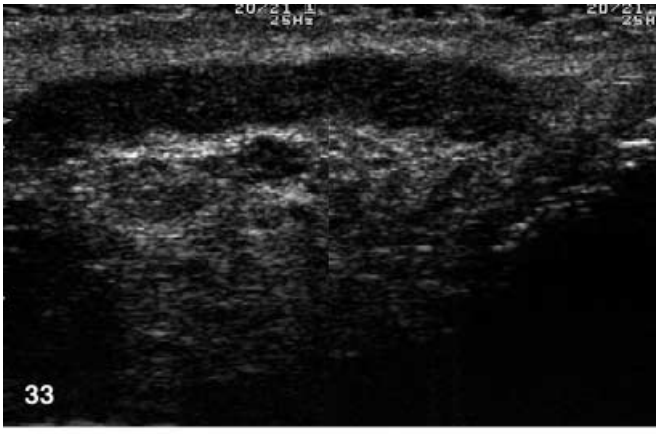


Fig. 33 Agenesis of the deferent duct. Patient with azoospermia. The epididymal body ends abruptly. There is no tail and no deferent duct

Fig. 34 Obstruction of the epididymis. Sagittal view: typical (and symmetric) dilation of the efferent ducts in the epididymal body and tail after vasectomy

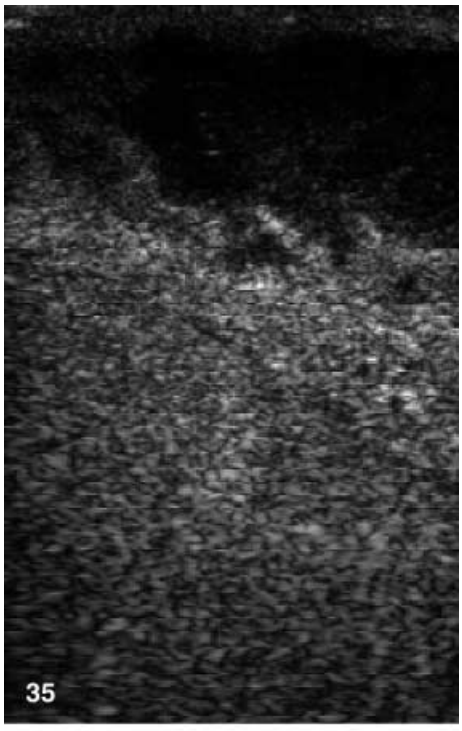


Fig. 35 Abscess. Abscess in the scrotal wall, probably originating in a sebum cyst

Fig. 36 Abscess. Large abscess in the scrotal wall in a paraplegic patient

A severe varicocele or right varicocele in an older man warrants further (sonographic) examination to exclude underlying disease processes causing secondary varicoceles (e.g., renal tumors, retroperitoneal masses).

Hernia

The clinical diagnosis of inguinal hernias is usually straightforward and imaging is not indicated. Occasionally, inguinal hernias may mimic other scrotal disorders, necessitating further examination. At US, an inguinal hernia presents as a structure of varying shape and echo texture, which moves in the inguinal canal with breathing, and is continuous with the peritoneal content. Bowel loops may be recognized by peristaltic activity. In incarcerated hernia, peristalsis is only occasionally demonstrated or absent. When the hernia only contains fat, discrimination from lipoma or liposarcoma may be impossible. The testis and epididymis should be delineated and are normal.

Pathology of the scrotal wall

Sometimes, diseases of the scrotal wall (e.g., sebum cyst, epidermoid cyst, abscess) are found (Figs. 35, 36). They present as echogenic or cyst-like masses in the confines of the scrotal wall. With inflammation, hyperemia can be shown with color Doppler.

The scrotum after orchiectomy

The range of normal and abnormal findings in patients after orchiectomy, including the appearances of the normal postorchiectomy space, acute and subacute hematomas, recurrent neoplasm, second primary tumor in the remaining testis, and testicular prostheses, can be evaluated with US [82].

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