Chapter 4
Scrotal Ultrasound

Etai Goldenberg and Bruce R. Gilbert

Introduction

Portability, safety, low cost and efficiency, together with the ability to accurately define pathology rapidly, have made ultrasound the primary imaging modality for evaluation of the scrotum, testis and paratesticular structures. These factors provide for timely diagnosis and treatment. Scrotal ultrasound is particularly helpful when a physical examination is inconclusive or a disease process prevents adequate examination. The detailed imaging of ultrasonography is often an essential component of the diagnosis of a variety of symptoms including scrotal pain or trauma, infertility and abnormal findings on physical exam. This chapter will explore the techniques and protocols for performing scrotal ultrasounds in order to make the most thorough assessment of patient symptoms leading to diagnosis.

Scanning Technique and Protocol

It is our belief that the ultrasound examination is best performed by a skilled sonographer using defined protocols. In this chapter we present our approach, realizing that many experienced sonographers will modify it to fit in with their needs. Nonetheless, it provides a basis to assure consistency in the examination appropriate documentation. Chapter 7 gives the protocol for performance of a normal scrotal ultrasound examination in detail.
The scrotal ultrasound is most often performed with the patient in the supine position. There are several different techniques to support the scrotum. The easiest is to use the patient’s legs for support. Other approaches use towels placed across the patient’s thighs or under the scrotum. The phallus is positioned up on the pubis held by the patient and/or covered by a towel for privacy (Figs. 1 and 2). The transducer is held with examiner’s hand against the patient for stability (Figs. 3 and 4).
Fig. 3  Sonographer performing a longitudinal view of the testis. Note the use of the fifth finger on the patient’s thigh to help steady the transducer and minimize movement of the testis in the scrotum.

Fig. 4  Sonographer positioning the transducer for a transverse view of the testis. Note again, the use of the fifth finger on the patient’s thigh to help steady the transducer and minimize movement of the testis in the scrotum.
Transducer Selection

The choice of the frequency used is determined by a balance between depth of penetration required and the detail of the image required. As the frequency increases, the image resolution (axial resolution) improves and the depth of penetration decreases. Broad bandwidth transducers allow for multiple focal zones, eliminating the need for adjustment during the examination. Multiple frequency transducers allow the transducer to be set to several distinct frequencies. A high frequency (7.5–18 MHz) array transducer is most often used for scrotal scanning. A linear array probe with a “footprint” able to measure the longitudinal length of testis is ideal. A curved array probe can be used with a thickened scrotal wall or in the presence of scrotal edema or for a large testis. The curved array transducer is also useful to compare echogenicity of the testes, however, the frequency is usually lower with a curved array probe, resulting in decreased axial resolution. Color and spectral Doppler are essential elements of scrotal ultrasound because they provide documentation of testicular blood flow and paratesticular findings. The highest possible frequency, normally in the 7.5–18 MHz range, providing the best axial resolution and blood flow detection, should be used [1].

Overview of the Examination

In the longitudinal view, the standard orientation of the image should be with the superior pole of the testis to the left and the inferior pole to the right on the monitor screen (Fig. 5). In the transverse plane, the standard orientation is for the patient’s right testis to be on the right side of the screen. Therefore, for the right testis, the lateral aspect is located on the left side of the screen and the medial aspect to the right. Conversely, for the left testis, the lateral aspect should be to the right and the medial aspect to the left (Fig. 6).

The evaluation of the scrotal contents should begin with a longitudinal survey scan, progressing medial to lateral to get an overall impression of the testis and
paratesticular structures. If the testis is larger than the footprint of the transducer, it is important to document views of the superior and inferior portions of the testis including the epididymis in these regions. The transverse view is obtained by rotating the transducer to 90°. A survey scan is performed using the mid-testis as a starting point and proceeding first towards the superior pole then back to the mid-testis before scanning to the inferior pole.

At least one image should visualize both testes to document the presence of two testes and their relative echogenicity (Fig. 7). Measurements of the testicular width and height are taken and documented at the mid-testis. A measurement should also be made of the long axis at the mid-testis and a testicular volume is calculated (Fig. 8). If the equipment being used has split-screen capabilities, comparative views of echogenicity can easily be made and documented.

**Fig. 6** Schematic view of transverse scrotal ultrasound as seen on the ultrasound screen with the right testis on the left and left testis on the right. The relative positions of each epididymis are also demonstrated.

**Fig. 7** Gray scale side-by-side view of both testes in a single image. This image is important to confirm the presence of two testes.
All relevant extratesticular structures should be evaluated, including but not limited to the epididymis, spermatic cord, and scrotal skin. Techniques that improve visualization, such as Valsalva maneuver or upright positioning, may be used as needed.

**Color and Spectral Doppler**

Color and spectral Doppler should be considered an integral part of the scrotal US examination. Many inflammatory, neoplastic, and benign conditions have characteristic flow patterns that can assist in diagnosis. At least one side-by-side image containing both testes with identical Doppler settings should be included to evaluate symmetry of flow. If blood flow cannot be visualized on color Doppler (Fig. 9a), power Doppler may increase the sensitivity to detect blood flow (Fig. 9b) [1].
**Documentation**

The written report and archived images are a reflection of the quality of the examination. The old adage “If it’s not documented, it wasn’t done” should guide the sonographer in developing a quality report. The static images obtained during the evolving ultrasound examination should represent the sonographer’s impression of the findings. If electronic storage space is available and the equipment allows, video clips, which demonstrate important findings and survey scans, can and should be obtained. A quality report can aid in diagnosis, and is therefore in the best interest of our patients.

All the measurements and anatomical findings of the examination should be documented. Images should be attached to the report. It is essential to include patient identification information, the examination date, and the indications for performing the examination. The transducer used and its frequency should also be documented. The area of interest should be clearly identified. The orientation and measurements should be labeled along with the pertinent anatomy and any abnormalities. There is no minimum number of images that are required for proper documentation. It is a best practice to provide images that depict the measurements being taken and the pathology being described. The physician who performed the examination should sign the report.

**Indications**

There are many specific indications for scrotal ultrasound (Table 1). Scrotal ultrasound is often performed when the physical examination is inconclusive or difficult to complete (or both) because of patient discomfort or inability of the examiner to precisely identify the scrotal structures on palpation. In these instances the scrotal ultrasound examination is therefore an integral part of the physical examination of the male genitalia. In other situations ultrasound evaluation is essential to diagnosis and treatment and is well supported in the literature. However, the decision on whether or not to obtain an ultrasound study is discretionary and without a clearly defined evidence based approach. “Appropriateness” criteria are necessary and high level evidence base studies are required in order to determine appropriateness. Part of the work of urologic imaging research in the future should look to assess the limitations of the current literature and then create an evidence base that will define the value of the imaging services critical to the practice of urology [2, 3].

**Normal Anatomy of the Testis and Paratesticular Structures**

The normal scrotal wall thickness varies between 2 and 8 mm. The scrotal wall contains the following structures: rugated skin, superficial fascia, dartos muscle, external spermatic fascia, cremasteric fascia and internal spermatic fascia. The scrotum
is separated into right and left hemiscrotal compartments by a septum termed the median raphe. As the testis descends in utero from the abdomen, it acquires each layer of the scrotal compartment. The external spermatic fascia is derived from the external oblique fascia and is attached to the external inguinal ring. The cremasteric fascia and muscle derive from the internal oblique muscle. Encasing each testis is the tunica vaginalis, derived from the peritoneum, which consists of parietal and visceral layers. These layers are normally separated by 2–3 ml of straw colored fluid often referred to as a physiologic hydrocele. Ultrasound of this fluid is seen as a thin echo free rim around the head of the epididymis [4] (Fig. 10). The parietal and

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<td>Detection of occult primary tumors in patients with metastatic germ cell tumors</td>
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<td>Evaluation of intersex conditions</td>
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<td><strong>Investigation of empty/abnormal scrotal sac</strong></td>
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<td>Undescended testis</td>
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<td>Thickened scrotal skin</td>
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<td><strong>Evaluation of male infertility and related issues</strong></td>
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<td>Varicocele</td>
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<td>Intratesticular microcirculation</td>
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<td>Atrophic testis</td>
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<td>Microlithiasis</td>
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<td>Impaired semen quality</td>
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<td>Azoosperma</td>
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<td>Antisperm antibody</td>
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<td><strong>Post operative follow up</strong></td>
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<td>Patients with indeterminate scrotal masses</td>
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visceral layers join at the posterolateral aspect of the testes where the tunica attaches to the scrotal wall [5].

The testes descend into the scrotum at approximately the 28th week of gestational age through the inguinal canal along with the processus vaginalis. The processus vaginalis gradually closes through infancy and early childhood. The size and shape of the testis changes with the age, influenced by gonadotropic hormones testicular volume gradually rises from birth to up to 5 months of age due to peak in gonadotropic hormones levels [6, 7]. After 5 months of age, the testicular volume steadily declines and reaches its minimum volume at approximately 9 months of age and remains approximately the same size until puberty [8]. In newborns, the testis is round and gradually becomes ovoid with growth. The echogenicity of the testis increases in puberty due to the development of germ cell elements [9].

The adult testis is a smooth ovoid gland, approximately 4–5 cm long, 3 cm wide, 2–3 cm in the anterior-posterior (AP) dimension, and typically between 20 and 30 ml in volume. The testis exhibits medium homogenous echogenicity. A dense fibrous capsule the tunica albuginea envelops the testis, which is apparent as a thin echogenic line on ultrasound. Each testis has approximately 200–300 cone shaped lobules each containing at least one seminiferous tubule [10] (Fig. 11). The lobules are separated by the fibrous septa of tunica albuginea that extend from the mediastinum of the testis in to the parenchyma of the testis [11]. Testicular lobules are occasionally identified on ultrasound as lines radiating from the mediastinum testis (Fig. 12). The seminiferous tubules contained within the lobules open into dilated spaces called rete testis within the mediastinum. The seminiferous tubules are long V-shaped tubules, both ends of which usually terminate in the rete testis. The rete testis is connected to the head (caput or globus major) of the epididymis with about 8–12 efferent ductules. The normal rete testis is sonographically evident in 18% of patients as a hypoechoic area with a striated configuration adjacent to the mediastinum testes [12]. The mediastinum testes appears as a linear avascular echogenic band on ultrasonography [13] (Fig. 13).

The adult epididymis is 6–7 cm long and has three parts, the head (caput) measuring 10–12 mm in diameter, the body (corpus) measuring 2–4 mm in diameter, and the tail (cauda) about 2–5 mm in diameter. In the normal epididymis, the head is routinely identified at posterolateral to the upper pole of the testis. The
**Fig. 11** Schematic cross section of the testis

**Fig. 12** Gray scale ultrasound of a normal testis demonstrating testicular lobules separated by fibrous septa (*arrows*)

**Fig. 13** The mediastinum testis appears as an avascular echogenic line (*arrow*)
The caput epididymis is triangular in shape, often has the same echogenicity as the testis (Fig. 14). However, it can be heterogenous with areas that are hyper- or hypochoic. The smaller corpus epididymis can be seen as a hypoechoic structure containing multiple echogenic linear structures representing the coiled epididymal tubule, and lies posteriorly along the long axis of the testis (Fig. 15).

The testicular appendages are the remnants of the mesonephric and paramesonephric ducts. There are four testicular appendages: the appendix testis, the appendix epididymis, the vas aberrans, and the paradidymis [14] (Fig. 16). The appendix testis and the appendix epididymis are commonly seen on scrotal ultrasound [15]. The appendix testis (hydatid of Morgagni) is a small ovoid structure usually at the upper pole of the testis in the groove between the testis and the epididymis, better seen
in the presence of fluid around the testis. The appendix testis is the vestigial remnant of the paramesonephric (Mullerian) duct (Fig. 17). The appendix epididymis originates from the mesonephric (Wolffian) duct and is seen associated with the epididymal head on ultrasound images (Fig. 18).

The spermatic cord is normally seen superior to the posteromedial aspect of the testis and contains the vas deferens, the testicular and cremasteric and deferential arteries, the pampiniform plexus of veins, genital branch of the genital femoral nerve, testicular plexus of the sympathetic trunk, and lymphatic vessels [11]. The blood supply to the scrotal structures is from three primary arteries: the testicular, deferential, and cremasteric arteries (Fig. 19). The testicular artery testis or gonadal artery, which arises from the aorta and courses through the scrotum with the spermatic cord, is the major supply to the testis. The deferential artery, which arises from the superior vesical artery and supplies the vas deferens and epididymis. The cremasteric artery, a branch of the inferior epigastric artery, which supplies the scrotal skin and coverings of the spermatic cord. As the testicular artery approaches the posterolateral aspect of the testis it divides. The branches pierce through the tunica albuginea to run in a layer called the tunica vasculosa. Capsular arteries run peripherally in the tunica vasculosa, supplying centripetal arteries that course towards the mediastinum and divide further to recurrent rami that flow away from the mediastinum [13]. The veins draining the testis and epididymis converge to form the pampiniform plexus at the mediastinum on the superior pole of the testis. The
pampiniform plexus is primarily drained by the testicular and external pudendal veins [16]. The testicular vein on the left drains into the renal vein and the testicular vein on the right directly into the inferior vena cava [17].

Ultrasongraphy with Color-Flow imaging provides visualization of the intratesticular, epididymal, and paratesticular blood flow. Under normal conditions, Color Flow images show equivalent vascularity of the bilateral testis. When vascularity is not well visualized, Power Doppler increases the sensitivity of detection. Spectral Doppler is used to calculate the Resistive Index (RI) of intratesticular arteries. The
RI of intratesticular arteries has been found to correlate with testicular function, namely spermatogenesis.

**Sonoelastography**

The ability to access pathology by palpation has long been a key part of the physician’s physical examination. Hard lesions are often a sign of pathology. Sonoelastography (tissue elasticity imaging) is an evolving ultrasound modality which adds the ability to evaluate the elasticity of biological tissues. Essentially, it gives a representation, using color, of the softness or hardness of the tissue of interest. The physics of this modality is given in an earlier chapter. Visually, the elasticity of a tissue is represented by color spectrum. Be aware that the color given to hard lesions is determined by the manufacturer of the equipment as well as being able to be set by the user. Therefore, just as in using color Doppler, the user needs to look at the color bar to know what color represents a “hard” and “soft” lesion.
Table 2  Ultrasound characteristics of non-neoplastic intratesticular masses

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<tr>
<th>Intratesticular lesion</th>
<th>Ultrasound findings</th>
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<tr>
<td>Simple testicular cyst</td>
<td>Well-circumscribed, anechoic, increased through-transmission</td>
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<tr>
<td>Epidermoid cyst</td>
<td>Classic appearance: an onion ring due to alternating layers of hypoechogeticity and</td>
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<td>hyperechogeticity</td>
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<td>Tubular ectasia of the rete testis (TERT)</td>
<td>Avascular cystic dilations in the rete testis</td>
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<td>Intratesticular varicocele</td>
<td>Anechoic, tortuous structure with a venous waveform on Doppler color flow study</td>
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<tr>
<td>Tunica albuginea cyst</td>
<td>Cyst at upper or lateral margin of testis; may be clinically palpable</td>
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<tr>
<td>Testicular hemATOMA</td>
<td>Avascular hyperechoic lesion within the testicular parenchyma</td>
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<td>Congenital testicular adrenal rests</td>
<td>Bilateral hypoechoic or hyperechoic lesions with or without posterior acoustic</td>
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Testicular Pathology

Malignant Lesions of the Testis

Testicular malignancies account for approximately 1% of all the malignancies in men. The predicted 5-year survival rate is approximately 95%, believed to be due to early detection as patient appreciation of abnormality in a superficially palpable organ and tumor sensitivity to chemotherapy and radiotherapy. The most common presentation is of a painless scrotal mass, with pain being reported in only 10% of cases [18]. Ultrasonography is the gold standard imaging modality for diagnosis. Ultrasound characteristics differ significantly for malignant as compared to benign (Table 2) intratesticular masses.

Germ Cell Tumors

Germ cell tumors account for 95% of testicular malignancies and can be divided into seminomatous and non-seminomatous germ cell tumors. The remaining minority of testis tumors are histologically sex cord stromal tumors, lymphomas, or metastases.

The most common germ cell tumor is seminoma, which comprises up to 50% of all germ cell tumors. Seminoma occurs in men predominantly between the ages of 35 and 45. Bilateral seminomatous germ cell tumors are rare and are reported only 2% of the cases [19]. On gross pathology, they are lobulated and pale in color and may vary in size from small well-defined lesions to masses that completely replace normal testicular parenchyma [19]. The sonographic appearance of seminoma typically is a homogeneous well-defined hyperechoic lesion, with cystic areas
found only in 10% of cases [20]. Larger tumors tend to be more heterogeneous and may have poorly defined margins, are often diffusely infiltrative and multifocal (Fig. 20a, 20b).

Nonseminomatous germ cell tumors (NSGCT) generally occur in younger men between ages 25 and 35. NSGCT are mixed germ cell tumors comprised of embryonal carcinoma, yolk sac tumor, choriocarcinoma and teratoma. They can be locally aggressive with invasion of the tunica albuginea or the epididymis or the spermatic cord. The ultrasonographic findings reflect the diversity of the components and characteristically appear irregular with a heterogeneous parenchyma pattern, representing calcification, hemorrhage, or fibrosis and cystic lesions [21, 22] (Fig. 21a, 21b).

Pure embryonal cell carcinoma makes up 2–3% of all germ cell tumors. An embryonal cell carcinoma is an aggressive tumor with ultrasonographic findings often demonstrating irregular and indistinct margins, with a heterogeneous echotexture. These tumors are characteristically smaller in size without enlargement of the testis [23]. Yolk sac tumor, also known as endodermal sinus tumor or infantile embryonal carcinoma, most commonly occurs in children younger than 2 years [23].
sonographic appearance of yolk sac tumors of the testis is inhomogeneous and can have areas of hemorrhage, however it is difficult to differentiate from other solid tumors of the testes based solely on ultrasonography [24]. Choriocarcinoma carries the worst prognosis of all germ cell tumors, with early metastatic spread to the lung, liver, gastrointestinal tract, and brain, and is associated with an elevated human chorionic gonadotropin level. Ultrasound is characterized by cystic and solid areas, corresponding to areas of hemorrhagic necrosis [24].

Teratoma is the second most common pediatric testicular tumor, and a mature teratoma is often benign in children. A teratoma will demonstrate endodermal, mesodermal and ectodermal components in a disorganized arrangement [21]. Echogenic foci in these tumors represent elements of its embryologic composition—immature bone, fat, and fibrosis.

Epidermoid cysts of the testis are rare benign germ cell tumors. Epidermoid cysts usually present between 20 and 40 years of age. They are normally unilateral, however bilateral occurrence is rarely reported [25]. Epidermoid cysts are variable on sonographic appearance attributable to their contents with keratin and variable maturation. The characteristic “onion ring” sonographic appearance of the epidermoid cyst is due to alternating layers of hypo- and hyperechogenicity without internal flows [15, 26, 27] (Fig. 22a, 22b). An epidermoid cyst of less than 3 cm in size with negative tumor markers can be managed conservatively by enucleation provided that frozen sections are obtained to confirm the diagnosis [28].

Non-germ Cell Tumors

Non-germ cell tumors are rare, but most commonly arise from Leydig or Sertoli cells. Leydig cells are the principle source of male testosterone. Leydig cell tumors
represent fewer than 3% of all testis tumors, they are usually benign but have malignant potential. Male patients have virilizing or feminizing characteristics due to androgen secretion. Ultrasound features are nonspecific, but if Leydig cell tumor is suspected, tumor enucleation may be performed. Sertoli cell tumors represent approximately 1% of testicular tumors and can occur in children and adults. Sertolic cell tumors are usually found in patients younger than 40, do not secrete hormones, and can occur bilaterally in 20% of patients [29]. Both Leydig cell and Sertoli cell tumors may be amenable to testis-sparing resection, where intra-operative ultrasonography is an essential component of the procedure.

**Testicular Lymphoma**

Primary testicular lymphoma is the most common testicular malignancy in men over the age of 60 [30–32]. The most common histological type is large B-cell non-Hodgkins lymphoma. The ultrasound demonstrates diffuse enlargement of the testis with increased vascularity on Doppler color flow (Fig. 23a, 23b). Orchidectomy had been advocated as diagnostic and therapeutic procedure. The treatment recommendation was recently changed to a combined modality of systemic doxorubicin-based chemotherapy, prophylactic intrathecal chemotherapy and orchidectomy or scrotal radiotherapy [31]. Lymphoma found in the testis may also be the initial site found with widespread disease or the site of recurrence for previously treated lymphoma as the testis a sanctuary organ due to the blood-gonad barrier that blocks accumulation of chemotherapy agents [24].

**Metastasis**

Ultrasonography cannot differentiate metastatic disease to the testicle from a primary testicular lesion. Metastasis to the testis is rare and usually occurs with advanced disease. The most common cancers to metastasize to the testis are melanoma, prostate, and lung [33, 34].
Regressed or Burn-Out Germ Cell Tumor

Some patients present with widespread metastatic disease, to the retroperitoneum or beyond, without identification of a primary tumor. Scrotal ultrasound performed for these patients may find an area of calcification in the testis, representing the “burnt-out” primary lesion. One theory to explain the genesis of the burned out tumor is that the tumor outgrows its blood supply and then subsequently involutes, resulting in fibrosis and calcification [35] (Fig. 24).

Incidentally Discovered Non-palpable Testicular Lesions

Incidentally found solid testicular masses that are not palpable are usually benign. Significant risk factors for the presence of malignancy include size greater than 1 cm, ipsilateral atrophy, history of cryptorchidism, history of contralateral germ cell tumor, and severe oligospermia or azoospermia [36]. Previous work has shown that patients at low risk for malignancy can be managed with active ultrasound surveillance, proceeding with testis sparing excision biopsy or radical orchiectomy if the lesion size should increase in size [37, 38]. Patients at high risk for malignancy were managed with an ultrasound guided testis sparing excisional biopsy or radical orchiectomy [39].

With the introduction of sonoelastography, non-palpable lesions can be differentiated into “hard” or “soft”. Two recent studies have used real-time elastography to attempt to separate benign from malignant testicular lesions, as it is postulated that malignant lesions have an increased stiffness due to a higher concentration of vessels and cells compared to surrounding tissues (Fig. 37a–37c). Goddi et al. assessed 88 testis with 144 lesions and found a 93% positive predictive value, 96% negative predictive value, and 96% accuracy in differentiating benign from malignant lesions [40]. Similarly, Algner et al. assessed 50 lesions and found a 92% positive predictive value, 100% negative predictive value, and 94% accuracy [41]. Real time tissue elastography is an exciting new innovation in assessing abnormalities on
scrotal examination, and may be used to predict the risk of malignancy in a testicular lesion. We believe that this modality may be used to avoid surgical intervention on benign lesions based on the finding the lesion to be “soft” on elastography. A possible approach to the evaluation of the non-palpable sub-centimeter testicular lesion is depicted in Fig. 25.

### Benign Abnormalities of the Testis

#### Torsion of the Spermatic Cord or Testicular Torsion

Ultrasound is often used to assess boys and adolescents with acute scrotal pain when the urologist is concerned for testicular torsion. Testicular torsion can be classified as extravaginal or intravaginal. The extravaginal form of torsion is found exclusively in newborn infants. Intravaginal torsion is more common and is due to a bell-and-clapper deformity in which the tunica vaginalis has an abnormally high insertion on the spermatic cord and completely encircles the testis, leaving the testis free to rotate within the tunica vaginalis. The deformity is bilateral in most cases. Intravaginal testicular torsion occurs most frequently in adolescent boys, with two thirds of cases occurring between 12 and 18 years of age. Intravaginal torsion may occur in testes that are retractile or are not fully descended. Blunt trauma, sudden forceful rotation of the body, or sudden exertion also predispose to testicular torsion.
Ultrasound is very effective in differentiating testicular torsion from other causes of acute scrotal pain. The severity of torsion of the testis can range from 180° to 720°, but complete occlusion of blood flow is thought to occur after 450° of torsion [11]. Transient or intermittent torsion with spontaneous resolution sometimes occurs. Venous congestion or occlusion progresses to arterial occlusion, testicular ischemia, and infarction. The collateral blood flow is typically not adequate to provide viability to the testicle if the testicular artery is occluded. There is a 90% chance of salvaging the testicle when ischemia has been present for less than 6 h, which decreases to 50% at 12 h and 10% at 24 h [42]. While irreversible testicular damage is presumed after 4 h of torsion, only 50% of men who were detorsed less than 4 h after their symptoms began were noted to have normal semen quality [43].

On gray scale ultrasound, the affected testis usually appears hypoechoic (Fig. 26a) and Doppler color flow study shows decreased or no flow in the affected testis (Fig. 26b). Testicular size can vary from increased to decreased when compared to its counterpart depends up on the duration of the torsion. The sonographer should always compare the affected testis with the contralateral side using longitudinal, transverse, and coronal views. When the sonographer attempts to align the transducer parallel to flow, apical views can be particularly informative. In patients with acute torsion, the epididymis may appear hypoechoic and enlarged, similar to epididymitis. With testicular torsion ultrasound may also demonstrate that the spermatic cord immediately cranial to the testis and epididymis is twisted, which gives it a characteristic “torsion knot” or “whirlpool appearance” (Fig. 27a, 27b).

Acute unilateral scrotal pain may be of a non-emergent etiology, due to epididymitis or torsion of a testicular or epididymal appendage. Waldert et al. retrospectively reviewed the charts of 298 boys who presented with an acute scrotum and underwent color Doppler ultrasonography followed by exploratory surgery, regardless of the sonographic findings. Twenty percent were diagnosed with testicular torsion, 56% with torsion of an appendage, 8% with epididymitis, and 11% with no definite diagnosis. Color Doppler sonography sensitivity, specificity, positive predictive value and negative predictive value for testicular torsion were 96.8, 97.9, 92.1 and 99.1% respectively. The two boys in this study misdiagnosed as epididymo-orchitis were both found to have 90° of torsion and no venous drainage but with residual arterial flow [44].

Despite the findings that color Doppler sonography has a high sensitivity and specificity, it is our feeling that torsion remains a clinical diagnosis proven only at
surgery. Ultrasound should only be used to document findings. Many conditions including torsion-detorsion, intermittent torsion, persistent capsular flow, and color flow artifacts can suggest apparent flow in cases where none exists. Therefore, ultrasound does not diagnose or “rule out” torsion, only surgical exploration is indicated when the diagnosis of testicular torsion is suspected.

**Primary Orchitis and Testicular Abscess**

The ultrasound findings of patients with orchitis are often an enlarged testis with homogenous appearance. Orchitis may be diffuse or focal, with focal orchitis appearing as multiple hypoechoic lesions with increased testicular blood flow (Fig. 28a, 28b). Additionally, the RI of the epididymal and testicular artery has been shown to
be significantly lower in patients with epididymo-orchitis than in control subjects [45]. If inflammation progresses, the pressure of intratesticular edema may compromise blood flow leading to infarction; the ultrasound will demonstrate absence of blood flow and surrounding reactive hyperemia [46].

A testicular abscess is seen in approximately 5% of patients with orchitis and usually appears 1–7 weeks after orchitis, often as a result of ineffective treatment. The clinical hallmarks of a testicular abscess include persistent fever, scrotal pain and swelling. These findings may resemble a tumor, yet evidence of inflammation and absence of Doppler flow will often differentiate an abscess from a tumor [47] (Fig. 29).

**Nonpalpable Testis**

When the testis is nonpalpable in the scrotum, a search is initiated to confirm its presence or absence. Ultrasound is often the initial diagnostic imaging modality because of its sensitivity in the inguinal canal where most undescended testes are found. If the absent testis is not identified within the inguinal canal, computerized tomography (CT) or magnetic resonance imaging (MRI) is can be used in an attempt to locate an intra-abdominal testis. Surgical exploration, however, remains the “gold standard” for identifying an intra-abdominal testis. A cryptorchid testis in the inguinal canal, identified by the presence of the mediastinum testis, is usually small in size (hypotrophic). It can be differentiated from an inguinal hernia by the absence of peristalsis and highly reflective omental fat.
The etiology of testicular microcalcification (TM) is unknown. It has been suggested that the calcified concretions within the lumen of seminiferous tubules originates from sloughing of degenerated intratubular cells and failure of the Sertoli cells to phagocyte the debris [48, 49]. TM has been defined as five or more microcalcifications within the testicular parenchyma. TM appears on ultrasound as hyperechogenic lesions measuring between 1 and 3 mm sized multiple foci within the testicular parenchyma. The prevalence of TM varies from 1.5 to 5.6% of asymptomatic healthy men, compared with 0.8–20% in infertile men [50]. Acoustic shadowing on ultrasound is often absent, likely due to the small size of the calcifications [51, 52] (Figs. 30 and 31). They are usually bilateral, but occur unilaterally in 20% of the cases. Goede et al. reported 2.4% prevalence of TM in young asymptomatic boys [53]. TM is also described in association with various benign conditions including varicocele, cryptorchidism, male pseudo hermaphroditism, Klinefelter’s syndrome, neurofibromatosis, and Down syndrome [54].

**Fig. 30** Gray scale imaging demonstrating multiple bilateral microcalcifications of the testis. Note the lack of acoustic shadowing

**Fig. 31** Color Doppler study showing multiple microcalcifications

**Testicular Microcalcification**
The risk of subsequent development of carcinoma in-situ (CIS) and testicular germ cell tumor in patients presenting with TM is less clear [52, 55]. Data from several investigators suggest that TM is a benign, nonprogressive condition, at least when followed for up to 45 months [56, 57]. However, several recent case reports have documented the development of testicular tumors in patients with TM when follow up was extended for several years [57, 58]. The risk of CIS of testis in men with history of undescended testis is approximately 2–4% [59]. Men with TM and associated risk factors should be considered for long-term follow up including testicular biopsy as indicated.

**Testicular Macrocalcification**

Intratesticular macrocalcifications can be secondary to the presence of a germ cell tumor, a burnt out germ cell tumor, a Sertoli cell tumor, prior trauma, infection (TB), infarction or inflammation (sarcoidosis) [60].

Extratesticular calcifications can be found with the tunica vaginalis space and can result from inflammation of the tunica vaginalis or from a sloughed testicular appendage. When these calcifications are freely mobile, they are known as scrotal pearls or scrotoliths.

**Cystic Lesions**

**Intratesticular Cysts**

*Simple Testicular cysts* occur in approximately 8–10% of patients [61]. The common causes for the testicular cysts include trauma, surgery and inflammation. Cysts most commonly are found at the mediastinum testis. Testicular cysts are usually simple cysts: on ultrasound they are anechoic, demonstrate an imperceptible wall and have through transmission. Testicular cysts normally have a size range from 2 mm to 2 cm in diameter [47] (Fig. 32).
Cystic teratoma appears on ultrasound as a cystic mass with solid components, and should be considered whenever cystic testicular lesions are found. Cystic teratoma occurs in children and adults. In children, they behave as a benign tumor, whereas in adults and adolescents they are known to metastasize [62].

Cysts of the Tunica Albuginea

Tunica albuginea cysts arise from within the layers of the tunica albuginea. They are benign cysts and are clinically palpable by virtue of their location. These cysts meet the criteria for a simple cyst by ultrasound [63, 64] (Fig. 33).

Tubular Ectasia of Rete Testis

*Tubular ectasia of the rete testis (TERT)* is a benign clinical entity in which cystic dilation of rete testis results from partial or complete obstruction of the efferent ducts [65, 66]. TERT often present an asymptomatic finding in men older than 50 years with unremarkable physical examination of the testes. On ultrasound, it is seen as multiple anechoic, avascular structures within the mediastinum (Fig. 34a, 34b). TERT is often associated with ipsilateral spermateceles and usually found
It is important to differentiate this benign cystic tumor from malignant cystic tumors of the testis and thus avoid unnecessary orchidectomy. Cystic malignant tumors, most commonly the cystic teratomas, can be distinguished sonographically by the presence of multiple cystic areas, often surrounded by a soft tissue. Tumors are almost always unilateral and are located anywhere in testicular parenchyma, not limited to the mediastinum [67].

**Intratesticular Varicocele**

Intratesticular varicocele has been defined as dilated veins radiating from the mediastinum testis into the testicular parenchyma [68, 69]. It is a clinically occult condition that may occur in association with extratesticular varicocele. The sonographic features of intratesticular varicoceles are similar to those of extratesticular varicoceles. Color flow Doppler sonography demonstrates tubular or serpentine vascular structures more than 2 mm in diameter with a positive Valsalva maneuver (Fig. 35a, 35b). Valsalva maneuver plays an important role in the diagnosis of intratesticular varicocele because in most cases the retrograde flow will not show up spontaneously on color flow Doppler sonography [70]. Approximately 40% of intratesticular varicoceles are present bilaterally [71]. Patients with intratesticular varicocele may have testicular pain in up to 50% of cases secondary to venous congestion, resulting in stretching of the tunica albuginea. Bucci et al. reported 2% incidence of intratesticular varicocele in their series of 342 patients who were evaluated with color Doppler ultrasound for a fertility evaluation [69]. Color flow Doppler sonography helps to differentiate intratesticular varicocele from the tubular ectasia of rete testis adjacent to the mediastinum. Spectral Doppler yields the definitive diagnosis by confirming venous flow.

**Congenital Testicular Adrenal Rests**

Congenital adrenal hyperplasia (CAH) is an autosomal recessive disease characterized by deficiency of adrenocortical enzymes. More than 90% of cases of congenital adrenal hyperplasia are caused by 21-hydroxylase deficiency [72, 73].
Congenital testicular adrenal rests are seen in about 29% of patients with congenital adrenal hyperplasia [74]. An increase in adrenocorticotropic hormone (ACTH) levels causes hyperplasia of adrenal remnants in the testes in patients with CAH and results in the development of intratesticular masses. Sonographically, these masses appear as hypoechoic intratesticular masses in both testes and Doppler color flow shows increased vascularity located in the region of the mediastinum testis [74, 75] (Fig. 36a, 36b). Scrotal ultrasound is the diagnostic modality of choice for their diagnosis. Congenital testicular adrenal rests may have the appearance of other testicular tumors, however the presence of bilateral lesions in patients with CAH should be considered congenital adrenal hyperplasia. The lesions should be followed by ultrasound and should regress with steroid replacement therapy [76].

**Sarcoidosis**

Involvement of the testis and epididymis with sarcoid is rare. Clinically it presents as a painless epididymal or testicular mass or as epididymitis. Sonographically the lesion is an irregular hypoechoic mass that may be calcified, multifocal and bilateral [77]. Sonoelastography might also be useful. It demonstrates a “hard” lesion with tumor (Fig. 37a) and soft’ lesion with benign lesions such as Leydig and sertoli cell nodules (Fig. 37b) and can give an “intermediate” elasticity measurement (Fig. 37c).

**Testicular Trauma**

Testicular trauma accounts for less than 1% of all trauma related injuries with peak occurrence at ages 10–30 [78, 79]. Common causes of trauma are motor vehicle accident and athletic injury. Blunt trauma accounts for 85% of scrotal trauma and penetrating trauma for 15% of total injuries [80]. Physical examination may be difficult in these patients with scrotal trauma due to tenderness and swelling of the scrotal

**Fig. 36 a** Ultrasound of testicular adrenal rests (*arrow*), located adjacent to the mediastinum testis and typically found bilaterally. **b** Doppler color flow study shows increased vascularity of testicular adrenal rests
Contents. The scrotal ultrasound remains the standard imaging study to evaluate the testicular and epididymal integrity and assess the vascular status [79]. Findings after severe scrotal trauma include hematocele, testicular hematoma, and testicular rupture. Buckley and McAninch reported 100% sensitivity and 93.5% specificity when comparing ultrasound results of blunt trauma of the testes to the findings at surgical exploration [81]. Guichard et al. also reported sensitivity and specificity of ultrasound for testis rupture were 100 and 65% respectively when compared to surgical findings [82]. When ultrasound cannot be performed, magnetic resonance imaging (MRI) is a possible alternative, as MRI had 100% diagnostic accuracy for the diagnosis of testicular rupture [83].

An intratesticular hematoma after trauma is diagnosed when images show an intact tunica albuginea and intratesticular hypoechoic areas with no blood flow on Doppler color flow study (Fig. 38). A discrete hypoechoic stripe in the testicular parenchyma and interruption of tunica albuginea are evidence of testicular rupture [84] (Fig. 39). A hematocele is an accumulation of blood within the tunica vaginalis. Hematoceles are usually secondary to trauma, yet may also be present after

**Fig. 37** a Sonoelastography and gray scale images of a testicular non-seminomatous germ cell tumor. Note the “hardness” of the lesion based on color bar. b Sonoelastography, gray scale images of a sertoli cell nodule in a patient presenting with infertility. Note the “softness” of the lesion based on color bar. c Sonoelastography and gray scale images of a patient with testicular sarcoidosis. Note the “intermediate” elastography pattern of the lesion based on color bar.
testicular torsion, presence of a tumor and scrotal surgery. Ultrasonography of a hematocoele reveals a complex heterogeneous appearance and may demonstrate mass effect with distortion of the testis [85].

The current management strategy for testicular rupture advocates early surgical intervention with the goal of preventing testicular loss. These recommendations are also applied in boys with a large hematocoele since up to 80% of significant hematocoeles are due to testicular rupture [86]. The importance of early identification of testicular rupture is that 80% of testis can be salvaged if surgical exploration is performed within 72 h of injury. Additionally, any abnormalities found on scrotal ultrasound at the time of trauma must be followed by ultrasound until resolution, as 10–15% of testicular tumors manifest after trauma [80].
Extratesticular Findings

Hydrocele

Hydrocele is the most common cause of painless scrotal swelling. A hydrocele is a serous fluid collection between the parietal and visceral layers of the tunica vaginalis. The tunica vaginalis is a mesothelium-lined sac that results from closure of the superior portion of the processus vaginalis. This fascial structure normally covers the entire testis except the posterior border. It has a visceral layer and an outer parietal layer that lines the internal spermatic fascia of the scrotal wall. Hydroceles can be congenital or acquired. The congenital hydrocele or communicating hydrocele occurs when a patent processus vaginalis allows fluid to pass from the peritoneal space into the scrotum [87]. The acquired hydrocele may be idiopathic with no identifiable cause. The incidence of hydroceles is about 1% of adult males. Hydroceles are usually anechoic on ultrasonography (Fig. 40). They may contain echogenic cholesterol crystals. The presence of septations is often associated with infection, trauma, or metastatic disease. Hydrocele may develop secondary to venous or lymphatic obstruction caused by infection, trauma, torsion, or tumor. About 10% of testicular tumors are accompanied by a hydrocele; clinical suspicion increases with new onset of hydrocele in men in their 30s or 40s [88]. Scrotal ultrasound is essential to rule out testicular pathology in these patients. The testis is often posteriorly

Fig. 40  Gray scale ultrasound showing a left hydrocele (H)
displaced by the hydrocele. A massive hydrocele exerts a pressure effect that may compromise blood flow within the testis. Vascular resistance in intratesticular arteries is increased, and color Doppler ultrasound may demonstrate an increase in the caliber of capsular arteries. Fluid aspiration and surgical excision of hydrocele sac has been shown to restore normal blood flow to the testis [89].

**Pyocele**

Pyocele is an accumulation of purulent material within the tunica vaginalis and is most often occurring because of untreated epididymo-orchitis. Pyoceles present with acute scrotal pain and symptoms of sepsis. A pyocele also appears heterogeneous on the ultrasonogram, and gas may be identified, causing hyperechoic reflections and shadowing [85] (Fig. 41).

**Scrotal Hernia**

Congenital inguinal hernia is due to failure of the processus vaginalis to obliterate and result in passage of intestinal loops or omentum or peritoneal fluid in the scrotal sac [11, 90, 91]. Right inguinal hernias are more common as the right processus vaginalis closes later. Scrotal ultrasound can be helpful for inconclusive physical
examination. Clinically occult contralateral hernia can also be assessed with the ultrasound [92]. Patients with a scrotal hernia usually present with mesenteric fat and/or bowel loops seen superior to the testis. Real time imaging can identify peristaltic activity or intestinal gas bubbles with their characteristic echogenic interfaces. Ultrasound of an omental hernia will demonstrate highly echogenic fat [92] (Figs. 42a, 42b and 43).

**Sperm Granuloma**

Sperm are highly antigenic, and an intense inflammatory reaction occurs when they exit the vas deference [93]. A sperm granulomas occur in at least 40% of men
following a vasectomy [94] (Fig. 44). Sperm granulomas are rarely symptomatic. However, 2–3% of vasectomy patients will have pain attributed to sperm granulomas, usually occurring 2–3 weeks postoperatively [95].

**Tumors of the Spermatic Cord**

*Lipomas* of the spermatic cord are very common benign lesions of the spermatic cord. They can be unilateral or bilateral, and often present as asymptomatic fullness of the spermatic cord. Ultrasound of a lipoma demonstrates homogeneous echogenicity similar to subcutaneous fat without internal color flow. The echogenicity of lipomas may be variable, and MRI may be helpful to confirm diagnosis, showing nonenhancing, fat saturated areas [29]. It is also important to differentiate a lipoma from an inguinal hernia by noting the intact external inguinal ring on physical examination and assessing for the presence of a hernia on ultrasound.

*Rhabdomyosarcomas* of the spermatic cord is a malignant lesion in children, and *liposarcoma* is the most common malignant tumor arising in the spermatic cord in adults, although both are rare. *Leiomyosarcomas* in the paratesticular space also have been reported. The ultrasound appearance of these lesions is an ill-defined solid mass with heterogeneous echotexture and increased vascular flow on Doppler color study (Fig. 45).

**Epididymal Findings**

**Epididymo-orchitis**

*Epididymitis* is the most common cause of subacute unilateral scrotal pain in preadolescent and adolescent boys and adult men. On physical examination the epididymis
can often be identified as an enlarged and tender structure posterolateral to the testis. The pain is often relieved with elevation of the testis over the symphysis pubis, known as Prehn’s sign. Among sexually active men younger than 35 years old, epididymitis often results from sexually transmitted infections, particularly *Chlamydia trachomatis* and *Neisseria gonorrhoea*. In older men, bacterial epididymitis can result from retrograde transit of bacteria from the vasa, and therefore the most common organisms are urinary pathogens: *Escherichia coli* and *Proteus mirabilis*. Rare infectious causes include brucellosis, tuberculosis, cryptococcus, syphilis and mumps. Epididymitis in prepubertal boys normally has a benign course, and these boys commonly are found to have positive titers for enteroviruses and adenoviruses and *Mycoplasma pneumonia* (M. pneumonia). Rare noninfectious causes include sarcoidosis and amiodarone. Blunt trauma as well as congestion following vasectomy are potential cause of epididymal inflammation [96, 97].

In patients with acute epididymitis, the epididymis is enlarged with increased vascularity. Epididymitis may lead to focally or global enlargement and thickening of the epididymis. Gray scale ultrasound demonstrates a hypoechoic or heterogeneous enlarged epididymis (Fig. 46). The color flow Doppler shows increased vascularity with high-flow, low-resistance pattern (Fig. 47). A reactive hydrocele is often present. Complications of epididymitis include infectious spread to the testis resulting in epididymo-orchitis, testicular abscess formation, and testicular infarction due to obstruction of venous flow which may result in testicular atrophy. Patients with chronic epididymitis often present with persistent pain. In these men, ultrasound examination reveals an enlarged epididymis with increased echogenicity and possible areas of calcifications (Fig. 48).
Fig. 46 Epididymo-orchitis: Gray scale image demonstrates enlarged and heterogeneous epididymis and testis.

Fig. 47 Epididymo-orchitis: Power Doppler ultrasound showing increased vascularity of the epididymis and the testis.

Fig. 48 Chronic epididymitis: Gray scale ultrasound showing increase of echogenicity and micro calcifications seen in the caput epididymis (arrows).
Torsion of the Appendix Epididymis and Testis

Torsion of the appendix testis is important to differentiate from torsion of the spermatic cord (testicular torsion), as this condition is self-limiting and does not threaten testicular viability. Clinically, the cremasteric reflex is preserved and a palpable nodule with bluish discoloration (blue dot) is often detected. Ultrasound shows a hyperechoic mass with central hypoechoic area adjacent to the testis or epididymis. Other associated findings include scrotal wall edema and epididymal enlargement. Blood flow in the peritesticular structures may be increased. Doppler ultrasound is helpful as blood flow within the testis is normal in torsion of the appendix testis.

Benign Epididymal Lesions

An epididymal cyst is a nonpainful cystic structure that, when large, displaces the testis inferiorly. Cysts of the epididymis occur in up to 40% of the men and contain lymphatic fluid. They are typically thin walled and well defined, usually with strong posterior acoustic enhancement and no internal echoes. These men will often have multiple cysts occurring present throughout the length of the epididymis.

Spermatoceles are benign cystic lesions, which contain spermatozoa, lymphocytes, and debris. Spermatoceles form as a result of efferent duct obstruction and usually located in the head of the epididymis. Ultrasonography cannot differentiate between epididymal cysts and spermatocele, but the spermatocele often has septations (Fig. 49).

Adenomatoid tumors are the most common tumors of the paratesticular tissues, accounting 30% of these lesions and up to 77% of the benign tumors arising from the epididymis. They are most commonly identified in men in their 20s to 40s. It has been suggested that they derive from vascular endothelium, the mesonephros, or müllerian epithelium, although most recent reports consider them to be mesothelial.
in origin [98]. They are round, firm, smooth, discrete masses measuring 0.5–5 cm in diameter that are usually asymptomatic and slow growing. Ultrasonography can confirm the extratesticular nature of these masses. Ultrasound of adenomatoid tumors reveals an isoechoic mass with increased vascularity (Fig. 50).

Papillary cystadenoma is a rare benign tumor of epithelial origin believed to arise from the efferent ductules of the head of the epididymis [99]. Papillary cystadenoma presents clinically as a firm, non-tender palpable mass in the epididymis. Two thirds of papillary cystadenomas occur in patients with von Hippel-Lindau (VHL) syndrome and are frequently bilateral [100]. Unilateral presentation is seen very rarely in sporadic cases. Sonographically, small papillary cystadenoma are usually solid and echogenic, but when large may appear vascular and cystic [100].

Leiomyomas are benign epididymal solid tumors. These lesions are most commonly seen in men over the age of 50. The ultrasound appearance is a well-defined solid mass with heterogeneous echotexture located in paratesticular space separate from the epididymis [101].

**Malignant Epididymal Lesions**

Malignant tumors arising from the epididymis are very rare, with the exact incidence of malignant tumors of the epididymis uncertain because of the small number of reported cases. Sarcoma of the epididymis comprises of more than half of the reported malignant neoplasms of the epididymis [102]. Fibrosarcoma of the epididymis has been reported in isolated case reports. Dowling et al. reported fibrosarcoma in a 60-year-old male confined to the epididymis on final pathology [103]. Leiomyosarcoma of the epididymis on ultrasound appears as a large hypoechoic
Clear Cell carcinoma of the Epididymis is very rare and has been reported in individual case reports [104]. Ultrasound findings may include large cysts, necrosis, and invasive margins.

**Scrotal Wall Lesions**

**Scrotal Infectious Findings**

Patients who are diabetic or immunocompromised are more susceptible to infection and scrotal wall cellulitis or abscess. Ultrasonography demonstrates thickening of the subcutaneous tissue and heterogeneity with increased blood flow on color Doppler study. The scrotal wall abscess appears on ultrasound as a well-defined hypoechoic lesion within the scrotal wall and no Doppler flow within the lesion [4].

*Fournier’s gangrene* is a polymicrobial rapidly progressing necrotizing fasciitis commonly involves perineum and genital regions. Fournier’s gangrene is a urologic emergency with mortality up to 50% [105, 106]. Computer tomography remains the imaging modality of choice [107]. However, ultrasonography can provide valuable clues at the time of initial presentation. Ultrasonography shows marked thickening of the scrotal skin with multiple hyper echogenic foci associated with shadowing, which are consistent with the presence of subcutaneous gas, pathognomonic of Fournier’s gangrene [108].
Benign Scrotal Lesions

Epidermoid Cysts of the Scrotal Wall

Epidermoid cysts or epidermal inclusion cysts are the most common cutaneous cysts of the scrotal wall. Epidermoid cysts result from the proliferation of epidermal cells within a circumscribed space of the dermis at the infundibulum of a hair follicle [109]. Epidermoid cysts may become infected and form scrotal wall abscess.

Henoch-Schonlein purpura (HSP) is a systemic vasculitis of unknown origin. It is characterized by a palpable skin rash, abdominal pain, and polyarthralgia. HSP has been reported to have scrotal wall swelling and ecchymosis in up to 38% of cases [110].

Scrotal fibrous pseudotumors are uncommon and are thought to be reactive, benign lesions. The sonographic appearance of the fibrous pseudotumor of the scrotum is variable depending on the contributing fibrous tissue components, presence or absence of calcification and the scrotal structure involved [111]. Pseudotumor of the scrotum is a benign condition and local excision of the mass is the treatment of choice, however, preoperative diagnosis is seldom made due to the nonspecific clinical and sonographic findings [112].

Acute idiopathic scrotal edema (AISE) is a self-limited disease of unknown origin. It presents with unilateral or bilateral scrotal swelling without pain and is associated with unilateral or bilateral inguinal lymphadenopathy. It is thought to be a variant of angioneurotic edema, often associated with eosinophilia. Physical examination findings include scrotal skin swelling and erythema that extends to the inguinal and perianal area. AISE is a diagnosis of exclusion. The characteristic ultrasound findings for AISE, include edema of the scrotal wall with hypervascularity and compressibility with enlargement of the inguinal lymph nodes, and normal testis and epididymis (Fig. 52) [113, 114].
The other noninflammatory causes of scrotal wall edema include congestive heart failure, renal failure, anasarca, hepatic failure, cirrhosis, nephrotic syndrome and poor nutritional status. The scrotal wall appears thickened in chronic venous or lymphatic obstruction secondary to filariasis, radiation and trauma, or surgery. Ultrasound demonstrates scrotal wall thickness with layers of alternating hypo- and hyperechogenicity [115, 116].

**Malignant Scrotal Lesions**

*Squamous cell carcinoma (SCC)* of the scrotum is an uncommon neoplasm. SCC is associated with occupational exposure to chemical or oil industries, radiation, chimney sweepers, human papilloma virus, chronic scar, and immune-related conditions such as psoriasis [117]. The literature concerning scrotal SCC is limited. Ultrasound evaluation of these lesions is not well defined.

**Male Infertility**

In men with impaired fertility, ultrasound can provide diagnostic information and provide documentation prior to and after intervention. Ultrasound, being a noninvasive, real-time imaging modality, is often used in the comprehensive evaluation of men with impaired semen quality to document the presence or absence of pathology, especially when the physical examination is inconclusive or suggestive of intrascrotal pathology.

**Varicocele**

A varicocele is a dilatation of the testicular vein and the pampiniform venous plexus within the spermatic cord. With bilateral varicoceles, the larger varicocele is often on the left side, most likely related to the angle of insertion in to the left renal vein and the length of the left testicular vein [118, 119]. The left testicular vein is 8–10 cm longer than the right, with a proportional increase in pressure. Varicoceles have been found to be a bilateral condition in more than 80% of cases in some series [119, 120]. Congenitally absent or incompetent venous valves have been thought to be the primary cause of varicocele [121–124].

The most common presentation of a varicocele is due to an investigation of male subfertility and infrequently due to scrotal pain. A varicocele is present in about 15% of normally fertile men, yet present in 30 to 40% of men with primary subfertility, and in as many as 80% of men with secondary subfertility [125, 126]. Clinically detectable varicocele has been associated with testicular hypotrophy or atrophy, an abnormal gonadotropin axis, histologic changes in testis, abnormal
spermatogenesis, and infertility [127]. Clinically significant varicoceles are associated with subfertility and impairments in semen quality [125]. After surgical varicocele ligation, semen analysis normally improves in approximately 70% of the patients, with an increase in motility being the most common, but also improvements in sperm concentration, morphology percentage, and total motile sperm concentration [128–130].

Ultrasound characteristics of varicoceles include finding of multiple, low-reflective serpiginous tubular structures most commonly superior and posteriolateral to the testis. Veins larger than 2 mm in diameter are considered to be abnormal [24, 131]. Color flow Doppler is important in documenting the presence and size of a varicocele and should show reversal of flow during the Valsalva maneuver [29]. Color flow will also differentiate an intratesticular varicocele from a dilated rete testis (Fig. 53).

Importantly, a varicocele may also be a sign of pathology in the retroperitoneum causing compression of the gonadal veins leading to varicocele. Imaging of the retroperitoneum is therefore necessary in men with large varicoceles that do not decrease in the supine position. Patients who have sudden onset of a varicocele, whose varicocele persists in the supine position, or have an isolated right varicocele should be further evaluated with imaging of the retroperitoneum to assess for a renal vein thrombus, renal or retroperitoneal mass [29].

**Azoospermia and Oligospermia**

In men with azoospermia, ultrasound as an initial modality of imaging study, can often define the underlying etiology to determine whether there is an obstructive or non-obstructive cause of azoospermia [132]. The ultrasound, as well as physical examination, is useful in patients with congenital bilateral absence of the vas deferens (CBAVD) to assess for presence of the vas deferens as well as other mesonephric developmental structures, and associated conditions such as congenital renal agenesis [133, 134].

![Fig. 53](image-url) Bilateral varicocele. **a** Doppler color flow study dilated veins on the superior aspect of the testis. **b** Doppler color flow study showing bilateral varicoceles.
Ultrasound will also reveal testicular atrophy. Atrophy may be related to age, trauma, torsion, infection, or inflammation, or may occur secondary to hypothyroidism, drug therapy, or chronic disease. The appearance on ultrasound is variable, and while related to the underlying cause, is usually characterized by decreased echogenicity with a normal appearing epididymis.

**Newer Ultrasound Technology to Assess Fertility**

Recent literature supports the use of spectral Doppler ultrasound in providing information about intratesticular blood flow and function [45, 130, 135, 136] (Fig. 54). Biagiotti et al. provided data suggesting that RI and PSV (Peak Systolic Velocity) of intratesticular vessels were better predictors of dyspermia than FSH and testicular volume [137]. Pinggera et al. [135] examined semen quality and the RI of intratesticular arteries in 160 men. In their study, the 80 men with a normal semen analysis had a RI of 0.54±0.05 and the 80 men with impaired semen analysis had a statistically higher RI of 0.68±0.06. This study concluded that an RI above the threshold of 0.60 was indicative of abnormal semen quality. This has also been confirmed by our group for subfertile men [138].

Additionally, sonoelastography has been studied in the infertile male (Fig. 55). Schurlich et al. reported that elastography could be used for structural analysis of the testicular tissue [139]. In another study, Li et al. used a five-point scoring system to describe the elastographic findings in azoospermic men. Patients with obstructive azospermia (OA) and healthy controls with a normal semen analysis
predominately had a high-strain score of 83% and 85%, respectively. Conversely, 82% of men with non-obstructive azoospermia (NOA) had a score of 3 or higher, and therefore may assist in the diagnosis NOA [140]. The initial data with elastography is intriguing and in the future this new modality may yield additional information on testicular function.

Intraoperative Testicular Ultrasound

Ultrasonography may be used to enhance the localization of intratesticular abnormalities at the time of surgery. Incidental non-palpable lesions may be found in men undergoing an ultrasound of the scrotum for other indications. An incidence of 6% of men who presented with male factor infertility were found to have an intratesticular mass on ultrasound evaluation [141]. Our proposed algorithm for evaluation of small testicular lesions is described earlier in the chapter (Fig. 25) and makes use of sonoelastography in the decision process. Testis sparing surgery removes suspicious lesions while maintaining testicular tissue for spermatogenesis and androgen production. Testes preservation is especially indicated in men with solitary testis, bilateral testes lesions, or with small incidental lesions.

Many of the lesions that are removed with the testis sparing approach are non-palpable and were diagnosed solely on ultrasound findings. In order to identify these lesion in the operating room, ultrasound is again used effectively isolate the lesion for testis-sparing surgery. Hopps and Golstein described using intraoperative ultrasound prior to opening the tunica albuginea for needle localization of the mass removal of incidental testicular lesions found in infertile men [141]. De Stefani et al. describe use of intraoperative ultrasound in 20 cases of testis-sparing excision of lesion less than 2 cm in size. They found only two of the lesions to be malignant and all patients were disease-free without hypogonadism at mean follow up of 1

Fig. 55  Real time elastography (RTE) images demonstrates elasticity in men with a normal semen analysis (a) and one in which the patient was azoospermic (b)
year [142]. Use of ultrasound at the time of testis-sparing surgery is extremely helpful tool to localize small lesions for testis sparing surgery.

**Conclusions**

Ultrasonography is the gold-standard evaluation for abnormalities of the scrotum. The use of ultrasound enhances findings found on physical examination and can determine the diagnosis in many pathologic conditions of the scrotum. New technological advances allow for improved visualization and novel diagnostic techniques, such as elastography. Overall, the ability to interpret ultrasonographic findings is a key component for any physician caring for patients with pathology of the scrotum, testis, epididymis or infertility.

**References**