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Learning objectives

To review the different scrotal disease entities in the pediatric population, focusing on acute scrotum.

To describe the ultrasound imaging findings of disorders that may produce acute painful scrotum.
Background

Acute scrotum is defined as an acute painful swelling of the scrotum or its contents, and is accompanied by local signs and general symptoms. Children with acute scrotal pain account for approximately 0.5% of total emergency department visits [7].

The differential diagnosis of an acute scrotum includes spermatic cord torsion, torsion of testicular appendages, epididymo-orchitis, trauma, irreducible inguinal hernia and tumor. Among these conditions, the spermatic cord torsion is of major concern because it requires immediate surgical intervention to avoid testicular loss.

Anatomy

The testicular size in the children changes in agreement to the age. The normal adult testis measures approximately 5x3x2 cm and is of homogeneous echotexture. Each testis is enveloped by tunica albuginea, a fibrous capsule that is seen as a hyperechoic line. A fold of tunica albuginea projects into the testis and forms mediastinum testis, which is seen as a hyperechoic linear band (Fig. 1). The tunica albuginea is covered by tunica vaginalis, which is a closed sac of peritoneum that consists of 2 layers: the visceral layer, which adheres to the testis, and the parietal layer, which lines the inside of the scrotal wall. A potential space between the two layers of tunica vaginalis normally contains a few milliliters of fluid. The testis is composed of multiple seminiferous tubules that coalesce toward the mediastinum to form a network of channels called the rete testis. These channels pass through the mediastinum and tunica albuginea toward the epididymal head. The epididymis lies along the posterolateral aspect of the testis and is of similar echogenicity to the adjacent testis. It consists of head, body, and tail ducts, which then continue as the vas deferens in the spermatic cord. The spermatic cord contains vas deferens, testicular vessels, pampiniform venous plexus, and nerves.

The right and left testicular arteries-branches of the abdominal aorta-provide the vascular supply to the testis. A transmediastinal artery branch of the testicular artery occurs in approximately one half of normal testes. It courses through the mediastinum to supply the capsular arteries and is usually accompanied by a large vein. The deferential artery, a branch of the superior vesicle artery, and the cremasteric artery, a branch of the inferior epigastric artery, supply the epididymis, vas deferens, and peritesticular tissue. Branches of the pudendal artery supply the scrotal wall. Venous drainage is via the pampiniform plexos (Fig. 2).

Four testicular appendages have been described: the appendix testis, the appendix epididymis, the vas aberrans, and the paradidymis. They are remnants of embryologic ducts. The appendix testis and the appendix epididymis are usually seen on scrotal
sonography. The appendix testis is attached to the upper pole of the testis in the groove between the testis and the epididymis. The appendix epididymis, another appendage is attached to the head of the epididymis and is encountered unilaterally in 34% and bilaterally in 12% of postmortem series [1]. Presence of minimal fluid facilitates their visualization on sonography (Fig. 3).

**Imaging Technique**

Radiologic evaluation of scrotal pathology is primarily accomplished by US (ultrasound) examination using a high-frequency (5-10 MHz) linear transducer. Patients are usually examined in the supine position and the testes are imaged in the sagittal and transverse planes (Fig. 4). A midline transverse image, including a portion of each testis, is essential in the comparison of echotexture and vascular flow.

When there is a palpable abnormality, the patient places a finger over the lesion and targeted ultrasound evaluation of that area is performed. It is important to obtain one image that captures both testicles for comparison of echotexture and vascularity. In patients being evaluated for an acute scrotum, the asymptomatic side should be scanned initially to set the gray scale and color Doppler gains to allow comparison with the affected side.

On US, the testes are normally homogenous with a granular echotexture. The mediastinum testis is seen as a linear area of increased echogenicity in the posterior part of the testis. The epididymis is best evaluated in the sagittal plane and is isoechoic to hypechoic in relation to the testis.

Color Doppler and pulsed color Doppler images are obtained to assess the vascularity of normal structures and for evaluation of focal masses. Color Doppler images need to be optimized to detect slow flow by using the lowest velocity scale and the lowest wall filter. Color gain setting is maximized for optimal sensitivity while limiting the excessive color noise. Because motion can mimic presence of blood flow on color Doppler images, imaging with pulsed color Doppler technique shows the presence of true blood flow and eliminates this potential pitfall. Evaluating the blood flow with power Doppler ultrasound is valuable when assessing perfusion in an acute setting such as torsion, scrotal trauma, and infection.

Additional techniques, such as the Valsalva's maneuver or upright positioning, can be used as needed for venous evaluation.

**Etiology**
Inflammatory causes

Epididymitis and orchitis

Acute epididymo-orchitis or epididymitis is the most common cause of acute scrotum in adolescent boys and adults. Infection most commonly affects the epididymis. Orchitis develops in 20% to 40% of cases of epididymo-orchitis by direct spread of infection [1]. Isolated orchitis is rare and is most commonly caused by a virus. Sexually transmitted Chlamydia trachomatis and Neisseria gonorrhea are common pathogens in men younger than 35 years. In prepubertal boys and men over 35 years of age, the disease is most frequently caused by E coli and Proteus mirabilis. Prehn described the clinical differentiation of scrotal pain associated with epididymitis and acute torsion. Pain associated with acute epididymo-orchitis is usually relieved when the testicles are elevated over the symphysis pubis; however, the scrotal pain associated with testicular torsion is not lessened with this maneuver (Prehn’s sign).

Ultrasonographic findings in epididymitis include hypoechoic enlargement of the head and body with increased blood flow on Doppler images. The entire epididymis or only focal areas may be involved. Scrotal wall thickening and hydrocele may also be present. When concurrent orchitis is present, the affected portions of the testis are hypoechoic and hypervascular (Fig. 5). Orchitis is most commonly diffuse, but may involve only a focal area.

Complications of acute epididymitis include chronic pain, abscess, gangrene, infertility, atrophy, and pyocele. Another complication of epididymitis is development of testicular ischemia, which occurs when epididymal edema compresses the testicular vessels, most commonly the draining veins. Absent or decreased testicular blood flow can also be present in testicular torsion; however, in most cases, with torsion there is no hypervascularity of the epididymis, which is more typically seen with infection. The difference in epididymal vascularity therefore can help differentiate these two entities.

Differential diagnosis includes scrotal trauma, which may also present with epididymal enlargement and hyperemia.

Other Causes of Scrotal Swelling

Acute idiopathic scrotal edema is a rare disease that can cause acute scrotal swelling and erythema in boys and is usually painless. Its exact cause is unclear, but it may have an allergic origin. Sonography and color Doppler show diffuse scrotal edema and hyperemia, with normal testicular flow (Fig. 6). Acute idiopathic scrotal edema is self-limited, and treatment is conservative.
A hydrocele is a large collection of serous fluid in the potential space between the visceral and parietal layers of the tunica vaginalis and is the most common cause of painless scrotal swelling. Hydroceles are seen secondary to an underlying pathologic process, are a congenital anomaly, or are idiopathic. Secondary causes include trauma, infection, torsion, or tumor. On US, a hydrocele is seen as a collection of anechoic fluid surrounding the anterolateral part of the testis, with good through transmission; internal echoes sometimes are seen, related to protein or cholesterol within the hydrocele (Fig. 7).

**Vascular**

*Testicular Torsion*

Testicular torsion can occur at any age; however, it is most frequently encountered in adolescent boys. In testicular torsion, venous obstruction occurs first, followed by obstruction of arterial flow and ultimately by testicular ischemia. The testicular salvage rate depends on the degree of torsion and the duration of ischemia. A nearly 100% salvage rate exists within the first 6 hours after the onset of symptoms, a 70% rate within 6 to 12 hours, and a 20% rate within 12 to 24 hours [3].

Patients with acute torsion present after a sudden onset of pain followed by nausea, vomiting, and a low-grade fever. Physical examination reveals a swollen, tender, and inflamed hemiscrotum. The cremasteric reflex is usually absent, and the pain cannot be relieved by elevation of the scrotum.

Torsion is extravaginal or intravaginal. Extravaginal testicular torsion occurs exclusively in newborns. Intravaginal torsion is caused by a long and narrow mesentery or a bell-clapper deformity, bilateral in most cases, in which the tunica vaginalis completely encircles the epididymis, distal spermatic cord, and testis rather than attaching to the posterolateral aspect of the testis. The deformity leaves the testis free to swing and rotate within the tunica vaginalis much like a clapper inside a bell.

Torsion results in edema of the testis with decreased or absent blood flow. On gray-scale images, the testis is enlarged, heterogeneous, and hypoechoic. Later, as the hemorrhagic infarction occurs, hyperechoic areas in the affected testis can be seen. Color and power Doppler images have an advantage compared with the gray-scale images because of early detection of the absence of flow in the affected testis. Depending on the duration and the degree of torsion, the amount of perfusion abnormality varies, initially affecting venous and then arterial flow. No detectable flow is eventually present on either color or power Doppler images. After 6 hours from the onset of torsion, reactive
hydrocele and skin thickening can be seen. After 24 hours, peritesticular tissues can become hyperaemic because of reactive vascular response (Fig. 8).

The epididymis can become enlarged and, rarely, also hyperemic. The contralateral testis should always be imaged for comparison. When spontaneous detorsion occurs, increased blood flow may be detected caused by reactive hyperemia. This finding may represent a diagnostic challenge because epididymo-orchitis has similar imaging findings.

False-negative Doppler evaluations can occur in the setting of partial torsion, spontaneous detorsion, or incorrect measurement of arterial waveforms along the periphery of the testicle. In these settings, repeat ultrasound should be considered, and attention should be made to the centripetal testicular arteries. False-positive Doppler evaluation can be seen in infants and young boys who often have normally reduced intratesticular blood flow, but this is currently less problematic with the availability of modern more-sensitive equipment. Moreover, comparison should always be made to the unaffected side for symmetry.

**Testicular Appendageal Torsion**

Testicular appendageal torsion is a common cause of acute scrotum in prepubertal boys (between 6 and 12 years). The appendages are normal remnants of embryonic tissue and are usually located at the superior testicle or epididymal head. Testicular appendages are more prevalent than epididymal appendages; however, the distinction is often difficult to make and is not important clinically.

On physical examination, a small firm nodule is usually palpable in the superior aspect of the testes and may exhibit the classic blue dot sign. The cremasteric reflex still can be elicited, although it is usually absent in testicular torsion.

Sonography may show an oval avascular mass (torsed appendage) with variable echogenicity located between the testicle and epididymis (Fig. 9). A reactive hydrocele and scrotal wall thickening are usually present. Doppler interrogation is of limited value because internal flow is not normally present in the normal appendage. Increased peripheral flow may be present in cases of torsion. The role of US is to exclude acute testicular torsion and acute epididymo-orchitis. Management of torsion of the appendix is conservative (pain management) with the pain resolving within a few days.

**Varicocele**
Venous drainage of the scrotum is via the pampiniform plexus of draining veins; it is formed around the upper half of the epididymis in a variable fashion and continues as the testicular vein through the deep inguinal ring. The right testicular vein empties into the inferior vena cava and the left testicular vein into the left renal vein. Abnormal dilatation of the veins of the pampiniform plexus results in varicocele, which is usually caused by incompetent valves in the internal spermatic vein. This results in impaired drainage of blood into the spermatic cord veins when the patient assumes an upright position or during a Valsalva's maneuver.

The veins of the pampiniform plexus normally range from 0.5 to 1.5 mm in diameter, with the main draining vein as large as 2 mm in diameter. Varicoceles are more common on the left side for the following reasons: the left testicular vein is longer, the left testicular vein enters the left renal vein at a right angle, in some men, the left testicular artery arches over the left renal vein, thereby compressing it, the descending colon distended with feces may compress the left testicular vein, and a "nutcracker" effect of compression of the left renal vein may occur between the superior mesenteric artery and the abdominal aorta.

Varicoceles can be diagnosed by physical examination, but sensitivity is only 70%, compared with ultrasonography which has sensitivity of 97% [2]. Scanning the patient in an upright position may improve detection.

On ultrasonographs, varicoceles appear as serpiginous anechoic tubular structures with diameters larger than 2.5 mm (Fig. 10). Doppler images may show stasis, antegrade flow, or retrograde flow. Internal echoes are occasionally caused by sluggish flow. During Valsalva maneuver, varicoceles should increase in diameter and show reversal of blood flow. Isolated right varicoceles are rare and should prompt evaluation of retroperitoneum to exclude an underlying mass. Because varicoceles negatively affect spermiogenesis, removal of varicoceles often significantly improves the quality of sperm.

**Trauma**

Traumatic testicular injuries are relatively uncommon because the testes are protected by mobility within the scrotum, laxity of the overlying skin, and coverage by the tunica albuginea. Scrotal trauma in boys is most commonly due to sports-related activity (> 50%) followed by motor vehicle accidents (17%) [8], and is frequently associated with severe injuries to the scrotal contents including hematoma, fracture or rupture of the testicle, and peritesticular structures. Ultrasonography is valuable in diagnosing conditions, such as testicular rupture, that might require immediate surgery. Discontinuity of tunica albuginea, contour abnormality, and heterogeneous echotexture are signs of testicular rupture. Abnormal contour of the testis is present because of extruded intratesticular parenchyma and is considered a secondary sign of tunica albuginea disruption. Heterogeneous intratesticular lesions can be caused by rupture, although they can also be caused by hemorrhage or infarction. Isolated presence of a heterogeneous testis therefore should not be considered diagnostic of rupture, unless accompanied by tunica albuginea...
disruption or contour deformity. Color Doppler evaluation of the injured testis should always be performed because tunica albuginea injuries are commonly associated with focal or diffuse loss of vascularity. Testicular fracture involves a break or discontinuity within the normal testicular parenchyma. However, the tunica albuginea remains intact, and thus the testicle maintains its normal shape.

Hematocele is a collection of blood between the layers of tunica vaginalis. It can occur in an isolated form or can be associated with testicular rupture. Depending on the chronicity of the hematocele, it can present as hyperechoic collection in acute phase or can appear as anechoic fluid with septations in a more chronic setting. Hematomas can occur in testis, epididymis, and scrotal wall. Hematomas are round, avascular lesions on Doppler ultrasound and their appearance varies with age too. In a chronic setting, hematoma may mimic a neoplasm.

Traumatic epididymitis occurs as sequela of contusion. Diffuse or focal enlargement of the epididymis is present with increase in vascularity.

On imaging, this condition may mimic epididymitis; however, history is crucial in differentiating these two conditions (Fig. 11).

Miscellaneous Conditions

Inguinal Hernia

Inguinal hernias are either indirect or direct; the former is lateral to the inferior epigastric artery, whereas the latter is located medial to it. An inguinal hernia is usually a clinical diagnosis; however, occasionally, it may present as a hard, irreducible mass that cannot be differentiated from a scrotal mass and may require imaging to differentiate. Indirect inguinal hernias pass through the internal inguinal ring and inguinal canal and enter the scrotum. They are more common in children and are associated with a patent processus vaginalis. The US characteristics of an inguinal hernia depend on the herniated visceral structure. Hernias involving omentum are hyperechoic, corresponding to omental fat (Fig. 12). Hernias containing bowel are fluid-filled or airfilled and have multiple bright echoes; the presence of air or gas results in shadowing. A strangulated hernia is seen as an akinetic, dilated loop of bowel within the hernial sac. Hyperemia of the scrotal soft tissue and bowel wall suggests strangulation (Fig. 13).

Intratesticular tumors
Testicular tumors in boys are rare, accounting for only 1-2% of all pediatric solid neoplasms [9]. Most (> 95%) intratesticular lesions are malignant and typically present as a painless mass, with treatment usually involving orchiectomy.

They are classified as germ cell tumors or non-germ cell tumors. Germ cell tumors are further classified as seminomas and nonseminomatous tumors. Seminomas are the most common testicular tumors among men, whereas nonseminomatous germ cell tumors are the most common testicular tumors among boys and include yolk sac tumors (also known as endodermal sinus tumors), teratomas, embryonal carcinomas, and choriocarcinomas. Non-germ cell tumors include Sertoli and Leydig cell tumors and are rare in boys.

Sometimes, these tumors can present with acute pain (Fig. 14). This presentation is usually secondary to epididymo-orchitis or hemorrhage within the tumor.

Seminoma is the most common tumor to masquerade as acute orchitis. It is presumed to infiltrate and obstruct the seminiferous tubules, and it results in orchitis. Leukemia and lymphoma can have a similar presentation. Gray scale findings of intratesticular tumors are nonspecific and usually hypoechoic in appearance. Hyperemia also can be seen in testicular tumors. Acute epididymo-orchitis and intratesticular tumors larger than 1.5 cm may have increased blood flow on color Doppler examination. Hypervascularity seen with tumors is sonographically indistinguishable from inflammatory hypervascularity. There are no reliable sonographic criteria to distinguish malignant from focal benign intratesticular lesions, such as infarction, hemorrhage, infection, or non-germ-cell tumor. The presence of epididymal involvement strongly suggests a nonneoplastic process.

**Tumor Mimickers**

Benign lesions include tunica albuginea cyst or simple intratesticular cyst. Tunica albuginea cysts occur at the periphery of the testis, originate from tunica albuginea, and commonly present as a palpable lump. On ultrasonographs, they have appearance of simple cysts and are typically smaller than 5 mm. Simple intratesticular cysts are usually idiopathic, but may be posttraumatic or postinflammatory. They range from 2 mm to 2 cm and can be single or multiple. Unlike tunica albuginea cysts, simple cysts are usually not palpable even when large. Ultrasound examination reveals round anechoic lesions with increased through-transmission (Figure 15). It is important to document absence of a perceptible wall, which can be seen in cystic teratomas.
Fig. 1: Longitudinal view of a normal testis demonstrates the mediastinum testis (arrow) as an echogenic band.

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Fig. 2: Anterior View of scrotum and contents.

Fig. 3: Appendix testis directly attached to the testis. Presence of fluid facilitates their visualization on US.

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**Fig. 4:** Ultrasound appearance of a normal testis, in transverse and longitudinal planes, in a 17-year-old boy.

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**Fig. 5:** Epididymitis. A 11-year-old boy with scrotal pain. Gray scale ultrasound images show enlarged, heterogeneous epididymal head (A) that has increased vascularity on color Doppler images (B, C). A normal testicular blood flow (D) and a testicular appendix (narrow) were observed. Hydrocele and scrotal wall thickening are present surrounding the testis.

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**Fig. 6:** Idiopathic acute scrotal edema. A 5-year-old boy with intense pain and scrotal edema. Gray scale US (A, B) images show only thickening of the scrotal wall. Color Doppler images (C, D) show hyperemia of the scrotal wall. This patient had both testicles in the canal inguinal (undescended).

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Fig. 7: Hydrocele. A 4-year-old boy with pain and scrotal enlargement. Gray scale images show a collection of anechoic fluid surrounding the testis, without connection to the abdomen (narrow shows the spermatic cord).

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Fig. 8: Surgically confirmed testicular torsion. A 14-year-old boy with left scrotal pain for more than 24 hours of evolution. Gray scale images show an enlarged heterogeneous testis, ipsilateral hydrocele and skin thickening (A). The epididymis is enlarged too (B). There was no blood flow in the testis or epididymis, with peripheral hyperemia on color Doppler examination (C, D).

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Fig. 9: Appendiceal torsion. A 9-year-old boy with scrotal pain. Longitudinal views of the testis show a circular mass predominantly hypoechoic between the testis and the epididymis.

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Fig. 10: Varicocele. A 14-year-old with increasing left scrotal pain since last night. Gray-scale ultrasound images show dilated vessels (>2.5 mm) within pampiniform plexus. Internal echoes are present within the lumen caused by sluggish flow (A). During Valsalva maneuver, the diameter of those vessels increased (4.8 mm).

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Fig. 11: Trauma. A 10-year-old with testicular trauma. Gray-scale US images (A, B, C) show an enlarged and heterogeneous epididymis with an increased vascularity in the testis, epididymis and scrotal wall on color Doppler images (D, E) consistent with epididymo-orchitis. Hydrocele is present.

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**Fig. 12:** Inguinal Hernia. A 11-year-old boy with scrotal pain of 4 days. Area of high echogenicity with vascularization, which correspond to omental fat herniated through the inguinal canal. Hydrocele associated.

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**Fig. 13:** Inguinal hernia. Infant with 4 months who presented edema and scrotal pain. Gray-scale images show an akinetic, dilated loop of bowel into the hernial sac consistent with strangulated hernia.

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**Fig. 14:** Testicular tumor. A 2-year-old boy with pain and testicular enlargement. Gray-scale images show a heterogeneous solid mass replacing the entire testis (A, B, C) with marked internal vascularity on color doppler images (D, E). Surgery revealed Yolk sac tumor.

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**Fig. 15:** Intratesticular cyst. A 3-year-old boy with scrotal pain. US images show a round anechoic lesion with increased through-transmission and absence of a wall.
Imaging findings OR Procedure details

Scrotal sonography is performed with the patient lying in a supine position and the scrotum supported by a towel placed between the thighs. Optimal results are obtained with 7- to 14-MHz high-frequency linear-array transducers.

The testes are studied in two planes (ie, along the long and transverse axes). The size and echogenicity of each testicle and the epididymis are compared with those on the opposite side. In patients being evaluated for an acute scrotum, the asymptomatic side should be scanned initially to set the gray scale and color Doppler gains to allow comparison with the affected side. Color Doppler and pulsed Doppler are optimized to display low-flow velocities, and blood flow in the testis and surrounding scrotal structures is documented, including the spectral Doppler recording of the intratesticular arterial flow in both testes. Transverse images with portions of each testis on the same image should be recorded in gray scale and color Doppler. Power Doppler also may be used to visualize intratesticular flow in patients with an acute scrotum. Additional techniques, such as the Valsalva's maneuver or upright positioning, can be used as needed for venous evaluation.
Conclusion

Many scrotal and testicular diseases can affect the pediatric population, ranging from acute disorders such as testicular torsion and traumatic injuries to other less common disorders such as malignancies. US is the first imaging performed in patients with acute scrotum. Knowledge of the normal and pathologic sonographic appearance of the scrotum and proper sonographic technique is essential for accurate diagnosis of acute scrotum.
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