US evaluation of acute scrotum in children: what a resident needs to know

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Learning objectives

The aim of this study is to describe the technique as well as the clinical, Grey-scale and colour Doppler Ultrasound (US) findings and furthermore to provide tips for a state of the art examination of scrotal emergencies in children. Additional it is important to be familiar with the US features of common and rare acute scrotal conditions in paediatric population. Grey-scale and colour Doppler US demonstrate high accuracy in the aetiological diagnosis of an acute scrotum and can differentiate between diseases that require immediate surgical intervention and those that can be treated conservatively. It is of great value to evaluate the key imaging findings for differential diagnosis in boys presented with acute scrotum.
Background

Acute scrotum is a pediatric emergency manifested with scrotal pain, swelling, and redness with sudden onset. Causes are illustrated in table 1.

**Table 1: Causes of acute scrotum (by incidence)**

<table>
<thead>
<tr>
<th>Causes</th>
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<tbody>
<tr>
<td>Epididymitis and epididymoorchitis</td>
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<td>Torsion of the testicular appendages</td>
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<td>Testicular torsion</td>
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<tr>
<td>- Intravaginal torsion (most common)</td>
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<td>- Extravaginal torsion (usualy in neonatal period due to deficient fixation of the spermatic cord)</td>
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<td>Testicular trauma</td>
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<td>- Testicular Rupture</td>
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<td>- Testicular Fracture</td>
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<tr>
<td>- Testicular Hematoma</td>
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<tr>
<td>Other (inguinoscrotal hernia, Henoch - Schönlein purpura, systemic diseases with scrotal involvement etc)</td>
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A child presenting with an acute scrotum is clinically one of the most difficult situations for paediatricians, paediatric surgeons and paediatric radiologists. Testicular torsion is the most important diagnosis of all diseases that cause acute scrotum, and delayed diagnosis may result in the loss of a testis. At the opposite, a proper clinical and/or imaging evaluation may result to avoid an unnecessary surgery in children which their disease can be treated conservatively. The determination of the best treatment and the possibility of other diseases that lead to an acute scrotum should be evaluated. Pertinent history and physical examination are often sufficient to make a diagnosis in the majority of cases and US is the most frequently used method to evaluate the acute scrotum in children (when it is necessary).

**Normal scrotum (anatomy, grey-scale and colour Doppler US).**

Since scrotal involvement is usually unilateral US study is better to start on the asymptomatic side to avoid further irritation and provide basis for comparison so it is fundamental to be familiar with the normal US anatomy of scrotum and especially with the normal US anatomy of the spermatic cord (to detect its torsion) (Fig. 1) as well as with normal testis vascularity (Fig. 2).
The scrotum (a saccular structure) divided by the median septum (raphe) into two compartments (Fig. 3). Each half contains a testicle, epididymis, vas deferens and the scrotal part of spermatic cord (Fig.4). The size of the testicle varies with age, increasing in size from birth to puberty and then decreasing later in life (adult testicle size: approximately 2 to 3 cm in width and 3 to 5 cm in length). The testes are surrounded by the tunica albuginea, which is covered by the tunica vaginalis. The tunica vaginalis has two layers: an outer layer (parietal) and an inner layer (visceral). These layers are separated by a small amount of fluid. In neonates and infants, the testis is visualized at US as an ovoid structure of low to medium echogenicity surrounded by an echogenic line, which corresponds to the tunica albuginea. Testicular echogenicity increases (progressively) from 8 years of age to puberty (development of germ cell elements). The posterior surface of the tunica albuginea projects into the testicle to form the mediastinum, which is seen as a thin echogenic line crossing the testis (Fig. 4). The three parts of the epididymis (head: on the top of the testis, body: behind the testis, tail: at the inferior pole of the testis) are better visualized on longitudinal views (Fig. 5). Also, there are five testicular appendages, which are the remnants of the mesonephric and paramesonephric ducts. From these appendages, three can be identified at US:

The appendix testis (hydatid of Morgagni), an oval structure in the groove between the testis and epididymis (isoechoic to the testis) (Fig. 6).

The appendix epididymis (Fig. 7, 8) at the head of the epididymis (often pedunculated, same size and echogenicity as the appendix testis).

The appendix of the epididymal tail (similar to the others but less commonly identified).

It is of note that the appendages of the testis are best seen when combined with hydrocele.

The spermatic cord appears as a smooth linear structure limited by a highly echogenic band (longitudinal scans) (Fig. 9) and as an ovoid structure with an echogenic margin (transverse scans). The spermatic cord contains testicular, deferential and cremasteric arteries and the pampiniform plexus of veins. Recognition of intratesticular, epididymal, and spermatic cord vessels depends on the Doppler sensitivity of the system, transducer frequency and expertise of the Radiologist.
Fig. 1: Image of the normal testicle [3yo] with the epididymal head (star) on the left, body of testicle with an echogenic line crossing it, which represent the mediastinum (arrow) and epididymal tail on the right (arrowhead).

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Fig. 2: Normal intratesticular vascular anatomy [5yo]. Transverse view of testis shows a capsular artery (at the periphery) and multiple centripetal arteries entering the testis as well as several small recurrent rami with blood flow in opposite directions. Testicular veins are accompanying the transtesticular arteries. All vessels are oriented in a radial pattern toward the mediastinum and the transtesticular vessels penetrate the mediastinum.

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Fig. 3: Normal anatomy [3yo]. Scrotum evaluation (two compartments) for testis estimation and comparison. Note the hydrocele at the left hemiscrotum.

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**Fig. 4:** Normal anatomy [6yo]. Scrotal part of spermatic cord (arrow). m: mediastinum (tunica albuginea projects into the testicle to form the mediastinum, a thin echogenic line crossing the testis), e: epididymis, t: testis.

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**Fig. 5:** Normal anatomy [2yo]. Head of epididymis (e) on the top of the testis, is better visualized on longitudinal views.

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Findings and procedure details

Scrotal US presupposes high-frequency linear-array transducers, supine position of the patient, scrotum supporting by towel placed between the thighs and a large amount of warm gel (to minimize pressure on the scrotal skin). Scanning each hemiscrotum in transverse and longitudinal planes is essential. Both testes and epididymides should have similar volume, texture, echogenicity and shape on gray-scale US and similar blood flow on colour Doppler studies. Any minor change should raise suspicion of pathology. The spermatic cord evaluation in the inguinal canal, and its course up to the posterosuperior border of the testis is an important part of the examination, particularly in patients with varicocele and suspected testicular torsion.

Epididymitis - Epididymoorchitis (Fig. 10, 11)

Epididymitis (epididymo-orchitis) is mainly of infectious origin and is a common cause of acute scrotum (up to 21% of cases). Patients typically present with gradual onset of scrotal pain with fever (clinical spectrum ranges from mild tenderness to severe febrile process). The scrotum may be affected by haematogenous epididymoorchitis, especially in cases of sepsis caused by Escherichia coli or Neisseria meningitides. In cases with mumps and subclinical involvement of the parotid, epididymoorchitis may mimic torsion of the testis. In younger children, epididymitis may be associated with congenital anomalies of the urogenital tract (urethral abnormalities, ectopic ureter, ectopic vas deferens, Müllerian duct cyst, neurogenic bladder, bladder extrophy, vesicoureteral reflux etc), so the US examination of these patients should comprise regions beyond the scrotum (bladder, kidneys, perineal region).

US may show an enlarged hypoechoic epididymis, scrotal oedema, and reactive hydroceles. Colour Doppler will show hyperemia around the epididymis. Concurrent orchitis may occur in 20-40% of cases. Treatment commonly involves antibiotics.

Testicular Appendages Torsion (Fig. 12)

The testicular appendages are remnants of the embryonic mesonephric and paramesonephric ducts and consist of vascularized connective tissue. The appendages are sessile structures, which predisposes them to torsion and the frequency of the ultrasonographic identification of these anatomic structures is around 89%. The appendix testis (also called hydatid of Morgagni) is most often affected, and is the major and most common cause of an acute scrotum in pediatric patients. The torsion of hydatid of Morgagni (appendix testis) accounts for 95% of cases of appendages torsion and occurs mainly in pre-pubertal boys (7-14 yo) while is more frequent on the left side. Affected children typically present with gradual and/or sudden intense pain, usually localized in the upper pole of the testis. In approximately one-third of patients, a nodule of the
upper scrotum with bluish skin discoloration ("blue dot" sign) is palpated. This latter is a pathognomonic feature, and US examination is not necessarily required for the diagnosis of this entity when it is present. Additional clinical and/or US findings may include scrotal oedema and reactive hydrocele.

US may show an extra-testicular round mass (which represent torsed appendage) with variable echogenicity (mostly high or mixed) depending on the evolution time, located between the testicle and epididymis.

Colour Doppler US will demonstrate the inflammatory reaction of the torsed apendix with increased vascularity in the adjacent structures. In most instances distinction between torsion of the hydatid of Morgani and epididymitis could not be made.

**Testicular Torsion**

Testicular torsion is actually testicular ischemia due to cutting off of the testicle’s blood supply after of spermatic cord twisting (Fig.13) and thus the term testicular torsion is equal to the definition twisting of the spermatic cord. The entity occurs in about 1 in 4,000 to 1 per 25,000 males per year before 25 years of age. Testicular torsion is the most important diagnosis to rule out as it is a surgical emergency. Because of the disruption of testicular blood supply in torsion, time is a crucial factor and the salvage rate can be up to 80-100% with surgery within 6 hours, and less than 20% with surgery after 12 hours. Apart from the duration of the torsion, the extent of testicular ischemia depends on the degree of twisting (180°-720°). Twisting of the spermatic cord, implies first venous and later arterial flow obstruction.

Testicular torsion usually presents with sudden, severe testicular pain (in groin and lower abdomen) and tenderness. This diffuse scrotal pain, is often associated with nausea and vomiting. Physical findings can include high-riding testicle and absent or decreased cremasteric reflex. On the basis of the surgical findings, two types of testicular torsion are recognized: extravaginal and intravaginal. Extravaginal torsion is seen mainly in newborns and occurs prenatally in most cases. The testis is usually necrotic at birth and the hemiscrotum is swollen and discolored.

Differentiation between testicular torsion and epididymo-orchitis is a clinical challenge, since scrotal pain, swelling, and redness or tenderness are clinical symptoms common to these two entities (useful differential diagnosis point: pain in testicular torsion has a sudden onset, in orchitis it is more gradual).

US evaluation is the imaging test of choice in the emergency department to diagnose torsion when the clinical diagnosis is not clear. Comparison of the painful testis to the asymptomatic one is the key and meticulous comparison of both testes using sectional views is mandatory.
The torsed testicle may be enlarged and appear hypoechoic, but it can appear relatively normal in the first few hours. Other findings may include visualization of a torsed spermatic cord (US evaluation of the spermatic cord is an essential part of the examination), scrotal oedema, and reactive hydroceles. Immediately after torsion (up to 3 h) testis volume and echogenicity may be normal. Later, increased testicular volume and hypoechogenicity or heterogeneous echogenicity or both, may be detected.

The point of cord twisting can be identified at the external inguinal orifice. The intrascrotal portion of the oedematous cord appears as a round, ovoid, or curled echogenic extratesticular mass, with the epididymal head wrapped around it. The identification of a twisted cord with intratesticular blood flow is a sign that the testis is viable and may be salvaged after reduction and orchidopexy (Fig. 14).

Colour Doppler usually shows reduced or absent blood flow to the testicle (a highly specific finding). A definitive diagnosis of complete testicular torsion is made when blood flow is visualized on the normal side but is absent on the affected side. False-negative Doppler findings can occur in partial torsion, spontaneous detorsion or incorrect measurement of arterial waveforms along the periphery of the testicle. In these settings, repeat US evaluation should be considered. False-positive Doppler evaluation can be seen in infants and young boys (often have normally reduced intratesticular blood flow) but this is currently less problematic with the availability of modern more sensitive equipment.

Extravaginal torsion: This type of torsion is often found in the neonatal period due to deficient fixation of the spermatic cord (about 10% of all cases) and it is often intrauterine, in which case the testis is usually lost or postnatal and thus immediate surgical intervention may salvage the testis. In some cases, extravaginal testicular torsion is bilateral. Complicated pregnancies and vaginal deliveries seem to be predisposing factors for extravaginal torsion.

**Testicular trauma (rapture - fracture - haematoma)**

Testicular trauma of any nature may result in simple contusion, testicular haemorrhage, epididymal haemorrhage and more serious conditions (testicular fracture or testicular rupture). When an obvious clinical history of scrotal trauma referred, US may be used to exclude secondary torsion or to stage the trauma. As an accurate history is difficult to obtain from children, particularly younger children, the findings on US may be the first indication of trauma. Grey-scale and colour Doppler US findings has an important role in detecting traumatic lesions:

Haematocoele: there is usually fluid and lumps in the scrotal sac.

Testicular fracture: intratesticular hypoechoic areas are seen.
Testicular rupture: the echogenic tunica albuginea is discontinuous. This finding has a sensitivity of 100% and specificity of 65%.

Minor trauma is very common in children and may mislead the radiologist in the diagnosis of other underlying lesions such as testicular torsion and tumors but in general, conservative treatment is recommended except in cases of impaired testicular flow. Furthermore testicular rupture is rare but should be suspected when the margins of the testis are poorly defined or disruption of the capsular blood flow is observed. Extratesticular hematomas may be quite large owing to scrotal elasticity and their echogenicity changes over time (echogenic in the acute state and anechoic during follow-up) (Fig. 15, 16, 17, 18).

Other Causes of Scrotal Swelling

**Acute idiopathic scrotal oedema** (Fig. 19) is a rare disease that can cause acute scrotal swelling and erythema in boys (usually painless; presentation age varies from 4 months to 18 years). Involvement is bilateral in the vast majority of cases; hence, this entity should be considered when bilateral US findings similar to those of inflammatory epididymitis are visualized. The condition is characterized by sudden onset of nonhemorrhagic of possible allergic origin oedema and redness of the scrotal wall. Clinical discomfort is minimal, and the edema usually resolves between 72 hours and 4 days with conservative treatment. The US findings, which include thickening of the scrotal walls and hypervascularity are characteristic. US and colour Doppler evaluation shows diffuse scrotal edema and hyperemia. Acute idiopathic scrotal edema is self-limited, and treatment is conservative. Several **systemic diseases** can occur with scrotal involvement. Another cause of acute scrotal pain and swelling in the pediatric population is Henoch-Schönlein purpura. Scrotal involvement is rare but can occur in up to 15% - 37% of patients with Henoch-Schonlein purpuras and the US findings typically include thickening of the scrotal skin enlargement of the epididymis and presence of a hydrocele. The major causes of scrotal swelling should initially be ruled out. Careful history and physical examination may guide the clinician into the appropriate diagnosis.

**Inguinoscrotal hernia:** Clinical diagnosis is easy in this entity and simple abdominal radiographs may detect them. US may be useful in the diagnosis of incarcerated inguinoscrotal hernias that present as a scrotal mass. Also grey-scale US alone can establish the final diagnosis of inguinoscrotal hernia if it shows that bowel loops, omentum, or both (echogenic tissue) are either surrounded or not by fluid inside the scrotal sac. The presence of a non-mobile bowel loop inside the scrotum is essential for the diagnosis of strangulation (sensitivity: 90% specificity: 100%).
**Fig. 6:** Appendix testis (hydatid of Morgagni) in transverse view. Note the hydrocele (containing cholesterol crystals) which is very helpful to reveal appendix testis.

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Fig. 7: Longitudinal US scan of the right hemiscrotum in a 7yo boy shows a highly hypo-echogenic well-defined mass at the upper pole of the epididymis (e) which represent appendix epididymis.

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**Fig. 8:** Same patient (Fig. 6) in transverse view.

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Fig. 9: Normal anatomy [7yo]. Longitudinal scan of the spermatic cord which appears as a smooth linear structure limited by a highly echogenic band and contains testicular, deferential and cremasteric arteries (extented to mediastinum) and the pampiniform plexus of veins (blue colour).

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Fig. 10: Epididymitis [13yo]. Grey-scale US: the epididymis is totally enlarged, more markedly at its head (which usually is the most affected region) and body. Note the reactive hydrocele and wall thickening.

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Fig. 11: Epididymitis (same patient with Fig.2). Gray-scale and Colour Doppler US reveals increased blood flow in the enlarged epididymis. Note again the reactive hydrocele and wall thickening.

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**Fig. 12:** Torsion of appendix testis [9yo]: enlarged hypoechoic ovoid mass (right), scrotal oedema, and reactive hydrocele. Colour Doppler will show hyperemia around the mass. The difference between left and right testicle is prominent.

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Fig. 13: Testicular torsion [5yo] tc: spermatic cord twisting. Inhomogeneous appearance of testis (t) due to testicular ischemia (cutting off of the testicle's blood supply).

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**Fig. 14:** Testicular torsion (<360°): Longitudinal view. The identification of the hyperemic turbulent-like twisted cord with intratesticular blood flow is a sign that the testis is viable (surgically proven).

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Fig. 15: Testicular fracture [11yo]: prominent scrotal oedema and intratesticular hyperechoic (arrow) and hypoechoic (*) areas are seen. Findings are consist with areas of haemorage in subacute and acute phase respectively. Colour Doppler images show decreased colour signal in the affected hemiscrotum (nt: normal testis).

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Fig. 16: Testicular complex injury [13yo]: Fluid and lumps in the scrotal sac with diffuse surrounding oedema. Note the hyperechoic oval structure (measurement with x,+) which is an appendiceal testis torsion (as a consequence to trauma).

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**Fig. 17:** Testicular complex injury [same patient]: Colour Doppler images show decreased colour signal in the affected hemiscrotum and no colour signal in the appendiceal testis torsion.

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**Fig. 18:** Idiopathic scrotal edema [6yo]. Transverse US scan of both hemiscrotum shows marked thickening of the scrotal walls. The testes and their tunicae appear normal. Increased vascularity was seen at color Doppler imaging (not shown).

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Conclusion

US is a valuable complementary tool to clinical examination in cases of acute scrotum. US facilitates differential diagnosis and provides imaging parameters important for prognosis. Colour and Power Doppler techniques should be considered as part of the examination to access testicular perfusion.
References