The acute scrotum in childhood or adolescence is a medical emergency (1, 2). The acute scrotum is defined as scrotal pain, swelling, and redness of acute onset (Figure 1). Because the testicular parenchyma cannot tolerate ischemia for more than a short time, testicular torsion must be ruled out rapidly as the cause (3, e1). Testicular torsion accounts for about 25% cases of acute scrotum, with an incidence of roughly 1 per 4000 young males per year. The goal of this CME article is to present a structured diagnostic and therapeutic approach to the acute scrotum, by means of which unnecessary operations and irreversible damage to the testicular parenchyma can be avoided.

Learning objectives
This article is intended to acquaint the reader with
● the standardized diagnostic evaluation,
● the necessary therapeutic measures, and
● the indications for surgery in cases of acute scrotum.

Methods
For this article, we selectively searched the PubMed database for articles containing the terms [“acute scrotum” OR “testicular torsion”] AND “children.” We also refer to the current guidelines of the German Society for Pediatric Surgery (Deutsche Gesellschaft für Kinderchirurgie) and our own experience.

Diagnostic evaluation
The diagnostic evaluation begins with history-taking. The patient should be asked about the exact temporal course of events, the intensity of the pain, and, in particular, when the pain began (1, 2, 4). If the patient is a very small child, this information can only be obtained from a parent. The physician must also ask any new systemic symptoms or diseases already known to be
present (Box 1) (1, 2, 4), particularly local problems, such as an inguinal hernia. B symptoms of hematologic disease and any newly arisen hematomata or petechiae should be asked about specifically. On physical examination (Box 2), the scrotum should be inspected, and a brief general physical examination should be performed (4). The involved testis should be palpated, and its position, size, and tenderness (if any) should be noted in comparison to the other side. The testis and epididymis should be evaluated separately, if possible. Next, the inguinal canal and the abdomen are palpated, and the cremasteric reflex is tested (4, 5, e2). The Ger and Prehn signs are no longer relevant in everyday practice (the former is retraction of the scrotal skin that may indicate testicular torsion in an early stage, and the latter is improvement of pain when the affected testicle is supported against gravity) (4, e2). The current German guidelines state that the Prehn sign remains useful to some extent, but this sign cannot be tested reliably in childhood.

In recent years, ultrasonography has emerged as the decisive radiological study for diseases of the scrotum, although there is no consensus on its reliability for the exclusion of testicular torsion (6–9, e3–e9). Some authors consider it reliable for this purpose as long as the ultrasonographic technique meets certain specified criteria (6, 8), while others report, for example, cases of missed partial testicular torsion (e9). The physician who needs to know whether the testis may be damaged can accept no compromise on the reliability of diagnostic information. Two essential factors are the expertise of the physician performing the ultrasonographic study and the high quality of the apparatus used, which must have a 7–13 Mhz linear transducer with Dopper and power-Doppler functions (3, e3). Morphologically, an ultrasonographic study yields an estimate of testicular volume and an assessment of the echogenicity and any pathological features of the right and left testes in comparison to each other. For differential diagnosis, the study should include a search for an enlarged epididymis, a hydatid, a hematoma, or a tumor (3, e3, e4).

The ultrasonographic evaluation of testicular perfusion includes both the arterial and the venous flow signals (Figure 2) (3). The demonstration of central vessels in the testicular parenchyma is important, as perfusion may be preserved in the periphery and the outer coverings of the testis even in the presence of

**History-taking**
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**Phyiscal examination**
The scrotum should be inspected and a brief general physical examination should be performed. The involved testis should be palpated, and its position, size, and tenderness (if any) should be noted in comparison to the other side.
testicular torsion. In a personal case series including 61 cases of testicular torsion, the main author of this review found that all 61 were identifiable by the criterion of demonstrable central perfusion (6).

For accurate flow measurements in the testicular parenchyma, the wall filter and the pulse repetition frequency should be adapted to the flow velocity (1–5 cm/s). The wall filter permits a choice of especially low frequency ranges, so that low flow velocities can be measured. The pulse repetition frequency corresponds to the impulse-generator frequency and should be low for low flow velocities. The gain should be set optimally to keep artefacts to a minimum. The resistance index (RI) of the testicular vessels should be determined as well (3, 7, 10, e10). An RI above 0.7 (mean: 0.43–0.75 [10]) with reversal of diastolic flow may indicate partial torsion (7, 10, e11). This cutoff value is appropriate from puberty onward (10, 12); for pre-pubertal children, RI values up to 1.0 are considered normal (mean: 0.39–1.0 [10]). Diastolic flow and the venous flow curve may be hard to demonstrate in infants and small children. The examiner can also try to demonstrate the testicular vessels in the area of the funiculus. Here, the finding of a spiral course is highly sensitive (96%) for testicular torsion (12, e12, e13). A comparison of the two sides is obligatory.

Aside from the performance of the individual tests mentioned, it is medicolegally very important for the findings and their interpretation to be thoroughly documented in the medical record.

Theoretically, testicular perfusion could also be evaluated with magnetic resonance imaging or scintigraphy (e14–e18), but these tests are of little value for the diagnostic assessment of the acute scrotum in routine clinical practice because they are time-consuming, expensive, and hard to obtain.

There is no single laboratory test that can exclude testicular torsion. A reasonable laboratory profile to obtain in cases of suspected torsion consists of a complete blood count (with differential, if indicated) and serum C-reactive protein concentration. A urine sediment is needed to rule out urinary tract infection.

Etiology and differential diagnosis

The acute scrotum in childhood and adolescence has many potential causes. The differential diagnosis includes torsion, infection, trauma, tumor, and rarer causes (Table) (1–3, 7, e1, e5, e19).

### Differential diagnosis

The differential diagnosis includes torsion, infection, trauma, tumor, and rarer causes.

### Torsion

Testicular torsion is a suddenly occurring rotation of a testis about its axis, resulting in twisting of the spermatic cord (Figure 3). The venous drainage of the testis is choked off and arterial perfusion is reduced, resulting in hemorrhagic infarction of the parenchyma. Subsequently, perfusion of the testis is totally lost. Complete testicular torsion, by definition, involves a full 360° rotation. Irreversible damage of the testicular parenchyma can be seen after four hours of ischemia (13). Studies have shown that only 50% of children who have had testicular ischemia for four hours or more go on to have normal spermiogram findings in adulthood (13). The cause of testicular torsion is thought to be an abnormal degree of mobility of the suspension of the entire testis, or of the testis within its coverings, so that the testis can rotate about its own axis during physical exercise, trauma, or a suddenly occurring cremasteric reflex. Anatomical variants such as the bell-clapper anomaly, in which the gubernaculum, testis, and epididymis are not anchored as they normally are, predispose to testicular torsion (14, e20). Supravaginal torsion (i.e., torsion occurring above the tunica vaginalis) is more common in infants, while intravaginal torsion of the spermatic cord is the usual variant occurring in adolescence and is much more common overall (4).
The pain is acute and severe and may be accompanied by vomiting; shock-like symptoms are rare (1). The involved testis is often fixed in position near the body, or else it may lie obliquely instead of vertically, because of shortening of the twisted spermatic cord (4, e21). Absence of the cremasteric reflex is a sign of testicular torsion (5, e2).

The morphological appearance of the testis on ultrasonography depends on the duration of parenchymal ischemia. In the initial phase, there is usually a progressive increase in volume and a rather diffuse hypoechogenicity (3, 15, e3–e5, e7, e22). Later on, inhomogeneities arise that are taken to represent irreversible parenchymal damage (15, 16). There is a lack of consensus in the literature about the reliability of Doppler ultrasonography for assessing testicular parenchymal perfusion (6–9, 17, e5–e9, e23). Overall, its sensitivity and specificity are generally estimated at 89% to 100%, though different publications on this question use different ultrasonographic criteria for establishing the diagnosis, so that the comparability of findings across studies is limited (6, 18, e9). The decisive criterion for adequate testicular perfusion is the unambiguous demonstration of central arterial and venous flow (1, 3). The demonstration of an arterial flow signal alone cannot exclude partial torsion. Spectral analysis (triplex mode) should be performed, and the RI should be determined (10, e11). The finding that the vessels of the spermatic cord are twisted into a spiral can be helpful in the differential diagnosis (13, e12, e13). A comparison with the other testis is obligatory in every case. In complete testicular torsion, no central perfusion can be seen.

Whenever Doppler ultrasonography arouses suspicion of testicular torsion, emergency surgical exploration of the testis is indicated (1, 2). The surgical approach can be either inguinal or scrotal. Infants nearly always have supravaginal torsion and should thus be operated on by an inguinal approach.

After detorsion of the vessels, the degree of ischemic damage of the testicular parenchyma should be assessed. Primary orchiectomy should be performed only if the testis is clearly necrotic (1); in all other cases, the testis should be anchored to the scrotum with two sutures. Having been left in place, the testis can later be reassessed ultrasonographically for reperfusion and potential secondary ischemic damage.

Testicular torsion: history
The pain is acute and severe and may be accompanied by vomiting; shock-like symptoms are rare. The involved testis is often fixed in position near the body, or else it may lie obliquely instead of vertically.

Testicular torsion: Doppler ultrasonography
Whenever Doppler ultrasonography yields a suspected diagnosis of testicular torsion, emergency surgical exploration of the testis is indicated.
parenchymal changes (6). Contralateral orchiopexy is obligatory as well, because the second testis is also at elevated risk of torsion (1).

Intermittent testicular torsion is a special case in which the initially severe acute pain rapidly improves (e24). Doppler ultrasonography reveals a hyperperfused testis. The differential diagnosis must include orchitis, although the pain of orchitis is normally continuous. Perfusion must be reassessed with Dopper ultrasonography at close intervals (every six hours at first), so that further episodes of torsion will not be missed (3).

Neonatal testicular torsion is another special case (15, 19, e25–e29). The torsion event often occurs before birth, making the diagnosis difficult (15). The percentage of severe testicular damage is 100%, according to some studies (e27, e29), although there have been reports of testicular preservation by direct surgical intervention (15, 20, e25, e28). Accordingly, there are strongly conflicting opinions about the urgency of intervention in neonatal testicular torsion (e25, e27, e30, e31), ranging from the view that this is an acute emergency demanding immediate testicular exploration all the way to diagnostic and therapeutic nihilism (e25, e27, e30). Ultrasonography can yield additional information about the current extent of parenchymal damage (15). The principal author has reported elsewhere that recovery can be expected in this entity, the initially severe acute pain rapidly improves. Doppler ultrasonography reveals a hyperperfused testis.

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if the testicular parenchyma is homogeneous (15). Doppler ultrasonography of the testis can be difficult to perform in a neonate. Whenever perfusion cannot be demonstrated with certainty, immediate exploration of the testis must follow (15, e31). Marked inhomogeneity or atrophy of the parenchyma on ultrasonography may be an exceptional reason to consider delayed testicular exploration (15).

Pathophysiologically, the processes of ischemia and reperfusion lead to a cascade of reactions in which neutrophilic leukocytes are activated and inflammatory cytokines (TNF-α and IL-1β, among others) and adhesion molecules are released. N-acetylcysteine (NAC) has been found to have a protective effect on testicular tissue in animal models; thus, in the future, there may well be a form of drug therapy that will be given to patients with testicular torsion in addition to surgery (21, 22).

**Hydatid torsion**

In hydatid torsion, small appendages of the testis and epididymis undergo torsion and become ischemic. These appendages are embryologic remnants of the Müllerian and Wolffian ducts (appendix testicularis and appendix epididymidis) (23). The clinical manifestations resemble those of testicular torsion. An important point for differential diagnosis is that the point of maximal tenderness is often directly above the testis; in some cases, resistance can be palpated in this area. On transillumination, a bluish shimmering structure (the “blue dot sign”) is often visible (e32). Ultrasonography often reveals a twisted hydatid as a hyper- or hypoechoic structure between the testis and the epididymis (23, e3–e5) (Figure 4), but demonstration of a hydatid alone is not pathognomonic for torsion, as non-twisted hydatids can be seen as well (e33). Doppler ultrasonography also often reveals accompanying hyperemia of the epididymis (23).

Hydatid torsion is generally treated symptomatically, with bed rest, local cooling, and, in some cases, anti-inflammatory drugs (1, 2). For severe and persistent symptoms, operative removal of the hydatid can be considered in rare cases (1, 2).

**Infection**

**Epididymitis and orchitis**

Epididymitis and orchitis are either viral or bacterial infections of the epididymis and testis. Bacterial infections are very rare in children, unlike in adults (24, e34, e35). The symptoms of both conditions generally arise more slowly than those of testicular torsion; unlike in testicular torsion, the testis is neither fixed nor in a higher position (4). The cremasteric reflex is usually preserved. There may be dysuria, indicating a concomitant urinary tract infection (4).

In these disease entities, scrotal ultrasonography reveals hyperemia with increased vascularization, along with enlargement of the epididymis or testis (25, e3). Low RI values may be seen (e5, e10). Further findings may include thickening of the tunica albuginea or an accompanying hydrocele (25, e5).

Urinalysis is an obligate part of the work-up of these infectious conditions (1, 2, e36). In cases of recurrent infection, extended diagnostic evaluation is indicated for the exclusion of structural anomalies (the evaluation might include, for example, renal ultrasonography, uroflowmetry, cystoscopy, and micturition cysto-urethrography) (1–3, e36).

The symptomatic treatment of epididymitis and orchitis resembles that of hydatid torsion. The need
for antibiotic treatment (e.g. cefuroxime 100 mg/kg/d) in the absence of a demonstrated urinary tract infection is currently debated (e24).

**Trauma**
Blunt trauma can cause a hematocele or edema of the testis or scrotum (e5, e37, e38). Ultrasonographic imaging is needed to rule out post-traumatic torsion or capsule rupture (e5, e38). The treatment is then decided upon individually in each case.

**Systemic disease**
The acute scrotum as the initial manifestation of a systemic disease is a challenge for differential diagnosis. When the scrotum is involved in Henoch–Schönlein purpura, the epididymis and testis are often enlarged (e39, e40). Physical examination reveals the pathognomonic petechiae on the calves. Both leukemia and lymphoma can also present with scrotal involvement as their initial manifestation. In such cases, the ultrasonographic findings are generally not definitive, but laboratory tests reveal the diagnosis.

**Other diseases**
Incarcerated inguinal hernia can cause testicular ischemia, sometimes presenting highly acutely. A thick swelling in the area of the inguinal canal points to the diagnosis. Here, too, ultrasonography is a useful aid in differential diagnosis, complementary to the physical examination. If complete reposition is not possible, immediate surgery is indicated.

Acute idiopathic scrotal edema and emphysema is an entity in which the scrotum becomes swollen for unknown reasons (e41–e43) (Figure 5). The testes are not involved. The marked swelling makes diagnosis by palpation impossible; the condition can only be diagnosed with ultrasonographic imaging.

Acute abdominal inflammation or infection (e.g., appendicitis) can also present with the clinical picture of an acute scrotum. In such cases, the physical examination, laboratory tests, and ultrasonography usually suffice to establish the diagnosis (e44).

Testicular tumors are generally painless. Intratumoral hemorrhage can, however, present with an acute scrotum (e45). Ultrasonography reveals the tumor mass (e5). Germ-cell tumor markers should be determined (alpha-fetoprotein, β-HCG).

**Overview**
The acute scrotum is a medical emergency because any unnecessary delay can bring about irreversible damage to the testicular parenchyma. The percentage of patients with an acute scrotum who need emergency scrotal exploration because of testicular torsion is probably less than 20%. It is, therefore, of vital importance to identify the patients who do not need surgery by use of the appropriate diagnostic procedures. A standardized diagnostic approach is recommended in which Doppler ultrasonography plays a central role (Figure 6). The treatment is decided upon on the basis of the findings of the physical examination and Doppler ultrasonography, as soon as these have been performed. Whenever any question remains as to the central perfusion of the testis, emergency surgical exploration is the treatment of choice. When in doubt, explore! (e46)

**Epididymitis and orchitis**
These are viral or bacterial infections of the epididymis and testis. Bacterial infections are very rare in children. The symptoms generally arise more slowly than those of testicular torsion.

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Testicular tumors

Testicular tumors are generally painless. Intra-tumoral hemorrhage can present with an acute scrotum. Ultrasonography reveals the tumor mass. Germ-cell tumor markers should be determined.

Overview

If any question remains as to the central perfusion of the testis, emergency surgical exploration is the treatment of choice. When in doubt, explore!
24. Somekh E, Gorenstein A, Serour F: Acute epididymitis in boys: 
25. Farriol VG, Comella XP, Agromayor EG, Creixams XS, Martinez De La 
Torre IB: Gray-scale and power doppler sonographic appearances 
of acute inflammatory diseases of the scrotum. J Clin Ultrasound 

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The CME unit “Confusional States in the Elderly” (Issue 21/2012) can be accessed 
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Please answer the following questions to participate in our certified Continuing Medical Education program. Only one answer is possible per question. Please select the answer that is most appropriate.

**Question 1**
What is the annual incidence of testicular torsion in young males?
- a) 1: 500
- b) 1: 4000
- c) 1: 10 000
- d) 1: 20 000
- e) 1: 100 000

**Question 2**
In the history of a patient with an acute scrotum, what sign should be asked about in particular?
- a) petechiae
- b) nevus lenticularis
- c) erythema
- d) milia
- e) comedones

**Question 3**
What reflex should be tested as part of the diagnostic evaluation of the acute scrotum?
- a) the anal reflex
- b) the pupillary light reflex
- c) the abdominal wall reflex
- d) the knee-jerk reflex
- e) the cremasteric reflex

**Question 4**
Which of the following is essential in the ultrasonographic evaluation of the acute scrotum, aside from the expertise of the examiner?
- a) a 1.5–3.5 MHz linear transducer with Doppler or power-Doppler function
- b) a 2–4 MHz linear transducer with Doppler or power-Doppler function
- c) a 2–5 MHz linear transducer with Doppler or power-Doppler function
- d) a 4–7 MHz linear transducer with Doppler or power-Doppler function
- e) a 7–13 MHz linear transducer with Doppler or power-Doppler function

**Question 5**
A six-year-old boy presents with a painful acute scrotum but feels better rapidly thereafter. Doppler ultrasonography reveals a hyperperfused testis. What is your suspected diagnosis?
- a) blunt trauma
- b) testicular tumor
- c) intermittent testicular torsion
- d) appendicitis
- e) incarcerated inguinal hernia

**Question 6**
Palpation of the acute scrotum of a 10-year-old boy reveals maximum tenderness above the testis. Transillumination reveals a bluish structure. Ultrasonography reveals a round, hyperechogenic, non-perfused structure next to the upper pole of the testis. What is the most likely diagnosis?
- a) scrotal edema
- b) hydatid torsion
- c) epididymitis
- d) intravaginal testicular torsion
- e) neonatal testicular torsion

**Question 7**
A standardized diagnostic evaluation including Doppler ultrasonography in a patient with an acute scrotum fails to demonstrate adequate central perfusion of the testis with certainty. In this situation, what is the treatment of choice?
- a) emergency surgical exploration of the testis
- b) intravenous antibiotics
- c) perfusion-promoting drugs
- d) bed rest
- e) measurement of tumor markers

**Question 8**
Doppler ultrasonography reveals a scrotal wall that is expanded by edema. Individual layers can no longer be distinguished. The central perfusion of the testis is within normal limits. What is the most likely diagnosis?
- a) hematocele
- b) hydatid torsion
- c) idiopathic scrotal edema
- d) intermittent torsion
- e) orchitis

**Question 9**
Which of the following can be used to treat hydatid torsion?
- a) anti-inflammatory drugs
- b) antibiotics
- c) anti-diuretic drugs
- d) anti-arrhythmic drugs
- e) anti-emetic drugs

**Question 10**
What disease can present with scrotal involvement as its initial manifestation?
- a) diabetes
- b) leukemia
- c) hypertension
- d) plasmocytoma
- e) rheumatoid arthritis
The Acute Scrotum in Childhood and Adolescence

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REFERENCES