ELSEVIER

CLINICAL
Pediatric
Emergency
Medicine

Diagnosis and Management of Testicular Torsion, Torsion of the Appendix Testis, and Epididymitis

Shan Yin, MD, MPH,* Jennifer L. Trainor, MD†

Because acute scrotal pain, swelling, and/or inflammation are a potential surgical emergency, prompt and accurate diagnosis is crucial. The 3 most common etiologies of acute scrotal pain in the pediatric age group are epididymitis, torsion of the appendix testis, and testicular torsion. There are numerous other causes of scrotal pain, which include hernia, hydrocele, trauma, Henoch-Schonlein purpura, idiopathic scrotal edema, and neoplasm, but only testicular torsion requires emergent surgery. History and physical examination, along with adjunctive imaging, can provide important keys to the diagnosis. This article reviews the differential diagnosis and management of the acute scrotal pain in the pediatric population, specifically focusing on testicular torsion, epididymitis, and torsion of the appendix testis.
Clin Ped Emerg Med 10:38-44

KEYWORDS testicular torsion, torsion of the appendix testis, epididymitis, ultrasonography, acute scrotal pain

Testicular torsion, epididymitis, and torsion of the appendix testis constitute the top 3 etiologies of the acute scrotal pain in pediatrics; however, the relative proportion of each varies widely among different published case series. Testicular torsion is generally quoted as affecting approximately 1 in 4000 patients younger than 25 years [1]. However, in 8 large case series, the percentage of children with acute scrotal pain ultimately diagnosed with testicular torsion ranges from 12% to 45% [2-9]. Epididymitis, once thought to be an uncommon entity in children, is diagnosed as the cause of acute testicular pain from 5% to 62% of the time depending on the case series. Torsion of the appendix testis ranges from 14% to 67% in the same series [2-9].

The great variability in the rates quoted is dependent on how the diagnosis was made and the potential referral bias in the populations studied. Moreover, although there is clearly a criterion standard for the diagnosis of testicular torsion, operative findings of an ischemic or dead testicle, there is no such standard for epididymitis and torsion of the appendix testis. With the advent of nearly universal access to ultrasonography, most children with acute scrotal pain who do not have clear clinical evidence to support testicular torsion (and even some who do) undergo ultrasound examination. In these case series, it is the ultrasonographer who makes the diagnosis and not the surgeon. Universally accepted criteria for ultrasound diagnosis of epididymitis have not been established. There is some thought that torsion of the appendix testis may be misdiagnosed as epididymitis on ultrasound because inflammation surrounding the ischemic appendage may mimic the focal hyperemia seen with true epididymitis. Interestingly, in a case series from Australia in which 92% of boys who presented with acute testicular pain (N = 187) underwent surgical exploration, torsion of the appendix testis accounted for 56% of all cases, torsion of the testis 21%, and epididymitis 13%. In this

*Division of Emergency Medicine, Department of Pediatrics, University of Colorado School of Medicine, The Children's Hospital Denver, Denver Health Medical Center, University of Colorado, Denver, CO.
†Division of Emergency Medicine, Department of Pediatrics, Feinberg School of Medicine, Children's Memorial Hospital, Northwestern University, Chicago, IL.
Reprint requests and correspondence: Shan Yin, MD, MPH, Division of Emergency Medicine, Department of Pediatrics, University of Colorado School of Medicine, The Children's Hospital Denver, Denver Health Medical Center, University of Colorado, 777 Bannock St, MC 0180, Denver, CO 80204. (E-mails: yin.shan@tchden.org, j-trainor@northwestern.edu)

1522-8401/$ - see front matter
doi:10.1016/j.cpem.2009.01.010

case series, only 16 patients had an ultrasound performed preoperatively. Of these, 9 had demonstration of increased flow to the epididymis. Only 3 were diagnosed operatively with epididymitis; 3 others had torsion of the appendix testis [4]. This suggests that ultrasound findings alone may overdiagnose epididymitis.

Testicular Torsion

Torsion of the testicle results from twisting of the spermatic cord, which then compromises the blood supply. Torsion may occur extravaginally (twisting proximal to the tunica vaginalis) or intravaginally (twisting within the tunica vaginalis). Extravaginal torsion occurs in the perinatal age group and makes up a small percentage of the total number of cases of testicular torsion. Intravaginal torsion occurs in older children and is believed to be due to abnormal fixation of the testis within the tunica vaginalis. In either case, the resulting ischemia can lead to changes in testicular morphology, sperm formation, or even complete testicular loss.

Pediatric testicular torsion has a bimodal age presentation with a small peak in neonates and a second larger peak in peripubertal children. Peripubertal children classically present with nausea, vomiting, and severe acute testicular pain, whereas infants with prenatal torsion typically are asymptomatic with a hard firm testicle [8]. The remainder of this section will be devoted to a discussion of torsion outside infancy. Neonatal torsion will be addressed separately.

Physical Findings and Historical Clues to Testicular Torsion

Various studies have compared the clinical presentation of epididymitis, torsion of the appendix testis, and testicular torsion to distinguish between the 3. Four separate retrospective studies have shown that an absent or decreased cremasteric reflex is the most sensitive physical examination sign for diagnosing testicular torsion [10]. A positive or normal cremasteric reflex is seen when the testicle retracts after light stroking of the inner ipsilateral thigh. In separate studies by Rabinowitz [10] and Kadish and Bolte [5], the cremasteric reflex was absent in 100% of patients (56 and 13 patients, respectively) with torsion. Although absence of the cremasteric reflex did not confirm the diagnosis of torsion, in these 2 studies, the presence of the cremasteric reflex effectively ruled it out. However, 2 other studies have failed to reproduce 100% sensitivity for this examination finding. Karmazyn et al [6] reported that only 28 (90.3%) of 31 of patients with torsion in their case series had an absent or decreased cremasteric reflex, and Ciftci et al [3] demonstrated that an absent cremasteric reflex had a 92% sensitivity in diagnosing 36 patients with torsion. Another finding that performed well was the presence of a diffusely tender testicle. This finding was present in 13 of 13 patients with torsion in the study of Kadish and Bolte [5] and in 38 (92.7%) of 41 patients with torsion in the study of Karmazyn et al [6]. The presence of a diffusely tender testicle was not explicitly reported in the other 2 studies.

In addition, patients with torsion were more likely to present earlier and have an abnormal testicular orientation than patients with epididymitis [3,5,6]. With the exception of the Rabinowitz study in which the methodology is unclear, these studies are all retrospective. In the Karmazyn and Ciftci studies, it is not clear who was documenting the physical examination findings and how patients were classified if no physical examination findings were charted. Lastly, Karmazyn produced a clinical scoring system in which a patient receives one point for each of the following findings: pain less than 6 hours, diffusely tender testicle, and absent or decreased cremasteric reflex. Of the 30 patients in his series who had 0 points or none of the findings, none had testicular torsion [6]. A prospective validation of this scoring system is necessary before any recommendations can be made regarding its use in ruling out testicular torsion.

The Role of Imaging

Because history and physical examination are not entirely reliable in diagnosing testicular torsion, many studies have examined the use of ultrasound as an adjunctive tool. The published sensitivity of color Doppler ultrasonography for diagnosing testicular torsion has a wide range of 63% to 100% with a specificity of 80% to 100% [5,6,8,9,11-15]. These studies primarily used the absence of preserved blood flow to diagnose torsion. However, in multiple case series, there are examples of torsion with preserved blood flow on ultrasound, accounting for the lowered sensitivity in some of the case series [12,16-18].

Figure 1 is an example of preserved testicular flow on scrotal ultrasound in a 16-year-old boy who presented to

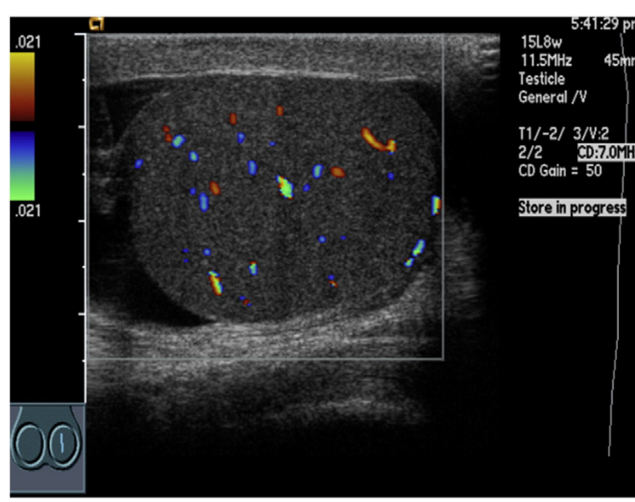

Figure 1 Testicular ultrasound in missed torsion case demonstrating presence of flow.

the emergency department with a 2-day history of scrotal pain and was ultimately determined to have testicular torsion. He was initially diagnosed with epididymitis based on the presence of an enlarged supratesticular mass seen on ultrasound (Figure 2). On closer inspection of the mass from a different angle, there is blood flow in a corkscrew linear pattern through the mass, revealing that this is the twisted edematous spermatic cord and not the epididymis (Figure 3).

Indeed, studies that have examined direct imaging of the spermatic cord for signs of twisting, as well as color Doppler for blood flow, show promising results. In a study by Kalfa et al [13], high-resolution direct ultrasound imaging of the spermatic cord was able to correctly identify 44 patients with torsion, whereas color Doppler would have missed 13 of those patients [16]. Furthermore, a multicenter study examining the use of high-resolution ultrasound imaging of the cord combined with color Doppler showed a sensitivity of 100% and a specificity of 99% in 208 patients with testicular torsion. However, the sensitivity of ultrasound is heavily dependent on operator experience [13]. Any decision to discharge a patient based on a negative ultrasound should be made with consideration of the ultrasound technician's experience, the radiologist's experience interpreting pediatric scrotal ultrasounds, as well as history and physical examination findings. In a patient where the diagnosis is virtually certain given history and physical findings, an ultrasound may add an unnecessary delay to definitive surgical treatment.

Intermittent testicular torsion is another possible cause for a false-negative ultrasound. A child who presents with multiple episodes of significant testicular pain that resolves spontaneously may have intermittent testicular torsion. Notably, a horizontal lie, even in an asymptomatic child, is suggestive of torsion [19,20]. Although it may resolve spontaneously, intermittent testicular torsion is associated with the bell clapper deformity [19,21], and elective scrotal exploration should be considered because earlier orchiopexy improves the salvage rate in these patients [21].

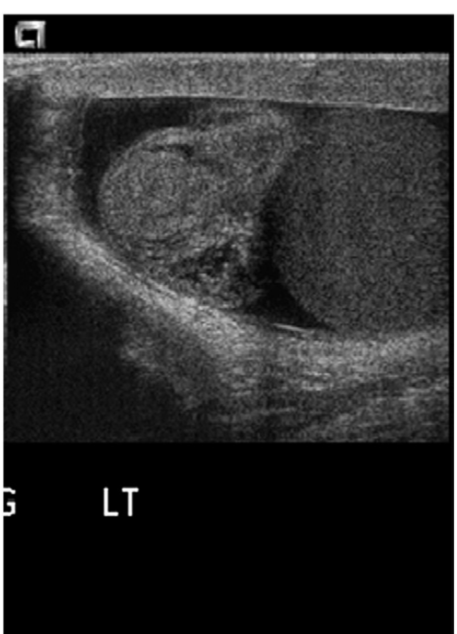

Figure 2 Mass visualized on ultrasound initially identified as the enlarged epididymis.

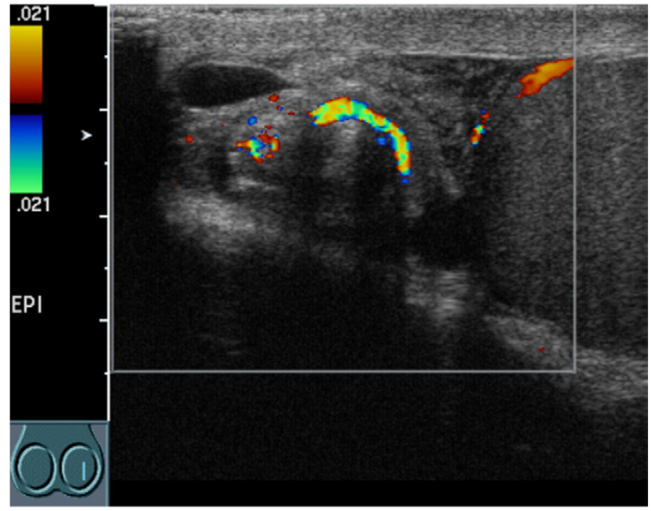

Figure 3 Mass seen in Figure 2 when evaluated with color Doppler from a different angle is revealed to be the cork-screwed spermatic cord.

Historically, scintigraphy has also been used as an adjunctive diagnostic modality. Testicular scintigraphy is a nuclear medicine imaging technique that typically uses technetium Tc 99m pertechnetate as a radionuclide. Studies comparing scintigraphy with ultrasound have consistently failed to demonstrate that either modality is superior [22-24]. A study by Wu et al [25] showed scintigraphy to be superior largely because ultrasound performed extremely poorly in their study. Given that other studies have consistently demonstrated ultrasound to be highly sensitive and specific, the poor results in this study can perhaps be attributed to operator error. Because of concern for the exposure to radiation and potential sequelae in children, ultrasound is generally considered the modality of choice. Some authors recommend that if ultrasound is not definitive, then scintigraphy can be performed to aid in the diagnosis. There are no outcome-directed studies that evaluate this strategy, and there is insufficient evidence available to make this a clear recommendation. In addition, if the clinical suspicion for testicular torsion is strong, obtaining another study may add an unnecessary delay. However, if ultrasound is not available but nuclear medicine is, testicular scintigraphy remains a viable option for adjunctive imaging in clinically equivocal cases.

Testicular Salvage Rates

Early surgical exploration with restoration of blood flow clearly improves the rate of testicular salvage. Visser and Heyns [26] examined both the salvage and late atrophy rate in 2 meta-analyses of 1140 patients from 22 case series and 535 patients in 8 case series. In their meta-analysis, exploration within 6 hours yielded a testicular salvage rate of higher than 90%, which then dropped consistently to approximately 20% at 24 to 48 hours. This same analysis found the testicular atrophy rate to approach 0% when salvaged within 6 hours and higher than 70% when salvaged at more than 24 hours. The methodology used in conducting this meta-analysis is unclear, but the results appear consistent with other published rates [4,27]. Testes salvaged greater than 8 hours after presentation showed a significant decrease in postpubertal size and exocrine function [28]. All evidence indicates that surgical exploration and repair should be done as quickly as possible. A small but significant percentage of late presenters can be salvaged so urologic consultation should not be deferred for patients with late presentations.

Neonatal Torsion

Traditionally, neonatal torsion has been treated as a single entity. Recently, there have been efforts in the literature to change the terminology to encompass 2 distinct entities: (1) in utero or prenatal torsion and (2) postnatal torsion [29]. Approximately 70% to 80% of perinatal torsion is prenatal [30,31]. Prenatal torsion is almost universally unsalvageable. Brandt et al [29] showed that 23 of 23 patients presenting with an abnormal scrotal examination result at birth and surgically explored had no viable or salvageable testes. The case series published by Kaye et al [31] and John et al [32] found that 13 of 13 and 24 of 24 testes were unsalvageable, respectively.

However, Pinto et al [30] were able to salvage 2 of 30 testicles in neonates with torsion. Both of these patients were explored within 6 hours of diagnosis, and salvage was defined as no testicular atrophy at 1 year of age. One of their patients likely had postnatal torsion and was diagnosed at 21 hours of life. The other patient was diagnosed at birth [30]. Management of prenatal torsion remains controversial in the urologic literature, with some authors recommending immediate exploration and others recommending observation or delayed exploration [29,33]. In the emergency department, immediate urologic consultation is recommended for any newborn infant presenting with suspected torsion.

In contrast to infants with prenatal torsion, infants with postnatal torsion tend to present with the classic signs of acute inflammation (erythema, swelling, and tenderness). However, the parental complaint may be increased fretfulness or irritability. The outcome of postnatal torsion may not be as bleak as that seen in prenatal cases. In a recent case series that specifically stratified prenatal from postnatal torsion, one of the 3 infants had a testicle that was salvageable [31]. It remains to be seen whether this infant will have long-term atrophy of the salvaged testicle. In another study, 4 of 10 neonates with postnatal torsion had testicular salvage. The authors were able to follow the 4 salvaged patients at 6 months of age and noted normal growth of the testes [34]. Given this low published salvage rate, one might infer that there is a delay in presentation for postnatal torsion. Even so, an infant with a normal testicular examination result at birth who then presents with an acute scrotal pain should be surgically explored immediately. The role of ultrasound in diagnosing neonatal torsion is controversial, with some authors reporting 100% sensitivity with experienced operators and others acknowledging false-negative as well as false-positive results. Blood flow to the neonatal testis may be difficult to evaluate with Doppler ultrasonography even when present and normal [32-34].

Manual Detorsion

Because of the urgency involved in restoring blood flow to the affected testis, manual detorsion has been suggested as a treatment modality for torsion outside the neonatal period. Traditionally, torsion of the testicle was thought to occur primarily in a medial direction so that an attempt at detorsion would involve twisting the affected testis in a lateral direction in a maneuver similar to opening a book. Numerous studies have demonstrated good success rates ranging from 68% to 86% with manual detorsion [35-37]. However, caution should be observed before attempting this technique. Sessions et al [35] observed that 54 (33%) of 162 of torsions occurred in a lateral direction. Therefore, manual manipulation to the lateral direction in many patients would worsen the degree of torsion. Immediate relief of symptoms is described with successful manual detorsion; therefore, increasing severity of symptoms with attempted detorsion may be an indication that lateral torsion is present.

Another potential pitfall of manual detorsion is failure to completely untwist the cord, because torsion may involve multiple revolutions. In the study by Sessions et al [35] in which 70 patients underwent orchiectomy for torsion, the median amount of rotation observed was 540°, with a range of 180° to 1080°. One manual rotation will reduce the torsion by 180° to 360°. This may cause a significant reduction in pain if some blood flow is restored, but it may not result in complete resolution. Hence, manual detorsion is not a substitute for exploration and fixation. Manual detorsion with the aid of ultrasound is likely the most prudent approach because ultrasound can provide information about the direction of twist as well as evidence of successful detorsion. This requires either expertise in use of bedside ultrasound or immediate availability of radiologic assistance.

Epididymitis

Epididymitis is the result of inflammation of the epididymis, a small structure that lies on the testicle and connects the efferent ducts of the testicle to the vas deferens. Epididymitis in the pediatric population can be divided into 3 distinct clinical groups: (1) the neonate, (2) the prepubescent child, and (3) the sexually active teenager. The diagnosis should be made only after ruling out testicular torsion. As stated previously, torsion cannot be effectively ruled out with history and examination alone. However, studies do indicate that epididymitis is likely to present with localized pain of the epididymis (90%-97%) [5,38], scrotal erythema (67%-80%) [5,38], and delayed presentation as compared with testicular torsion [5]. In the past, Prehn's sign (relief of pain with elevation of the scrotum) had been thought to distinguish epididymitis from torsion. In fact, Prehn's sign was positive in only 8% of patients with epididymitis in one case series [38]. Ultrasound typically demonstrates increased blood flow to the testicle [39].

Traditionally, acute epididymitis was thought to be the result of an ascending bacterial infection, and all cases were treated with antibiotics. Indeed, this appears to be the case with neonatal epididymitis. Chiang et al [40] described a cohort of 7 infants younger than 3 months diagnosed with orchitis/epididymo-orchitis between 1994 and 2004. Six of these infants were checked for urinary tract infections, and all 6 were positive.

In prepubescent boys, however, multiple studies have demonstrated that epididymitis is generally not an acute infectious process and will resolve without antibiotics [38,41,42]. Lau et al [41] showed bacterial growth in only 4 (8.3%) of 48 patients with epididymitis. In addition, one patient had pyuria without bacterial growth. Thirty-six patients had negative urine study findings and were managed without antibiotics. The remaining 7 patients did not have urine tested, were pretreated with antibiotics, or were treated with antibiotics despite negative urine study findings. Haecker et al [38] showed that 2 of 49 patients with epididymitis had bacteriuria, but only 14 patients had urine cultures performed in this series. Three of 38 patients tested had pyuria, and all patients received antibiotics. In a prospective study by Somekh et al [42], only 1 of 44 children with epididymitis diagnosed by ultrasound had a positive urine culture. In addition, these authors demonstrated that these patients had significantly higher rates of positive titers for mycoplasma, enterovirus, and adenovirus when compared with healthy controls suggesting a postinfectious etiology. The case definition for epididymitis in these studies was somewhat variable, making their interpretation problematic.

In the sexually active teenager, epididymitis should be treated in the same manner as with adults. Testing for sexually transmitted illness should be performed, and presumptive treatment of chlamydial or gonococcal infection should be started, pending culture results.

To summarize, epididymitis in the neonatal age group and the sexually active teenager should be treated with antibiotics. The first episode of epididymitis in a well-appearing prepubescent boy can likely be observed without antibiotics pending the result of a urine culture.

The Role of Adjunctive Imaging

Because epididymitis was traditionally thought to be due to an ascending bacterial infection, renal ultrasound and voiding cystourethrogram (VCUG) have been recommended as adjunctive studies after resolution of the acute episode of epididymitis. A few studies have examined the incidence of anatomical genitourinary abnormalities in children diagnosed with epididymitis. Al-Taheini [43] et al found that 15 of 15 patients with epididymitis who had either an intravenous pyelogram or renal ultrasound had normal study results and 12 of 13 patients with epididymitis who had a VCUG had normal study results. Interestingly, 10 of their 16 patients had positive urine cultures. These authors, however, still recommended renal ultrasound and VCUG in patients with epididymitis and a positive urine culture. Merlini et al [44] found that 3 (21%) of 14 of older children with epididymitis had genitourinary malformations. One of the 3 also had a urinary tract infection. In a study by Siegel et al [45], 5 (42%) of 12 prepubescent children with epididymitis had underlying urogenital anomalies. All of these children also had positive urine cultures. Cappele et al [46] found that 7 (18.4%) of 38 children with epididymitis had anatomical anomalies, although only one required surgery, and the authors concluded that follow-up imaging was not necessary after one episode of aseptic epididymitis. Again, the case definition of epididymitis was either not stated in these case series or was variable.

There is no strong evidence currently that a well-appearing child with a single episode of aseptic epididymitis requires further imaging. On the other hand, neonates and infants diagnosed with epididymitis appear to be at an elevated risk for anatomical abnormalities, and present evidence suggests that they all deserve further imaging. In different case series, neonates and infants with epididymitis have a high rate of genitourinary malformations ranging from 73% to 75% [44,45]. Because of this association, infants with epididymitis should receive VCUG and renal ultrasound.

Torsion of the Appendix Testis

There can be multiple testicular appendages normally found in the male child. Any one of these can twist and cause pain. The 2 most commonly found types are appendages of the testis and of the epididymis, which constitute remnants of the müllerian and wolffian ducts, respectively. Torsion of the appendix testis makes up about 91% to 95% of torsed appendices [20].

The presentation of torsion of a testicular appendage can be similar to testicular torsion or epididymitis. Patients typically present with sudden onset of pain. These patients are more likely to have isolated tenderness to the superior pole of the testicle than patients with testicular torsion or epididymitis [5]. In the study by Kadish and Bolte [5], patients with torsion of the appendix testis presented in a similar time frame to patients with testicular torsion. In addition, they were more likely to have a normal lie [5], although in one study, this did not reach statistical significance because of the small number of patients, and in another study, there was no statistical analysis done on the differences [3].

The "blue dot" sign commonly described in textbooks is present in a minority of cases of torsion of the testicular appendage. In one case series, the blue dot sign was noted in only 3 (23%) of 13 patients [5]. This may be due to the time of presentation and progression of disease process at that point. Early on in the torsion event, arterial flow to the appendage continues, whereas venous egress is interrupted. This leads to a swollen appendage filled with deoxygenated blood. Before edema of the scrotal skin develops, this swollen appendage may be visible as the blue dot beneath the skin. As the inflammatory process continues, scrotal edema interferes with the visibility of the swollen appendage, and the once-visible sign is lost.

Patients with torsion of the testicular appendage can be treated supportively once testicular torsion has been excluded. Nonsteroidal antiinflammatory drugs are recommended, as well as limitation of activity to minimize pain. In addition, scrotal support with a pediatric athletic supporter or tight-fitting brief-style underwear can minimize mobility of the testicle and hence pain. Patients can experience torsion of an appendix multiple times because of the potential presence of multiple appendages.

Summary

Any child presenting with an acute scrotal pain should be treated as if they have a potential surgical emergency. Testicular torsion, epididymitis, and torsion of the appendix testis are the 3 most common nontraumatic causes of acute scrotal pain. Prompt diagnosis is crucial to avoid ischemic injury to the testicle. Physical examination findings combined with adjunctive imaging can usually provide the correct diagnosis. Imaging alone, however, cannot reliably exclude testicular torsion, and the emergency physician should seek urologic consultation in the presence of concerning history or physical examination findings, even when testicular blood flow appears to be preserved. The use of high-resolution ultrasonography to identify twists in the spermatic cord may ultimately prove to be a better diagnostic test than color Doppler ultrasonography alone. The true incidence and etiology of pediatric epididymitis remains to be determined. However, a school-aged child with a normal urinalysis and a negative urine culture who is diagnosed with epididymitis via ultrasound is unlikely to have a bacterial illness or require antibiotic treatment.

References

1. Williamson RC. Torsion of the testis and allied conditions. Br J Surg 1976;63:465.
2. Varga J, Zivkovic D, Grebeldinger S, et al. Acute scrotal pain in children—ten years' experience. Urol Int 2007;78:73-7.
3. Ciftci AO, Senocak ME, Cahit Tanyel F, et al. Clinical predictors for differential diagnosis of acute scrotum. Eur J Pediatr Surg 2004;14:333-8.
4. Mushtaq I, Fung M, Glasson MJ. Retrospective review of paediatric patients with acute scrotum. ANZ J Surg 2003;73:55-8.
5. Kadish HA, Bolte RG. A retrospective review of pediatric patients with epididymitis, testicular torsion, and torsion of testicular appendages. Pediatrics 1998;102:73-6.
6. Karmazyn B, Steinberg R, Kornreich L, et al. Clinical and sonographic criteria of acute scrotum in children: a retrospective study of 172 boys. Pediatr Radiol 2005;35:302-10.
7. Anderson PAM, Giacomantonio JM. The acutely painful scrotum in children: review of 113 consecutive cases. Can Med Assoc J 1985;132:1153-5.
8. Lewis AG, Bukowski TP, Jarvis PD, et al. Evaluation of acute scrotum in the emergency department. J Pediatr Surg 1995;30:277-82.
9. Gunther P, Schenk JP, Wunsch R, et al. Acute testicular torsion in children: the role of sonography in the diagnostic workup. Eur Radiol 2006;16:2527-32.
10. Rabinowitz R. The importance of the cremasteric reflex in acute scrotal swelling in children. J Urol 1984;132:89-90.
11. Patriquin HB, Yazbeck S, Trinh B, et al. Testicular torsion in infants and children: diagnosis with Doppler sonography. Radiology 1993;188:781-5.
12. Bentley DF, Ricchiuti DJ, Nasrallah PF, et al. Spermatic cord torsion with preserved testis perfusion: initial anatomical observations. J Urol 2004;172:2373-6.
13. Kalfa N, Veyrac C, Lopez M, et al. Multicenter assessment of ultrasound of the spermatic cord in children with acute scrotum. J Urol 2007;177:297-301.
14. Lam WW, Yap T, Jacobsen AS, et al. Colour Doppler ultrasonography replacing surgical exploration for acute scrotum: myth or reality? Pediatr Radiol 2005;35:597-600.
15. Baker LA, Sigman D, Mathews RI, et al. An analysis of clinical outcomes using color Doppler testicular ultrasound for testicular torsion. Pediatrics 2000;105:604-7.
16. Allen TD, Elder JS. Shortcomings of color Doppler sonography in the diagnosis of testicular torsion. J Urol 1995;154:1508-10.
17. Kalfa N, Veyrac C, Baud C, et al. Ultrasonography of the spermatic cord in children with testicular torsion: impact on the surgical strategy. J Urol 2004;172:1692-5.
18. Arce JD, Cortes M, Vargas JC. Sonographic diagnosis of acute spermatic cord torsion. Pediatr Radiol 2002;32:485-91.
19. Eaton SH, Cendron MA, Estrada CR, et al. Intermittent testicular torsion: diagnostic features and management outcomes. J Urol 2005;174:1532-5.
20. Dogra VS, Bhatt S, Rubens DJ. Sonographic evaluation of testicular torsion. Ultrasound Clin 2006;1:55-6.
21. Stillwell TJ, Kramer SA. Intermittent testicular torsion. Pediatrics 1986;77:908-11.
22. Livne PM, Sivan B, Karmazyn B, et al. Testicular torsion in the pediatric age group: diagnosis and treatment. Pediatr Endocrinol Rev 2003;2:128-33.

23. Paltiel HJ, Connolly LP, Atala A, et al. Acute scrotal symptoms in boys with an indeterminate clinical presentation: comparison of color Doppler sonography and scintigraphy. Radiology 1998;207:223-31.
24. Nussbaum Blask AR, Bulas D, Shalaby-Rana E, et al. Color Doppler sonography and scintigraphy of the testis: a prospective, comparative analysis in children with acute scrotal pain. Pediatr Emerg Care 2002; 18:67-71.
25. Wu HC, Sun SS, Kao A, et al. Comparison of radionuclide imaging and ultrasonography in the differentiation of acute testicular torsion and inflammatory testicular disease. Clin Nucl Med 2002;27:490-3.
26. Visser AJ, Heyns CF. Testicular function after torsion of the spermatic cord. Br J Urol Int 2003;92:200-3.
27. Makela E, Lahdes-Vasama T, Rajakorpi H, et al. A 19-year review of paediatric patients with acute scrotum. Scand J Surg 2007;96:62-6.
28. Bartsch G, Frank S, Margerger H, et al. Testicular torsion: late results with special regard to fertility and endocrine function. J Urol 1980; 124:375-8.
29. Brandt MT, Sheldon CA, Wacksman J, et al. Prenatal testicular torsion: principles of management. J Urol 1992;147:670-2.
30. Pinto KJ, Noe HN, Jerkins GR. Management of neonatal testicular torsion. J Urol 1997;158:1196-7.
31. Kaye JD, Levitt SB, Friedman SC, et al. Neonatal torsion: a 14-year experience and proposed algorithm for management. J Urol 2008;179: 2377-83.
32. John CM, Kooner G, Mathew DE, et al. Neonatal testicular torsion-a lost cause? Acta Paediatr 2008;97:502-4.
33. Yerkes EB, Robertson FM, Gitlin J, et al. Management of perinatal torsion: today, tomorrow or never? J Urol 2005;174:1579-83.
34. Sorensen MD, Galansky SH, Striegl AM, et al. Perinatal extravaginal torsion of the testis in the first month of life is a salvageable event. Urology 2003;62:132-4.
35. Sessions AE, Rabinowitz R, Hulbert WC, et al. Testicular torsion: direction, degree, duration and disinformation. J Urol 2003;169: 663-5.
36. Garel L, Dubois J, Azzie G, et al. Preoperative manual detorsion of the spermatic cord with Doppler ultrasound monitoring in patients with intravaginal acute testicular torsion. Pediatr Radiol 2000;30:41-4.
37. Cornel EB, Karthaus HF. Manual derotation of the twisted spermatic cord. Br J Urol Int 1999;83:672-4.
38. Haecker FM, Hauri-Hohl A, von Schweinitz D. Acute epididymitis in children: a 4-year retrospective study. Eur J Pediatr Surg 2005;15: 180-6.
39. Tracy CR, Steers WD, Costabile R. Diagnosis and management of epididymitis. Urol Clin N Am 2008;35:101-8.
40. Chiang MC, Chen HW, Fu RH, et al. Clinical features of testicular torsion and epididymo-orchitis in infants younger than 3 months. J Pediatr Surg 2007;42:1574-7.
41. Lau P, Anderson PA, Giacomantonia JM, et al. Acute epididymitis in boys: are antibiotics indicated? Br J Urol 1997;79:797-800.
42. Somekh E, Gorenstein A, Serour F. Acute epididymitis in boys: evidence of a post-infectious etiology. J Urol 2004;171:391-4.
43. Al-Taheini KM, Pike J, Leonard M. Acute epididymitis in children: the role of radiologic studies. Urology 2008;71:826-9.
44. Merlini E, Rotundi F, Seymandi PL, et al. Acute epididymitis and urinary tract anomalies in children. Scand J Urol Nephrol 1998;32: 273-5.
45. Siegel A, Snyder H, Duckett JW. Epididymitis in infants and boys: underlying urogenital anomalies and efficacy of imaging modalities. J Urol 1987;138:1100-3.
46. Cappele O, Liard A, Barret E, et al. Epididymitis in children: is further investigation necessary after the first episode? Eur Urol 2000;38: 627-30.