Original Article

Clinical characteristics and management strategies of testicular torsion in children with cryptorchidism: a comprehensive analysis

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Background: Cryptorchidism increases the risk of testicular torsion, a condition requiring urgent intervention. However, the atypical presentation in these cases makes diagnosis challenging, necessitating improved clinical awareness and management strategies. This study aims to analyze the clinical characteristics, diagnostic methods, and treatment outcomes of testicular torsion in children with cryptorchidism. The goal is to enhance the understanding of this rare condition and provide valuable insights into its diagnosis and management, based on clinical and surgical findings.

Methods: A retrospective analysis was conducted on the clinical data of 21 children with cryptorchidism who experienced testicular torsion and were treated at Anhui Provincial Children's Hospital from January 2015 to June 2024. Among the 21 patients, five had bilateral cryptorchidism, all of which involved unilateral testicular torsion, with 16 cases on the left side and five on the right side. The median age of the patients was 48 months [interquartile range (IQR): 8.5–117.5 months]. The median onset time, defined as the time interval between the onset of symptoms and surgical intervention, was 24 hours (IQR: 12–72 hours).

Results: All patients underwent surgical exploration. The average surgery time was 60.9 [standard deviation (SD): 25.1] minutes, with an average blood loss of 4.5 (SD: 2.3) mL. The median torsion angle was 540° (IQR: 270°–720°). Intraoperatively, 18 testes were found to have irreversible necrosis and were removed, while three were successfully detorsed and preserved with good blood supply. Postoperative follow-up for an average of 50.4 (SD: 18.3) months showed no atrophy in the surviving testes, and the contralateral fixed testes developed well without recurrent torsion.

Conclusions: Testicular torsion in children with cryptorchidism is rare and often presents with subtle symptoms. Early diagnosis and treatment are crucial. Ultrasound plays a significant role in the diagnosis of testicular torsion in cryptorchidism. The degree of torsion and the time of onset are critical factors for improving testicular survival rates. It is recommended that surgical intervention be performed early in cryptorchid patients older than six months to reduce the risk of testicular torsion.

Keywords: Cryptorchidism; testicular torsion; children; surgical treatment; ultrasound diagnosis

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Introduction

Cryptorchidism refers to a common congenital anomaly in which the testes fail to descend normally into the scrotum, with a higher incidence observed in preterm and low birth weight infants (1). The testes may continue to descend up until the age of six months; however, after this period, the likelihood of natural descent significantly decreases (2). Yet, despite most cases of cryptorchidism being correctable through early surgical intervention, some patients miss the optimal treatment window due to factors such as parental neglect, lack of medical knowledge, or delayed diagnosis. This not only impacts the reproductive health of the affected boys but also increases the risk of testicular cancer later in life. Moreover, as they grow, these patients may face potential acute complications, such as testicular torsion (3).

Testicular torsion is an acute urological emergency, with an annual incidence of approximately 3.8 cases per 100,000 males under the age of 18 years (4). It is characterized by the rotation of the testis along the axis of the spermatic cord, leading to obstruction of the testicular blood supply. If not treated promptly, the risk of testicular ischemia and necrosis is extremely high (5). After the onset of torsion, there is a four-to-eight-hour window during which surgical intervention is critical for saving the testis (6). Treatment within six hours of symptom onset can save 90–100% of the testes; if treated within six-to- twelve hours, the salvage rate drops to 20–50%; beyond twelve hours, the rate falls to less than 10% (7). Testicular torsion in children with cryptorchidism is rare, and previous studies have been limited in number and sample size, hindering comprehensive conclusions on its clinical features, diagnosis, and treatment outcomes. Due to the unique anatomical position of the testes in children with cryptorchidism, typical symptoms of testicular torsion, such as scrotal redness and pain, are often absent. Instead, patients may present with groin pain or a mass, which can easily be misdiagnosed as an incarcerated inguinal hernia or mistaken for appendicitis or other acute abdominal conditions, leading to treatment delays and a reduced testicular survival rate (8,9).

This study aims to analyze the clinical characteristics, diagnostic methods, and treatment outcomes of testicular torsion in children with cryptorchidism, providing clinicians with effective diagnostic and therapeutic guidance, and further enhancing the understanding and management of this condition. We present this article in accordance with the STROBE reporting checklist (available at https://tau.amegroups.com/article/view/10.21037/tau-24-468/rc).

Highlight box

Key findings

- Testicular torsion in children with cryptorchidism is rare but poses significant diagnostic and therapeutic challenges. Among 21 cases analyzed, 86% of affected testes were necrotic and required removal. Early diagnosis and intervention significantly improved testicular salvage.

What is known and what is new?

- Cryptorchidism increases the risk of testicular torsion, particularly in older children. Delayed diagnosis often results in testicular necrosis.
- This study provides a detailed analysis of clinical characteristics, diagnostic methods, and surgical outcomes of testicular torsion in children with cryptorchidism. It emphasizes the role of ultrasound in early diagnosis and highlights the impact of torsion degree and symptom duration on testicular viability.

What is the implication, and what should change now?

- Greater awareness of the atypical presentations of testicular torsion in cryptorchid children is crucial. Healthcare providers should prioritize the use of ultrasonography for early detection and employ surgical intervention promptly to prevent irreversible damage.
- It is recommended to consider early orchiopexy in cryptorchid patients, particularly those older than six months, to minimize the risk of torsion. Enhanced education for clinicians and caregivers about the urgency of testicular torsion symptoms can further improve outcomes.

Methods

This study was a retrospective cohort study. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Ethics Committee of Anhui Provincial Children's Hospital (No. EYLL-2023-02-008). Eligible patients were enrolled after obtaining written informed consent from their legal guardians.

Clinical data

This study retrospectively analyzed the clinical data of 21 children with cryptorchidism and testicular torsion who were treated at Anhui Provincial Children's Hospital from January 2015 to June 2024. The primary symptoms included sudden severe pain in the groin or lower abdomen, nausea, vomiting, and, in some cases, fever. Physical examination revealed a tender mass in the groin area (*Figure 1*). All patients underwent color Doppler ultrasound examination, which showed the affected testis located in

the groin, accompanied by testicular enlargement, reduced echogenicity, and diminished or absent blood flow signals (*Figure 2*). Ultrasound diagnosis indicated testicular torsion in 20 cases. In one patient, despite normal blood flow on color Doppler ultrasound, clinical suspicion of testicular torsion was high, and the diagnosis was confirmed intraoperatively. Detailed clinical data are shown in *Table 1*.

Inclusion and exclusion criteria

Inclusion criteria: (I) cryptorchidism with surgically confirmed testicular torsion; (II) children with at least one follow-up visit; (III) complete clinical data available.

Figure 1 A tender mass is visible in the right inguinal region.

Exclusion criteria: (I) patients who did not undergo surgery; (II) neonatal testicular torsion (NTT) cases; (III) incomplete clinical or follow-up data.

Treatment methods

The median onset time (treatment delay) was 24 hours [interquartile range (IQR): 12–72 hours]. All patients underwent emergency surgical exploration. The surgeries were performed by experienced urologists at our hospital. Under combined general anesthesia, the patient was placed in a supine position, and a transverse incision was made in the inguinal canal of the affected side. The external oblique aponeurosis was incised, and the spermatic vessels were carefully dissected. The type of torsion (intravaginal or extravaginal) and the degree of torsion were determined (*Figure 3*), and the twisted testis was promptly detorsed. A warm saline gauze was applied for 15 minutes to observe the recovery of testicular blood circulation. The tunica albuginea was incised deep into the medulla, and the testicular surface was observed for more than 10 minutes. If the testicular color improved and fresh bleeding appeared, orchiopexy was performed; if no fresh bleeding occurred, testicular necrosis was considered, and orchiectomy was performed with parental consent, followed by pathological examination (*Figure 4*). All patients underwent contralateral testicular fixation.

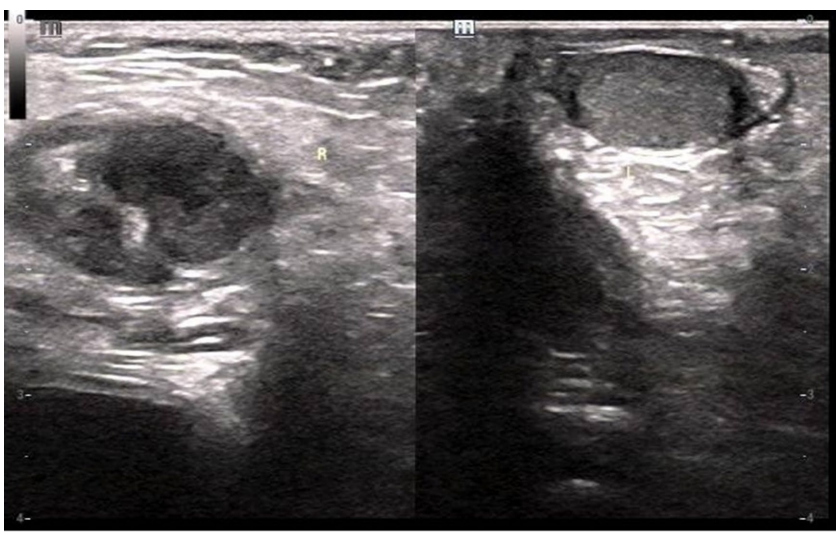

Figure 2 Ultrasound of the right inguinal region shows an irregular, testicular-like structure with reduced echogenicity and fissure-like hypoechoic areas, resembling a "broad bean", with no blood flow on CDFI. CDFI, color Doppler flow imaging.

Table 1 Clinical data and characteristics of the patients

Clinical and demographic feature	Value
Age (months), median [IQR]	48 [8.5–117.5]
Time of onset (hours), median [IQR]	24 [12–72]
Laterality, n (%)	
Left side	16 (76.2)
Right side	5 (23.8)
Symptoms, n (%)	
Inguinal pain	20 (95.2)
Lower abdominal pain	2 (9.5)
Vomiting	3 (14.3)
Fever	2 (9.5)
Surgery, n (%)	
Orchidopexy	3 (14.3)
Orchiectomy	18 (85.7)
Contralateral orchidopexy	21 (100.0)
Degree of torsion (degrees), median [IQR]	540 [270–720]
Location of torsion, n (%)	
Intravaginal	17 (81.0)
Extravaginal	4 (19.0)
Duration of surgery (minutes), mean (SD)	60.9 (25.1)
Intraoperative blood loss (mL), mean (SD)	4.5 (2.3)
Postoperative follow-up time (months), mean (SD)	50.4 (18.3)

IQR, interquartile range; SD, standard deviation.

Figure 3 Inguinal exploration shows torsion and necrosis within the tunica vaginalis.

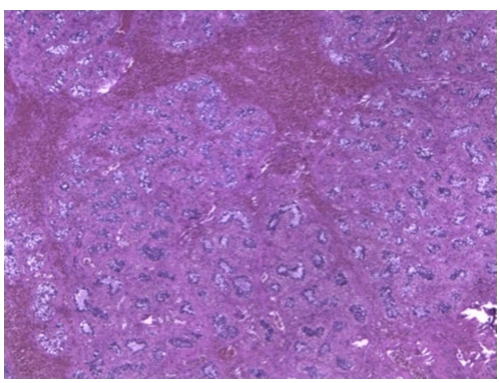

Figure 4 Postoperative pathology indicates that the testis is necrotic (hematoxylin and eosin stain, magnification ×100).

Follow-up

All patients were scheduled for regular follow-ups at two weeks, one month, three months, six months, one year, and annually thereafter. Follow-up assessments included physical examinations and ultrasound evaluations to assess the recovery of the torsed testis and the development of the contralateral testis.

Statistical analysis

Data recorded during the study period were analyzed using SPSS 21.0 statistical software. The normality of discrete and continuous variables was tested using the Kolmogorov-Smirnov test. Normally distributed data were expressed as mean [standard deviation (SD)], while skewed data were expressed as median (IQR, Q1–Q3). Categorical data were expressed as case numbers (percentages).

Results

A total of 21 children with cryptorchidism and testicular torsion were included in this study. Among the 21 cryptorchidism patients, five had bilateral cryptorchidism, all

of which involved unilateral testicular torsion, with 16 cases on the left side and five on the right side. The median age of the patients was 48 months (IQR: 8.5–117.5 months). The median onset time, defined as the time interval between the onset of symptoms and surgical intervention, was 24 (IQR: 12–72) hours. The incidence of testicular torsion in cryptorchidism cases was 8.8% (21/238). Color Doppler ultrasound showed the affected testis located in the groin, accompanied by enlargement, reduced echogenicity, and diminished or absent blood flow signals. Preoperative ultrasound diagnosed testicular torsion in 20 cases. Surgical exploration revealed 17 cases of intravaginal torsion and 4 cases of extravaginal torsion, with a median torsion angle of 540° (IQR: 270°–720°). Intraoperatively, 18 testes were found to have irreversible necrosis and were removed; in three cases, where the torsion angle was 180° and the onset time was less than 12 hours, the testicular blood supply recovered well after detorsion, and the testis was preserved. In the three patients with testicular survival, preoperative color Doppler ultrasound showed normal blood flow in one testis and reduced blood flow in two testes. These three patients had a median age of 49.7 months (range, 35–60 months), a median onset time of 6.7 hours (range, 4–12 hours), and a torsion angle of 180°. Contralateral orchiopexy was performed in all cases. The average surgery time was 60.9 (SD: 25.1) minutes, with an average blood loss of 4.5 (SD: 2.3) mL. The average follow-up period was 50.4 (SD: 18.3) months. Follow-up physical and ultrasound examinations showed no testicular atrophy in the surviving testes; the development of the contralateral fixed testes was good, and no recurrence of testicular torsion was observed in any patient.

Discussion

Cryptorchidism is a relatively common congenital developmental defect in the pediatric urogenital system, with a complex etiology involving endocrine, mechanical, and genetic factors during embryonic development (10,11). During early fetal development, testes are initially located in the retroperitoneal region and descend into the scrotum through the inguinal canal. However, in some cases, this process is incomplete, leading to cryptorchidism. Most testes descend within three months, with 1% of one-year-old having cryptorchidism. Treatment is recommended by six-to-twelve months, no later than eighteen months (12). Cryptorchidism not only affects reproductive function but can also lead to severe complications, including infertility and germ cell tumors. Cryptorchidism is also a significant risk factor for testicular torsion (13). The exact mechanism of testicular torsion in cryptorchidism remains unclear, but an unclosed processus vaginalis is considered a potential risk factor (14). Due to insufficient fixation of the testes within the scrotum, coupled with possible spasmodic contraction of the cremaster muscle, cryptorchid testes are more prone to torsion (15). Additionally, the attachment of the gubernaculum and the unclosed processus vaginalis create a space within the tunica vaginalis for the testis to rotate, increasing the risk of torsion (16). Neonatal testicular torsion (NTT) occurs with an incidence of 6.1 per 100,000 live births, representing 10% to 12% of all pediatric testicular torsion cases (17). Prenatal torsion accounts for 70% to 80% of NTT cases, indicating that torsion often occurs in utero (18). Therefore, we excluded neonatal cryptorchidism with torsion from this study. Cryptorchidism increases the risk of testicular torsion approximately tenfold compared to normal children, accounting for 6.8% to 9.7% of all cases of testicular torsion (19). In this study, we found that torsion of cryptorchid testes accounted for 8.8% of concurrent testicular torsion cases. All cases presented as unilateral testicular torsion, with the left side being more commonly affected, consistent with trends reported in previous literature (20). This may be related to the higher incidence of left-sided cryptorchidism and the longer anatomical structure of the left spermatic cord.

The typical clinical presentation of testicular torsion is the acute onset of severe scrotal pain, accompanied by scrotal swelling, tenderness, abnormal testicular position, and possibly nausea and vomiting (21). In cryptorchid patients, the testicular position is usually in the inguinal region, accounting for approximately 80% of cases, with a minority located in the abdominal cavity (22). This anatomical location may result in clinical manifestations of testicular torsion that differ from typical scrotal pain, more commonly presenting as inguinal or lower abdominal pain. In cases where the cryptorchid testis is located within the abdominal cavity, pain localization may be more diffuse and widespread. In clinical practice, this atypical pain presentation may complicate initial diagnosis, particularly when pain does not involve the scrotum. Additionally, the young age of cryptorchid patients often precludes them from accurately expressing or describing the nature and location of the pain, further increasing diagnostic challenges (23). Some younger patients may only present with non-specific symptoms such as irritability, crying, or refusal to eat, requiring clinicians to maintain a high level of vigilance

to avoid misdiagnosis or delayed diagnosis. Moreover, the anatomical location of the cryptorchid testis may affect the accuracy of imaging examinations, as intra-abdominal testes are often more difficult to assess through conventional examination methods (24). Therefore, when cryptorchid patients present with inguinal or lower abdominal pain, especially if accompanied by symptoms such as crying or vomiting that cannot be explained by other acute abdominal conditions, clinicians must consider the possibility of testicular torsion, promptly perform a genital examination, and arrange appropriate imaging studies to identify early signs of torsion in cryptorchid patients and immediately proceed with surgical intervention to salvage the testis and prevent treatment delays.

Color Doppler ultrasound combined with clinical signs is a key tool in diagnosing testicular torsion, playing a crucial role in assessing testicular blood flow and morphological changes (25). Doppler ultrasound can identify several characteristic changes associated with testicular torsion, including the potential twisting and thickening of the affected spermatic cord, testicular enlargement due to impaired blood return, heterogeneous echogenicity of the testicular parenchyma indicative of ischemic changes, and significantly diminished or absent blood flow signals (26). In the early stages of testicular torsion, particularly within the first four hours, the testicular artery may not yet be compromised, and the testis may still appear healthy (27). However, as time progresses, focal hemorrhage and necrosis become more pronounced, and abnormal echogenicity may appear within the testicular parenchyma, further confirming the severity of the torsion. The diagnostic value of color Doppler ultrasound lies in its high sensitivity and specificity. The sensitivity of color Doppler ultrasound in diagnosing testicular torsion ranges from 90% to 100%, with a specificity of 76%, making it the preferred method for confirming testicular torsion in clinical practice (28). The accuracy of diagnosis or misdiagnosis may vary due to differences in operator experience (29). However, it is worth noting that in cases of testicular torsion in cryptorchidism, the abnormal position of the testes, interference from surrounding tissues, and intestinal gas may affect the accuracy of ultrasound evaluation (30). These interfering factors may lead to less accurate diagnosis of cryptorchid torsion, particularly in cases of intra-abdominal cryptorchidism. For intra-abdominal cryptorchid torsion, computed tomography (CT) scans can avoid the interference of intestinal gas and provide more accurate diagnostic results (31). 99mTc testicular scintigraphy also aids in diagnosis but is typically not used as a routine auxiliary examination method due to the lengthy process and potential surgical delays it may cause (32). In this study, ultrasound showed a diagnostic accuracy of 95.2%, further confirming its importance in diagnosing cryptorchid testicular torsion.

Typically, cryptorchid torsion results in the loss of function of the affected testis. Even if detorsion is successful and testicular tissue is temporarily preserved, testicular disappearance, atrophy, or malnutrition may still occur (33). For patients suspected of cryptorchid torsion, immediate surgical exploration is required to detorse the twisted cryptorchid testis via an inguinal incision or laparoscopic approach (34). Surgical exploration confirms testicular torsion, assesses its severity and blood supply, and promptly corrects the torsion to restore circulation and preserve testicular function as much as possible. If testicular tissue necrosis is observed, orchiectomy is performed. Following detorsion and restoration of blood supply, testicular fixation is recommended to prevent recurrent torsion and protect testicular function. For scrotal testicular torsion, manual detorsion is a commonly used initial treatment method, particularly in the early stages of acute onset (35). Manual detorsion involves manually rotating the testis to relieve the torsion and restore blood flow, thereby preserving testicular function (36). However, in cases of cryptorchidism, the testis is often located deep within the abdomen or inguinal canal, making it challenging to accurately locate and manipulate. Even when detorsion is attempted, the success rate is very low, particularly in cases of intra-abdominal cryptorchidism where manual detorsion is impossible. The prophylactic fixation of the contralateral testis in cryptorchid patients remains controversial (37). Given the severe consequences that may result from testicular torsion, performing prophylactic fixation of the contralateral testis can prevent the risk of losing the contralateral testis in the event of an unforeseen adverse event (38). We recommend routine fixation of the contralateral testis to avoid potential risks. In this study, all participating patients underwent contralateral testicular fixation, and no cases of contralateral testicular torsion occurred postoperatively, with the contralateral testis developing well.

The timing and degree of testicular torsion are key factors influencing treatment outcomes and testicular survival rates (39). Testes are highly sensitive to ischemia, with the risk of testicular non-viability increasing by 4.8% for every 10-minute delay in treatment. The first six hours after the onset of symptoms is the golden time to save the

testis (40). The longer the duration of torsion, the longer the period of testicular ischemia, increasing the risk of tissue necrosis. Generally, testicular survival rates are high if torsion is relieved within six hours; the risk of necrosis increases after twelve hours, and survival is unlikely after twenty-four hours (41). The degree of torsion is also crucial; minor degrees of torsion may partially obstruct blood flow, while greater degrees of torsion can completely cut off blood supply, accelerating tissue necrosis. When testicular torsion occurs at 270 degrees, patients typically experience tissue necrosis within two to three days after onset; if the torsion angle is 180 degrees, necrosis appears in three to four days; and with 90 degrees of torsion, necrosis generally does not occur within four to five days (42). When testicular torsion exceeds 360 degrees, testicular atrophy may occur within 4 hours (43). In this study, we successfully preserved three cases of testicular torsion with torsion times not exceeding 12 hours and torsion angles of 180 degrees, further confirming that the timing and degree of torsion play important roles in testicular survival. In the 21 cases of testicular torsion with cryptorchidism, we used the Arda scoring system to assess the possibility of testis preservation. The score is based on the observation of testicular bleeding at the surgical site, categorized into three levels: Grade I (rapid and significant bleeding with adequate blood supply, testis can be preserved), Grade II (bleeding within 10 minutes with poor blood supply, preservation may be attempted), and Grade III (no bleeding within 10 minutes, severe ischemia, typically resulting in orchiectomy). In this study, two Grade I testes and one Grade II testis were preserved, while Grade III cases were removed. Although some Grade III testes were preserved at the request of the family, follow-up revealed that these testes almost always atrophied (44). For the preserved Grade II testes, while there was partial blood supply postoperatively, some may still experience atrophy during follow-up. However, in this study, one Grade II preserved testis showed no atrophy on follow-up. The literature on testicular torsion is limited, and a review of recent studies shows that the testis preservation rate in cryptorchidism with testicular torsion ranges from 11.1% to 26.3%. These studies typically report smaller case series with similar clinical presentations, diagnostic challenges, and surgical outcomes (45,46). Our testis preservation rate was 14.3%, which is consistent with previous studies.

There are some limitations to this study. First, due to the single-center nature of the study, the sample size is small, which may introduce selection bias. Second, due to limited time and funding, the study did not investigate long-term changes in testicular function in the preserved torsion patients, particularly regarding the endocrine function of the testis. Finally, due to the study's focus on a younger age group, the assessment of fertility function was not possible. Future multi-center studies with larger sample sizes should focus on the long-term outcomes and changes in reproductive function in these patients.

Conclusions

This study demonstrates that although testicular torsion in cryptorchidism is relatively rare in clinical practice, its insidious onset makes timely diagnosis and treatment crucial. Color Doppler ultrasound is currently the most important diagnostic tool. For patients confirmed with cryptorchid torsion, immediate surgical exploration and correction are recommended, and prophylactic fixation of the contralateral testis is advisable to prevent potential risks. The timing and degree of torsion directly affect the survival rate of the testis, making early identification and intervention vital for improving outcomes. Strengthening the follow-up and management of patients with cryptorchidism and promptly addressing potential testicular torsion can effectively reduce the occurrence of complications and improve the quality of life for patients.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://tau.amegroups.com/article/view/10.21037/tau-24-468/rc

Data Sharing Statement: Available at https://tau.amegroups.com/article/view/10.21037/tau-24-468/dss

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and approved by the Ethics Committee of Anhui Provincial Children's Hospital (No. EYLL-2023-02-008). Eligible patients were enrolled after obtaining written informed consent from their legal guardians.

References

1. Holmboe SA, Beck AL, Andersson AM, et al. The epidemiology of cryptorchidism and potential risk factors, including endocrine disrupting chemicals. Front Endocrinol (Lausanne) 2024;15:1343887.
2. Boyd GE, Patel B, McBride CA. Pre-referral ultrasound for cryptorchidism: Still common, still not necessary. J Paediatr Child Health 2024;60:867-73.
3. Ergül RB, Bayramoğlu Z, Keçeli AM, et al. Risk for testicular germ cell tumors and spermatogenesis failure in post-pubertal undescended testes. Int Urol Nephrol 2024;56:2269-74.
4. Feng S, Yang H, Lou Y, et al. Clinical Characteristics of Testicular Torsion and Identification of Predictors of Testicular Salvage in Children: A Retrospective Study in a Single Institution. Urol Int 2020;104:878-83.
5. Seizilles de Mazancourt E, Khene Z, Sbizerra M, et al. Cut-off time for surgery and prediction of orchiectomy in spermatic cord torsion: a retrospective multicentric study over 15 years. World J Urol 2023;41:3789-94.
6. Demirbas A, Demir DO, Ersoy E, et al. Should manual detorsion be a routine part of treatment in testicular torsion? BMC Urol. 2017;17(1):84.
7. Pogorelic Z, Neumann C, Jukic M. An unusual presentation of testicular torsion in children: a single - centre retrospective study. Can J Urol 2019;26:10026-32.
8. Naouar S, Braiek S, El Kamel R. Testicular torsion in undescended testis: A persistent challenge. Asian J Urol 2017;4:111-5.
9. Erginel B, Soysal FG, Celik A, et al. Neonatal perforated appendicitis in incarcerated inguinal hernia in the differential diagnosis of testis torsion. Pediatr Int 2017;59:831-2.
10. Mitsui T. Effects of the prenatal environment on cryptorchidism: A narrative review. Int J Urol 2021;28:882-9.
11. Cheng Z, Wang M, Xu C, et al. Mutational analysis of HOXA10 gene in Chinese patients with cryptorchidism. Andrologia 2017.
12. Gurney JK, McGlynn KA, Stanley J, et al. Risk factors for cryptorchidism. Nat Rev Urol 2017;14:534-48.
13. Zhong HJ, Tang LF, Bi YL. Cryptorchid testicular torsion in children: characteristics and treatment outcomes. Asian J Androl 2021;23:468-71.
14. Zvizdic Z, Jonuzi A, Glamoclija U, et al. Clinical characteristics and outcome of children with acute cryptorchid testicular torsion: A single-center, retrospective case series study. Am J Emerg Med. 2024, 82: 4-7.
15. Elder JS. Surgical Management of the Undescended Testis: Recent Advances and Controversies. Eur J Pediatr Surg 2016;26:418-26.
16. Beaud N, Kanbar A, Abdessater M. Anatomical risk factors for spermatic cord torsion and their involvement in the choice of orchidopexy technique. Morphologie 2021;105:1-9.
17. Kaefer M, Agarwal D, Misseri R, et al. Treatment of contralateral hydrocele in neonatal testicular torsion: Is less more? J Pediatr Urol 2016;12:306.e1-4.
18. Martin AD, Rushton HG. The prevalence of bell clapper anomaly in the solitary testis in cases of prior perinatal torsion. J Urol 2014;191:1573-7.
19. Pogorelić Z, Mrklić I, Jurić I, et al. Testicular torsion in the inguinal canal in children. J Pediatr Urol 2013;9:793-7.
20. Dupond-Athénor A, Peycelon M, Abbo O, et al. A multicenter review of undescended testis torsion: A plea for early management. J Pediatr Urol 2021;17:191.e1-191.e6.
21. Zhang K, Zhang Y, Chao M. Clinical characteristics and identification of risk factors of testicular torsion in children: A retrospective study in a single institution. Front Surg 2023;9:1040487.

22. McDowall J, Adam A, Gerber L, et al. The ultrasonographic "whirlpool sign" in testicular torsion: valuable tool or waste of valuable time? A systematic review and meta-analysis. Emerg Radiol 2018;25:281-92.
23. Wang S, Tang H, Zhang J, et al. Comparison of clinical features and outcomes between two age groups of cryptorchidism testicular torsion in children: a retrospective study in single center. Front Pediatr 2024;12:1296222.
24. Karami H, Yaghoobi M, Hasanzadeh Hadad A. Emergency laparoscopic orchiectomy for intra-abdominal testicular torsion--a case report. Urol J 2013;10:1013-5.
25. Ota K, Fukui K, Oba K, et al. The role of ultrasound imaging in adult patients with testicular torsion: a systematic review and meta-analysis. J Med Ultrason (2001) 2019;46:325-34.
26. Mori T, Ihara T, Nomura O. Diagnostic accuracy of point-of-care ultrasound for paediatric testicular torsion: a systematic review and meta-analysis. Emerg Med J 2023;40:140-6.
27. Chen P, Yang Z, Chen N, et al. Diagnosis and treatment of cryptorchid testicular torsion in children: A 12-year retrospective study. Front Pediatr 2022;10:968997.
28. Spaziani M, Lecis C, Tarantino C, et al. The role of scrotal ultrasonography from infancy to puberty. Andrology 2021;9:1306-21.
29. Klang E, Kanaan N, Soudack M, et al. Torsed and Nontorsed Inguinal Undescended Testis: Comparison of Computed Tomography Findings. J Comput Assist Tomogr 2017;41:633-7.
30. Moore CP, Marr JK, Huang CJ. Cryptorchid testicular torsion. Pediatr Emerg Care 2011;27:121-3.
31. Indiran V. Cryptorchid testis with torsion: Inguinoscrotal whirlpool sign. Indian J Urol 2016;32:247-8.
32. Siraj QH. Functional Imaging of Testicular Torsion. Semin Nucl Med 2023;53:797-808.
33. Mao CK, Cao YS, Liu X, et al. The diagnosis and treatment of testicular torsion in children with non-scrotal initial symptoms. Front Pediatr 2023;11:1176345.
34. Şener NC, Bas O, Karakoyunlu N, et al. A rare emergency: testicular torsion in the inguinal canal. Biomed Res Int 2015;2015:320780.
35. Yığman M, Ekenci BY, Durak HM, et al. Predictive factors for manual detorsion success in testicular torsion. Int Urol Nephrol 2024;56:3797-804.
36. Vazquez JL, Fernandez MJ, Comendador-Morales A, et al. Testicular torsion and ultrasound-assisted manual detorsion. Pediatr Radiol 2024. [Epub ahead of print]. doi: 10.1007/s00247-024-06008-1.
37. Abdelhalim A, Chamberlin JD, McAleer IM. A Survey of the Current Practice Patterns of Contralateral Testis Fixation in Unilateral Testicular Conditions. Urology 2018;116:156-60.
38. Canbaz FA, Gerçel G, Sag S. The management of testicular torsion: A survey of Turkish pediatric surgeons and pediatric urologists. Ulus Travma Acil Cerrahi Derg 2024;30:685-93.
39. Kabore FA, Kabore KK, Kabore M, et al. Predictive factors for orchiectomy in adult's spermatic cord torsion: a case-control study. Basic Clin Androl 2021;31:2.
40. Gold DD, Lorber A, Levine H, et al. Door To Detorsion Time Determines Testicular Survival. Urology 2019;133:211-5.
41. Mellick LB, Sinex JE, Gibson RW, et al. A Systematic Review of Testicle Survival Time After a Torsion Event. Pediatr Emerg Care 2019;35:821-5.
42. Guo X, Sun L, Lei W, et al. Management of testicular torsion <360 degrees in children: a single-center, retrospective study. J Int Med Res 2020;48:300060519895861.
43. Deng T, Zhang X, Wang G, et al. Children with Cryptorchidism Complicated by Testicular Torsion: A Case Series. Urol Int 2019;102:113-7.
44. Yu CJ, Zhao J, Luo J, et al. Long-term follow-up results of testicular torsion in children. Asian J Androl 2022;24:653-9.
45. Yang M, Wen S, Lin T, et al. Diagnosis, treatment, outcome, and reasons for delayed treatment of cryptorchidism with torsion in children: a 16-year retrospective study in a large pediatric medical center. Asian J Androl 2022;24:386-9.
46. Komarowska MD, Pawelczyk A, Matuszczak E, et al. Is Testicular Torsion a Real Problem in Pediatric Patients With Cryptorchidism? Front Pediatr 2021;8:575741.

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