were transferred from another facility. We hypothesized that factors other than symptom duration, such as transfer from an outside facility, age, time of day of presentation, insurance type or ethnicity, may affect testicular salvage in patients with acute scrotum.

METHODS

Following approval from the local institutional review board, we retrospectively reviewed charts of all patients with a diagnosis of acute testicular torsion presenting between 2005 and 2011. Charts to be abstracted were identified based on having an ICD-9 code for testicular torsion (608.2, 608.20, 608.21, 608.22). All charts were electronic. We included all patients seen in the emergency department (ED) who underwent surgical exploration at our institution. Our referral center is the main pediatric treatment facility for a large geographic area, routinely caring for patients who live more than two hours away. Patients who were transferred were sent from the outside facilities' EDs to the ED at our facility, where they were reevaluated prior to surgery. A diagnosis of testicular torsion was made prior to surgical exploration and confirmed at the time of surgery. All patients underwent Doppler ultrasonography either at their presenting hospitals or at our institution prior to surgical exploration. We excluded from the analysis patients with neonatal torsion and suspected intermittent torsion who were treated in a non-emergent fashion.

All charts were reviewed and data extracted by a single reviewer (the lead author). Data were extracted from hospital charts regarding age, insurance type, ethnicity, whether or not the patient was transferred, presentation before 5pm vs. after 5pm, duration of symptoms prior to presentation in any ED, time from first presentation in any ED to surgical exploration, and results of scrotal exploration (orchiectomy vs. orchidopexy). We decided to use a cutoff time of 5pm to analyze patients, hypothesizing that the time the patient presented could influence the decision to transfer a patient to our facility. The decision to proceed with orchiectomy or orchidopexy was made by each individual surgeon based on the appearance of the testicle during exploration. Insurance type was categorized as Medicaid, private (PPO/HMO), or managed Medicaid (Medi-cal HMO). We excluded from the analysis seven patients with a particular type of insurance (CPCMG) as these patients are contractually obligated to be treated at our facility. Symptom duration was recorded as the longest duration of symptoms prior to initial presentation reported by the patient or caregiver to any provider during the evaluation. We characterized ethnicity as Hispanic or non-Hispanic. Records from transferring facilities were not available for review in all cases; therefore, we could not record the reason for transfer or whether or not a local urologist was contacted before initiating transfer. We calculated the time to surgical exploration as time from first presentation in any ED to the operating room start time recorded on the anesthesia record at our facility.

Univariate comparative statistics including Mann-Whitney u-test and Spearman Rank correlation for continuous, non-normally distributed variables, and Chi^2 test and Fisher's exact test for categorical variables, were used to examine associations between our variables of interest and testicular salvage. Age was found to have a bimodal distribution and was examined as both a continuous measure and grouped into younger than eight years vs. ≥ eight years-old. We used binary logistic regression models (multivariate) to determine significant predictors of testicular salvage in the overall cohort, as well as separately in the younger than eight and older than eight-year-old age groups. Variables at or approaching significance on univariate analysis ($p<0.2$) and clinically relevant variables were entered in the models. We included in the final models only variables that remained significant. All tests were performed using SPSS v 17.0 (Chicago, IL, USA) with statistical significance set a priori at $\alpha<0.05$.

RESULTS

We included 114 patients in the final analysis. Testicular salvage was possible in 63 patients (55.3%), and orchiectomy was performed in 51 patients. The mean age of the cohort was 11.3 ± 4.7 years. Thirty-five (31%) patients were transferred to the pediatric hospital after presenting in another ED, compared with 79 (69%) who presented primarily. In the entire cohort, median duration of symptoms prior to ED presentation was seven hours, and median time to operating room from first presentation was 3.33 hours. Testicular salvage rate was not different between patients who were transferred to our facility vs. those who presented primarily (60% vs. 53.2%, $p=0.55$). On univariate analysis, age, time to the operating room and duration of pain, was significantly different amongst patients who underwent orchiectomy vs. orchidopexy. Patient characteristics and results of the univariate analysis are listed in Table 1. Patients older than eight years of age were more likely to undergo orchidopexy than those younger than eight years (61.5% vs. 30.4%, $p=0.01$). Median duration of pain prior to presentation was higher in the orchiectomy vs. orchidopexy groups (42 vs. 4 hours, $p<0.001$). Patients who had symptoms for less than six hours were much more likely to undergo orchidopexy than those with symptoms for six hours or more (90% vs. 28.6%, $p<0.001$). Median time to the operating room from first presentation was higher in the orchiectomy group compared to the orchidopexy group (240 vs. 180 minutes, $p=0.02$). Ethnicity, insurance type, and laterality did not affect the testicular salvage rates.

Table 2 compares patients who were transferred to those who presented primarily. Transferred patients had longer median times to the operating room than primary patients (260 vs. 177 min, $p<0.001$). In regards to insurance status, transferred patients more likely to have Medicaid than those who presented primarily (40% vs. 19%, $p=0.05$); however,

Table 1. Patient characteristics, univariate analysis comparing testicular salvage.

	Orchiectomy n=51	Orchidopexy n=63	p-value
Median age (IQR), years	12 (4-14)	13 (12-14)	0.17
Age group			0.01
<8 years (n=23)	16 (69.6%)	7 (30.4%)	
≥8 years (n=91)	35 (38.5%)	56 (61.5%)	
Race			0.85
Hispanic (n=53)	24 (47.4%)	29 (52.6%)	
Other (n=57)	27 (45.3%)	30 (54.7%)	
Side			0.56
Left (n=69)	33 (47.8%)	36 (52.2%)	
Right (n=44)	18 (40.9%)	26 (59.1%)	
Insurance			0.09
Private (PPO/HMO) (n=48)	18 (37.5%)	30 (62.5%)	
Medi-cal HMO (n=37)	15 (40.5%)	22 (59.5%)	
Medicaid (n=29)	18 (62.1%)	11 (37.9%)	
Admission			0.55
Primary (n=79)	37 (46.8%)	42 (53.2%)	
Transfer (n=35)	14 (40%)	21 (60%)	
Median time to operating room (IQR), minutes	240 (163-320)	180 (140-240)	0.02
Median duration of pain prior to operating room (IQR), hours	42 (18-72)	4 (2-6)	<0.001
Duration of pain			<0.001
<6 hours (n=50)	5 (10%)	45 (90%)	
≥6 hours (n=63)	45 (71.4%)	18 (28.6%)	

PPO, preferred provider organization; *HMO*, health maintenance organization

this was not statistically significant. Time of day, ethnicity, and age group did not affect transfer status.

On multivariate analysis of factors associated with testicular salvage, only duration of symptoms prior to presentation of less than six hours remained a significant predictor of testicular salvage (OR 22.5, p<0.001) (Table 3). Transfer status, age, time to operating room from first presentation, race, and insurance status were not significant predictors of testicular salvage. In a subgroup analysis of the patients ≥ eight years old, duration of symptoms was again the only predictor of testicular salvage (OR 22.5, p<0.001). In subgroup analysis of patients < eight years of age (n=23), no variables examined were predictive of testicular salvage.

DISCUSSION

Our study showed that duration of symptoms prior to presentation was the most significant factor in testicular salvage overshadowing other factors such as age and transfer status. This was especially the case in older patients. Neither transfer status nor time to surgical exploration independently predicted testicular salvage. While transfer status did delay surgical exploration in our patient cohort, transferring a patient did not change overall outcome in our series. Nevertheless, delaying definitive surgical exploration may have resulted in orchiectomy in a small number of patients. In other words, transferring patients who already have relatively long duration of symptoms prior to presentation may result in orchiectomy. It is impossible to truly know whether transferred patients could have been salvaged had they not been transferred.

Children from surrounding areas are frequently transferred to our center, not only for treatment of urologic emergencies, but also for diagnostic tests. Lack of pediatric expertise at community treatment facilities, such as pediatric anesthesiology or pediatric radiology, may also necessitate transfer of pediatric patients. While such inter-hospital transfer is appropriate and essential in many cases, there is concern that it results in delay of care for time-dependent conditions such as testicular torsion.

Bayne et al.[1] reported a series of 97 testicular torsion patients. Those investigators found that transfer delay in patients with potentially salvageable testes (i.e. those with symptoms less than 24 hours duration) puts those children at risk for orchiectomy. Patients who underwent orchiectomy also had longer pain duration and lived farther away from the

Table 2. Comparison of primary and transferred patients.

	Primary	Transfer	p-value
Salvage			0.546
Orchiectomy (n=51)	37 (46.8%)	14 (40%)	
Orchidopexy (n=63)	42 (53.2%)	21 (60%)	
Age group			1.00
<8 (n=23)	16 (20.3%)	7 (20%)	
≥8 (n=92)	63 (79.7%)	28 (80%)	
Ethnicity			0.68
Hispanic (n=53)	36 (46.8%)	17 (51.5%)	
Other (n=59)	43 (41 (53.2%)	16 (48.5%)	
Time of day			0.42
Day (n=62)	45 (57%)	17 (48.6%)	
Night (n=52)	34 (43%)	18 (51.4%)	
Insurance			0.05
Private insurance (PPO/HMO) (n=48)	35 (44.3 %)	13 (37.1%)	
Medi-cal HMO (n=37)	29 (36.7%)	8 (22.9%)	
Medicaid (n=29)	15 (19%)	14 (40%)	
Median time to operating room (IQR), minutes	177 (140-229)	260 (220-360)	<0.001
Median duration of pain prior to operating room (IQR), hours	8.5 (3.8-48)	6 (2-24)	0.11

PPO, preferred provider organization; *HMO*, health maintenance organization

Table 3. Multivariate analysis predicting orchidopexy in the overall cohort and in patients ≥ 8 years old.

Duration of symptoms < 6 hours prior to ED presentation (≥6 = ref)	OR	95% CI		p-value
Overall cohort (n= 114)	22.5	7.69	65.83	<0.001
Age ≥ 8yr (n=91)	22.5	6.74	75.15	<0.001

ED, emergency department

hospital. Similar to our findings, the investigators reported that age was not an independent risk factor predicting orchiectomy, even though patients who received orchiectomy were younger than those who avoided orchiectomy.[1]

The clinical presentation of testicular torsion, especially in younger children may overlap other non-surgically managed processes, such as torsion of an appendix epididymis or appendix testis. While most adult men would be able to describe symptoms, such as sudden onset of pain, quality of pain, and duration of pain, pediatric patients are much less reliable historians. Because obtaining an accurate history is difficult, we have found that exploration for all acute scrotums may lead to many negative explorations. This has described by Lam et al.[5] Therefore, most patients with the acute scrotum that present to our ED go immediately to ultrasound, a practice that has been endorsed by the American College of Radiology in their recommendations regarding imaging for acute onset scrotal pain.[6]

The current series failed to identify any predictors of testicular salvage in patients younger than eight years. Younger children may have difficulty communicating their symptoms to caregivers and may not have noticeable physical findings such as scrotal swelling or firmness until later in the course of their disease. Children who do not require as much assistance for bathing or using a toilet may not have close monitoring of their genitalia by their caregivers. Therefore, these young children may be the most vulnerable group, as they may not express their symptoms clearly. The duration of symptoms in this group may be even longer than what caregivers communicated in the patient's history in the current series. In several studies, children with acute testicular torsion have symptoms other than scrotal pain and swelling, such as abdominal pain, nausea, and vomiting.[7-9] It is crucial for providers to perform a focused genital examination for boys who present with abdominal pain, especially when patients may not be able to accurately describe their symptomatology.

Other researchers have shown that despite disease severity, children who are uninsured or have Medicaid insurance are more likely to undergo hospital transfer.[10,11] We initially hypothesized that insurance status or socioeconomic factors may affect the rate of testicular salvage or transfer rates in our cohort. While insurance

status did not impact the rate of testicular salvage, there was an alarming trend toward increasing transfer rates in patients with Medicaid compared to private insurance. While our study was not able to truly demonstrate statistical significance, this trend may very well be clinically relevant. Larger studies are needed to further characterize the effects of insurance on patient outcomes.

LIMITATIONS

Our study has several important limitations, including the retrospective nature of the data. Chart reviews and historical accounts may have significant inaccuracies in regards to subjective information such as duration of symptoms. Charts and data from transferring institutions were not always available for review, making it difficult to know why patients were transferred. For the transferred patients, we could not determine if there was a local urologist available or if a local urologist had been contacted prior to initiating a transfer to our facility. We were also not consistently able to calculate distances from patients' homes to the ED where they presented or if there was any correlation between home zip code and insurance type. Outcomes for those patients who were surgically treated at outside facilities instead of being transferred are also not known. We also may have had an inadequate sample size to detect significant differences resulting from insurance type. Specifically, the number of transferred patients was small compared to the number of patients who presented primarily, and the number of patients younger than eight years was small compared to patients older than eight years. Finally, we do not have long-term follow-up data for most of our patients, especially in terms of postoperative testicular viability in patients who underwent testicular salvage. Despite these important limitations, the current data reinforces conclusions in prior studies[1,4,14] that delays in presentation and treatment are more likely to be associated with the need for orchiectomy.

CONCLUSION

Time to presentation to the ED is the most important factor in predicting testicular salvage in patients with acute testicular torsion. Boys with acute scrotum should be referred quickly for emergency care to increase their chances of testicular salvage. Evaluation of abdominal pain should include a brief genital exam, especially in younger patients who may not be able to accurately describe their symptoms. Children and families should be educated on the seriousness of severe testicular pain and its consequences.

Address for Correspondence: Puneeta Ramachandra, MD, Valley Children's Hospital, 9300 Valley Children's Place, Madera, CA 93636. Email: puneeta.ramachandra@gmail.com.

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REVIEW ARTICLE

Testicular torsion: a race against time

S. Kapoor

SUMMARY

Torsion of the testis is a medical emergency that is most commonly encountered in adolescents. Patients usually present with sudden onset scrotal pain associated with nausea and vomiting. On physical examination the involved testis is tender, high riding and usually horizontal. The cremasteric reflex is usually absent. If left untreated irreversible ischaemia starts appearing in 6 h. Doppler ultrasound is the diagnostic imaging of choice. The ideal treatment is surgical exploration and orchidectomy with contralateral orchidopexy or bilateral orchidopexy depending on the condition of the affected testis. If surgical options are delayed then manual detorsion should be attempted.

Review Criteria

Information for this review was gathered by a search of PubMed using the keywords testicular torsion, acute scrotum, ultrasound, orchidectomy and orchidopexy.

Message for the Clinic

Testicular torsion is a condition that almost all physicians be it internists, paediatricians, emergency medicine physicians, primary care physicians, surgeons or urologists come across or are likely to come across. It is an emergent condition that requires timely recognition and immediate intervention to prevent testicular loss.

IL, USA

Correspondence to:
Shailendra Kapoor, MD
Email: trasoy9@aol.com

Disclosure
None.

Introduction

Testicular torsion was first described by Hunter. It is a medical and a urological emergency as it can lead to permanent ischaemic injury of the involved testis (1,2). The incidence rate of torsion in men < 25 years of age is one in 4000. Cummings et al. in a recent study reported that nearly 61% of the patients were < 21 years of age (3). The age distribution is bimodal with two peaks, one in the neonatal period and the other around 13 years of age (4). The oldest age at which torsion has been reported is 69 years. But overall torsion is rare in the elderly (5). According to Stehr et al., nearly 9% of children who present with an acute scrotum have underlying testicular torsion (6). Interestingly, higher incidence rates of torsion have been reported during the colder months, especially December (14%) (7).

Aetiology

Based on anatomy and age, testicular torsion is divided into two types:

Intravaginal

This is the more common type of testicular torsion. The most common anatomic anomaly identified in this type of testicular torsion is a narrow attachment of the tunica vaginalis from the spermatic cord to the testes secondary to high insertion of the tunica on the spermatic cord. This results in the bell clapper anomaly characterised by increased testicular mobility. In nearly 80% of patients this anomaly is bilateral. Intravaginal testicular torsion is commonly seen in adolescents and older males. This type of torsion commonly occurs during sleep. Torsion may also occur secondary to trauma. In these cases other lesions may accompany the torsion. For instance, Kwon et al. (8) recently reported the case of a patient who developed testicular torsion along with rupture of the epididymis, secondary to trauma.

Extravaginal

This type of testicular torsion is usually seen in the prenatal or neonatal period. Prenatal torsion usually occurs in utero around 32 weeks. Its exact cause is unknown and usually no anatomic defect that can explain the torsion can be identified. It is usually present at birth and carries a poor prognosis in terms of testicular salvage rates.

Extravaginal torsion is commonly seen in neonates and is often mistaken for a scrotal haematoma. For instance, Diamond et al. (9) recently reported a case series of five neonates initially diagnosed with torsion who were ultimately found to have scrotal haematomas.

An interesting yet rare phenomenon is familial torsion of the testes. Only a few cases have been reported so far. For instance, Okeke and Ikuerowo (10) recently reported a familial series of a man and

his three children all of whom developed left testicular torsion at the age of 15 years.

Pathology

Testicular torsion results in rotation of the testicular vascular pedicle resulting in testicular ischaemia and ultimately infarction if it is not addressed emergently. Uisser and Heyns have shown that the extent of the ischaemia and infarction depends on the duration and the degree of the torsion (11). The median degree of torsion in patients who undergo surgical exploration but do not require orchidectomy is less (360°) compared with those who undergo surgical exploration and require orchidectomy (540°) (12). Depending on the duration, the gross pathological changes may vary from congestion in the early stages to haemorrhagic infarction in the later stages. In nearly half of the patients an ipsilateral hydrocele is found on surgical exploration. As already mentioned perinatal torsion is usually extravaginal in contrast to torsion in later ages which is usually intravaginal. Extravaginal torsion is usually unilateral. However, rarely it may be bilateral (13). For instance, Sorensen et al. (14) recently reported the case of a male newborn who developed bilateral extravaginal testicular torsion. In extravaginal torsion, the torsion occurs outside the tunica vaginalis while in intravaginal torsion, it occurs within the tunica vaginalis. Besides the usual types of torsions, pathological variations in patterns of torsion may occur. For instance, Wiedemann et al. (15) recently reported the case of a 14 years old with testicular duplication who developed torsion of his supernumerary testis.

Clinical presentation

Patients usually present with hemiscrotal pain which is acute and excruciating in nature. Patients may also complain of abdominal pain. Nausea and vomiting are usually present (16). Low-grade fever may also be present in later stages. Patients usually deny any urinary complains. Torsion is usually unilateral, with only 2% of the patients developing bilateral torsion. For instance, Kuremu recently reported the case of a patient with bilaterial torsion (17). The left side tends to be more commonly affected. Torsion in undescended testes is also more common on the left side. In fact, Zilberman et al. in a recent study reported that 73% of all torsions in undescended testes occurred on the left side (18). It also needs to be remembered that although torsion is more common in the younger age groups it may occur at any age. For instance, Davol and Simmons (5) recently reported the case of a 68-year-old man who was initially thought to have orchitis but was ultimately found to have testicular torsion. Physicians should also be aware that torsion is 10 times more likely in individuals with cryptorchidism. For instance, Candocia and Sack-Solomon (19) recently reported the case of a 7 months old with cryptorchidism who developed torsion of the testes in the inguinal canal. Hence, any patient with a history of undescended testes who presents with sudden abdominal pain should always be evaluated for possible torsion. As mentioned before, higher rates of torsion have been reported during the colder months. For instance, Williams et al. (7) in a recent study reported an incidence rate of 30% during the fall season and 24% during the winter season compared with 22% in the summer season. Similar results have been reported by Al-Hunayan et al. (20).

Barada et al. (21) in a retrospective study has shown that there is an age-related variance in the presentation of testicular torsion. In general males < 18 years of age tend to present later than those more than 18 years of age. This hesitancy on the part of the patients', especially younger males further worsens the prognosis and testicular salvage rates. This is because after 10 h nearly 80% of affected testes are infarcted while after 24 h nearly 100% of involved testes are infarcted and thus non-salvageable (22).

On palpation the involved testes is exquisitely tender, so much so that clinical examination may be impossible. The affected testis generally tends to be retracted and higher in the scrotum and is usually horizontal (23). Anterior presentation of the epididymis is another common clinical sign. Testicular elevation (Prehn's sign) does not relieve the pain, unlike in patients with orchitis. Typically, it is difficult to elicit the cremasteric reflex on the affected side. Previous studies by Rabinowitz (24) had suggested that the sensitivity of an absent cremasterix reflex in diagnosing torsion was 100%. However, this test might be less sensitive than previously reported (25). For instance, Paul et al. (26) in a recent study reported that the reflex has a sensitivity of only 88.2% and a specificity of 86.2%.

In prenatal torsion the new born has a testicular swelling at birth. The swelling is usually non-tender and hard, thus making it difficult to distinguish from a tumour. Intra-uterine torsion of testicular tumours has also been reported. For instance, Fuhrer et al. (27) recently reported the case of intra-uterine torsion of a testicular teratoma.

Chronic intermittent torsion

In chronic intermittent torsion, the patient complains of recurrent episodes of acute unilateral scrotal pain. The pain usually resolves spontaneously within

a few hours. The clinical examination is usually normal by the time the patient presents to the physician. Similarly, the imaging studies are usually normal if the patient presents after resolution of the torsion. As recently reported by White et al., chronic intermittent torsion may rarely result in segmental ischaemia of the testis (28).

Differential diagnosis

Testicular torsion needs to be distinguished from other acute causes of acute scrotal pain such as strangulated hernias, orchitis, epididymitis and torsions of the testicular appendages. In testicular torsion, the pain is more severe and acute in onset compared with epididymo-orchitis. Torsion of a testicular appendage accounts for 35–67% of all cases of acute scrotal pain in children (29). Torsion of a testicular appendage can be distinguished by its gradual onset and the presence of the blue dot sign, localised tenderness at the upper pole of the testis and the absence of nausea and vomiting. The cremasteric reflex is usually present in sharp contrast to testicular torsion. The disease process is self-limited and complete resolution of symptoms occurs within a few days. Dunne and O'Loughlin (22) in a study reported that of 99 patients who underwent surgical exploration for possible torsion 15 were found to have epididymo-orchitis while another 8 were found to have torsion of a testicular appendage. Hence, clinical differentiation between these disease entities may be extremely difficult. If there is history of acute trauma testicular fracture and haematoceles should also be high on the differential. Prostatitis may also present with intermittent testicular pain. Other causes of acute scrotum include Henoch-Schonlein purpura and polyarteritis nodosa (30).

In the paediatric age group, appendicitis forms another important part of the differential as it may mimic torsion. Varga et al. (31) in a recent study have reported that acute epididymitis is the commonest cause of acute scrotum in children. In their study, testicular torsion was responsible for 11.7% of all cases of acute scrotal pain. In neonatal torsion, the differential diagnosis should include testicular neoplasms, adrenal haemorrhages, haematoceles, hydroceles, inguinal hernias and meconium peritonitis (32). As reported by Raveenthiran et al. recently, scrotal and peri-scrotal abscess may also mimic torsion (33).

Investigations

Blood tests

The complete blood count is usually normal. In contrast, elevated white blood cell counts may be seen in infectious processes such as orchitis.

Urinalysis

The urinalysis is usually normal. Rarely pyuria may be seen. Overall although, pyuria is more common in prostatitis and epidymitis (34).

Imaging

Immediate imaging is necessary if testicular torsion is high on the differential. Modalities of imaging commonly used include:

Doppler ultrasound

Over the past few years, ultrasound has become the diagnostic imaging of choice when testicular torsion is high on the differential (35). Ideally, both pulsed and colour Doppler ultrasound should be used. In complete torsion the blood flow is completely absent on Doppler imaging. In incomplete torsion the blood flow may still be seen. The ultrasound findings differ depending on the duration of the torsion. In general, the affected testis may be enlarged and have a heterogenous appearance (36). Nussbaum et al. have also shown that increased epididymal size when accompanied by avascularity is an additional indicator of testicular torsion (37). In contrast, Doppler ultrasound usually demonstrates increased blood flow in epididymo-orchitis. According to Baker et al., colour Doppler has a sensitivity of 88.9% and specificity of 98.8% (38). Colour Doppler has also been shown to be slightly less sensitive compared with power Doppler. Interestingly, ultrasounds can also be used to diagnose prenatal torsion (39). For instance, Herman et al. recently reported a case in which prenatal torsion in utero in a 33-year-old multigravida was diagnosed using ultrasound imaging (40).

Magnetic resonance imaging

Magnetic resonance imaging (MRI) can also be used for the diagnosis of torsion (41). In a recent retrospective study, Terai et al. (42) reported that MRI imaging has a sensitivity rate of 93% and a specificity rate of 100% in diagnosing testicular torsion.

Radionuclide scintigraphy

This imaging modality can also be used to assess testicular blood flow. The sensitivity of radionuclide scintigraphy is 95% while the specificity varies from 80% to 100% (43). The isotope commonly used is Tc 99. Testicular torsion is associated with poor Tc 99 uptake and appears as a cold spot on the scintigram. In contrast to ultrasound imaging, radionuclide scintigraphy requires an intravenous (i.v.) access and the procedure usually takes a longer time (1).

Infrared thermography

Capraro et al. (44) in a recent study demonstrated the effectiveness of infrared thermography in diagnosing testicular torsion. Further studies involving this temperature-based method are necessary to evaluate its sensitivity and specificity in humans.

Complications

Infertility

Spermatogenesis is significantly impaired in most of the patients who experience torsion. Nearly 36% of the patients have sperm counts < 20 million/ml (11). Recent studies by Fu et al. (45) suggest that antisperm antibodies and inhibin B can be used as markers of testicular function following surgery.

Affect on the contralateral testes

Various researchers including Akgur et al. (46) have suggested that unilateral testicular torsion may cause biochemical changes in the contralateral testis which may be further exacerbated by manual or surgical detorsion. Vigueras et al. (47) in a recent animal study reported that the percentage of seminiferous tubules affected in the contralateral testis was significantly higher in the animals that underwent detorsion (58.6%) following torsion compared with those who underwent orchidectomy (48%) following torsion. It has been postulated that neuro-hormonal pathways might be involved in this contralateral damage. Various medications such as pentoxifylline have been shown to increase the blood flow to bilateral testes following unilateral detorsion (48). However, the issue of contralateral damage is still controversial as other researchers such as Stern et al. (49) have refuted these claims.

Management

Any male presenting with an acute tender scrotal swelling should be considered as having torsion unless the history, examination or imaging points to the contrary. If a diagnosis of testicular torsion is confirmed by imaging or if there is any doubt about the correct diagnosis emergent surgical exploration is necessary.

General

Providing appropriate analgesia is of prime importance. An i.v. access should also be established immediately.

Manual detorsion

Manual detorsion may be attempted if the surgical option is not available or while preparations for surgery are being made. Manual detorsion may also be attempted in patients with a history chronic intermittent torsion presenting with unresolving scrotal pain (50). Adequate i.v. sedation or spermatic cord anaesthesia may be necessary as this is undoubtedly a painful procedure. Vigueras et al. (51) have also reported the successful use of naloxone to relieve the pain. The testes are usually detorsed from the medial side to the lateral side. Thus, the right testis is rotated in a counterclockwise direction while the left testis is rotated in a clockwise direction. The subjective end-point is resolution of scrotal pain, which is dramatic if the manoeuvre is successful. Restoration of Doppler blood flow is the objective end-point. If manual detorsion is indeed attempted it should not delay surgical exploration. The manual detorsion of testicular appendages can also be attempted under ultrasound guidance. In fact, in a recent study by Park et al. (52) a success rate of 80% was achieved by using this technique.

Surgical exploration

Urgent surgical intervention is necessary in all cases with an acute scrotum if a definitive diagnosis has been made by Doppler or if the diagnosis is not clear. This is because if left alone irreversible ischaemia starts occurring after 6 h. Anderson and Williamson (53) have shown that nearly 75% of patients need orchidectomy if surgery is delayed for more than 12 h. Scrotal erythema usually indicates a poor prognosis. Testicular salvage rates in undescended testes are worse than those for torsion in descended testes. In fact, Zilberman et al. (18) in a recent case series reported severe necrosis or ischaemia in 45% of the patients who underwent exploration for torsion of an undescended testis. Similarly, various researchers including Cummings et al. (3) have shown that testicular torsions at a later age are associated with a greater risk of orchidectomy.

The trans-scrotal approach is usually used. On exploration, surgical derotation of the affected spermatic cord and testes is performed. Viability of the testes is assessed after detorsion. Orchidectomy is performed if the testes are necrotic and non-viable. Mansbach et al. have reported that nearly 34% of all patients presenting with torsion end up getting an orchidectomy (54). Lower rates of orchiectomies, some as low as 19.6% have been reported from other countries (20). Whenever possible, orchidectomy should be accompanied by orchidopexy on the contralateral side. If after detorsion the testes are found to be viable then orchidopexy should be performed on both sides. Orchidopexy for torsion involves suturing the tunica albuginea to the dartos muscle.

The use of non-absorbable sutures during orchidopexy has been shown to be associated with lower torsion recurrence rates after surgery. Bolln et al. (55) in a recent study reported that 85% of surgeons use the suture technique while 15% use the sutureless technique for fixation. They also reported that nearly 95% of surgeons fix the contralateral testes routinely. Fixation may be one-, two-, three- or four-points. Pearce et al. (56) in a recent survey of urologists reported that nearly 57% of those surveyed usually used three-point fixation.

As reported by Halland and Jonler recently, torsion may recur after fixation (57). Testicular atrophy may also develop following surgery. Al-Hunayan et al. (20) in a recent case series reported that 13.5% of the patients developed testicular atrophy on follow up after 3 months. In another recent study, Arap et al. (58) studied the effects of surgical management of torsion on postoperative semen parameters. They reported that patients showed a decrease in sperm count and morphology irrespective of whether they underwent orchidectomy or orchidopexy.

The treatment for chronic intermittent torsion is also elective orchidopexy on the affected side with prophylactic orchidopexy on the other side. Eaton et al. (59) in a recent study have reported that the mean number of painful scrotal episodes prior to surgery in patients with intermittent torsion is 4.3.

Studies by Cuervo et al. and others have shown that in neonates with testicular torsion the testicular salvage rates are poor (60). Hence, the primary reasons for surgical exploration in neonatal torsion is to confirm the diagnosis, remove the necrotic testes and differentiate it from other possible conditions such as malignancies. Exploration in neonatal torsion also allows for orchidopexy of the contralateral testis.

Some researchers believe that surgical exploration and subsequent testicular detorsion may cause ischaemia–reperfusion injury (61). The free oxygen radicals such as superoxides produced during reperfusion result in lipid peroxidation of plasma membranes and increased cellular damage. Recent research has focused on chemicals that might prevent this reperfusion injury. In this regards allopurinol, caffeic acid phenethyl ester (CAPE), vitamin E, verapamil, tetronic 1107 and sildenafil have shown promising results (62–64). Abasiyanik and Dagdonderen have also shown that melatonin is another potent agent that is more effective than allopurinol in protecting the testes against ischaemia–reperfusion injury (65). Other chemicals that have been recently reported to have a protective affect against reperfusion injury in animal studies include propofol, α-lipoic acid, ibuprofen, dexpanthenol and even rosglitazone (66–70).

Conclusions

Testicular torsion needs to be ruled out in all patients presenting with an acute scrotum. It is a medical emergency as irreversible ischaemia starts developing as early as 6 h after the torsion. Immediate surgical intervention is necessary if there is any doubt about the diagnosis. Nearly 75% of patients need an orchidectomy if surgery is delayed for more than 12 h (53). Clearly, timely diagnosis and intervention can go a long way in decreasing the chances of testicular loss.

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REGULAR ARTICLE

Testicular torsion: a 15-year single-centre clinical and histological analysis

AK Saxena (amulya.saxena@medunigraz.at), C Castellani, EM Ruttenstock, ME Höllwarth

Department of Pediatric and Adolescent Surgery, Medical University of Graz, Graz, Austria

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Correspondence
A K Saxena, M.D., Department of Pediatric and Adolescent Surgery, Medical University of Graz, Auenbruggerplatz-34, A-8036 Graz, Austria.
Tel: +43 316 3853762 |
Fax: +43 316 3852775 |
Email: amulya.saxena@medunigraz.at

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ABSTRACT

Aim: This study reviewed the demographic, epidemiological and clinical factors of boys seen at a single centre who underwent surgical exploration for testicular torsion.

Methods: Retrospective single-centre review of boys with testicular torsion between 1996 and 2011 was made.

Results: Testicular torsion (right n = 43, left n = 60, bilateral n = 1) was identified in 104 boys between 0 and 18 years. Ten newborns presented with 11 intrauterine torsions. Nine torsions presented in undescended inguinal testes (one intrauterine). In 94 boys with descended testes, presentation included pain (76%), scrotal swelling (65%) and abdominal symptoms (22%). Ultrasonography was performed in 85 patients with false-negative results in 4 (4.7%). Orchiectomy was performed during initial exploration in 41, with significantly higher rates of orchiectomies in patients with late (>6 h) versus patients with early referrals (<6 h) (56% vs. 9.1%). Histological evaluation was carried out in 68 testes, with 43 resected testes demonstrating haemorrhagic necrosis. In 25 biopsied testes, histology revealed acute parenchymal bleeding (n = 14), onset of parenchymal infarction (n = 8), orchitis (n = 1) and normal tissue (n = 2). Eighty-two patients were followed up with pathological findings in four patients: testicular atrophies requiring orchiectomy (n = 2), testicular autolysis (n = 1) and small testicular vein thrombosis (n = 1).

Conclusion: Chances of testicular salvage after torsion are higher if patients present early. The majority of patients presenting late (>6 h) require orchiectomy owing to testicular necrosis.

AIM

The spectrum of testicular torsion encompasses a wide age range in the paediatric population, which affects newborns to children and adolescents (1,2). The aetiology of testicular torsion can be widely divided into (i) extravaginal types, which are common in the perinatal age groups, and (ii) intravaginal types, which are predominant in children and adolescents. In children and adolescents, a variety of clinical predictors such as pain duration of >24 h, nausea or vomiting, high position of the testicle, and abnormal cremasteric reflex have been identified to be associated with higher likelihood of torsion (3). In a recent report, even seasonal variations have also been implicated to contribute towards testicular torsion, with seasons with lower temperatures and humidity such as spring and winter being associated with increased incidences (4). Once suspicion of testicular torsion is raised, multiple investigations should be avoided to prevent any delays in surgical exploration and definitive intervention (5).

The diagnosis of testicular torsion falls under the category of acute scrotum, and Doppler ultrasound examination (DUS) has been found to be reliable for excluding other pathologies (6). DUS has proven to decrease the number of emergency scrotal explorations and the length of hospital stay and hence to reduce the cost of management of acute scrotum (7). However, it must be noted that ultrasound findings vary with the duration of the torsion, number of turns in the spermatic cord and the tightness in the compression of the vessels of the cord (8). An enlarged, spherical and hypoechogenic testis without detectable arterial and venous testicular flow at colour and power DUS is considered diagnostic of acute testicular ischaemia. The presence of a colour or power Doppler signal in one part of the testis does not exclude testicular torsion. Similarly, significantly diminished blood flow near or inside the mediastinum is observed in the partial or incomplete testicular torsion. Also, the presence of a large echogenic extra-testicular mass

Key notes

- Testicular torsion may present variations in doppler ultrasound, and hence, clinical evaluation is important to justify surgical exploration.
- Histological evaluation using intraoperative biopsies can assist in the decision of testicular salvage when severe ischaemia or haemorrhage is present.
- The possibility of testicular salvage after torsion is higher when the patients present within 6 h after the onset of symptoms.

distal to the site of the torsion that is frequently misinterpreted as a chronic epididymitis can provide the clues to the diagnosis of testicular torsion. Furthermore, a small arterial sign with a low-amplitude waveform may be present with an increased resistive index on the affected side because of a diminished, absent or reversed diastolic flow. The variations in DUS observed in testicular torsion and the interpretation of these results hence depend to a large extent on the expertise of the person performing the investigations.

In the perinatal age group, testes affected by prenatal torsions are never salvageable and hence may not necessitate emergent intervention, whereas those associated with postnatal torsions are invariably salvageable, and a judicious approach to surgical exploration is advocated (9). In any case, in order to warrant the timing of surgical exploration, investigation by DUS should be performed to determine the type of sonographic–pathologic stage of the affected testis (*Type 1 – Acute phase of testicular torsion*: marked enlargement of the affected testicle with heterogeneity in echogenicity, subtunica fluid and no detectable Doppler flow, *Type 2 – Earlier phase of progressive parenchyma atrophy*: normal testis size symmetric to uninvolved testis, peripheral hypoechogenicity and a small hydrocele, *Type 3 – Later phase of progressive parenchyma atrophy*: markedly diminished testicular size, areas of increased echogenicity throughout the testicle and no hydrocele) (10).

Although major strides have been made in the implementation of DUS in the diagnosis of testicular torsion both in the adolescent and in the paediatric age group, difficulties often remain in the conclusive interpretation of results for which surgical exploration is warranted. The aim of this study was to analyse the testicular torsion outcomes in the paediatric and adolescent age group in our population cohort with regard to time of presentation, diagnostic strategy, surgical findings and their correlation with histopathology, complications and follow-up results.

METHODS

The hospital database was retrospectively searched for all boys in the last 15 years who presented with testicular torsions. Inclusion criteria evaluated all patients with testicular torsion who underwent surgical explorations. Data were collected with regard to the age at presentation, time of presentation after developing symptoms (perinatal, *Group 1*: <6 h and *Group 2*: >6 h), diagnostic investigations, surgical findings, correlation with histopathology findings, complications, results of follow-up and outcomes. Statistical data analysis between the groups was performed using IBM SPSS statistical software version 19 (IBM Corporation, Armonk, NY, USA). All metric data are presented as median (minimum–maximum). For nominal data, crosstabs and Pearson's chi-squared test were used in search for statistical significances. In case of metric data, nonparametric Mann–Whitney *U*-test was performed. p-Values <0.05 were considered statistically significant.

RESULTS

During the period of evaluation from 1996 to 2011, the hospital database identified a total of 104 boys who presented with testicular torsion and had undergone surgical exploration or management (Table 1). The median age at presentation was 13.0 years (range 0–18). In this cohort, 43 boys (41%) presented with right-sided testicular torsion, while 60 boys (58%) had their left side affected, with one patient presenting with bilateral torsions. Ten newborns presented with intrauterine torsions, with the only patient presenting with bilateral torsions belonging to this age group.

The localization of the affected testis with regard to testicular descent was also analysed, and results showed that nine torsions were presented in boys with inguinal testis which included one newborn with intrauterine or prepartal testicular torsion. In the 94 boys with normally descended testes, the symptoms documented at the time of presentation were local pain (76%), scrotal oedema or swelling (65%) and abdominal symptoms (22%). DUS was performed in 85 patients with false-negative results in four patients (4.7%).

Time to referral and treatment was another important factor that was analysed with regard to salvage of the affected testis after torsion. In the 10 newborns presenting with prepartal or intrauterine torsions, no salvage of the affected testis was possible. Also, in this group, the neonate that presented with bilateral testicular torsion, testicular salvage was not possible and bilateral orchiectomy had to be performed. Besides the neonates with prepartal torsions, the

Table 1 Management overview of 104 paediatric and adolescent patients presenting with testicular torsion over a 15-year period

			Paediatric/adolescent n = 94	
Surgical management	Total torsions n = 104	Perinatal n = 10	Group 1 Presentation <6 h; n = 44 [Median age (range)] years	Group 2 Presentation >6 h; n = 50 [Median age (range)] years
Detorsion and unilateral orchidopexy	6	–	4 [14 (13–15)]	2 [11.2 (10–12)]
Detorsion and bilateral orchidopexy	56	–	36 [14.3 (0.6–18)]	20 [13.5 (1–16)]
Semicastration and contralateral orchidopexy	41	9	4* [10 (0.8–18)]**	28* [12.8 (0–17)]**
Castration	1	1	–	–

Significant differences were found with regard to testicular loss and time of presentation (*$p < 0.001$, χ^2 test), but not between testicular loss and age at presentation (**$p = 0.721$; Mann–Whitney *U*-test).

paediatric and adolescent patients were divided into two groups with regard to the time of referral or presentation in the emergency room: (i) *Group 1*: time to presentation <6 h and (ii) *Group 2*: time to presentation >6 h. The group sizes were comparable with 44 patients in *Group 1* and 50 in *Group 2* (Table 1). Unilateral detorsion and orchidopexy was possible in four patients in *Group 1* and two patients in *Group 2*, whereas unilateral detorsion and bilateral orchidopexy was performed in 36 patients in *Group 1* when compared to 20 patients in *Group 2*. Differences between the groups were found in patients undergoing ipsilateral orchiectomy along with contralateral orchidopexy with only four patients affected in *Group 1* and 28 patients in *Group 2*, which indicated that boys presenting <6 h of the onset of symptoms were significantly less likely to undergo orchiectomy of the affected testis ($p < 0.001$, χ^2 test). However, no significant differences were found with regard to testicular loss and age at presentation (except newborn testicular torsions) between the groups: *Group 1* – median age 14.3 years (range 1–18) and *Group 2* – median age 12.8 years (range 0–17) ($p = 0.721$; Mann–Whitney *U*-test).

Orchiectomy was performed during initial exploration in 41 patients, with delayed orchiectomies necessary in two patients. Histological evaluation was carried out in 68 testes, with 43 testes resected demonstrating haemorrhagic necrosis. In 25 testes biopsied, histology revealed acute parenchymal bleeding ($n = 14$), onset of parenchymal infarction ($n = 8$), orchitis ($n = 1$) and normal ($n = 2$). Follow-ups for a mean of 2.5 years (18 months to 5 years) were carried out in 82 patients with pathological findings in 4, two testicular atrophies requiring orchiectomy, one testicular autolysis and one small testicular vein thrombosis. Wound healing disturbances were documented in seven patients with revision necessary in one patient.

Prostheses were implanted in nine boys at a median age of 16.6 years (15–17) after a median interval of 1.1 years (0.1–4.4). Three of the implanted prostheses were associated with wound healing disturbances which were managed as follows: conservative treatment ($n = 1$), wound revision ($n = 1$) and prosthesis removal ($n = 1$).

DISCUSSION

Testicular torsion has two peaks with regard to the age at presentation in the paediatric population: (i) adolescence and (ii) newborns. Salvage of the affected testis, in prenatal testicular torsion presenting first at the time of birth, is not possible even if surgery is performed in an emergency setting (11). Complicated pregnancies such as prolonged labour, pre-eclampsia, gestational diabetes, twin pregnancy, higher birth weight as well as vaginal deliveries have been found to predispose patients to testicular torsion (9). This suggests that foetal stress and/or mechanical factors during pregnancy or delivery play a role in the pathogenesis of perinatal testicular torsion. Furthermore, contrary to previous reports, neonatal testicular torsions do not appear to favour one side or the other (9). In our cohort, unilateral prenatal testicular torsion was found in 9 of 10 patients with bilateral limited to only one patient. This is contrary to publications that have reported on bilateral perinatal testicular torsions and have estimated these torsions to be as high as 10–22% (12). Interestingly, there are several reports on prenatally detected testicular torsions on ultrasound, but the implications of this are unclear at present (13). Urgent extraction of the foetus might be justified in the last weeks of pregnancy in suspected acute bilateral prenatal testicular torsion, on the assumption that diagnosis was made shortly after torsion, but this intervention has not been reported so far.

In paediatric and adolescent patients, overlaps exist between testicular torsion and other pathologies that are associated with acute scrotum. Whereas DUS is an indispensable imaging modality for the clinical assessment of patients with acute scrotum, in the presence of a clinical suspicion of testicular torsion, even with an apparently normal-colour DUS, surgical exploration is still indicated (14). Hence, the importance of an accurate history and physical examination of boys with acute scrotum should not be underestimated. Keeping in mind the variations in DUS in various stages of testicular torsion, surgical explorations were carried out owing to the presence of clinical symptoms in our four patients with false-negative DUS findings. Among these, age, worsening pain, nausea/vomiting, severe pain at rest, absence of ipsilateral cremaster reflex, abnormal or high testicular position and scrotal skin changes have been shown to be predictive of torsion (15).

Under the aspect of physical examination, the option of manual detorsion of the testis needs to be considered. It deserved to be mentioned here that the traditional teaching that testicular torsion occurs primarily in the medial direction is misleading, because in a third of cases it occurs in the lateral direction (16). Hence, if manual detorsion is attempted, precaution should be taken to rotate the testis in the correct direction to relieve the torsion instead of further aggravating it. One option to be considered if manual detorsion is attempted is to perform it under DUS control in order to determine the correct direction of testicular rotation (17). However, it should be clearly stated that manual detorsion of the spermatic cord is not a substitute for surgical exploration and bilateral orchidopexy will be still necessary in these patients.

Time of presentation after the onset of testicular torsion plays the most important role in determining the possibility of testicular salvage. Late presentation to hospital is the major cause of delay leading to orchidectomy in patients with testicular torsion. With regard to the time of presentation, 'early' presentation in which the highest probability of testicular salvage is possible is accepted as referrals made <6 h after the onset of symptoms (18). In our present study, contrary to the fact that all testes presenting early are salvageable, four orchiectomies were performed in patients who presented early. The discrepancy here could possibly be incorrectness in the information provided by the patient or the caretaker with regard to the time of referral in these patients. 'Delayed' presentation (time of presentation >6 h) was responsible for 56% of the orchiectomies in our patients; nevertheless, a high percentage of testes could still

be salvaged in this group (44%). However, while comparing presentation <6 h to >6 h in our series, the rates or orchiectomies were 9% and 56%, respectively.

Determination of the viability and fate of a testis affected by ischaemia perfusion injury after testicular torsion at the time of surgical exploration and management solely depends on the discretion and experience of the surgeon. As surgical exploration of testicular torsion and its management is not a planned procedure, the availability of histopathology expertise is not possible round the clock. After exploration, and detorsion of the testis, the policy at our centre is to wrap the testis in warm saline gauze and to wait for 10–15 min and reassess the testis for visual signs of reperfusion. If no signs of reperfusion are evident, an orchiectomy is performed. In our patients, unilateral orchiectomy was performed during initial exploration in 41 patients at the time of initial exploration in which the testis did not demonstrate signs of reperfusion. Also, bilateral orchiectomy was performed in the neonate with bilateral testicular torsion. All the 43 testes that were resected demonstrated haemorrhagic necrosis in histopathology.

In 25 patients, it was possible to obtain testes biopsies that were sent for analysis during the exploration. Histopathology in these patients revealed acute parenchymal bleeding, onset of parenchymal infarction, orchitis and normal findings, and testicular salvage was opted in these patients. However, two of these patients with intraoperative histopathology findings demonstrating onset of parenchymal infarction, in whom the testes were salvaged, demonstrated testicular atrophy at a later stage which required delayed orchiectomies. In one patient with intraoperative histopathology findings demonstrating acute parenchymal bleeding, testicular autolysis was found during follow-up examinations.

Another aspect of testicular torsion in the paediatric patient is the possibility of torsion in a undescended or inguinal testis. Testicular torsion can be one of the complications of the cryptorchidism (19). The incidence of cryptorchidism in preterm neonates is 30%, which is much higher than that of full-term infants: 3.4% (19,20). Considering this, the testicular torsion is likely to occur in preterm infants with high incidence of undescended testes. Besides preterm neonates, cryptorchidism in children is also associated with poor rates of surgical salvage, which has been mainly attributed to delays in parental response and in primary physician referral to the hospital (21). Parents have a crucial role in early diagnosis, are often unaware of this urological emergency and are often surprisingly unaware of the presence of cryptorchidism. By increasing the awareness regarding this entity among medical practitioners and parents, torsion of the 'cryptorchid testis' will no longer necessarily be synonymous with 'crypt-torsion' (21).

Although the literature is synonymous with testicular salvage and orchidopexy and/or orchiectomy and contralateral orchidopexy for testicular torsion, recurrent torsion may occur years following the primary procedure (22). This has been described even in cases in which either polyglactin or, notwithstanding, polypropylene sutures have been applied, in accordance with the common practice used in the last two decades. Increased awareness regarding this possibility is imperative for early diagnosis and prevention of testicular loss. The higher incidence of recurrent torsion after fixation using absorbable rather than nonabsorbable sutures may be caused by a greater number of fixations being carried out using absorbable suture. However, the use of nonabsorbable suture is limited because it is associated with a high rate of abscess formation. Hence, it has been suggested that the most important factor for adhesion formation would appear to be the eversion of the tunica vaginalis, and it is recommended that this is carried out at all testicular fixations (23).

When considering the prophylactic aspect, light should also be shed on patients presenting with intermittent testicular torsion. Intermittent testicular torsion should be a diagnostic consideration in patients who present with recurrent acute scrotal pain with rapid spontaneous resolution (24,25). Recurrent severe pain with rapid onset and resolution seems to be highly characteristic. The risks of segmental ischaemia of the testis as well as acute testicular infarction have been demonstrated in patients with intermittent testicular torsion (26,27). Horizontal lie on examination is highly correlated with the bell-clapper deformity at surgical exploration (28). Surgery may be recommended in these patients as it results in pain relief in the majority, is likely to prevent future testicular infarction and is associated with low morbidity (29).

Testicular torsion is an emergency and its management presents challenges. DUS may present variations, and clinical evaluation is important to justify surgical exploration. Although testis after prenatal testicular torsion cannot be salvaged, our retrospective single-centre study that is limited in patient numbers presented favourable outcomes in boys who presented <6 h after the onset of symptoms. Histological evaluation using intraoperative biopsies can assist in the decision of testicular salvage when severe ischaemia or haemorrhage is present; however, this expertise is not available in all centres round the clock.

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