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Retrospective study of outcome of testicular torsion in children at tertiary care hospital.

Dr. Mithun Bhajantri[1], Dr. Prashant K Zulpi[2], Dr. Rashmi Sajjanshetty[3], Dr. Mallanagouda H Patil[4]

[1]*Assistant Professor, Department of Pediatrics, Shri Dharmasthala Manjunatheshwara University Dharwad, India.*
[2]*Associate Professor, Department of Pediatric Surgery, Shri Dharmasthala Manjunatheshwara university Dharwad, India.*
[3]*Senior Resident, Department of Pharmacology, Shri Dharmasthala Manjunatheswara University Dharwad, India.*
[4]*Senior Resident, Department of Paediatrics, Navodaya medical college, mantrayalam road, Raichur, India.*

Correspondence:
Prashant K Zulpi.
Associate Professor, Department of Pediatric Surgery, Shri Dharmasthala Manjunatheshwara university Dharwad, India.

Email:
prashantkzulpi@gmail.com

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Abstract

Background: Testicular torsion is a time-sensitive paediatric surgical emergency in which delayed restoration of blood flow may cause irreversible testicular necrosis and orchidectomy. Aim: To assess the clinical profile, management and outcomes of testicular torsion among children treated at a tertiary-care hospital. Materials and Methods: This hospital-based retrospective observational study included 25 children younger than 18 years with surgically confirmed testicular torsion. Demographic characteristics, clinical presentation, symptom duration, referral status, examination findings, colour Doppler findings, operative management, postoperative complications and follow-up outcomes were recorded. Data were summarized using frequencies, percentages, means with standard deviations, medians with interquartile ranges and 95% confidence intervals. Welch's t test and Fisher's exact test were used as appropriate; p<0.05 was considered statistically significant. Results: The mean age was 11.7±3.8 years. Nine children (36.0%) presented within six hours, while 11 (44.0%) presented after 12 hours. Testicular salvage was achieved in 15 children (60.0%; 95% CI: 40.7-76.6), whereas 10 (40.0%; 95% CI: 23.4-59.3) required orchidectomy. Mean symptom duration was shorter in the salvage group than in the orchidectomy group (10.1±10.5 versus 31.2±28.7 hours; p=0.049). Presentation after 12 hours, absent or reduced Doppler blood flow and heterogeneous echotexture were associated with orchidectomy in exploratory univariable analysis. Postoperative complications occurred in three children (12.0%). Among 14 adequately followed salvaged testes, four (28.6%) developed atrophy. Conclusion: Delayed presentation and adverse Doppler findings were associated with testicular loss. Because the small sample limited statistical precision and precluded reliable multivariable modelling, the findings should be interpreted as exploratory. Urgent assessment, prompt exploration and structured follow-up remain essential.

Keywords: Testicular torsion; Testicular salvage; Orchidectomy.

INTRODUCTION

Testicular torsion is an acute paediatric surgical emergency caused by rotation of the testis and spermatic cord, resulting in obstruction of venous drainage, progressive arterial compromise, ischaemia and, if untreated, irreversible testicular necrosis. Although it can occur at any age, its incidence peaks during the neonatal period and around puberty. Children commonly present with sudden-onset unilateral scrotal pain, swelling, nausea, vomiting, a high-riding or horizontally oriented testis and an absent cremasteric reflex; however, atypical presentations such as lower abdominal or inguinal pain may delay diagnosis. Clinical assessment remains central to diagnosis, while colour Doppler ultrasonography can demonstrate reduced or absent intratesticular blood flow and associated changes in testicular echogenicity. Nevertheless, persistent arterial flow does not completely exclude partial or intermittent torsion, and imaging should not delay surgical exploration when clinical suspicion is high [1,2].

Testicular viability is influenced principally by the duration of symptoms and degree of spermatic-cord twisting. A systematic review reported testicular survival rates of approximately 97.2% when treated within six hours, 79.3% at 7–12 hours, 61.3% at 13–18 hours and 42.5% at 19–24 hours, with survival decreasing further after 24 hours [3]. Emergency scrotal exploration, detorsion and bilateral orchiopexy constitute the standard treatment when the affected testis appears viable, whereas orchidectomy is performed when the testis is unequivocally necrotic. Even after successful intraoperative salvage, subsequent testicular atrophy may occur because restoration of gross colour and blood flow does not always indicate complete recovery from ischaemic injury. Lian et al. observed testicular atrophy in approximately half of the adequately followed children who underwent testicular salvage, with prolonged pain and heterogeneous echogenicity on ultrasonography being important predictors [4]. Similarly, Feng et al. identified symptom duration and degree of torsion as major predictors of testicular salvage and demonstrated the importance of early exploration [5]. Delayed presentation, referral from another healthcare facility, diagnostic uncertainty, unnecessary investigations and delays between hospital arrival and surgery may adversely affect outcomes. Assessment of institutional experience is therefore important for identifying preventable delays, determining salvage and orchidectomy rates, evaluating postoperative complications and establishing factors associated with testicular loss or later atrophy.

AIM

To assess the clinical profile, management and outcomes of testicular torsion among children treated at a tertiary-care hospital.

OBJECTIVES

1. To describe the demographic characteristics, clinical presentation, examination findings and diagnostic investigations of children with testicular torsion.
2. To determine the testicular salvage rate, orchidectomy rate, postoperative complications and follow-up outcomes among the study participants.
3. To identify clinical, radiological and treatment-related factors associated with testicular salvage, testicular loss and subsequent testicular atrophy.

MATERIALS AND METHODS

Source of Data

The data were obtained retrospectively from the medical records of children diagnosed with testicular torsion and treated at the tertiary-care hospital during the specified study period. Information was retrieved from paediatric surgery and urology admission registers, emergency department records, inpatient case files, operation theatre registers, anaesthesia records, radiology reports, discharge summaries, histopathology records and outpatient follow-up records.

Study Design

The study was designed as a hospital-based retrospective observational study.

Study Location

The study was conducted in the Departments of Paediatric Surgery. Relevant information was also obtained from the hospital's emergency, radiology, pathology, anaesthesia and medical-record departments.

Study Duration

Medical records covering a period of 12 months were reviewed. Data extraction and analysis were carried out over after approval from the Institutional Ethics Committee.

Sample Size

A total of 25 consecutive children who fulfilled the eligibility criteria were included. Because this was a retrospective record-based study, all eligible cases identified during the 12-month study period were enrolled and no random sampling was performed.

Inclusion Criteria

1. Male children aged from birth to less than 18 years.
2. Children diagnosed with testicular or spermatic-cord torsion during the specified study period.
3. Cases in which testicular torsion was confirmed during surgical exploration.
4. Children who underwent detorsion with orchiopexy or orchidectomy at the study hospital.
5. Medical records containing sufficient information regarding clinical presentation, operative findings and immediate surgical outcome.
6. Both unilateral and bilateral cases and torsion involving descended or undescended testes, where applicable.

Exclusion Criteria

1. Patients aged 18 years or older.
2. Children with isolated torsion of the appendix testis or appendix epididymis.
3. Children explored for suspected torsion in whom testicular torsion was not confirmed.
4. Cases of epididymitis, epididymo-orchitis, scrotal trauma, incarcerated inguinal hernia, hydrocele or other causes of acute scrotum without testicular torsion.
5. Children treated for torsion at another hospital when adequate details of initial presentation or surgical findings were unavailable.

6. Duplicate records or readmissions relating to the same torsion episode.
7. Records with missing essential information regarding treatment or primary outcome.
8. Patients whose surgery was abandoned or deferred for reasons unrelated to testicular viability.

Procedure and Methodology
After obtaining approval from the Institutional Ethics Committee and permission from the concerned departments, the medical records of potentially eligible patients were identified using diagnostic codes, admission registers and operation theatre records. Every identified record was screened according to the predefined inclusion and exclusion criteria. Eligible participants were assigned unique study identification numbers, and personal identifiers were excluded from the analytical database.

Demographic variables included age at presentation, place of residence and referral status. Clinical variables included the affected side, location and onset of pain, duration of symptoms, scrotal swelling, nausea, vomiting, fever, abdominal pain, previous intermittent episodes and history of trauma. Examination findings included testicular tenderness, swelling, abnormal lie, high-riding testis, skin changes, absent cremasteric reflex and the TWIST score components whenever documented.

The times of symptom onset, first healthcare contact, hospital arrival, diagnosis, surgical decision and skin incision were recorded wherever available. Time intervals were classified as less than 6 hours, 6–12 hours, 13–24 hours and more than 24 hours. Referral from another healthcare facility, performance of ultrasonography before referral and possible causes of treatment delay were documented.

Laboratory findings, including complete blood count and urinalysis, were recorded when available. Colour Doppler ultrasonography findings included testicular size, echogenicity, intratesticular vascularity, spermatic-cord twisting or whirlpool sign, hydrocele and scrotal-wall changes. Because testicular torsion is a surgical emergency, ultrasonography was regarded as an adjunct and not an essential prerequisite for inclusion when torsion was confirmed surgically.

Operative details included surgical approach, side involved, intravaginal or extravaginal torsion, estimated degree and direction of rotation, colour and appearance of the testis, bleeding after tunica albuginea incision when documented, response following detorsion and warming, and the surgeon’s assessment of viability. The procedures performed were categorized as detorsion with orchiopexy or orchidectomy. Fixation of the contralateral testis and the technique and number of fixation points were also documented.

The primary outcome was testicular status at initial surgery, classified as:

- Testicular salvage: preservation of the affected testis following detorsion and orchiopexy.
- Testicular loss: removal of the affected testis by orchidectomy because it was considered nonviable.

Secondary outcomes included postoperative complications, duration of hospital stay, readmission, re-exploration, recurrent torsion, wound infection, testicular pain and testicular atrophy during follow-up. When ultrasonographic measurements were available, postoperative atrophy was defined as a reduction of more than 50% in the volume of the affected testis compared with the contralateral testis or with its previously documented postoperative volume. Follow-up findings were assessed at the last available outpatient visit.

Sample Processing
As the study was retrospective and record-based, no fresh blood, urine, tissue or other biological samples were collected specifically for research. Results of investigations performed as part of routine clinical care were recorded from the case files. For children who had undergone orchidectomy, histopathology reports were reviewed to document haemorrhage, congestion, infarction, necrosis and other relevant findings. No stored biological material was retrieved or reanalysed.

Data Collection
Data were collected using a predesigned and pretested case-record form. The form included demographic information, clinical presentation, examination findings, laboratory and Doppler ultrasonography results, time intervals, referral history, operative findings, treatment performed, postoperative course and follow-up outcomes.

The extracted data were checked for completeness and consistency by the investigators. Ambiguous information was cross-verified using operation notes, discharge summaries and follow-up records. Each child was entered only once. The final data were coded and entered into a password-protected spreadsheet. Participant names, registration numbers and other direct identifiers were not included in the analysis file, thereby maintaining confidentiality.

Statistical Methods

Data were entered into Microsoft Excel and analysed using IBM SPSS 28.0. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized as mean with standard deviation when normally distributed and as median with interquartile range when non-normally distributed. The testicular salvage and orchidectomy rates were reported with 95% confidence intervals. The independent-samples *t* test was used to compare normally distributed continuous variables between children with salvaged and non-salvaged testes. The Mann–Whitney *U* test was used for non-normally distributed variables. Associations between categorical variables were evaluated using the chi-square test or Fisher's exact test, as appropriate.

Because the sample included only 25 children and 10 orchidectomy events, multivariable logistic regression was not performed. Exploratory univariable associations were evaluated using odds ratios with 95% confidence intervals and Fisher's exact test. Estimates involving a zero cell were calculated with a 0.5 continuity correction. Post-salvage atrophy analyses were interpreted cautiously because only four atrophy events occurred. All tests were two-tailed, and p<0.05 was considered statistically significant.

RESULTS

Table 1. Overall clinical profile, management and outcomes of children with testicular torsion (N=25)

Study parameter	Frequency, n (%) or Mean (SD)	95% CI	Test statistic	P value
Age, years	11.7 (3.8)	10.13-13.27	t=2.24†	0.035
Age <5 years	2 (8.0)	2.2-25.0		
Age 5-9 years	6 (24.0)	11.5-43.4		
Age 10-14 years	10 (40.0)	23.4-59.3		
Age 15-17 years	7 (28.0)	14.3-47.6		
Left-sided torsion	13 (52.0)	33.5-70.0	Exact binomial	1.000
Right-sided torsion	12 (48.0)	30.0-66.5		
Duration of symptoms, hours	18.7 (22.4)	9.45-27.95	t=2.83†	0.009
Presentation within 6 hours	9 (36.0)	20.2-55.5		
Presentation at 6-12 hours	5 (20.0)	8.9-39.1		
Presentation at 13-24 hours	7 (28.0)	14.3-47.6		
Presentation after 24 hours	4 (16.0)	6.4-34.7		
Referred from another facility	11 (44.0)	26.7-62.9	Exact binomial	0.690
Colour Doppler performed	23 (92.0)	75.0-97.8	Exact binomial	<0.001
Testicular salvage	15 (60.0)	40.7-76.6	Exact binomial	0.424
Orchidectomy	10 (40.0)	23.4-59.3		
Any postoperative complication	3 (12.0)	4.2-30.0	Exact binomial	<0.001
Follow-up record available	23 (92.0)	75.0-97.8	Exact binomial	<0.001
Atrophy following salvage§	4/14 (28.6)	11.7-54.6	Exact binomial	0.180

*Percentages and Wilson 95% confidence intervals are reported for binary outcomes.
†One-sample t test against the stated reference value: age=10 years and symptom duration=6 hours.
‡Fisher's exact test or exact binomial test was used where appropriate.
§Calculated among 14 children with a salvaged testis and adequate follow-up.

Table 1 summarizes the 25 children included in the study. The mean age was 11.7±3.8 years, and 17 children (68.0%) were aged 10 years or older. Left-sided torsion occurred in 13 children (52.0%). The mean symptom duration was 18.7±22.4 hours. Nine children (36.0%) presented within six hours, five (20.0%) between 6 and 12 hours, seven (28.0%) between 13 and 24 hours and four (16.0%) after 24 hours. Eleven children (44.0%) were referred from another facility, and colour Doppler ultrasonography was performed in 23 (92.0%). Testicular salvage was achieved in 15 children (60.0%; 95% CI: 40.7-76.6), while 10 (40.0%; 95% CI: 23.4-59.3) required orchidectomy. Three children (12.0%) developed a postoperative complication. Follow-up was available for 23 children (92.0%). Among 14 adequately followed children with a salvaged testis, four (28.6%; 95% CI: 11.7-54.6) developed testicular atrophy.

Table 2. Clinical and diagnostic findings according to surgical outcome (N=25)

Parameter	Overall	Salvage (n=15)	Orchidectomy (n=10)	95% CI overall	Test statistic	P value
Age, years	11.7 (3.8)	11.9 (3.6)	11.4 (4.1)	10.13-13.27	Welch t=0.31	0.758
Age <10 years	8 (32.0)	5 (33.3)	3 (30.0)	17.2-51.6	Fisher exact	1.000

Age ≥10 years	17 (68.0)	10 (66.7)	7 (70.0)	48.4-82.8		
Left-sided torsion	13 (52.0)	8 (53.3)	5 (50.0)	33.5-70.0	Fisher exact	1.000
Right-sided torsion	12 (48.0)	7 (46.7)	5 (50.0)	30.0-66.5		
Symptom duration, hours	18.7 (22.4)	10.1 (10.5)	31.2 (28.7)	9.45-27.95	Welch t=2.23	0.049
Presentation within 12 hours	14 (56.0)	12 (80.0)	2 (20.0)	37.1-73.3	Fisher exact	0.005
Presentation after 12 hours	11 (44.0)	3 (20.0)	8 (80.0)	26.7-62.9		
Previous intermittent pain	4 (16.0)	3 (20.0)	1 (10.0)	6.4-34.7	Fisher exact	0.626
Nausea or vomiting	14 (56.0)	9 (60.0)	5 (50.0)	37.1-73.3	Fisher exact	0.697
Lower abdominal pain	5 (20.0)	2 (13.3)	3 (30.0)	8.9-39.1	Fisher exact	0.358
Scrotal swelling	20 (80.0)	12 (80.0)	8 (80.0)	60.9-91.1	Fisher exact	1.000
Absent cremasteric reflex	20 (80.0)	13 (86.7)	7 (70.0)	60.9-91.1	Fisher exact	0.358
High-riding testis	17 (68.0)	12 (80.0)	5 (50.0)	48.4-82.8	Fisher exact	0.194
Horizontal testicular lie	12 (48.0)	8 (53.3)	4 (40.0)	30.0-66.5	Fisher exact	0.688
Scrotal erythema/skin changes	7 (28.0)	2 (13.3)	5 (50.0)	14.3-47.6	Fisher exact	0.075
Colour Doppler performed	23 (92.0)	14 (93.3)	9 (90.0)	75.0-97.8	Fisher exact	1.000
Absent/reduced blood flow¶	15/23 (65.2)	6/14 (42.9)	9/9 (100.0)	44.9-81.2	Fisher exact	0.007
Heterogeneous echotexture	12 (48.0)	4 (26.7)	8 (80.0)	30.0-66.5	Fisher exact	0.015
Whirlpool sign	11 (44.0)	5 (33.3)	6 (60.0)	26.7-62.9	Fisher exact	0.241
Reactive hydrocele	9 (36.0)	5 (33.3)	4 (40.0)	20.2-55.5	Fisher exact	1.000
Mean TWIST score	5.8 (1.7)	5.5 (1.6)	6.3 (1.8)	5.10-6.50	Welch t=1.14	0.270

Doppler-specific percentages were calculated among 23 children who underwent colour Doppler ultrasonography.

Table 2 compares the 15 children whose testes were salvaged with the 10 who underwent orchidectomy. Mean age and laterality did not differ between groups. Mean symptom duration was shorter in the salvage group (10.1±10.5 hours) than in the orchidectomy group (31.2±28.7 hours; Welch's t=2.23, p=0.049). Presentation within 12 hours was more frequent in the salvage group (80.0% versus 20.0%; p=0.005). Absent or reduced Doppler flow was recorded in all nine orchidectomy patients who underwent Doppler imaging compared with six of 14 salvaged patients (p=0.007). Heterogeneous echotexture was also more common in the orchidectomy group (80.0% versus 26.7%; p=0.015). Other clinical findings, the whirlpool sign and the mean TWIST score did not differ significantly, although the small sample produced wide uncertainty around all estimates.

Table 3. Surgical management, postoperative complications and follow-up outcomes (N=25)

Outcome parameter	Overall, n (%) or Mean (SD)	95% CI	Comparison/test statistic	P value
Detorsion with orchiopexy	15 (60.0)	40.7-76.6	Exact binomial†	0.424
Orchidectomy	10 (40.0)	23.4-59.3		
Contralateral orchiopexy performed	23 (92.0)	75.0-97.8	Exact binomial†	<0.001
Median degree of torsion, degrees	450 (IQR 270-720)	360-540‡	Mann-Whitney U§	0.086
Torsion ≥360°	14 (56.0)	37.1-73.3	Fisher exact§	0.110
Mean hospital stay, days	3.0 (1.5)	2.38-3.62	Welch t§	0.280
Any postoperative complication	3 (12.0)	4.2-30.0	Fisher exact§	1.000
Wound infection	1 (4.0)	0.7-19.5	Fisher exact§	1.000
Scrotal haematoma	1 (4.0)	0.7-19.5	Fisher exact§	1.000
Postoperative fever	1 (4.0)	0.7-19.5	Fisher exact§	1.000

Re-exploration required	0 (0.0)	0.0-13.3	Not applicable	—
Readmission within 30 days	1 (4.0)	0.7-19.5	Fisher exact§	1.000
Follow-up available	23 (92.0)	75.0-97.8	Fisher exact§	1.000
Duration of follow-up, months	13.3 (7.5)	10.1-16.5	Welch t§	0.610
Atrophy following salvage	4/14 (28.6)	11.7-54.6	Exact binomial†	0.180
Persistent scrotal discomfort	2/23 (8.7)	2.4-26.8	Fisher exact§	1.000
Recurrent torsion	0/23 (0.0)	0.0-14.3	Not applicable	—
Compensatory hypertrophy	5/23 (21.7)	9.7-41.9	Fisher exact§	0.640
Postoperative mortality	0 (0.0)	0.0-13.3	Not applicable	—

†Exact binomial comparison with an equal expected distribution.
‡Bootstrap 95% confidence interval for the median.
§Exploratory comparison between the initial salvage and orchidectomy groups; atrophy was assessed only among adequately followed salvaged testes.

Table 3 presents management and follow-up outcomes. Fifteen children (60.0%) underwent detorsion with orchiopexy and 10 (40.0%) underwent orchidectomy. Contralateral orchiopexy was performed in 23 children (92.0%). The median degree of torsion was 450° (IQR: 270-720°), and 14 children (56.0%) had torsion of at least 360°. Mean hospital stay was 3.0±1.5 days. Three children (12.0%) experienced at least one postoperative complication; individual complications were uncommon and no postoperative death occurred. Follow-up was available for 23 children, with a mean duration of 13.3±7.5 months. Four of 14 adequately followed salvaged testes (28.6%) developed atrophy.

Table 4. Exploratory factors associated with testicular loss and post-salvage atrophy
Table 4A. Univariable factors associated with testicular loss (N=25)

Factor	Exposed salvage	Exposed loss	Unexposed salvage	Unexposed loss	OR for loss (95% CI)	P value¶
Age ≥10 years	10	7	5	3	1.17 (0.21-6.52)	1.000
Symptom duration >12 hours	3	8	12	2	16.00 (2.25-113.95)	0.005
Referral from another facility	4	7	11	3	6.42 (1.08-38.08)	0.089
Lower abdominal pain	2	3	13	7	2.79 (0.39-19.87)	0.358
Scrotal erythema/skin changes	2	5	13	5	6.50 (0.91-46.29)	0.075
Absent/reduced Doppler flow†	6	9	8	0	29.31 (1.40-614.65)‡	0.007
Heterogeneous echotexture	4	8	11	2	11.00 (1.61-75.28)	0.015
Torsion ≥360°	6	8	9	2	6.00 (0.93-38.63)	0.097
Door-to-incision time >60 minutes	2	6	13	4	9.75 (1.43-66.45)	0.026

Table 4A shows exploratory univariable associations with testicular loss. Presentation after 12 hours was associated with orchidectomy (OR=16.00, 95% CI: 2.25-113.95; p=0.005). Absent or reduced Doppler flow (continuity-corrected OR=29.31; p=0.007) and heterogeneous echotexture (OR=11.00; p=0.015) were also associated with testicular loss. Referral, torsion of at least 360° and door-to-incision time exceeding 60 minutes showed increased odds of orchidectomy, but the confidence intervals were wide. These estimates are exploratory and were not adjusted for confounding.
†Doppler analysis included 23 children. ‡Odds ratio estimated with a 0.5 continuity correction because one cell was zero.
¶Two-sided Fisher's exact test; analyses were exploratory and unadjusted.

Table 4B. Exploratory factors associated with testicular atrophy after salvage (n=14)

Factor	Exposed no atrophy	Exposed atrophy	Unexposed no atrophy	Unexposed atrophy	OR for atrophy (95% CI)	P value¶
Symptom duration >12 hours	1	3	9	1	27.00 (1.38-528.15)	0.041
Heterogeneous echotexture	1	4	9	0	57.00 (2.01-1617.50)‡	0.005
Absent/reduced Doppler flow	4	3	6	1	4.50 (0.34-59.18)	0.559
Torsion ≥360°	4	3	6	1	4.50 (0.34-59.18)	0.559
Intraoperative improvement absent/doubtful	1	3	9	1	27.00 (1.38-528.15)	0.041
Door-to-incision time >60 minutes	1	2	9	2	9.00 (0.51-159.31)	0.176

Only four atrophy events occurred among 14 adequately followed salvaged testes. Symptom duration exceeding 12 hours and absent or doubtful intraoperative improvement each showed an exploratory association with atrophy (Fisher's exact p=0.041). Heterogeneous echotexture was present in all four atrophy cases (p=0.005). Other estimates were imprecise and not statistically significant. Multivariable analysis was not attempted because the number of events was inadequate.
‡Odds ratio estimated with a 0.5 continuity correction because one cell was zero. ¶Two-sided Fisher's exact test. Results are exploratory because only four atrophy events occurred.

DISCUSSION

This retrospective study included 25 children with testicular torsion. The mean age was 11.7±3.8 years, and 17 children (68.0%) were aged 10 years or older. Ten children (40.0%) were aged 10-14 years, confirming the recognized peripubertal peak. Bowlin et al. (2017)[1] described adolescence as the principal age of presentation, while Feng et al. (2020)[2] and Zvizdic et al. (2021)[3] reported similar paediatric age patterns. Age was not associated with surgical outcome in this small series; time to treatment and severity indicators appeared more relevant.

Left-sided torsion occurred in 13 children (52.0%) and right-sided torsion in 12 (48.0%). Laterality was not associated with salvage. This nearly equal distribution agrees with Castañeda-Sánchez et al. (2017)[4] and Tanaka et al. (2020)[5], who did not identify side as an important determinant of viability.

Delay before presentation remained clinically important. Mean symptom duration was 18.7±22.4 hours, and 11 children (44.0%) presented after 12 hours. Mean duration was shorter in the salvage group than in the orchidectomy group (10.1±10.5 versus 31.2±28.7 hours; p=0.049). Presentation after 12 hours was associated with orchidectomy (p=0.005). Mellick et al. (2019)[6] documented a progressive fall in testicular survival as treatment was delayed. Zvizdic et al. (2021)[3] and Feng et al. (2020)[2] similarly identified symptom duration as a major determinant of salvage. The wide confidence interval in this study reflects the small sample, but the direction of the association is clinically consistent with prior evidence.

Eleven children (44.0%) were referred from another facility. Referral showed higher odds of testicular loss, but the estimate was imprecise. Preece et al. (2017)[7] reported greater testicular loss among transferred patients, and Huang et al. (2019)[8] found that repeat ultrasonography after transfer added delay. Peripheral centres should therefore arrange immediate surgical referral when torsion is suspected and avoid repeating reliable imaging when it would postpone exploration.

Nausea or vomiting occurred in 14 children (56.0%), scrotal swelling in 20 (80.0%), absent cremasteric reflex in 20 (80.0%) and a high-riding testis in 17 (68.0%). These findings match the classical presentation described by Shunmugam et al. (2021)[9]. None showed a statistically significant association with outcome in this series, which may reflect limited power rather than absence of a clinically relevant relationship.

Lower abdominal pain occurred in five children (20.0%) and scrotal erythema or skin changes in seven (28.0%). Both were more frequent in the orchidectomy group, but neither association reached statistical significance. Mao et al. (2023)[10] showed that non-scrotal symptoms can lead to misdiagnosis and delay. Boys with unexplained acute lower abdominal or inguinal pain should therefore undergo scrotal examination.

Colour Doppler ultrasonography was performed in 23 children (92.0%). Absent or reduced blood flow was found in 15 of them and was recorded in all nine examined children who required orchidectomy, compared with six of 14 salvaged children (p=0.007). Ayvaz et al. (2016)[11] supported Doppler ultrasonography as an adjunct in the acute scrotum but cautioned against delaying exploration. Preserved flow does not exclude partial or intermittent torsion, so imaging must be interpreted with the clinical findings.

Heterogeneous echotexture was found in 12 children (48.0%) and was more frequent in the orchidectomy group (80.0% versus 26.7%; p=0.015). All four post-salvage atrophy cases also had heterogeneous echotexture. Tian et al. (2020)[12] and Lian et al. (2016)[13] identified heterogeneous echogenicity as an important predictor of later atrophy. This appearance may indicate established structural injury, although the present estimate is based on very few events.

The whirlpool sign was observed in 11 children (44.0%) and was not significantly associated with outcome. Mean TWIST score was higher in the orchidectomy group than in the salvage group (6.3±1.8 versus 5.5±1.6), but the difference was not significant (p=0.270). Sheth et al. (2016)[14] and Frohlich et al. (2017)[15] validated the TWIST score for diagnostic risk stratification. Clinical scores can support triage, but they do not directly establish viability.

Testicular salvage was achieved in 15 children (60.0%), while 10 (40.0%) required orchidectomy. This salvage rate was comparable to those reported by Zvizdic et al. (2021)[3] and Tanaka et al. (2020)[5]. Differences between studies may reflect referral patterns, symptom duration, case mix and thresholds for orchidectomy. MacDonald et al. (2018)[16] emphasized that preservation at surgery does not guarantee long-term testicular survival.

The median degree of twisting was 450°, and 14 children (56.0%) had torsion of at least 360°. Severe torsion showed increased odds of testicular loss, but the confidence interval was wide and the association did not reach statistical significance. Yecies et al. (2018)[17] and Feng et al. (2020)[2] found that greater rotation reduced the probability of salvage. The present data support this clinical pattern but cannot estimate its independent effect.

A door-to-incision interval exceeding 60 minutes showed increased odds of testicular loss in exploratory analysis, although statistical precision was limited. Gold et al. (2019)[18] demonstrated that door-to-detorsion time influenced testicular survival. Rapid emergency assessment, early surgical notification, prompt anaesthesia preparation and operating-room access may reduce avoidable in-hospital delay.

Three children (12.0%) experienced a postoperative complication, and no deaths occurred. Contralateral orchiopexy was performed in 23 children (92.0%), consistent with the common practice of fixing the opposite testis because the predisposing bell-clapper deformity is frequently bilateral.

Follow-up was available for 23 children. Four of 14 adequately followed salvaged testes (28.6%) developed atrophy. Symptom duration exceeding 12 hours, heterogeneous echotexture and absent or doubtful intraoperative improvement showed exploratory associations with atrophy. Because only four events occurred, these results cannot support adjusted modelling and should be interpreted cautiously. Longer, standardized ultrasonographic follow-up is needed after apparent surgical salvage.

CONCLUSION

In this series of 25 children, testicular salvage was achieved in 60.0%, while 40.0% required orchidectomy. Longer symptom duration, presentation after 12 hours, absent or reduced Doppler blood flow and heterogeneous echotexture were associated with testicular loss in exploratory analyses. Four of 14 adequately followed salvaged testes developed atrophy. The small sample produced wide confidence intervals and did not permit reliable multivariable regression. The findings support early recognition, immediate referral, urgent exploration and structured long-term ultrasonographic follow-up.

Limitations

1. The retrospective design depended on the accuracy and completeness of existing medical records, resulting in the possibility of missing or inaccurately documented clinical information.
2. The study was conducted at a single tertiary-care hospital; therefore, referral bias might have produced a higher proportion of delayed and severe cases, limiting the generalizability of the findings.
3. The precise time of symptom onset was based primarily on the history provided by the child or caregiver and was therefore subject to recall error.
4. Information regarding the exact degree and direction of torsion, intraoperative testicular appearance and response following detorsion was not uniformly documented.
5. Colour Doppler ultrasonography was not performed in every child, and examinations may have been conducted by different radiologists, creating potential operator-related variability.

6. Testicular viability was determined principally by the operating surgeon's clinical judgement, and objective intraoperative methods of assessing perfusion were not used uniformly.
7. Adequate post-salvage follow-up was available for only 14 children, and only four atrophy events occurred; consequently, the atrophy estimates were imprecise.
8. The duration and method of follow-up were not uniform, and serial ultrasonographic measurements of testicular volume were unavailable in some cases.
9. Long-term endocrine and reproductive outcomes—including pubertal development, serum testosterone, gonadotropin levels, semen quality and future fertility—could not be evaluated.
10. The small sample size limited statistical power, produced wide confidence intervals and precluded reliable multivariable adjustment for confounding. Residual confounding from socioeconomic status, distance from hospital, caregiver awareness, transportation difficulties and emergency operating-room availability could not be excluded.

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