Clinical risk factors for testicular torsion and a warning against falsely reassuring ultrasound scans: a 10-year single-centre experience

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ABSTRACT

Background We sought to determine which demographic, clinical and ultrasonography characteristics are predictive of testicular torsion (TT) and to determine factors associated with time to treatment.

Methods We retrospectively reviewed all medical records of patients (0–17 years) with acute scrotal syndrome (ASS) who were treated in our hospital in Lithuania between 2011 and 2020. We extracted patients' demographic data, in-hospital time intervals, clinical, US and surgical findings. TT was determined at surgery or clinically after manual detorsion. Test characteristics of demographic, clinical and US findings for the diagnosis of TT versus other causes of ASS were determined. We performed a multivariate analysis to identify independent clinical predictors of torsion, and factors associated with surgical delay.

Results A search of medical records yielded 555 cases: 196 (35%) patients with TT and 359 (65%) patients with other ASS causes. Multivariate logistic regression analysis showed that age between 13 and 17 years (OR 8.39; 95% CI 5.12 to 13.76), duration of symptoms <7 hours (OR 3.41; 95% CI 2.03 to 5.72), palpated hard testis (OR 4.65; 95% CI 2.02 to 10.67), scrotal swelling (OR 2.37; 95% CI 1.31 to 4.30), nausea/vomiting (OR 4.37; 95% CI 2.03 to 9.43), abdominal pain (OR 2.38; 95% CI 1.27 to 4.45) were independent clinical predictors of TT. No testicular blood flow in Doppler US had a specificity of 98.2% and a positive predictive value of 94.6%. However, 75 (41.7%) patients with TT had normal testicular blood flow, yielding low sensitivity (58.3%) and negative predictive value of 81.3% for this US finding. In-hospital waiting time for surgery was longer in patients with TT with normal testicular blood flow by USS (195 min) compared with no blood flow (123 min), p<0.01. Higher orchiectomy rates were associated with longer duration of symptoms (p<0.001) and longer waiting time for USS (p=0.029) but not with false-negative US.

Conclusions Pubertal age, symptoms duration of <7 hours, nausea/vomiting, palpated hard testis, abdominal pain and scrotal swelling are predictive factors for TT. Time lost between symptom onset and seeking medical care, and between arrival and US are associated with the need for orchiectomy. Preserved blood flow in USS does not rule out TT and may contribute to delays to surgery.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Previous studies suggested that testicular torsion (TT) incidences are highest during the first year of life and between ages 12 and 15 years.
⇒ Duration of symptoms prior to surgery is associated with orchiectomy rate; however, as symptoms of torsion can be mimicked by other causes of acute scrotum syndrome, so it is important to know which characteristics are most indicative of torsion to speed diagnosis.
⇒ A positive US with Doppler has been used for the past decade to help determine if torsion is present; however, the impact of a negative or indeterminate US is not known.

WHAT THIS STUDY ADDS

⇒ In this observational study of patients with acute scrotal syndrome over 10 years, we found pubertal age, presenting with acute scrotal pain and nausea/vomiting is highly suspicious for TT.
⇒ False-negative US findings of testicular US were not uncommon in cases of TT (41.7%) and may potentially cause delay to surgery once at hospital.
⇒ Clinical risk stratification may be required to decrease time to further evaluation, prioritise resources including US and subsequent management.
⇒ The time lost between symptom onset and seeking medical care remains the main issue for a delay in treatment.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ . If the patient presents with typical clinical characteristics for Testicular Torsion (TT), we suggest seeking urgent paediatric surgeon consultation and not delay the consultation because of US scan.

INTRODUCTION

Acute scrotum syndrome (ASS) is a common paediatric urological emergency. In most of the cases, it is caused by torsion of the testis or its appendages epididymo-orchitis (EO), or testicular trauma.[1 2] It is extremely important to differentiate those causes of the syndrome that immediately require surgical intervention from situations when conservative treatment is sufficient. Testicular torsion (TT) may result in testicular ischaemia and necrosis which, if

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Table 1 Demographic, clinical features and clinical course of patients with AAS according to diagnosis

Patient characteristics N=555	Testicular torsion (n=196)	Other ASS causes (n=359)	P value
Demographic data			
Age, median (IQR)	14 (12–16)	10 (8–12)	<0.001
Age groups			
0–6 years, n (%)	13 (6.6)	59 (16.4)	
7–12 years, n (%)	39 (19.9)	222 (61.8)	<0.001
13–17 years, n (%)	144 (73.5)	78 (21.7)	
Clinical data			
Nausea/Vomiting, n (%)	63 (32.1)	15 (4.2)	<0.001
Abdominal pain, n (%)	63 (32.1)	43 (12)	<0.001
Groin pain, n (%)	36 (18.6)	38 (10.6)	0.009
Hard testis, n (%)	41 (20.9)	20 (5.6)	<0.001
Scrotal oedema, n (%)	161 (82.1)	249 (69.4)	0.001
Torsed appendage, n (%)	3 (1.5)	42 (11.7)	<0.001
Blue dot, n (%)	4 (2)	49 (13.6)	<0.001
Scrotal erythema, n (%)	83 (42.3)	209 (58.2)	0.001
Lateralisation left, n (%)	96 (49)	180 (50.1)	0.794
Painful palpation, n (%)	186 (96.4)	350 (97.5)	0.580
Painful/More frequent urination, n (%)	2 (1)	15 (4.2)	0.041
Diarrhoea, n (%)	5 (2.6)	3 (0.8)	0.103
Temperature >37°C, n (%)	31 (15.8)	36 (10)	0.06
Symptom onset to assessment in ED, hours (median (IQR))	7 (4–24)	24 (10.0–60.5)	<0.001
Clinical assessment to US, min (median (IQR))	31.9 (18–45)	33.0 (15–41)	0.134
Clinical assessment to OR, min, (median (IQR))	137 (91.0–228.5)	241 (177.8–355.5)	<0.001

ASS, acute scrotum syndrome.

not treated in the appropriate time frame, require orchiectomy, increasing the risk of infertility.[3]

Most laboratory and radiological tests for diagnosis of TT take time and may delay treatment.[4–6] Moreover, a significant proportion of teenagers have been reported to conceal acute scrotal pain from their parents and presented to the ED with complaints of abdominal or inguinal pain, resulting in significantly delayed presentation.[7] These factors are thought to lead to worse outcomes of TT treatment.

Ultrasonography with Doppler is one of the key tools in the ASS diagnostic procedure. Classically, colour Doppler US shows absent blood flow in the affected testicle or significantly less than in the normal contralateral testicle. Recently, additional ultrasonographic features such as 'whirlpool sign', 'redundant spermatic cord sign', superb microvascular imaging modality have been described, improving the accuracy of TT diagnosis.[1 7–10] Even though many of these sonographic signs could help in diagnosing TT, sometimes US examination might be a reason for delayed diagnosis or inaccurate differentiation of ASS.[11]

Our object was to assess demographic, clinical and ultrasonography characteristics contributing to differential diagnosis of ASS and to determine main factors associated with delays in treatment.

METHODS

Setting

This retrospective observational study was conducted at the Hospital of Lithuanian University of Health Sciences Kaunas Clinics. Our hospital is the largest tertiary healthcare institution in Lithuania. Medical records from paediatric surgery department and ED were used. USS performed by radiologists in ED were analysed.

Participants

We reviewed all medical records of patients (0–17 years) presenting from January 2011 to December 2020 in paediatric surgery department whose International Classification of Diseases, 10th Revision coded first-time discharge diagnosis were: torsion of testis (N44), orchitis and epididymitis (N45).

Sample size

Sample size was based on the number of patients identified with one of the above diagnoses constituting patients with ASS. This study period was chosen for pragmatic reasons, beginning with the time of introduction of the electronic database for US findings until data analysis by the authors.

Data collection

A standard case record form was used. The data collection instrument was pilot tested. Medical records included initial medical history, patients' demographic data, anamnesis (age, duration of symptoms before seeking medical attention, history of fever, dysuria, nausea/vomiting, trauma), physical examination findings (side of involved testis, presence of erythema, swelling, tenderness over the testis, palpation results), localisation of pain, in-hospital time intervals (duration from initial examination to US and/or surgery), US findings, surgical findings (viable testis or orchiectomy). Chart abstraction and review was performed by two trained study researchers: residents in paediatric surgery (ID and DN). Single patient episodes were extracted by one reviewer only; inter-rater reliability was not assessed and abstractors were not blinded to the patient's outcomes. Individual uncertain cases were reviewed by a paediatric surgeon who did not know the final diagnosis. Missing data were noted within the final dataset and excluded from subgroup comparisons. If physical examination findings were not listed as either present or absent, we excluded these persons from the analysis of that variable.

Reference standard

Patients were categorised into two groups, those with TT and those with other ASS causes—testicular appendage torsion (TAT), trauma and acute EO. The final diagnosis was made clinically, and in most cases confirmed by scrotal exploration. (In some cases of TT, manual detorsion was accomplished without surgery.) Those who did not go to operating room (OR) were followed up in the paediatric surgery department for at least 24 hours. Discharge diagnosis was used as the final diagnosis in these cases.

Outcomes

We determined the test characteristics of clinical and US findings in patients with TT. We reported determined prehospital pain duration, examination in ED to US performed, examination in ED to OR comparing those with torsion versus non-torsion, normal or more intense testicular blood flow versus no blood flow confirmed by USS. We determined clinical factors independently associated with a diagnosis of torsion and and factors associated with orchiectomy. Orchiectomy was considered as a proxy for delay in treatment.

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Table 2 Diagnostic test characteristics for objective clinical findings by reference standard diagnosis

Clinical characteristic	Sensitivity	Specificity	NPV (%)	PPV (%)	Positive likelihood ratio	Negative likelihood ratio
Lateralisation left	49.0	51.2	65.4	34.8	0.98 (0.82 to 1.17)	1.02 (0.86 to 1.22)
Scrotal oedema	82.1	30.6	75.9	39.3	1.18 (1.08 to 1.30)	0.58 (0.42 to 0.82)
Scrotal erythema	20.9	41.8	49.2	16.4	0.36 (0.27 to 0.58)	1.89 (1.64 to 2.18)
Hard testis	20.9	94.4	68.6	67.2	3.75 (2.27 to 6.22)	0.84 (0.78 to 0.90)
Painful palpation	94.9	5.2	65.5	34.7	0.97 (0.94 to 1.01)	2.04 (0.84 to 4.92)
Palpable torsed appendage	1.5	88.5	62.5	6.7	0.13 (0.04 to 0.42)	1.12 (1.07 to 1.16)
Blue dot sign	2.0	88.3	62.3	8.7	0.15 (0.05 to 0.41)	1.13 (1.08 to 1.19)
Painful/More frequent urination	1.0	95.8	63.9	11.8	0.24 (0.06 to 1.06)	1.03 (1.01 to 1.06)
Nausea	32.1	95.8	72.1	80.8	7.69 (4.50 to 13.14)	0.71 (0.64 to 0.78)
Vomiting	30.1	99.2	74.3	94.6	32.36 (10.25 to 102.21)	0.74 (0.68 to 0.80)
Diarrhoea	2.6	99.2	65.1	62.5	3.05 (0.74 to 12.64)	0.98 (0.96 to 1.01)
Groin pain	18.4	89.4	66.7	48.7	1.74 (1.14 to 2.64)	0.91 (0.85 to 0.98)
Abdominal pain	32.1	88.0	70.4	59.4	2.68 (1.90 to 3.79)	0.77 (0.70 to 0.86)
Temperature >37°C	15.8	90.0	66.2	46.3	1.58 (1.01 to 2.47)	0.94 (0.87 to 1.00)

NPV, negative predictive value; PPV, positive predictive value.

Statistical analysis

For descriptive statistics, variables were expressed as either number (percentage), or mean (SD), or median (minimum-maximum) as appropriate. Demographic, clinical and radiological characteristics as well as treatment results were compared between those with TT or other causes of ASS using the χ^2 statistics and Fisher's exact test. Student's t-test was applied for interval data that were normally distributed. All clinical factors which were found to be associated with TT in a univariate analysis were included in the multivariate analysis using backward selection in logistic regression. The choice of predictive variables was carried out by an automatic procedure. It involved starting with all candidate variables, testing the deletion of each variable using a chosen model fit criterion, deleting the variable whose loss gives the most statistically insignificant deterioration of the model fit and repeating this process until no further variables can be deleted without a statistically significant loss of fit.

For clinical findings, sensitivity and specificity, positive (PPV) and negative predictive values (NPV) and likelihood ratios (LR) were determined using the reference standard described above and were calculated using MedCalc software.

Table 3 Diagnostic model of TT constructed by using multivariate regression analysis

Predictive factor	OR (95% CI)	Significance (p value)
Age ≥13 years	8.39 (5.12 to 13.76)	<0.001
Duration of symptoms <7 hours	3.41 (2.03 to 5.72)	<0.001
Palpated hard testis	4.65 (2.02 to 10.67)	<0.001
Scrotal oedema	2.37 (1.31 to 4.30)	0.004
Nausea/Vomiting	4.37 (2.03 to 9.43)	<0.001
Abdominal pain	2.38 (1.27 to 4.45)	0.007

503 patients (177 patients with TT and 326 patients with other ASS causes) were included into logistic regression analysis. χ^2=230.98; p<0.05. Hosmer-Lemeshow test χ^2=6.22; p=0.514. Nagelkerke R^2=0.507. Significance at p<0.05. Other clinical features (groin pain, diarrhoea, temperature >37°C, lateralisation left) were analysed. These characteristics were deleted after backwards selection of the variables.
ASS, acute scrotal syndrome; TT, testicular torsion.

Similarly, we determined sensitivity, specificity, NPV, PPV and LRs for each US finding against the reference standard (MedCalc).

Based on our a priori hypothesis, we included patient age, time intervals before treatment and false-negative USS in the multivariate analysis for orchiectomy. Statistical analysis was carried out using IBM SPSS V.25 (SPSS, Chicago, Illinois, USA). Subjects with missing clinical data were excluded from multivariate analysis. A p value of <0.05 was considered to be statistically significant.

Patient and public involvement

No patients involved. There was no public opinion sought for this study.

RESULTS

Patient characteristics

Total number of 555 patients (0–17 years) with acute scrotal syndrome were included in the study: TT 196 (35%); TAT 228 (41%); EO 97 (18%); testicular trauma 34 (6%). Basic demographic information is described in table 1. TT had the highest incidence in the age group of 13–17 years, while other ASS causes were mostly observed in the age group of 7–12 years (p<0.001). TT was the most common cause (65%) of ASS in the age group of 13–17 years. All patients complained of scrotal pain. Compared with other diagnoses, more patients in the TT group patients presented with nausea/vomiting (p<0.001), abdominal or groin pain (p<0.001 and p=0.009, respectively), hard testis (p<0.001) and scrotal oedema (p=0.001). Palpable torsed testicular appendage (p<0.001), blue dot sign (p<0.001) and scrotal erythema (p=0.001) were more frequently observed in the other ASS causes group.

Patients with TT diagnosis presented to the hospital earlier (7 hours; IQR 4–24 hours) than patients with other ASS causes (24 hours; IQR 10.0–60.5 hours), p<0.001. US was done in average 32.7±21.0 min from arrival to the ED and time to US examination was similar in TT and non-TT groups (p=0.134). The median time from the examination in the ED to the scrotal exploration in OR was 137.0 min (IQR 91.0–228.5 min) in TT group and 241.0 min (IQR 177.8–355.50 min) in other ASS causes group, p<0.001.

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Table 4 Test characteristics and univariate analysis of US characteristics for testicular torsion

US characteristic	Frequency	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Positive likelihood ratio (95% CI)	Negative likelihood ratio (95% CI)
Absent testicular blood flow	111/512	58.3 (50.8–65.6)	98.2 (96.1–99.3)	94.6	81.3	32.28 (14.47 to 72.01)	0.42 (0.36 to 0.50)
Hypoechogenic zones	88/512	34.4 (27.5–41.9)	92.2 (88.7–94.8)	70.5	72.3	4.40 (2.89 to 6.70)	0.71 (0.64 to 0.79)
Hydrocele	186/512	66.7 (59.3–73.5)	48.5 (42.9–54.1)	42.0	73.8	1.29 (1.12 to 1.50)	0.69 (0.54 to 0.87)
Tissue oedema	83/512	18.9 (13.5–25.4)	84.8 (80.4–88.5)	41.0	66.1	1.24 (0.83 to 1.85)	0.96 (0.88 to 1.04)
Oedema of epididymis	175/512	30.6 (23.9–37.8)	62.7 (57.2–68.0)	68.6	36.9	0.82 (0.63 to 1.07)	1.11 (0.97 to 1.26)
Oedema of appendage	17/512	5.0 (2.9–7.9)	99.4 (96.9–100.0)	94.1	36.0	0.11 (0.01 to 0.84)	1.05 (1.02 to 1.08)
Swollen spermatic cord	24/512	6.7 (3.5–11.4)	96.3 (93.6–98.1)	50.0	65.7	1.79 (0.82 to 3.90)	0.97 (0.93 to 1.01)

NPV, negative predictive value; PPV, positive predictive value.

Test characteristics for each individual objective clinical examination finding are presented in table 2. Based on positive LR, vomiting was the most indicative clinical characteristic for TT, although sensitivity of 'vomiting' was quite low (~30%). Nausea, diarrhoea, abdominal pain, hard testis by palpation were highly specific clinical characteristics for TT. Following clinical findings had low positive LR for TT.

Diagnostic model for TT

Multivariate logistic regression analysis showed that age between 13 and 17 years (p<0.001), duration of symptoms <7 hours before arrival to ED (p<0.001), palpated hard testis (p<0.001), scrotal oedema (p=0.004), nausea/vomiting (p<0.001), abdominal pain (p=0.007) were independent predictive factors for detection of TT (table 3). Of all factors, older age was the most indicative factor of TT with OR of 8.39 (95% CI 5.12 to 13.76). Shorter duration of symptoms, palpated hard testis, nausea and/or vomiting were other indicative factors, suggesting around fourfold increase of TT probability. Scrotal oedema and abdominal pain were less indicative factors of TT.

US findings

US with Doppler was performed in the ED by radiologists and documented in most of the cases (n=512, 92.3%). In 130 cases (23.4%), US findings showed no pathological signs of ASS. In the TT group, 105 patients presented with no registered testicular blood flow by US (58.3%). Seventy patients (38.9%) presented with normal blood flow measured by US, while in five cases of TT (2.8%) blood flow was evaluated as more intense than normal. In total, misleading blood flow was in 75 cases (41.7%) of TT. No testicular blood flow in Doppler US showed a high specificity (98.2%) and a PPV (94.6%), although lower sensitivity (58.3%) and an NPV (81.3%) in TT diagnosis (table 4). Hypoechogenic zones were found more often in patients with TT diagnosis (p<0.001). In the group of patients without TT, oedema of testicular appendage (p=0.009) was observed more often than in the group of patients with TT and showed high PPV for other ASS cause.

Surgical outcomes

In total, 426 patients out of 555 underwent surgery (76.8%). Surgical intervention was performed more often in TT group (n=177, 90%) than in other ASS causes group (n=249, 69.4%), p<0.001. Orchiectomy was performed in 26 patients with TT (13.3%), while in 170 (86.7%) TT cases testicles were salvaged.

Median duration of symptoms to arrival at the ED in a group of patients with viable testicles was 6 hours (IQR 3–14 hours), while in the group of patients who underwent orchiectomy was 50 hours (IQR 28.0–85.5 hours), p<0.001, (see table 5). The waiting time between initial examination and surgical treatment was longer in patients with TT with normal or more intense testicular blood flow confirmed by USS (195 min, IQR 123.0–467.50 min) compared with patients with TT with no testicular blood flow (123 min, IQR 85.8–172.8 min), p=0.0001.

Patients with TT who underwent orchiectomy waited longer for USS than patients with TT with salvaged testis (41.5 min, IQR 21.5–57.8 min vs 25 min, IQR 14.0–38.0 min, p=0.01).

Multivariate logistic regression analysis showed that greater time between symptom onset and seeking medical care (p<0.001) and longer waiting time from clinical assessment to USS (p=0.029) were independently associated with orchiectomy. However, false-negative USS (p=0.349) and younger age (0.139) were not significant factors for orchiectomy.

DISCUSSION

TT is a challenging and time-sensitive diagnosis that is encountered frequently in daily practice, especially in the emergency room.[10] It must be differentiated from other causes of testicular pain.[7 12–14] Studies showed that the incidence of TT among patients with ASS was about 25%.[13–15] In our study, TT rate was slightly higher (35%). TAT was the most common cause of ASS in many studies, presenting from 43.6% to 75% of all ASS cases.[12–15] These figures were consistent with our own, where TAT was the most common cause of ASS and comprised 41% of all cases.

Age is a crucial predictive factor for TT and different studies suggest two peaks of incidences, one during the first year of life,

Table 5 Multivariate regression analysis of potential factors associated with orchiectomy in patients with testicular torsion

Predictive factor	No orchiectomy (n=170)	Orchiectomy (n=26)	Univariate p value	OR (95% CI)	P value for OR
Duration of symptoms onset to assessment in ED, hours (median (IQR))	6 (3–14 hours)	50 (28.0–85.5)	<0.001	1.03 (1.02 to 1.05)	<0.001
Waiting time from clinical assessment to US, min (median (IQR))	25(14–38)	41.5 (21.5–57.8)	<0.001	1.02 (1.01 to 1.04)	0.029
False-negative US (n, %)	66 (42.9)	8 (31)	0.212	1.70 (0.55 to 5.23)	0.349
Age <13 years (n, %)	42 (25)	8 (31)	0.341	1.11 (0.97 to 1.27)	0.139

171 patients (24 orchiectomy and 147 salvaged testis cases) were included into logistic regression analysis. χ^2=42.85; p<0.05. Hosmer-Lemeshow test χ^2=4.33; p=0.826. Nagelkerke R^2=0.399. Significance at p<0.05.

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the other between ages 12 and 15 years.[13–15] Older age (≥13 years) was the strongest indicative characteristic of TT in our multivariate analysis, increasing the probability of TT almost ninefold. This clinical feature showed high NPV in TT diagnosis, suggesting a low probability of TT in younger age. However, we did not observe peak of incidence during the first year of life. Only six cases of TT were observed during the first year of life. In addition to age, we found duration of symptoms <7 hours before arrival to ED, palpated hard testis, scrotal swelling, nausea/vomiting, abdominal pain were independently predictive of TT.

Prior studies show that most of the patients with TT go to ED in 4–6 hours after symptoms begins whereas patients with other ASS causes tend to wait longer before seeking medical care, and in most of the cases they arrive to ED after 24 hours or later.[11 12 14 16] In our study, patients with TT usually arrived at ED in 7 hours after initial testicular pain, while patients with other ASS causes arrived a median of 24 hours after symptom onset. There is typically a 4–8 hours window before significant ischaemic damage occurs, manifested by morphological changes in testicular histopathology.[17] In our study, median duration of symptoms until surgical exploration was 6 hours in a group of patients with saved testicles, while in those requiring orchiectomy, symptoms usually lasted a median of 50 hours. These results correspond with other studies, showing almost 100% of salvaged testes in patients treated within 6 hours from onset of symptoms.[13–15] Once at the hospital, it took only around 2 hours from the examination in the ED to scrotal exploration in OR for patients with TT. The time lost between symptom onset and seeking medical attention is therefore crucial and remains the main issue for a delay in treatment and worse outcome. Our multivariate analysis showed that longer waiting time between symptoms onset and seeking medical care was significant predictor of orchiectomy. Raising awareness in the community for young boys and parents may improve rates of testicular salvage.[11 12 18]

Nausea and vomiting is caused by reflex stimulation of the coeliac ganglion in case of testicular pain[19] and it is considered to be predictive factor for TT diagnosis in ASS.[12 14] Our multivariate analysis showed that nausea/vomiting remained a significant predictive sign of TT after adjusting for possible cofounding factors. This clinical feature showed high PPV in TT diagnosis, indicating patient with ASS with nausea/vomiting as highly suspicious for TT.

Scrotal swelling is a common feature of TT and it is widely used in different scoring systems to predict TT.[20 21] However, scrotal swelling is also a common sign for other ASS causes.[14] Almost 70% of our subjects with other ASS causes presented with scrotal swelling. Therefore, single characteristic of scrotal swelling is not specific enough to diagnose TT.

Absent testicular blood flow in US is an important radiological finding of TT, with a sensitivity of 100% and specificity of 76% seen in prior studies.[9 15] However, our study showed that presence of testicular blood flow in US is common in TT cases (75 out of 180), suggesting high risk of false-negative errors in TT diagnosis. Other studies also suggest that blood flow in both testicles may look symmetrical with preserved arterial and venous flow and still represent TT.[22 23] Possible explanation for a high number of patients with TT with normal testicular blood flow by US could be the lack of diagnostic accuracy by doctors working in ED,[24] however in our case USS were performed by radiologists working in ED, although they are not subspecialised in paediatric radiology. Regardless, if patients wait for the US, and it shows normal blood flow, the paediatric surgeon will not be called immediately, although testicle might be torsed. In our study, patients with TT with normal testicular blood flow waited for surgical treatment 1 hour more, compared with patients with TT with absence of testicular blood flow. However, false-negative USS did not increase risk of orchiectomy, although longer waiting time from clinical assessment to USS was significant risk factor for orchiectomy. We had only small number of orchiectomies. It means that an association between longer waiting time from clinical assessment to US and orchiectomy should be considered exploratory.

Our study represents data of the last decade. In this period, US diagnosis of acute TT has advanced with improved technology and findings that point to incomplete torsions (such as 'whirlpool' sign, 'redundant spermatic cord' sign, superb microvascular imaging modality).[10 25] The multicentre study by Khalfa *et al* showed the value of combining different TT signs in US. For example, visualisation of a spermatic cord twist and/or absence of the testicular blood flow in high-resolution US could give a sensitivity of 100% in TT diagnosis, when performed by a senior radiologist.[26] A study from 2020 found that scrotal point-of-care US (POCUS) performed by paediatric emergency physicians had 100% sensitivity in detecting TT and US results were generated 73 min before radiology department results.[27] The systematic review and meta-analysis from 2022 demonstrated that POCUS had high sensitivity and specificity in identifying TT in paediatric patients.[28] However, authors emphasised that the quality of the evidence of the studies analysed was moderate owing to a high risk of bias in patient selection and heterogeneity. High number of false-negative USS in our study also suggest the limitations of even formal US and concerns of potential over-reliance.

Our study shows that combinations of different clinical characteristics are highly indicative for TT. These six clinical features that were predictors in the multivariable model are simple to assess clinically. This derived model may be clinically useful to predict TT in daily practice in ED but would need prospective validation. Thus if the patient presents with typical characteristics for TT, we suggest seeking urgent paediatric surgeon consultation and not delay the consultation because of USS.

Limitations

The study was conducted on retrospective basis and there was no follow-up of the patients, which limits assessment of long-term outcomes. Orchiectomy was considered as a proxy for delay in treatment and small number of orchiectomies limits generalisation of this study outcome. These data should be considered exploratory. Not all differential diagnoses of ASS were confirmed by surgical exploration and a second reference standard was used for those diagnosed clinically. Another significant limitation was imprecise or missing information due to documentation. Also, abstractors were not blinded to outcome. Moreover, US diagnosis of acute TT has advanced through the last decade with improved technology and US findings that point to incomplete torsion, which we did not include in our study. Finally, this study examined the clinical data of a single centre, thus limiting generalisability.

CONCLUSIONS

In this study, combination of clinical symptoms—pubertal age (13–17 years), scrotal pain duration of <7 hours before arrival to ED, nausea/vomiting, palpated hard testis, abdominal pain and scrotal swelling—differentiated TT from other ASS causes. Time lost between symptom onset and seeking medical care, and between arrival and US are associated with the need for

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orchiectomy. Preserved blood flow on US does not rule out TT and should be substantiated with other US findings. We recommend further prospective work to validate a diagnostic algorithm based on the most indicative clinical features of TT.

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