



Validation of the TWIST score for testicular torsion in adults

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Abstract

Purpose The TWIST (Testicular Work-up for Ischemia and Suspected Torsion) score was developed to allow for expedited diagnosis of testicular torsion (TT) in children based on clinical variables: edema (2 points), hard mass (2), absent cremasteric reflex (1), high-riding testis (1) and nausea/vomiting (1). We sought to validate the TWIST Score applied by non-expert physicians for the diagnosis of testicular torsion in an adult population.

Methods We prospectively analyzed all consecutive males presenting to a tertiary hospital with acute scrotum. Patients with previous scrotal pathology or trauma were excluded. Physical examination was performed by a general surgeon and variables of TWIST were recorded. All patients underwent Scrotal Doppler Ultrasound. Measures of accuracy of the TWIST score and ROC curves were generated to evaluate its performance in diagnosing TT in adults.

Results Of 68 patients, 34 had TT (50%). Median age was 24.9 years. According to the original cutoffs of TWIST, 23 patients had a score ≤ 2 among which none had TT. Fifteen patients had a score of 3–4, among which seven had TT. Thirty patients had a score ≥ 5 , among which 27 had TT. All 18 patients with a score of 6 or greater had TT (100% PPV). ROC curve revealed an AUC of 0.95.

Conclusion The TWIST Score is valid for the diagnosis of Testicular Torsion in adults, presenting a PPV of 90% for a cutoff of 5 points and 100% for six points. In all patients with a score of 2 or less, the disease could be safely excluded (100% NPV).

Keywords Acute scrotum · Testicular torsion · Score · Emergency medicine

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Introduction

Acute scrotum is a common condition in the Emergency Department (ED), encompassing different diagnostic possibilities. Testicular torsion (TT) is the most important because it requires immediate diagnosis and treatment. Time is essential in this context as salvage rates can reach 97% if surgery is performed within 6 h of symptom onset, falling below 60% if it exceeds 12 h [1, 2]. Although most commonly associated with the pediatric population, it is of note that up to 30% of cases are found in adults [3–5].

Physical exam is essential for the evaluation of acute scrotum. Nevertheless, no isolated sign or symptom can either confirm or exclude testicular torsion. Even cremasteric reflex can be preserved in cases with documented torsion [6]. High definition scrotal Doppler Ultrasound (DUS) has demonstrated elevated accuracy rates, and is regarded as the standard imaging for the diagnosis of TT [7]. However, as TT is found in less than 30% of patients with acute scrotum [8, 9], routine DUS may delay treatment to positive cases on one hand, and burden the system with unnecessary tests on the other. This can significantly impact services with limited availability of diagnostic resources, as well as busy EDs with prolonged wait times.

In a previous report, we presented the Testicular Workup for Ischemia and Suspected Torsion (TWIST) score for diagnosis of TT in a pediatric population with acute scrotum [10]. The purpose is to screen for TT based on five clinical variables: edema, hard mass, absent cremasteric reflex, high-riding testis and nausea or vomiting. In the original series, based on cutoff scores of 2 points for low and 5 points for high risk categories, this tool achieved both positive and negative predictive values of 100% for TT [10].

Prospective and retrospective series [11–14] have further validated this tool; all of them focusing on children and adolescents. Therefore, the present study aims to evaluate the performance of the TWIST score for the diagnosis of TT in the adult population, when applied by non-specialist practitioners, namely general surgeons.

Materials and methods

Institutional Review Board approval was obtained prior to the beginning of investigations. We prospectively collected data of all patients presenting with acute scrotal pain to the ED of a tertiary academic hospital between June 2018 and February 2020. Subjects were included if they were older than 18 years of age, or older than 16 if at post-pubertal stage (Tanner stage V). Patients presenting

with scrotal trauma or with previous scrotal pathology or surgery were excluded.

A general surgeon, who was the first physician to evaluate patients, performed the initial clinical evaluation and physical examination. Patients were examined by one of six general surgeons, whom had been trained to apply the TWIST score and obtain corresponding data from physical examination. Clinical findings were systematically registered by the physician into an electronic database, which calculated a TWIST score for each patient. Subsequently, patients were referred to an attending urologist. All subjects underwent a scrotal Doppler ultrasound by an experienced radiologist, which served as the gold standard for TT diagnosis.

The TWIST score consists of the sum of the following clinical findings: testicular swelling (2 points), hard testicle (2 points), absent cremasteric reflex (1 point), nausea or vomiting (1 point), and high-riding testicle (1 point). Following the original cutoffs [10] patients were stratified according to the risk for testicular torsion: Low (0–2 points), Intermediate (3–4 points), and High risk (5–7 points) groups. Based on the final DUS result, the Sensitivity, Specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of the TWIST score were calculated. We assessed the impact of changing the high-risk cutoff score (5, 6 and 7 points) on the tool's performance.

The receiver operating characteristic (ROC) curve and the area under the curve (AUC) for the TWIST score were calculated for this population. All statistical analyses were performed with SPSS Software 23.0 (IBM, United States).

Results

A total of 81 patients were initially evaluated, of whom 1 was excluded due to history of trauma, 3 were excluded for previous scrotal pathology and nine did not meet age criteria. After exclusion of these subjects, 68 patients met the study criteria and were included in the analysis. A final diagnosis of Testicular Torsion was made in 34 (50%) of them. Median patient age was 24.9 years (Interquartile Range 19.0–42.7 years), and the median time of symptoms onset was 20 h (Interquartile Range 7–59 h). As shown on Table 1, no patient among the 23 in the low-risk group (0–2 points) had TT. Among the 15 patients with a score of 3 or 4 points (intermediate risk group), we found 7 cases of TT, 7 of orchiepididymitis and 1 incarcerated inguinal hernia. Thirty patients scored 5 or more and were deemed high-risk: 27 were diagnosed with TT; 2 had a scrotal abscess requiring orchiectomy, being of those due to tuberculosis, and 1 had orchiepididymitis.

In this series, a score of 2 or less points yielded a 100% NPV for testicular torsion (95% confidence interval 82.1–100%). On the other hand, a score of 5 or more points

Table 1 Number of patients diagnosed with testicular torsion and without testicular torsion according to their TWIST scoring

TWIST score	Final diagnosis of testicular torsion	
	Testicular torsion <i>n</i> (%)	No torsion <i>n</i> (%)
0	0	7 (100%)
1	0	3 (100%)
2	0	13 (100%)
3	1 (25%)	3 (75%)
4	6 (54%)	5 (45%)
5	9 (75%)	3 (25%)
6	13 (100%)	0
7	5 (100%)	0

resulted in a Sensitivity of 79% and a PPV of 91% (Table 2). As all 18 patients with a score ≥ 6 had TT in this series, a shift in the positive cutoff from 5 to 6 points provides Specificity and a PPV of 100% each. The ROC curve reveals an Area Under Curve of 0.95 (95% CI 0.908–0.996; $p < 0.001$), as seen on Fig. 1. Table 2 summarizes accuracy measures including sensitivity and predictive values for different cut-offs for the high-risk category definition.

Among the 34 patients with a final diagnosis of TT, 20 underwent orchiopexy, 13 had orchiectomy and one requested to be managed at an external facility (unknown procedure). Considering the 20 patients for whom testicular salvage was possible, mean symptom duration was 6.5 h (range 0–15 h). Among six patients with TT and a score 3–4 managed in our hospital, all underwent orchiopexy; of nine patients with TT and a score of 5, four (44%) had an orchiopexy and five had an orchiectomy. Of 13 patients with a score of 6, 8 (61%) had the testis preserved and of 5 patients with a score of 7, 3 (60%) had the testis preserved.

Discussion

Herein we present the first study to validate the TWIST score for the diagnosis of testicular torsion specifically in an adult population. In our series, when applied by non-expert physicians, the score performed similarly to previous pediatric series, supporting that this tool may be applied to adults with

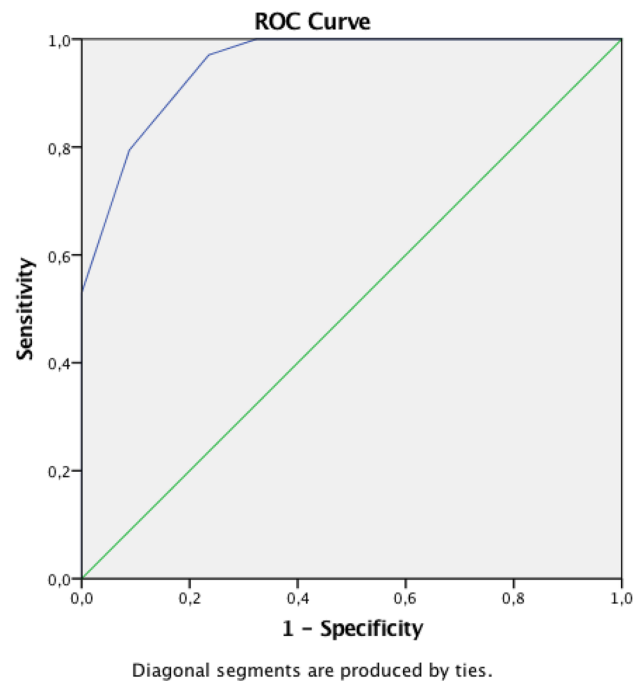


Fig. 1 A Receiver Operating Characteristic curve illustrates the performance of the TWIST score for prediction of testicular torsion. The area under curve is 0.95 (95% CI 0.908–0.996; $p < 0.001$)

acute scrotum as well. In this population scores ≥ 5 points yielded a PPV of 90% and scores ≥ 6 presented 100% PPV. Conversely no cases of TT would be missed with a negative cutoff score of 2 or less (NPV of 100%). This finding could be useful in the setting of limited availability of DUS or in busy emergency services with a long waiting time.

The TWIST score represents an effort towards reducing the necessity of imaging exams and expediting diagnosis and treatment [15]. A number of series have tested the TWIST score in the pediatric population. Baskovic et al. [14] retrospectively studied 280 children (mean age of 14.7 years) with acute scrotum evaluated by pediatric surgeons. They report an NPV of 98.4% when a negative cutoff score of 2 points was used. For patients scoring 5 or more points, the tool reaches a PPV of 92.8%.

Manohar et al. [13] did a retrospective analysis of the TWIST score in a mixed adult and pediatric population (age

Table 2 Sensitivity, specificity, positive predictive value and negative predictive value for different cutoffs of the TWIST score for diagnosis of testicular torsion

TWIST cutoff	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Positive LR (95% CI)	Negative LR (95% CI)
5	79.4% (61.5–90.6%)	91.1% (75.1–97.6%)	90.0% (72.3–97.3%)	81.5% (65.1–91.6%)	9.0 (3.0–26.8)	0.22 (0.11–0.43)
6	52.9% (35.3–69.8%)	100% (87.3–100%)	100% (78.1–100%)	68.1% (53.1–80.0%)	∞	0.47 (0.32–0.67)
7	14.7% (5.5–31.8%)	100% (87.3–100%)	100% (46.2–100%)	53.9% (41.0–66.4%)	∞	0.85 (0.74–0.98)

range 8–28 years). Based on the original cutoff values of 2 and 5 points, they found an NPV of 96.6% and a PPV of 92.8% for the Score.

Frohlich et al. [12] conducted a prospective study of 258 children presenting with acute scrotum. In their protocol the TWIST score was applied by emergency pediatric attending physicians, residents or fellows. In this series, the authors found a slightly lower performance (AUC 0.82; 95% CI 0.71–0.94) compared to previous reports. Interestingly, such accuracy did not differ substantially from the AUC of DUS in their series, which as reported at 0.89 (95% CI 0.81–0.97).

Sheth et al. [11] assessed the TWIST Score applied by trained non-physician health care providers to a prospective cohort of 128 patients (age range 0–21 years). To keep up with a performance comparable to previous series (PPV 93.5%, NPV 100%), the cutoff values had to be adjusted: only scores ≥ 6 points were regarded as positive, whereas a negative result required a score of 0.

Similarly, Manohar et al. [13] observed an increase in the PPV from 92.8% to 100% when the cutoff is elevated to 6 points. In the two other series that disclosed their data [11, 12], only a score of 7 points would yield a 100% PPV for the tool.

Our findings are in keeping with such reports, since a 100% PPV was only reached with a positive cutoff of 6 points. Conversely, this is in contrast with the original report of TWIST, which found a value of 100% PPV even for a cutoff of 5 points [9]. It should be noted that in our series, of three patients with a score of 5 with a false positive, two had a testicular abscess that eventually required orchiectomy. Therefore, the PPV may be underestimated in this series if one considers that surgical exploration is the common endpoint for all positive cases.

In the light of such evidence, it may be debated whether the positive cutoff for diagnosis of TT should be shifted to 6 points. A number of factors should be taken into account, including the level of expertise of the personnel applying the score, the profile of the population and also the setting and resources available. As per the reported series, it appears that the accuracy of the score was the highest when applied by urologists, and decreased when performed by non-expert physicians. Also of note, we hypothesize that, in adults, cases of orchiepididymitis with longer duration of symptoms may evolve with a hard testicle and hence lead to higher scores of TWIST. Furthermore, if the patient is evaluated in a setting where DUS is not readily available, we believe the social burden of up to 10% of negative surgical explorations does not exceed that of testicular loss due to prolonged waiting. In any case, the attending physician must be aware of the tradeoff between specificity and sensitivity when determining to use a given cutoff.

On the other hand, a score 2 or less remains consistent to rule out TT. In our series, no patient in the low-risk group

with 2 points or less had a final diagnosis of TT, determining a NPV of 100 (95% CI 82–100%) for this threshold. This parameter should be useful in ruling out an exploration in a setting without resources, or in determining lower-priority for the management of such cases in busy EDs.

Finally, Ridgway et al. [16] reviewed the data from the four series that directly assessed the TWIST score. They found consistent Sensitivity rates between 95%–100% for low-risk patients, whereas Specificity reached 97–100% in the high-risk group. This further supports the TWIST score as a reliable resource for the evaluation of patients with acute scrotum.

The present study should be interpreted in the context of some limitations. The setting of the research was a tertiary referral center bearing a relatively elevated duration of symptoms. Furthermore, our sample size is relatively limited. However, acute scrotum in a less common condition among adults, which makes it difficult for a large series to be evaluated by a limited number of physicians uniformly trained so as to keep consistence of the evaluation. Even so, accuracy measures in our study presented consistent statistical results and confidence intervals. In all, there is mounting evidence that the TWIST Score remains an accurate tool when applied by non-Urologists [12–14] and non-medical personnel [11].

Future studies should focus on clinical protocols to screen patients with acute scrotum based on the TWIST score, providing early discharge for those at low risk, whereas moving those at high risk to the OR without further delay, and evaluate a possible impact on time to treatment.

Conclusions

The present study shows that the TWIST Score is valid for the diagnosis of Testicular Torsion in adults. In our data, when used by non-specialists and in adults, a cutoff level of 5 points provided 90% PPV while a cutoff of 6 points revealed 100% PPV. In all patients with a score of 2 or less, the disease could be safely excluded.

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Compliance with ethical standards

Conflict of interest None.

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