Predictivity of Clinical Findings and Doppler Ultrasound in Pediatric Acute Scrotum

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Purpose: To evaluate the role of Doppler ultrasonography (DUS) in diagnosing pediatric testicular torsion (TT), and its diagnostic accuracy, and helping clinicians increase specificity and decrease negative exploration rates.

Materials and Methods: We performed a retrospective study of all consecutive patients with acute testicular symptoms referring to our pediatric emergency department (ED) from January 2010 to December 2013.

Results: We analyzed 1091 patients, with a mean age of 9 years. DUS was performed in 498 patients (40.8%); 107 patients (8.8%) underwent surgery and 41 patients (3.3%) had a TT. The following clinical findings were collected: presence of scrotal pain, erythema and swelling, spermatic cord pain and abnormal cremasteric reflex. The clinical findings significantly associated with TT were spermatic cord pain (OR = 37, 95% CI: 11.9-111.1, $P < .001$) and abnormal cremasteric reflex (OR = 47.6, 95% CI: 13.5-166.6, $P < .001$); the presence of swelling was not associated with TT (OR = 2.3, 95% CI: 0.7-8.4, $P < .001$). Scrotal pain was not significantly associated with TT ($P = .9$), while erythema made TT unlikely (OR = 0.22, 95% CI: 0.07-0.7, $P = .0445$). In all cases the DUS significantly increased the predictivity.

Conclusion: TT was present in 3.3% of patients presenting with testicular symptoms. The predictivity based on clinical findings resulted high and the negative exploration rate for TT was 62%. DUS increased the predictivity in all patients.

Keywords: acute scrotum; children; testicular torsion; ultrasonography; pediatric surgery

INTRODUCTION

Acute scrotum in the pediatric population is defined by the sudden onset of scrotal pain, erythema and swelling. Acute scrotum may become a surgical emergency, since it can lead to the loss of the affected testicle, especially when a failure in diagnosing and an erroneous management occur. Despite the presence of recent guidelines[1], the management of acute scrotum is not uniform world-wide. In many institutions an immediate surgical exploration is performed in all males presenting with acute scrotum, in order to save the highest number of testicles; however other institutions use a more conservative approach, unless testicular torsion is evident[2-4]. The main causes of acute scrotum in pediatric age are testicular torsion (TT), torsion of the appendage of the testis (TAT) and epididymo-orchitis (EO). The annual incidence of TT is 1:4000 in males aged under 18 which accounts for 5-25% of acute scrotum in children. Furthermore, the bimodal distribution of TT, with peaks in the perinatal period and in adolescence, reflects the distinction between the extravaginal and the intravaginal torsion, which are respectively typical of newborns and older children. Anamnestic data and clinical findings are the cornerstones to diagnose acute scrotum. Thus many studies have been performed in order to achieve clinical scores that could help surgeons in diagnosis and treatment[5-7]. Typically, TT presents with a sudden onset of severe pain followed by scrotal and inguinal swelling. Often, a high riding testis, which can also lie transversely, is found. The absence of cremasteric reflex is one of the most consistent findings that supports the diagnosis of TT[2,8,9]. An increased incidence of TT has been also associated with seasonal variations and lower temperatures[10,11]. In addition to clinical examination, Doppler ultrasonography (DUS) has been progressively used in TT diagnostic management. It can provide very good and useful information about anatomy and perfusion, with a reported sensitivity of 64-91% and specificity of 97-100%[1,12]. DUS has become the standard imaging method in acute scrotum management, because of its wide availability, easy performance, non-invasiveness and low costs. However, it is limited by high operator dependency and non-negligible number of false-negative results that may lead to loss of the testicle. The aim of the present study was to identify reliable clinical findings associated with TT and to evaluate the role of testicular DUS in diagnosing pediatric testicular torsion, under the aspect of diagnostic accuracy

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and improvement, with an aim to achieve specificity increase and decrease in negative exploration rates.

PATIENTS AND METHODS

Study Population and inclusion criteria

We performed a retrospective analysis of all consecutive patients with acute testicular symptoms presenting to the emergency department (ED) of our hospital from January 2010 to December 2013. Patients were selected from the hospital database using ICD 9th edition codes: EO (6040, 60490, 60499), TAT (60823), TT (60820), testicular pain (6089). 1091 patients were included in the analysis, for a total of 1219 ED admissions. Patients with a diagnosis of intrauterine testicular torsion, varicocele, hydrocele, and cryptorchidism were excluded from the study.

Procedures and Evaluations

Data were collected using patient charts and operating room records. Regarding medical history, data included the age of the patient, time of arrival at the ED, first evaluation (ED, another hospital, general practitioner), duration of symptoms, and history of possible trauma. All patients were physically examined by a pediatric surgeon, who evaluated erythema, swelling, spermatic cord pain and consistency, cremasteric reflex, and fever (T > 38°C). A reduced or absent cremasteric reflex was considered an abnormal finding. DUS was performed by a pediatric radiologist using Philips iU22 Ultrasound Machine (Philips Corporation, Andover, MA, USA) adjusted and optimized for testicular structures; ultrasonography was performed with a 12.5 Hz linear transducer. The scanning method consisted of the visualization of the scrotum and its contents with longitudinal and transverse axes. Both testicles were scanned in order to provide a comparison of anatomy and blood flow. The entire testicle was evaluated from one extreme to another, then the scan was repeated after rotating the probe 90° to obtain a transverse image of the testicle. Once the gray-scale imaging was complete, the power Doppler examination was performed. Power Doppler and pulsed Doppler parameters were optimized to adequately evaluate the blood flow in testicles and their adjacent structures. The color gain was calibrated carefully to avoid any artifactual appearance of flow. A diagnosis of TT was made in cases of uncertainty or absent central perfusion. All patients presenting with scrotal symptoms and a clinical or a DUS suspicion for TT underwent surgical exploration. In TT cases, the testis was detorqued and placed in warm sponges for 15-20 minutes; if no sign of perfusion was observed, an orchiectomy was performed, then the surgeons proceeded with a contralateral orchiopexy using the three-stitch triangular technique with a reabsorbable suture. In case of a viable testis, it was fixed in with 3-4 stitches.

Statistical Analysis

Statistical analysis was performed using the SPSS software version 15.0 (SPSS, Inc, Chicago, IL). The difference between groups was calculated using the Fisher's test and a binary logistic multivariate backward stepwise analysis with variable inclusion threshold $P < .1$, expressed as odds ratios (OR) and 95% confidence intervals (CI). Finally we calculated the R2 Nagelkerke index in order to evaluate the predictivity of the model.

Table 1. Reported symptoms and clinical findings

Characteristic		Value	Percentage
Mean age (year)		9.11	
Side			
	Right	592	48.56%
	Left	558	45.77%
	Bilateral	69	5.67%
Trauma			
	Yes	74	6.07%
	No	1145	93.93%
Pain			
	Yes	1144	93.92%
	No	75	6.08%
Pain location			
	Diffuse	475	41.52%
	Upper pole	31	2.71%
	Lower pole	638	55.77%
Swelling			
	Yes	528	43.31%
	No	691	56.69%
Erythema			
	Yes	430	35.27%
	No	789	64.73%
	Painful	50	4.10%
Spermatic cord			
	Thickened	4	0.33%
	Thickened and painful	20	1.64%
	Normal	1145	93.93%
Cremasteric reflex			
	Normal	1108	90.89%
	Reduced	62	5.08%
	Absent	49	4.03%
Fever (T > 38°C)	Yes	13	1.06%
	No	1206	98.94%

Abbreviations: T = temperature

RESULTS

The data from 1091 patients were analyzed, but since 128 patients were visited twice, 1219 ED visits were included in the final analysis. The mean age of the study population was 9.1 years (range 6 months – 16 years). The reported symptoms and clinical findings of the study population are summarized in **Table 1**. The mean time of presentation to the ED from the onset of symptoms was 21.49 hours (range 45 minutes – 72 hours). For patients who underwent surgery, the mean duration was 19.89 hours (range

Table 2: Sensitivity, specificity, positive predictive value and diagnostic accuracy of clinical data and Doppler ultrasonography in diagnosis of testicular torsion.

	Clinical	DUS
Sensitivity	94.11%	75.86%
Specificity	95.37%	98.93%
Positive predictive value	47.05%	81.48%
Diagnostic Accuracy	95.32%	97.59%

Abbreviations: DUS, Doppler ultrasonography

Table 3: Analyzed clinical and DUS findings

	OR	95% CI
Erythema	0.22	0.07-0.7
Swelling	2.3	0.7-8.4
Spermatic cord pain/thickness	37	11.9-111.1
Abnormal cremasteric reflex	47.6	13.5-166.6

Abbreviations: DUS = Doppler ultrasonography, OR = odd ratio, CI = confidence interval

45 minutes – 48 hours). However, once there was a suspicion of a TT, the mean time between the physical examination and the operation was 1.07 hours (range 30 minutes - 2 hours and 15 minutes). Diagnostic results were: TT in 41 patients (all by surgical exploration), TAT in 323 (288 by clinical and DUS examination, 35 by surgical exploration), EO in 506 (479 by clinical and DUS examination, 27 by surgical exploration), and other pathological diagnosis in 349 patients (including trauma, not-otherwise-specified testicle pain, idiopathic scrotal edema, inguinoscrotal hernia; 345 by clinical and DUS examination, 4 by surgical exploration). DUS was performed in 498 patients (40.85%), whose reports were compatible with the following diagnoses: EO 279 (56.02%), TT 27 (5.42%), TAT 41 (8.24%), normal 144 (28.92%), uncertain 5 (1%), hematoma 1 (0.20%), inguinoscrotal hernia 1 (0.20%). All 27 patients with a DUS report compatible with TT underwent surgical exploration, however in 5 patients the diagnosis changed to a non-TT category (3 EO, 1 TAT, 1 hematoma). Of the 471 cases with DUS reports compatible with non-TT, 7 underwent surgical exploration due to a strong TT suspicion and the TT diagnosis was confirmed. Surgical exploration was performed in 107 cases (8.77%) and the diagnosis of TT was confirmed in 41 patients (3.36%). Orchiectomy rate was 14.02%. None of patients discharged from the ED returned with TT. The negative exploration rate was 62%. The overall sensitivity, specificity, positive predictive value (PPV), and diagnostic accuracy of both clinical and DUS findings have been presented in **Table 3**. **Table 3** Sensitivity, specificity, positive predictive Then we analyzed the association between the presence of scrotal pain, erythema, swelling, spermatic cord pain and/or thickness, and abnormal cremasteric reflex. (**Table 3**) A prior selection was made using Fisher's test, then a multivariate analysis model was produced. The clinical findings associated with TT were spermatic cord pain and/or thickness (95% CI: 11.9-111.1, OR = 37, $P < .001$), and abnormal cremasteric reflex (95% CI: 13.5-166.6, OR = 47.6, P < .001). The presence of erythema resulted associated with non-TT (95% CI: 0.07-0.7, OR = 0.22, $P = .0445$) while the presence of swelling was not associated with TT (95% CI: 0.7-8.4, OR = 2.3, $P < .001$). The presence of pain was excluded from the analysis model because of its low statistical specific relevance (P = .9). Furthermore, the presence of spermatic cord pain and/or thickness (95% CI: 17.2-76.9, OR = 37, $P < .001$), abnormal cremasteric reflex (95% CI: 5.3-18.2, OR = 9.9, $P < .001$), and swelling (95% CI: 2.4-9.3, OR = 4.6, $P < .001$) were associated with surgical indication. In the second analysis we added the "DUS findings compatible with TT" to the model, in order to verify contingent differences in predictivity. The DUS variable was strongly associated with TT (95% CI: 11.9-250, OR = 55.55, $P < .001$). Finally we calculated the R2 Nagelkerke index to evaluate the predictivity of the model. First only considering clinical findings, the R2 index was 0.649, then adding DUS variable, it increased to 0.784. This means that the DUS significantly increases the predictivity of acute scrotum diagnostic process.

Discussion

Children presenting at the ED with acute testicular symptoms require an immediate examination. The most frequent causes of acute scrotum are TT, EO, and TAT. In this study, the incidence of TT cases was lower (3.36%) than in previous reports[6,13-16]. This can be explained by the fact that the current study included all patients with acute testicular symptoms, even those without abnormalities on physical examination. The optimal diagnostic management of acute scrotum should identify patients who require an immediate surgical exploration, in order to recognize all TTs and save the highest number of twisted testicles. In our study we focused on spermatic cord pain and/or thickness, and abnormal cremasteric reflex. The presence of pain and/or thickness of the spermatic cord showed to be highly predictive of TT, but we could not find reports in literature that consider this finding in their analysis. The abnormality of the cremasteric reflex was also strongly associated with an increased likelihood of TT. This result is supported by other studies[13,16,17,19-21], even if some of them[13,22] found an abnormal cremasteric reflex in all patients with TT. In the present study, 4 of the 41 patients with TT had a preserved cremasteric reflex. This difference can be explained by the large study population (1091 patients), in fact the previous series involved a smaller number of patients. Moreover, a similar result can be found in recent reports[17,18]. The presence of at least one of these findings should induce the suspicion of TT in children presenting at ED with acute testicular symptoms, in fact all patients with TT showed at least one of them. Furthermore, no TT was found in patients without either finding. Our negative exploration rate was of 62%, lower than in the known literature[17,18]. The implementation of this approach would have further decreased it by 28%. The presence of erythema makes TT unlikely, as it is reported in several studies[17,18,23]. The presence of swelling resulted slightly, but not significantly, associated with TT[19,23]. The presence of pain was not statistically significant, because it is a common symptom of all causes of acute scrotum. However many stud-

ies demonstrated the association of a pain duration lower than 24 hours, with TT[2,17,18,20,22,24]. In the last few years, DUS became an important part of the diagnostic process of acute scrotum, since it can evaluate the reduction/absence of central perfusion, it is a fast non-invasive procedure, and its costs are limited. However DUS is highly operator dependent and in many institutions is not available during night hours. In the current study, we recorded a 75.86% sensitivity and a 98.93 specificity, similarly to what is written in international literature[25,26]. From the statistical analysis, we found a strong association between DUS findings and TT. Nevertheless, DUS cannot substitute the clinical examination, in fact 7 patients with TT had a preserved central perfusion. This circumstance occurred in other reports[2,17] as well and confirms our results. A limitation of the current study was that DUS has been performed on 40.85% of patients, even if groups were statistically comparable. These results allow us to claim that clinical and DUS findings must be enrolled together in order to increase the specificity, lowering the negative exploration rate and improving the model predictivity (R2 Nagelkerke index: 0.649 → 0.784). Thus we suggest to perform a DUS before surgical exploration, unless either the suspicion of TT or the risk of a testicle loss are high. This approach is also consistent with other reports[17,27,28], even if there are studies that suggest an immediate surgical exploration in all patients with acute scrotum[4].

Conclusion

Acute scrotal symptoms are a common causes of presentation to a pediatric ED. TT incidence is low (3.36%). Clinical findings show high sensitivity, but low specificity; thus there are no missed TT, but a high number of negative exploration. The spermatic cord pain and/or thickness and an abnormal cremasteric reflex are two essential findings to search for when diagnosing TT. The DUS can not replace the physical examination, but it is an actual aid for all cases of uncertain clinical suspicion. The ensemble of clinical and DUS findings allow clinicians to improve diagnostic accuracy and specificity, and lower negative exploration rate.

CONFLICT OF INTEREST

None declared.

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