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Prospective evaluation of predictors of testis atrophy after surgery for testis torsion in children

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Abstract

Objective: To prospectively correlate pain duration, red scrotal skin, ultrasound appearance of testis, and intra-operative testis color to future testis atrophy after acute testicular torsion.

Methods: Consecutive children 2 months to 18 years old with unilateral acute scrotum were enrolled in a NIH trans-cutaneous near infrared spectroscopy study, with a sub-group analysis of the true torsion group. Presence/absence of red scrotal skin, pain duration, testicular heterogeneity on pre-operative ultrasound, and intra-operative testis color based on a novel visual chart 5 minutes after detorsion were recorded. All testes underwent orchiopexy regardless of appearance. Percent volume difference between normal and torsed testicles on follow up ultrasound was compared between patients with and without risk factors.

Results: 30/56 patients who had surgical detorsion underwent scrotal ultrasound a mean of 117 days after surgery. A color 5 minutes after detorsion of black/hemorrhagic, pain duration >12 hours, and heterogeneous parenchyma on pre-operative ultrasound were associated with

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significant testis volume loss in follow up compared to normal testis. All patients with a black or hemorrhagic testis had >80% volume loss. Erythematous scrotal skin was not significantly associated with smaller affected testis volume in follow up.

Conclusion: Based on the high atrophy rate, orchiectomy can be considered for testes that are black or hemorrhagic 5 minutes after detorsion. Pain duration >12 hours and parenchymal heterogeneity on preoperative ultrasound was also associated with testis atrophy. Red scrotal skin was not a reliable predictor of atrophy and should not delay exploration.

Introduction

Testis torsion, primarily seen in the newborn and young adult patient, occurs in 1 in 4000 males younger than 25.^{1,2} It is the most common diagnosis in a pubertal male patient presenting with unilateral acute onset scrotal pain.³ Other common presenting signs and symptoms include nausea, vomiting, high riding testis, hard testis, absent cremasteric reflex, and red scrotal skin.⁴⁻⁶ At initial evaluation and exploration, a surgical decision must be made if the torsed testicle is viable and thus pexied versus removed. The surgeon must balance the possible risks of leaving in a potentially nonviable testicle (pain, postoperative infection and theoretical concern for anti-sperm antibody mediated infertility⁷) versus leaving the child with a solitary testicle (future trauma risk to solitary organ, psychological impact of monorchia⁸). Unfortunately, 32–42% of torsed testes are removed at time of surgical exploration nationally.^{1,9} Previous studies have shown that testicular function¹⁰ and semen quality⁷ may be compromised after orchiectomy for torsion.

Any pre-operative or intra-operative factor which may help the provider to determine which testicles will survive and which will atrophy can thus be of great benefit to the patient and physician. According to previous reports, the risk of testis loss or atrophy after torsion is significant 4–24 hours after onset of pain¹¹⁻¹⁵, with heterogeneous echogenicity of the affected testicle on ultrasound^{13,16}, increasing or decreasing patient age^{15,17}, absence of testicular tissue bleeding at the time of surgery¹⁸, and presence of red scrotal skin¹⁹. However, decision-making is not as simple as that, as torsion can be intermittent, of variable degrees of twist over variable lengths of the spermatic cord, and may have postoperative compartment syndrome after detorsion which can lead to demise not appreciated at the time of surgery²⁰. Factors that have been found to make no difference in testicular salvage include ethnicity, insurance type, and time of day¹⁵. Unfortunately, many of these previous studies are weakened by small sample size, the retrospective nature, and the fact that not all testicles were left in place at the time of surgery which introduces a selection bias.

The purpose of this study was to prospectively assess classic risk factors for atrophy after testis torsion and to correlate them with future testis atrophy. The hypothesis was that certain physical exam, imaging, and intra-operative findings could predict future testis atrophy and thus may be used to guide the clinician for or against orchiectomy after testicular detorsion.

Methods

After approval by the University of Texas Southwestern institutional review board, enrollment in a single center, NIH prospective clinical device trial of trans-scrotal near

infrared spectroscopy (NIRS) for the diagnosis of acute testicular torsion began March 19, 2013 and ended March 25, 2015. Correlation of pre-operative factors with future testis atrophy after testicular torsion was a secondary endpoint of the NIRS study, the results of which have been previously published²¹.

All males 2 months of age to 18 years from any ethnic background who presented to Children's Medical Center Emergency Department in Dallas, TX with acute scrotum were prospectively invited to participate in the study. Acute scrotum was described as any male presenting with waddling gait from painful scrotum, acute scrotum or testes, or abdominal pain with localizing scrotal findings. Patients with synchronous bilateral testicular torsion or known testicular or scrotal pathology were excluded as were patients with chronic respiratory, hematological or vascular problems that could affect total body tissue oxygenation levels.

Potential subjects were approached by emergency medical technician personnel and screened for study inclusion. Clinical trial data was collected while patients were receiving emergency care to avoid any delay. Patients proceeded with standard of care treatment which consisted of history and physical examination and scrotal ultrasound. Sonography was used as the gold standard for diagnosis of testicular torsion. Measurements obtained on ultrasound included testis size (height, length, width), presence or absence of blood flow, and presence or absence of testicular heterogeneity as determined by the radiologist interpreting the study. Patients with presumed testicular torsion were immediately taken to the operating room for scrotal exploration, detorsion of the torsed testicle, and bilateral orchiopexy.

Per study protocol, the following classic predictors of testis atrophy were tabulated for all patients explored for testicular torsion: presence or absence of red scrotal skin, duration of scrotal pain prior to surgery, presence or absence of testicular parenchymal heterogeneity of the torsed testicle on pre-operative scrotal ultrasound, and intra-operative testis color 5 minutes after detorsion as determined by the surgeon. Duration of pain was calculated by subtracting the minutes that passed from when the patient first experienced symptoms to time of surgical detorsion. The intra-operative testis color was assigned a numerical score based on a novel visual testis color scale which we created (Figure 1). All surgically explored patients who were discovered to have testicular torsion had detorsion with both testicles pexied regardless of detorsion testis appearance without tunica vaginalis patch per study protocol in order to follow the natural history of all testes after torsion. Percent volume difference between the normal (contralateral) and affected (torsed) testicle on follow up ultrasound (at a postoperative visit 3–6 months after surgery) was compared between patients with and without the above mentioned “classic” risk factors for testicular atrophy after acute torsion. Significant percent volume difference was considered >80% loss.

Data were prospectively collected using REDCap (CTSA NIH Grant UL1TR001105) and stored on secure servers. Continuous data was compared by Wilcoxon rank sum test or Kruskal-Wallis test with Dunn's test used for multiple comparisons between groups. A p-value of 0.05 was considered statistically significant. Statistical analysis was performed with Stata 12 (College Station, TX).

Results

For the overall NIRS study, 316 male patients with acute scrotum were assessed and 154 were enrolled. Of these 154, 56 were explored for testicular torsion diagnosed by sonography. At surgery, 1 patient was determined to have an incarcerated inguinal hernia and not acute testicular torsion. The remaining 55 patients had acute torsion confirmed in the operating room. All patients tolerated the procedure well and were discharged home as an outpatient. Thirty patients (67%) had a follow up scrotal ultrasound performed a median of 111 days after surgery (89–136) (Table 1). The remaining 25 torsion patients were lost to follow up or returned for an office appointment but did not complete their post-operative scrotal ultrasound. There were no reported complications, such as infection, from pexying all testicles.

Median duration of pain prior to detorsion was 8.4 hours (IQR 5.6–49.6 hours), Table 1. When categorized into groups of 0–6 hours, 6–12 hours, and > 12 hours; size of affected testis in follow up was different between the three groups ($p<0.001$, Kruskal-Wallis test). Comparing each group by Dunn's test, there was no difference in size of the affected testicle in follow up compared with the contralateral normal testicle in patients who presented with pain ranging from 0–6 hours compared with those who presented with a pain duration of 6–12 hours ($p=0.3$). However, patients with a pain duration greater than 12 hours had significantly more volume loss than patients who had pain 0–6 hours ($p<0.001$) and those with pain 6–12 hours ($p=0.005$) (Table 2).

The median (IQR) affected testis volume percent difference from the normal contralateral testis on follow up ultrasound and number with >80% smaller volume was grouped by the color of the affected testicle 5 minutes after surgical detorsion (Table 3). Normal pink to light blue testicles were slightly smaller in size while dark blue/purple testicles had a wider range of volume change. All patients with a black or hemorrhagic/necrotic testicle had 80% smaller volume compared with the normal contralateral testicle, respectively (Tables 2, and 3).

Twelve patients (22%) had red scrotal skin on physical exam prior to surgery. While those with an erythematous scrotum had a smaller affected testicle size compared with the normal contralateral testicle, 5/12 patients with red scrotal skin did not have >80% smaller volume in the affected testis in follow up, Table 2. Five of 12 patients (41.6%) with red scrotum had a black/hemorrhagic testis versus 1 of 14 (7.1%) without red scrotum had a black/hemorrhagic testis.

Nineteen patients (35%) had abnormal testicular parenchyma with heterogeneity of the affected testicle on pre-operative scrotal ultrasound. The patients who had abnormal parenchyma had a median 80% smaller testicular size compared with the normal contralateral testicle, Table 2. This difference in size between the normal and affected testicle was significantly different than those patients who had normal testicular parenchyma on pre-operative ultrasound ($p<0.001$), Table 2.

Discussion

Testicular loss or atrophy is a significant complication of testicular torsion¹³. Unfortunately, due to delays in care as well as diagnostic uncertainty or errors, loss or atrophy of a torsed testicle may occur despite appropriate identification and treatment. Because of the potential adverse effects on testicular function after orchiectomy¹⁰ as well as the psychological impact related to the loss of the testicle⁸, it would be of great benefit to both the patient and physician to determine what pre-operative factors may predict testicular loss both for surgical planning and patient counseling. This study prospectively evaluated potential risk factors for testicular atrophy and found that pain duration as well as appearance of the testicle on pre-operative ultrasonography and intra-operative testis color may be used to predict testicular salvage.

Patients with pain duration over 12 hours prior to detorsion had a median volume loss of 88% compared with the normal contralateral testicle. This is significantly more volume loss than in patients who had pain duration of less than 12 hours. This is consistent with previous publications which found that testicular necrosis or atrophy was significantly more common with pain duration of greater than 10 to 24 hours^{13,14,18,22}. However, we also found that some patients with pain duration less than 6 hours prior to detorsion had an up to 44% decrease in size of the affected testis compared to the normal contralateral testicle. This reveals that even despite timely diagnosis and detorsion, there may be ischemic damage or possibly a reperfusion injury secondary to edema and a “testicular compartment syndrome”²⁰. This is important information for counseling patients and their families on post-operative expectations. In addition, not all patients with pain over 12 hours had complete testicular loss which may be explained by intermittent torsion during the time between onset of pain and surgery or due to patchy testicular reperfusion. There were two pre-pubertal patients, one with history consistent with possible intermittent torsion and one with history of testis trauma followed by worsening pain, who had over 12 hours duration of pain and had 7% and 21% atrophy respectively. Thus, we do not advocate that all patients with pain duration over 12 hours have an orchiectomy or that surgery should be delayed in this population but rather pain duration can be used along with other risk factors to determine testicular salvageability and counsel families preoperatively.

Another potential guiding factor for predicting future testicular atrophy is the pre-operative testicular appearance on ultrasonography. This study found that patients with heterogeneity of the testicular parenchyma on ultrasound had a median of 80% volume loss of the affected compared with the contralateral testicle. This was significantly different than those patients who did not have abnormal testicular parenchyma on ultrasound as this group only had a median of 19% volume difference between testicles. This too is consistent with the existing literature with studies finding that heterogeneous echogenicity on pre-operative ultrasound was universally predictive of organ loss¹⁶ and significantly associated with testicular atrophy¹³. These findings are intuitive as the heterogeneous appearance is due to necrosis and edema from prolonged lack of blood flow to the testicle. Some patients with heterogenous parenchyma did not have >80% volume loss which suggests this finding should also not be used to delay surgery in all cases.

Finally, we introduce our preliminary experience and validation with the intra-operative testis color scale (Figure 1) and found that intra-operative testicular color 5 minutes after detorsion appeared to be the best predictor of future atrophy. Using this scale, black and hemorrhagic/necrotic testicles had an 80–100% decrease in volume compared with the normal contralateral testicle. Though the use of testicular appearance for determination of testicular salvageability is undisputed in clinical practice, we can find no studies in the literature which actually assessed atrophy risk and intra-operative testicular color. We found this risk factor was associated with significant atrophy in this study and thus may be useful in guiding clinicians on when to perform an orchiectomy. Our color scale could be easily posted in the operating room to assist in intra-operative decision making about testicular salvageability.

Under the hypothesis that a red or erythematous scrotum may herald an underlying necrotic testicle, we also examined the association of pre-operative red scrotal skin appearance to testicular atrophy rates. While patients with red scrotal skin did have a median 80% decrease in size of the affected testicle compared with the contralateral testicle, four patients (33%) had less than 40% volume decrease. Therefore, our study does not support the notion that “red is dead” and at this time we would not recommend delay of surgical treatment based on the outward scrotal appearance alone. As this information can have medicolegal implications, multiple aspects must be taken into consideration when deciding on the timing and type of treatment for testicular torsion.

A weakness of the study is the missing data from the patients lost to follow up which may introduce a bias in that patients who suspected a problem (i.e. decrease in the size of their testicle) returned to the clinic while those without concerns did not return for follow up. However, the patients who did not follow up were not significantly different from the patients who did have a follow up ultrasound in terms of age, race, duration of pain, and Tanner stage. Another potential weakness is that we did not have measurement of the pre-operative volume of the affected testicle prior to the torsion event. It is possible that some patients had volume loss of the torsed testicle prior to surgery either from intermittent testicular torsion or other causes such as varicoceles or normal asynchronous pubertal testicular growth. Moreover, previous studies have shown that all patients had atrophy after torsion by 14 months¹³, and thus some of the patients included in this study may have further testicular atrophy with longer follow up. The measurement of testis size by ultrasound has some expected measurement error. However, this measurement error is not expected to be systematic or associated with the predictor and should not lead to observed associations.

Strengths of the study include the prospective nature and the fact that all testicles underwent orchiopexy emergently regardless of pain duration or color appearance in the operating room in hopes to allow for observation of the true natural history of the testicle after detorsion and orchiopexy. This truly sets this project apart as most other papers present a retrospective review of patients after orchiopexy for presumed viable testicles with those that were determined to be non-viable removed and not included in the outcomes. This study pexied every testicle regardless of appearance and thus truly follows testicular outcomes after a torsion event in all comers.

Conclusions

Preoperative risk factors of pain duration over 12 hours, heterogeneous testis parenchyma on ultrasound, and red scrotal changes were associated with future testis atrophy but should not be reasons to delay surgery as some patients did not have complete atrophy. Intraoperatively, all patients with black or hemorrhagic appearing testes had >80% less volume than the normal contralateral testis on ultrasound and orchiectomy can be considered at time of scrotal exploration for torsion in these patients.

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Clinical Trial Registration: Registry name: Near-infrared Spectroscopy for Pediatric Acute Scrotum and Testicular Torsion; Registration number: NCT01812109; <https://clinicaltrials.gov/ct2/show/NCT01812109?term=NCT01812109&rank=1>

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Figure 1:
Intra-Operative Testis Color Scale

Table 1:**Patient Characteristics**

Mean age in years (range)		13.3(1.4–17.3)
Race		
	White	7 (23.3%)
	Hispanic	12 (40.0%)
	Black	9 (30.0%)
	Asian	1 (3.3%)
	Other	1 (3.3%)
Tanner Stage		
	1	3 (10.0%)
	2	3 (10.0%)
	3	8 (26.7%)
	4	13 (43.3%)
	5	3 (10.0%)
Median hours of pain prior to detorsion (IQR)		9.6 (5.6 to 49.6)
Red scrotal skin¹		12/26 (46.2%)
Testis color 5 minutes after detorsion		
	(1) Normal pink	3 (10.0%)
	(2) Mottled pink/light blue	7 (23.3%)
	(3) Light blue	8 (26.7%)
	(4) Dark blue/purple	6 (20.0%)
	(5) Black	5 (16.7%)
	(6) Hemorrhagic/necrotic	1 (3.3%)

¹Four patients did not have presence or absence of red scrotal skin recorded

IQR = interquartile range

Table 2:**Predictors of Testis Atrophy**

	Median affected testis volume percent difference from normal testis (IQR)	P-value	Number with >80% smaller testis
Red scrotal skin			
Yes (n=12)	−80% (−91% to −31%)	0.02 ^I	7/12 (58%)
No (n=14)	−20% (−62% to −5%)		3/14 (21%)
Testis color 5 min after detorsion			
1–4 (n=24)	−30% (−68% to −7%)	0.01 ^I	5/24 (21%)
5–6 (n=6)	−86% (−90% to −80%)		6/6 (100%)
Pain duration (hrs)			
0–6 (n=10)	−16% (−33% to −5%)	<0.001 ²	0/10 (0%)
6–12 (n=7)	−35% (−62% to −3%)		1/7 (9%)
>12 (n=13)	−88% (−92% to −80%)		10/13 (78%)
Abnormal parenchyma on TUS ³			
Yes (n=19)	−80% (−90 to −37%)	0.002 ^I	11/19 (58%)
No (n=11)	−19% (−34 to −6%)		0/11 (0%)

¹Wilcoxon rank sum²Krskal-Wallis equality of populations rank test³Heterogenous or abnormal echogenicity of affected testis parenchyma

IQR = interquartile range; TUS = testicular ultrasound

Table 3:

Testicular Volume Change by Testis Color 5 Minutes after Detorsion

Testis color 5 minutes after detorsion	Median testicular volume change (IQR)	Number (%) >80% smaller than contralateral
Normal pink (n=3)	+9% (−7% to 25%)	0/3 (0%)
Mottled pink/light blue (n=7)	−27% (−37% to −12%)	0/7 (0%)
Light blue (n=8)	−13% (−49% to −4%)	1/8 (13%)
Dark blue/purple (n=6)	−89% (−92% to −73%)	4/6 (67%)
Black (n=5)	−88% (−90% to −80%)	5/5 (100%)
Hemorrhagic/necrotic (n=1)	−84% (n/a)	1/1 (100%)

A negative mean volume change indicates testis was smaller in follow up and a positive mean volume change indicates testis was larger in follow up

IQR = interquartile range