Pilot Feasibility Study of Transscrotal Near Infrared Spectroscopy in the Evaluation of Adult Acute Scrotum

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Abbreviations and Acronyms

MRI = magnetic resonance imaging

NIRS = near infrared spectroscopy

US = ultrasound

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Purpose: We investigated the usefulness of transscrotal near infrared spectroscopy that measures testicular oxygen saturation (StO_2%) in the diagnosis of testicular torsion vs other causes of the acute scrotum in adults.

Materials and Methods: Between January and May 2009, 16 adult males presenting with acute scrotum underwent StO_2% measurement of the affected and unaffected testis using near infrared spectroscopy followed by color Doppler ultrasound. If surgically explored, near infrared spectroscopy was performed at surgery and on postoperative day 1. Data were presented as means ± SD and/or normalized to the internal control. Cutoff value was generated for the StO_2% difference between the affected testis and control side.

Results: Sixteen males with acute scrotum of mean duration 12 hours were enrolled. Of 11 patients with abnormal Doppler undergoing surgical exploration, mean StO_2% of the affected testis at presentation and at surgery decreased from 40.09 ± 2.66 (range 36 to 44) to 37.18 ± 3.31 (range 32 to 42), respectively, while StO_2% of the unaffected testis remained 63.09 (range 55 to 69) both at presentation (SD 4.72) and at surgery (SD 4.98). Of the 11 surgically explored, 4 had orchiectomy and 7 patients underwent surgical detorsion. At presentation and at surgical exploration of the detorsed group, the mean normalized difference between the StO_2% values of the affected and unaffected sides was −16.12 and −25.9, respectively. A cutoff value of −11.5 was measured for the StO_2% difference between the affected testis and control side at presentation in patients who underwent surgery.

Conclusions: Near infrared spectroscopy identified all surgically confirmed cases of testicular torsion when affected testis StO_2% was more than 11.5 units lower than the contralateral testis. In pilot testing, near infrared spectroscopy is a rapid, noninvasive, easy and safe method for the differential diagnosis of adult human testicular torsion.

Key Words: scrotum; spectroscopy, near-infrared; spermatic cord torsion; ultrasonography, Doppler

Testicular torsion is a urological emergency with an incidence of 1/4,000 in males younger than 25 years old.[1–3] Appropriate medical care, diagnosis, and treatment are often delayed. Unfortunately, testicular torsion results in orchiectomy in 30% of cases in the US.[4]

Testicular torsion is one of the possible diagnoses in a patient presenting with acute scrotal pain.[1,5] The differential diagnosis of testicular torsion mainly depends on clinical history and physical examination.[6] Doppler ultrasound should be performed in a patient

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with possible diagnosis of testicular torsion unless unequivocal presentation leads to direct surgical exploration.[1,7–11]

Limitations of Doppler US include availability, need for an experienced radiologist or technician, and difficulty to perform in patients with small testicular volume.[6,8] Nuclear scintigraphy is the alternative diagnostic tool to assess testicular blood flow.[1,12] Limitations of scintigraphy include requirement for intravenous access, radiation exposure, availability and long investigation time.[1,8,13] MRI can also be used to diagnose testicular torsion.[1,14] However, the need for patient cooperation, on demand emergency access to MRI and extra time limits its practical application.[6,8]

The rate of negative surgical exploration in patients with possible preoperative diagnosis of testicular torsion is between 2% and 88%.[8,15–20] Possible reasons of negative scrotal exploration include limitations in the availability of diagnostic tools or clinicians to use them, and strong clinician desire not to miss a possible case of testicular torsion.[6,8,15]

NIRS is a noninvasive diagnostic tool that can measure total tissue oxygen status of the arterial and venous sides using algorithms to interpret changes in the light absorbance and reflection of hemoglobin redox status.[6,15] NIRS can measure testicular oxygenation (StO_2%) up to 3 to 4 cm deep to the skin and may potentially be used as a noninvasive tool for the rapid diagnosis of testicular torsion, confirmation of manual torsion reduction and estimation of testicular viability intraoperatively.

We have recently evaluated NIRS to diagnose testicular torsion and blindly compared its accuracy with that of Doppler US in an adult rat model. We found that NIRS accurately reveals oxygen saturation, which is more vital than the blood flow on which Doppler US focuses.[6] Similarly NIRS was highly predictive of testicular torsion using rabbit and sheep models.[15,21] We investigated the usefulness of transscrotal NIRS to quantitate testicular oxygenation, which has never been used for the possible diagnosis of testicular torsion in men. To our knowledge this is the first prospective and controlled study investigating the feasibility and effectiveness of NIRS in diagnosing testicular torsion compared with Doppler US in men.

MATERIALS AND METHODS

The study protocol was approved by the institutional human trials ethics committee. Sixteen males presenting with unilateral acute scrotum between January and May 2009 were included in the study. Following physical examination, all patients were evaluated with transscrotal NIRS of the affected and unaffected testis by the same clinician followed by Doppler US imaging. Unaffected testicles served as internal controls. If surgically explored, patients were also evaluated with NIRS just before the surgical procedure and at postoperative day 1. Doppler US was blindly performed by the same radiologist to prevent possible bias. Data were presented as means ± SD and/or normalized to internal control (StO_2% of affected testis − StO_2% of unaffected testis).

Near Infrared Spectroscopy

NIRS is not a routine diagnostic tool used for the differential diagnosis of acute scrotum. However, there are more than 50 published reports and 4 randomized trials of NIRS performed for human conditions other than testicular torsion, including vascular and cerebral pathologies.[22–25] NIRS can measure mixed venous and arterial StO_2% of hemoglobin up to 3 to 4 cm deep to the skin. NIRS estimates total tissue oxygenation status of the arterial and venous sides by algorithms to interpret changes in the light absorbance and reflection of hemoglobin redox status.[15] The NIRS device has various probes suitable for neonatal, children and adult age groups. Since the size was more suitable for NIRS measurements of human testis, the neonatal probe was used for all patients in our study. The cost of the NIRS device is approximately 17,000 €, and the cost for the neonatal probe is about 100 €.

NIRS measurements were done for each testicle using the Invos® 5100C oximetry device (Covidien/Somanetics) with the OxyAlert™ somatic neonatal near infrared sensor probe in accordance with manufacturer instructions. The probe was placed horizontally on each testis which was carefully held using the 1st, 2nd and 3rd fingers. Each NIRS measurement of tissue oxygenation lasted 20 seconds or less for 1 testis. StO_2 expressed as a percent was measured by NIRS and noted blindly by a single clinician. The average of 2 consecutive measurements was noted. Doppler US was performed blindly by a single radiologist.

Statistical analyses

Statistical analyses were done using SPSS® 15.0. Repeated measures ANOVA test was used to find and compare the means of StO_2% for the affected and unaffected testicles. Wilcoxon signed rank test was used to interpret the StO_2% differences between the affected and unaffected testicles. For the exact diagnosis of testicular torsion, ROC curves were generated to find a cutoff value for StO_2% difference between the affected and unaffected testicles at presentation. Statistical significance was set at $p < 0.05$.

RESULTS

Sixteen consecutive males with a mean age of 18.27 years (range 16 to 29) were included in the study. No patients were excluded and none of the patients refused participation. All patients presented with acute scrotal pain with a mean duration of 12 hours (range 4 to 16). Doppler US was normal in 5 patients and no surgical exploration was performed. In these patients mean StO_2% values of the affected and unaffected (internal control) testicles were 61.4 ± 3.71 (range 55 to 64) and 62.4 ± 3.78 (range 57 to 66), respectively ($p > 0.05$, fig. 1, *A*). In every patient without testicular torsion StO_2% value of the affected testis was higher or no more than 9 units