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Diagnostic Accuracy of Doppler Ultrasound in Testicular Torsion Keeping Surgical Findings as the Gold Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of ultrasound with Doppler analysis in testicular torsion, keeping surgical findings as the gold standard.

Study Design: Cross-sectional validation study

Place and Duration of study: Radiology Department of Pakistan Institute of Medical Sciences, from Dec 2017 to Dec 2019.

Methodology: The study included 58 candidates of acute scrotum who were clinically equivocal with a strong suspicion of testicular torsion and were referred by the concerned surgery department to Radiology, where a senior resident performed the testicular ultrasound. The grey scale features, along with doppler findings, were noted. Only those cases that underwent surgical exploration were included. The clinical, sonological, and per-operative findings were recorded.

Results: The mean age of our study was 18.00±6.02 years. The sensitivity, specificity, positive predictive value and negative predictive value of Doppler ultrasound were 98%, 86%, 98% and 86%, respectively. The most consistent Doppler ultrasound feature was absent intra-testicular flow, found among 46 out of 50 surgically confirmed cases of testicular torsion, while four had reduced intra-testicular flow. Similarly, heterogeneous testicular echotexture was the most frequently met grey scale feature. The sonological Whirlpool sign in our study came had 69% sensitivity and 100% specificity.

Conclusion: The overall diagnostic accuracy of ultrasound is significantly high, especially when both greyscale and colour Doppler findings are simultaneously interpreted. The sensitivity of ultrasound in diagnosing testicular torsion is far more than its specificity.

Keywords: Doppler ultrasound, Intratesticular flow, Testicular torsion, Whirlpool sign.

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INTRODUCTION:

Testicular torsion presenting with acute scrotal pain is a surgical emergency where timely evaluation and prompt surgical intervention can yield testicular viability. The ability to confidently establish surgical versus non-surgical diagnosis in cases of the acute scrotum is very important.[1] Testicular torsion is defined as the spermatic cord twisting, resulting in obstruction of blood flow to and from the testicle. Testicular torsion implies first venous and later arterial flow obstruction.[1,2] It accounts for 10-15 percent of cases of acute scrotum. It has a peak incidence in the age group 10-25 years1. It can be intra-vaginal or extra-vaginal, with the former being a more common subtype, especially near puberty, accounting for 90 percent of the cases.[3] The Intravaginal type of torsion has a common association with variant anatomy named bell clapper deformity.[1,2] In Bell clapper deformity, there is an incomplete investment of testis and epididymis by tunica vaginalis leading to the anomalous testicular suspension. Bell clapper deformity is frequently bilateral, encountered in 50-80 percent of cases.[2] Extravaginal torsion is seen more frequently in newborns without bell clapper deformity. It is thought to result from a poor or absent testicular attachment to the scrotal wall, thus allowing rotation of testis, epididymis and tunica vaginalis as a unit resulting in torsion at the external inguinal ring.[3] Early recognition of testicular torsion via clinical and imaging studies is crucial to management because testicular torsion lasting more than 6 hours may lead to irreversible testicular infarction and subsequent fertility issues.[4] The literature review has exclusively highlighted the role of prompt surgical intervention stating that early surgical intervention within 6 hours of the onset of scrotal pain can yield testicular viability in 80-100% of cases, while surgical intervention within 6-12 hours of the onset of pain can yield testicular viability in 70 % cases.[1,5] The presenting features of testicular torsion are sudden onset of severe scrotal pain and acute scrotal swelling frequently accompanied by nausea and vomiting as well.[6] Atypical presentations are also seen. The clinical sign includes swollen hard testicle, high lying

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transverse testis, an absent cremasteric reflex and a negative Prehn's sign-relief of pain with elevation of the testicle.[5,6] However, the clinical assessment cannot reliably differentiate between the various causes of the acute scrotum, which include a) Epididymo-orchitis, b)Torsion of appendix testis, c) Idiopathic scrotal oedema, d) Segmental testicular infarction e) Strangulated hernia.[1,7] The role of imaging is to exclude these confounding differentials and to establish whether an acute scrotum needs medical management or surgical intervention. Ultrasonography remains the most effective imaging tool for assessing testicular torsion owing to its non-invasive nature, cost-effectiveness, availability and recent advancements.

One of the most important reasons for USG success in testicular USG is their superficial location, making them highly accessible for high-resolution USG using high-frequency linear USG probes. Important grey scale findings in testicular torsion include enlarged testicle, heterogeneous testicular echotexture, spermatic cord whirlpool sign or a redundant spermatic cord, while less common findings include reactive hydrocele and scrotal skin thickening.[1,3,4] The most striking greyscale feature is the heterogeneous echogenicity of testicular parenchyma [1,8] The spermatic cord whirlpool sign is another specific sonological sign defined as the twisting of the spermatic cord either at the external inguinal ring or within the scrotum.[9] After grey scale findings, the Doppler analysis is the next crucial part of the sonographic assessment, with absent intratesticular flow being the most important predictor of testicular torsion.[10]

Similarly, diminished flow in the involved testicle with dampened spectral waveform and absent or reverse diastolic flow is also seen.[10] However, residual perfusion in incomplete or early torsion cases can result in false negative results.[6] The Whirlpool pattern of vascularity can also be appreciated within the spermatic cord corresponding to the greyscale whirl-pool sign.[9] Testicular viability can reliably be assessed from greyscale and colour Doppler findings. Normal testicular parenchyma with mild testicular enlargement and preserved intratesticular parenchymal flow represent good signs of testicular viability. Thus combining the results of clinical and physical examination, the obtained information with ultrasound is sufficient to enable the correct diagnosis in most suspected cases of testicular torsion. This study emphasizes the importance of using Doppler assessment and greyscale imaging findings in patients with testicular torsion to detect it at the earliest to salvage the testis.

METHODOLOGY

This cross-sectional validation study was carried out at the Pakistan Institute of Medical Sciences Radiology department in collaboration with the concerned surgical department from December 2017 to December 2019. Approval from the Institutional Ethical Review Board was taken. The sample size was calculated by keeping a sensitivity of 94 % and specificity of 98 % with a prevalence of 0.025 % and a confidence level of 95 %.[5,7] The study enrolled 58 patients. Non probability consecutive sampling technique was used.

Inclusion Criteria: Patients of age 1-50 years, presenting with signs/symptoms of the acute scrotum and strong clinical suspicion of testicular torsion were included in the study.

Exclusion Criteria: Patients with chronic scrotal pain, trauma history and scrotal/testicular malignancies were excluded from the study.

An informed Consent was obtained from all selected cases. A single Senior Radiology Resident carried out testicular ultrasound on Toshiba Aplio 500 ultrasound machine in all patients after informed consent. For all those patients who underwent surgical exploration, their intraoperative findings were recorded on a set proforma. Patients with trauma and scrotal mass history were excluded from the study. The presenting symptoms and clinical signs were collected as documented by the emergency surgeon. Ultrasound examination was performed using a high-frequency linear probe (7.5MHz) with the patient lying in the supine position and the scrotum being supported by a towel between the thighs. After adequate gel application, each hemi-scrotum was examined in transverse and longitudinal planes. A meticulous comparison of the two testes in the transverse plane was mandatory for parenchymal echotexture and blood flow. Spermatic cord assessment was exclusively done as part of testicular ultrasound. The following grey scale sonological features were looked for: asymmetrical unilateral testicular enlargement, heterogeneous testicular echotexture, whirlpool sign, altered testicular lie, hydrocele and skin thickening.

The important part of the sonological assessment was the Doppler finding, based on which we defined our criteria for sonologically positive and sonologically negative cases. Sonologically positive cases were: a)

those who had absent intra-testicular flow irrespective of grey scale findings and b) diminished intratesticular flow with dampened spectral waveform or absent/reverse diastolic flow in the presence of complementary grey scale features (Enlarged testis, heterogeneous parenchyma, and whirlpool). Conversely, patients with the adequate intratesticular flow were labelled as sonologically negative. The final diagnosis was made on surgical exploration, and the outcome was recorded.

Statistical Package for Social Sciences (SPSS) version 22.0 was used for the data analysis. Diagnostic parameters were calculated using a 2x2 Table. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy were determined by using the standard formulae.

RESULTS

The study enrolled 58 candidates who were clinically labelled cases of testicular torsion and underwent surgical exploration. The mean age group in our study was 18.00±6.02 years. Among the presenting features, acute onset scrotal pain was found in 100% of the cases, with nausea and vomiting present in 86 % of surgically proven cases of testicular torsion. The usual presentation time was within 3 hours of the onset of pain. However, certain cases referred from remote areas presented after the safe window period of 6 hours. On ultrasound, 51 patients out of this total number of candidates were labelled to have testicular torsion, among which 50 had surgically confirmed testicular torsion (true positive cases) while one was false positive on surgical exploration.

Similarly, seven patients were sonologically negative for testicular torsion. However, they were re-evaluated by the surgeon, and despite being labelled as sonologically negative, they still underwent exploration based on strong clinical suspicion; among them, six were negative on exploration, while only one had surgically confirmed testicular torsion. The sonological whirlpool sign was observed in as many as 35 (69%) of sonologically positive cases, as shown in Figure-1A & 1B. The ultrasound findings, including the greyscale and colour Doppler, are summarized in Table-I. The commonest grey scale finding was hetero-geneous testicular echotexture, while the commonest colour Doppler feature among the true positive cases of testicular torsion was absent intra-testicular flow (Figure-2).

Table-I: Calculation of Sensitivity and Specificity of Ultrasonography in Diagnosis of Testicular Torsion taking Surgical Findings as Gold Standard

	Surgically Positive	Surgically Negative
Sonologically Positive	50 (86 %)	1 (2%)
Sonologically Negative	1 (2%)	6(10%)

*SensitivityTP/(TP+FN)=50/(50+1)*100=98%, Specificity=TN/(TN+FP)= 6/(6+1)*100=86%, Positive Predictive Value=TP/(TP+FP)*100= 50/(50+1)=98%, Negative Predictive Value=TN/(TN+FN)*100=6/(6+1)=86%, Diagnostic Accuracy=(TP+TN)/All patients*100=(50+6)/58=96%*

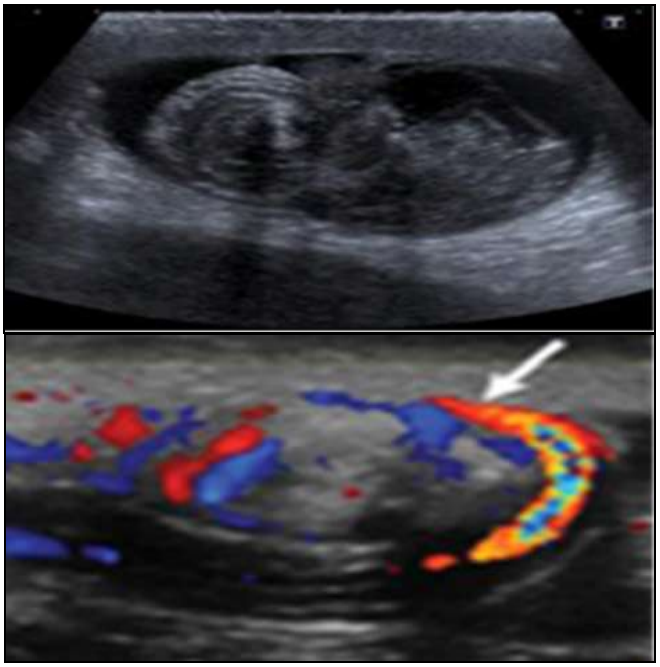

Figure-1A & 1B: Grey Scale and Doppler Ultrasound Images showing Sonological Whirlpool Sign

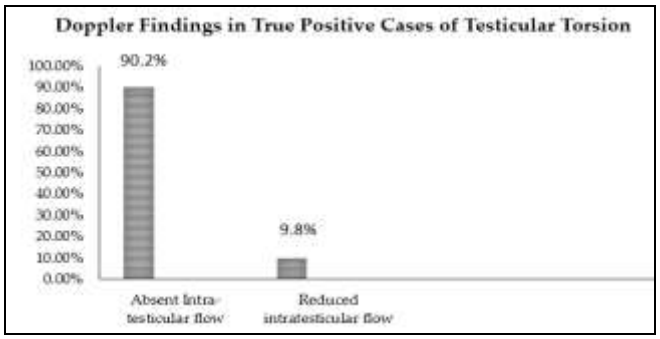

Figure-2: Doppler Findings Among True Positive Cases of Testicular Torsion

The sensitivity, specificity, positive predictive value and negative predictive value of Doppler ultrasound in the diagnosis of testicular torsion came out to be 98%, 86%, 98% and 86%, respectively (Table-II).

Table-II: Ultrasound Findings (n=58)

Grey Scale Findings	Frequency (%)
Heterogeneous Echotexture	45 (77.6)
Enlarged testis	42 (72.4)
Whirl pool sign on grey scale	35 (60.3)
Reactive Hydrocele	22 (38.0)
Skin thickening	18 (31.0)
Doppler Findings among Sonologically Positive Cases	
Absent intra-testicular flow	46 (90.2)
Reduced intra-testicular flow	5 (9.8)
Whirl pool pattern of vascularity	35 (69.0)

The various surgical findings included enlarged congested testis with or without necrosis, twisted spermatic cord, absent pulsation within spermatic cord vessels, and testicles turned upon themselves for almost one and a half turns. The torted testicle was salvageable among 18 out of 51 surgically confirmed cases who underwent surgical exploration within six hours of the onset of symptoms.

DISCUSSION

The acute scrotum is a surgical emergency, and depending upon the cause, the management is entirely different.[11] Testicular torsion is the most common genitourinary emergency in the pediatric and adolescent age groups; it is the second most common surgical emergency.[12] Earlier, when there was a lack of availability and advancement in sonography, the suspected testicular torsion cases were directly operated solely based upon the clinical assessment, which resulted in high rates of negative explorations amounting to up to two third of the cases. Optimum physical examination in patients of testicular torsion cannot be performed due to severe scrotal pain posing a major hindrance in early accurate diagnosis [13] In these circumstances, ultrasound, along with colour Doppler analysis, plays a valuable role in establishing the correct, timely diagnosis of the torted testicle followed by prompt surgical intervention.[14] Another important aspect of the role of ultrasound is to exclude the various confounding differentials where conservative measures can be made confidently. A delay in diagnosis compromises the viability of the testes, which is considerably reduced after 6 hours of ischemia [15,16] Hence, to avoid testicular loss, ultrasound B mode and Doppler assessment are the mainstays of imaging. Despite its high sensitivity and specificity, false positive and negative cases have been reported. Visualizing flow within the testis on colour Doppler in cases of late-phase torsion and partial torsion can give false reassurance of testicular viability, leading to false negative cases.[17] At the same time, the false positive cases are attributable to intermittent torsion or cases of de-torsion [18,19] In 2019, Ota *et al*. conducted a meta-analysis of 26 studies of 2116 patients taking into account the role of ultrasound in testicular torsion.[10] In this systematic review, ultrasound came out to be 94% sensitive and 96% specific for the detection of testicular torsion. Our study had a comparable Doppler ultrasound sensitivity and specificity of 98% and 85%, respectively. Another study performed in 2017 by Islam Fahed highlighted the role of Doppler sonography in testicular torsion, yielding a sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of 98%, 87.5%, 99%, 77.8%, and 97.5% respectively.[12] The most obvious Doppler finding in our study was absent intratesticular flow and all such cases, 46 in number, came out to be surgically confirmed testicular torsion, thus making this sign 100% sensitive and specific. The main hitch was categorizing cases showing reduced intra-testicular flow, which was observed among five sonologically positive cases.

However, four cases were surgically positive for torsion, while one was surgically negative. This false positive result could be attributable to testicular detorsion or intermittent torsion. Simi-larly, we had one false negative case in our study sho-wing reduced intratesticular flow along with a para-testicular rim of vascularity which came out to be a case of orchitis with grey scale finding of enlarged he-terogeneous testis mimicking torsion and orchitis both.

Another meta-analysis by McDowall *et al*. in 2018 took into account 226 cases of testicular torsion, exclusively evaluating the presence of sonological whirlpool signs in them [13] The study concluded that this sonological sign has a sensitivity of 73 percent and a high specificity of 99 percent. In our study, out of 50 surgically positive cases, this sign was observed among 35 patients, with all of them having confirmed twisted spermatic cord per-operatively, yielding an almost similar sensitivity and specificity of 69 percent and 100 percent, respectively.

CONCLUSION

The diagnostic precision of Doppler ultrasound of testis is significantly high in testicular torsion. Considering the Doppler findings along with greyscale features has a tremendous effect on increasing the diagnostic accuracy of this imaging modality. Hence, management based on sonological findings can minimize the cost of surgical care by avoiding unnecessary operative interventions.

Conflict of Intrest: None.

Author's Contribution

Following authors have made substantial contributions to the manuscript as under:

AS: Study design, data analysis, drafting the manuscript, critical review, approval of the final version to be published.

SZ: Critical review, drafting the manuscript, approval of the final version to be published.

BL & RL: Conception, study design, drafting the manuscript, approval of the final version to be published.

RR & ML: Data analysis, data interpretation, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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