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Evaluation of Scrotal Lesions Using High-Resolution Ultrasonography and Color Doppler: A Cross-Sectional Study

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Abstract

Background

Acute and chronic scrotal pathologies represent common urological emergencies and diagnostic challenges due to overlapping clinical presentations. Rapid and accurate differentiation between inflammatory, ischemic, and obstructive conditions is essential to guide timely management and prevent testicular loss. High-resolution ultrasonography combined with color Doppler imaging plays a pivotal role in evaluating scrotal lesions by providing detailed anatomical and vascular information.

Aim

To evaluate the spectrum of scrotal lesions using high-resolution ultrasonography and color Doppler imaging and to assess their diagnostic utility in characterizing scrotal pathologies.

Materials and Methods

A hospital-based prospective cross-sectional study was conducted over one year in the Department of Radiodiagnosis at Rohilkhand Medical College & Hospital, Bareilly. A total of 175 male patients presenting with scrotal pain and/or swelling were evaluated using high-resolution ultrasonography (7.5–15 MHz linear transducer) and color Doppler imaging. Scrotal lesions were assessed for location, size, echotexture, vascularity, and associated findings. Statistical analysis was performed using SPSS version 23.0, with a p-value <0.05 considered statistically significant.

Results

Among 175 patients, hydrocele was the most common diagnosis (47%), followed by epididymo-orchitis (36%), varicocele (7%), testicular torsion (6%), and incarcerated inguino-scrotal hernia (4%). Increased testicular and epididymal vascularity was characteristic of inflammatory conditions, whereas absent

intratesticular blood flow and the whirlpool sign were diagnostic of testicular torsion. A statistically significant association was observed between diagnosis and testicular echotexture, as well as vascularity patterns ($p < 0.001$).

Conclusion

High-resolution ultrasonography with color Doppler is a rapid, non-invasive, and highly effective imaging modality for evaluating scrotal lesions. It reliably differentiates inflammatory from ischemic and obstructive pathologies, thereby guiding appropriate clinical management and reducing unnecessary surgical interventions.

Keywords: Scrotal lesions; Ultrasonography; Color Doppler; Testicular torsion; Epididymo-orchitis; Acute scrotum.

1. Introduction

Scrotal pathologies constitute a common cause of presentation to emergency and outpatient departments and may involve inflammatory, ischemic, vascular, or obstructive conditions. Patients typically present with scrotal pain, swelling, or both, and accurate early diagnosis is essential to prevent complications such as testicular infarction, infertility, or unnecessary surgical intervention. Clinical examination alone is often insufficient due to overlapping symptoms among various scrotal disorders, particularly in cases of acute scrotum.

Among the causes of acute scrotal pain, epididymo-orchitis and testicular torsion are the most frequently encountered conditions. Differentiating between these two entities is critical, as their management differs significantly. Epididymo-orchitis is generally managed conservatively with antibiotics and supportive therapy, whereas testicular torsion represents a true urological emergency requiring immediate surgical intervention to preserve testicular viability. Testicular salvage rates decline sharply after six hours of ischemia, emphasizing the need for rapid and accurate diagnosis.

Various imaging modalities have been utilized in the evaluation of scrotal diseases. Computed tomography is not preferred due to radiation exposure to the gonads, while magnetic resonance imaging, although accurate, is limited by cost, availability, and longer examination times. In contrast, high-resolution ultrasonography (HRUS) is widely available, non-invasive, cost-effective, and free of ionizing radiation. Owing to the superficial location of scrotal contents, ultrasonography provides excellent spatial resolution for anatomical assessment.

The addition of color Doppler imaging significantly enhances diagnostic accuracy by allowing real-time evaluation of testicular and epididymal vascularity. Alterations in blood flow patterns help distinguish ischemic conditions such as testicular torsion from inflammatory conditions like epididymo-orchitis.

Specific Doppler findings, including absent intratesticular blood flow and the whirlpool sign of the spermatic cord, are highly suggestive of torsion, whereas increased vascularity is characteristic of inflammatory processes.

Apart from acute conditions, ultrasonography with color Doppler is also valuable in evaluating chronic scrotal pathologies such as hydrocele, varicocele, inguino-scrotal hernia, and testicular masses. It allows precise localization of lesions as intratesticular or extratesticular and aids in characterization based on echotexture, size, margins, and vascularity. This comprehensive evaluation plays a crucial role in guiding further management and follow-up.

Given the diagnostic challenges associated with scrotal lesions and the pivotal role of imaging, this study was undertaken to evaluate the spectrum of scrotal pathologies using high-resolution ultrasonography combined with color Doppler imaging and to assess its effectiveness in accurate diagnosis and characterization.

Materials and Methods

Study Design and Setting

This hospital-based prospective observational cross-sectional study was conducted over a period of one year in the Department of Radiodiagnosis, Rohilkhand Medical College & Hospital, Bareilly, Uttar Pradesh, India.

Study Population

The study included male patients of all age groups who presented with scrotal pain and/or swelling and were referred to the Department of Radiodiagnosis for ultrasonographic evaluation.

Sample Size

The sample size was calculated using the formula $4pq/L^2$, based on a prevalence rate of 12.5% as reported in previous literature. With an allowable error of 5%, a total sample size of 175 patients was obtained and included in the study.

Inclusion Criteria

- Male patients of any age presenting with scrotal pain and/or swelling
- Patients referred for scrotal ultrasonography

Exclusion Criteria

- Patients with a history of prior scrotal surgery

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of Rohilkhand Medical College & Hospital. Written informed consent was obtained from all patients or their guardians prior to examination.

Ultrasound Technique

All examinations were performed using high-resolution ultrasound machines (Samsung HS70A, HS40, RS80, and V7) equipped with high-frequency linear transducers (7.5–15 MHz). Patients were examined in the supine position with adequate scrotal support to ensure optimal visualization and patient comfort. Both testes were evaluated in transverse, sagittal, and oblique planes.

In selected cases, such as suspected varicocele or inguino-scrotal hernia, additional scanning was performed with the patient in an upright position and during the Valsalva maneuver. Evaluation of the spermatic cord in the inguinal canal and scrotal neck was performed when indicated.

Image Analysis

Scrotal lesions were assessed for:

- Location (intratesticular, extratesticular, or combined)
- Size and laterality
- Echotexture (homogeneous or heterogeneous)
- Presence of calcifications
- Testicular and epididymal vascularity on color Doppler imaging
- Associated findings such as hydrocele, scrotal wall thickening, or herniation

Statistical Analysis

Data were compiled and analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Descriptive statistics were expressed as frequencies, percentages, means, and standard deviations. Associations between variables were assessed using appropriate statistical tests, and a p-value <0.05 was considered statistically significant.

Results

A total of 175 male patients presenting with scrotal pain and/or swelling were evaluated using high-resolution ultrasonography and color Doppler imaging.

Distribution of Scrotal Pathologies

Among the studied population, hydrocele was the most common diagnosis, observed in 83 patients (47%), followed by epididymo-orchitis in 63 patients (36%). Varicocele was identified in 12 patients (7%), testicular torsion in 10 patients (6%), and incarcerated inguino-scrotal hernia in 7 patients (4%).

Age Distribution

Patients ranged in age from 2 to 80 years, with the highest number of cases seen in the 21–30 year age group (34%). The least number of cases were observed in the 1–10 year age group (8%). A statistically significant association was noted between age group and specific scrotal diagnoses, particularly for hydrocele and epididymo-orchitis.

Clinical Presentation

Scrotal pain was the most common presenting symptom, reported in 152 patients, followed by scrotal swelling in 129 patients and erythema in 90 patients. Pain was present in all cases of testicular torsion, epididymo-orchitis, varicocele, and incarcerated hernia. Swelling was universally present in hydrocele cases. The association between swelling and diagnosis was statistically significant ($p < 0.001$).

Ultrasonographic Findings

Testicular Echotexture

Normal homogeneous testicular echotexture was observed in 66% of cases. Heterogeneous echotexture was seen in 24%, while heterogeneously hypoechoic echotexture was noted in 10% of patients. A significant association was found between testicular echotexture and diagnosis ($p < 0.001$). Heterogeneously hypoechoic testes were predominantly associated with testicular torsion.

Testicular Vascularity

On color Doppler imaging, increased testicular vascularity was observed in 38% of cases, mainly associated with inflammatory conditions such as epididymo-orchitis. Absent intratesticular vascularity was noted in 9 patients, all of whom were diagnosed with testicular torsion. The association between diagnosis and testicular vascularity was statistically significant ($p < 0.001$).

Epididymal Findings

Heterogeneous epididymal echotexture was seen in 34% of cases, predominantly in epididymo-orchitis and testicular torsion. Increased epididymal vascularity was present in 36% of patients and was a consistent feature in all cases of epididymo-orchitis. Prominent venous channels were noted in cases of varicocele, while the whirlpool sign was identified in all cases of testicular torsion, confirming spermatic cord twisting.

Lesion Location

Based on ultrasonographic evaluation, 58% of lesions were extratesticular, 6% were intratesticular, and 36% involved both intra- and extratesticular components.

Discussion

Accurate evaluation of scrotal lesions is crucial due to overlapping clinical presentations and the need for prompt management, particularly in cases of acute scrotum. High-resolution ultrasonography combined with color Doppler imaging has emerged as the first-line imaging modality because it is rapid, non-invasive, widely available, and capable of providing both anatomical and vascular information.

In the present study, hydrocele (47%) was the most common scrotal pathology, followed by epididymo-orchitis (36%), findings that are consistent with previous studies by Gupta et al., Rathi et al., and Agrawal et al., where hydrocele and inflammatory conditions predominated. This reflects the high prevalence of benign and inflammatory scrotal conditions in routine clinical practice.

The maximum number of patients belonged to the 21–30 year age group, similar to observations reported by D'Andrea et al. and Thinyu et al. Younger patients more commonly presented with inflammatory conditions, whereas hydrocele and varicocele were more frequently encountered in adults. Testicular torsion, although less common overall (6%), was predominantly observed in children and young adults, emphasizing the need for a high index of suspicion in this population.

Testicular torsion represents a true urological emergency. In this study, all cases of torsion demonstrated absent intratesticular vascularity on color Doppler imaging, along with the whirlpool sign of the spermatic cord. These findings are consistent with reports by Vijayaraghavan, Kalfa et al., and Agrawal et al., who emphasized the whirlpool sign as a highly specific and reliable indicator of torsion. The absence of any partial or residual vascularity in our cases suggests complete torsion, underscoring the diagnostic accuracy of Doppler ultrasonography in such scenarios.

In contrast, epididymo-orchitis showed characteristic features of enlarged epididymis, heterogeneous echotexture, and markedly increased vascularity on color Doppler. These findings align with studies by Middleton et al. and Horstman et al., who reported hyperemia as the most sensitive Doppler feature of inflammatory scrotal disease. The consistent increase in epididymal vascularity observed in all epididymo-orchitis cases in our study reinforces the role of Doppler imaging in differentiating inflammatory from ischemic conditions.

Varicocele, diagnosed in 7% of patients, was identified by the presence of dilated, tortuous pampiniform plexus veins with venous reflux, which increased during the Valsalva maneuver. These findings correlate well with observations by Dogra et al. and Pauroso et al., who described color Doppler ultrasonography as the gold standard for varicocele evaluation.

Incarcerated inguino-scrotal hernia accounted for 4% of cases and was accurately diagnosed by identifying bowel loops or omentum within the scrotum, along with absent peristalsis in cases of incarceration. These findings are comparable to those reported by Ogata et al. and D'Andrea et al., highlighting the importance of real-time ultrasound evaluation in such cases.

Overall, the present study demonstrates that extratesticular lesions were more common than intratesticular lesions, a finding consistent with prior literature. The statistically significant association between diagnosis and ultrasonographic parameters such as echotexture and vascularity further emphasizes the diagnostic value of high-resolution ultrasound and color Doppler imaging.

Limitations

The study was conducted at a single center, and histopathological correlation was not available for all cases. Larger multicentric studies with surgical or pathological confirmation would further strengthen these findings.

Conclusion

High-resolution ultrasonography combined with color Doppler imaging is a reliable, rapid, and non-invasive modality for the evaluation of scrotal lesions. It provides accurate anatomical localization and vascular assessment, enabling effective differentiation between inflammatory, ischemic, vascular, and obstructive scrotal pathologies. Characteristic Doppler findings such as increased vascularity in epididymo-orchitis and absent intratesticular blood flow with the whirlpool sign in testicular torsion allow prompt and appropriate clinical management. Given its high diagnostic accuracy, accessibility, and safety profile, ultrasonography with color Doppler should be considered the first-line imaging investigation for patients presenting with acute or chronic scrotal symptoms.

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