

Role of Gray Scale and Colour Doppler in Evaluation of Scrotal Pathologies

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Abstract: ***Aims and objectives:** To differentiate between the intratesticular and extratesticular pathological lesions of the scrotum. To correlate the ultrasonic diagnosis with the clinical diagnosis in patients presenting with scrotal lesions. **Material and methods:** A prospective observational study was conducted on 50 patients presenting with scrotal pathologies at the Department of Radiodiagnosis, Government Medical College, Amritsar, over a period of one year. All patients underwent high-resolution ultrasonography using a Mindray DC-8 machine with a 7.5 MHz linear transducer. Comparative grayscale and color Doppler evaluation of both testes was performed. Statistical analysis was done using SPSS software; Chi-square test was applied, and $p < 0.05$ was considered significant. Sensitivity and specificity were calculated by correlating clinical and sonological diagnoses. **Results:** Most patients were aged 21–40 years, with swelling and pain as common complaints. Ultrasound identified 54% extratesticular, 24% intratesticular, and 22% mixed lesions. It provided superior diagnostic accuracy compared to clinical examination, especially in detecting inflammatory (e.g., epididymo-orchitis), vascular (e.g., torsion), and neoplastic conditions. Color Doppler was particularly effective in assessing vascularity, confirming all cases of torsion and epididymo-orchitis. Occult lesions such as spermatocele and undescended testes were identified in clinically normal scrotums. Ultrasonography, with high sensitivity and specificity, proved to be a critical first-line modality for diagnosis, triage, and treatment planning in scrotal disorders. **Conclusions:** Grayscale and color Doppler ultrasound play a crucial role in accurately differentiating intratesticular and extratesticular scrotal lesions. They demonstrate strong correlation with clinical findings while detecting lesions missed on physical examination. Ultrasound effectively identifies occult abnormalities and guides timely management decisions. Its routine use significantly enhances diagnostic accuracy and patient outcomes in scrotal pathologies.*

Keywords: Scrotal pathologies, Ultrasonography, Color Doppler, Grayscale ultrasound, Testicular torsion, Epididymo-orchitis, Hydrocele, Varicocele, Testicular mass, High-frequency ultrasound, Testicular perfusion, Non-invasive imaging, Scrotal swelling

1. Introduction

Scrotal pathologies encompass a diverse range of clinical conditions, from relatively benign and self-limiting disorders such as hydroceles and epididymo-orchitis, to life-threatening malignancies including seminomas and lymphomas. Moreover, acute surgical emergencies like testicular torsion further underscore the need for prompt and accurate diagnosis.¹ The clinical presentation of these disorders can be varied and often non-specific, therefore making a precise and timely diagnosis is essential to ensure optimal patient management and to prevent potential complications such as infertility, testicular loss, or systemic spread of malignancy.²

Historically, the diagnostic approach to scrotal diseases relied primarily on physical examination techniques, including palpation and transillumination. Although useful to a degree, these methods were often limited in scope. Deep-seated lesions or those presenting with acute pain and tenderness were frequently missed or misdiagnosed due to the lack of visualization capabilities inherent in these

traditional techniques.³ In particular, during the 1970s and earlier, the inability to assess internal vascular or structural changes within the scrotal sac limited the clinician's ability to differentiate between various disease processes with overlapping clinical features.⁴

The advent of high-resolution ultrasonography, particularly with colour Doppler imaging, has revolutionized the scrotal pathology assessment.⁵ Ultrasonography has become first-line imaging modality because of its many advantages: it is non-invasive, devoid of ionizing radiation, cost-effective, and readily available.⁶ In addition, it is capable of producing real-time images, enabling dynamic assessment of both the structural and vascular components of the scrotum. As a bedside tool, it is especially advantageous in acute settings, such as emergency departments, where rapid decision-making is crucial.⁶

Grayscale ultrasound provides detailed anatomical visualization of the scrotal contents, allowing for the identification of abnormalities such as testicular masses, fluid collections, and parenchymal changes.⁷ When complemented by colour Doppler imaging, the diagnostic

value increases substantially.⁸ Doppler ultrasound enables the perfusion and vascular dynamics evaluation, which is pivotal in diagnosing conditions such as testicular torsion (characterized by absent or decreased blood flow) and epididymo-orchitis (typically associated with increased blood flow).⁹ These vascular patterns are not only diagnostic but also guide the urgency and type of clinical intervention required.¹⁰

Scrotal ultrasonography has thus become the preferred method for imaging in cases of acute scrotal pain.¹¹ Unlike CT and MRI, which have limited roles in scrotal pathology due to cost, availability, and radiation exposure (in the case of CT), ultrasound offers a safer and more accessible alternative.¹² Moreover, CT delivers radiation to the highly radiosensitive gonads, posing a significant risk in young male patients, while MRI, though offering excellent soft-tissue contrast, is often impractical in emergency conditions due to time constraints and limited access.¹³

The use of scrotal ultrasound extends beyond emergency scenarios. In chronic or subacute conditions, such as infertility evaluation, testicular microlithiasis, varicocele, or scrotal masses, ultrasound plays a crucial role in identifying underlying etiologies and aiding in the planning of appropriate management strategies.¹⁴ It is very useful in distinguishing malignant lesions from benign based on echotexture, vascularity, and lesion borders. Additionally, ultrasound assists in evaluating the position and presence of undescended testes, a common congenital anomaly with long-term implications.¹⁵

Given the anatomical complexity and functional significance of the scrotum, which houses structures vital to spermatogenesis and endocrine function, achieving precise and timely diagnosis is of paramount importance. Disorders of the scrotum can significantly affect fertility, hormonal balance, and overall quality of life, further highlighting the need for reliable diagnostic tools.¹¹

2. Material and Methods

A prospective observational study was conducted on 50 patients with scrotal pathologies at the Department of Radiodiagnosis, Government Medical College, Amritsar, over one year. Patients referred from Surgery and Medicine departments underwent high-resolution ultrasound using a Mindray DC-8 machine with a 7.5 MHz transducer. Both grayscale and color Doppler evaluations were performed. Inclusion criteria included all age groups with clinical scrotal symptoms; exclusions were prior treatment or surgery. Data were analyzed using SPSS. Chi-square test was applied, and $p < 0.05$ was considered significant. Sensitivity and specificity were calculated by comparing clinical and sonological diagnoses.

3. Results

Out of 50 patients studied, the majority (60%) were in the 21–40 year age group, with the highest incidence in 21–30 years (32%). Swelling (90%) and pain (62%) were the most

common presenting symptoms. Less frequent complaints included fever (16%), sterility (4%), and empty scrotum (4%).

Clinically, hydrocele was the most common provisional diagnosis (32%), followed by epididymo-orchitis (16%) and torsion testis (8%). On ultrasound, bilateral hydrocele was the most common finding (18%), with epididymo-orchitis (14%), hernia, varicocele, and torsion each at 6%. One patient had normal ultrasound findings.

Based on lesion location, ultrasound identified 54% extra-testicular, 24% intra-testicular, and 22% mixed lesions. This distribution closely matched clinical assessment, validating the anatomical classification.

Color Doppler significantly improved diagnostic accuracy, particularly for epididymo-orchitis, torsion, and orchitis, where it identified more cases than grayscale alone. A strong correlation was noted with final or surgical diagnoses (Chi-square = 37, $df = 8$, $p = 0.044$).

Ultrasound demonstrated superior sensitivity and specificity compared to clinical diagnosis. For instance:

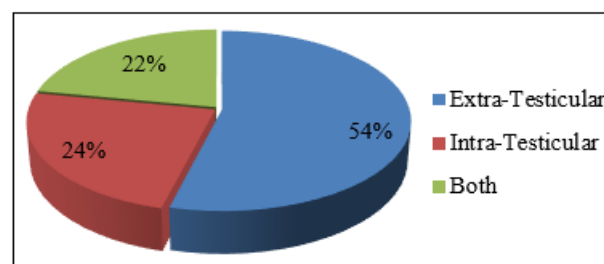
- Hydrocele: Clinical sensitivity 88.9%, USG 100%.
- Varicocele: Clinical sensitivity 66.7%, USG 100%.
- Epididymo-orchitis: USG achieved 100% accuracy, avoiding overdiagnosis seen clinically.
- Rare or subtle conditions (e.g., spermatocele, cord hydrocele, undescended testis) were missed clinically but detected on ultrasound with 100% accuracy.

Clinical examination failed to identify any normal scrotums, while ultrasound correctly detected one (100% specificity), emphasizing its role in ruling out disease.

Although secondary Chi-square analysis for modality sensitivity showed no statistical significance ($p = 1.00$), qualitative trends confirmed the diagnostic superiority of ultrasound, especially in subtle or complex cases.

Table 1: Location of Lesions based on Ultrasound Diagnosis

Mass	No. of Patients	Percentage
Extra-Testicular	27	54%
Intra-Testicular	12	24%
Both	11	22%
Total	50	100%



Graph 1: Location of Lesions based on Ultrasound Diagnosis

Table 1: Comparative Analysis Between Clinical, Ultrasound, and Histopathological Diagnosis

Diagnosis	Diagnosis Clinically		Diagnosis Ultrasound		Surgical/histopathological diagnosis/ Treatment Response	
	N	%	N	%	N	%
Bilateral hydrocele	8	6%	9	18%	9	18%
Encysted hydrocele of spermatic cord	0	0%	1	2%	1	2%
Epididymal cysts	0	0%	1	2%	1	2%
Epididymoorchitis	11	22%	7	14%	7	14%
Fourniers gangrene	1	2%	1	2%	1	2%
Testicular growth	3	6%	3	6%	3	6%
Haematocele	1	2%	1	2%	1	2%
Haematoma testes	2	4%	2	4%	2	4%
Hernia	4	8%	3	6%	3	6%
Left hydrocele	3	6%	3	6%	3	6%
Normal	0	0%	1	2%	1	2%
Orchitis	1	2%	2	4%	2	4%
Right hydrocele	5	10%	4	8%	4	8%
Spermatic cord hydrocele	1	2%	1	2%	1	2%
Spermatocele	2	4%	2	4%	2	4%
Testicular abscess	0	0%	1	2%	1	2%
Torsion testis	4	8%	3	6%	3	6%
Undescended testis	2	4%	2	4%	2	4%
Varicocele	2	4%	3	6%	3	6%
Total	50	100%	50	100%	50	100%

$\chi^2=6.56$; d.f.=36; P-Value: 1 (p>0.05; Not significant)

Table 2: Sensitivity and Specificity Analysis

Diagnosis	Clinical Sensitivity (%)	Clinical Specificity (%)	Ultrasound Sensitivity (%)	Ultrasound Specificity (%)
Bilateral hydrocele	88.9	100.0	100.0	100.0
Encysted hydrocele of spermatic cord	0.0	100.0	100.0	100.0
Epididymal cysts	0.0	100.0	100.0	100.0
Epididymoorchitis	100.0	90.7	100.0	100.0
Fourniers gangrene	100.0	100.0	100.0	100.0
Testicular growth	100.0	100.0	100.0	100.0
Haematocele	100.0	100.0	100.0	100.0
Haematoma testes	100.0	100.0	100.0	100.0
Hernia	100.0	97.9	100.0	100.0
Intratesticular growth	NA	100.0	NA	100.0
Left hydrocele	100.0	100.0	100.0	100.0
Normal	0.0	100.0	100.0	100.0
Orchitis	50.0	100.0	100.0	100.0
Right hydrocele	100.0	97.8	100.0	100.0
Spermatic cord hydrocele	100.0	100.0	100.0	100.0
Spermatocele	100.0	100.0	100.0	100.0
Testicular abscess	0.0	100.0	100.0	100.0
Torsion testis	100.0	97.9	100.0	100.0
Undescended testis	100.0	100.0	100.0	100.0
Varicocele	66.7	100.0	100.0	100.0

4. Discussion

In this study, most patients with scrotal pathologies were between 21 and 40 years of age (60%). Swelling (90%) and pain (62%) were the most common presenting symptoms.

Clinically, hydrocele was the most frequent diagnosis (32%), followed by epididymoorchitis (22%) and testicular torsion (8%). On ultrasound, bilateral hydrocele (18%) and epididymoorchitis (14%) were the leading findings. Most lesions were extra-testicular (54%).

Color Doppler proved superior to grayscale in improving diagnostic accuracy, particularly in differentiating epididymoorchitis from torsion by detecting increased (30%)

or absent (6%) vascularity. In cases of varicocele and testicular tumors, Doppler successfully identified cases that had been misdiagnosed clinically. Statistical analysis ($\chi^2 = 37$, p = 0.044) confirmed a significant correlation between Doppler findings and the final diagnoses.

Color Doppler ultrasound significantly enhanced the evaluation of scrotal pathologies by detecting vascular abnormalities often missed on grayscale imaging. In early or mild orchitis, grayscale findings could appear normal, whereas Doppler detected increased vascularity, thereby improving diagnostic confidence. In all surgically confirmed cases of testicular torsion, Doppler consistently demonstrated absent or reduced intratesticular flow.

Hydroceles were reliably detected with grayscale ultrasound. Epididymo-orchitis was often overdiagnosed clinically, while ultrasound achieved 100% sensitivity and 90.7% specificity. Orchitis alone showed lower sensitivity on grayscale, but Doppler improved early detection through identification of hyperemia.

Intratesticular tumors, including seminomas and lymphoma, were accurately identified on both grayscale and Doppler. One case initially misdiagnosed as epididymo-orchitis highlighted the limitations of physical examination alone.

Varicocele detection was enhanced with Doppler, particularly in subclinical cases, showing 66.7% sensitivity and 100% specificity. Hernias, which may mimic hydrocele or cord lesions, were also identified with high specificity.

Less common lesions, such as spermatoceles, epididymal cysts, and undescended testes, were not always apparent clinically but were diagnosed with 100% sensitivity and specificity on ultrasound. Rare conditions, including testicular abscesses and encysted hydroceles, were also accurately detected with high-resolution sonography.

Overall, this study reinforces the value of combining high-frequency grayscale ultrasound with color Doppler as the first-line imaging modality for scrotal pathologies, enabling early detection, accurate differentiation, and improved patient outcomes.

5. Summary

- Color Doppler ultrasound significantly enhances the evaluation of scrotal pathologies by detecting vascular changes that may be missed on grayscale imaging.
- It is particularly effective in diagnosing testicular torsion, where absent or reduced blood flow is a key finding.
- Doppler improves differentiation between torsion and inflammatory conditions, which often present similarly but show increased vascularity.
- Grayscale ultrasound reliably identifies fluid-filled lesions such as hydroceles and hematoceles with high sensitivity and specificity.
- Epididymo-orchitis may be clinically overdiagnosed; ultrasound improves diagnostic accuracy and reduces false positives.
- Intratesticular masses are accurately detected on ultrasound and should be presumed malignant until proven otherwise.
- Doppler ultrasound is valuable in identifying subclinical varicoceles and distinguishing hernias from other scrotal masses.
- Rare or clinically occult lesions such as spermatoceles, epididymal cysts, and undescended testes are consistently

diagnosed with ultrasound.

- The combination of grayscale and color Doppler ultrasound is superior to clinical evaluation alone for early, accurate diagnosis.
- Ultrasound should be the first-line imaging modality for evaluating scrotal pathologies, enabling better clinical outcomes through precise, non-invasive assessment.

6. Conclusion

Grayscale and color Doppler ultrasound together offer a highly accurate, non-invasive, and readily available diagnostic tool for evaluating a wide spectrum of scrotal pathologies. This combined modality not only enhances lesion detection and anatomical localization but also improves differentiation between conditions with overlapping clinical features, such as torsion and epididymo-orchitis. Color Doppler adds critical value by assessing testicular perfusion, enabling timely diagnosis of emergencies like torsion and aiding in the evaluation of subclinical or equivocal cases. The findings of this study support the use of high-resolution ultrasound with Doppler as the first-line imaging modality in the workup of scrotal swelling and pain, leading to improved diagnostic confidence, reduced unnecessary interventions, and better patient outcomes.

7. Strengths

This study highlights the effectiveness of grayscale and color Doppler ultrasound as a non-invasive, radiation-free, and widely available modality for evaluating scrotal pathologies. The combined use of grayscale for anatomical details and Doppler for vascular assessment enhanced diagnostic accuracy. Categorization of various scrotal conditions and age-based analysis added clinical relevance. The prospective approach and clinical correlation in most cases further strengthened the reliability of the findings.

8. Limitations

However, the study had certain limitations. Being a single-center study with a relatively small sample size may limit the generalizability of results. Lack of histopathological confirmation in all cases could lead to diagnostic uncertainty. Ultrasound's operator dependency introduces variability, and absence of interobserver agreement analysis is another drawback. Moreover, no long-term follow-up was performed to assess outcomes or progression.

Cases

Case 1

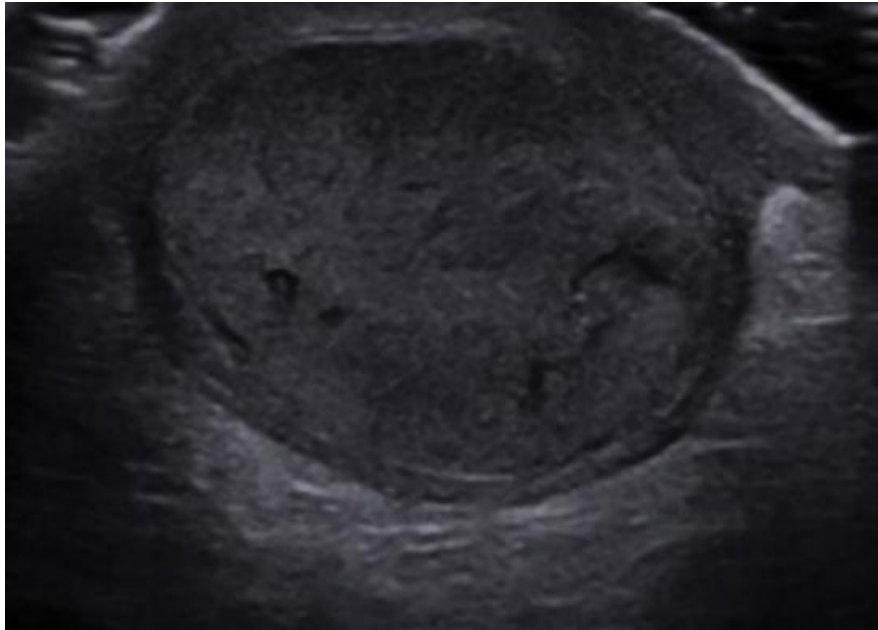


Figure A

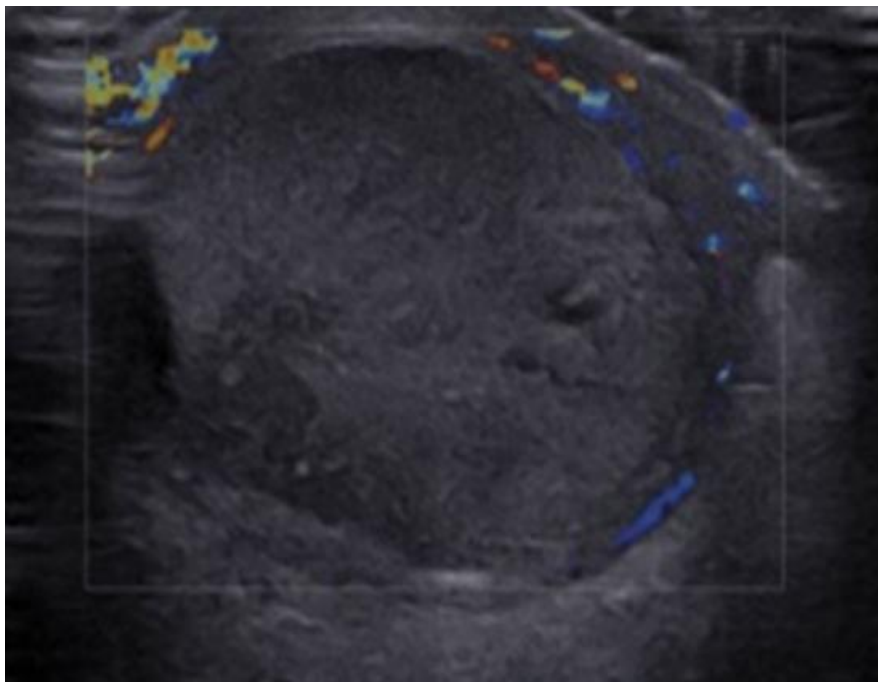


Figure B

Figure A & B Shows gray scale and colour doppler images of the left testis showing twisted, enlarged and edematous testis with heterogenous echogenicity and absent vascularity on colour doppler- consistent with Testicular torsion.

Case 2



Figure A

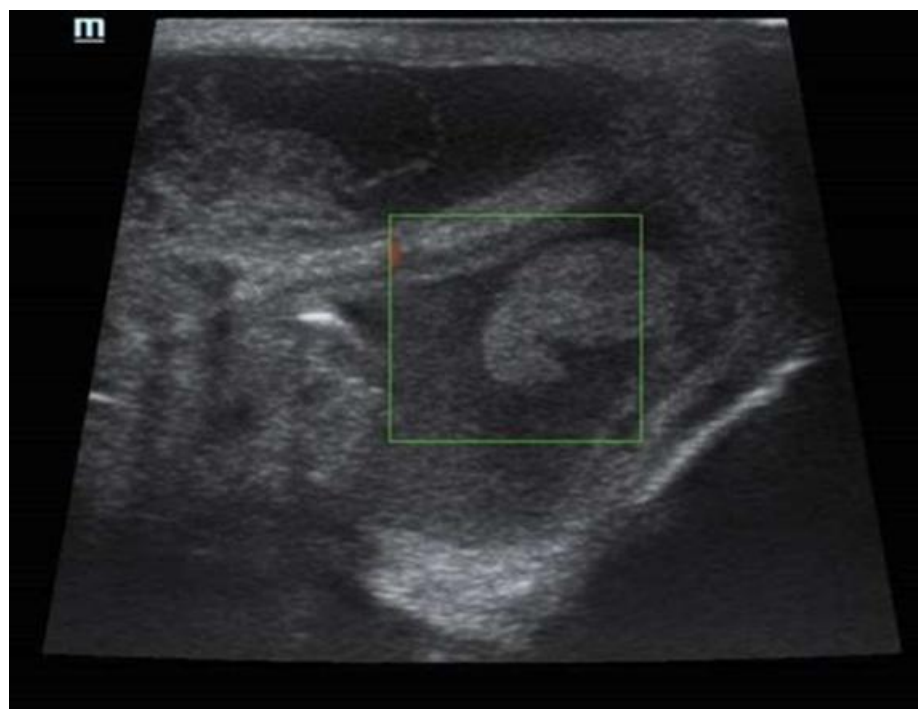


Figure B

Figure A & B shows gray scale and colour doppler images showing moderate amount of fluid in the right scrotal sac with internal echoes, consistent with the hydrocele.

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