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Original Research Article

ROLE OF GRAYSCALE AND COLOR DOPPLER IN EVALUATION OF SCROTAL PATHOLOGIES

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ABSTRACT

Background: Scrotal swelling and pain are prevalent in clinical settings, and while a detailed history and physical examination are often initial steps, many cases require additional diagnostic imaging for a comprehensive evaluation. This study aims to assess the effectiveness of ultrasonography (USG), including both grayscale and color Doppler, in diagnosing scrotal diseases.
Objective: To evaluate the role of high-resolution real-time grayscale ultrasound and color Doppler imaging in diagnosing various scrotal disorders and to compare their diagnostic efficacy.
Materials and Methods: This prospective observational study, conducted at the Department of Radiodiagnosis, Index Medical College Hospital and Research Centre, Indore, included 50 patients referred for scrotal ultrasound and color Doppler imaging due to symptoms such as acute scrotal pain, swelling, redness, or tenderness. The study adhered to institutional ethical guidelines, with written informed consent obtained from all participants. Imaging was performed using GE Voluson S8 and GE Logiq P9 machines with appropriate transducers. The study involved comprehensive clinical evaluation, bimanual palpation, and detailed imaging in various positions and with specific maneuvers for varicocele assessment. Statistical analysis was performed using IBM SPSS version 22.0, with comparisons made using chi-square tests and independent t-tests.
Results: Majority of patients were aged 21-40 years, with an average age of 35.74 years. Inflammatory conditions were most common (30%), followed by scrotal hernia (14%). Hydrocele was the most frequent fluid collection, observed in 36.8% of cases, primarily confined to the tunica vaginalis. Hematocele showed more complex internal features than hydrocele. Varicocele was present in 8.8% of cases, with notable vessel enlargement and tortuosity. Orchitis was found in 57.1% of cases, epididymitis in 78.6%, and funiculitis in 14.3%. Inguinoscrotal hernias occurred in 8% of cases. The color flow study was 100% accurate in diagnosing testicular torsion.
Conclusion: Ultrasound, particularly with color Doppler, is a highly effective, noninvasive, and cost- efficient modality for evaluating scrotal diseases. It enhances diagnostic accuracy, reduces the need for invasive procedures, and plays a crucial role in distinguishing between conditions requiring emergency surgery and those amenable to medical treatment. Further research comparing grayscale versus color Doppler imaging could provide deeper insights into optimizing scrotal pathology diagnostics.
Keywords: Scrotal swelling, pain, ultrasound, color Doppler, testicular torsion, epididymitis, scrotal pathologies.

INTRODUCTION

Scrotal swelling and pain are common in clinical settings, and while history and physical examination may suffice for some patients, many require additional studies for comprehensive evaluation.[1] The scrotum, a fibromuscular sac housing the testicles, epididymis, and lower spermatic cord, can be affected by pathological conditions including congenital, simple inflammatory, or neoplastic conditions.[2]

Clinical examination can be misleading or nonspecific, particularly when pain and swelling hinder proper assessment. Although the testis is accessible for examination, diagnosing acute scrotal issues is challenging due to symptom non-specificity and the difficulties in examining a sensitive, swollen scrotum. A detailed clinical history is crucial for diagnosing acute scrotal conditions.[3]

Epididymitis is the most common cause of acute scrotal pain, but testicular torsion requires immediate surgical intervention to preserve testicular function. Therefore, assessing testicular perfusion is critical for any imaging used in this scenario.[4] Early surgical exploration has traditionally been recommended, but this can lead to unnecessary operations, as approximately 80% of scrotal conditions are inflammatory.[5] Prompt diagnosis is essential to distinguish between conditions requiring emergency surgery and those suitable for medical treatment.[6]

Imaging modalities for scrotal disorders include gray scale ultrasound (USG), ultrasound (US) with color Doppler, magnetic resonance imaging (MRI), testicular angiography, and radioisotope studies. High-frequency linear transducer sonography with color Doppler has significantly advanced scrotal disease assessment. Although CT scans involve radiation and MRI is less accessible.[7]

B-mode ultrasonography has been essential in examining testes and scrotum since Miskin and Bain's 1974 report.[8] Advances in ultrasonography over the past two decades have made it an indispensable diagnostic tool for scrotal pathology, used for various indications such as palpable masses (hydrocele, epididymal cysts, tumors, varicocele), pain (infection, torsion, trauma), infertility (hypogonadism, varicocele), cryptorchidism (undescended testis), and follow-up of previous conditions. Scrotal lesions are classified as testicular or extratesticular; testicular lesions include torsion, trauma, neoplasms, and inflammation, while extratesticular lesions involve the spermatic cord, epididymis, and scrotal wall. Distinguishing between these is crucial as extratesticular masses are generally benign, whereas intratesticular solid masses may be malignant.[1]

High-resolution real-time ultrasonography provides excellent accuracy and sensitivity for detecting, characterizing, and localizing intrascrotal abnormalities. With 100% sensitivity, USG can effectively diagnose and differentiate a range of scrotal disorders. It is a simple, quick, noninvasive, cost-effective, and widely available technique that does not involve radiation. The addition of color Doppler ultrasound has enhanced the ability to noninvasively evaluate small vessels in superficial organs, making it a gold- standard diagnostic tool for scrotal conditions.[1] An emergency scrotal Doppler scan may be necessary to diagnose testicular torsion.[9]

Color Doppler flow index has proven most impactful in assessing the testes among superficial organs. It has refined differential diagnosis, reducing the need for scrotal surgery and aiding in accurate diagnosis of acute scrotal pain.[1]

However, there is a lack of studies comparing the effectiveness of grayscale versus color Doppler imaging in distinguishing scrotal pathologies. Thus, the present study aims to evaluate the role of ultrasonography (USG) to examine various scrotal diseases and to diagnose and identify different disorders utilizing high-resolution US and color Doppler.

MATERIALS AND METHODS

After approval from the institutional ethical committee, the present prospective observational study was undertaken in the Department of Radiodiagnosis, Index Medical College Hospital and Research Centre, Indore and 50 patients of all age groups referred from the outpatient department for an ultrasound and colour doppler examination of the scrotum with signs and symptoms related to scrotal pathologies (acute onset pain, including or excluding swelling, redness, and tenderness of the scrotum) and satisfying the inclusion and exclusion criteria were included. A written informed consent was obtained from all patients after explaining the study protocol and enrolment was done.

Inclusion Criteria

- Patients of all ages referred from the OPD for an ultrasound and colour doppler examination of the scrotum with signs and symptoms related to scrotal pathologies (acute onset pain, including or excluding swelling, redness, and tenderness of the scrotum)
- Patients who consented for the study

Exclusion Criteria

- Non-consenting patients
- Patients with a documented history of scrotal injuries, who did not provide informed consent, and those who were lost to follow-up

Methodology

A meticulous clinical evaluation was conducted prior to the scan, including a detailed history of symptoms and presenting complaints. Bimanual palpation of the scrotal contents was performed to assess their status.

For imaging, real-time grayscale ultrasound and color Doppler studies were utilized using USG machines (GE Voluson S8, GE logiq P9) equipped with 7–12 MHz linear array transducers, and a 3.5 MHz transducer for deeper penetration in cases of large scrotal swelling or retroperitoneal lymphadenopathy. The scrotum was examined in the supine position from anterior, lateral, and inferior surfaces in both longitudinal and transverse planes. The spermatic cord and groin region were also evaluated when necessary. For varicocele assessment, the examination was conducted in supine, erect postures, and with the Valsalva maneuver to confirm the diagnosis.

Findings from the symptomatic side were compared with the asymptomatic side. In cases suspected of testicular tumors, additional scans of the kidneys, liver, and para-aortic regions were performed to check for metastases and any backpressure changes in the kidneys.

Statistical Analysis

The raw data was recorded on a Microsoft Excel spreadsheet and analyzed using IBM Statistical Package for Social Sciences (SPSS), version 22.0. The mean and standard deviation were used to compare continuous parametric data while meaning and interquartile range was used for continuous non-parametric data and percentages for categorical data. The comparison of categorical data was conducted using Chi-square test, while that of continuous data was done using an independent t-test. A 'p' <0.05 was considered statistically significant.

RESULTS

A total of 50 patients with clinical symptoms related to scrotal pathology, who were referred from the outpatient department, were evaluated using high-resolution ultrasound. Majority of cases were found in the 21-40 years age group, with 17 cases (34%), followed by the 41-60 years age group, which had 11 cases (22%). The mean age of the cases was 35.74 years. Among 50 patients, inflammatory conditions are the most prevalent, affecting 30% of the patients followed by scrotal hernia accounting for 14%.

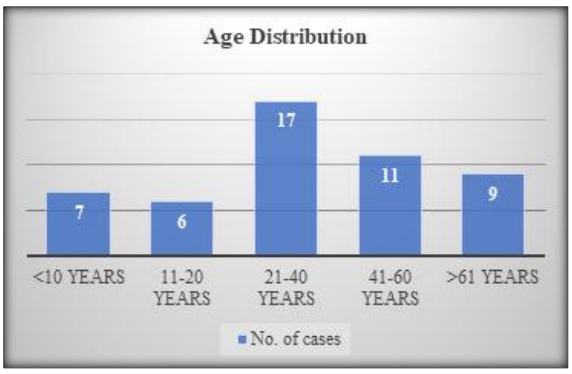

Figure 1: Age Distribution

Fluid collections were the most frequently observed abnormality in sonographic examinations. Hydrocele was detected in 21 cases (36.8%), making it the most common type of fluid collection. Among these, 90.4% had fluid confined to the tunica vaginalis cavity, while 9.6% were identified as encysted hydroceles of the spermatic cord, appearing as focal anechoic collections above the testis and epididymis. Hematocele, in contrast, typically exhibited septations and internal echoes more frequently than hydrocele. Varicocele was present in 8.8% of all cases. In 40% of cases, the maximum vessel diameter exceeded 4 mm in an erect posture, and vessel tortuosity was observed in 60% of cases. All instances showed enhancement during the Valsalva maneuver and in an erect position.

Final diagnoses revealed 11 cases of orchitis (57.1%), 14 cases of epididymitis (78.6%), and 3 cases of funiculitis (14.3%) among the 18 patients, some of whom had combinations of these conditions. Testicular involvement was noted in 50% of cases, while 83.33% of cases involved the epididymis. Of the affected epididymides, 66% showed heterogeneous echotexture, 18% were hypoechoic, and 18% had a normal echotexture. Calcifications were present in chronic inflammation of both the testis and epididymis, with three cases each. Inguinoscrotal hernias were observed in 8% of cases, with omentum herniating in three instances and bowel loops in five. The color flow study was entirely accurate in diagnosing testicular torsion.

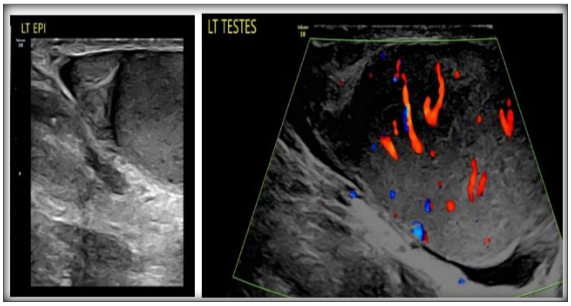

Figure 1: Bulky Epididymis with Heterogenous Echotexture & Increased Vascularity on CD (Epididymorchitis.)

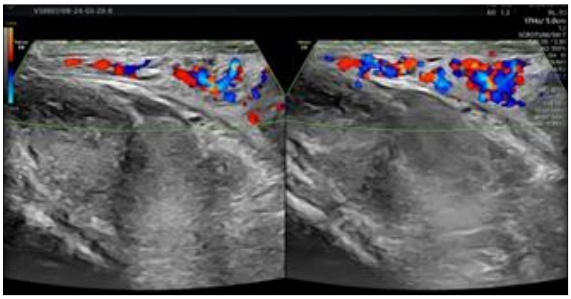

Figure 2: Enlarged, Oedematous, Heterogenous Spermatic Cord with Increased Vascularity. (Funiculitis)

Figure 3: Small, Well Defined, Anechoic Cystic Lesion in the Head of Epididymis (Epididymal Cyst)

Figure 4: Small, Heterogeneous Lesion Noted with Testicular Parenchyma Not Showing Vascularity On CD. (Testicular Abscess)

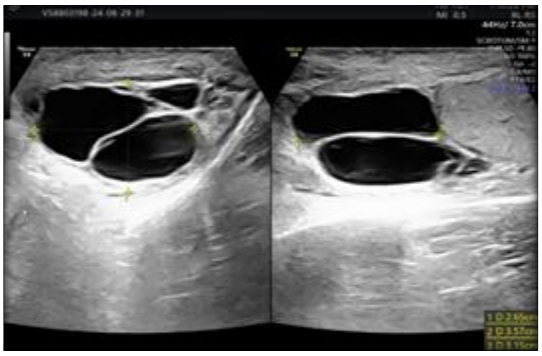

Figure 5: Well-Defined, Epididymal Lesion with Low Level Internal Echoes & Septations Demonstrating Posterior Acoustic Enhancement. (Spermatocele/ epididymal cyst)

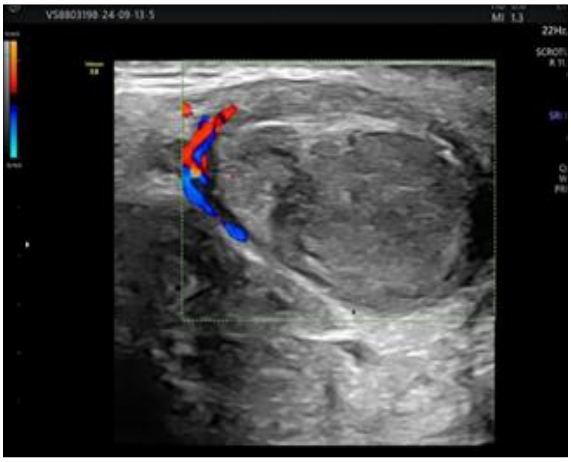

Figure 6: Small & Heterogenous Echotexture of Testis with No Vascularity On CD. (Testicular Torsion)

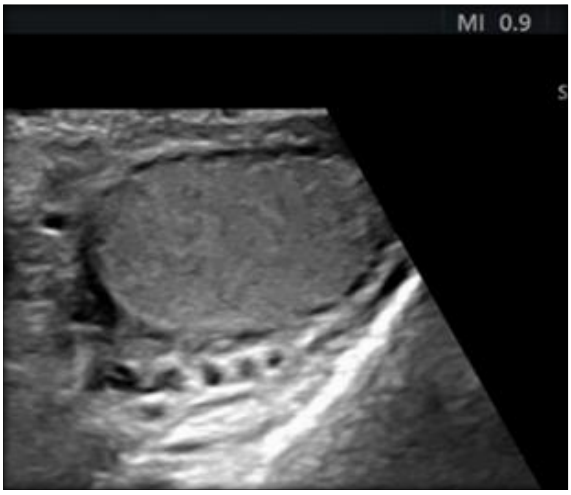

Figure 7: Multiple Dilated Pampiniform Plexus of Veins (Varicocele)

Table 1: Extra testicular lesions

Pathology	No. of cases	Percentage
Hydrocele	21	36.8%
Hernia	8	14.0%
Acute epididymitis	7	12.2%
Varicocele	6	10.5%
Chronic epididymitis	3	5.3%
Hematocele	3	5.3%
Epididymal cyst	2	3.5%
Pyocele	2	3.5%
Spermatocele	1	1.75%
Extratesticular abscess	1	1.75%
Funiculitis	1	1.75%
Scrotolith	1	1.75%
Fournier's gangrene	1	1.75%
Total	57	100%

Table 2: Intra testicular lesions

Pathology	No. of cases	Percentage
Acute orchitis	5	22.7%
Chronic orchitis	3	13.6%
Torsion	3	13.6%
Testicular tumor	2	9.1%
Ectasia of rete testis	2	9.1%
Undescended testis	2	9.1%
Testicular atrophy	1	4.5%
Testicular cyst	1	4.5%
Testicular microlithiasis	1	4.5%
Testicular trauma	1	4.5%
Testicular abscess	1	4.5%
Total	22	100%

Table 3: Sonographic features of fluid collections in tunica vaginalis sac (n = 24)

S. no	Ultrasound features	Hydrocele (n - 21)	%	Hematocele (n - 3)	
1	**Site**				
	Tunica vaginalis cavity	19	90.4	3	100%
	Encysted in spermatic cord	3	9.6	0	0
2	**Size**				
	Minimal	10	47.7	2	66%
	Moderate	7	33.3	1	34%
	Large	4	19.0	0	0
3	**Internal echoes**				
	Present	8	38.1	3	100%
	Absent	13	61.9	0	0
4	**Septations**				
	Absent	15	71.4	3	100%
	Present	6	29.6	0	0
5	**Associated finding**				
	Inflammatory disease	10	47.6	0	0
	Hernia	3	14.3	0	0
	Torsion	1	4.7	0	0

Table 4: Sonographic features of varicocele (n = 5)

S. no.	Ultrasound features	No of cases (n=5)	%
1	**Maximum diameter of spermatic/intratesticular veins**		
	2-3 mm	1	20%
	3-4 mm	2	40%
	>4 mm	2	40%
2	**Tortuosity**		
	Present	3	60%
	Absent	2	40%
3	**Accentuation on**		
	Valsalva	5	100%
	Erect posture	4	80%
4	**Color Doppler (CD)**		
	Grade 0: no flow	0	0
	Grade I spotty flow	0	0
	Grade II scattered flow	1	20%
	Grade III continuous flow	4	80%

Table 5: Grayscale features of acute inflammation (n = 15)

		Testis (n- 5)		Epididymis (n - 7)		Spermatic Cord (n - 3)	
S no.	Ultrasound features	No. of cases	%	No. of cases	%	No. of cases	%
1	**Side**						
	Unilateral	3	60%	5	71.4%	2	66%
	Bilateral	2	40%	2	28.6%	1	34%
2	**Size**						
	Normal	1	20%	1	14.3%	0	0
	Increased	4	80%	6	85.7%	3	100%
	Decreased	0	0	0	0	0	0
3	**Echotexture**						
	Normal	1	20%	0	0	0	0
	Hypoechoic	4	80%	2	28.6%	0	0
	Hyperechoic	0	0	3	42.8%	0	0
	Heterogeneous	0	0	1	14.3%	3	100%
4	**Involvement pattern**						

	Focal	0	0	4	57.1%	0	0
	Diffuse	5	100%	3	42.9%	3	100%
5	**Associated findings**						
	Involvement of epididymis	3	60%	-	-	3	100%
	Involvement of testis	-	-	3	42.9%	3	100%
	Involvement of spermatic cord	1	20%	1	14.3%	-	-
	Peritesticular fluid	4	80%	6	85.7%	3	100%

Table 6: Sonographic features of torsion testis (n = 3)

S. no.	Ultrasound features	No of cases (n=3)	%
1	**Size**		
	Normal	1	20%
	Increased	2	40%
	Decreased	2	40%
2	**Echotexture**		
	Normal	3	60%
	Hypoechoic	2	40%
	Hyperechoic		
	Heterogeneous		
3	**Peritesticular fluid**		
	Absent	5	100%
	Present	4	80%
4	**Color Doppler**		
	Grade 0: no flow	0	0
	Grade I: spotty flow	0	0
	Grade II: multiple scattered flow	1	20%
	Grade III: continuous flow	4	80%

Table 7: Sonographic features in the inguinoscrotal hernia (n = 8)

S. no	Ultrasound features	Omentocele (n =3)		Enterocele (n=5)	
		No. of cases	%	No. of cases	%
1	**Number**	3	37.5%	5	62.5%
2	**Echopattern**				
	Normal	0	0	0	0
	Hypo	0	0	5	100%
	Hyper	3	100%	0	0
3	**CDFI (within mass)**				
	Gr 0	0	0	3	60%
	Gr 1	0	0	2	40%
	Gr 2	3	100%	0	0
	Gr 3	0	0	0	0
4	**Associated findings**				
	Hydrocele	0	0	5	100%

DISCUSSION

The scrotal contents are well-suited for sonographic examination due to their superficial location. Advances in high-frequency real-time ultrasound with color Doppler technology have significantly enhanced the diagnostic accuracy of scrotal imaging. Scrotal ultrasound has evolved to the extent that it can now serve as the primary and sole imaging modality needed to assess the scrotal structures.

In the present study, the age of patients ranged from 1 year to 80 years with mean age being 35.74 + 11.2 years. The age group of 21-40 years had the highest number of cases (17 cases, 34%), followed by the 41-60 years group (11 cases, 22%). This was in concurrence with findings of study done by Kumar K et al,[5] who also reported 21-40 years as the most common age group with scrotal pathologies.

Hydrocele was the most frequently observed condition, present in 21 out of 50 cases. This was followed by inguinal hernia (8 cases), acute epididymitis (7 cases), varicocele (6 cases), and acute orchitis (5 cases). Additionally, hematocele, torsion, and epididymal cyst were noted in 3 cases each, while epididymal cyst appeared in 2 cases. These results are consistent with the findings of Gajbhiye et al,[10] who also identified hydrocele as the most prevalent condition in their prospective study involving 200 patients. Kumar K et al,[5] reported findings similar to ours, with hematocele being the most common condition, observed in 25 out of 60 cases. This was followed by inguinal hernia (12 cases), undescended testis (8 cases), varicocele (7 cases), epididymal cyst (7 cases), acute epididymo-orchitis (5 cases), and scrotal neoplastic tumors (3 cases).

Epididymitis and epididymo-orchitis are primary causes of acute scrotal pain. In cases of epididymitis, around 20% of patients also have testicular involvement. Brown et al,[11] established that a peak systolic velocity (PSV) of ≥15 cm/second provides diagnostic accuracies of 90%

for orchitis and 93% for epididymitis using Doppler ultrasound criteria. Mevorach RA et al,[12] found a strong correlation between ultrasound and pathological findings in eight cases of surgically confirmed testicular abscesses. Garriga et al,[13] assessed grayscale and power Doppler sonographic features in 20 cases of acute scrotal inflammation and concluded that while power Doppler is not superior to color Doppler for diagnosis, it is simpler and faster to use.

Chronic inflammation and tuberculous epididymitis may arise from retrograde extension from the prostate and seminal vesicles, or from hematogenous dissemination or perivasal lymphatics. Gow et al,[14] in their research indicated that the condition predominantly affects one side of the epididymis, with orchitis present in 14% of patients.

Kim et al,[15] conducted scrotal sonography on 10 patients with tuberculous epididymitis and observed enlarged, markedly heterogeneous epididymides, often with involvement of the testis. They noted occasional calcifications in the testis, epididymis, and tunica vaginalis. While Kim et al,[15] suggested that the disease typically begins in the tail of the epididymis, this finding was not observed in Chung et al.'s study.[16] Kim et al. proposed that an enlarged and heterogeneous epididymis is a reliable indicator for distinguishing tuberculous from non-tuberculous epididymitis.

In contrast, Chung et al,[16] evaluated 22 patients with tuberculous epididymitis and/or orchitis and concluded that heterogeneous and hypoechoic swelling of the epididymis and/or testis, along with associated sinus tracts or extratesticular calcifications, can aid in diagnosing the condition. They found that tuberculous orchitis without epididymal involvement is quite rare.

Testicular torsion occurs when the spermatic cord becomes twisted, and some argue that the more accurate term is spermatic cord torsion. The condition is often predisposing by a short mesenteric attachment of the testis, known as the bell clapper deformity. Sidhu et al,[17] reviewed the clinical features and the role of color Doppler sonography in diagnosing this condition. They noted that while color Doppler sonography is effective for imaging acute epididymo-orchitis, it is not infallible for detecting spermatic cord torsion and lacks a definitive imaging gold standard.

Arce et al,[18] investigated the importance of directly imaging the spermatic cord for diagnosing acute spermatic cord torsion. Their study demonstrated that sonography could reveal rotation of the spermatic cord on the affected side in all patients. They concluded that detecting a rotated spermatic cord is a highly reliable and direct sign of testicular torsion, especially when intratesticular blood flow is present on color Doppler imaging on the symptomatic side.

Patriquin HB et al,[19] used color Doppler sonography to assess 65 boys aged 0–18 years and found that this technique has a sensitivity of 89% and a specificity of 100% for detecting testicular torsion in this age group.

Subramanyam et al,[20] examined six patients with scrotal hernia using sonography and found that small bowel hernias appeared as an anechoic mass surrounding the normal testicular elements, while omental hernias showed a highly echogenic mass separated from the testis, which aligns with our findings. Dogra et al,[21] highlighted that real-time peristalsis on ultrasound is diagnostic for identifying bowel within a scrotal hernia.

Ultrasound is particularly useful for evaluating the testis when obscured by a large hydrocele. It typically appears as an anechoic collection with good sound transmission, although internal echoes or hyperechoic fluid may be present due to cholesterol crystals in the hydrocele fluid.

Dogra et al,[21] also reviewed the sonographic features of hematocele and pyocele, noting that both conditions present as complex cystic lesions with internal septations and loculations, which is consistent with our observations.

Varicocele is observed in about 10% of adolescents past puberty and 15% of adult men. Sonographically, it appears as multiple, hypoechoic, serpiginous, tubular structures larger than 2 mm in diameter, typically visible superior and/or lateral to the testis.

Dhabuwala et al,[22] studied 178 subfertile men using continuous Doppler technique and classified reflux into three grades for varicocele detection. Hirsch et al,[23] found that continuous Doppler might be overly sensitive, as 40% of reflux cases detected by Doppler were negative on selective venography. Chiou et al,[24] developed a scoring system incorporating maximal venous diameter, the presence of a venous plexus, and changes in flow on Valsalva maneuver. A score of 4 or more, indicating CDFI- positive varicocele, showed a sensitivity of 95% and specificity of 85% compared to clinical examination. Liguori et al,[25] reviewed the use of color Doppler ultrasound for diagnosing varicocele and found it effective for detecting even subclinical varicocele by measuring venous diameter and flow parameters

CONCLUSION

This study highlights the effectiveness of high-resolution sonography combined with color Doppler flow imaging (CDFI) in evaluating scrotal pathologies. Sonography accurately defined the morphology and vascularity of scrotal lesions and achieved 100% accuracy in distinguishing between solid and cystic masses. It proved to be 100% sensitive in diagnosing hydrocele, differentiating it from conditions caused by trauma, infections, or lymphatic obstruction. The technology also reliably assessed inflammatory scrotal diseases, detected scrotal hernias, and differentiated between bowel and fat contents. Additionally, CDFI was crucial in

diagnosing and differentiating testicular torsion and inflammation, especially when grayscale images were inconclusive. Overall, high-resolution sonography with CDFI is recommended as the primary diagnostic tool for scrotal conditions, providing comprehensive and precise evaluations.

REFERENCES

1. Prabha T, Singh R, Arora S. Role of Grayscale and Color Doppler Ultrasonography in Evaluation of Scrotal Pathologies. J Mahatma Gandhi Univ Med Sci Tech 2020;5(1):16–22.
2. Adekanmi AJ, Obajimi GO, Okafor EA, Adeniji-Sofoluwe A. A 10-year review of ultrasonographic findings of scrotal diseases in Ibadan, South Western, Nigeria. Afr J Med Health Sci. 2018; 17:60.
3. Blaivas M, Sierzenski P, Lambert M. Emergency evaluation of patients presenting with acute scrotum using bedside ultrasonography. Acad Emerg Med. 2001; 8:90–93.
4. Ong CY, Low HM, Chinchure D. Scrotal emergencies: an imaging perspective. Med J Malaysia. 2018; 73:445–451.
5. Kumar K, Kumari M, Kumar V, Suman SK. Evaluation of Scrotal Pathologies by Ultrasound and Color Doppler. Cureus. 2023 Mar 27;15(3):e36776.
6. Mirochnik B, Bhargava P, Dighe MK, Kanth N. Ultrasound evaluation of scrotal pathology. Radiol Clin North Am. 2012; 50:317–332.
7. Wright S, Hoffmann B. Emergency ultrasound of acute scrotal pain. Eur J Emerg Med. 2015; 22:2–9.
8. Miskin M, Bain J. Bmode ultrasonic examination of the testes. J Clin Ultrasound 1974;2(4):307– 311.
9. Ibrahim MZ, Tabari AM, Igashi JB, Lawal S, Ahmed M. Scrotal doppler ultrasound evaluation in Zaria, Nigeria. Niger J Basic Clin Sci. 2016; 13:89–93.
10. Gajbhiye DI, Shah SA, Gajbhiye MI. Role of ultrasonography & colour Doppler in scrotal pathologies. J Med Sci Clin Res. 2020; 10:8–5
11. Brown JM, Hammers LW, Barton JW. Quantitative Doppler assessment of acute scrotal inflammation. Radiology 1995;197(2):427–431.
12. Mevorach RA, Lerner RM. Testicular abscess: diagnosis by ultrasound. J Urol 1986;136(6):12– 13.
13. Garriga VF, Xavier PC, Elena GA, et al. Grey scale and power Doppler sonographic appearances of acute inflammatory diseases of the scrotum. J Clin Ultrasound 2000;28(2):67–72.
14. Gow JG. Genitourinary tuberculosis. In: Campbell's Urology Walsh PC, Gittes RF, Permutler AD, et al., ed., vol. 1, ch. 23 5th ed., Philadelphia: WB Saunders Co.; 1986. p. 1045.
15. Kim SH, Pollack HM, Cho KS, et al. Tuberculous epididymitis and epididymo-orchitis: sonographic findings. J Urol 1993;150(1):180–184.
16. Chung JJ, Kim MJ, Lee T, et al. Sonographic findings in tuberculous epididymitis and epididymo- orchitis. J Clin Ultrasound 1997;25(7):390– 394.
17. Sidhu PS. Clinical and imaging features of testicular torsion: role of ultrasound. Clin Radiol 1999;54(6):343–352.
18. Arce JD, Cortes M, Vargas JC. Sonographic diagnosis of acute spermatic cord torsion. Rotation of the cord: a key to the diagnosis. Pediatr Radiol 2002;32(7):485–491.
19. Patriquin HB, Yazbeck S. Testicular torsion in infants and children. Diagnosis with colour Doppler sonography. Radiology 1993;188(3):758–781.
20. Subramanyam BR, Balthazar EJ, Raghvendra BN, et al. Sonographic diagnosis of scrotal hernia. Am J Roentgenol 1982;139(3):535–553.
21. Dogra VS, Gottlieb RH, Mayumi O, et al. Sonography of the scrotum. Radiology 2003;227(1):18– 36.
22. Dhabuwala C, Kumar A, Kerkar P, et al. Patern of Doppler recordings and its relationship to varicocele in infertile men. Int J Androl 1989;12(6):430–438.
23. Hirsch AV, Camerson KM, Tyler JP. The Doppler assessment of varicoceles and internal spermatic vein reflux in infertile men. Br J Urol 1980;52(1):50–55.
24. Chiou RK, Anderson JC, Wobig RK. Color Doppler ultrasound criteria to diagnose varicoceles: correlation of a new scoring system with physical examination. Urilogy 1997;50(6):953–956.
25. Liguori G, Trombetta C, Garaffa G, et al. Color Doppler ultrasound investigation of varicocele. World J Urol 2004;22(5):378–381. DOI: 10.1007/s00345-004-0421-0.