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Original Article

Evaluation Of Scrotal Pathologies Using Ultrasound In A Rural Tertiary Care Hospital

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ABSTRACT

Background: High-frequency ultrasonography with colour doppler is the first-line modality for evaluating scrotal disease. It enables differentiation of inflammatory from ischemic conditions and facilitates timely surgical decision-making.
Methods: A prospective, single-centre, cross-sectional study was conducted over 6 months, enrolling 90 consecutive symptomatic patients undergoing standardized grayscale and colour/power doppler ultrasound. Diagnostic spectrum, anatomical distribution, sonographic markers (echogenicity, perfusion), time-critical entities, and performance against clinical or surgical confirmation were analyzed.
Results: The peak age group was 31–40 years (43.3%). Presenting complaints included swelling (56.7%), pain (30.0%), and screening (13.3%). Common diagnoses were hydrocele (18.9%), epididymo-orchitis (10.0%), funiculitis (8.9%), and torsion (7.8%); 10.0% of cases were normal. Lesions were predominantly extratesticular (72.2%). Hyperechoic (45.6%) and hypoechoic (44.4%) patterns predominated. Doppler flow was normal in 52.2%, increased in 40.0% (inflammatory/infective), and decreased in 7.8% (ischemic). Time-critical entities included torsion (7.8%) and fournier's gangrene (5.6%). Ultrasound achieved accuracy 87.8%, sensitivity 97.5%, and ppv 97.5%, with excellent correlation to final diagnosis (r = 0.99).
Conclusions: Scrotal ultrasound with colour doppler provides high diagnostic sensitivity and accuracy, effectively differentiates inflammatory from ischemic disease, and rapidly identifies surgical emergencies. The predominance of extratesticular pathology reinforces its role as a first-line, triage-accelerating modality in routine surgical practice.

Keywords*: Scrotal ultrasound, colour doppler, testicular torsion, epididymo-orchitis, extratesticular lesions.*

INTRODUCTION

Scrotal complaints are common in surgical and emergency practice and span congenital, inflammatory/infective, vascular, and neoplastic conditions. Although rare anomalies such as accessory scrotum (often associated with perineal lipomatous lesions) are classically reported in case literature [1,6], surgeons more frequently confront a broad differential that also includes ectopias of genitourinary structures and variant development of male external genitalia [2]. In this context, high-resolution scrotal ultrasound (US)—with grayscale and colour/power Doppler—is the first-line imaging modality because it is rapid, noninvasive, and capable of simultaneously depicting parenchymal echotexture, fluid collections, vascular perfusion, and paratesticular pathology in a single sitting [3].

Sound clinical assessment remains indispensable. Innervation and reflex arcs (notably the genitofemoral nerve and the cremasteric reflex) shape bedside examination and urgency thresholds before and during imaging, particularly when ischemia (e.g., torsion) is a concern [4,5]. Ultrasound complements this by differentiating testicular from extratesticular masses, separating inflammatory hyperaemia from ischemic hypoperfusion, and recognizing uncommon but important entities (e.g., accessory scrotum with lipoma) that may alter operative planning [1,3,6].

Against this background, we conducted a prospective single-centre evaluation of symptomatic patients undergoing scrotal US. We report the case-mix of final ultrasound diagnoses, the anatomic distribution (testicular vs extratesticular), key sonographic markers (echogenicity and Doppler patterns), identification of time-critical entities, and overall diagnostic performance in routine surgical practice.

AIMS & OBJECTIVES

Primary aim

- To delineate the spectrum of scrotal pathology on high-frequency ultrasonography with colour/power Doppler and to define its diagnostic role in routine surgical practice.

Secondary objectives

1. To describe ultrasonographic findings (parenchyma, collections, paratesticular lesions) across common scrotal conditions.
2. To evaluate colour/power Doppler in distinguishing and characterizing perfusion patterns (e.g., increased flow in inflammation/infection vs decreased/absent flow in ischemia) for acute scrotal disease.
3. To determine anatomic localization accuracy of ultrasound in separating testicular from extratesticular lesions.

MATERIALS AND METHODS

Study design and setting

This was a prospective, single-centre, cross-sectional imaging study conducted in the Department of Radiology, Parul Institute of Medical Sciences & Research (PIMSR), Vadodara, India. Consecutive symptomatic referrals for scrotal ultrasound were enrolled over 6 months following institutional ethics approval and written informed consent.

Participants

Source population: Patients referred from surgical/urology services to Radiology for evaluation of suspected scrotal pathology.

Inclusion criteria

- Symptomatic patients of any age with clinical suspicion of scrotal disease (e.g., swelling, pain, palpable mass, screening for suspected pathology).
- Ability to undergo high-frequency ultrasonography with colour/power Doppler in the same visit.

Exclusion criteria

- History of prior scrotal surgery or therapy likely to confound sonographic interpretation (e.g., recent operative bed changes).
- Inguinal hernia as the primary condition (extra-scrotal pathology outside the study scope).

Sampling was pragmatic and consecutive. The final analytic cohort comprised N = 90 patients.

Ultrasound acquisition protocol

All studies were performed on a Mindray DC-60 (or equivalent) using a high-frequency linear transducer (5–12 MHz). Standardized scanning included:

- Grayscale imaging of both testes (size, contour, echotexture), epididymides, spermatic cord, tunica, and scrotal wall in longitudinal, transverse, and oblique planes.
- Colour/power Doppler to assess intratesticular and peritesticular perfusion at low wall-filter and appropriate PRF settings, with spectral Doppler as required.
- Dynamic manoeuvres where indicated: Valsalva and standing for venous evaluation (varicocele), gentle compression to assess tenderness/collapse of venous channels, and cord tracking from the external ring for funiculitis/cord lesions.
- Targeted evaluation for suspected emergencies (e.g., torsion: side-to-side vascular comparison, spermatic cord "whirlpool" sign; Fournier's: scrotal wall thickening, subcutaneous gas with reverberation/comet-tail artifacts, fascial plane involvement).

Operational definitions

- Hydrocele / encysted hydrocele of cord: anechoic or low-level echo fluid collections around the testis or along the cord; septations/debris documented when present.
- Varicocele: pampiniform venous dilation with venous diameter criteria and reflux on Doppler, accentuated by Valsalva or standing.
- Epididymo-orchitis / epididymitis: enlarged hypoechoic/hyperechoic epididymis/testis with increased color flow; reactive hydrocele and scrotal wall edema noted.
- Torsion: decreased/absent intratesticular flow relative to the contralateral side ± whirlpool appearance of the twisted cord and testicular positional changes.
- Funiculitis: thickened, hyperaemic spermatic cord with surrounding echogenic fat.

- Testicular abscess: complex avascular collection with peripheral hyperaemia.
- Fournier's gangrene: echogenic foci with dirty shadowing/reverberation consistent with gas, with fascial thickening and subcutaneous oedema.
- Testicular vs extratesticular localization: assigned by anatomic origin and tissue planes (tunica albuginea as boundary).

Outcomes

1. Final ultrasound diagnosis spectrum (counts and percentages across predefined categories).
2. Anatomic distribution (testicular vs extratesticular).
3. Sonographic markers: echogenicity (isoechoic, hyperechoic, hypoechoic, heterogeneous) and Doppler perfusion (normal, increased, decreased).
4. Time-critical entities: counts and classic signs for torsion, Fournier's, and testicular abscess.
5. Diagnostic performance of ultrasound versus final diagnosis (clinical/surgical/end-point confirmation), reported as accuracy, sensitivity, positive predictive value (PPV); agreement summarized by correlation (r) as available in the dataset.

Data management and statistical analysis

Data were entered prospectively into a structured worksheet. Categorical variables are presented as n (%). Continuous measurements (if any) are summarized as mean ± SD or median (IQR). Diagnostic performance indices (accuracy, sensitivity, PPV) were calculated against the recorded final diagnosis; specificity/NPV were not emphasized given the case-mix with few true negatives. Analyses were performed using standard spreadsheet/statistical software (e.g., Excel/SPSS). A two-sided $p < 0.05$ threshold was used where hypothesis tests were applicable (e.g., proportion comparisons), though this study was primarily descriptive.

Ethics

The study received Institutional Ethics Committee approval prior to initiation. All participants (or guardians, where applicable) provided written informed consent. Patient confidentiality was maintained throughout, and the study adhered to the principles of the Declaration of Helsinki.

RESULTS

1. Study cohort and presentations

Ninety consecutive patients were enrolled over 6 months. Age distribution peaked at 31–40 years (43.3%). The most common presenting complaint was scrotal swelling, followed by pain and screening.

Table 1. Baseline characteristics (N = 90)

Variable	Category	n	%
Age (years)	1–10	2	2.2
	11–20	4	4.4
	21–30	17	18.9
	31–40	39	43.3
	41–50	17	18.9
	51–60	5	5.6
	61–70	1	1.1
	71–80	5	5.6
Presenting complaint	Swelling	51	56.7
	Pain	27	30.0
	Screening	12	13.3

Note: Values are counts and percentages of the total cohort (N=90).

2. Overall ultrasound spectrum (final USG diagnosis)

Hydrocele was the single most frequent diagnosis (18.9%), followed by epididymo-orchitis (10.0%), funiculitis (8.9%), and torsion (7.8%). The overall case-mix skewed extratesticular, consistent with routine referral patterns (Table 2). A compact visual of the common categories is provided in Figure 1.

Table 2. Final ultrasound diagnosis (N = 90)

Diagnosis	n	%
Hydrocele	17	18.9
Epididymo-orchitis	9	10.0
Funiculitis	8	8.9
Torsion	7	7.8
Varicocele	6	6.7
Encysted hydrocele of cord	6	6.7

Epididymal lesions	5	5.6
Fournier's gangrene	5	5.6
Haemorrhage / Hematoma	5	5.6
Testicular abscess	3	3.3
Para-testicular mass	3	3.3
Extratesticular sebaceous cyst	3	3.3
Scrotal wall pathologies	2	2.2
Testicular neoplasm	2	2.2
Normal	**9**	**10.0**
Others†	**0**	**0.0**

†In the source table, "Others (n=9, 10%)" encompassed normal studies; here we present them explicitly as "Normal" for clarity, with no residual "Others." Totals sum to N=90.

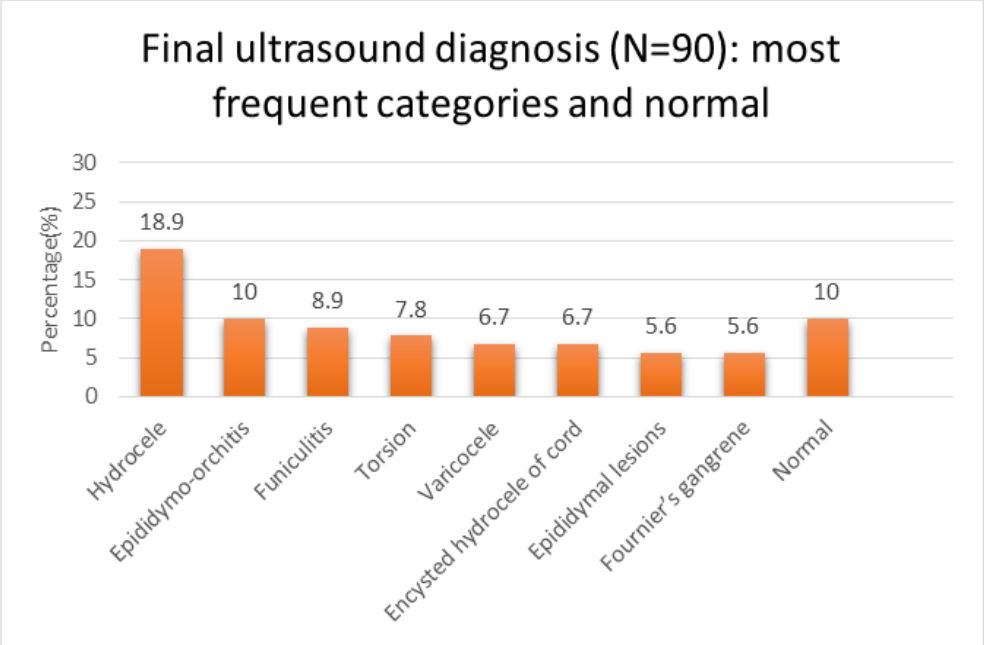

Figure 1. *Final ultrasound diagnosis in symptomatic cohort (N=90). Bars show the percentage for the most frequent categories; Normal is included for context. The leading diagnoses were hydrocele (18.9%), epididymo-orchitis (10.0%), funiculitis (8.9%), and torsion (7.8%); remaining categories were each ≤6.7%. Normal studies: 10.0%. Overall, the case-mix was predominantly extratesticular. (Full distribution in Table 2.)*

3. Anatomic distribution: testicular vs extratesticular

Lesions were predominantly extratesticular (72.2%), with testicular pathology comprising 27.8% of cases—an expected triage pattern in symptomatic referrals, where hydroceles, cord lesions, and epididymal disease are common.

Table 3. Anatomic location summary (N = 90)

Location	n	%	Typical examples (from this cohort)
Testicular	25	27.8	Torsion; testicular abscess; testicular neoplasm
Extratesticular	65	72.2	Hydrocele; encysted hydrocele of cord; funiculitis; epididymal lesions; varicocele; extratesticular sebaceous cyst; scrotal wall pathologies

Note: Examples list diagnoses from this cohort grouped by anatomical location; full category counts are in Table 2.

4. Sonographic markers (echogenicity and Doppler)

Echogenicity clustered around hyperechoic (45.6%) and hypoechoic (44.4%) patterns, with smaller proportions of heterogeneous (5.6%) and isoechoic (4.4%) testes/epididymides. On Doppler, normal flow was most common (52.2%), while increased flow (40.0%) aligned with inflammatory entities (e.g., epididymo-orchitis), and decreased flow (7.8%) corresponded to ischemic processes (e.g., torsion).

Table 4. Sonographic characterization (N = 90)

Panel A — Echogenicity

Category	n	%
Isoechoic	4	4.4
Hyperechoic	41	45.6
Hypoechoic	40	44.4
Heterogeneous	5	5.6

Panel B — Colour/Power Doppler

Category	n	%
Normal	47	52.2
Increased	36	40.0
Decreased	7	7.8

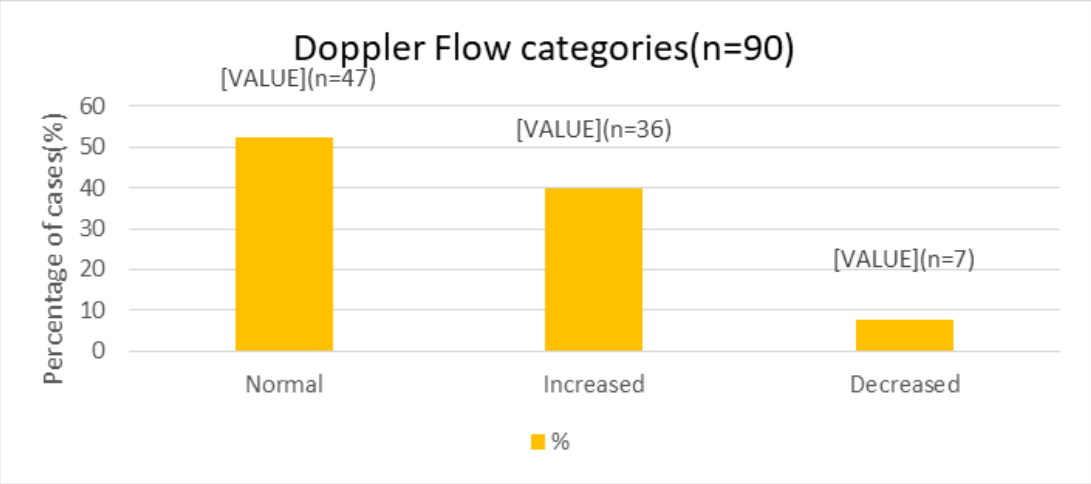

Figure 2. *Doppler flow categories on scrotal ultrasound (N=90). Bars display the percentage of cases with normal (52.2%, n=47), increased (40.0%, n=36), or decreased (7.8%, n=7) perfusion. Increased flow aligned with inflammatory/infective entities (e.g., epididymo-orchitis), whereas decreased flow corresponded to ischemic processes (e.g., torsion).*

5. Key urgent entities

Ultrasound promptly identified time-critical conditions: torsion in 7/90 (7.8%) and Fournier's gangrene in 5/90 (5.6%), expediting surgical/critical care. Torsion typically showed decreased/absent intratesticular flow (often with a whirlpool sign of the spermatic cord), whereas Fournier's demonstrated subcutaneous gas with fascial thickening. Testicular abscess was seen in 3/90 (3.3%), appearing as a complex avascular collection with peripheral hyperaemia.

Table 5. Time-critical diagnoses (N = 90)

Diagnosis	n	%	Characteristic USG sign (short)
Torsion	7	7.8	Decreased/absent intratesticular flow; whirlpool sign
Fournier's gangrene	5	5.6	Subcutaneous gas, fascial thickening
Testicular abscess	3	3.3	Complex collection, peripheral hyperaemia, no internal flow

Note: These entities were triaged urgently based on ultrasound, aligning perfusion loss with ischemia (torsion) and soft-tissue gas with necrotizing infection (Fournier's).

6. Diagnostic performance vs final diagnosis

Ultrasound demonstrated high diagnostic performance, with accuracy 87.8%, sensitivity 97.5%, and PPV 97.5% against clinical/surgical/end-point confirmation. Agreement with final diagnosis was very high ($r \approx 0.993$). Given the case-mix and limited true negatives, specificity/NPV were not emphasized.

Table 6. Diagnostic performance of ultrasound

Metric	Estimate
Accuracy	87.8%
Sensitivity	97.5%
Positive Predictive Value (PPV)	97.5%

Metrics derived against clinical/surgical/end-point confirmation. Case-mix (predominantly positive pathology and few true negatives) limits interpretability of specificity and NPV in this cohort. Agreement with final diagnosis: r ≈ 0.993.
In summary, across this 6-month cohort (N=90), ultrasound delineated a predominantly extratesticular case-mix, accurately identified time-critical entities, provided actionable tissue/perfusion characterization, and showed high concordance with final diagnoses

DISCUSSION

Our prospective cohort (N=90) showed a predominantly extratesticular case-mix with high overall ultrasound performance (accuracy 87.8%, sensitivity 97.5%, PPV 97.5%), findings that fit the long-standing role of scrotal US as a first-line test for symptomatic presentations while also underscoring the need for diagnostic stewardship. For example, Annick et al. highlighted overuse and misapplication of scrotal US in undescended testes work-ups, cautioning that context and pre-test probability shape perceived accuracy [7]. In contrast, our cohort comprised symptomatic referrals with a clear clinical question, a setting where ultrasound performance is typically strongest and most actionable.

Time-critical conditions were reliably identified. A meta-analysis by Ota et al. reported high diagnostic performance of ultrasound for testicular torsion, with pooled sensitivity/specificity in the upper ranges across adult series; absent or markedly reduced intratesticular flow remains the key discriminator, reducing delays to detorsion [8]. Our torsion yield (7/90, 7.8%) and Doppler "decreased" flow category (7.8%) align with these benchmarks, and the pattern of rapid triage mirrors their conclusion that ultrasound expedites definitive care [8]. At the other end of the inflammatory–ischemic spectrum, Bhaskar documented that increased flow on colour Doppler tracks with epididymo-orchitis and related infections, consistent with our 40.0% increased-flow rate and a 10.0% frequency of epididymo-orchitis in the case-mix [9].

The dominance of extratesticular pathology (72.2%) in our material is expected given the prevalence of hydroceles, epididymal/cord processes, and varicocele in symptomatic adult referrals. Rafailidis et al. reviewed paratesticular lesions, emphasising their diversity and the pivotal role of US in distinguishing benign, inflammatory, and rarer neoplastic entities—an observation that mirrors our broad "extra-testicular" spectrum, led by hydrocele (18.9%) and cord/epididymal conditions [10]. Technique also matters: in varicocele, Kim et al. showed that Valsalva and standing examinations improve diagnostic yield and reproducibility, particularly in borderline or subclinical cases [11]. We incorporated these manoeuvres in routine scanning, which likely supported consistent categorisation in our cohort.

Spectrum coverage extended to spermatic cord and pericordal disease. Karbasian et al. detailed the sonographic appearances of cord pathologies (e.g., funiculitis, encysted hydrocele of the cord), highlighting Doppler and anatomic landmarks that reduce misclassification [12]. Our frequencies for funiculitis (8.9%) and encysted cord hydrocele (6.7%) fall within the plausible ranges described and illustrate the advantage of a systematic cord-to-testis sweep [12]. For Fournier's gangrene, Chen et al. reported that point-of-care ultrasound rapidly identifies subcutaneous gas and fascial thickening, accelerating critical care mobilisation; our 5.6% Fournier's rate is consistent with a tertiary-care, symptomatic cohort and the described sonographic hallmarks [13].

Beyond grayscale and colour Doppler, contemporary reviews argue for multiparametric ultrasound in selected acute scrotum scenarios. Schillirò et al. synthesised evidence for contrast-enhanced ultrasound (CEUS) and advanced Doppler to refine vascular assessment, particularly when conventional Doppler is equivocal [14]. While our study used conventional modalities only, our very high agreement with final diagnosis ($r \approx 0.993$) suggests that, in a typical symptomatic mix, standard US/Doppler resolves most clinical questions without escalation. When POCUS is the first touchpoint—especially in children—Elsayed and colleagues showed that rapid bedside imaging reduces time to intervention for torsion and triages inflammatory cases more efficiently [15]. The directionality of our Doppler data (increased flow with infection, decreased with torsion) matches that acute-care paradigm.

Our overall distribution of testicular vs extratesticular pathology and the echogenicity/perfusion profiles also map onto classic differentiators. Hamm outlined how US reliably separates testicular from paratesticular masses using echogenicity, margins, and vascularity—principles echoed in our tables where hyperechoic/hypoechoic patterns predominate and Doppler categories separate inflammation from ischemia [16]. Age-related patterns provide additional context: Aragona et al. showed differing prevalence of painless scrotal masses across pediatric age bands; while our cohort is not pediatric-focused, that work reinforces how epidemiology drives pre-test probabilities and therefore apparent accuracy [17]. Region and referral filters also modulate case-mix—for example, higher catheterisation or STI rates may increase infectious presentations and push Doppler "increased-flow" proportions upward, whereas different emergency thresholds might alter torsion prevalence.

Taken together, the literature supports our central signals: (i) ultrasound delivers high sensitivity and concordance in symptomatic scrotal disease, (ii) colour Doppler cleanly separates inflammatory from ischemic processes in most cases, (iii) extratesticular conditions dominate routine adult referrals, and (iv) time-critical entities (torsion, Fournier's) are rapidly triaged with characteristic sonographic signatures [7–17]. Variations in operator expertise, protocol (e.g., Valsalva/standing), and access to adjuncts (e.g., CEUS) explain residual differences across series, but the directionality is

stable: in a prospective symptomatic cohort like ours, scrotal ultrasound functions as a high-yield, decision-shaping test that shortens time-to-treatment and reduces unnecessary escalation.

Limitations

Single-centre cohort over 6 months with a modest sample size (N=90) and symptomatic referral bias; thus specificity/NPV were not emphasized given few true negatives. Ultrasound is operator-dependent and we did not perform interobserver analysis or uniform surgical gold-standard confirmation in all cases. Long-term outcomes were beyond scope.

CONCLUSION

In a prospective symptomatic cohort, scrotal ultrasound with colour Doppler provided high sensitivity (97.5%), good overall accuracy (87.8%), and decision-relevant characterization (perfusion, echogenicity), while reliably identifying time-critical entities (torsion, Fournier's). The case-mix was predominantly extratesticular, and Doppler patterns aligned with inflammatory vs ischemic processes, supporting ultrasound as a first-line, triage-accelerating modality. Broader multicentre studies with interobserver assessment and surgical correlation (and selective use of advanced techniques such as CEUS when equivocal) are warranted to refine performance estimates and generalizability.

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