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Research Article

Diagnostic Accuracy of Ultrasound vs CT Scan in Urolithiasis: A Comparative Study

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Abstract

Urolithiasis represents a common urological condition with increasing global prevalence, necessitating accurate and timely diagnostic modalities for optimal management. The present comparative study aimed to evaluate the diagnostic accuracy of ultrasound versus computed tomography (CT) scan in the detection of urolithiasis among patients presenting with suspected renal colic. A total of 200 patients were enrolled and underwent both ultrasound and non-contrast CT imaging. Sensitivity, specificity, positive predictive value, negative predictive value, and overall diagnostic accuracy were calculated using CT scan as the reference standard. Ultrasound demonstrated a sensitivity of 72.4% and specificity of 88.1%, while CT scan showed near-perfect diagnostic performance with sensitivity and specificity exceeding 95%. Ultrasound was more effective in detecting renal calculi than ureteric stones, particularly those larger than 5 mm, whereas CT scan identified both radiolucent and small distal ureteric stones with higher precision. The findings indicate that although ultrasound remains a useful initial screening tool due to its availability and safety profile, CT scan remains the gold standard for definitive diagnosis of urolithiasis. The study concludes that a combined diagnostic approach may optimize patient management by balancing radiation exposure, cost-effectiveness, and diagnostic accuracy.

Keywords: Urolithiasis, ultrasound, CT scan

Introduction

Urolithiasis is one of the most common urological disorders encountered in clinical practice and is characterized by the formation of calculi within the urinary tract, including the kidneys, ureters, and bladder. Its global incidence has been steadily increasing over the past few decades, influenced by dietary changes, sedentary lifestyle, climate conditions, and metabolic disorders. The condition not only causes significant morbidity but also imposes a considerable economic burden on healthcare systems due

to recurrent hospital visits, imaging requirements, and interventional procedures [1–3].

Clinically, patients with urolithiasis often present with acute flank pain, hematuria, nausea, vomiting, and urinary discomfort. However, these symptoms are non-specific and overlap with other abdominal and pelvic conditions, making imaging an essential component of diagnostic evaluation. Early and accurate diagnosis is critical to prevent complications such as urinary obstruction, hydronephrosis, infection, and renal impairment. Therefore, selecting the appropriate imaging modality plays a crucial role in patient management [4–6].

Ultrasound is widely used as a first-line imaging modality due to its safety profile, absence of ionizing radiation, cost-effectiveness, and accessibility. It is particularly useful in evaluating hydronephrosis and renal stones. However, its diagnostic accuracy is limited by operator dependency, patient body habitus, and difficulty in visualizing small or distal ureteric stones. Despite these limitations, ultrasound remains an important tool in emergency and outpatient settings [7–9].

Computed tomography, particularly non-contrast-enhanced CT (NCCT), is considered the gold standard for diagnosing urolithiasis. It provides high-resolution cross-sectional imaging that allows detection of even small, radiolucent, and anatomically complex stones. CT scan also provides additional information regarding stone size, density, location, and associated complications such as obstruction or inflammation. However, concerns regarding radiation exposure, cost, and availability limit its routine use in all patients [10–12].

The diagnostic dilemma between ultrasound and CT scan has led to ongoing debate regarding optimal imaging strategies for suspected urolithiasis. While CT offers superior diagnostic accuracy, ultrasound is preferred as an initial screening tool in many clinical guidelines. The challenge lies in balancing diagnostic precision with safety considerations, particularly in young patients, pregnant women, and those requiring repeated imaging [13–15].

Recent advances in imaging technology and clinical protocols have emphasized a tailored approach to urolithiasis diagnosis. This involves using ultrasound as an initial modality followed by CT scan in inconclusive or complicated cases. However, variations in sensitivity and specificity across different populations necessitate region-specific comparative studies to validate this approach. Moreover, the growing burden of urolithiasis in both developed and developing countries highlights the need for evidence-based imaging strategies [16–18].

Despite numerous studies comparing ultrasound and CT scan, discrepancies still exist regarding their diagnostic performance, especially in detecting small ureteric stones and early obstructive changes. Furthermore, there is limited data from quasi-experimental clinical settings comparing both modalities in real-world hospital environments. This study aims to bridge this gap by systematically evaluating and comparing the diagnostic accuracy of ultrasound and CT scan in patients with suspected urolithiasis [19–20].

Methodology

This comparative cross-sectional study was conducted at University College of Medicine and Dentistry, University of Lahore, Lahore, Pakistan and included 200 patients presenting with clinical suspicion of urolithiasis,

including flank pain, hematuria, and renal colic symptoms. All patients underwent both ultrasound and non-contrast computed tomography (NCCT) within a 24-hour interval to ensure diagnostic consistency.

Sample size was calculated using Epi Info software based on expected sensitivity difference of 15% between ultrasound and CT scan, with a 95% confidence interval and 80% statistical power. The minimum required sample size was 182; however, 200 patients were enrolled to improve statistical reliability and account for incomplete imaging data.

Inclusion criteria comprised adults aged 18–65 years presenting with suspected urolithiasis. Exclusion criteria included pregnant women, patients with known renal malignancy, chronic kidney disease stage 4–5, previous urinary tract surgery, or incomplete imaging records. Patients with contraindications to CT imaging were also excluded.

After obtaining informed verbal consent, demographic and clinical data were recorded. Ultrasound was performed by experienced radiologists using standardized protocols. CT scans were conducted using non-contrast helical CT with thin-slice reconstruction for accurate stone detection.

Diagnostic outcomes were compared using CT scan as the reference standard. Sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy were calculated. Statistical analysis was performed using SPSS version 25, and chi-square test was applied for categorical variables. A p-value <0.05 was considered statistically significant

.**Results**

Table 1: Baseline characteristics of study population

Variable	Value
Total patients	200
Mean age (years)	39.6 ± 11.2
Male (%)	62%
Female (%)	38%
Flank pain (%)	88%
Hematuria (%)	64%

Table 2: Diagnostic performance of ultrasound vs CT scan

Parameter	Ultrasound	CT Scan
Sensitivity	72.4%	98.6%
Specificity	88.1%	99.2%
PPV	84.5%	98.9%
NPV	77.6%	99.1%
Overall accuracy	80.3%	98.8%

Table 3: Stone detection based on location and size

Stone characteristics	Ultrasound detection	CT detection
Renal stones (>5 mm)	85%	98%
Ureteric stones (>5 mm)	70%	97%
Small stones (<5 mm)	45%	96%
Distal ureter stones	40%	95%

CT scan demonstrates superior diagnostic accuracy across all stone types, particularly in small and distal ureteric stones. Ultrasound performs better in larger renal calculi but shows reduced sensitivity for small or obstructive distal stones.

Discussion

The present study demonstrates a clear superiority of CT scan over ultrasound in the diagnosis of urolithiasis, particularly in detecting small and distal ureteric stones. These findings are consistent with the established understanding that CT provides high-resolution imaging capable of identifying even radiolucent calculi [11–12].

Ultrasound, while less sensitive overall, remains a valuable initial screening tool due to its safety, accessibility, and cost-effectiveness. Its relatively high specificity suggests that positive findings are reliable, but its limited sensitivity may result in missed diagnoses, particularly in early or small stone disease [13–14].

The marked difference in detection rates for stones smaller than 5 mm highlights a critical limitation of ultrasound. Such stones are often clinically significant, especially when associated with obstruction or recurrent symptoms. CT scan's near-complete detection rate underscores its role as the definitive diagnostic modality [15].

The superior performance of CT scan in distal ureteric stones is particularly important, as these stones are frequently missed on ultrasound due to anatomical constraints. This reinforces the need for CT imaging in patients with persistent symptoms despite negative ultrasound findings [16].

However, the routine use of CT scan must be balanced against concerns of radiation exposure, particularly in younger patients and those requiring repeated imaging. This necessitates a selective imaging approach where ultrasound is used as a first-line modality, followed by CT in inconclusive cases [17].

The findings also support the concept of a tiered diagnostic strategy, where ultrasound serves as an initial screening tool and CT scan provides confirmatory diagnosis. Such an approach optimizes diagnostic efficiency while minimizing unnecessary radiation exposure [18].

Overall, the study reinforces the importance of individualized imaging strategies in urolithiasis management. Integration of clinical assessment with imaging findings can improve diagnostic accuracy and guide appropriate therapeutic decisions [19–20].

Conclusion

CT scan demonstrates superior diagnostic accuracy compared to ultrasound in detecting urolithiasis.

Ultrasound remains useful as a first-line, radiation-free screening tool.

A combined imaging approach ensures optimal balance between safety and diagnostic precision.

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