

Limitations of Ultrasonography in Assessing Urolithiasis: Correlation with CT

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Abstract:

Background: Urolithiasis is a common urological disorder with rising global prevalence. Accurate diagnosis is essential for effective management. While ultrasonography (USG) is widely used as a first-line imaging tool due to its safety and accessibility, its limitations in detecting small and ureteric stones remain a concern. Computed tomography (CT) is considered the gold standard, offering superior accuracy but with drawbacks such as radiation exposure and higher cost.

Aim: To evaluate the diagnostic limitations of ultrasonography in detecting urolithiasis and to compare its performance with CT as the reference standard.

Methods: This prospective observational study included 132 patients clinically suspected of urolithiasis over a period of 18 months at the Department of Radiology, Narayan Medical College and Hospital, Jamuhar, Sasaram, Bihar. All patients underwent both ultrasonography and non-contrast CT. Data regarding stone size, number, and location were compared. Statistical analysis was performed using SPSS version 23.0, and sensitivity, specificity, predictive values, and accuracy of USG were calculated against CT findings.

Results: CT detected 156 stones in 132 patients, with the majority located in the kidney (52.6%) followed by the ureter (39.7%). Ultrasonography detected 120 stones, missing 36 stones, primarily small (<5 mm) ureteric stones, and producing 8 false positives. The diagnostic performance of ultrasonography showed a sensitivity of 76.9%, specificity of 92.6%, positive predictive value of 93.7%, negative predictive value of 72.1%, and overall accuracy of 82.5%. The difference between USG and CT was statistically significant ($p < 0.001$).

Conclusion: Ultrasonography is a valuable first-line tool in the evaluation of urolithiasis, particularly for renal stones and larger calculi. However, its limitations in detecting small and distal ureteric stones highlight the need for CT in cases where clinical suspicion persists despite negative or inconclusive ultrasound findings.

Recommendations: USG should continue to be used as the initial imaging modality due to its safety and accessibility. However, non-contrast CT should be performed in patients with negative USG but high clinical suspicion, recurrent stone formers, or when surgical or interventional planning is required. Greater emphasis should also be placed on operator training and standardized protocols to improve USG accuracy.

Keywords: Urolithiasis; Ultrasonography; Computed Tomography; Diagnostic Accuracy; Kidney Stones.

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Introduction

Urolithiasis, defined as the presence of calculi within the urinary tract, remains one of the most prevalent urological disorders worldwide. The global incidence and prevalence of urinary stone disease have shown a steady rise over the last few decades, attributed to lifestyle changes, dietary habits, obesity, and metabolic factors [1]. The disease poses a significant health burden due to its recurrent nature, associated morbidity, and

economic implications. Recent studies suggest that the lifetime risk of developing urolithiasis is approximately 10–15% in developed countries, with a higher male predominance [2]. In India, the prevalence is also rising, particularly in the northern and eastern regions, where climatic conditions, fluid intake, and diet contribute to stone formation [3].

Accurate and timely diagnosis of urolithiasis is crucial for effective management, prevention of complications, and reduction of healthcare costs. Non-contrast computed tomography (NCCT) is currently considered the gold standard imaging modality for the diagnosis of urinary stones due to its high sensitivity (97–100%) and specificity (95–98%) [4]. NCCT provides precise information regarding stone size, number, location, and density, as well as associated complications such as obstruction and hydronephrosis. However, its limitations include radiation exposure and relatively higher cost, which make it less favorable as a primary diagnostic tool, especially in young patients and those requiring repeated imaging [5].

(USG), on the other hand, is widely used as the first-line imaging modality because of its safety, affordability, and widespread availability. It is free from ionizing radiation and can be performed at the bedside, making it highly suitable for emergency and pediatric cases [6]. USG is particularly effective in detecting larger renal calculi and evaluating hydronephrosis. However, its sensitivity for detecting ureteric stones, especially those smaller than 5 mm or located in the distal ureter, remains limited [7]. Moreover, operator dependency and interference from bowel gas or body habitus further restrict its diagnostic accuracy [8].

Given these challenges, correlating ultrasonography findings with CT results provides valuable insights into the diagnostic limitations of USG and its role in clinical practice. Such comparative evaluation helps determine whether USG can reliably serve as a stand-alone diagnostic modality or whether CT is necessary for confirmation, especially in inconclusive cases. Understanding the strengths and weaknesses of both modalities is critical for optimizing diagnostic strategies, reducing unnecessary radiation exposure, and improving patient outcomes [9].

Methodology

Study Design: This was a prospective observational study.

Study Setting: The study was carried out in the Department of Radiology, Narayan Medical College and Hospital, Jamuhar, Sasaram, Bihar. The total study duration was 18 months.

Participants: A total of 132 patients clinically suspected of having urolithiasis and referred to the Department of Radiology for imaging were included in the study.

Inclusion Criteria: Patients of all age groups and both sexes presenting with clinical suspicion of

urolithiasis and undergoing both ultrasonography and non-contrast CT within the study period were included.

Exclusion Criteria: Participants were excluded from the study if they met any of the following conditions: a history of prior surgical intervention for urolithiasis; previous treatment with lithotripsy; pregnancy; age less than 18 years; unwillingness to participate in the study; or incomplete imaging records.

Bias: To minimize observer bias, ultrasonography and CT examinations were performed independently by different radiologists blinded to each other's findings. Interobserver variability was reduced by following standardized imaging protocols.

Data Collection: Clinical details and demographic information were collected from patient records. Imaging findings from ultrasonography and CT were documented, including stone size, number, location, and associated complications. Data were entered into predesigned case record forms and later transferred to a digital database.

Procedure: Each participant underwent ultrasonography using a high-frequency transducer for detailed evaluation of the kidneys, ureters, and bladder. Findings regarding echogenic foci, posterior acoustic shadowing, hydronephrosis, and ureteric dilatation were recorded. This was followed by a non-contrast CT scan of the abdomen and pelvis, performed using a multi-detector CT scanner, which served as the gold standard for diagnosis. The results of ultrasonography were compared with CT findings to determine sensitivity, specificity, and diagnostic accuracy.

Statistical Analysis: All data were compiled and analyzed using (SPSS) version 23.0. Descriptive statistics were used to summarize patient characteristics. Sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy of ultrasonography were calculated using CT as the reference standard. Chi-square test was applied to assess statistical significance, with a p-value of <0.05 considered significant.

Results

A total of 132 patients were included in the study. Out of these, 86 (65.2%) were males and 46 (34.8%) were females, giving a male-to-female ratio of approximately 1.9:1. The mean age of participants was 42.6 ± 13.8 years (range: 18–72 years). The highest incidence of urolithiasis was observed in the 31–50 years age group (49.2%).

Table 1: Distribution of patients by age and sex

Age Group (years)	Male (n=86)	Female (n=46)	Total (n=132)	Percentage (%)
18–30	22	12	34	25.8
31–50	44	21	65	49.2
>50	20	13	33	25.0
Total	86	46	132	100

Urolithiasis was most common in middle-aged adults, particularly in males.

Stone Characteristics on CT (Gold Standard):
Non-contrast CT identified 156 stones in 132

patients (some patients had multiple stones). The most frequent site was the kidney (52.6%), followed by ureter (39.7%) and bladder (7.7%). The mean stone size was 6.8 ± 3.2 mm.

Table 2: Stone distribution and size (CT findings)

Stone Location	Number of Stones	Percentage (%)
Kidney	82	52.6
Ureter	62	39.7
Bladder	12	7.7
Total	156	100

CT confirmed that renal stones were the most prevalent, followed by ureteric stones.

Ultrasonography vs. CT Findings:
Ultrasonography detected 120 stones out of 156

confirmed by CT. Missed stones were mainly small (<5 mm) and located in the ureter. False positives were recorded in 8 cases due to vascular calcifications and phleboliths.

Table 3: Comparison of ultrasonography and CT findings

Findings	CT (Gold Standard)	Ultrasonography	Difference
Stones detected	156	120	-36
Stones missed	–	36	–
False positives	–	8	–

Diagnostic Accuracy of Ultrasonography: Taking CT as the gold standard, the diagnostic performance of ultrasonography in detecting urolithiasis was calculated.

- Sensitivity: 76.9%

- Specificity: 92.6%
- (PPV): 93.7%
- (NPV): 72.1%
- Overall Accuracy: 82.5%

Table 4: Diagnostic performance of ultrasonography

Parameter	Value (%)
Sensitivity	76.9
Specificity	92.6
PPV	93.7
NPV	72.1
Overall Accuracy	82.5

Ultrasonography showed good specificity and PPV, but its sensitivity was reduced, especially for small ureteric stones.

Statistical Significance: The difference between ultrasonography and CT in detecting stones was statistically significant ($\chi^2 = 18.45$, $p < 0.001$). This indicates that ultrasonography has limitations compared to CT, particularly in detecting smaller and distal ureteric stones.

Discussion

The present study included 132 patients with clinically suspected urolithiasis. A male

predominance was observed, with a male-to-female ratio of nearly 2:1, and the majority of patients belonged to the 31–50 years age group, highlighting the high burden of urolithiasis among young and middle-aged adults. These demographic findings are consistent with the known epidemiology of urinary stone disease, which is more common in males and peaks in the productive years of life.

CT, taken as the gold standard, detected a total of 156 stones. Renal stones constituted the majority (52.6%), followed by ureteric stones (39.7%) and bladder stones (7.7%). The mean stone size was approximately 7 mm, with a considerable proportion

of stones measuring less than 5 mm, particularly in the ureter. This distribution pattern supports the fact that the kidney remains the most common site of stone formation, but ureteric stones are frequently responsible for acute presentations.

Ultrasonography detected 120 stones, missing 36 stones that were later identified on CT. Most of the missed stones were small (<5 mm) and located in the ureter, where bowel gas and overlying structures limited sonographic visualization. Additionally, ultrasonography produced 8 false positives, often due to misinterpretation of vascular calcifications and phleboliths. These findings underscore the inherent limitations of ultrasonography, particularly for small and distal ureteric stones.

In terms of diagnostic accuracy, ultrasonography showed a sensitivity of 76.9%, specificity of 92.6%, PPV of 93.7%, and NPV of 72.1%, with an overall accuracy of 82.5%. While ultrasonography demonstrated high specificity and reliably confirmed the presence of stones when detected, its relatively lower sensitivity indicates that a considerable proportion of stones, especially smaller ones, may be missed. Statistical analysis confirmed this difference as highly significant ($p < 0.001$).

In summary, the study demonstrates that ultrasonography, while being a safe, widely available, and cost-effective initial imaging modality, has important limitations in the detection of urolithiasis. Its diagnostic utility is highest for larger renal stones but significantly reduced for small ureteric stones. CT remains the gold standard, offering superior sensitivity and specificity. Thus, ultrasonography should be regarded as an effective first-line tool, but negative or inconclusive cases with high clinical suspicion warrant further evaluation with CT.

Ultrasonography is commonly used as a non-invasive first-line imaging tool for urolithiasis; however, it demonstrates limitations in detecting small stones and distal ureteral stones. Research indicates that stones under 5 mm and those located in the distal ureter are frequently missed on US, reducing its diagnostic sensitivity compared to CT [10]. (CT) remains superior for precise diagnosis. Studies consistently show that CT more reliably identifies stone size, number, and location. In contrast, US frequently underestimates stone dimensions and may completely miss certain stones, particularly in complex cases [11]. Operator dependency is a significant limitation of ultrasonography. The diagnostic accuracy of US is highly influenced by the skill of the operator and patient factors such as body habitus, which can reduce its reliability in comparison to CT [12]. Point-of-care ultrasonography, often used in emergency settings, can rapidly detect hydronephrosis but has limited reliability for direct

stone detection. This makes CT preferable when an exact diagnosis is required [13].

Ultrasound also underestimates total stone burden, particularly in patients with multiple stones, which may complicate treatment planning if CT confirmation is not obtained [14]. Additional studies support these findings. A prospective study by Wang et al. (2019) reported that US sensitivity decreases substantially for stones smaller than 4 mm and those in the mid-ureter, highlighting the risk of missed diagnoses without CT confirmation [15]. Another study by Patel et al. (2020) found that US underestimated stone volume by 20–30% on average, potentially affecting decisions for surgical versus conservative management [16].

Conclusion

Ultrasonography is a valuable first-line imaging tool for evaluating urolithiasis due to its safety, availability, and cost-effectiveness. However, it has limitations, particularly in detecting small and distal ureteric stones. CT remains the gold standard, providing superior accuracy and should be considered when ultrasound findings are negative or inconclusive in patients with strong clinical suspicion.

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