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Comparative Study of Diagnostic Accuracy of Ultrasound Versus Non-Contrast Computed Tomography in Detection of Urolithiasis in Adult Patients Presenting with Flank Pain

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ABSTRACT

Background: Urolithiasis is a common cause of acute flank pain in adults and requires prompt imaging-based diagnosis for early management. Although non-contrast computed tomography of the kidneys, ureters, and bladder (NCCT KUB) is considered the gold standard, ultrasonography remains an attractive initial imaging modality because it is inexpensive, widely available, and free of ionizing radiation.
Methods: This retrospective comparative study included 60 adult patients presenting with acute flank pain who underwent both ultrasonography and NCCT KUB. Data was collected from radiology reports as well as clinical notes. NCCT KUB was considered the reference standard for diagnosis of urolithiasis. Diagnostic accuracy of USG was assessed in terms of sensitivity, specificity, positive predictive value and negative predictive value.
Results: NCCT KUB detected urolithiasis in 54 of 60 patients (90.0%). Ultrasonography detected calculi in 42 patients (70.0%). Ultrasonography showed a sensitivity of 77.8% and specificity of 100.0%. It also showed positive predictive value of 100.0%, negative predictive value of 33.3% and diagnostic accuracy of 80.0%. Distal ureteric calculi were most commonly seen on NCCT KUB. Ultrasound demonstrated better sensitivity for PUJ and VUJ calculi and for larger stones. Hydronephrosis and haematuria were significantly associated with ultrasound positivity.
Conclusion: Ultrasonography showed good sensitivity and excellent specificity for detection of urolithiasis in adults with flank pain. However, NCCT KUB remained superior for overall stone detection particularly for small and ureteric calculi. Ultrasound can serve as the initial imaging modality whereas NCCT KUB can be used for equivocal or ultrasound-negative cases in whom there is high clinical suspicion for urolithiasis.

Keywords: *Urolithiasis, ultrasonography, non-contrast computed tomography, flank pain, diagnostic accuracy.*

INTRODUCTION

Urolithiasis is a major cause of acute flank pain in adults and it continues to be common cause of emergency department visits, radiological investigations and urology consultations worldwide. The lifetime incidence of urinary stone disease has been reported to approach 12%, while the prevalence varies considerably across geographic regions.[1] In Asian populations, the burden is especially notable, with several regions demonstrating prevalence rates high enough to make urinary stone

disease a routine clinical problem.[2] Acute ureteric obstruction by a calculus frequently presents with severe colicky pain and may be associated with hydronephrosis, infection, haematuria, and deterioration of renal function if diagnosis is delayed.[3]

Radiologic imaging plays a central role in the evaluation of patients presenting with flank pain suggestive of urolithiasis. Historically, plain radiography of the kidney, ureter, and bladder and intravenous urography were used for diagnostic assessment, but both techniques have important limitations. Plain radiography has low sensitivity, especially for radiolucent stones, and provides limited information regarding urinary tract anatomy, whereas intravenous urography requires contrast administration and carries the disadvantages of ionizing radiation and longer examination time. [4] Consequently, imaging strategies have shifted toward ultrasonography and computed tomography.

Non-contrast computed tomography has emerged as the reference standard for detecting urinary tract calculi because of its excellent sensitivity and specificity.[5] It is also known for accurate localization of stones, precise stone size assessment, and ability to identify alternative causes of abdominal pain. [6] Nevertheless, routine use of CT in all patients is limited by concerns regarding radiation exposure, higher cost, and resource utilization. This is particularly important in younger adults and in cases having history of recurrent stone formations who may require repeated imaging over time. [7]

Ultrasonography offers several advantages that make it an imaging modality for first-line investigation in patients with suspected urolithiasis. It is widely available, non-invasive, cost-effective, and free of any harmful ionizing radiation. In addition to direct visualization of calculi in selected patients, ultrasound is highly useful for demonstrating indirect signs of obstruction such as hydronephrosis and hydroureter. However, its diagnostic performance is influenced by stone size, stone site, body habitus, bowel gas, and operator experience, and the sensitivity of ultrasonography reported in literature has varied widely. [8]

Despite multiple studies comparing ultrasonography and CT in cases of urolithiasis doubts persist regarding their relative diagnostic value in routine adult practice. This is more so in settings where avoiding radiation and cost considerations are important. In addition, factors affecting ultrasound detection such as stone size, location and associated hydronephrosis have also not been uniformly addressed across studies. Therefore, the present study was undertaken with an objective to compare the diagnostic accuracy of ultrasound versus NCCT KUB in the detection of urolithiasis in adult patients presenting with flank pain. The primary aim of this study was to analyse whether ultrasonography can serve as a reliable initial imaging modality in such patients.

MATERIALS AND METHODS

This retrospective comparative observational study was conducted in the Department of Radiodiagnosis and urology at a tertiary care hospital over a predefined study period. The study included 60 adult patients presenting with acute flank pain who had undergone both ultrasound of the kidneys, ureters, and urinary bladder and NCCT KUB during the same episode of evaluation. Since this was a retrospective record-based study, no direct patient contact or intervention was involved. The sample size for the present study was fixed at 60 eligible cases based on the available hospital records meeting the study criteria during the study period.

The study data were collected exclusively from existing radiology reports and clinical notes. Demographic and clinical details including age, gender, side of pain, haematuria and other presenting features documented at hospital visit were extracted from the IPD papers and clinical records. Imaging variables were obtained from the archived radiology reports. Ultrasound reports were reviewed for the presence or absence of urolithiasis, site of calculus when documented, laterality and associated secondary findings such as hydronephrosis or hydroureter. Corresponding NCCT KUB reports were reviewed for confirmation of calculus, exact location, size, laterality, and additional urinary tract findings. Only documented report findings were analyzed, and no stored images were reinterpreted.

Ultrasound examinations included transabdominal assessment of the kidneys, ureters, and urinary bladder as documented in the departmental radiology reports. Radiology reports were assessed to note documentation about direct visualization of calculi and indirect evidence of obstruction such as hydronephrosis or hydroureter as usually seen in cases of mid-ureteric or vesico-ureteric junction calculus. NCCT KUB reports were considered the definitive imaging standard because of their superior sensitivity for urinary calculi as well as for their ability to define stone size and location more accurately as compared to ultrasound. For analysis, urolithiasis was categorized according to location such as renal, pelvi-ureteric junction, proximal ureter, mid ureter, distal ureter or vesicoureteric junction. Stone size, where mentioned was recorded in millimeters and grouped into clinically relevant categories.

Data was entered into Microsoft Excel and analyzed using IBM- SPSS 23.0 software. Categorical variables were expressed as frequency and percentage. Continuous variables were summarized as mean and standard deviation. The diagnostic performance of ultrasonography in detecting urolithiasis was assessed by calculating sensitivity, specificity, positive predictive value, negative predictive value and overall diagnostic accuracy. NCCT KUB was considered as the gold standard. The chi-square test or Fisher exact test was used for comparisons wherever appropriate. For Statistical purposes p value less than 0.05 was considered significant.

Inclusion Criteria

- Adult patients aged 18 years and above
- Patients presenting with acute flank pain
- Patients who underwent both ultrasound and NCCT KUB during the same episode of evaluation
- Availability of complete radiology reports and relevant clinical notes
- Records clearly documenting presence or absence of urolithiasis

Exclusion Criteria

- Patients younger than 18 years
- Patients with incomplete or missing radiology reports
- Patients without corresponding clinical notes
- Patients who underwent only one imaging modality
- Patients with postoperative urinary tract status, known urinary tract malignancy, or major congenital renal anomalies interfering with interpretation
- Records with inadequate documentation regarding stone status or stone location

RESULTS

A total of 60 adult patients presenting with acute flank pain were included in the study. The age distribution showed that the largest proportion of patients was in the 26–35 years age group, followed by the 18–25 years age group. The mean age of the studied cases was found to be 36.17 ± 11.05 years.

Table 1: Age-wise distribution of adult patients presenting with flank pain.

Age group (years)	Number of cases	Percentage
18–25	15	25.0
26–35	22	36.7
36–45	8	13.3
46–55	7	11.7
56–65	6	10.0
>65	2	3.3
Total	**60**	**100.0**
Mean Age	36.17 ± 11.05 years	

Male patients comprised **61.7%** of the study cohort, while females accounted for **38.3%**.

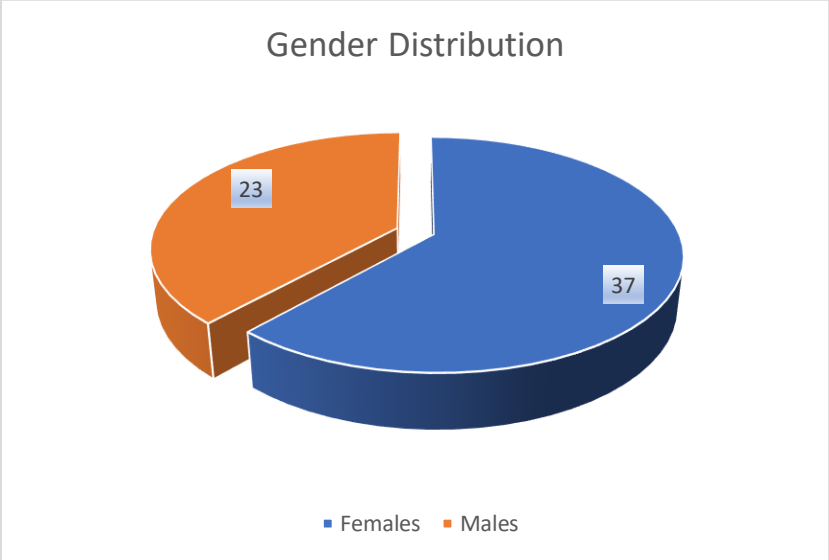


Table 2: Gender Distribution of studied cases.

On NCCT KUB, urolithiasis was identified in 54 cases (90.0%). While in 6 patients (10.0%) no calculus could be imaged. On ultrasonography, calculi were detected in 42 patients (70.0%), and 18 patients (30.0%) were reported negative. The difference in overall detection rate between NCCT and ultrasonography was statistically significant (p = 0.006) (Table 2).

Table 2: Detection of urolithiasis by NCCT KUB and ultrasonography.

Imaging modality finding	Number of cases	Percentage	p value
NCCT positive for urolithiasis	54	90.0	<0.006*
NCCT negative for urolithiasis	6	10.0	

USG positive for urolithiasis	42	70.0	
USG negative for urolithiasis	18	30.0	

Using NCCT KUB as the gold standard, ultrasonography yielded 42 true-positive, 6 true-negative, and 12 false-negative cases, with no false-positive results (Table 3).

Table 3: Cross-tabulation of ultrasonography findings against NCCT KUB in the diagnosis of urolithiasis.

	NCCT Positive	**NCCT Negative**	**Total**
USG Positive	42	0	42
USG Negative	12	6	18
Total	**54**	**6**	**60**

The diagnostic indices of ultrasonography, with NCCT KUB as the reference standard, are summarized below. Ultrasonography demonstrated good sensitivity, excellent specificity, and high positive predictive value (Table 4).

Table 4: Diagnostic performance of ultrasonography for detection of urolithiasis, with NCCT KUB as the reference standard.

Diagnostic parameter	**Value**	**95% Confidence Interval**
Sensitivity	77.8%	64.4–88.0
Specificity	100.0%	54.1–100.0
Positive predictive value (PPV)	100.0%	91.6–100.0
Negative predictive value (NPV)	33.3%	13.3–59.0
Diagnostic accuracy	80.0%	67.7–89.2

Site-wise analysis revealed that the distal ureter was the most common site of calculus on NCCT KUB (27.8%), followed by the proximal ureter (24.1%) and PUJ (22.2%). Ultrasonography showed the highest sensitivity for diagnosis of VUJ calculi (100%) as well as PUJ calculi (91.7%). Sensitivity was found to be lower for the diagnosis of mid ureteric calculi (60.0%) (Figure 2).

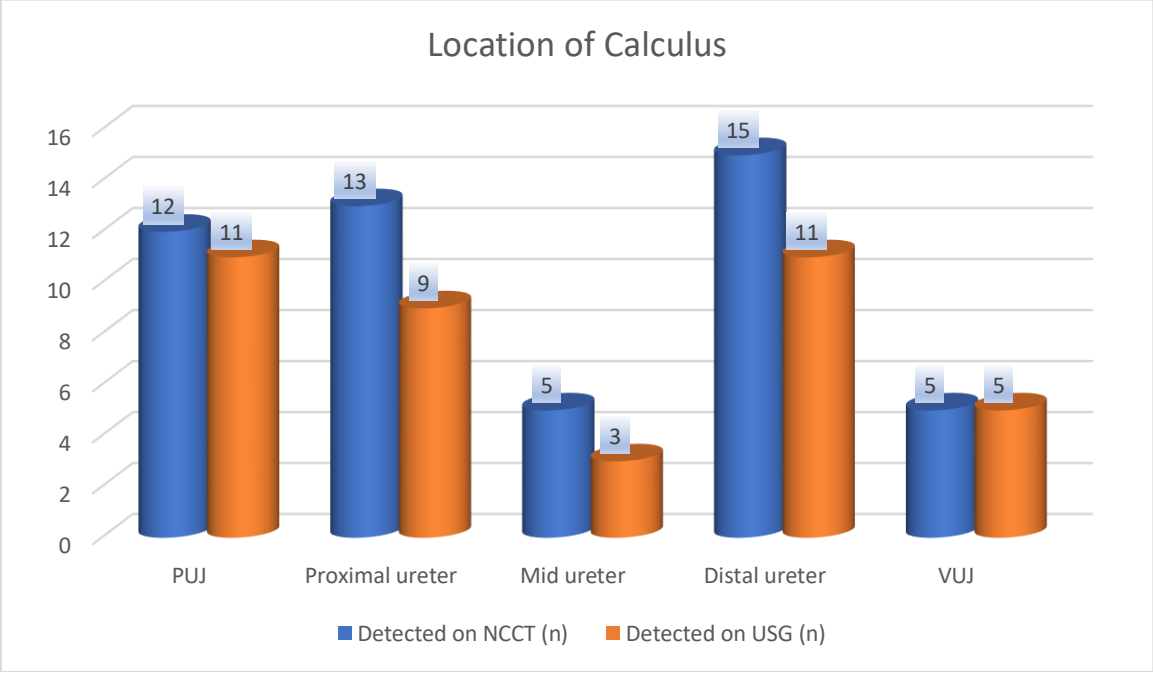


Figure 2: Site-wise distribution of calculi on NCCT KUB and corresponding sensitivity of ultrasonography.

Stone size analysis demonstrated a progressive increase in ultrasound sensitivity with increasing stone size. The lowest sensitivity (44.4%) was seen for calculi measuring less than 5 mm size while all stones measuring more than 15 mm were detected on ultrasonography. This association between stone size and ultrasound detection was statistically significant ($p = 0.012$) (Table 5).

Table 5: Stone size distribution on NCCT KUB and corresponding sensitivity of ultrasonography.

Stone size category	**Detected on NCCT (n)**	**Percentage**	**Detected on USG (n)**	**Sensitivity of USG (%)**	**p value**
<5 mm	9	16.7	4	44.4	0.012

5.1–10 mm	25	46.3	20	80.0	
10.1–15 mm	14	25.9	12	85.7	
>15 mm	6	11.1	6	100.0	
Total	**54**	**100.0**	**42**	**77.8**	

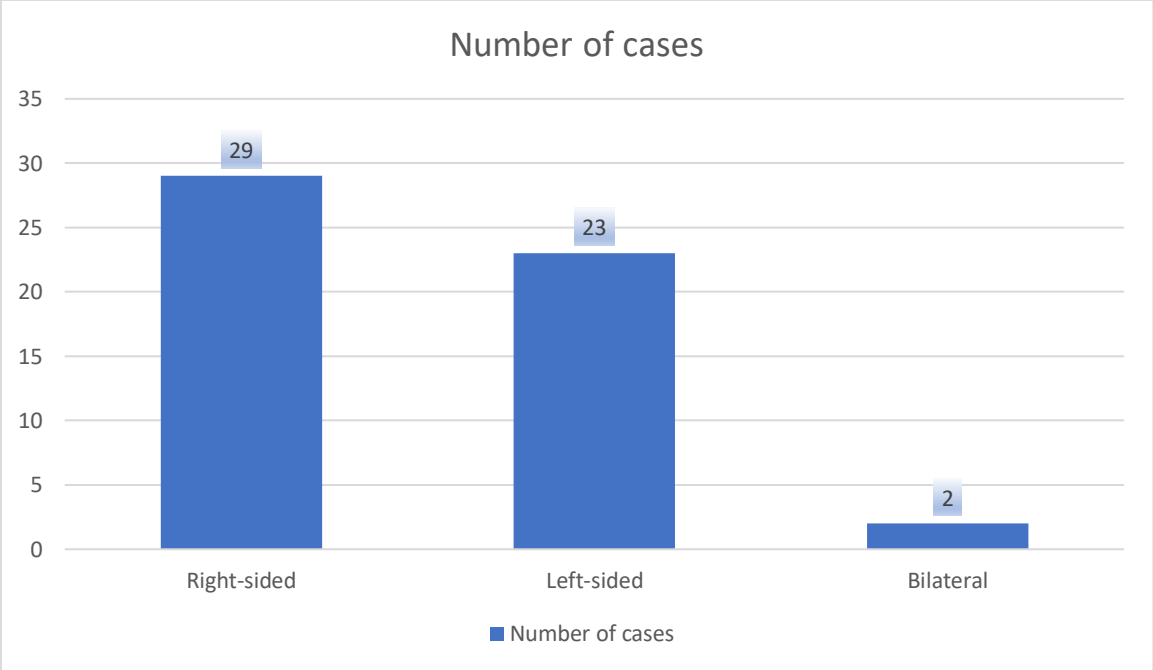
Hydronephrosis was present in 46 patients (76.7%), while haematuria was documented in 34 patients (56.7%). Ultrasound positivity was significantly higher among patients with hydronephrosis (p = 0.021) and among those with haematuria (p = 0.004) (Table 6).

Table 6: Association of hydronephrosis and haematuria with ultrasound detection of urolithiasis.

Variable	Category	USG Positive (n)	USG Negative (n)	Total	p value
Hydronephrosis	Present	36	10	46	0.021
	Absent	6	8	14	
Haematuria	Present	29	5	34	0.004
	Absent	13	13	26	

Out of 54 cases in whom urolithiasis was confirmed on the basis of imaging in 29 (48.3 %) cases calculus was located on right side whereas it was located on left side in 23 (38.3 %) cases whereas 2 (3.34%) cases were found to have bilateral calculi. In 6 (10%) cases calculi could not be imaged.

Table 9: Laterality of calculi detected on NCCT KUB.



DISCUSSION

In the present study, the majority of patients were young to middle-aged adults, with the highest representation in the 26–35 years age group, and there was a clear male predominance. This demographic pattern is consistent with the established epidemiology of stone disease in symptomatic populations. In their comparative study of patients with renal colic, Patlas et al[9] reported a typical symptomatic distribution of ureteric calculi, while Pichler et al[10] observed that younger adults, especially those with favorable body habitus, are a group in whom ultrasonography performs well as an initial diagnostic test. Our findings therefore fit the commonly encountered clinical profile of adult urolithiasis, which frequently affects younger male patients and places a substantial burden on routine emergency imaging practice.

The overall diagnostic findings of our study showed that NCCT KUB detected urolithiasis in 90.0% of patients, whereas ultrasonography detected calculi in 70.0%, with ultrasound demonstrating a sensitivity of 77.8%, specificity of 100.0%, positive predictive value of 100.0%, and diagnostic accuracy of 80.0%. These results are comparable to previously published studies. Passerotti et al reported that ultrasound had a sensitivity of 76% and specificity of 100% when compared with CT.[11] Similarly Sheafor et al demonstrated the higher sensitivity of nonenhanced CT over ultrasound for evaluating renal colic.[12] Taken together, these studies reinforce the central message reflected in our results: CT remains the reference standard, but ultrasound still performs well enough in selected patients to justify its role as an initial investigation.

A notable finding in our study was the variation in ultrasound performance according to the site of calculus. Distal ureteric stones were the most common on NCCT, yet ultrasound sensitivity was highest for VUJ and PUJ calculi and lower for mid

ureteric and some distal ureteric stones. This site-specific pattern has been described in prior literature. Yilmaz et al[13] showed that spiral CT was superior for depicting ureteral stones, especially where ultrasound underperformed, while Abdel-Gawad et al[14] found that Doppler-enhanced ultrasound could diagnose many ureteral stones but that performance was influenced by stone location. These observations support the explanation that anatomical accessibility and acoustic windows influence the sensitivity of ultrasonography for different ureteric segments.

This study also demonstrated a progressive rise in ultrasound sensitivity for detection of calculi with increasing calculus size. This trend is strongly supported by earlier work. Kanno[15] et al reported that the detection rate of ultrasound increased with stone size, and Fowler et[16] al showed that many calculi missed by ultrasound were small stones. Passerotti et al. similarly observed that stones missed by ultrasound were smaller on average than those detected sonographically.[11] These findings emphasize that stone size should always be interpreted as a determinant of imaging performance rather than as a purely descriptive variable.

Another important observation in our study was that ultrasound positivity was significantly associated with hydronephrosis and haematuria, supporting the broader concept that secondary signs and clinical context improve the usefulness of sonography. Riddell et al[17] reported that hydronephrosis on bedside ultrasound is a useful indicator of ureteral stone in CT-proven cases, while Leo et al[18] found that hydronephrosis severity on ultrasound carries diagnostic importance in renal colic. Rosen et al also showed that bedside ultrasonography can identify hydronephrosis with useful diagnostic performance in suspected nephrolithiasis. [19] These observations explain why ultrasound may remain clinically valuable even when the stone itself is not directly visualized.

From a practical standpoint, the findings of the present study support the use of ultrasonography as the initial imaging modality in adults presenting with acute flank pain, particularly where cost, availability, and radiation exposure are relevant considerations. This approach is in line with the recommendations discussed by Nicolau et al who emphasized an "ultrasound first" strategy in renal colic, and supported ultrasound in routine initial evaluation while reserving CT for unresolved or high-suspicion cases.[20] Our results therefore support a rational imaging strategy in which ultrasonography is used first and NCCT KUB is reserved for equivocal, complicated, or ultrasound-negative patients with persistent clinical suspicion.

CONCLUSION

Ultrasonography demonstrated good sensitivity as well as specificity and was found to have high positive predictive value in detecting. However, NCCT KUB was found to be superior for overall detection of urolithiasis particularly for small and ureteric calculi. Ultrasound performed better for larger stones and in the presence of hydronephrosis. Given its non-invasive nature, radiation-free and low-cost ultrasonography can be used as the initial imaging modality. NCCT KUB should be reserved for equivocal or cases in whom there is persistent clinical suspicion despite non-visualisation of calculi on ultrasound imaging.

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