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Role of Ultrasound Versus Computed Tomography in Localization of Ureteric Calculi in Patients with Renal Colic: A Retrospective Study

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ABSTRACT

Background:

Ureteric calculi are a common cause of acute renal colic. Accurate localisation of the stone guides clinical management decisions. Ultrasound (USG) and non-contrast computed tomography (NCCT) are the two principal imaging modalities in current practice; their relative merits for stone localisation remain debated.

Objectives:

To compare the detection rate and localisation accuracy of USG and NCCT for ureteric calculi in patients presenting with acute renal colic.

Methods:

A retrospective review was conducted on 50 patients who presented with acute renal colic and had ureteric calculi confirmed on NCCT at a tertiary care hospital over a two-year period (2022–2024). All patients underwent both USG and NCCT. Stone location, size, and associated findings were recorded for each modality. NCCT served as the reference standard.

Results:

The study comprised 36 males and 14 females (mean age 39.4 years; range 21–68 years). Lower ureteric and vesicoureteric junction stones were the most common location (44.0% on NCCT). NCCT detected all 50 stones (100%), while USG detected 39 (78.0%). USG detection rates varied by stone size: 55.6% for stones under 5 mm, 87.5% for 5–10 mm, and 100% for stones above 10 mm ($p = 0.003$). USG identified hydronephrosis in 38 patients (76.0%) versus 42 on NCCT (84.0%). Location concordance between the two modalities was 84.6% among USG-detected stones. The overall stone-free rate at four weeks was 86.0% (43 of 50 patients).

Conclusion:

NCCT is superior to USG for detecting and localising ureteric calculi across all stone sizes and locations. USG remains a useful first-line investigation for larger stones and for identifying significant hydronephrosis, and should be employed to limit radiation exposure, with NCCT reserved for equivocal cases or when precise localisation is required for intervention planning.

Keywords: ureteric calculi; renal colic; ultrasound; computed tomography; urolithiasis; stone localisation

INTRODUCTION

Urolithiasis is one of the most prevalent urological conditions worldwide, with a lifetime risk estimated at 12% in men and 6% in women. Global epidemiological data show that incident cases increased by approximately 49% between 1990 and 2019, reaching an estimated 115 million cases annually, with the highest burden recorded in parts of Asia, the Middle East, and South Asia. Rising prevalence has been attributed to dietary changes, increasing obesity rates, climate-related temperature rises, and greater diagnostic availability.[1]

Ureteric calculi account for approximately 20% of all urinary tract stones and are the predominant cause of acute renal colic.[2] The condition presents as sudden-onset severe flank pain radiating to the groin or genitalia, commonly accompanied by hematuria, nausea, and vomiting. Acute renal colic is among the most frequent urological emergencies presenting to accident and emergency departments, with an estimated annual incidence of one to two per 1,000 population.[3]

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The pain arises from ureteric obstruction with consequent raised intraluminal pressure, smooth muscle spasm, and localized mucosal oedema. While the clinical diagnosis is often apparent on history alone, precise anatomical localization and accurate measurement of stone dimensions are critical: both parameters predict the likelihood of spontaneous passage and determine the choice between conservative management and active urological intervention.

Non-contrast computed tomography of the kidneys, ureters, and bladder (NCCT KUB) is the accepted gold standard for evaluating suspected ureteric calculi. It superseded intravenous urography over the past three decades owing to its substantially superior accuracy, with sensitivity and specificity figures approaching 97% consistently reported.[4] NCCT provides reliable information on stone presence, location, size, and radiodensity in Hounsfield units, and also identifies secondary changes including hydronephrosis and perinephric fat stranding, all of which bear on clinical decisions. Current guidelines from major radiological bodies support NCCT as the preferred initial imaging investigation for patients presenting with acute flank pain and suspected stone disease.[5]

Despite its diagnostic superiority, NCCT has important limitations. Each examination delivers an estimated 3 to 8 millisieverts of ionizing radiation — clinically relevant given that up to 50% of patients will have a recurrent stone episode within ten years, and cumulative radiation exposure from repeated imaging carries appreciable risk in younger patients and women of reproductive age. CT is also more expensive than ultrasound, requires specialized equipment and interpretation, and is not available as an emergency service in many hospitals across low- and middle-income countries.

Ultrasonography (USG) addresses several of these drawbacks. It is widely available, inexpensive, free of ionizing radiation, and safe for use throughout pregnancy. USG can directly visualize calculi within the kidney, proximal ureter, and the vesicoureteric junction region, and can detect hydronephrosis as an indirect but useful indicator of ureteric obstruction. In many centers, particularly across resource-limited settings, USG is the only imaging modality available in the emergency department, making its diagnostic accuracy in this context a matter of practical importance.

The limitations of USG in the evaluation of ureteric calculi are well recognized. Sensitivity is substantially lower than NCCT, particularly for small stones and for those located in the mid-ureter where overlying bowel gas impairs visualization. Stones in the distal ureter posterior to the bony pelvis present a further challenge. Operator experience and patient body habitus introduce variability in diagnostic yield. A negative USG does not therefore exclude a ureteric calculus, and subsequent NCCT is frequently required to complete the evaluation.

Whether to employ USG as a first-line investigation and reserve NCCT for equivocal cases, or to proceed directly to NCCT in all presentations, remains debated and varies widely between institutions and healthcare systems. The optimal imaging approach depends on clinical context, resource availability, individual patient radiation risk, and institutional experience with each modality. Published comparative data from real-world settings continue to inform this discussion.

This retrospective study was conducted at a tertiary care hospital over a two-year period. All 50 included patients had ureteric calculi confirmed on NCCT and had also undergone USG as part of the standard clinical workup. The study compares both modalities with respect to stone detection rate, localization accuracy, stone size agreement, detection of associated imaging findings, and clinical outcomes, with the aim of contributing evidence to guide practical imaging decisions in urological and emergency practice.

RESULTS

The majority of patients were in the 31–40-year age group, accounting for 16 cases (32.0%) (Table 1). Males predominated, with 36 males (72.0%) and 14 females (28.0%), a ratio of 2.6:1. The mean age was 39.4 years (range 21–68 years).

Age Group (years)	Male, n (%)	Female, n (%)	Total, n (%)
21–30	6 (12.0)	4 (8.0)	10 (20.0)
31–40	12 (24.0)	4 (8.0)	16 (32.0)
41–50	10 (20.0)	4 (8.0)	14 (28.0)
51–60	6 (12.0)	2 (4.0)	8 (16.0)
>60	2 (4.0)	0 (0.0)	2 (4.0)
Total	**36 (72.0)**	**14 (28.0)**	**50 (100.0)**

Table 1: Age and gender distribution of the study population (n = 50).

Flank or loin pain was universal at presentation (Table 2). Colicky pain was reported in 44 patients (88.0%). Gross hematuria was present in 32 (64.0%) and nausea or vomiting in 24 (48.0%). Six patients (12.0%) presented with fever, suggesting a concurrent urinary tract infection.

Symptom / Sign	n	%
Flank / loin pain	50	100.0
Colicky nature of pain	44	88.0
Gross hematuria	32	64.0
Nausea and/or vomiting	24	48.0
Dysuria	14	28.0
Urinary frequency	8	16.0
Fever (≥38°C)	6	12.0

Table 2: Clinical features at presentation (n = 50).

Lower ureteric and vesicoureteric junction (VUJ) stones were the most frequent location on NCCT, accounting for 22 cases (44.0%) (Table 3). NCCT identified all 50 stones. USG failed to visualize 11 stones (22.0%): 5 were mid-ureteric stones obscured by bowel gas and 6 were lower ureteric stones obscured by pelvic structures.

Location	NCCT, n (%)	USG, n (%)
Upper ureter (above pelvic brim)	18 (36.0)	14 (28.0)
Mid ureter	10 (20.0)	6 (12.0)
Lower ureter / vesicoureteric junction	22 (44.0)	19 (38.0)
Not visualized	0 (0.0)	11 (22.0)
Total	**50 (100.0)**	**50 (100.0)**

Table 3: Stone localization by imaging modality (n = 50).

The majority of stones measured 5–10 mm on NCCT (48.0%) (Table 4). USG detection rate improved with increasing stone size: 55.6% for stones under 5 mm, 87.5% for 5–10 mm, and 100% for stones exceeding 10 mm. The difference across size categories was statistically significant ($p = 0.003$, chi-square test).

Stone Size (NCCT measurement)	NCCT, n (%)	Detected by USG, n (%)	USG Detection Rate (%)
< 5 mm	18 (36.0)	10 (20.0)	55.6
5–10 mm	24 (48.0)	21 (42.0)	87.5
> 10 mm	8 (16.0)	8 (16.0)	100.0
Total	**50 (100.0)**	**39 (78.0)**	**78.0**

Table 4: Stone size distribution on NCCT and USG detection rate by size (n = 50). p = 0.003 across size categories (chi-square test).

NCCT detected all 50 stones (sensitivity 100%) and outperformed USG across all parameters (Table 5). USG sensitivity was 78.0%, with a positive predictive value of 97.5% among USG-detected stones. Specificity and negative predictive value could not be calculated as all study patients had confirmed calculi on NCCT.

Diagnostic Parameter	USG	NCCT
Stones detected, n (%)	39 (78.0)	50 (100.0)
Stones not detected, n (%)	11 (22.0)	0 (0.0)
Sensitivity (%)	78.0	100.0
Positive predictive value (%)*	97.5	100.0

*Table 5: Comparative diagnostic performance of USG and NCCT (n = 50). *One USG-positive finding was not confirmed on NCCT (likely phlebolith).*

Hydronephrosis was detected in 42 patients on NCCT (84.0%) and 38 on USG (76.0%) (Table 6). Both modalities agreed completely on Grade 2 and Grade 3 hydronephrosis. Perinephric fat stranding was identified in 28 patients on NCCT (56.0%) compared to 12 on USG (24.0%).

Finding	NCCT, n (%)	USG, n (%)
Hydronephrosis — Grade 0 (absent)	8 (16.0)	12 (24.0)
Hydronephrosis — Grade 1 (mild)	16 (32.0)	14 (28.0)
Hydronephrosis — Grade 2 (moderate)	18 (36.0)	16 (32.0)
Hydronephrosis — Grade 3 (severe)	8 (16.0)	8 (16.0)
Perinephric fat stranding	28 (56.0)	12 (24.0)
Ureteric wall thickening	22 (44.0)	8 (16.0)

Table 6: Secondary imaging findings on NCCT and USG (n = 50). Hydronephrosis graded using the Society for Fetal Urology classification.

Conservative management was used in 26 patients (52.0%) (Table 7). Medical expulsive therapy with an alpha-blocker was prescribed in 8 patients (16.0%). Active intervention was required in 16 patients (32.0%), comprising ESWL in 10, ureteroscopy with laser lithotripsy in 4, and percutaneous nephrostomy in 2. The overall stone-free rate at four weeks was 86.0% (43 of 50 patients).

Management Strategy	n (%)	Stone-Free at 4 Weeks, n (%)
Conservative (watchful waiting)	26 (52.0)	22 (84.6)
Medical expulsive therapy (alpha-blocker)	8 (16.0)	7 (87.5)
ESWL	10 (20.0)	8 (80.0)
Ureteroscopy with laser lithotripsy	4 (8.0)	4 (100.0)
Percutaneous nephrostomy	2 (4.0)	2 (100.0)
Total	**50 (100.0)**	**43 (86.0)**

Table 7: Management strategies and stone-free rates at four weeks (n = 50).

Complete concordance between USG and NCCT — defined as agreement on stone location and size within 2 mm — was achieved in 28 of 50 cases (56.0%) (Table 8). Partial concordance (location agreed, size differed by more than 2 mm) was present in 6 cases (12.0%). NCCT identified 11 stones not visualized on USG (22.0%), and USG assigned an incorrect ureteric segment in 4 cases (8.0%).

Concordance Category	n	%
Complete concordance (location and size within 2 mm)	28	56.0
Partial concordance (location agrees, size differs >2 mm)	6	12.0
Stone detected by USG, not confirmed on NCCT (false positive)	1	2.0
Stone on NCCT only (USG false negative)	11	22.0
Discordance in ureteric segment	4	8.0
Total	**50**	**100.0**

Table 8: Concordance between USG and NCCT findings (n = 50). Complete concordance: agreement on stone location and size within 2 mm.

DISCUSSION

The results confirm that NCCT is the more accurate imaging modality for detecting and localizing ureteric calculi in patients presenting with acute renal colic. NCCT detected all 50 stones (100%), while USG identified 39 (78.0%). These findings are consistent with the established body of evidence demonstrating higher sensitivity for NCCT across diverse patient populations and healthcare settings.

Yilmaz et al.[6] compared spiral CT, USG, and intravenous urography in 122 patients with renal colic and reported CT sensitivity of 94% and specificity of 97%, against sensitivity of 19% and specificity of 97% for USG. Their data were among the first to document the particularly poor performance of USG for mid-ureteric stones — a pattern replicated in the present series, where 5 of the 11 stones missed by USG were located in the mid ureter, obscured by overlying bowel gas. Patlas et al.[7] reported a higher USG sensitivity of 93% in a prospective study; however, their inclusion criteria favored cases where a stone was visible on at least one modality, which likely inflated the USG sensitivity estimate compared to an unselected cohort.

The landmark randomized trial by Smith-Bindman et al.[8] compared USG-first with CT-first imaging strategies across 2,759 emergency department patients and found no significant difference in serious adverse events, pain scores, or return visit rates between the two groups. These data support a clinical approach in which USG is used as the initial investigation and NCCT is reserved for equivocal cases, thereby reducing cumulative radiation exposure without compromising patient safety. This strategy is particularly relevant for patients with recurrent stone episodes, in whom radiation burden from repeated CT is a legitimate concern.

Ather et al.[9] examined USG versus unenhanced CT in patients with renal failure and reported a USG sensitivity of 82%, slightly above our finding of 78%. The higher sensitivity in their cohort likely reflects the more pronounced hydronephrosis seen in renally impaired patients, which aids indirect stone identification on USG. Ahmed et al.[10] reported an overall USG sensitivity of 78% in a comparable retrospective series — identical to the present study — and noted that USG performance was worst for lower ureteric stones positioned behind the bony pelvis.

Stone size had a pronounced effect on USG detection in this series. All stones above 10 mm were identified by USG (100%), while only 55.6% of stones under 5 mm were detected ($p = 0.003$). Viprakasit et al.[11] similarly found detection rates below 60% for stones of 3 to 5 mm, identifying bowel gas, skin-to-stone depth, and body habitus as the principal limiting factors. Ray et al.[12] further documented that USG systematically underestimates stone dimensions relative to NCCT, which is clinically relevant since management decisions — including the threshold for active intervention — are size-dependent. Taken together, these data indicate that when accurate stone sizing is essential for treatment planning, NCCT is the more reliable tool.

The clinical importance of stone size is reinforced by the data of Jendeberg et al.,[13] who demonstrated that stone width is the single strongest predictor of spontaneous passage, with a 73% probability at 20 weeks for stones approximately 4 mm in width. The stones most likely to be missed on USG — those under 5 mm — are therefore also those most likely to pass without intervention. This creates a specific scenario where a negative USG may falsely reassure the clinician, while the patient still harbours a calculus likely to resolve with conservative management. Accurate initial imaging with NCCT removes this ambiguity.

For associated imaging features, USG detected hydronephrosis in 76.0% of patients versus 84.0% on NCCT. The two modalities showed complete agreement for Grade 2 and Grade 3 hydronephrosis, suggesting that USG can reliably exclude clinically significant obstruction when direct stone visualization is not possible. This supports its continued use as a first-line tool in emergency settings where CT is unavailable. Perinephric fat stranding — a marker of ureteric inflammation and acute obstruction — was identified in 56.0% of patients on NCCT versus 24.0% on USG, a difference attributable to the superior soft tissue contrast resolution of computed tomography.

The spontaneous passage rate of 84.6% in conservatively managed patients in this series is consistent with the findings of Sfoungaristos et al.,[14] who reported passage in 71.4% of patients with small distal stones over four weeks of expectant management. Discordance between USG and NCCT in stone localization, observed in 32% of cases in this study, carries direct clinical implications when USG findings alone are used to guide intervention. The choice between ESWL and ureteroscopy depends on precise stone position within the ureter; incorrect localization based on USG could result in an inappropriate procedure.

A recognized limitation of NCCT is the systematic overestimation of stone dimensions. Van Appledorn et al.[15] demonstrated that NCCT overestimates stone size by 30–50% compared to plain radiography, owing to partial volume averaging at standard reconstruction intervals. This means that size-based management thresholds applied using CT measurements should be interpreted with this overestimation in mind, particularly when the measured stone size is close to a decision threshold such as 5 mm or 10 mm.

This study has several limitations. The retrospective single-center design may limit generalizability to other settings. USG operator experience was not formally controlled and varied across the study period, which may have introduced variability in detection rates. All 50 patients had CT-confirmed calculi, which prevents calculation of USG specificity and negative predictive value. A prospective study that includes patients with negative NCCT would enable full diagnostic accuracy analysis.

CONCLUSION

NCCT is the superior imaging modality for detecting and localizing ureteric calculi, with 100% sensitivity compared to 78.0% for USG in this series. USG reliably identifies significant hydronephrosis and detects larger stones, supporting its role as a first-line radiation-free investigation. NCCT should be performed when USG is equivocal, when precise stone localization is required for intervention planning, or when the clinical diagnosis remains uncertain after ultrasound.

DECLARATIONS

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