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Comparative study of ultrasonography and computed tomography for detecting stones in case of renal colic

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Abstract

Introduction: Nephrolithiasis is most common cause of renal colic encountered. Computed Tomography of kidneys, ureters and bladder (CT-KUB) was found to be extremely sensitive and specific for ureteric calculi. This study aimed to compare the diagnostic performance of ultrasonography (USG) and CT-KUB in patients presenting with renal colic based on previous studies by Sharad Kondekar, Iqbal Minne & Doaa N Anas, Khaled Elshafey et.al.

Method: This is a retrospective study. The USG and CT-KUB findings of 2574 patients were retrospectively analyzed over four years. The data was compiled using XLSX Spreadsheet. Sensitivity, specificity, diagnostic accuracy, positive predictive value and negative predictive values of USG were calculated taking CT-KUB as the gold standard.

Result: In 2574 sets of data, the majority of patients were ≤ 30 years old with males predominating. In 2269 cases, renal calculi were detected in both USG and CT-KUB and CT-KUB alone detected renal calculi in 2554 cases. USG detected maximum 1435 cases with 5-10mm sized renal calculi and CT-KUB too detected maximum of 5-10 mm calculi in 1430 cases. The sensitivity, specificity, diagnostic accuracy, positive predictive value and negative predictive values of USG taking CT-KUB as the gold standard, were 88.21%, 17.6%. 87.75%, 99.38% and 0.98% respectively.

Conclusion: Although CT-KUB exposes patients to ionizing radiation, it remains the gold standard due to its higher diagnostic accuracy. USG, while less specific, may serve as an initial, no-invasive screening tool.

Keywords: CT; Renal colic; Radiation hazards; Ultrasonography

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Introduction

Nephrolithiasis is the occurrence of renal calculi produced by an interference in the balance between solubility and precipitation of salt in the kidneys and the urinary tract.[1] Nephrolithiasis progress when urine is supersaturated with insoluble compounds comprising calcium phosphate (CaPO4) and calcium oxalate (CaOx) crystals.[2] Lithiasis can be prevented by avoiding super saturation.[1] Nephrolithiasis can be associated with diseases like hypertension, obesity and type 2 diabetes mellitus.[1] Ultrasound is one of the best suitable and beneficial assessment tool, it is simply accessible, radiation free, reproducible, economical, non-invasive and reliable for renal stones.[3-7] A positive ultrasonography for renal stones may or may not progress to unenhanced computed tomography (CT-KUB) but all negative ultrasonography will undergo CT-KUB for further assessment.[1] (Severe flank pain is extremely painful condition and is the typical presentation of nephrolithiasis.[2] Colicky pain is often episodic, each episode lasting from twenty to sixty minutes,[2] commonly encountered in the emergency department.[6] CT-KUB has become the most common imaging modality for investigating nephrolithiasis.[6] CT is gold standard due to its high sensitivity for stone detection, ability to assess stone size and utility in making alternate diagnoses.[6,7] The limitations of CT-KUB include exposure of ionizing radiation, increased cost and its lack of demonstrated correlation with improved patient outcomes.[6,7] When the calculi move down the urinary tract, there are chances of blockage of urinary flow and hydronephrosis, sometimes present with atypical symptoms of nausea, vomiting, abdominal pain, frequency and urgency of urination [2] . Ultrasonography is a initial modality for detecting nephrolithiasis in underdeveloped country like Nepal with patient presenting with renal colic which is easily available and at low cost. Although CT-KUB is considered as the gold standard in diagnosing nephrolithiasis and urolithiasis, but due to its unavailability at primary health care centers, ionizing radiations, contraindicated in pregnant women make it less suitable to be used as the initial diagnostic imaging modality.[2] This study aims to compare the diagnostic accuracy of ultrasonography and CT-KUB in patients presenting with renal colic. The rationale of my study is CT-KUB remains the gold standard compared to USG as USG detects nephrolithiasis limiting the sizes of calculi, difficult to detect calculi <4 mm, in case of flank pain, however CT-KUB can detect tiny nephrolithiasis and ureteral stones, characterizes the density (Hounsfield unit) and nature of stones so that it can help the surgeons to do the needful.

Method

This is a retrospective study carried out in Radiology and Imaging Department of Patan Academy of Health Sciences (Ref. drs2412171971**)** for a period of four years from November 2020 to June Dec 2024 who has undergone USG and CT-KUB for suspected renal stones and urinary tract calculi. Principal Investigator (PI) including co investigators retrieved the data. The hospital and encounter numbers of all patients who underwent both USG and CT-KUB were retrieved from the radiology imaging console,. CT-KUB reports were available from the computer records of CT reporting room where all the reports are stored using patient's name, CT-KUB number along with the encounter number and diagnosis too would be obtained. In the CT- KUB reports, brief history of ultrasound findings regarding nephrolithiasis, ureteric and urinary bladder calculi were written. From the computer records, we collected the data regarding USG diagnosis and CT-KUB diagnosis of renal and urinary tract calculi and comparison between the two was made. The minimum sample size for this study was calculated using sensitivity and specificity of a similar study done in Pakistan [2]. CT-KUB was done in the department of Radiology using Philips 128 sliced CT scanner with a dedicated protocol. Patients with a full bladder were positioned supine on CT examination table and scanned from the upper abdomen to the symphysis pubis with image reconstructed at 5mm intervals. Calculus is distinct as hyper dense focus in the kidney, ureter and/or bladder. USG was performed using new generation Philips 70G ultrasound scanners. USG includes evaluation of kidneys in multiple anatomic planes, maximum calculus measurement being recorded0. Curved phase array transducers are used. Calculus on USG is typically exhibited as highly echogenic focus with definite posterior acoustic shadowing.

All patients who underwent both ultrasound and CT KUB scan for renal colic were included in the study. Patients who had a single kidney. Patients who had undergone renal transplantation or who were undergoing dialysis. Patients who had only ultrasound report.

Patients who had only CT-KUB done were excluded from the study.

Result

The age distribution shows that the majority of patients were aged ≤30 years, accounting for 1038(40.30%), followed by those aged 31–40 years with 617(24.00%), 41–50 years with 444(17.20%), and ≥51 years with 475(18.50%). Males were predominant, comprising 1510(58.70%) of the study population, compared to 1064(41.30%) females, Table 1.

In our study, all 2574 patients underwent both USG and CT KUB. USG detected renal calculi in 2269 patients (88.15%), while 305 patients (11.85%) had no calculi detected. CT KUB detected calculi in 2554 patients (99.22%), did not detect calculi in 17 patients (0.66%), and CT findings were missing in 3 patients (0.12%). The small discrepancy seen in the cross-tabulation (USG-detected cases 2267 vs 2269 overall) is due to exclusion of the 3 CT-missing cases, which reduces the number of complete USG–CT pairs to 2571, Table 2.

By ultrasonography, calculi <5 mm were found in 609 patients (23.70%), 5–10 mm calculi in 1435 patients (55.70%), and calculi >10 mm in 530 patients (20.60%), for a total of 2574 patients, Table 3.

By CT KUB, calculi <5 mm were seen in 517 patients (20.10%), 5–10 mm in 1430 patients (55.56%), and >10 mm in 591 patients (23.00%), while stone size data were missing for 36 patients (1.40%), giving a total of 2574 patients, Table 4.

Table 1. Distribution of participants by age group and sex (N=2574)

Variable	Category	n (%)
Age groups	≤30	1038(40.30)
	31–40	617(24.00)
	41–50	444(17.20)
	≥51	475(18.50)
Sex	Male	1510(58.70)
	Female	1064(41.30)

Table. 2 Detection of renal calculi by USG and CT KUB N=2574)

Modality	Finding	n (%)
USG	Present	2269(88.15)
	Absent	305(11.85)
	Total	2574(100.00)
CT KUB	Present	2554(99.22)
	Absent	17(0.66)
	Missing	3(0.12)
	Total	2574(100.00)

Table 3. Size of renal calculi on ultrasonography (N=2574)

Calculus size (mm)	n (%)
<5	609(23.70)
5–10	1435(55.70)
>10	530(20.60)
Total	2574(100.00)

While comparing the two modalities, CT KUB and USG, in detecting renal calculi among the 2571 patients with results from both tests, CT KUB detected stones in 2554 cases and did not detect stones in 17 cases, whereas USG detected stones in 2267 cases and did not detect stones in 304 cases, Table 5.

Using CT KUB as the reference standard, USG showed a sensitivity of 88.21% and specificity of 17.65%, with a positive predictive value of 99.38% and a negative predictive value of 0.99%, and an overall diagnostic accuracy of 87.75% (N=2571), Table 6.

Discussion

This study was done in Patan Academy of Health Sciences (PAHS) at Patan Hospital to compare USG and CT-KUB to detect stones in renal colic. The total number of patients was 2574 in whom both USG and CT_KUB were performed. The sensitivity of this comparative study was 88.21%, positive predictive value of 99.38%, negative predictive value of 0.98% and diagnostic accuracy of 87.75% respectively. This was calculated using Openepi website [15] screening 2 table filled as crosstabs to get sensitivity and specificity. A 2019 study done in Lahore, Pakistan[2] had a sensitivity of 74.47%,positive predictive value of 94.49% and diagnostic accuracy of 86.27% which was comparable to our study. In a similar study done in Tanta university, Egypt[3] sensitivity, specificity and diagnostic accuracy were 67.8%,100% and 81.2% respectively where diagnostic accuracy was similar to

Table 4. Size of renal calculi on CT KUB (N=2574)

Calculus size on CT (mm)	n (%)
<5	517(20.10)
5–10	1430(55.56)
>10	591(23.00)
Missing	36(1.40)
Total	2574(100.00)

Table 5. Renal calculi USG* Renal calculi CT Cross tabulation

	CT present (N=2554)	CT absent (N=17)
USG present	2253(88.21)	14(82.35)
USG absent	301(11.79)	3(17.65)
Total	2554(100.00	17(100.00)

Table 6. Diagnostic performance of USG for detection of renal calculi using CT KUB as reference (N=2571): sensitivity, specificity, predictive values, and accuracy.

	Positive	Negative	Total
Positive	2253	14	2267
Negative	301	3	304
	2554	17	2571
Parameter	Estimate	Lower-Upper 95%	
Sensitivity	88.21%	86.91, 89.41	
Specificity	17.65%	6.191, 41.03	
Positive Predictive Value	99.38%	98.97, 99.63	
Negative Predictive Value	0.9868%	0.3362, 2.861	
Diagnostic Accuracy	87.75%	86.42, 88.96	

our study, sensitivity was lower and specificity higher than our study. Similarly a clinical trial[6] done across 15 different ER departments showed a sensitivity of 57% and specificity of 88%, where sensitivity was lower and specificity higher than our study. In a 2024 study done in Vadodara, India[8] USG had low sensitivity (18.87%),high specificity (100%) than our study whereas CT had high sensitivity (99.99%) and high specificity (100%) than our study. A study done in 2020 in Karnataka, India[5] stated that USG in detecting ureteric calculi had low sensitivity (12%),much lower than our study, high specificity of 97% and the accuracy was 81%, similar to our study.

Age ranged from ≤30 years (40.3%) to ≥51 years (17.2%). Among 2574 cases, males predominated at 1510 (58.7%) versus females at 1064 (41.3%). These demographics aligned closely with prior studies: the 2024 Vadodara study[8] reported ages 18-75 years (majority 21-40 years at 41.81%; male:female ratio 1.9:1); a clinical trial[6] showed ages 18-76 years; a Karnataka study[5] found ages 20-49 years with male predominance (though our upper age limit was higher); and a 2022 Kaski, Nepal[4] teaching hospital study noted the 20-40 years group most affected (62.0%) with males at 60.9% versus females at 39.1%.

In our study, USG detected calculi in 2269 patients (88.2%) and could not detect in 305 cases (11.8%) and CT KUB was able to detect calculi in 2554 cases (99.3%) and could not detect in 17 cases (0.7%). The 2022 Kaski study[4] reported similar USG limitations due to factors like patient obesity, poor compliance, and small calculi size, with CT KUB detecting nearly all cases despite potential changes in stone position or size between scans. This aligns with the Karnataka study[5], which found USG had little value for renal calculi detection (sensitivity 53%), and a clinical trial[6] noting no proven patient outcome benefits from increased CT use despite its superior sensitivity.

The study done in Egypt[3] stated that low dose CT showed more number of renal and ureteral stones than USG. A 2020 study. [1] showed that USG had limited value for the detection of renal calculi as USG might miss calculi within some parts of the urinary tract , however CT KUB has the capacity to obtain the volume of data that comprises the whole urinary system.

In our study, ultrasonography detected 609 cases of <5mm calculi equivalent to 23.7%, 1435 cases of 5-10 mm calculi which is equivalent to 55.7% and 530 cases of >10mm calculi which is equivalent to 20.6%. The 2020 study[1] stated that the mean size of calculi noticed on USG was 7.6mm +/-4.1mm or 7.1mm+/-1.2mm. The Karnataka study[5] stated that the minimum, maximum and average size of renal calculi detected on USG were 3.5mm, 22mm and 6.8 mm respectively, the majority of calculi not detected on USG were </= 5mm. These findings were similar to our study with maximum sizes of renal calculi lying in 5-10mm size and minimum in <5mm size. In our study, CT KUB detected 517 cases of < 5mm sized renal calculi equivalent to 20.1%, 1430 in 5-10mm size equivalent to 55.6%, 591 in >10mm size equivalent to 23% and 36 cases equivalent to 1.4% were missing in the system. The 2020 study[1] stated that the mean size of renal calculi detected on CT KUB was 4.2mm+/-0 0.4mm and seventy three percent of calculi not visualized on USG were 3mm or less in size. Karnataka study [5] stated that the majority of calculi not detected by USG measured <5mm with a minimum size of 3 mm. However there is no significant differences between the two modalities USG and CT KUB in detecting different sizes of renal calculi in our study.

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Conflict of Interest

None

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