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Original Article

Comparative study between USG and CT scan in the diagnosis of renal stones

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Abstract

There is no consensus on which imaging method is more appropriate for people with suspected nephrolithiasis, computed tomography (CT) or ultrasound. In regular clinical practice, ultrasonography can be a useful alternative of CT for evaluating suspected nephrolithiasis, as suggested by the new study. Despite not being as sensitive as CT, USG provides equivalent accuracy while exposing patients to less cumulative radiation and reducing the number of high-risk diagnoses with consequences. This cross-sectional analytical study was carried out from May 2022 to May 2023 in the Department of Urology in collaboration with Department of Radiology and Imaging at Bangabandhu Sheikh Mujib Medical University (BSMMU), Bangladesh to compare the USG and CT scan methods in the diagnosis of renal stone. In this study a total of 206 suspected cases of nephrolithiasis were enrolled initially from outpatient department (OPD), among them 160 cases were primarily diagnosed with renal stones and 46 without renal stones by physical examinations and x-ray. Then 206 suspected cases were scheduled for USG and CT scans to confirm the stone after obtaining consent. A data collection questionnaire was used to record the detailed history of these patients, including USG and CT scan reports. The statistical package for social sciences (SPSS) version 21.0 were used to analyze the data. Study found that male-female ratio was 1.61:1; where male was 61.7%. More than half (54.4%) patients were young/ early adults (21–40 years) and 45.6% of them was in middle age group (41–60 years). Calcium oxalate was the most prevalent type of stone, followed by calcium phosphate (38.1%), cysteine (5.6%), and uric acid (3.8%). Out of 206 suspected cases, 160 patients were accurately diagnosed with renal stones and 46 diagnosed without renal stone. Among the diagnosed renal stone patients 138 were positive and 22 were negative in the USG, with 138 being true positive and 22 being false negative. In 46 patients who were diagnosed without renal stone, 36 were found to be negative and 10 were found to be positive in USG, with these cases being true negative and false positive respectively. Out of the 160 patients diagnosed with renal stones, 148 were diagnosed positive and 12 were negative on CT scan, these were true positive and false negative cases. In 46 patients who were diagnosed without renal stone, 37 were labeled as negative and 9 were labeled as positive on CT scan, these were true negative and false positive cases respectively. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy of USG in diagnosis of renal stone were 86.3%, 78.3%, 93.2%, 62.1% and 84.5% respectively. Whereas sensitivity, specificity, PPV, NPV and accuracy of CT scan in diagnosis renal stone were 92.5%, 80.4%, 94.3%, 75.5% and 89.8% respectively. The study found that both imaging modalities USG and CT scan were effective in diagnosing renal stones. However, CT scan results were better, so USG should be considered if CT is not available.

Keywords: *Renal stone, CT scan and ultrasonography.*

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INTRODUCTION

Renal calculi are a prevalent issue globally. Its rising prevalence is exerting a substantial economic burden on both emerging and industrialized countries. Renal stone formation is typically attributed to the crystallization of minerals in urine, which serve as a nucleus for further sedimentation and ultimately lead to the development of a kidney stone.[1] Calculi result from the aberrant accumulation of specific substances such as oxalate, phosphate, and uric acid. These calculi may be located in the kidney, urethra, or urinary bladder. Renal stones have been linked to systemic disorders such as Type 2 diabetes mellitus, obesity, dyslipidaemia, and hypertension.[2] Lifestyle and environmental variables play a substantial role in their development. The presentation of renal colic is prevalent; hence treatment is administered promptly. In the absence of preventive interventions, almost 50% of renal stones may recur.[3]

Individuals with renal calculi often necessitate immediate or emergency medical attention due to intense pain.[4] The preliminary assessment often includes laboratory tests to evaluate renal function and diagnostic imaging. The predominant imaging technique in the emergency department is non-contrast CT,[5] favored for adults with suspected renal stones because of its detailed cross-sectional anatomy and superior sensitivity and specificity.[6] Despite ultrasound's inferior sensitivity and specificity compared to CT,[7] it effectively detects clinically significant stones and is the preferred initial imaging technique.[8] A recent randomized experiment investigated clinical outcomes when renal ultrasound was employed as the primary imaging technique for stable patients with suspected renal stones and no clinical signs of sepsis.[9] The initial renal ultrasound decreased the average radiation exposure by over 50% without any rise in adverse events or alternative high-risk diagnoses compared to CT. A significant proportion of individuals who received initial ultrasonography subsequently underwent CT; yet, the average total expenditures remained lower for those assigned to ultrasonography. This work emphasizes a critical research inquiry: which initial imaging modality was most suitable? Utilizing clinical decision rules, such as the sex, timing, origin, nausea, erythrocytes (STONE) score, to assess the likelihood of symptomatic ureteral stones may diminish unnecessary imaging and radiation exposure from CT in high-risk patients, while allowing for ultrasound or omitting imaging in low-risk patients.[10]

Ultrasonography (USG) is a readily available, cost-effective imaging technique that does not involve the dangers associated with ionizing radiation present in CT scans. Denton et al.[11] established the ability to detect stones as small as 2 mm using ultrasonic imaging in a porcine model over 30 years ago. Ultrasound can efficiently depict radiopaque and radiolucent calculi, hydronephrosis, renal inflammation, ruptured fornices, ureteric jets, and resistive index, hence providing substantial clinical insights.[12]

Despite the broader accessibility of ultrasound (US) units and heightened bedside application, the nationwide utilization of USG for renal colic remained largely unchanged from 2000 to 2008, whilst the employment of CT scans surged considerably.[13] A CT scan can evaluate the size and location of the stone as well as the overall health of the kidney, and the stone's density in Hounsfield units can predict its chemical composition.[14] The present study was conducted to compare USG and CT scan in diagnosis of renal stones.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted in the Department of Urology in collaboration with Department of Radiology and Imaging, BSMMU to compare the USG and CT scan methods in the diagnosis of renal stone.

In this study a total of 206 suspected cases of renal stones were enrolled initially from outpatient department (OPD), among them 160 cases were primarily diagnosed with renal stones and 46 without renal stones by physical examinations and x-ray. Then 206 suspected cases were scheduled for USG and CT scans to confirm the stone after obtaining consent. Ethical approval was taken from the institutional review board, and it was in accordance with the Declaration of Helsinki. All patients were informed regarding the study and written consent was taken from each patients. After enrollment in this study, general information such as name, age, gender etc. were recorded. A thorough clinical examination was done. USG Scan and CT scan was done for each patient. All information was recorded in a predesigned questionnaire and later on were feed into computer using SPSS software.

Statistical analyses were performed using SPSS 20.0 software (SPSS, Chicago, IL, USA). Data presented on categorical scale were expressed as frequency and corresponding percentages and were compared between groups using Chi-square test, while data presented on continuous scale were expressed as mean and standard deviation and were compared between groups by using Student's t-Test and $p < 0.05$ was taken as statistically significant. Sensitivity, specificity, positive predictive value, negative predictive value of USG and CT scan were calculated.

CT machine

The CT images had been conducted using (TOSHIBA aquilion 64 slices) CT scanner. The scan parameter (3mm slice, 120 kvp, 225 MAS) with using the electronic caliper within the scanner the following diameters were measured. The features of CT scanner are: 256 slices in one rotation with .5mm slice thickness Coverage of 13cm in patient axis direction Advanced Sure Workflow software with PhaseXact, largest couch capacity in the industry – 180cm long by 47cm wide 40% dose reduction compared to previous models.

CT KUB technique

CT KUB (non-contrast enhanced CT of kidney, ureter and bladder) is useful to determine the number and location of urinary tract calculi. The patient will lie supine on CT scanner table. Scout view will be obtained. A low radiation dose technique will be used to scan from the top of the kidney to the bladder base with slice thickness of 5 mm or less as determine by CT scanner.

USG Machine

GE medical system LOQIC 5 Expert, made by yocogama medical systems. LTD –JAPAN – model 2302650, serial number 1028924, manufactured April 2005, Choice of transducer: -Use 3.5 MHz for adults, curvilinear probe, 5 MHz for children and thin adults. Setting the correct gain: -Start by placing the transducer longitudinal central and at the top of the abdomen (the xiphoid angle). Ask the patient to take a deep breath and hold it in. Angle the transducer beam towards the right side of the patient.

Abdomen USG technique

Patient will be advised not to take anything by mouth for 8 hours preceding the examination. In case of dehydration, only water should be given.

RESULTS

Table I shows demographic characteristics of the study subjects, here male to female ratio was 1.61:1 and male was 61.7%. According to the age distribution; 72 (35.0%) were in age group 31–40 years followed by 52 (25.2%), 42 (20.4%) and 40 (19.4%) were in the age groups of 41–50 years, 51–60 years and 21–30 years respectively. Mean age of the study subjects was 45.28 ± 8.30 years.

Table I: Demographic characteristics of the study subjects (N=206)

	Frequency (n)	Percentage (%)
Age (years)		
21 - 30	40	19.4
31 - 40	72	35.0
41 - 50	52	25.2
51 - 60	42	20.4
Mean ± SD	40.24 ± 10.48	
Gender		
Male	127	61.7
Female	79	38.3

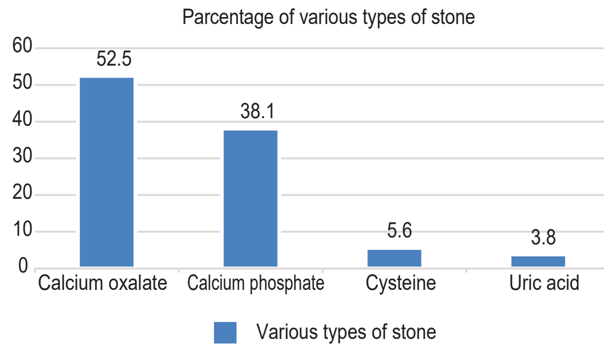

Figure- 1: Various types of stone (N=160)

Figure 1 displays the different types of stones take out from the patients were calcium oxalate (52.5%), calcium phosphate (38.1%), cysteine (5.6%) and uric acid (3.8%)

Table II represents the detection of renal stone by ultrasound imaging; among 160 diagnosed renal stone patients 138 were diagnosed positive and 22 were diagnosed negative in USG, they were true positive and false negative respectively. Among 46 diagnosed without renal stone cases 36 were diagnosed negative and 10 were diagnosed positive in USG, they were true negative and false positive respectively.

Table II: Detection of renal stone by ultrasound imaging (N=206)

Diagnosis of renal stone by USG	Renal stone			
	Present	Absent	Total	p-value
Present	138 (86.3)	10 (21.7)	148 (71.8)	<0.001
Absent	22 (13.8)	36 (78.3)	58 (28.2)	Total
	160	46	206 (100.0)	

Table III displays the detection of renal stone by imaging with CT scan; among 160 diagnosed renal stone patients 148 were diagnosed positive and 12 were diagnosed negative in CT scan, they were true positive and false negative respectively. Among 46 diagnosed without renal stone cases 37 were diagnosed negative and 9 were diagnosed positive in CT scan, they were true negative and false positive respectively (Table 4).

Table III: Detection of renal stone by imaging with CT scan (N=206)

Diagnosis of renal stone by CT scan	Renal stone			
	Present	Absent	Total	p-value
Positive	148 (92.5)	9 (19.6)	148 (71.8)	<0.001
Negative	12 (7.5)	37 (80.4)	58 (28.2)	
Total	160	46	206 (100.0)	

Table IV contains diagnostic efficacy of USG and CT scan for renal stone sensitivity, specificity, PPV, NPV and accuracy of USG in diagnosis renal stone were 86.3%, 78.3%, 93.2%, 62.1% and 84.5% respectively. Whereas sensitivity, specificity, PPV, NPV and accuracy of USG in diagnosis renal stone were 92.5%, 80.4%, 94.3%, 75.5% and 89.8% respectively

Table IV: Diagnostic efficacy of USG and CT scan for renal stone (N=206)

	USG	CT scant
Sensitivity	86.3	92.5
Specificity	78.3	80.4
Positive predictive value	93.2	94.3
Negative predictive value	62.1	75.5
Accuracy	84.5	89.8

DISCUSSION

In this study, maximum patients were in age group 31 – 40 years (35.0) followed by 41 – 50 years (25.2%), 51 – 60 years (20.4%) and 21 – 30 years (19.4%). Mean age was 45.28 ± 8.30 years. Rajesh and Akhtar[15] revealed that 46.1% patients were in age group 31-40 years followed by 21-30 years (31.6%), 11 – 20 years (15.8%) and >40 years (6.5%).

In this study, maximum study subjects were male 61.7% and 38.3% were female. Male to female ratio was 1.61:1. Similar finding also observed in the study of Rajesh and Akhtar[15] they found males were 57.9% and females were 42.1%. Almost similar finding also observed in the study of Shams et al.[16].

Types of stone were calcium oxalate (52.5%), calcium phosphate (38.1%), cysteine (5.6%) and uric acid (3.8%) in this study. Calcium oxalate was prevalent in the study of Rajesh and Akhtar[15], they found calcium oxalate in 43, calcium phosphate in 8, cystine in 21 and uric acid in 4 cases.

In this study, sensitivity, specificity, PPV, NPV and accuracy of USG in diagnosis renal stone were 86.3%, 78.3%, 93.2%, 62.1% and 84.5% respectively. Whereas sensitivity, specificity, PPV, NPV and accuracy of USG in diagnosis renal stone were 92.5%, 80.4%, 94.3%, 75.5% and 89.8% respectively.

The sensitivity of the CT scan was determined to be 95%, whereas the ultrasound exhibited a sensitivity of 92%. The specificity of ultrasound was 91%, while that of computed tomography was 87% (Rajseh and Akhtar, 2019).[15] Bonigala and Varusai[17] determined that the sensitivity and specificity of ultrasound imaging were 54.0% and 91.0%, respectively. The sensitivity of ultrasound (USG) compared to computed tomography of the kidneys, ureters, and bladder (CT KUB) was 83.7%, while the specificity was 100%.[18] Fowler et al. (2002) noted diminished diagnostic accuracy with sonography, reporting a sensitivity of 24% and a specificity of 90%. The total accuracy of sonography in identifying a stone in the right kidney by radiologists 1 and 2 was 67% and 77%, respectively. The accuracy scores for the left kidney were 53% and 54%, respectively.[19] The sensitivity, specificity, positive predictive value, negative predictive values and diagnostic accuracy of ultrasonography in detecting renal calculi was 74.47%, 96.36%, 94.59%, 81.54% and 86.27% respectively.[16]

CONCLUSIONS

According to this study, CT scan show up as preferred imaging modality for uorolithiasis over ultrasound because of its higher sensitivity and accuracy than USG in identifying renal and ureteral stones. However, USG is a readily available, cost-effective imaging technique that does not involve the dangers associated with ionizing radiation present in CT scans. CT resulted in better results and hence USG should be considered if CT is not present.

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