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Research Article

Comparative Study of Patients with Suspected Ultrasound and Computerized Tomography for Nephrolithiasis Detection

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Abstract: ***Background:*** Kidney stones have been associated with an increased risk of chronic kidney diseases, end-stage renal failure, cardiovascular diseases, diabetes, and hypertension. It has been suggested that kidney stone may be a systemic disorder linked to the metabolic syndrome. Nephrolithiasis is responsible for 2 to 3% of end-stage renal cases if it is associated with nephrocalcinosis**.** There is a lack of consensus about whether the initial imaging method for patients with suspected nephrolithiasis should be computed tomography (CT) or ultrasonography. ***Material and Methods:*** This is a Prospective study was carried out at Dept. of Radiology & Imaging, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh July 2012 to June 2013. Total 120 patients' USG and CTU were compared for the presence of calculi. Sensitivity, specificity, accuracy, positive predictive value and negative predictive value of USG were calculated with CTU as the gold standard. Patient with full urinary bladder was positioned supine on CT examination table and scanned from the upper abdomen to the symphysis pubis with image reconstructed at 5 mm intervals. No oral or intravenous contrast media was given. ***Results:*** From the 120 sets of data collected, 41 calculi were detected on both USG and CTU. The sensitivity and specificity of renal calculi detection on USG were 53.3% and 85% respectively. The mean size of the renal calculus detected on USG was 6.8 mm ± 3.8 mm and the mean size of the renal calculus not visualized on USG but detected on CTU was 3.5 mm ± 2.7 mm. The sensitivity and specificity of ureteric calculi detection on USG were 11.6% and 96.6% respectively. The sensitivity and specificity of urinary bladder calculi detection on USG were 20% and 100% respectively. ***Conclusion:*** US is an ideal first-line imaging modality for nephrolithiasis due to its advantages such as low cost, absence of radiation, and easy availability. But the reason for its limited use is due to its decreased sensitivity and reduced accuracy in measuring the stone size, the areas in which CT scores over US. This study showed that the accuracy of US in detecting renal, ureteric and urinary bladder calculi were 68.3%, 80% And 99.1% Respectively.
Keywords: Nephrolithiasis, Ultrasound, Computed Tomography.

INTRODUCTION

Kidney stones have been associated with an increased risk of chronic kidney diseases, end-stage renal failure, cardiovascular diseases, diabetes, and hypertension [1]. It has been suggested that kidney stone may be a systemic disorder linked to the metabolic syndrome. Nephrolithiasis is responsible for 2 to 3% of end-stage renal cases if it is associated with nephrocalcinosis [2]. Kidney stones or Nephrolithiasis are mainly lodged in the kidney(s). Mankind has been afflicted by urinary stones since centuries dating back to 4000 B.C., and it is the most common disease of the urinary tract. The prevention of renal stone recurrence remains to be a serious problem in human health [3]. The prevention of stone recurrence requires better understanding of the mechanisms involved in stone formation. The symptoms of kidney stone are related to their location whether it is in the kidney, ureter, or urinary bladder [4]. Initially, stone formation does not cause any symptom. Later, signs and symptoms of the stone disease consist of renal colic (intense cramping pain), flank pain (pain in the back side), hematuria (bloody urine), obstructive uropathy (urinary tract disease), urinary tract infections, blockage of urine flow, and hydronephrosis (dilation of the kidney). These conditions may result in nausea and vomiting with associated suffering from the stone event [4]. Globally, kidney stone disease prevalence and recurrence rates are increasing, with limited options of effective drugs. Recent studies have reported that the prevalence of urolithiasis has been increasing in the past decades in both developed and developing countries. This growing trend is believed to be associated with changes in lifestyle modifications such as lack of physical activity and dietary habits and global warming [5]. Urolithiasis affects about 12% of the world population at some stage in their lifetime [6]. It affects all ages, sexes, and races but occurs more frequently in men than in women within the age of 20–49 years [7]. Therefore, prophylactic management is of great importance to manage urolithiasis. Ultrasound (USG) is the most appropriate and useful screening tool as it is easily available, radiation-free, reproducible, inexpensive and non-invasive. A USG that is negative for calculi may prompt the need for unenhanced computed tomography urogram (CTU). CTU was shown to be highly sensitive and specific for ureteric stones [8]. Its significant advantages over other modalities in the detection of urolithiasis includes accuracy, non-usage of intravenous contrast media, as well as the abilities to evaluate secondary effects of obstruction, and detect other potential sources of pain but patients are inevitably exposed to radiation [9].

MATERIALS AND METHODS

This is a Prospective study was carried out at Dept. of Radiology & Imaging, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh July 2012 to June 2013. Total 120 patients' USG and CTU were compared for the presence of calculi. Patient with full urinary bladder was positioned supine on CT examination table and scanned from the upper abdomen to the symphysis pubis with image reconstructed at 5 mm intervals. No oral or intravenous contrast media was given. Calculus was defined as hyper dense focus in the kidney, ureter and/or bladder. USG was performed using multiple new generation ultrasound scanners (Toshiba, Philips and GE Logic).

Ultrasound included evaluation of the kidneys in multiple anatomic planes and maximum calculus measurement was recorded. Curved-phase array transducers were used with varied transducer frequency depending on the body habitus to optimise both patient penetration and image resolution. Calculus on ultrasound was characteristically demonstrated as highly echogenic focus with distinct posterior acoustic shadowing.

Statistical analysis

Demographic data including age, sex and ethnicity were collected. A review of the USG and CTU of each patient was done with documentation of the imaging findings including presence or absence of calculus, site (right or left urinary tract or both), location (kidney, ureter or bladder), and calculus size in millimeter. With CTU as the gold standard, sensitivity, specificity, accuracy, positive predictive value and negative predictive value of USG for the detection of calculus at each of the three locations (kidney, ureter and bladder) were calculated. Statistical Package for Social Sciences (SPSS) version 23 was used for statistical analyses.

RESULTS

Table 1: Distribution of age groups

Age group	No. of patients	Percentage
25-39 Years	50	41.6
40-59 Years	38	31.7
60-79 Years	32	26.7
Total	**120**	**100**

A total of 120 patients were included in the study. In table 1, the patients were predominantly in the late adulthood and elderly age groups, with 54 patients (41.6%), 38 patients (31.7%) and 32 patients (26.7%) aged between 25-39, 40-59 and 60-79 years old respectively.

Table 2: Distribution of sex

Sex	No. of patients	Percentage
Male	68	56.6
Female	52	43.4
Total	**120**	**100**

In table 2, the mean age was 52 years old. Gender wise distribution, there were maximum no. of patients were 68 males and 52 females.

Table 3: Calculi described as staghorn have been classified as ≥10.1 mm

Findings	% Error in USG
True positive	38
True negative	29
False positive	8
False negative	45
Total	**120**

In table 3, from the 120 data collected patients, 38 renal calculi were detected on both USG and CTU. There were 8 false positive cases. The sensitivity and specificity of renal calculi detection on ultrasound were 51.6% and 85.8% respectively. The positive predictive value (PPV) was 84.2% and negative predictive value (NPV) was 56.6%. The accuracy of ultrasound in detecting renal calculi was 68.3%.

Table 4: Size of detected and undetected renal calculi on USG

Calculus size (mm)	Number detected (%)	Number undetected (%)
≤ 5	13 (32.5)	28 (84.8)
5.1 – 10	17 (42.5)	4 (12.1)
≥ 10.1	10 (25.0)	1 (3.1)
Total	**40 (100)**	**33 (100)**

In table 4, the majority of calculi detected by USG measured 5.1-10 mm. The minimum, maximum and average size documented was 3.5 mm, 22 mm and 6.8 mm ± 3.8 mm respectively. 40 renal calculus detected and 33 renal calculi were not detected on USG but positive on CTU and 31 findings were true negative.

Table 5: Detection of ureteric calculi on USG and CTU

USG	CTU Percentage		
	Normal	**Abnormal**	**Total**
Normal	67	49	116
Abnormal	1	3	4
Total	**68**	**52**	**120**

In table 5, ultrasound detected only 4 of the 16 ureteric calculi that were detected on CTU giving a low sensitivity of 11.6%. However, it showed a high specificity of 96.6%. The accuracy of ultrasound in detecting ureteric calculi was 80.8%. The PPV and NPV were 63.3% and 80.8% respectively.

Table 6: Detection of urinary bladder calculi on USG and CTU

USG	CTU Percentage		
	Normal	**Abnormal**	**Total**
Normal	116	2	118
Abnormal	1	1	2
Total	**117**	**3**	**120**

In table 6, detection of urinary bladder calculi for the detection of urinary bladder calculi, ultrasound achieved 20% sensitivity and 100% specificity. The PPV was 100% with NPV of 98.3%. The accuracy was 98.3%.

DISCUSSION

Kidney stones develop when urine becomes "supersaturated" with insoluble compounds containing calcium, oxalate (CaOx), and phosphate (CaP), resulting from dehydration or a genetic predisposition to over-excrete these ions in the urine. There has been little direct comparison between USG and CTU in the detection of urolithiasis. CTU as being the gold standard, our study aims to determine the sensitivity of USG in detecting urinary tract calculi. The patients suspected of having renal tract calculi undergo a work-up that includes urine analysis, KUB radiograph, and USG as first line investigations. A positive USG may or may not proceed to CTU but all negative USG will undergo CTU for further evaluation. This study showed that USG had limited value for the detection of renal calculi. The sensitivity and specificity of 53.3% and 85% respectively were lower compared to two previous studies that had reported 80.8% and 100%, and 75.8% and 100% for sensitivity and specificity respectively [10, 11]. However, our sensitivity exceeded that of another study, which reported a sensitivity of 24.2%, but a slightly higher specificity of 90% [12]. The longer time interval between ultrasound and CTU (45% within 1 month, the rest 1 month or more) in this study could have contributed to this discrepancy, in contrast to 1 month or less in previous studies. The poor sensitivity and the high false negative rates (40.8%) of USG demonstrated in this study are related to multiple factors. Calculi may be missed at USG due to lack of acoustic shadowing of the calculus [13]. The other factors would be the body habitus, 6 the selection of the transducer power, and focal length [14]. The excellent contrast resolution of CTU allows discrimination of slight differences in attenuation, allowing better visualisation of stones. Furthermore, CTU has the ability to acquire a volume of data that includes the entire urinary system and not just the kidneys only. USG may miss stones within some parts of the urinary tract, 8 especially the ureters. In this study, the false positive rate (FP) was 15% for USG and may have been due to renal vascular calcification [15,16]. With regard to the size of renal calculi that were detected, this study showed that the mean size of the calculi detected on USG was 7.6 mm ± 4.1 mm, comparable to a study that reported a mean size of 7.1

mm ± 1.2 mm. 7 Of the 53 renal calculi not detected on USG, 85% measured ≤ 5 mm. A previous study showed that the mean size of calculus detected on CTU was 4.2 mm ± 0.4 mm [17]. Seventy-three percent of calculi not visualized on USG were 3 mm or less in size [18]. The USG in which a 12-mm calculus had been missed but was detected later on CTU was performed by a junior trainee, and the time interval between USG and CTU was between 1 – 3 months. The presence of posterior acoustic shadowing depends on the size of the calculus. Therefore, the smaller the calculus, the more likely it could be missed [19]. However, the reason for a large calculus not being identified on USG is not clear. One way to improve on USG skill is to repeat the USG whenever a false negative or false positive result is noted on CTU. With regard to the detection of ureteric calculi, a prospective study in 1998 achieved a sensitivity of 19.1% and a specificity of 96.6% [20]. Another study in 2007 showed a slightly higher sensitivity of 23.3% and specificity of 100% [21]. In this study, almost similar results were achieved, with low sensitivity of 11.6% and high specificity of 96.6%. The low sensitivity is attributable to the presence of bowel gas, which commonly obscures the ureters, and a large body habitus with thick subcutaneous fat that reduces visibility [22,23]. The specificity of calculi detection on USG is greater in the ureter than in the kidneys. This is because the diagnosis of ureteric calculus is greatly aided by the presence of hydro ureter [24]. USG is not equivalent to CTU in detecting urinary tract calculi. However, this does not mean that every patient suspected of having a urinary tract calculus should undergo a CTU. Based on the findings of this study, the following imaging algorithm is recommended. A limitation of this study is the extended time interval between ultrasound and CTU. Approximately 55% of the patients had their ultrasound and CTU done at more than 1 month apart. Accuracy of ultrasound could be affected as calculi could have moved or changed in size during this period of time.

CONCLUSION

US is an ideal first-line imaging modality for nephrolithiasis due to its advantages such as low cost, absence of radiation, and easy availability. But the reason for its limited use is due to its decreased sensitivity and reduced accuracy in measuring the stone size, the areas in which CT scores over US. The sensitivity and specificity of USG in detecting renal calculi was 51.6% and 85.8% respectively and the mean size of renal calculi not visualized on USG was 3.5 mm ± 2.7 mm. Our study showed that the accuracy of USG in detecting renal, ureteric and urinary bladder calculi was 68.3%, 80% and 99.1% respectively.

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