Original Research Article

7The accuracy of USG KUB region for detection of urinary tract calculus in comparison to NCCT - A retrospective analysis

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Received: 15-09-2021 / Revised: 18-10-2021 / Accepted: 27-11-2021

Abstract

Objective: To evaluate the accuracy of ultrasonography (USG) in detecting the urinary tract stone (Urolithiasis) using non-contrast computed tomography (NCCT) as the gold standard. In addition, we correlated the accuracy of sonography with stone size. **Patients and methods:** We retrospectively identified a total of 368 patients at our institution with a diagnosis of urinary tract stone, who underwent USG followed by non-contrast computed tomography (NCCT). The stone size (maximum diameter) and stone location were collected in USG and data validated by NCCT. Data of the stone size in USG were classified into four groups (0–4, 4.1–6, 6.1–10, and >10 mm) and then compared with NCCT data. **Results:** A total of 368 USG and CT examinations met the inclusion criteria. Overall, the sensitivity of USG was 72.6%. Among all patients, NCCT detected 552 stones, while USG could identify 426 (77.2%) stones. Detection rate of mid and distal ureteral stone was lower than that at other locations. The detection rate increased with the stone size. About 73% concordance was obtained for the stone size measured by USG and NCCT. Factors such as the stone size, amount of hydronephrosis, and body weight affected the detection rate of the urinary tract stone using USG. **Conclusion:** No significant difference in measuring the size of urinary stones using USG and CT in most of cases. However, USG may slightly overestimate stones in some cases, USG has limited imaging modality in detecting urinary tract stone, especially in the case of smaller stone size, obese patient, and low grade of hydronephrosis with uretric calculi..

Keywords: Non-Contrast Computed Tomography, Ultrasonography, Urinary Tract, Stone

Introduction

Renal stones can be radiopaque or radiolucent[1]. Eighty percent of all renal stones composed of calcium oxalate and phosphate are radiopaque, 15% are composed of struvite, 1% are composed of cystine, and 4% are composed of uric acid or xanthine or are matrix stones. Matrix stones and those composed of struvite, uric acid, or xanthine are radiolucent[2].

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Urolithiasis is one of the most prevalent and current diseases among urologic disorders with a lifetime incidence of 12%[3]. The gold standard imaging modality to diagnose urinary tract stone in patients with acute flank pain is non- contrast enhanced computed tomography (NCCT), which was reported to have a sensitivity of 95%–98%[4]. High ionizing dose, high rate of incidental findings, and high cost of NCCT are the limiting factors to its widespread use[4]. On the other hand, USG is widely used for detecting renal stone; it is a safe, noninvasive, and cheap method and in circumstances such as pregnancy and pediatric age, it is the modality of choice for calculi detection[5]. Previous studies report the sensitivity of USG for detecting renal stones were 24%–81% [6,7].However, many factors such as body weight, age, and stone size affect the diagnosis of ureteric stone using USG[8]. The aim of this study was to determine the accuracy of USG for detecting urinary tract stones by using computed tomography as the gold standard reference.

Patients and methods

Study design and participants

In this retrospective study, we included patients of all age group and this study was conducted from 1st September 2019 to 31st August 2021 on 458 patients who visited the emergency department and general OPD of our institute L.N. Medical College & J.K. Hospital Bhopal (MP). Among 458 patients 368 had undergone for USG and NCCT both. Of whom 220 (59.8%) were men and 148 (40.2%) were women. Indications for radiologic investigation were acute flank pain in 240 (65.2%) cases, hematuria in 26 (7.1%) cases, and a history of previous urinary tract stones in 102 (27.7%) subjects.

All clinical data including age, weight, sex, stone location and size in NCCT were collected.

Exclusion criteria

All patients with staghorn stone and urinary tract diversions, those who received NCCT in other hospitals, patients with a time interval of >1 month between USG and NCCT, those with a probability of stone displacement, and pregnant women were excluded from this study.

Abdominal USG acquisition

USG was performed by a experienced radiologist using gray-scale GE Versana Premier Ultrasound equipment using a 3–5 MHz curved transducer.

Since a small stone may not cause an acoustic shadow, all echogenic foci seen in the renal pelvis, ureter, or calyces on USG were diagnosed as urinary tract stones. The sensitivity and accuracy of USG for detecting the urinary tract stone were recorded. Furthermore, the stones were classified according to their size into 4 groups 0–4, 4.1–6, 6.1–10, and >10 mm using NCCT as the gold standard.

Abdominal CT acquisition

All upper abdominal area to the pelvis scans images were obtained with one CT system (Optima 660, GE). The patients were scanned in supine position during breath holding. The main imaging parameters were: tube voltage = 120 kVp, automatic tube current modulation (30-70 mAs), pitch = 0.99-1.22 mm, matrix = 512 x 512, slice thickness = 10 mm, FOV = 350 mm X 350 mm. All images were then reconstructed at 1 or 2 mm interval.

Results

In this study, 552 stones were detected by NCCT in 368 patients, while USG could detect 426 (77.2%) stones. The mean sensitivity of USG was 72.6%. The mean age of the patients was 47.7 years. The mean right- and left-side stone detection was 54% (298) and 46% (254), respectively. The mean weight of the patients was 71.7 kg. The mean stone size in NCCT was 8.9 mm.

The detection rate of specific stone by USG was examined for different locations (Table 1); it was found that the detection sensitivity rate was low in the mid & distal parts of the right ureter and left ureter (42.8% & 51.8%, and 50% & 60% respectively). And maximum sensitivity of USG for stone detection was at renal pelvis followed by lower pole of each kidney.

We also examined the detection rate of USG according to the size of the stone (Table 2), and the detection rate was found to increase with size. The sensitivity levels for 0–4, 4.1–6, 6.1–10, and >10 mm were 54.4%, 72.8%, 73.9% and 89.4%, respectively, and it was considered clinically important when the stone size was >5 mm.

To obtain the accuracy of the stone size measured by USG, we compared the stone size of both NCCT and USG. About 73% concordance was obtained for the stone size measured by USG and NCCT. Then, we classified the stone sizes into four groups (0–4, 4.1–6, 6.1–10, and >10 mm) and measured the sizes separately by USG and NCCT.

The size of the stones that were missed by USG was significantly smaller than that of the stones detected by NCCT. Many factors affect the detection of renal stone by USG (Table 3). The stone size, amount of hydronephrosis (HDN), and weight affected the detection rate of the urinary tract stone using USG.

Table 1. Detection rate of the urinary tract stone by ultrasonography based on location (Fig. 1-6)

Location	Left Kidney		Missed no.	Sensitivity (%)
	Total no.	Detected no.		
Upper calyx	22	16	06	72.7
Mid calyx	30	24	06	80.0
Lower calyx	91	81	10	89.0
Renal pelvis	30	27	03	90.0
Proximal ureter	33	21	12	63.6
Mid ureter	08	04	04	50.0
Distal ureter	40	24	16	60.0
Total	**254**	**197**	**57**	
	Right Kidney			
Upper calyx	28	20	08	71.4
Mid calyx	50	40	10	80.0
Lower calyx	84	74	10	88.0
Renal pelvis	42	40	02	95.2
Proximal ureter	24	20	04	83.3
Mid ureter	14	06	08	42.8
Distal ureter	56	29	27	51.8
Total	**298**	**229**	**69**	

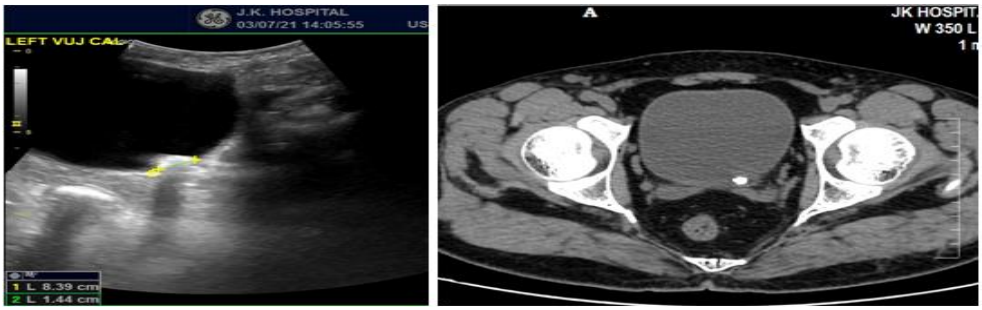

Fig- 1 & 2. USG KUB of 45 year male showing an echogenic foci with PAS seen at left VUJ & CT axial of same patient showing hyperdense calculus at same location respectively. USG - slightly overestimate the size. (USG size -8.4 mm, NCCT size-7.8 mm)

Fig- 3 & 4. USG KUB of 65 year male showing an echogenic foci with PAS seen at right mid ureter & CT coronal of same patient showing hyperdense calculus at same location respectively. USG -slightly overestimate the size. (USG size -7.6 mm, NCCT size-7.2 mm)

Fig- 5 & 6. USG abdomen of 39 year & 25 year old male showing an echogenic foci with PAS seen at lower pole of right kidney & multiple calculi with prominent PCS in right kidney respectively.

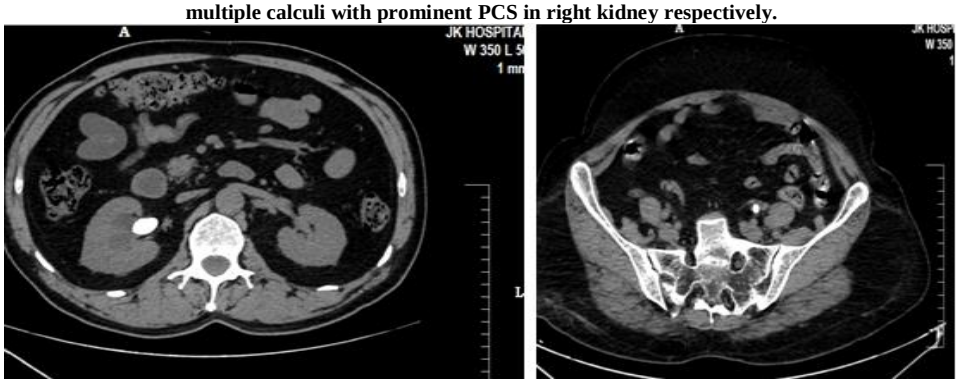

Fig-7 & 8. Axial CT images of 47 year male & 55 year old female showing hyperdense calculus (Avg-HU 1332)at right PUJ causing mild hydronephrosis & hyperdense (Avg-HU 940) calculus at left mid ureter respectively.

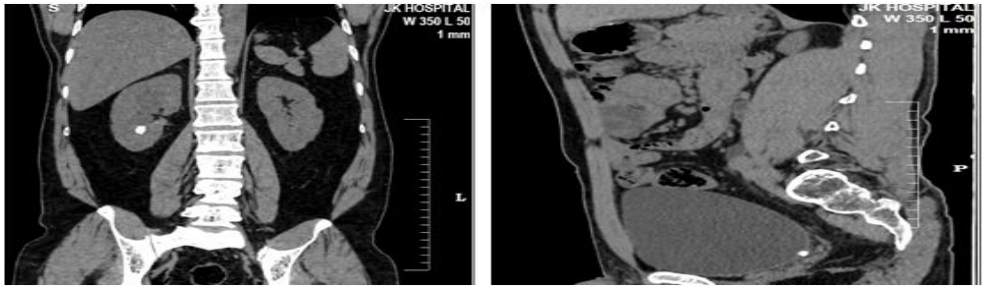

Fig-9 & 10. Coronal & Sagittal CT images of 37 year male & 65 year old female showing hyperdense calculus (Avg-HU 1150) at right lower calyx & hyperdense (Avg-HU 790) calculus at left VUJ respictively.

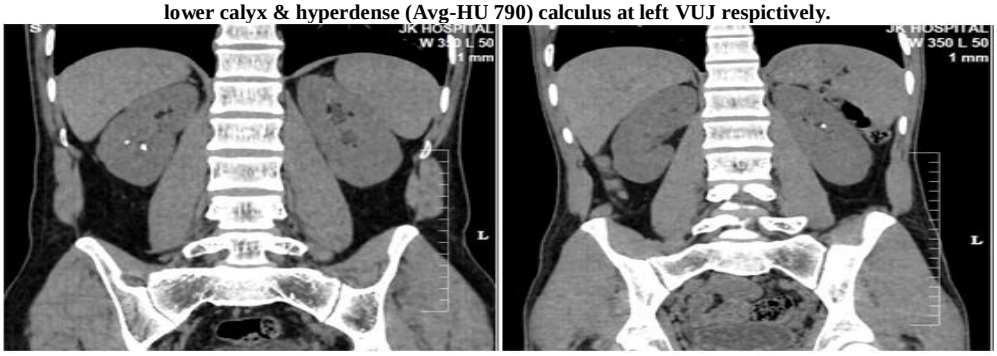

Fig-11 & 12. Coronal CT images of 59 year male & 42 year female showing small sized right renal calculi & left renal calculus respectively, which were missed in USG.

Table 2. Stone size in NCCT (Fig.7-12)

Stone size in NCCT (mm)	Total no.	Detected by USG	Missed by USG	Sensitivity (%)
0-4	68	37	31	54.4
4.1-6	92	67	25	72.8
6.1-10	230	170	60	73.9
>10	162	152	10	89.4
Total	**552**	**426**	**126**	**72.6 %**

Table 3. Factors affecting the USG detection rate

Factors	USG positive (n=426)	USG negative (n=126)
Average age	47.7	47.1
Average weight (Kg)	71.7	77.0
Average stone size (mm)	8.9	4.7
Amount of Hydronephrosis		
Normal	150	28
Mild	174	68
Moderate	86	26
Severe	16	04
Laterality		
Right	229	69
Left	197	57
Sex		
Male	164	56
Female	130	18

Discussion

The gold standard modality used for detecting renal stone is NCCT. Whereas USG is used as initial investigation due to easily available with non use of radiation, cost effective and repeatable .This can make important decisions concerning the renal stone diagnosis[9].

In the current study, in line with the literature reports, sonography was less sensitive than NCCT in initially detecting stones when located in the mid or distal part of the ureter and this may be due to obscurity by the bowel gas[10].Patlas et al compared USG and NCCT for detection of ureteric stone in 62 patients, yielding a sensitivityof 93% [10].

Despite all these differences, in our study, the sensitivity of USG for detection of stones was similar to that previously reported (about 72.6%). Other factors that may affect USG diagnosis include the presence of HDN, stones abutting renal sinus fat, and vascular calcifications, as well as experience and knowledge of the upper urinary tract anatomy and the presence of bowel gas, which may obscure the ureteral calculi. Additionally, measurement of stones in multiple orthogonal planes affects reproducibility. Vascular calcifications and other artifacts may also be mistaken for stones and may partially account for the reduction in sensitivity & specificity[11-13].

In another study, Kanno et al showed that the stone sizes detected by USG were almost the same as those detected by NCCT[9]. Similarly, in our study, about 73% concordance obtained for the stone size confirms the reliability of the stone size measurement by USG and suggests that USG mightbe adequate and worth performing.

A previous study investigated the factors affecting the accuracy of USG for the detection of urinary stone. Goertz reported that the increasing degree of HDN was associated with an increase in the ureteric stone diagnosis using USG[14]. Kanno et al reported that the stone size in USG was associated with detection rate of the renal

stone[9]. Our result was close to the previous study and found that the stone size and increasing degree of HDN are associated with increasing detection rate of urinary stone in USG.Pichler et al reported that age and body weight affected the diagnosis of ureteral stone by USG[8]. In contrast, our study suggests that the detection rate of the urinary tract stone is not correlated with age; however, it is correlated with weight.

Conclusion

The stone size obtained by sonography was almost the same as that detected by NCCT in most of cases; USG may slightly over estimate stones size in some cases. Also it has limitation in detecting urinary tract stone, especially in the case of smaller stone size, obese patient, and low grade of HDN. However, USG still plays an important role in the primary diagnosis of patients with suspected urinary tract stone, as well as during the follow-up.

Abbreviations

USG: Ultrasonography; NCCT: Non contrast computed tomography; HDN: Hydronephrosis; MHz: Mega hertz; FOV: Field of view.

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Conflict of Interest: Nil
Source of support: Nil