Original Article

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Radiology Section

Present Role of Gray Scale Ultrasound Combined with Doppler in the Evaluation of Ureteric Calculi: Correlation with CT-Scan

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ABSTRACT

Introduction: One of the commonest causes for acute flank pain is ureteric calculi. Presently imaging modalities available in the evaluation of ureteric calculi include plain radiography, ultrasound, intravenous urography, non-contrast computed tomography and CT urography. In this study we evaluated the role of ultrasonography with respect to CT-scan for detection of ureteric calculi.

Aim: To evaluate the role of gray scale ultrasound combined with Doppler in the diagnosis of ureteric calculi and to compare it with CT-scan.

Materials and Methods: This was a prospective study and 80 patients with ureteric calculi who underwent CT-Kidney, Ureter, Bladder (KUB) examinations were randomly selected for ultrasound examination. The results of ultrasonography were correlated with the findings on CT-scan and the sensitivity, specificity of ultrasonography when compared with CT-scan was evaluated.

Results: Total 80 cases of ureteric calculi detected by CT. Ultrasound could detect 74 cases and rest 6 of the cases showed only indirect signs of obstruction like hydroureteronephrosis. The overall sensitivity, specificity, positive predictive value and negative predictive value for detection of ureteric calculi by ultrasounds were found to be 92.5 %, 100 %, 100% and 93% respectively.

Conclusion: Ultrasound combined with Doppler is an effective, cost-effective method for diagnosing ureteric calculi and thereby reduces the number of patients subjected to CT examination.

Keywords: Acute obstruction, Flank pain, Twinkling artifact, Ureteric jet

INTRODUCTION

Patients with obstructive uropathy present to the Emergency Department with complaints of hematuria, flank pain, renal colic, acute abdominal pain or difficulty in passing urine [1]. The cause for such clinical presentation is usually a ureteric calculus. In the emergency setting, plain KUB X-ray has been the first imaging procedure done to investigate the cause of such a clinical presentation. The main aim is to find out the radio opaque calculi in the urinary pathway, if any. Presently non-enhanced computed tomography (NECT) and CT urography has gained widespread acceptance for examining patients with acute ureteric colic, since it can accurately diagnose the cause and level of obstruction [1-8]. Although ultrasound cannot be as sensitive and specific in diagnosing ureteric calculi, when compared with CT, it has got its own advantages [1]. As simple, quick and non-invasive method of investigation, ultrasound can provide diagnosis of ureteric calculi and its secondary effects [1]. In present scenario, the role of intravenous urography (IVU) remains questionable since CT has better sensitivity in the detection of ureteric calculi and also it can demonstrate additional findings [5,7,8]. The aim of the present study was to assess the role of gray scale ultrasound combined with Doppler ultrasound in the detection of ureteric calculi when compared with CT-scan.

MATERIALS AND METHODS

This prospective study was conducted in the Department of Radiodiagnosis in association with the Department of Urology in SRM Medical College Hospital and Research Centre, Kancheepuram, India, during the period of June 2015 to June 2016 for the duration of 1 year after obtaining ethical clearance from Institutional Ethics Committee. The study group comprised of 80 patients referred to Radiology Department for CT-scan of Kidney, Ureter, Bladder (KUB) region for whom ureteric calculi was suspected based on clinical symptoms and signs. All the patients referred to Radiology Department who had ureteric calculi on CT-scan were included in the study

except for patients not willing for ultrasound examination. Patients with history of trauma were excluded from the study. Written informed consent was taken from all the patients before CT and ultrasound examinations. CT examinations was performed using 64 slice CT, Siemens Medical Systems, Germany. The findings of CT-scan like whether ureteric calculi is present or not and the size, number and location of ureteric calculi, along with their CT density were noted. Presence of other ancillary findings like hydroureteronephrosis, perinephric fat stranding and fluid was also noted. All the patients who had ureteric calculi on CT-scan also underwent ultrasound examination. Ultrasound examinations were done on PHILIPS HD (High definition) 11 XE ULTRASONIC MACHINE, using 2-5 MHz curvilinear transducer. Sonography was done by a radiologist with atleast 5 years experience in ultrasound. All sonographic examinations were carried out within the first 24 hours of patient's hospital stay, mostly within 1-5 hours of admission. Scanning was done with full bladder. No other prior preparation was done. The whole abdomen including the pelvis was scanned. Patients were scanned first in supine position and then in prone. Every effort was made to see for any echogenic calculus with acoustic shadowing within the renal pelvicalyceal systems or ureters or within the bladder. Ureter if dilated on the symptomatic side was traced upto the level of obstruction. If a ureteric calculus is seen, then their size, number and location would be evaluated. Doppler ultrasound was also performed to look for twinkling artifact, assess resistivity index and ureteric jets. The radiologist performing the ultrasound was blinded to the results of CT examination. The findings of ultrasonography were compared with that of CT-scan findings. Appropriate statistical analysis was done using latest version of SPSS software to evaluate the sensitivity, specificity, positive and negative predictive value of grey scale ultrasound combined with Doppler in the detection of ureteric calculi when compared with CT-scan.

RESULTS

A total of 80 patients with acute abdominal pain and/or hematuria were included in this study. The youngest patient in our study was 5 years old and the oldest was 70 years of age. A definite male predominance with a male: female ratio of 3: 1 was observed. Most patients in the present study were under the age group 21 – 30 years (41 patients) accounting for 51% of the study group [Table/Fig-1]. The study group comprised of 56 males and 24 females (n = 80). The commonest presenting symptoms were abdominal pain (100%) and hematuria (38%). The commonest accompanying symptoms were that of disturbed sleep and difficulty in micturation. Out of 80 patients 25 complained of disturbed sleep due to pain [Table/Fig-2].

Out of the 80 patients in the present study, ultrasonography showed ureteric calculus in about 74 patients. In 30 out of 74 cases the calculus was situated in the pelvi–ureteric junction. In 22 cases it was seen in the proximal ureter. In 10 cases it was seen in the vesicoureteric junction. In 8 cases the calculi was in mid ureter and in 4 cases it was in distal ureter. In majority of cases (41%) ureteric calculi was identified in the pelvi-ureteric junction by ultrasonography [Table/Fig-3].

Age group (in years)	Males	Females	Total	Percentage
0-10	1	-	1	1%
11-20	4	2	6	8%
21-30	25	16	41	51%
31-40	5	2	7	9%
41-50	8	3	11	14%
51-60	10	1	11	14%
61-70	3	-	3	4%
Total	56	24	80	

[Table/Fig-1]: Age & sex distribution.

Symptoms	No. of Patients	Percentage
Abdominal pain	80	100%
Hematuria	30	38%
Back pain	10	13%
Difficulty in micturation	15	19%
Fever	10	13%
Disturbed sleep	25	31%
Signs		
Tenderness	80	100%
Guarding & Rigidity	15	19%
Raised body temperature	20	25%
Tachycardia	35	44%
Pallor	22	28%

[Table/Fig-2]: Presenting symptoms and signs.

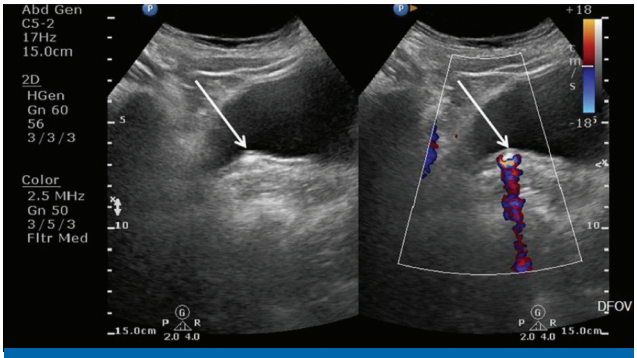
In all the 74 cases, the calculus was unilateral. No case of bilateral ureteric calculi was recorded among the study group. Most of the cases (46 cases), the affected side was right side. In all the 74 cases, it was single ureteric calculus [Table/Fig-4]. 70 out of 80 patients in this study showed renal enlargement. In this study, all the 80 patients had hydronephrosis. Twinkling artifacts were seen in about 95% of cases [Table/Fig-5]. Co–existent renal calculi were seen in 30 cases (38%). Posterior acoustic shadowing due to calculi was seen in 81% cases [Table/Fig-6]. Increased resistivity index was seen in 30 (38%)

Location of Calculus	No. of Cases 74	Percentage
Pelvi-ureteric Junction	30	41 %
Proximal Ureter	22	30 %
Mid Ureter	8	11%
Distal Ureter	4	5%
Ureterovesical Junction	10	14 %

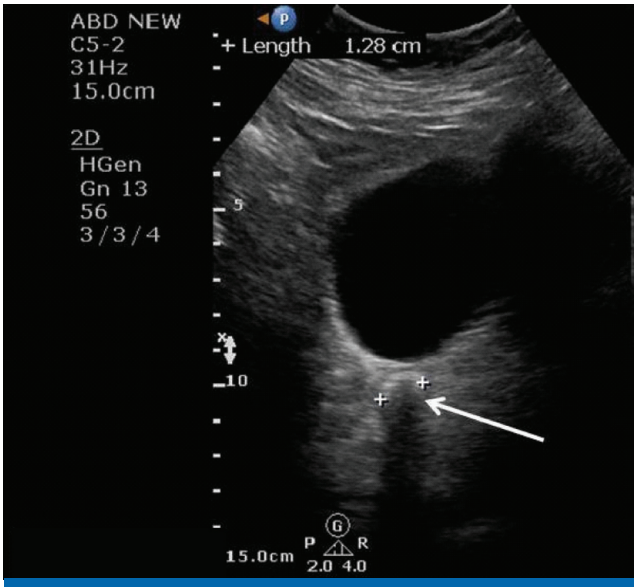
[Table/Fig-3]: Ultrasonography findings.

Sl. No.	Ureteric Calculi	No. of Cases (n=74)	Percentage
1.	**Side**		
	Right	46	62%
	Left	28	38%
	Unilateral	74	100%
	Bilateral	-	-
2.	**Number**		
	Single ureteric calculus	74	100%
	Multiple ureteric calculi	-	-
3.	**Size**		
	<3mm size	12	16%
	>3mm size	62	84%
4.	**Urinary Obstruction (n=80)**		
	Complete obstruction	15	19%
	Partial obstruction	65	81%

[Table/Fig-4]: Characteristics of ureteric calculi as per ultrasonography.



[Table/Fig-5]: Ultrasound image showing right vesicoureteric junction calculus with twinkling artifact (white arrows).



[Table/Fig-6]: Ultrasound image showing right lower ureteric calculus with posterior acoustic shadowing (white arrow).

and absent ureteral jet on the side of obstruction was seen in 15 (19%) [Table/Fig-7].

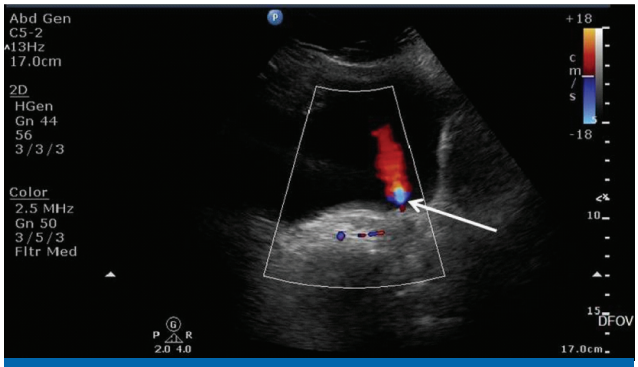
Out of the six cases in which ultrasound could not detect ureteric calculi, four had small sized calculi of 2 to 3mm and two patients were obese. Even in those cases there were signs of obstruction like hydronephrosis, absent ureteric jet and increased resistivity index in intrarenal arteries. Of these 6 cases, 4 cases had midureteric calculus and 2 had calculus in proximal ureter [Table/Fig-8]. Of these six cases, all cases showed hydroureteronephrosis, two cases showed raised intrarenal resistivity index and 3 cases showed presence of ureteric jet indicating partial obstruction [Table/Fig-9].

Sl. No.	Associated Findings	No. of Cases (n=80)	Percentage
1.	Hydronephrosis	80	100 %
2.	Renal enlargement	70	88 %
3.	Posterior acoustic shadowing	60 (n=74)	81%
3.	Co-existent renal calculi	30	38 %
4.	Ureteral dilation	80	100 %
5.	Twinkling artifacts	70 (n=74)	95%
6.	Perirenal fluid collection	10	13 %
7.	Increased RI in intra renal vessels	30	38%
8.	Absent ureteric jet on affected side.	15	19 %

[Table/Fig-7]: Associated findings in ureteric calculi detected by ultrasonography.

Sl. No.	Site of Ureteric Calculus	USG No. of Cases	CT No. of Cases
1.	Pelviureteric Junction (PUJ)	30	30
2.	Proximal ureter	22	24
3.	Mid ureter	8	12
4.	Distal ureter	4	4
5.	Vesicoureteric junction	10	10

[Table/Fig-8]: Correlation of ultrasound findings with CT-KUB (n=80).



[Table/Fig-9]: Ultrasound image showing normal ureteric jet on left side in a patient with left upper ureteric calculus indicating partial obstruction (white arrow).

The overall sensitivity, specificity, positive predictive value and negative predictive value for detection of ureteric calculi by ultrasound were found to be 92.5 % (95% CI: 83.8 - 96.9 %), 100 % (95% CI: 94.2 – 100 %), 100%(95% CI: 93.8-100%) and 93% (95% CI: 84.8 -97%) respectively [Table/Fig-10].

	Calculi Absent	Calculi Present
Test positive	0	74
Test negative	80	6
Total	80	80

[Table/Fig-10]: Calculation of sensitivity, specificity, PPV and NPV for detection of ureteric calculi by ultrasound when correlated with CT-KUB.

DISCUSSION

Ultrasound is a simple inexpensive investigation which requires neither radiographic contrast media nor ionizing radiation. Gray scale ultrasound provides anatomic information regarding obstruction and also the level and cause of obstruction. Doppler ultrasound can provide physiologic and functional data regarding obstruction [9]. Although non-contrast CT has higher sensitivity and specificity for diagnosing ureteral stones, it always carries risk of ionizing radiation, slightly expensive and not freely available [1].

Presence of echogenic calculus is the direct sign of ureteric calculi on ultrasound which was seen in 74 out of 80 cases in our study. Posterior acoustic shadowing which is a sign of calculi was seen in 81% of ureteric calculus in our study. The most important indirect signs of ureteric obstruction in renal ultrasonography are intrarenal and ureteral dilatation. Separation of central renal sinus echoes by anechoeic structures that can be connected is characteristic of collecting system dilatation and is referred to as “hydronephrosis.” It is well recognized that all dilated renal collecting systems are not obstructed. Because ultrasound relies purely on identification of collecting system dilation, false positive studies can be frequent. Causes for a false positive study include an extrarenal pelvis, prominent renal vasculature, residual dilation as a result of vesicoureteric reflux, congenital megacalices, papillary necrosis, pyelonephritis, distended urinary bladder and other rarer causes [9-12]. Even if a dilated collecting system is owing to an anatomical ureteric obstruction, the degree of dilation does not determine whether the obstruction is functionally significant. Addition of Doppler ultrasound can overcome some of these false positive cases. Doppler usage has been applied to 3 main situations 1, Differentiation of central vasculature from the collecting system 2, Evaluation of ureteral patency by Doppler analysis of ureteral jets 3, Identifying functionally significant obstruction by detection of increased intrarenal arterial resistance [9]. Distinguishing vessels from a mildly dilated collecting system is important because even mild dilation in the proper clinical setting may indicate true obstruction. Another use of Doppler analysis in the evaluation of possible obstruction is assessment of ureteral jets. When a ureter is patent, a jet of urine can be detected within the urinary bladder near the ureterovesical junction. Identification of a ureteral jet implies ureteral patency or at least absence of complete obstruction. Examinations of ureteral jets can be time consuming and are operator and experience dependent. In our study, ureteric jet was absent on the affected side in about 15 cases. Absence of ureteric jet on affected side strongly correlates with high grade obstruction [13]. Twinkling artifacts which is a color-flow artifact seen as a rapidly changing color encoding behind a strongly reflecting structure were seen in 95% of cases, making it the most important sign of calculi in our study [14].

Doppler assessment of intrarenal arterial resistance may be a marker for significant obstruction. Many investigators believe that hemodynamic changes are central to renal damage from obstruction. To characterize intrarenal Doppler waveform, most investigators have used the resistivity index (RI). Obstruction can produce an elevated RI. Normal intrarenal RI value upper limit is 0.7. This can be applied in case of ureteric calculi obstruction. In the current study, RI was seen elevated in 30 out of 80 cases. The intrarenal resistivity index should not be interpreted in isolation as normal indices do not rule out the absence of obstruction [15].

False negative cases (obstruction but no collecting system dilation) are less common. Causes include very early acute obstruction, hypovolemia, dehydration, retroperitoneal metastasis and retroperitoneal fibrosis [9]. In our study, collecting system and ureteric dilatation was present in all cases and no false positive cases were encountered. Six cases of ureteric calculi which were missed by ultrasound also showed hydroureteronephrosis and other indirect evidence of obstruction in Doppler ultrasound. In our study we encountered most commonly single ureteric calculus which was most often seen on right side. We did not encounter a single case of multiple ureteric calculi and calculi smaller than 3mm were less common in our study.

Ultrasonography was able to pick up the echogenic ureteric calculi on the symptomatic side in most of the cases in our study. Addition of Doppler ultrasound also increased the sensitivity and specificity of ureteric calculi detection by twinkling artifact assessment, measurement of resistivity index and ureteric jet assessment. The overall sensitivity, specificity, positive predictive value and negative predictive value for detection of ureteric calculi by ultrasound were found to be 92.5 %, 100 %, 100% and 93% respectively in our study. In our study only direct visualization of ureteric calculi was considered to be positive study. The study done by Patlas M et al., [16] showed sensitivity and specificity of 93% and 95% for diagnosing ureteric calculi in ultrasound with sensitivity correlating with our study and specificity slightly more in our

study. In the study done by Park et al., [17] the sensitivity and specificity for diagnosing ureteric calculi was found to be 98.3% and 100 % with specificity correlating with our study and sensitivity slightly more than that of our study.

LIMITATIONS

The limitations of this study is small sample size, further studies with larger sample size can accurately assess the sensitivity of ultrasound in diagnosing ureteric calculi.

CONCLUSION

Dedicated ultrasounds with Doppler are very effective in diagnosis and follow-up of ureteric calculi and most of these patients can avoid CT, thereby reducing the chance of radiation exposure. Present ultrasound machines with advanced technology have improved the sensitivity and specificity of ultrasound in detecting ureteric calculi.

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