Diagnostic Accuracy of Ultrasound and Plain X-Ray KUB (Kidney, Ureter, Bladder) Compared to Non-Contrast CT (Computed Tomography) in Patients of Ureteric Calculi

N. Imdad Ali[1], Noor Elahi Pasha[2], Ravishankar T.H.S.[3]

[1, 2, 3] Department of Urology, Vijayanagar Institute of Medical Sciences, Bellary, Karnataka, India.

ABSTRACT

BACKGROUND

Imaging plays a major role in the diagnosis and management of patients with urolithiasis. Non-Contrast Computed Tomography (NCCT) is generally accepted as the gold standard, but there are concerns over higher radiation exposure from NCCT to the patient population. Our prospective study compared the diagnostic accuracy of plain X-ray KUB (Kidney, Ureter, Bladder) and USG (Ultrasonography) with NCCT in the evaluation of patients with ureteric colic.

METHODS

This study conducted from December 2018 to January 2020 in the Department of Urology, Vijayanagar Institute of Medical Sciences, and attached Hospital. 230 patients with ureteric colic were evaluated for ureteric calculi with x-ray KUB, USG (Ultrasonography) abdomen and pelvis and NCCT (Non-Contrast Computed Tomography) KUB region.

RESULTS

Out of 230 patients, 168 (73 %) were males and 62 (26.9 %) were females. Ages of the study population ranged from 18 to 55 yrs. 198 of the 230 patients were confirmed to have ureteric calculus, with lower ureteric calculus 97 (48.9 %), upper ureteric 65 (32.8 %), middle ureteric 29 (14.6 %), and multiple 7 (3.5 %). X-ray and USG (Ultrasonography) group yielded a sensitivity of 86.3 %, a specificity of 87.5 %, positive predictive value 97 %, and negative predictive value 51 %. While On NCCT (Non-Contrast Computed Tomography), a total of 192 patients (96 %) demonstrated ureterolithiasis of the 198 patients confirmed to have ureteric calculi (Table 2). X-ray and USG group yielded a sensitivity of 96.9 %, specificity of 93.6 %, positive predictive value 98.9 %, and negative predictive value 83 %.

CONCLUSIONS

Combination of x-ray KUB and USG, and NCCT were found to be excellent imaging modalities for the detection of ureteric calculi. X-ray KUB and USG can be used as the first investigation of choice for patients with ureteric colic and for follow up of patients after treatment.

KEYWORDS

Ureteric Colic, Ureterolithiasis, Ultrasonography

Corresponding Author:
Dr. Ravishankar T.H.S.,
Department of Urology,
Vijayanagar Institute
of Medical Sciences,
Bellary, Karnataka, India.
E-mail: raviths@yahoo.com

DOI: 10.18410/jebmh/2020/567

How to Cite This Article:
Ali NI, Pasha NE, Ravishankar THS. Diagnostic accuracy of ultrasound and plain X-ray KUB (kidney, ureter, bladder) compared to non-contrast CT (computed tomography) in patients of ureteric calculi. J Evid Based Med Healthc 2020; 7(47), 2762-2766. DOI: 10.18410/jebmh/2020/567

Submission 25-08-2020,
Peer Review 04-08-2020,
Acceptance 12-10-2020,
Published 23-11-2020.

BACKGROUND

Ureteric calculi, one of the most painful urologic disorders, are very commonly seen in OPDs (Out Patient Department) and emergencies,[1] with its increasing prevalence, they are imposing a significant economic burden for both developing and developed nations The occurrence of renal stone is usually believed to be due to crystallization of minerals inside the urine, which act as the nidus for more sedimentation and finally the formation of a stone within the kidney.[1] Imaging plays a major role in the diagnosis and management of patients with urolithiasis.[2] Non-Contrast Computed Tomography (NCCT) is generally accepted as the gold standard among the commonly used imaging modalities because of its high sensitivity as well as specificity,[3,4] shorter examination time, avoidance of iv contrast medium and increased detection of abnormalities unrelated to ureteral stones. However, lately, there are concerns over higher radiation exposure from NCCT to the patient population.[5,6] Plain x-ray KUB lack sensitivity and specificity as radiolucent calculi and other causes of non-calculus obstruction cannot be identified. Differentiation of phleboliths, which are common pelvic calcifications, from urinary tract calculi is not always possible with plain x-ray KUB.[7]

Transabdominal USG (Ultra-Sono-Graphy) despite having lower sensitivity for calculus detection than NCCT has the advantage of universal availability, repeatability, inexpensive, non-invasive, quick, portable, no radiation exposure to the patient, no IV (Intra-Venous) contrast reactions and concerns to the patient and its use and results does not depend on kidney function; hence USG is the first investigation of choice for the initial evaluation of urinary tract symptoms like calculus disease or other urological diseases. Moreover, the avoidance of ionizing radiation makes it attractive screening modality in pregnancy.[8,9] The AUA (American Urological Association) best practice statement and EAU (European Association of Urology) guidelines recommend that plain X-ray KUB and USG should be used for urinary tract stones, especially on follow-up, because both imaging modalities, plain x-ray KUB and USG eliminate the risk of radiation exposure, and the cost compared with NCCT is lower.[4,10] This consideration has led us to evaluate the use of the combination of plain X-ray KUB and transabdominal USG for the diagnosis of patients with ureteric calculi.

Our prospective study compared the diagnostic accuracy of combination of plain X-ray KUB and USG with NCCT in the evaluation of patients with ureteric colic.

METHODS

This study conducted over a period from December 2018 to January 2020 at the Department of Urology, Vijayanagar Institute of Medical Sciences and attached hospital. 230 patients attending out patient department in our department of urology, presenting with signs and symptom of ureteric colic were evaluated for the diagnosis of ureteric calculi with the use of all three imaging modalities i.e., X-ray KUB, USG abdomen and pelvis and NCCT of KUB region, done on the same day. All patients with confirmed diagnosis of ureteric calculi on either X-ray KUB with USG group or the NCCT group were subjected to ureteroscopy for confirmation of diagnosis as well as treatment. The study has been approved by the Ethical Committee of the institution.

X-Ray KUB was obtained as digital images in our institution. A single anteroposterior film of the whole urinary tract was obtained with the patient in the supine position, lying on his / her back straight, without any rotation of shoulders, from xiphisternum to lower end of the pubic symphysis in full inspiration to increase the exposure of the organs. No bowel preparation was used. Although, X-rays were taken on an empty stomach with overnight fasting while liquids were allowed, the criteria for diagnosis of ureteric calculi on x-ray KUB was a radiopaque shadow seen in the bilateral ureteric regions or psoas areas.

USG of the abdomen and pelvis was performed using grayscale sonography (Toshiba SSA550A, Toshiba Medical Systems, Tokyo, Japan) with a 3.5-MHz convex transducer. All USG examinations were performed by a consultant radiologist of our institute, who was blind to the study. Patients were examined in an empty stomach with overnight fasting and full urinary bladder in the supine position. Complete evaluation of kidney, ureter, bladder region and whole abdomen and pelvis was done and all abnormalities noted relating to urology and non-urological conditions. The criteria for diagnosis of ureteral calculi on USG required the demonstration of an intraluminal hyperechoic structure causing acoustic shadowing, mere presence of hydronephrosis or perinephric collection was not taken as a confirmed diagnosis of ureteric calculi. The presence of hydronephrosis and perinephric fluid were also noted.

NCCT (Toshiba Aquilion ONE 640, Toshiba Medical Systems, Tokyo, Japan) was performed from the upper abdomen to the pelvis with images reconstructed at 1- to 2-mm intervals. The CT (Computed Tomography) examinations were reviewed by a consultant radiologist of our institute, who was blind to the study, patients were examined on an empty stomach with full bladder in supine position after explaining the procedure to the patients, and were evaluated for the presence of ureteral calculi, perinephric or periureteric stranding, hydronephrosis and all other non-urological abnormalities were also noted. The diagnosis of ureteral calculi was established by clear visualization of a high attenuation structure (greater than 200 Hounsfield units) within the ureteral lumen. Only the presence of the hydronephrosis or perinephric collection which are indirectly suggestive of ureteric calculi were not taken as confirmed diagnosis of ureteric calculi.

All the data obtained from all the three imaging investigation were collected and compiled and compared.

NCCT examinations and ultrasound examination was performed by 2 different consultant radiologists of the Department of Radiology of our institute and both were blinded to the study to avoid bias.

All patients between 18 years to 55 years attending out-patients department of Department of Urology, presenting with signs and symptoms of ureteric colic were included in

the study. Pregnant females and patients suspected of congenital urological anomalies on USG were excluded from the study.

Statistical Analysis

The data values were entered into MS-Excel and statistical analysis has been done by using SPSS Version 19. For categorical variables, the values are expressed as numbers and percentages, and to test the association between the two groups, chi square test as well as the McNemar's test was used. For continuous variables, the values are expressed as mean ± standard deviation, all p-values are having less than 0.05 are considered statistically significant.

RESULTS

Out of 230 patients in our study, 168 (73 %) patients were males and 62 (26.9 %) patients were females. Ages of the study population ranged from 18 to 55 years. 198 of the 230 patients were confirmed to have ureteric calculus based on stone recovery or urological interventions. The majority of patients diagnosed were with lower ureteric calculus 97 (48.9 %), upper ureteric 6 5 (32.8 %), middle ureteric 29 (14.6 %), and multiple 7 (3.5 %) as shown in the Table 1. The mean stone size of ureteric calculus was 7.6 mm.

Pathology unrelated to urinary stones was demonstrated in 36 patients and included appendicitis, cholelithiasis, cholecystitis, diverticulitis, cystitis, PID (Pelvic Inflammatory Disease), adnexal mass, ovarian cyst. All of these conditions were detected by USG and NCCT. X-ray and USG group demonstrated ureterolithiasis in 171 of 198 patients (83 %) confirmed to have ureteral calculi (Table 1). The X-ray and USG group yielded a sensitivity of 86.3 %, a specificity of 87.5 %, positive predictive value of 97 %, and negative predictive value of 51 % as shown in table 2 and table 3.

While on NCCT, a total of 192 patients (96 %) demonstrated ureterolithiasis, of the 198 patients confirmed to have ureteric calculi (Table 2). The X-ray and USG group yielded a sensitivity of 96.9 %, specificity of 93.6 %, positive predictive value of 98.9 %, and negative predictive value of 83 % as shown in Table 2 and 3.

Location of Calculi in Ureter	Number of Patients	Percentage of Patients
Upper Ureter	65	32.8 %
Middle Ureter	29	14.6 %
Lower Ureter	97	48.9 %
Multiple Calculi	7	3.5 %

Table 1. Location of Calculi in Ureters

	Ureteric Calculi Positive	Ureteric Calculi Negative	Percentage
X-Ray KUB and USG			
Positive	171	4	83 %
Negative	27	28	
NCCT			
Positive	192	2	96 %
Negative	6	30	

Table 2. Imaging Results for Ureteric Calculi

KUB (Kidney, Ureter and Bladder); NCCT (Non-Contrast Computed Tomography); USG (Ultrasonography)

Test	Sensitivity	Specificity	PPV	NPV
X-Ray KUB and USG	86.3 %	87.5 %	97 %	51 %
NCCT	96.9 %	93.6 %	98.9 %	83 %

Table 3. Sensitivity, Specificity, PPV, NPV of the Imaging Modalities

KUB (Kidney, Ureter and Bladder); NCCT (Non-Contrast Computed Tomography); NPV (Negative Predictive Value); PPV (Positive Predictive Value); USG (Ultrasonography)

	X-Ray KUB and USG Positive	X-Ray KUB and USG Negative	Total Number of Patients
NCCT Positive	171	23	194
NCCT Negative	4	32	36
Total	175	55	230

Table 4. Comparison between NCCT Group and X-Ray KUB with USG Group for Detection of Ureteric Calculi

Comparing X-ray KUB and USG group with NCCT group for the detection of ureteric calculi against each other, McNemar's test was applied and found to have p-value is 0.000256 (< 0.05) which is statistically significant.

Out of 198 patients confirmed to have ureteric calculus either by stone recovery or by urological intervention, in x-ray KUB and USG group 171 (83 %) patients showed calculus and in NCCT group 192 (96 %) patients were positive for calculus. This difference is statistically significant with a p-value of 0.0007 (< 0.05).

This study showed NCCT to be better than x-ray KUB combined with USG for the detection of ureteric calculi and the difference being statistically significant as the p-value is 0.0007 (< 0.05).

DISCUSSION

The emergency department is a common setting for the initial presentation of patients with ureteric colic. Diagnosis can be suspected without imaging; however, clinicians need to be open to wide differential diagnosis for the patients with severe flank pain.[11] Imaging modalities with high sensitivity say that symptoms might be of an alternative pathology when calculi are not seen and imaging modalities with high specificity demonstrate that a patient's symptoms are related to calculus disease when they are seen on imaging. In addition to diagnosis, initial imaging is the first step in disease management. Broadly available imaging modalities include CT, USG, X-ray KUB, IVU, and MRI. The sensitivity, specificity, positive predictive value, negative predictive value may vary.

Since its introduction in 1923 until around 2000, Intra-Venous Urography (IVU) was considered to be gold standard investigation for diagnosis of calculus disease. However, with the advent of CT scanning, CT is currently considered as the gold standard to imaging modality for the urinary tract.[12] The lack of need for bowel preparation and fasting, faster acquisition of CT, which is shorter than the time required for IVU (Intravenous Urography), were some benefits of CT over IVU,[13] other benefits include less time required for diagnosis, and lack of necessity of intravenous contrast agents for evaluation of urolithiasis, as it is shown that contrast agents carry a 5 - 10 % rate of contrast reactions like anaphylaxis, acute renal failure. Also, CT has

more sensitivity and specificity for many other pathologies relating to urinary tract and is definitely superior to all other imaging techniques for the diagnosis of renal masses, haematuria, and assessment of regional lymph nodes.[14]

Ultrasonography is a safe, low cost, rapidly available, that does not rely on ionizing radiation to the patient for diagnosis of most ureteric calculi and is becoming a primary alternative to NCCT but the accuracy of USG decreases in the mid ureter due to bowels gases and due to many other misleading non-calculus echoes.[15] The advantages of ultrasound include lack of necessity of ionizing radiation to the patients and the risk of radiation hazards, portable, and no requirement of IV contrast material injection to patient and its easy availability and repeatability.[16] Recent studied have shown, the specificity of ultrasound can vastly improve just with the addition of Doppler studies to it by looking at resistive indices and the sensitivity.[16] However, the limitation of ultrasound includes poor ureter visualization in obese patients. Plain X-ray KUB lacks sensitivity and specificity, as radiolucent calculus and obstruction due to non-calculus cause are not differentiated, phleboliths, and other pelvic and abdominal calcifications, are not always easily differentiated from urinary tract calculi.[7] This is a commonly occurring phenomenon and as a compensation for this, USG and KUB x-ray can be performed in conjunction, and hence enabling the higher sensitivity of USG for calculi to augment the higher specificity of x-ray KUB,[8.] NCCT is now the gold standard investigative imaging modality for the detection of urinary calculus disease.[1]

The present study was conducted to compare X-ray KUB done together with USG with an NCCT scan in the diagnosis of ureteric calculi for patients presenting with ureteric colic. The current study shows that the incidence of ureteric calculus is higher in males as compared to females (2.7:1). This is higher than most of the studies done previously, Yan et al (1.55:1), Edmonds et al (1.14:1), and Kobayashi et al (1.68:1).[17,18,19]

The location of ureteric calculus was most common in the lower ureter 97 (48.9 %), upper ureter 65 (32.8 %), middle ureter 29 (14.6 %), and multiple calculi in 7 (3.5 %). The mean stone size of ureteric calculus was 7.6 mm which was comparable to most of these studies.

Our study of diagnostic accuracy for ureterolithiasis that was performed showed that ultrasonography had lower sensitivity and specificity compared to NCCT: the sensitivity was 86.3 %, specificity was 87.5 %, and the sensitivity and specificity for NCCT were 96.9 % and 93.6 % respectively. Dalla Palma et al[20] evaluated 120 patients with renal colic using the USG and plain x-rays and achieved 95 % sensitivity but 67 % specificity; in this study they have classified USG as the positive for ureteric calculi when either ureteric calculi were seen or hydronephrosis was present. However, in our study, only cases with a definite demonstration of ureteral calculi with intraluminal hyper echogenicity with acoustic shadowing and not just hydronephrosis were classified as positive and hence, our results have higher specificity of 87.5 % comparing to this study of Dalla Palma et al[20] stating only 67 % sensitivity in detecting ureteric calculi.

Miller et al[21] in his study has demonstrated unenhanced spiral CT has 96 % sensitivity and 100 % specificity. Similarly, our study also shows NCCT to be 96.9 % sensitive in detecting ureteric calculi. Other studies with similar sensitivity and specificity are mentioned in Table 5.

Name of the Study	Sensitivity	Specificity
Smith et al, 1996[1]	97 %	96 %
Dalrymple et al, 1998	95 %	98 %
Miller et al, 1998[21]	95 %	98 %
Our study	96 %	93 %

Table 5. Comparing Sensitivity and Specificity of NCCT

In our study NCCT shows better sensitivity and specificity compared to the combination of x-ray KUB and USG, but both are excellent modalities for the diagnosis of ureteric calculi. Detection of ureteric calculi by NCCT is better (96.9 %), compared to x-ray KUB and USG (83 %) which is statistically significant. Hence NCCT is better than x-ray KUB and USG, but x-ray and USG are alternatives where NCCT is not available, when cost is a factor, or when radiation exposure is not desirable. X-ray KUB and USG can be used as first line investigation for patients with ureteric colic presenting in emergencies.

CONCLUSIONS

The combination of x-ray KUB and USG, and NCCT were found to be excellent imaging modalities for the detection of ureteric calculi; both show great sensitivity and specificity in the detection of ureteric calculi. NCCT is considered to be the gold standard investigation for the diagnosis of ureteric calculi because of its better imaging quality, avoidance of IV contrast medium injection, objective evidence of calculi, better sensitivity, and positive predictive value. But because of its sparse availability, high cost, high dose of radiation exposure associated with it, with risk of radiation hazard to the patient, USG with x-ray KUB is an excellent imaging modality for the diagnosis of ureteric calculi as they are less costly, readily available, no ionizing radiation exposure, and easy repeatability. We would suggest x-ray KUB and USG to be used as the first investigation of choice for patients presenting with signs and symptoms of ureteric colic in emergencies and for follow up of patients of ureteric calculi after surgical and medical treatment.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

REFERENCES

[1] Smith RC, Rosenfield AT, Choe KA, et al. Acute flank pain: comparison of non-contrast-enhanced CT and

intravenous urography. Radiology 1995;194(3):789-794.
[2] Dhar M, Denstedt JD. Imaging in diagnosis, treatment, and follow-up of stone patients. Advances in Chronic Kidney Disease 2009;16(1):39-47.
[3] Worster A, Preyra I, Weaver B, et al. The accuracy of non-contrast helical computed tomography versus intravenous pyelography in the diagnosis of suspected acute urolithiasis: a meta-analysis. Annals of Emergency Medicine 2002;40(3):280-286.
[4] Turk C, Knoll T, Petrik A, et al. Guidelines on Urolithiasis. Eur Urol 2014;14:1102-1106.
[5] Chen TT, Wang C, Ferrandino MN, et al. Radiation exposure during the evaluation and management of nephrolithiasis. Journal of Urology 2015;194(4):878-885.
[6] Denton E, Mackenzie A, Greenwell T, et al. Unenhanced helical CT for renal colic - is the radiation dose justifiable? Clinical Radiology 1999;54(7):444-447.
[7] Koelliker SL, Cronan JJ. Acute urinary tract obstruction. Urologic Clinics of North America 1997;24(3):571-582.
[8] Fulgham PF, Assimos DG, Pearle MS, et al. Clinical effectiveness protocols for imaging in the management of ureteral calculous disease: AUA technology assessment. Journal of Urology 2013;189(4):1203-1213.
[9] Shokeir AA. Renal colic: new concepts related to pathophysiology, diagnosis and treatment. Current Opinion in Urology 2002;12(4):263-269.
[10] Pearle MS, Goldfarb DS, Assimos DG, et al. Medical management of kidney stones: AUA Guideline. Journal of Urology 2014;192(2):316-324.
[11] Fwu CW, Eggers PW, Kimmel PL, et al. Emergency department visits, use of imaging and drugs for urolithiasis have increased in the United States. Kidney International 2013;83(3):479-486.
[12] Hale Z, Hanna E, Miyake M, et al. Imaging the urologic patient: the utility of intravenous pyelogram in the CT scan era. World J Urol 2014;32(1):137-142.
[13] Masarani M, Dinneen M. Ureteric colic: new trends in diagnosis and treatment. Postgrad Med J 2007;83(981):469-472.
[14] Lim GS, Jang SH, Son JH, et al. Comparison of non-contrast-enhanced computed tomography and intravenous pyelogram for detection of patients with urinary calculi. Korean J Urol 2014;55(2):120-123.
[15] Gavant ML. Low-osmolar contrast media in the 1990s. Investigative Radiology 1993;28:13-19.
[16] Wu T, Duan X, Chen S, et al. Ureteroscopic lithotripsy versus laparoscopic ureterolithotomy or percutaneous nephrolithotomy in the management of large proximal ureteral stones: a systematic review and meta-analysis. Urol Int 2017;99(3):308-319.
[17] Edmonds ML, Yan JW, Sedran RJ, et al. The utility of renal ultrasonography in the diagnosis of renal colic in emergency department patients. Canadian Journal of Emergency Medicine 2010;12(3):201-206.
[18] Kobayashi T, Nishizawa K, Watanabe J, et al. Clinical characteristics of ureteral calculi detected by nonenhanced computerized tomography after unclear results of plain radiography and ultrasonography. Journal of Urology 2003;170(3):799-802.
[19] Yan JW, McLeod SL, Edmonds ML, et al. Normal renal sonogram identifies renal colic patients at low risk for urologic intervention: a prospective cohort study. Canadian Journal of Emergency Medicine 2015;17(1):38-45.
[20] Dalla PL, Stacul F, Bazzocchi M, et al. Ultrasonography and plain film versus intravenous urography in ureteric colic. Clin Radiol 1993;47(5):333-336.
[21] Miller OF, Rinner SK, Reichard SR, et al. Prospective comparison of unenhanced spiral computerized tomography and IVU in the evaluation of acute flank pain. Urology 1998;52(6):982-987.