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Original Research Article

The role of CT urogram and ultrasonogram in the evaluation of calculus obstructive uropathy

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ABSTRACT

Background: Obstructive uropathy is a critical condition that requires prompt diagnosis, with imaging techniques like ultrasound and multidetector CT playing essential roles in evaluating urinary tract obstruction. The purpose of this study is to assess the effectiveness of CT urogram and ultrasonogram (USG) in diagnosing calculus obstructive uropathy. The aim of the study was to evaluate the effectiveness of CT USG in diagnosing calculus obstructive uropathy.

Methods: This cross-sectional study was conducted at the Department of Radiology and Imaging, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, from January to December 2018. It included 45 adult patients with clinically suspected calculus obstructive uropathy referred for USG and CT urogram. Imaging findings, including stone size, location, and hydronephrosis, were recorded, with CT urogram as the reference standard. Data were analyzed using SPSS to assess diagnostic accuracy, sensitivity, specificity, and predictive values.

Results: The study of 45 patients, mostly male with a mean age of 35.8 years, found CT more effective than USG in diagnosing calculus obstructive uropathy. CT detected stones in 75% of patients with a sensitivity of 93.75% and specificity of 100%, whereas USG detected stones in 57.5% with a sensitivity of 61.29% and specificity of 88.88%. CT demonstrated superior diagnostic accuracy compared to USG.

Conclusions: Unenhanced CT KUB shows higher diagnostic accuracy than USG in evaluating calculus obstructive uropathy, providing essential information for timely and accurate management.

Keywords: CT urogram, Ultrasonogram, USG, Calculus obstructive uropathy, Imaging techniques

INTRODUCTION

Obstructive uropathy is a critical clinical condition that requires prompt diagnosis by both nephrologists and urologists. The approach to urinary tract imaging in cases of obstruction has advanced over time. In the past, the intravenous urogram (IVU) was the standard method for evaluating acute urinary tract obstruction.[1] However, nowadays, ultrasound or computed tomography (CT) scans are typically the first-line imaging techniques used in most healthcare settings.

Ultrasound has become a key tool in assessing renal obstruction, especially with advancements such as Doppler interrogation to evaluate renal blood flow and color Doppler imaging to detect urine flow into the bladder. Ultrasound (USG) is widely available, cost-effective, safe, rapid, non-invasive, and free from radiation, making it a preferred investigative modality.

Meanwhile, multidetector CT (MDCT) offers the advantage of obtaining thin, sub-millimeter collimated images of the entire urinary tract in a single, brief breath hold. These high-resolution images provide greater spatial detail, making CT the preferred diagnostic method for obstructive uropathy.[2]

A variety of imaging studies are available to assess patients with potential urinary tract obstruction, with the choice of test depending on the acuity of the obstruction, as well as the patient's age and renal function. In non-acute cases, where obstruction is suspected based on rising serum creatinine, medical history, or previous urinary tract abnormalities, ultrasound is typically used as the initial screening tool.[3] If the ultrasound shows no significant hydronephrosis or hydroureter, it is generally concluded that the patient does not have substantial obstruction.

If ultrasound reveals hydronephrosis or hydroureter, additional studies are conducted to identify the location and cause of the obstruction. In adults, intravenous pyelography (IVP) is commonly used to pinpoint the site of obstruction and, ideally, to determine its cause.

The management of acute renal colic has evolved in recent years, with non-contrast spiral CT now being the preferred screening tool for flank pain and suspected ureteral stones. This method is faster, more accurate, and also capable of identifying non-urologic causes of pain.[4] Intravenous pyelography (IVP) remains important in diagnosing obstruction, as it allows visualization of filling defects or stones in the renal pelvis or ureter, as well as changes in renal contour and the course of the ureters to determine the level and cause of obstruction. In our department, we accept creatinine values of 1.5 or lower for patients undergoing IVP.[5]

CT is particularly well-suited for detecting obstructing stones and is highly effective in differentiating stones from other potential causes of obstruction, such as blood clots or tumors. Spiral CT scans can identify stones that may not be visible on plain radiographs (KUB) due to factors like stone composition, size, or interference from artifacts such as bowel gas. The diagnosis of a ureteral stone using CT is based on both primary and secondary findings. Secondary findings, such as hydronephrosis, hydroureter, or perinephric fat stranding, have high positive and negative predictive values, helping to confirm the presence or absence of a ureteral stone.

While CT scans detect most stones, including those that are typically visible on plain films, they may miss obstructions caused by non-opaque substances, such as indinavir crystals. In some cases, contrasted CT scans are performed after a spiral (non-contrasted) CT to better define the path of the ureter, especially if there is uncertainty about whether a calcification is within the ureter or a blood vessel.[6] The purpose of the study was to assess the effectiveness of CT urogram and USG in diagnosing calculus obstructive uropathy.

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METHODS

This cross-sectional study was conducted at the Department of Radiology and Imaging, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, in collaboration with the Department of Pathology and the Department of Urology, between January 2018 and December 2018. The study focused on patients with clinically suspected calculus obstructive uropathy referred for USG and CT urogram. A total of 45 participants were included in the study.

Inclusion criteria

Patients aged ≥18 years with clinically suspected obstructive uropathy. Patients referred for USG and CT urogram. Serum creatinine >1.5 mg/dl.

Exclusion criteria

Patients aged <18 years. Uncooperative patients or those who did not provide consent.

Informed written consent was obtained from all participants, ensuring confidentiality and voluntary participation. A structured pre-designed questionnaire was used to collect demographic data (age, sex) and clinical history (e.g., urinary retention, oliguria, abdominal distension). Imaging protocols included CT urogram performed using a SIEMENS SOMATOM DEFINITION 128-slice CT scanner with non-contrast imaging of the kidney, ureter, and bladder (KUB) region (16×0.625 mm collimation, 1–2 mm slice thickness, pitch of 1.75), and ultrasonography (USG) conducted using a VOLUSON 730 Pro ultrasound scanner with a 5–7.5 MHz linear transducer. Patients were positioned prone, and calculi were identified by direct visualization within the ureteric lumen, with or without associated hydronephrosis. Imaging findings (stone size, location, hydronephrosis) were recorded for USG and CT urogram, with final diagnosis confirmed by CT urogram in all cases.

Statistical analysis

Data were analyzed using SPSS (Statistical Package for the Social Sciences), with sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy calculated for each modality. Continuous variables were presented as means with standard deviations, and categorical variables as counts with percentages, considering a p-value <0.05 statistically significant. The study protocol was approved by the

Institutional Review Board (IRB) of Bangabandhu Sheikh Mujib Medical University (BSMMU), and confidentiality of patient data was maintained throughout the study.

RESULTS

The study included a total of 45 patients, with an age range of 21 to 62 years. The mean age of the participants was 35.8±17.9 years. The largest proportion of patients (30.0%) were in the 41–50 years age group, followed by 31–40 years (20.0%), 51–60 years (22.5%), 21–30 years (17.5%), and those above 60 years (10.0%). In terms of gender distribution, 26 patients (57.8%) were male, while 19 patients (42.2%) were female. Table 2 shows that on USG, 25 (57.5%) patients had calculus detected. Stone in Kidney or PUJ were detected in 20% of the patients, while stones in the ureter or urinary bladder were detected in 37.5% of the patients. The presence of hydronephrosis or hydroureter was observed in 20 (50%) patients. The mean size of the stones detected on USG was 7.6±4.1 mm.

Table 1: Demographic characteristics of the study subjects (n=45).

Variable		Number of patients	Percentage
Age (in years)	21-30	8	17.5
	31-40	9	20.0
	41-50	13	30.0
	51-60	10	22.5
	>60	5	10.0
	Mean ± SD	35.8 ± 17.9	
	Range (minimum-maximum)	(21-62)	
Gender	Male	26	57.8
	Female	19	42.2

Table 2: USG findings in patients (n=45).

Findings	USG	
	Number	Percentage
Stones present	25/45	57.5
Stone in kidney or PUJ	8	20.0
Stone in ureter	11	27.5
Stone in bladder	4	10.0
Presence of hydronephrosis	11	27.5
Presence of hydroureter	9	22.5
Ureteric wall thickening	2	5.0
Mean size of stone detected	7.6 mm ± 4.1	

Table 3: CT findings in patients (n=45).

Findings	USG	
	Number of patients	Percentage
Stones present	36/45	75.0
Number of stones	42	0.0
Stones per patient	1.9	0.0
Stone in kidney or PUJ	15	37.5
Stone in ureter	13	32.5
Stone in bladder	2	5.0
Presence of hydronephrosis	15	37.5
Presence of hydroureter	13	32.5
Ureteric wall thickening	4	10.0
Mean size of stone detected	4.2 mm ± 0.4 mm	

Table 3 shows that on CT, stones were detected in 36 out of 45 patients (75.0%). The total number of stones identified was 42, with an average of 1.9 stones per patient. Stones were located in the kidney or PUJ in 15 patients (37.5%), in the ureter in 13 patients (32.5%), and in the bladder in 2 patients (5.0%). Hydronephrosis was present in 15 patients (37.5%), while hydroureter was observed in 13 patients (32.5%). Ureteric wall thickening was noted in 4 patients (10.0%). The mean size of stones detected on CT was 4.2±0.4 mm.

Table 4: Diagnostic accuracy of USG and CT KUB.

Final diagnosis				
		Positive	**Negative**	**Total**
Final results on USG	Positive	23 (TP)	02 (FP)	25
	Negative	12 (FN)	08 (TN)	20
	Total	35	10	45
Final results on CT	Positive	35 (TP)	00 (FP)	35
	Negative	02 (FN)	08 (TN)	10
	Total	37	8	45

Table 4 compares the diagnostic accuracy of USG and CT KUB. For USG, 23 true positives, 2 false positives, 12 false negatives, and 8 true negatives were identified, resulting in 35 positive and 10 negative diagnoses. CT KUB showed 35 true positives, 0 false positives, 2 false negatives, and 8 true negatives, resulting in 37 positive and 8 negative diagnoses. CT KUB demonstrated higher accuracy with no false positives compared to USG.

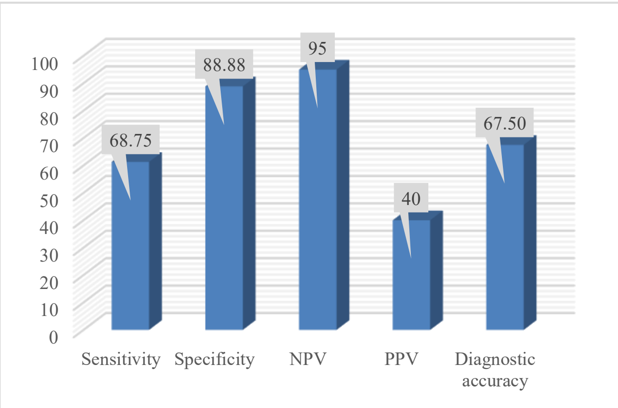

Figure 1: Sensitivity, specificity, and predictive values of USG in evaluating calculus obstructive uropathy.

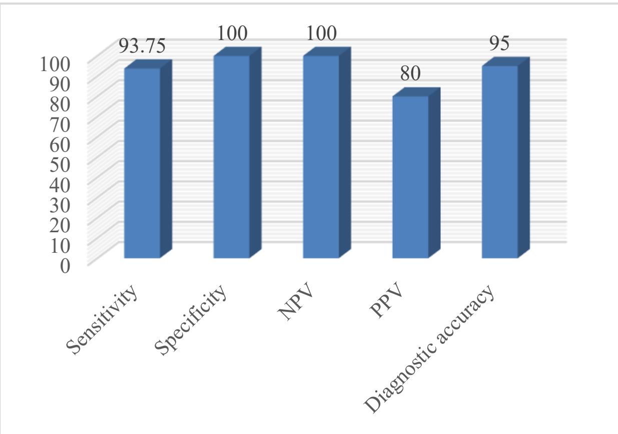

Figure 2: Sensitivity, specificity, and predictive values of CT in evaluating calculus obstructive uropathy.

Figure 1 shows that the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of USG in evaluating calculus obstructive uropathy were 68.75%, 88.88%, 95%, 40%, and 67.5%, respectively.

Figure 2 shows that the sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of CT in evaluating calculus obstructive uropathy were 93.75%, 100%, 100%, 80%, and 95%, respectively.

Figure 3 shows that CT is more sensitive and specific than USG in evaluating calculus obstructive uropathy.

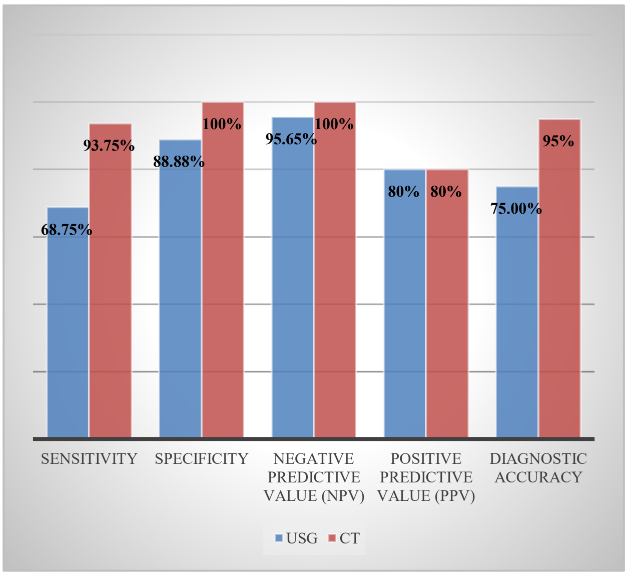

Figure 3: Comparison of sensitivity, specificity, and predictive values of USG and CT in evaluating calculus obstructive uropathy.

DISCUSSION

Imaging plays a crucial role in diagnosing, managing, and monitoring urolithiasis. Urologists have historically relied on various imaging techniques, such as plain radiography of the kidneys, ureters, and bladder (KUB), intravenous urography (IVU), ultrasound (US), magnetic resonance urography (MRU), and computed tomography (CT), each offering distinct benefits and limitations. Non-enhanced helical CT has proven highly sensitive for detecting genitourinary calculi and is considered by many to be the preferred imaging modality for evaluating renal colic and renal stone disease.

In this present study, the proportion of male patients has been observed to be quite high (57.8% vs. 42.2%) compared to some previous studies, which noted a considerably lower rate of female patients. For instance, in the study by Chowdhury et al, the ratio of female patients was very low (27.5% vs. 57.5%) compared to male patients. Similar results were found in a study by Nadeem et al who reported 30% female and 70% male patients.[8] Literature indicates a significantly higher prevalence of urolithiasis in males compared to females.

The common age interval for the occurrence of urolithiasis is between 30 to 60 years. In this study, the largest proportion of patients (30.0%) were in the 41–50 years age group. The mean age was found to be 35.8±17.9 years, with a range from 21 to 62 years.

Yilmaz et al has shown that CT outperforms both ultrasound (US) and intravenous urography in detecting ureteral calculi.[9] In their study, US had a sensitivity of only 19% for detecting ureteral calculi, while non-enhanced CT showed a much higher sensitivity of 94%. Ultrasound offers several advantages as an imaging method, including being cost-effective, non-invasive, and free from ionizing radiation, with the added benefit of being portable for bedside use. However, its sensitivity for evaluating acute renal colic is highly variable, depending on factors such as stone size, the experience of the examiner, and patient conditions. Fowler et al found that US was particularly poor at detecting stones smaller than 4.0 mm.[10] A significant limitation of US is the difficulty in identifying stones within the ureter, as patient body habitus or overlying bowel gas can obscure portions of the ureter. Recent studies have confirmed that non-contrast spiral CT is the preferred imaging modality for detecting ureteral calculi in patients suspected of having renal colic.

In another comparative study, which included 34 patients, Sommer et al reported that reformatted non-contrast spiral CT images were superior to the combination of US and plain abdominal films for detecting ureteral calculi, with sensitivities of 93.75%, 100%, 100%, 80%, and 95% respectively.[11] In our study, a similar comparison was made among spiral CT and US in a group of 45 patients. In accordance with previous reports, spiral CT proved to be the best modality for demonstrating ureteral stones, with a sensitivity of 93.75%, specificity of 100%, positive predictive value of 100%, negative predictive value of 80%, and diagnostic accuracy of 95%. In the study by Smith et al, these figures were 97%, 96%, 96%, and 97%, respectively.[12] The results of both studies show that spiral CT is extremely useful in demonstrating and excluding ureterolithiasis.

In our study, the sensitivity, specificity, positive predictive value, and diagnostic accuracy of US were comparable to those of spiral CT, which suggests that if a ureteral stone is seen on US, then spiral CT may be unnecessary to confirm the diagnosis. However, both US and plain films had a low sensitivity and negative predictive value compared to spiral CT, indicating that they are not ideal for excluding ureterolithiasis. If US results are normal, a ureteral stone cannot be excluded unless spiral CT is performed. The low sensitivity and negative predictive value of US can be explained by the fact that the parts of the ureters between the ureteropelvic junction and the UVJ are difficult to visualize with this technique. Similarly, plain films may not show ureteral stones in many cases, either due to bowel superimposition or insufficient contrast resolution. Spiral CT has the advantage of providing axial images free from superimposition, and its high contrast resolution allows for better visualization of stones.

The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of CT KUB for detecting urolithiasis were noted to be 93.75%, 100%, 100%, 80%, and 95%, respectively. These results are in agreement with the findings of different studies, such as those of Nadeem et al, Ather et al, and Rekant et al, who reported similar sensitivity parameters for CT KUB.[8,13,14]

Our sensitivity exceeded that of another study, which reported a sensitivity of 24% but a slightly higher specificity of 90%. The poor sensitivity and high false negative rates (25%) of USG demonstrated in this study are related to multiple factors, including the lack of acoustic shadowing of the calculus. Other factors include body habitus, transducer power selection, and focal length. The excellent contrast resolution of CTU allows discrimination of slight differences in attenuation, providing better visualization of stones. Furthermore, CTU has the ability to acquire a volume of data that includes the entire urinary system, not just the kidneys. USG may miss stones in some parts of the urinary tract, especially in the ureters. In this study, the false positive rate (FP) for USG was 1 (2.5%), which may have been due to renal vascular calcification.

Regarding the size of renal calculi detected, this study showed that the mean size of calculi detected by USG was 7.6±4.1 mm, comparable to a study that reported a mean size of 7.1±1.2 mm.[10] A previous study showed the mean size of calculi detected by CTU to be 4.2±0.4 mm. Seventy-three percent of calculi not visualized by USG were 3 mm or less in size.[15] In the detection of ureteric calculi, a prospective study in 1998 achieved a sensitivity of 19% and specificity of 97%.[16] Another study in 2007 showed a slightly higher sensitivity of 23% and specificity of 100%.[17] In this study, almost similar results were achieved, with a low sensitivity of 12% and high specificity of 97%. The low sensitivity is attributable to the presence of bowel gas, which commonly obscures the ureters, and to large body habitus, which reduces visibility. The specificity of detecting calculi on ultrasound (USG) is higher in the ureter than in the kidneys. The diagnosis of a ureteral calculus is significantly improved when hydroureter is present, as this condition helps to confirm the presence of an obstruction caused by the stone.

Due to its many advantages, non-contrast enhanced CT is becoming the preferred imaging modality for physicians in emergency response departments. It is favored for its ability to rapidly triage patients in busy emergency settings. However, the increasing prescription of CT tests is also contributing to the rising rate of negative CT results. In this present study, the efficacy of USG was compared with CT KUB for the diagnosis of urolithiasis, and it was observed that the efficacy of CT was extremely high compared to USG. The CT study identified more stones, including smaller ones, some of which did not require immediate intervention but warranted active surveillance.

Limitations of the study

This study was conducted in the Department of Radiology and Imaging at BSMMU, Shahbagh, Dhaka. Therefore, the majority of participants are residents of Dhaka, and as such, the results of this study may not represent the regional distribution of the population. A large-scale study across different areas should be conducted to draw more definitive conclusions. A small sample size was also a limitation of this study. Therefore, future studies with larger sample sizes may be undertaken to strengthen the findings. The present study was conducted over a very short period of time. Other causes of obstructive uropathy (e.g., mass, neoplasm) were not evaluated using the investigation methods.

CONCLUSION

The results of this study reveal that unenhanced CT KUB has higher diagnostic accuracy compared to USG for the diagnosis of calculus obstructive uropathy in suspected patients. CT provides more efficient information about patients presenting with acute renal colic, with significantly higher sensitivity and specificity in diagnosing urolithiasis compared to USG. CT urography has proven to be an essential modality for evaluating urinary tract abnormalities. Considering its diagnostic value, CT has earned a pivotal role in the evaluation of urinary tract disorders, ensuring accurate and timely management for patients with calculus obstructive uropathy.

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