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Comparison of ultrasonography (USG) and non- contrast computed tomography (NCCT) in diagnosing ureteric calculi-a cross sectional study.

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Abstract

The ureters are bilateral thin (3 to 4 mm) tubular structures that connect the kidneys to the urinary bladder, transporting urine from the renal pelvis into the bladder. The muscular layers are responsible for the peristaltic activity that the ureter uses to move the urine from the kidneys to the bladder.

Embryologically, the ureter originates from the ureteric bud, which is a protrusion of the mesonephric duct, a part of the genitourinary system development.

The ureters begin at the ureteropelvic junction (UPJ) of the kidneys, which lie posteriorly to the renal vein and artery in the hilum. The ureters then travel inferiorly inside the abdominal cavity. They pass over (anterior to) the psoas muscle and enter the bladder on the posterior bladder aspect in the trigon.

Three areas along the path of the ureter are clinically significant for renal stones lodging. These areas are: the ureteropelvic junction (UPJ), the ureterovesical junction (UVJ), and the crossover of the common iliac arteries. The UPJ is where the pelvis of the kidney transitions into the ureter and the UVJ is where the ureters enter the bladder.

The blood supply to the ureter is segmental. The upper ureter closest to the kidneys receives blood directly from the renal arteries. The middle part is supplied by the common iliac arteries, branches from the abdominal aorta, and the gonadal arteries. The most distal part of the ureter receives blood from branches of the internal iliac artery. (1)

Urinary stones are polycrystalline concretions occurring in the urinary tract of humans and animals. Like bones

and teeth, they are biominerals. While the non-pathological products of biomineralization, formed in genetically determined processes, display a high degree of biological organization, uroliths are a special case. Their formation is governed by pathoanatomical and physicochemical factors.

Around 97% of urinary stones are found in the kidneys and ureters (kidney stones), the remaining 3% in the urinary bladder and urethra. Urinary stones can range in size from micrometers to several centimeters in diameter. They frequently remain unnoticed for long periods before manifesting themselves—often very painfully—or being discovered incidentally on radiography or ultra sound. [2]

The gold standard imaging modality to diagnose urinary tract stones in patient with acute flank pain is non contrast enhanced computed Tomo graphy (NCCT), which was reported to have a specificity of 94%–99% and sensitivity of 95%–98%.

High ionizing dose, high rate of incidental findings, and high cost of NCCT are the limiting factors to its widespread use. On the other hand, ultrasonography (US) 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. Previous studies report the sensitivity and specificity of US for detecting renal stones as 24%–81% and 83%–100%, respectively. [3]

Since its first introduction by Smith et al. in 1995, non-contrast helical computed Tomography (NCT) has evolved into a tool for rapid examination of patients suspected of having ureterolithiasis, without the limitations of plain films, intravenous urography and ultrasound. 2-4 NCT has become the method of choice for evaluating patients with acute renal colic.5-8 Transabdominal ultrasound (US) has the advantages of being universally available, not exposing the patient to radiation and being independent of kidney function.

Because of these advantages, US is preferred by referring clinicians for evaluating acute renal colic. Recent studies have shown NCT to be more effective than US for imaging ureterolithiasis in patients with acute renal colic

Aim: To compare ultrasonography (USG) and non-contrast computed tomography (NCCT) in diagnosing ureteric calculi

Material and Methods: A Observational cross sectional studywas done on patients with ureteric calculi coming to radiology department at tertiary health care centerfor a duration of November 2020 to November 2022. Total 20 patients, were included in this study.

Patient were followed from 6 weeks to 6 months on OPD basis at intervals of 6 weeks, 12 weeks, 6 monthsand was evaluated. Findings were recorded in the proforma and entered in Microsoft Excel 2010. Data analysis was done with the help of SSPS Software version 20.0.

Results: We included a total of 316 cases coming to tertiary care center. Out of 316 cases maximum patients were from the age group of 31 to 40 years (21.52%),22 patients (6.9%) were from <20yrs of age, 62 (19.6%) were from 21 to 31 years of age, 46 patients (14.56%) were from 41 to 50 years of age, 59 patients (18.67%) were from 51 to 60 years of age and 59 patients (18.67%) were from 61 to 70 years of age.Among which 161 (50.9%) were males and 155 (49.1%) were females. There was no significant association of gender with ureteric calculus. Also 62 cases (19.6%) did not show calculus on USG and 254 (80.4%) cases showed calculus on USG.

Calculus was seen on NCCT in all cases.cases on USG, 64(20.3%) cases showed a calculus of 0-3.5mm, 10 cases (3.2%) showed calculus of 3.6 – 5mm, 119 (37.7%) cases showed calculus of 5.1 – 10mm and 123 (38.9%) showed calculus of >10mm

Whereas on NCCT, 1(0.3%) case showed a calculus of 0 - 3.5mm, 34 cases (10.8%) showed calculi between 3.6 – 5 mm, 129 cases (40.9%) cases showed calculi between 5.1 - 10 mm and 152 cases (48%) showed calculi >10mm.

Out of 316 patients, hydroureter was present in 225 patients on USG as well as on NCCT.

It was absent in 91 patients on USG, out of which 84 patients showed hydroureter on NCCT and 7 patients did not show hydroureter on NCCT.USG has high sensitivity and specificity for detection of hydronephrosis. It has very low negative predictive value (NPV) but high positive predictive value (PPV) and a diagnostic accuracy of 99.4 %Hydronephrosis was seen in 313 cases on USG as well as on NCCT but 3 cases showed no hydronephrosis on USG out of which 2 cases showed hydronephrosis on NCCT.

Conclusion: USG is a limited imaging modality in detecting urinary tract stones specially in
the case of smaller stone size and low degree of hydronephrosis.

The stone size obtained by USG was not significantly different to that found by
NCCT.

- Ultrasonography is a first-line diagnostic method in emergency situations for renal stones due to its excellent diagnostic accuracy, low cost and no radiationexposure.
- USG is less suited for ureteric calculi due to multiple factors like bowel gasshadows causing reduced diagnostic accuracy than NCCT. However, this is supported as an initial diagnostic modality because to its simplicity, lack of adverse effects, lack of contraindications, and cost effectiveness. Only when ultrasonography is inconclusive can a CT scan be done.

Keywords: Non Contrast Computed Tomography, Vesicu Ureteric Junction, Pelviureteric Junction, Ultrasonography

Introduction

Urine is transported from the renal pelvis into the bladder via the ureters. Ureters are two thin (3–4 mm) tube structures that link the kidneys to the bladder. The peristaltic movement that the ureter employs to transfer urine from the kidneys to the bladder is caused by the muscular layers.

According to embryology, the mesonephric duct protrusion known as the ureteric bud, which is a stage in the development of the genitourinary system, is where the ureter gets its start.

The ureteropelvic junction (UPJ) of the kidney, which is posterior to the renal vein and artery in the hilum, is where the ureters start. After that, the ureters move inferiorly within the abdominal cavity.

They enter the bladder on the posterior bladder aspect in the trigon after passing across (anterior to) the psoas muscle.

Renal stone lodging is clinically significant in three locations along the ureters course. The ureterovesical junction (UVJ), the ureteropelvic junction (UPJ), and the crossing of the common iliac arteries are these regions. The kidney pelvis changes into the ureter at the UPJ, and the ureters enter the bladder at the UVJ.

Segmental blood flow supplies the ureter. Blood is drawn straight from the renal arteries into the portion of the upper ureter closest to the kidneys. The gonadal arteries, branches from the abdominal aorta, and the common iliac arteries all supply blood to the middle region. Branches of the internal iliac artery provide blood to the furthest portion of the ureter.12

Polycrystalline concretions known as urinary stones can develop in both human and animal urinary tracts. They are biominerals, just like teeth and bones. Uroliths are a particular instance, even if the non – pathological by-products of biomineralization, created through genetically controlled processes, have a high degree of biological order. Pathoanatomical and physicochemical variables control how they develop.

Approximately 97% of urinary stones are renal stones, with the remaining 3% occurring in the urinary bladder and urethra. Urinary stones can be as little as a few micrometers or as large as several centimeters. Often, they go undiscovered for a long time before manifesting—often in a very painful way—or being unintentionally found on radiography or ultrasound.2

The gold standard imaging modality to diagnose urinary tract stones in patient with acute flank pain is non contrast enhanced computed tomography (NCCT), which was reported to have a specificity of 94%–99% and sensitivity of 95%–98%.

NCCT's broad usage is constrained by its high ionizing dosage, high rate of accidental findings, and expensive cost. On the other hand, ultrasonography (USG) is a common approach for identifying kidney stones; it is inexpensive, safe, and non-invasive, and it is the modality of choice for calculiidentification in situations like pregnancy and paediatric age. According to earlier research, USG has a sensitivity and specificity of 24%-81% and 83%-100% for finding renal stones, respectively. 3

Non-contrast helical computed tomography (NCCT), initially introduced by Smith et al. in 1995, has developed into a technique for quick screening of patients suspected of having ureterolithiasis, free from the restrictions of plain films, intravenous urography, and ultrasound. The preferred technique for assessing individuals with acute renal3

colic is now NCCT. The benefits of transabdominal ultrasonography (USG) are its accessibility worldwide, lack of radiation exposure, and independence from kidney function.

Referring doctors prefer USG for assessing acute renal colic due to these benefits. NCCT is more useful than USG for imaging ureterolithiasis in patients with acute renal colic, according to recent research.

Objective

To compare accuracy of Ultrasonography (USG) With Non-Contrast Computed Tomography (NCCT) in detecting ureteric calculiSensitivity and specificity of Ultrasonography (USG) vs Non contrast Computed Tomography (NCCT).

Material and methods

A Observational cross sectional studywas conducted over period of two years from November 2020 to November 2022 in Radiology department of Ashwini rural medical college, hospital and research Centre, Solapur.

All patients admitted with Intertrochanteric fracture were included in the study. All patients with ureteric colic undergoing USG and NCCT in Tertiary Care Center.

Patients were excluded in whom CT scan is contraindicated such as pregnant females, Patients with ureteric or renal injuries, Patients who underwent surgical procedures /stenting for preexisting renal/ vesical calculi, Patients with renal calculi

Data Collection Procedure

After obtaining approval from Ethical committee and informed consent form from patients, all the patients referred for Ultrasonography (USG) and CT scan of abdomen for ureteric colic were included in the study. Relevant clinical history, demographics and other relevant details were recorded as per structured proforma. CT was done on multislice CT scanner available in the department. Ultrasonography was performed in the USG machine available in the department. The findings were recorded in the structured proforma. Statistical analysis –

Data was entered in Excel sheet and analyzed using IBM SPSS software version 21.0. Statistical test for significance was applied wherever necessary like Chi-square test. p value <0.05 was considered for significance. Descriptive statistics like mean, SD, percentage were used to present the data.

Clinical Evaluation

During this study in most patients there was evidence of flank pain, hematuria, colicky pain or some patients were asymptomatic.

Statistical analysis

Data was entered in EXCEL sheet and analysed using SSPS Software version 20.0. Data was presented in the form of tables, charts and graphs and also in terms of mean, SD and percentage; and assessed by ANOVA test. P-value is set at 0.05 at a confidence interval of 95%.

Results and observations

Present study consists of 316 patients with ureteric calculi.

Table 1: Age Distribution

Age	No of cases	Percentage (%)
≤ 20	22	6.96
21 – 30	62	19.62
31 – 40	68	21.52
41 – 50	46	14.56
51 – 60	59	18.67
61 – 70	59	18.67
Total	316	100

Table 1 shows distribution of cases as per age.

Table 2: gender distribution

Gender	No of cases	Percentage (%)
Male	161	50.95
Female	155	49.05
Total	316	100

Table 2 shows gender distribution of calculi.

Table 3: SIDE

Side	No of cases	Percentage (%)
Left	159	50.32
Right	157	49.68
Total	316	100

Table 3 shows affected side.

Table 4: Number of Calculi

No of calculi	USG		NCCT	
	No of cases	Percentage (%)	No of cases	Percentage (%)
0	62	19.62	0	0
1	254	80.38	316	100

Table 4 shows presence and absence of calculi on USG and NCCT

Table 5: Size of calculi

Size of calculi	USG		NCCT	
	No of cases	Percentage (%)	No of cases	Percentage (%)
0 – 3.5	64	20.25	1	0.32
3.6 – 5	10	3.16	34	10.76

5.1 – 10	119	37.66	129	40.82
> 10	123	38.92	152	48.10

The Table 5 showing number of calculi

Table 6: Hydroureter

USG	NCCT	
	Present	Absent
Present (225)	225	0
Absent (91)	84	7

Table 6 shows presence and absence of hydroureter

Table 7: Hydronephrosis

USG	NCCT			
	Mild	Moderate	Gross	Absent
Mild (98)	76	5	17	0
Moderate(70)	12	40	18	0
Gross(145)	11	24	110	0
Absent (3)	2	0	0	1

Table 8:

USG	NCCT	
	Present	Absent
Present	313	0
Absent	2	1

Table 9:

Sensitivity	99.37%
Specificity	100%
PPV	100%
NPV	33.33%
Diagnostic accuracy	99.40%

Table 7 shows degree of hydronephrosis

Discussion

The NCCT scan is the gold standard for urolithiasis diagnosis, but its usage is restricted because of ionising radiation and the lack of availability at low level medical facilities in resource-constrained nations. Contrarily, ultrasonography is a quick, affordable, and simple to use imaging technique for detecting kidney stones. Present study was conducted with the aim of to compare ultrasonography (USG) and non-contrast computed Tomo graphy (NCCT) in diagnosing ureteric calculi

Age

In the present study 21.52% cases were observed having age from 31 to 40 years of age, 19.62% cases were observed having age from 21 to 30 years of age, followed by 18.67% each cases were observed having age from 51 to 60 years of age and having age from 61 to 70 years of age, 14.56% cases were observed having age from 41 to 50 years of age where 6.96% cases were observed having age less than or equal to 20 years of age.

In study conducted by Shams HA et al[100] (2019), 38.24% cases were observed having age less than 30 years, 33.33% cases were observed having age from 31 to 40 years of age, 17.65% cases were observed having age from 41 to 50 years of age where 10.78% cases were observed having age more than 50 years of age.In study conducted by Ahmed F et al[101] (2018), 47.5 years mean age was observed

Gender

In the present study 50.95% were male cases and 49.05% were female cases. So there was no significant relation in my study related to gender in ureteric calculi.

However, some study shows Upper urinary tract stone disease occurs more commonly in men than in women. Early epidemiological studies placed the incidence rate of stone disease in men at 2.2 to 3.4 times that of women.

Recent evidence suggests these gender ratios may be changing. Updates of the original epidemiologic studies suggest the incidence rate ratio has narrowed to 1.3.

Other reports using national databases of hospital admissionsand outpatient care have found similar results. Furthermore, patient self-reports suggest an increasing burden of stone disease among women.[104]

Side

In the present study 50.32% cases were observed having calculi on left side where 49.68% cases were observed having calculi on right side. So there was no significant relation to any particular side in my study.

Number of calculi

In the present study 19.62% cases were observed with 0 calculi on USG Findings where 80.38% cases were observed with 1 calculus whereas on NCCT all cases were observed with 1 calculus.

De Souza et al[11] conducted a study in which Among the 52 patients studied, 40 ureteral stones were detected on NCT, thus giving a prevalence of 77%. The locations of the calculi were: UVJ (47%), proximal (30%), distal (18%) and mid-ureteral (5%).

CT identified 40 calculi, and US demonstrated only nine, thus corresponding to sensitivity of 22%, specificity of 100% and accuracy of 40%. The agreement between the US performed by the group of senior residents and the NCCT read by the experienced radiologists was very low (k = 0.06). In all cases when CT was negative for ureteral stones, the results matched those from US.

Patlas et al[13]conducted a study ,43 of the 62 patients were confirmed to have ureteral calculi based on stone recovery or urological interventions.

US demonstrated ureterolithiasis in 40 of the 43 patients confirmed to have ureteral calculi (sensitivity 93%, specificity 95%, positive predictive value 98%, negative predictive value 86%). Four calculi were located in the upper third of the ureter, four in the middle third and 32 in the distal ureter.

Size of Calculi

In the present study on USG examination 20.25% cases were observed with 0 to 3.5mm calculi, 3.16% cases were observed with 3.6 to 5 mm calculi, 37.66% cases were observed with 5.1 to 10 mm calculi where 38.92% cases were observed with having size more than 10mm calculi size whereas on NCCT examination 0.32% cases were observed having calculi size from 0 to 3.5mm, 10.76% cases with 3.6 to 5 size, 40.82% cases were observed with 5.1 to 10 size and 48.10% cases were observed having calculi size more than 10 mm.

In study conducted by Shams HA et al[100] (2019), sensitivity, specificity, positive & negative predictive values and diagnostic accuracy of ultrasonography in detecting renal calculi was 74.47%, 96.36%, 94.59%, 81.54% and 86.27% respectively. While sensitivity, specificity, positive & negative predictive values and diagnostic accuracy of ultrasonography in detecting ureteric calculi was 12.0%, 92.59%, 81.82%, 27.47% and 33.33% respectively.

In study conducted by Ahmed F et al[101] (2018), US detected 213 (75.5%) stones whereas NCCT detected 276 (97.2%) stones. US with CI had a sensitivity of 75.4% (0.7-0.8) and a specificity of 16.7% (0.03-0.56); it also had a positive predictive value of 97.18% and a negative predictive value of 1.69%. They compared the stone sizes assessed by NCCT and US in order to determine the accuracy of the US measurement. For the stone size evaluated by US and NCCT, there was around 73% concordance (Pearson's correlation value was 0.841; P 0.001). Then, we divided the stone sizes into four categories—0–3.5, 3.6–5, 5.1–10, and 10 mm—and measured each by the US and NCCT individually.

In study conducted by Sternberg KM et al[102] (2016), both US and NCCT revealed a stone for size comparison in 79 patients (51.0%). Two patients (1.3%) had a stone recorded on US but not seen on NCCT, while 58 patients (37.4%) had a stone visualised on NCCT but not visible on US. They also observed the stones missed on US had an average NCCT size of 4.5 mm. US overestimated stone size by 2.2 mm (P .001) when comparing the average greatest stone diameter for US (9.1 mm) to NCCT (6.9 mm). US overestimated the size of stones by 84.6% for those under 5 mm, 27.1% for those between 5.1 and 10 mm, and 3.0% for those over 10 mm.

In study conducted by Kanno T et al[103] (2014), 169 individuals had stones found by NCCT, compared to 98 by US, with a sensitivity of 57.3% and a specificity of 97.5%. Expectedly, the detection rate of US decreased for distal ureters but increased with stone size. They also observed that, the sensitivity of US increased with hydronephrosis from 57.3% to 81.3%. In 68 out of 98 patients (69.4%), stone sizes determined by US were consistent with those determined by NCCT and had a positive correlation with computed tomography measurements. It's interesting to note that ureteral stone identification by US was altered independently by stone size and hydronephrosis.

Hydroureter

In the present study 225 cases were observed with hydroureter on both USG And NCCT Examination, 84 cases were observed with absent of hydroureter on USG where it showed presence of hydroureter on NCCT, 7 cases were observed with absent on both examination for hydroureter. With respect of predicting hydroureter 72.82% sensitivity was observed, 100% specificity and positive predictive value was observed, 7.69% negative predictive value was observed where in diagnosing calculi by both methods 74.17% diagnostic accuracy was observed. (p=0.0001***)

Hydronephrosis

On USG and NCCT examination out of 76 cases were observed with mild hydronephrosis on NCCT, 5 cases were observed with moderate size and 17 cases were observed with gross on size. Out of moderate cases of USG examination 12 cases were observed with mild on NCCT and USG, 40 cases were observed as moderate on USG and NCCT both, 18 cases were observed as moderate on USG but they were observed as gross hydronephrosis on NCCT. Out of gross cases 11 cases were observed as mild on NCCT examination, 24 cases were observed as moderate, 110 cases were observed as gross in size in both examinations. 2 cases were observed as absence hydronephrosis on USG where on NCCT it showed up with mild hydronephrosis.

where only 1 case was observed with absence of hydronephrosis on both examinations. On predicting change in hydronephrosis on USG and NCCT 99.37% sensitivity was observed, 100% specificity and positive predictive value was observed, 33.33% negative predictive value was observed where 99.40% diagnostic accuracy was observed.

Patlas et al, conducted a study in which he found Hydronephrosis was seen in 44 cases. The degree of hydronephrosis demonstrated by US examination was graded as minimal in 22 patients, mild in 11 patients and moderate in 11 patients.

Perinephric fluid was demonstrated in three patients. Of the 43 patients with calculi, CT detected 39 (sensitivity 91%, specificity 95%, positive predictive value 98%, negative predictive value 82%). 5 calculi were demonstrated in the proximal ureter, 4 in the midureter (Figure 3) and 30 in the distal ureter[13].

Conclusion

USG is a limited imaging modality in detecting urinary tract stones specially in the case of smaller stone size and low degree of hydronephrosis.

- The stone size obtained by USG was not significantly different to that found by NCCT.
- Ultrasonography is a first-line diagnostic method in emergency situations for renal stones due to its excellent diagnostic accuracy, low cost and no radiation exposure.

USG is less suited for ureteric calculi due to multiple factors like bowel gas shadows causing reduced diagnostic accuracy than NCCT. However, this is supported as an initial diagnostic modality because to its simplicity, lack of adverse effects, lack of contraindications, and cost effectiveness. Only when ultrasonography is inconclusive can a CT scan be done.

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