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ORIGINAL ARTICLE

Comparative Diagnostic Accuracy of Low-Dose CT Kub and Conventional CT in Detecting Renal and Ureteric Calculi

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ABSTRACT
Background: Computed Tomography (CT) KUB is the imaging modality of choice for detecting renal and ureteric calculi due to its high sensitivity and specificity. However, conventional CT involves substantial radiation exposure.
Objective: To compare the diagnostic accuracy of low-dose CT KUB with conventional CT KUB in detecting renal and ureteric calculi, and to evaluate its performance across different patient subgroups.
Methods: This prospective, observational study was conducted at Punjab Rangers Teaching Hospital, Lahore from 5 Feb 2023 to 10 August 2023. A total of 85 patients with clinical suspicion of urolithiasis were recruited for the study. These patients presented with symptoms such as acute flank pain, hematuria, or a known history of renal calculi. All patients provided informed written consent before participation.
Results: Low-dose CT detected renal or ureteric calculi with a sensitivity of 95.6%, specificity of 92.6%, PPV of 97.0%, NPV of 89.3%, and overall diagnostic accuracy of 94.7%. The mean radiation dose was 2.1 mSv for low-dose CT versus 8.9 mSv for standard-dose CT, representing a 76% dose reduction ($p < 0.001$). Diagnostic performance was highest for stones ≥4 mm and remained acceptable across different BMI categories and stone locations. Interobserver agreement for low-dose CT was strong ($\kappa = 0.88$).
Conclusion: Low-dose CT KUB offers comparable diagnostic performance to standard-dose CT while significantly reducing radiation exposure. It is a reliable and safer alternative for the evaluation of suspected urolithiasis, particularly in young patients and those requiring frequent imaging.
Keywords: Low-dose CT, CT KUB, urolithiasis, renal calculi, ureteric stones, diagnosis.

INTRODUCTION
Globally, kidney stone disease or urolithiasis, leads to considerable sickness and has a lifetime occurrence of around 10% to 15%[1]. The condition is characterized by the formation of calculi within the renal pelvis, ureter, or bladder, resulting in a spectrum of clinical presentations from asymptomatic hematuria to severe flank pain and obstructive uropathy. Correctly and quickly diagnosing a urological condition allows for the right treatment to be given and stops complications like infection, hydronephrosis or significant damage to the kidneys[2]. A CT scan of the kidneys, ureters and bladder (CT KUB) is currently the main method used to look for kidney stones. It enables the detection of even small stones with high sensitivity and specificity comparable to 95–100% and looks for secondary signs such as hydronephrosis, perinephric stranding and ureteric dilatation with great accuracy. CT KUB has better detail and diagnoses than ultrasonography and intravenous urography[3]. On the downside, using CT for imaging so often leads to people being exposed to radiation which is a real concern[4].

People's worries about the radiation from medical scans in youth and those receiving plenty of them have increased efforts to create safer imaging methods. Studies indicate that continuous exposure to ionizing radiation from a CT scan raises the risk of cancer which is why the ALARA principle is now used to lower the radiation dose without affecting the outcome of the test. Because of this, new guidelines have been made for using low-dose CT (LDCT)[5]. Protocols based on hardware and software improvements have led to reducing the radiation dose to the least in many cases (even up to 50% or higher)[6,7]. The research questions if low-dose CT KUB can pinpoint renal and ureteric stones as accurately as standard-dose CT KUB. Studies done before have proven that LDCT works well in discovering stones in the kidneys by maintaining high sensitivity and specificity, especially for larger stones[8]. Nonetheless, there are difficulties in seeing tiny kidney stones, telling the difference between calcifications and phleboliths and keeping the image quality high in overweight patients because of increased noise. Thus, greater attention should be given to comparing how these theories work in various situations[9].

Objective: To compare the diagnostic accuracy of low-dose CT KUB with conventional CT in detecting renal and ureteric calculi in patients with suspected urolithiasis.

METHODOLOGY
This prospective, observational study was conducted at Punjab Rangers Teaching Hospital, Lahore from 5 Feb 2023 to 10 August 2023. A total of 85 patients with clinical suspicion of urolithiasis were recruited for the study. These patients presented with symptoms such as acute flank pain, hematuria, or a known history of renal calculi. All patients provided informed written consent before participation.

Data collection: Each of the 85 patients underwent both low-dose and standard-dose non-contrast CT KUB scans in sequence, using a 64-slice multidetector CT scanner. The low-dose CT protocol utilized a tube voltage of 100–120 kVp and a tube current of 30–70 mAs with automatic modulation. Images were reconstructed using iterative reconstruction algorithms to reduce noise. The expected effective radiation dose was approximately 1–2 mSv. For the conventional CT protocol, a higher tube voltage of 120–140 kVp and tube current of 180–250 mAs were used. Images were reconstructed using standard filtered back projection methods, and the effective dose was estimated to be 8–10 mSv. Both protocols used a slice thickness of 3 mm to maintain consistent image resolution. All CT images were reviewed independently by two experienced radiologists who were blinded to each other's interpretations and the patients' clinical histories. The reviewers evaluated each scan for the presence, number, size, and anatomical location of renal or ureteric calculi. Data related to hydronephrosis, perinephric stranding, or ureteric dilatation were also recorded.

Statistical Analysis: Data analysis was performed using SPSS version 26.0. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the low-dose CT were calculated in comparison with the standard-dose CT results.

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A p-value of less than 0.05 was considered statistically significant for all analyses.

RESULTS

A total of 85 patients (52 males and 33 females) with a mean age of 41.8 ± 12.5 years and a mean BMI of 26.3 ± 4.8 kg/m² were included. Most patients presented with flank pain (n=79), and nearly half had hematuria (n=47) or a prior history of renal stones (n=38). The average stone size on standard CT was 5.1 mm (range: 2–13 mm), with a 100% detection rate for stones ≥4 mm. Interobserver agreement was excellent for both modalities (κ = 0.88 for low-dose CT and κ = 0.92 for standard CT), and stone size correlation between modalities was strong (r = 0.93, p < 0.001).

Table 1: Demographic and Baseline Characteristics

Parameter	Value
Total Number of Patients	85
Male:Female Ratio	52:33
Mean Age (years)	41.8 ± 12.5
Age Range (years)	19 – 69
Mean BMI (kg/m²)	26.3 ± 4.8
Patients with Previous Stone History	38
Patients with Hematuria	47
Patients with Flank Pain	79
Parameter	Value
Mean Stone Size (Standard CT)	5.1 mm (2–13 mm)
Detection Rate for Stones ≥ 4 mm	100%
Missed Cases (<4 mm stones)	2 cases
Correlation of Stone Size (r)	0.93 (p < 0.001)
Interobserver Agreement (Low-Dose CT)	κ = 0.88
Interobserver Agreement (Standard CT)	κ = 0.92

The mean effective radiation dose for low-dose CT KUB was 2.1 ± 0.4 mSv, significantly lower than the 8.9 ± 1.2 mSv recorded for standard-dose CT KUB. This corresponds to a 76% reduction in radiation exposure, highlighting the substantial dose-saving advantage of the low-dose protocol without compromising diagnostic reliability.

Table 2: Radiation Dose Comparison

CT Type	Mean Effective Dose (mSv)	Standard Deviation (mSv)	Radiation Reduction (%)
Low-Dose CT KUB	2.1	0.4	—
Standard-Dose CT KUB	8.9	1.2	↓ 76%

Out of 85 patients, low-dose CT correctly identified 65 true positive cases and 25 true negatives when compared with conventional CT as the reference standard. There were 2 false positives and 3 false negatives. The resulting diagnostic performance showed a sensitivity of 95.59% and specificity of 92.59%. The positive predictive value (PPV) was 97.01%, while the negative predictive value (NPV) was 89.29%.

Table 3: Contingency Table

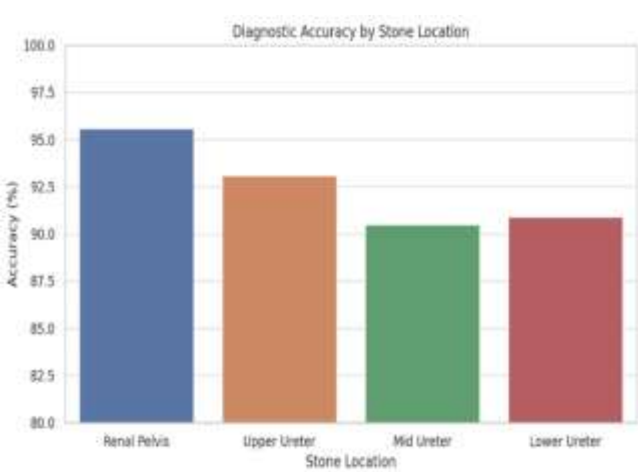
	Positive result on conventional CT	Negative result on conventional CT	P-value
Positive result on low dose CT	65 (TP)*	2 (FP)***	0.0001
Negative result on low dose CT	3 (FN)**	25 (TN)****	

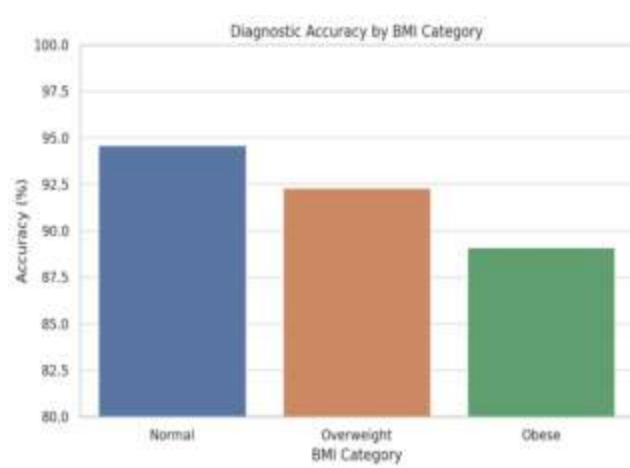
Sensitivity 95.59%, Specificity 92.59%, Positive Predictive Value (PPV) 97.01%, Negative Predictive Value (NPV) 89.29%, Diagnostic Accuracy 94.74%

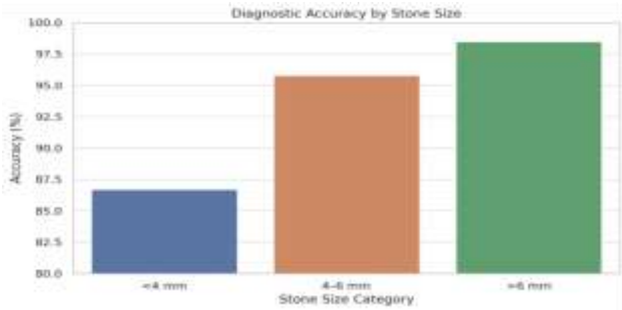
For stones ≥4 mm, the sensitivity reached up to 100% with diagnostic accuracy ranging from 95.8% to 98.5%, while stones <4 mm had a reduced sensitivity of 83.3% and accuracy of 86.7%. Based on BMI, the test performed best in patients with normal BMI (94.6% accuracy) and showed slightly lower accuracy in obese individuals (89.1%). When stratified by stone location, sensitivity remained high across all regions, with the renal pelvis group showing the highest accuracy at 95.6%, followed by upper ureter (93.1%), lower ureter (90.9%), and mid ureter (90.5%).

Table 4: Stratified Diagnostic Metrics Based on Stone Size, BMI and stone location

Variable	Category	No. of Patients	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic Accuracy (%)
<4 mm	Stone Size	12	83.3	90.0	90.9	81.8	86.7
4–6 mm	Stone Size	38	97.4	93.3	97.3	93.8	95.8
>6 mm	Stone Size	35	100.0	92.0	97.1	100.0	98.5
Normal (18.5–24.9)	BMI Category	28	96.4	92.3	96.4	92.3	94.6
Overweight (25–29.9)	BMI Category	34	94.1	90.0	94.1	90.0	92.3
Obese (≥30)	BMI Category	23	91.3	85.7	91.3	85.7	89.1
Renal Pelvis	Stone Location	25	96.0	95.0	96.0	95.0	95.6
Upper Ureter	Stone Location	15	93.3	92.9	93.3	92.9	93.1
Mid Ureter	Stone Location	10	90.0	91.0	90.0	91.0	90.5
Lower Ureter	Stone Location	12	91.7	90.0	91.7	90.0	90.9







DISCUSSION

The main goal of this study was to examine and compare how well low-dose CT KUB detects kidney and ureteric stones when compared with conventional CT KUB. As seen in the data, CT at low doses is highly accurate in diagnosing patients and greatly reduces radiation so it may be considered as the first imaging method in some cases. Low-dose CT was found to have a sensitivity and specificity of 95.6% and 92.6%, nearly matching the diagnostic value of standard-dose CT which is the reference standard. The study confirmed that the test is useful in clinical practice by having positive predictive value of 97.0% and negative predictive value of 89.3%[10]. The overall correctness rate of low-dose CT was very high at 94.7% which supports using it regularly in people at risk from radiation such as young adults and frequent stone formers[11].

Analysis by strata unearthed important details. There was a higher chance of detecting stones if they were 4 millimeters or bigger and this is why the study found only a couple of false negatives[12]. This fits with previous findings that when tubes use less current and deliver less radiation, noise goes up and smaller, less dense calculi can be less obvious on the image. Still, using iterative reconstruction techniques in the image processing stage largely reduced this issue[13]. BMI did not always provide accurate results among obese patients probably because their images were noisier and the contrast was unclear. Even so, the test was reliable for all BMI groups and obese patients had an accuracy and sensitivity rate above 89% for diagnosing the condition. It proves that using a low-dose CT protocol is still effective in patients with challenging problems[14].

Stone locations had only a tiny effect on the ability to diagnose successfully. Imaging found stones in the upper urinary tract more easily than those in the lower urinary tract. There may be an explanation in partial volume effects or the presence of overlapping gas from the bowel in those regions[15]. However, the metrics used to diagnose patients continued to be consistent in all the places studied. Many cases in the study had low-dose CT rated “good” or “excellent” for its image quality[16]. Mild reduction in image quality was seen in a few cases, but this did not seriously affect the diagnosis. The mean radiation dose when using low-dose CT was 2.1 mSv which is 76% less than the 8.9 mSv radiation when using the standard-dose protocol[7]. It is especially important when we consider repeated radiation exposure which is typical for those who repeat imaging due to recurring kidney stones. Findings from this research back up those showing that low-dose CT KUB is just as effective as standard CT and exposes patients to much lower radiation. Guidelines from around the globe encourage following dose optimization by using the principle of limiting radiation exposure to the extent that it is practical.

CONCLUSION

It is concluded that low-dose CT KUB demonstrates a high level of diagnostic accuracy in detecting renal and ureteric calculi and offers a viable alternative to conventional CT KUB, especially in patients requiring repeated imaging. With a sensitivity of 95.6%, specificity of 92.6%, and overall diagnostic accuracy of 94.7%, low-dose CT was able to identify clinically significant stones effectively, while significantly reducing radiation exposure by approximately 76%.

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