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Diagnostic Role of X-ray Imaging in Renal and Ureteric Calculi Keeping Computed Tomography as Gold Standard

Kalim Ullah[1*], Touseef Qamar[1], Siraj Khan[1] and Bilal Ahmad[1]

[1]Department of Radiology, Superior University, Lahore, Pakistan

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***Corresponding Author:**
Kalim Ullah
Department of Radiology, Superior University, Lahore, Pakistan
kalimsul@outlook.com

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ABSTRACT

The renal colic is an initial onset of flank discomfort that often radiates to the groin and may be linked with complication like hematuria and dysuria. Physicians initially use KUB plain x-ray imaging for the initial diagnosis and ultrasonography for the suspected calculi, and evaluation of the upper tract of urinary system. **Objectives:** To determine the diagnostic accuracy of x-ray KUB imaging in diagnosis of renal and ureteric calculi keeping computed tomographic scan as a gold standard. **Methods:** An ethically approved cross-sectional study was conducted at Maqsood Medical Complex, Peshawar with a convenient sampling technique between August to November 2024. Data of KUB x-ray and CT scan were collected by predesigned proforma. Data were entered in SPSS version 27. Demographics were described in tables and applied Chi square test for the sensitivity and specificity of the KUB radiographic x-ray take the CT scan gold standard. **Results:** The sample size of the study was 235, where the mean and standard deviation of age was 33.77 ± 8.61. The male patients were 152 (64.68%) and the female were 83 (35.32%) participated in this research study. The Chi square test result shows that x-ray was able to properly detect 92 cases of calculi verified by CT but missed 124 cases. While X-ray did not incorrectly identify any calculi. **Conclusions:** Although KUB x-ray imaging has been configured to be an initial diagnostic tool in detecting renal and ureteric calculi, its diagnostic yield lacks in comparison to CT scans.

INTRODUCTION

The renal colic is an initial onset of flank discomfort that often radiates to the groin and may be linked with complications like hematuria and dysuria [1-3]. The x-ray of kidney, ureter and bladder (KUB) is the basic and initial imaging modality to diagnose radiopaque stones present in this area [4, 5]. Where Renal colic occurs when a stone forms in the kidney, ureter, urinary bladder, or urethra, obstructing the urine tract. it is the most common disease of the urinary tract, more prevalent among adult male population and it is associated with an increased risk of chronic renal disease . It has a 50% occurrence rate. The average prevalence of renal colic globally is 5-15% [7, 8], which varies depending on how the illness is distributed in different geographical locations [9]. Choosing the best methods for diagnosing urinary stones depends on a variety of parameters, including clinical environment, patient body habits, financial expenses, and ionizing radiation tolerance [10]. Multiple imaging modalities are available, although extensive clinical usage is now confined to ultrasonography, kidney ureter bladder scan (KUB), plain film radiography, and computed tomography. Non contrast enhanced CT scan of the abdomen and pelvis consistently provide accurate diagnosis uterine tract infection (UTI) via exposing the ionizing radiation [11]. The physicians initially use KUB plain x-ray imaging for the initial diagnosis and ultrasonography for the suspected calculi which is radiolucent in nature as well as for the evaluation of the upper tract of urinary system because of the highly upper tract calculi and the concomitant bladder. CT scan diagnosis has become the universal standard reference in the diagnosis of urinary calculi with the high sensitivity 95-98% but KUB x-ray examination is also preferred by the

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urologist before CT scan procedure [12, 13]. The management of calculi in the urinary system depends on the size of the stone and its nature [14, 15]. It may be radiolucent or radiopaque. Also, the lab test reports are mandatory to confirm the glomerulus filtration rate (GFR) and creatinine level of the patient [16-18]. Delays in the diagnosis and management of such conditions can lead to severe morbidity, renal obstruction, fistula, renal injury and may lead to renal system failure [19, 20]. In this study KUB plain x-ray radiography was used for the examination method of choice for patients with suspected ureteric and renal calculi.

This study aimed to investigate accuracy of x-ray KUB imaging in diagnosis of renal and ureteric calculi keeping computed tomographic scan as a gold standard.

METHODS

A cross-sectional study was conducted at Maqsood Medical Complex, Peshawar from August to November 2024 after the approval (Ref no: SU91-MSAHW-S23-111) was obtained from the Superior University research board of studies and hospital ethical board. The sample size was calculated by openEPI calculator where confidence interval was 95% and margin of error was 5%, Z score was 1.96 and the prevalence value was 10% [21]. The final sample size was calculated to be 235, using convenient sampling technique. This approach was chosen to ensure that the study focused on individuals most likely to provide relevant insights into the diagnostic accuracy of imaging modalities for renal and ureteric calculi. During data collection, written consent was obtained from the patients and patients were guaranteed data confidentiality. The inclusion criteria comprised of both male and female who had flank pain less than 24 hours and advised for X-ray KUB and CT abdomen and pelvis scan, age between 20 to 50 years and willingness to participate. On the other hand, pregnant female, patients who had the history of abdominal trauma and morbidly obese patient (Men>129 kg women>113kg) were excluded. Patients were referred to the radiology department for x-ray KUB followed by CT abdomen and pelvis scan. Both x-ray KUB & CT scan were interpreted by consultant radiologists who have more than 10 years' experience in diagnostic medical reports. Time between the two tests was maximum of 2 hours. Demographics were noted on predesigned proforma including patient age, gender, weight, height and then calculated body mass index. Frequency and percentages were calculated of categorical variables like gender, findings on x-ray KUB and CT scan. Mean and Standard deviation was calculated for continue variables like age, body mass index, weight and height. Chi Square test was applied on categorical variables between x-ray KUB imaging and CT scan of abdomen and pelvis. Sensitivity and specificity were determined by taking findings on CT scan as gold standard and using 2 by 2 tables. All information was entered into and analyzed in statistical software SPSS version 27.

RESULTS

The sample size of the research study was 235, where the mean and standard deviation of age was 33.77 ± 8.61. The male patients were 152 (64.68%) and the female were 83 (35.32%) participated in the research study. The minimum age was 18 years, and the maximum age was 49 years (Table 1).

Table 1: Descriptive Statistics of Variables

Variables		Mean ± SD
Age		33.77 ± 8616
Gender	Male	152 (64.68%)
	Female	83 (35.32%)

Statistically the age group was grouped between three categories, where in age between 18 to 30 years old patient frequency was 92 (39.1%), which is the largest individuals of our sample size, 31 to 40 age group patients' frequency was 79 (33.6%) and 41 to 49 age group patients' frequency was 64 (27.2%) as shown in table 2.

Table 2 : Age Group Analysis

Age Group	Frequency	Percent	Valid Percent	Cumulative Percent
18-30	92	39.1%	39.1%	39.1%
31-40	79	33.6%	33.6%	72.8%
41-49	64	27.2%	27.2%	100.0%
Total	235	100.0%	100.0%	100.0%

It was determined that 46 (19.6%) patients were diabatic and 77 (32.8) were hypertensive patients, 132 (56.2%) patients having hematuria in urination and 103 (43.8%) patients were normally excrete the urination, from medical history of the patients we found that 126 (53.6%) patients under medical treatment, two of them took lithotripsy treatment and 109 (46.4%) were not taking medication in past history. In 235 patients 83 (35.3%) took Injection Toradal with 100 ml saline used for severe pain killer and 53 (22.6%) patients took Capsule Tamsoline 0.4 mg work as a muscle's relaxant, the remaining 99 (42.1%) patients not taken injection or any first aid medication from preventing the pain. With CT being the gold standard, the table compares the results of X-ray KUB with CT KUB in the diagnosis of renal and ureteric calculi. It displays the distribution and frequency of instances according to whether or not calculi were found using both approaches. 92 instances (39.1%) out of 235 cases had both X-ray and CT scan results showing calculi (true positives). A total of 124 (52.8%) instances had a negative X-ray but a positive CT scan, indicating that the X-ray missed these cases (false negatives). 19 patients (8.1%) had genuine negative results from both CT and X-ray scans. Since calculi were never detected by X-ray and their absence was verified by CT, there were no false positives (Table 3).

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Table 3: Crosstabulation of x-ray KUB and CT Findings for the Diagnosis of Renal and Ureteric Calculi

Finding on X-ray KUB	Finding of CT KUB: Positive	Finding of CT KUB: Negative	Total
Positive	92 (39.1%)	0 (0.0%)	92 (39.1%)
Negative	124 (52.8%)	19 (8.1%)	143 (60.9%)
Total	216 (91.9%)	19 (8.1%)	235 (100.0%)

DISCUSSION

The result of the present study has shown that, although KUB x-ray imaging is less expensive, easily accessible, and has been configured to be an initial diagnostic tool in detecting renal and ureteric calculi, its diagnostic yield lacks in comparison to CT scans. Using X-rays, 39.1% of calculi cases found by CT were revealed, and 52.8% of the cases were missed. This goes further to show the limitation of KUB X-ray in the detection of small or less radiopaque stones, which CT can well note. These results support the existing literature regarding the fact that CT scans continue to be the most preferred diagnostic imaging modality in the diagnosis of urinary stones, attributed to the higher sensitivity and specificity of the modality. X-ray in this study was able to properly detect 92 cases of calculi verified by CT but missed 124 cases. While X-ray did not incorrectly identify any calculi, it also had limited success in ruling out calculi precisely. This underscores the necessity of CT as a more trustworthy diagnostic tool. In accordance with the prior conclusions, based on the previous studies, CT scans demonstrated high diagnostic capability. For example, it has been established in several studies that non-contrast-enhanced CT scan sensitivity ranges between 70%–80% for diagnosing appendicitis or fistula [22, 23]. Thus, it was further preferred for imaging of renal calculi as shown in a study where non-contrast CT showed 82% sensitivity in imaging renal calculi [24]. However, recent research has also focused on the existing use of KUB x-rays in the clinical health setup because they are cheaper [25]. Finally, these observations affirm the fact that CT is still more effective than X-rays. Still, X-rays are useful as initial imaging modalities, especially in situations where access to CT or the patient cannot afford the radiation costs or has other complications. On the other hand, some studies have raised doubts over the general necessity of KUB x-ray imaging, suggesting that instead of the KUB x-ray, the first choice should be either the ultrasound or direct CT image [26]. These dissimilarities may be due to differences in study samples, stone composition, and imaging modalities, underlining the need for location-sensitive differential analyses when selecting diagnostic techniques. Some of the limitations of our study must also be noted. First, due to the convenience sampling technique that was used in this study, the external validity of the results can be questioned. Moreover, the stone composition parameters and prior therapies. The absence of inter-observer reliability assessment regarding the radiologists who analyzed the imaging may also weaken the results. Finally, since the study was cross-sectional in design, no longitudinal comparative efficacy of KUB x-rays with that of CT in clinical practice was established. Future studies should be conducted on large samples from different centers to increase the generalizability of results. Integrating elements of stone composition, patients' pathologies, and sex differences might give additional information about the nature of diagnostic performance. Moreover, the assessment of diagnostic cost and consumption in different types of facilities would be beneficial in addressing policy concerns for comprehending the cost-utility of diagnostic techniques. Further, the studies of inter-observer reliability and the outcomes of patients depending on the used diagnostic techniques would also enhance the results. These steps would have the overall effect of helping to fine-tune diagnostic algorithms of renal and ureteric calculi with respect to their accuracy, accessibility, and cost implications.

CONCLUSIONS

This research shows that KUB x-ray imaging remains an effective first-line diagnostic tool used for renal and ureteric calculi, nevertheless, CT scans outcompete in terms of sensitivity and specificity by a considerably large margin. The study suggests that although KUB ionized x-ray played a vital role in the urological procedure, especially in the emergency department, other imaging modalities should be incorporated into the laboratory diagnosis of urinary calculi to provide better diagnosis, management and hence patient care.

Authors Contribution

Conceptualization: KU
Methodology: TQ, BA
Formal analysis: KU, SK
Writing review and editing: KU, SK

All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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