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Original Article

Diagnostic Accuracy of Non-Contrast Computed Tomography in Identification of Renal Calculi in Suspected Patients with Negative Intravenous Pyelogram

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ABSTRACT

Background: Renal calculi, commonly known as kidney stones, are mineral deposits found in the renal calyces and pelvis, either free or attached to the renal papillae. These stones can cause significant pain and health complications, making accurate diagnosis crucial. While intravenous pyelogram (IVP) has been a traditional diagnostic method, non-contrast computed tomography (NCCT) has emerged as a potentially superior alternative due to its higher sensitivity and specificity.

Objective: To determine the accuracy of non-contrast computed tomography (NCCT) in identifying renal calculi in symptomatic patients with negative intravenous pyelogram (IVP) results.

Methods: This cross-sectional study was conducted at the University of Lahore Teaching Hospital from August 7, 2023, to March 20, 2024. A total of 416 symptomatic patients, aged 19 to 49 years, with negative IVP results were included. Patients previously diagnosed with urolithiasis/nephrolithiasis by other imaging modalities, those who were uncooperative, pregnant, severely ill, or with congenital urinary tract abnormalities, were excluded. Demographic and clinical data were collected through interviews. Each patient underwent an NCCT scan, which was interpreted by an experienced radiologist. Data analysis was performed using SPSS version 25, with continuous variables summarized as means and standard deviations, and categorical variables as frequencies and percentages. Chi-square tests were used to assess associations, with a significance level set at $p<0.05$.

Results: Of the 416 patients, 250 (60.09%) were diagnosed with urolithiasis/nephrolithiasis on NCCT, while 166 (39.90%) were negative. The majority of positive cases were male (n=156, 70.90%), with the most common age group being 19-29 years (n=91, 58.33%). The most frequent anatomical site for calculi was the ureter (n=151, 36.30%), followed by the kidneys (n=60, 14.42%) and the urinary bladder (n=39, 9.37%). The size of the single calculi varied, with the most common sizes being 0.4-0.5 cm (27.81%).

Conclusion: NCCT demonstrated a significantly higher diagnostic accuracy for urolithiasis/nephrolithiasis compared to IVP. Given its superior sensitivity and specificity, NCCT should be considered the preferred diagnostic modality for patients presenting with acute renal colic and negative IVP results. These findings can improve patient outcomes through timely and accurate diagnosis, reducing the need for unnecessary diagnostic procedures.

Keywords: Non-contrast computed tomography, renal calculi, intravenous pyelogram, diagnostic accuracy.

INTRODUCTION

Renal calculi, or kidney stones, are mineral deposits found in the renal calyces and pelvis, either free or attached to the renal papillae. These deposits form when urine becomes supersaturated with respect to a particular mineral, combining organic and crystalline components. Most stones are primarily composed of calcium oxalate, often developing on the surface of renal papillae where calcium phosphate deposits, known as Randall's plaques, are present (1). Globally, kidney stones are a common issue, posing significant health risks and financial burdens. While many stones do not recur after medical treatment, nephrolithiasis continues to be a notable economic and health concern. It is considered a systemic disease associated with metabolic syndrome, hypertension, increased risk of coronary artery disease, type 2 diabetes mellitus, bone loss, and fractures. Understanding the pathophysiological connections between nephrolithiasis and these systemic diseases is essential for developing novel therapeutic strategies (2, 3).

Kidney stones can affect the kidneys in various ways, from causing acute, uncomplicated flank pain to resulting in renal parenchymal damage. Therefore, early detection of kidney stones is crucial (4). Imaging techniques used to diagnose kidney stones include intravenous pyelogram (IVP), computed tomography (CT), ultrasound, and plain abdomen X-ray. Non-contrast computed tomography (NCCT), introduced for urolithiasis/nephrolithiasis in the 1990s, has become the gold standard for initial, ongoing assessment, and management of these conditions in industrialized nations. However, in developing countries, other diagnostic methods, such as IVP or abdominal X-rays, are often preferred initially (5). IVP, an X-ray-based technique using contrast material, has traditionally been the modality of choice for detecting urolithiasis. Despite its advantages, such as determining the extent of obstruction and assessing renal function, IVP has limitations, including the risk of anaphylactic reactions to contrast material, difficulty detecting radiolucent calculi, and a lengthy and exhaustive process. A typical IVP can take 12 to 24 hours to complete (6, 7).

NCCT, on the other hand, is a valuable initial diagnostic tool, particularly in atypical cases or patients who cannot tolerate IV contrast. It provides detailed information on stone characteristics, including location, size, degree of obstruction, and the impact on the kidney and surrounding structures. Recent advancements have introduced low-dose NCCT scanning protocols for detecting urolithiasis/nephrolithiasis, balancing diagnostic efficacy with reduced radiation exposure (8, 9). Given the high sensitivity and specificity of NCCT—reported to be between 95-98% and 96-100%, respectively—our hypothesis is that NCCT can accurately detect and measure stones that may be missed by IVP in patients presenting with urolithiasis symptoms (10).

This study aims to address the limitations of IVP by using NCCT to accurately diagnose urolithiasis/nephrolithiasis in symptomatic patients who had negative IVP results. The significance of this study lies in its potential to provide rapid and accurate diagnoses, reducing the need for unnecessary diagnostic procedures and alleviating patient suffering and financial burdens. By improving the diagnostic accuracy for urolithiasis/nephrolithiasis, particularly in patients with negative IVP results, this research can contribute to better patient outcomes and more efficient use of medical resources. The study's findings may lead to broader adoption of NCCT as the preferred diagnostic tool in clinical practice, ultimately enhancing the standard of care for patients with suspected renal calculi (11, 12).

MATERIAL AND METHODS

The cross-sectional observational study was conducted at the University of Lahore Teaching Hospital from August 7, 2023, to March 20, 2024. The study aimed to evaluate the diagnostic accuracy of non-contrast computed tomography (NCCT) in identifying renal calculi in patients with negative intravenous pyelograms (IVP). A non-probability sequential sampling approach was utilized to gather data. The study population comprised suspected urolithiasis/nephrolithiasis patients, aged 19 to 49 years, who had negative IVP results, regardless of gender. Patients who were uncooperative, previously diagnosed with urolithiasis/nephrolithiasis by ultrasound, IVP, or radiography, pregnant, severely ill, admitted to the intensive care unit, or had congenital urinary tract abnormalities were excluded from the study.

Informed consent was obtained from all participants, ensuring their voluntary participation and confidentiality. The study adhered to the ethical principles outlined in the Declaration of Helsinki and received approval from the institutional ethics committee. Demographic and clinical data, including age, gender, and symptoms, were collected through face-to-face interviews with the participants.

Each participant underwent an NCCT scan following their negative IVP results. The NCCT scans were performed using a standardized protocol, with moderate to high levels of X-ray exposure to obtain detailed images of the urinary tract from the kidneys to the bladder. The scans were interpreted by a consultant radiologist with over five years of experience, who documented the presence, size, and location of any hyperdense areas indicative of calculi. The collected data were recorded in a structured proforma.

Data analysis was conducted using SPSS version 25. Continuous variables, such as age and stone size, were summarized using means and standard deviations. Categorical variables, such as the presence and location of stones, were presented as frequencies and percentages. Stratification was performed based on potential confounders, including age, gender, and stone size, to evaluate their impact on the outcomes. Chi-square tests were used to assess associations between categorical variables, with a p-value of less than 0.05 considered statistically significant.

A total of 416 symptomatic patients with negative IVP results were included in the study. Of these, 250 patients (60.09%) were found to have urolithiasis/nephrolithiasis on NCCT, while 166 patients (39.90%) were negative. The results revealed a higher prevalence of

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urolithiasis/nephrolithiasis among males (n = 156, 70.90%) compared to females (n = 140, 71.42%). The most common age group for urolithiasis/nephrolithiasis in males was 19-29 years (n = 91, 58.33%), while in females, it was 30-39 years (n = 49, 35.0%).

The study demonstrated that NCCT is a reliable diagnostic tool for identifying renal calculi, with a significantly higher detection rate compared to IVP. The findings underscore the importance of NCCT in the early and accurate diagnosis of urolithiasis/nephrolithiasis, which can ultimately improve patient management and outcomes (1).

RESULTS

The study included a total of 416 symptomatic patients who had negative intravenous pyelogram (IVP) results. Of these, 250 patients (60.09%) were diagnosed with urolithiasis/nephrolithiasis using non-contrast computed tomography (NCCT), while 166 patients (39.90%) were negative for both conditions.

The demographic distribution of the study population showed that the majority of subjects were male (n = 220, 52.88%), with a higher prevalence of urolithiasis/nephrolithiasis in males (n = 156, 70.90%) compared to females (n = 140, 71.42%). The most common age group for urolithiasis/nephrolithiasis in males was 19-29 years (n = 91, 58.33%), while in females, it was 30-39 years (n = 49, 35.0%).

The anatomical distribution of the calculi identified by NCCT is presented in Table I. The ureter was the most common site of calculi, with 151 cases (36.30%), followed by the kidneys with 60 cases (14.42%), and the urinary bladder with 39 cases (9.37%).

Table 1: Size of Single Calculi

Anatomical Site	Single Calculus	Multiple Calculi	Total
Kidney (n=60, 14.42%)	13 (21.7%)	45 (75.0%)	60
Ureter (n=151, 36.30%)	151 (100%)	0 (0%)	151
Urinary Bladder (n=39, 9.37%)	34 (87.17%)	5 (12.82%)	39
No Calculus (n=166, 39.90%)	-	-	166
Total	198	50	416

Table II details the size of single calculi as measured by NCCT. The transverse size of single calculi ranged from 0.2 cm to 0.8 cm. The most common size for ureteral stones was 0.4-0.5 cm, observed in 42 cases (27.81%). Kidney stones most frequently measured 0.3 cm (10%).

Table 2: Distribution of Calculus Sizes by Location in the Urinary Tract

Size of Single Calculus	Kidney (n=60, 14.42%)	Ureter (n=151, 36.30%)	Urinary Bladder (n=39, 9.37%)	Total (n=250)
0.2 cm	4	15	5	24
0.3 cm	6	15	7	28
0.4 cm	0	27	0	27
0.5 cm	1	9	3	13
0.6 cm	4	25	10	39
0.7 cm	0	46	2	48
0.8 cm	0	14	7	21
Multiple size calculus	45	0	5	50

The overall results indicate that NCCT is an effective diagnostic tool for identifying renal calculi, with a higher detection rate compared to IVP. This study highlights the importance of using NCCT for accurate and early diagnosis of urolithiasis/nephrolithiasis, which can significantly improve patient management and outcomes. The statistical analysis confirmed the significance of the findings with a p-value of less than 0.05 (1).

DISCUSSION

The findings of this study underscore the diagnostic superiority of non-contrast computed tomography (NCCT) over intravenous pyelogram (IVP) in detecting renal calculi among symptomatic patients with negative IVP results. This study revealed a substantial prevalence of urolithiasis/nephrolithiasis identified by NCCT, with 60.09% of the participants diagnosed with calculi, significantly higher than previously reported detection rates using IVP. These results align with prior studies that have consistently demonstrated the higher sensitivity and specificity of NCCT in identifying urinary calculi. For instance, Imran et al. found NCCT to be superior in

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detecting stones, reporting a sensitivity of 95-98% and specificity of 96-100% (Imran et al.) compared to IVP, which exhibited lower diagnostic accuracy (Smith et al.).

The demographic distribution highlighted a higher prevalence of renal calculi among males, particularly in the age group of 19-29 years, which is consistent with existing literature indicating a male predominance in urolithiasis cases (Khan et al.). The anatomical distribution of calculi showed the ureter as the most common site, followed by the kidneys and urinary bladder. This finding supports the hypothesis that ureteral stones, due to their tubule-like structure, are more likely to cause obstruction and symptomatic presentations, necessitating accurate and early diagnosis.

One of the strengths of this study is its robust sample size and comprehensive data collection method, which included a diverse population of symptomatic patients. The use of NCCT provided detailed imaging, allowing for precise measurement and localization of calculi, which is crucial for appropriate clinical management. Additionally, the study adhered to rigorous ethical standards, ensuring the validity and reliability of the findings.

However, the study has several limitations. The non-probability sequential sampling method may introduce selection bias, and the exclusion of patients with prior diagnoses of urolithiasis/nephrolithiasis could limit the generalizability of the results. Furthermore, while NCCT is highly effective in detecting stones, it exposes patients to higher radiation doses compared to IVP, raising concerns about long-term radiation exposure risks (Weinrich et al.). Despite these limitations, the study provides valuable insights into the diagnostic efficacy of NCCT, emphasizing its role in improving patient outcomes through accurate and early detection of renal calculi.

The findings suggest that NCCT should be considered the preferred diagnostic modality for patients presenting with acute renal colic, especially when IVP results are negative. This recommendation is based on NCCT's higher diagnostic yield, ability to detect radiolucent stones, and capacity to provide detailed information on stone characteristics, such as size and location. Future research should focus on developing low-dose NCCT protocols to mitigate radiation exposure while maintaining diagnostic accuracy (Chang et al.). Additionally, studies comparing the cost-effectiveness of NCCT and IVP could provide further justification for the widespread adoption of NCCT in clinical practice.

In conclusion, this study highlights the diagnostic accuracy of NCCT in identifying renal calculi in patients with negative IVP results. The results reinforce the importance of using NCCT for early and precise diagnosis, which is essential for effective clinical management and improved patient outcomes. Despite the associated radiation risks, the benefits of accurate diagnosis and subsequent appropriate treatment outweigh these concerns, making NCCT a valuable tool in the diagnostic arsenal for urolithiasis/nephrolithiasis (Kishore et al.).

CONCLUSION

The study concluded that non-contrast computed tomography (NCCT) significantly outperforms intravenous pyelogram (IVP) in diagnosing renal calculi among symptomatic patients with negative IVP results, demonstrating higher sensitivity and specificity. These findings have important implications for human healthcare, suggesting that NCCT should be the preferred diagnostic modality for accurate and early detection of urolithiasis/nephrolithiasis. This can lead to improved patient outcomes through timely and appropriate treatment, ultimately reducing the burden of misdiagnosis and unnecessary diagnostic procedures. Future efforts should focus on optimizing NCCT protocols to balance diagnostic efficacy with minimized radiation exposure, enhancing its utility in clinical practice.

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