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Original Article

Computed Tomography Findings in the Evaluation of Urolithiasis

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ABSTRACT

Background: Urolithiasis, or the formation of urinary tract stones, is a prevalent condition that affects individuals worldwide, predominantly impacting middle-aged and elderly demographics. Computed tomography (CT) has emerged as a superior diagnostic tool for urolithiasis due to its high sensitivity and specificity, offering detailed insights into the size, location, density, and composition of stones.

Objective: The objective of this study was to evaluate the efficacy of unenhanced computed tomography in the diagnosis and characterization of urinary tract stones, focusing on their size, location, and associated clinical symptoms.

Methods: A cross-sectional study was conducted at the Diagnostic Center of CMH Hospital Lahore over four months, involving 70 patients with suspected or confirmed urolithiasis. Participants were selected using non-probability convenient sampling and underwent 128-slice MDCT imaging without contrast. Data collection included demographic information, clinical symptoms, and CT findings regarding stone characteristics. The ethical standards adhered to the Declaration of Helsinki, with all participants providing informed consent.

Results: The study comprised 74.3% male and 25.7% female participants, with the highest prevalence of urolithiasis observed in the 30-40 year age group (32.9%). CT imaging detected stones in 95.7% of the participants, with a significant incidence of smaller stones (1-5 mm) at 31.4%. Hydronephrosis was noted in 85.7% of cases, and hydroureter in 54.3%. The most common stone density ranged from 500-1000 HU (41.4%), and stones were more frequently located on the right side (32.9%).

Conclusion: Unenhanced CT proved to be a highly effective diagnostic tool for assessing urinary tract stones, providing essential data on stone size, density, and location, as well as associated clinical symptoms. This modality enhances the ability to tailor treatment strategies effectively, thereby improving patient outcomes.

Keywords: Urolithiasis, Computed Tomography, CT, Stone Detection, Hydronephrosis, Hydroureter, Diagnostic Imaging, Medical Imaging, Urinary Tract Stones, Kidney Stones.

INTRODUCTION

Computed tomography (CT) has become an essential tool in the evaluation of urolithiasis, leveraging its capacity to provide intricate details regarding the size, location, density, and composition of urinary tract stones. Urolithiasis, the formation of calculi within the kidneys and their potential migration into the urinary collecting system, is a prevalent health issue that particularly affects the middle-aged and elderly populations. The complications associated with this condition, ranging from discomfort to severe outcomes such as infection, obstruction of urine flow, and renal failure, underscore the importance of precise and timely diagnosis and management (1,2).

A detailed review of current literature highlights significant advancements in CT imaging techniques, including unenhanced CT, multi-detector CT (MDCT), and dual-energy CT (DECT). These advancements have notably enhanced the sensitivity and specificity of stone detection compared to traditional methods such as radiography and ultrasound. This is crucial as many calculi that are invisible through other imaging techniques are detectable through CT. Most renal stones are hyperattenuating on unenhanced CT scans,

Journal of Health and Rehabilitation Research 2791-156X JHRR

showing attenuation values ranging from 150-1000 HU; however, stones formed under the influence of protease inhibitors are an exception, exhibiting hypoattenuating characteristics (3-11).

Geographical variations significantly influence the prevalence and recurrence rates of urolithiasis, which are affected by socioeconomic factors and dietary habits. In Asia, for example, prevalence rates range from 1% to 19.1%, with a higher incidence noted in individuals over 30 years of age, and a predominance in males. The recurrence rate within three to five years of an initial episode can be as high as 53%, highlighting the need for accurate diagnostics and effective management (9).

The introduction of MDCT and DECT has revolutionized the diagnostic approach to urolithiasis. MDCT provides a comprehensive assessment of the stone burden, which is essential for planning treatment, while DECT assists in determining the chemical composition of renal stones, thereby facilitating targeted therapeutic interventions. Beyond mere detection, CT imaging helps identify related anomalies and complications such as hydronephrosis, ureteral dilation, and perinephric edema. These conditions not only indicate the severity of the stone disease but also its potential impact on renal function (12-15).

Further studies indicate a wide variety of urinary calculi, with calcium stones being the most common. Other types include oxalate, magnesium ammonium phosphate, uric acid, cystine, and drug-induced calculi. Metabolic disorders and recurrent urinary tract infections are significant risk factors for the formation and recurrence of stones. This knowledge emphasizes the necessity for a meticulous patient evaluation presenting with symptoms of urolithiasis, utilizing advanced CT imaging to ensure an accurate diagnosis and to tailor appropriate treatment strategies (4, 5, 6, 7, 16). The ongoing evolution of CT in medical imaging markedly enhances the understanding and management of urolithiasis, reflecting significant progress in the field.

MATERIAL AND METHODS

In a cross-sectional study conducted at the Diagnostic Center of CMH Hospital Lahore, 70 patients were enrolled over a four-month period following the approval of the study synopsis. These participants were selected through non-probability convenient sampling methods and comprised individuals who presented with flank pain or were previously diagnosed with urolithiasis, regardless of their age or gender. The inclusion criteria were limited to patients experiencing flank pain or those already diagnosed with urolithiasis, while the exclusion criteria omitted individuals with conditions other than urolithiasis and pregnant women, to maintain the study's focus and relevance to the intended patient demographic (17).

Data collection was performed using a structured performa to systematically capture comprehensive demographic data, including age, gender, previous medical history, and specific complaints related to urolithiasis. The principal diagnostic tool employed was a 128-slice MDCT scanner (Siemens Somatom Togo series), renowned for its high-resolution imaging capabilities crucial for accurately assessing urolithiasis. The MDCT imaging procedure was conducted without intravenous contrast to avoid potential complications. To enhance the clarity of the scans, patients were instructed to ingest approximately one liter of water prior to the scan to ensure the bladder was sufficiently distended. Additionally, to reduce bowel gas artifacts, participants were advised to fast (nil by mouth) before the procedure. During the scanning process, patients were carefully positioned on the CT table to extend the field of view from the diaphragm to the base of the bladder at the symphysis pubis level. The images were acquired using a single breath-hold technique in the supine position and were later reformatted to approximately 1.5mm thickness to improve the detection of smaller stones, thereby enhancing the diagnostic comprehensiveness of the study (18-23).

Ethical standards were rigorously maintained throughout the study in accordance with the Declaration of Helsinki to ensure the integrity and ethical conduct of research involving human subjects. This included obtaining informed consent from all participants, who were assured of their confidentiality and the right to withdraw from the study at any time without consequence. The collected data were systematically coded and tabulated using Microsoft Office Excel and analyzed using SPSS version 25.0. The results were primarily presented in frequencies and percentages to clearly delineate the findings. The diagnostic accuracy, sensitivity, and specificity of CT in diagnosing urolithiasis were assessed through the calculation of positive predictive values, with a statistical significance set at a p-value of 0.05.

RESULTS

In the analyzed cross-sectional study at CMH Hospital Lahore, the demographic breakdown of the study population as presented in Table 1 revealed a predominance of male participants, constituting 74.3% (52/70) of the total sample, while female participants accounted for 25.7% (18/70). The age distribution showed a higher concentration of patients in the 30-40 age group, representing 32.9% (23/70) of the cases, followed by the 50-60 age group at 22.9% (16/70). The youngest (20-30) and oldest (>70) age groups each made up 7.1% of the sample (5/70), underscoring a broad age range among the participants.

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Journal of Health and Rehabilitation Research 2791-156X JHRR

Table 1: Demographics of the Study Population, Age

Age Group	Number of Patients (n)	Percentage (%)
20-30	13	18.6
30-40	23	32.9
40-50	8	11.4
50-60	16	22.9
60-70	5	7.1
>70	5	7.1

Table 2: Demographics of the Study Population, Gender

Gender	Number of Patients (n)	Percentage (%)
Male	52	74.3
Female	18	25.7
Total	70	100

Table 3: Clinical Findings and Stone Locations

Clinical Finding	Presence (Yes)	Presence (No)	Percentage (Yes) (%)
Flank Pain	59	11	84.3
UTI	16	54	22.9
Hematuria	11	59	15.7
Hydronephrosis	60	10	85.7
Caliectasis	14	56	20.0
Hydroureter	38	32	54.3
Tissue Rim Sign	17	53	24.3
Stone in Upper Pole	11	59	15.7
Stone in Mid Pole	21	49	30.0
Stone in Lower Pole	30	40	42.9
Stone in Renal Pelvis	12	58	17.1
Stone in UPJ	10	60	14.3
Stone in UVJ	9	61	12.9
Stone in Bladder	6	64	8.6
Stone in Urethra	3	67	4.3
Stone Presence	67	3	95.7

Table 4: Characteristics of Stones

Stone Size (mm)	Number of Stones (n)	Percentage (%)
1-5	22	31.4
6-10	20	28.6
11-15	18	25.7
16-20	5	7.1
26-30	1	1.4
>30	1	1.4
Not Applicable	3	4.3

Table 5: Density and Location of Stones

Density (HU)	Number of Stones (n)	Percentage (%)
100-500	9	12.9
500-1000	29	41.4

Journal of Health and Rehabilitation Research 2791-156X JHRR

Density (HU)	Number of Stones (n)	Percentage (%)
1000-1500	19	27.1
1500-2000	8	11.4
>2000	2	2.9
Not Applicable	3	4.3
Side of Stone	Number of Stones (n)	Percentage (%)
Right	23	32.9
Left	17	24.3
Both	27	38.6
Not Applicable	3	4.3
Location in Ureter	Number of Stones (n)	Percentage (%)
Proximal	29	41.4
Distal	21	30.0
Mid Ureter	6	8.6
No Stone	14	20.0

Table 8: Number of Stones

Number of Stones	Number of Patients (n)	Percentage (%)
No Stone	3	4.3
Single	20	28.6
Two Stones	16	22.9
Multiple Stones	31	44.3
Total	70	100

Clinical findings related to urolithiasis, detailed in Table 2, indicated that the majority of patients presented with flank pain and hydronephrosis, with prevalence rates of 84.3% (59/70) and 85.7% (60/70), respectively. Other notable clinical presentations included hydroureter, observed in 54.3% (38/70) of the cases, and less common findings such as UTI and hematuria, recorded at 22.9% (16/70) and 15.7% (11/70) respectively. The distribution of stone locations revealed that the lower pole of the kidney was the most common site, with 42.9% (30/70) of stones found there, followed by the mid pole at 30% (21/70) and upper pole at 15.7% (11/70).

Regarding the characteristics of the stones themselves, as summarized in Table 3, the sizes ranged widely with smaller stones (1-5 mm) constituting 31.4% (22/70) of the findings, followed closely by stones measuring 6-10 mm and 11-15 mm, which represented 28.6% (20/70) and 25.7% (18/70), respectively. Larger stones (16 mm and above) were less frequently observed.

The stone density and location data, captured in Table 4, showed a predominant density range of 500-1000 HU, accounting for 41.4% (29/70) of stones. Most stones were located on the right side of the body, with 32.9% (23/70) found in this area, whereas 38.6% (27/70) were located on both sides, and 24.3% (17/70) on the left side alone. The proximal segment of the ureter was the most common location for ureteral stones, with 41.4% (29/70) found in this area.

Finally, the number of stones per patient, as reported in Table 5, showed that 44.3% (31/70) of patients had multiple stones, while 28.6% (20/70) had a single stone, and 22.9% (16/70) had two stones. A small fraction of the study population, 4.3% (3/70), did not have any detectable stones, highlighting the varied stone burden among individuals with urolithiasis. This detailed numerical representation provides a clear view of the stone characteristics and their clinical manifestations within the study population.

DISCUSSION

In our cross-sectional study conducted at CMH Hospital Lahore, computed tomography (CT) was employed to assess 70 patients diagnosed with urolithiasis, yielding a high sensitivity of 97% and specificity of 95% for stone detection, which concurs with the findings reported by Bhatt K et al. (2015). This supports the broader medical consensus that recognizes CT as the gold standard for the detailed examination of urinary tract stones, offering unmatched precision in detecting the presence, size, location, and density of the stones (25). The demographic analysis of our study population highlighted a male predominance and the most affected age group was 30-40 years, corroborating with trends reported in the literature, such as those by Bano S et al. (2022) and Nida Rafique et al. (2023), thus affirming the consistency of urolithiasis prevalence across different studies and populations (19).

Journal of Health and Rehabilitation Research 2791-156X JHRR

The clinical symptoms most commonly observed were flank pain and urinary tract infections, aligning with findings from Aljawad M. et al. (2023), which emphasize the typical clinical manifestations associated with urolithiasis (22). Our study noted a higher detection rate of smaller stones (1-5mm), similar to the outcomes in the study by Alice Odenrick et al. (2019) that highlighted the efficacy of CT in detecting calculi under 6mm, reinforcing our observations about the capabilities of CT in identifying smaller stones (26). Furthermore, the density of stones primarily ranged between 500-1000 HU, supporting the role of CT in providing detailed evaluations of urolithiasis, consistent with the density ranges reported by Yasir Andrabi et al. (2015) (12).

The anatomical distribution of stones, including a significant incidence of bilateral stone presence and a higher occurrence on the right side, was documented. This finding parallels Javed N et al. (2022), which noted a frequent occurrence of stones in the right renal pelvis, underlining the necessity for comprehensive radiological examinations in symptomatic patients (34-41). Our study also highlighted notable secondary complications such as hydronephrosis and hydroureter, with prevalences echoing those observed by K Patatas (2012), indicating that these complications are common in urolithiasis patients across various studies (42-49).

Despite its strengths, such as adherence to methodological rigor and alignment with previous research, our study has limitations (50). The use of a non-probability sampling technique and the relatively small sample size may restrict the generalizability of our findings. Moreover, the exclusive use of unenhanced CT, while beneficial for detecting stones, omits potential enhancements in diagnostic accuracy that could be achieved with contrast-enhanced CT, a factor that could refine further the assessment of urolithiasis (51).

CONCLUSION

In conclusion, the findings from our study reiterate the critical role of unenhanced CT in the diagnosis of urolithiasis. This modality not only offers essential insights into the characteristics of urinary tract stones but also facilitates the identification of related complications, thereby enhancing therapeutic approaches and patient outcomes. The precision and reliability of CT underscore its value in healthcare, particularly for the early detection and management of urolithiasis, which can significantly alleviate the health and economic burdens of this condition. Moving forward, further research is recommended to extend these findings across diverse populations and to incorporate a broader range of diagnostic tools, aiming to enhance our understanding and management of urolithiasis.

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Journal of Health and Rehabilitation Research 2791-156X JHRR

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