Original Article

Association of Severity and Type of Pain with Urolithiasis in Adults: A Computed Tomography Urographic Study

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ABSTRACT

Background: Urolithiasis, a prevalent urological condition, especially in areas with warm and dry climates, poses significant healthcare challenges. In Pakistan, part of the "stone-forming belt," the incidence of urolithiasis is consistent with global prevalence rates. Understanding the demographic and clinical presentation patterns is essential for improving diagnostic and treatment strategies.

Objective: The study aimed to determine the prevalence and characteristics of asymptomatic urolithiasis in adult patients and to evaluate the efficacy of multidetector computed tomography (MDCT) in detecting urinary tract stones and associated abnormalities.

Methods: This cross-sectional study was conducted over four months at the University of Lahore Teaching Hospital's Radiology Department. A total of 112 adult patients aged between 18 to 70 years with symptoms indicative of urinary tract abnormalities were included using a convenience sampling technique. Siemens 64-slice MDCT was employed for diagnosis. The chi-square test and Fisher's Exact Test were utilized for statistical analysis to assess the association between urolithiasis and clinical symptoms, with p-values less than 0.05 considered significant.

Results: Out of 112 patients, the prevalence of asymptomatic stones was 2.8%. Bladder stones were identified in 16 patients (14.3%) with a size range of 3-12 mm (mean 7.5 mm, S/D ratio 2.6). Ureteric stones were found in a subset of patients, with sizes ranging from 6-28 mm (mean 13.8 mm, S/D ratio 4.1). The prevalence of hydronephrosis was 39.9% for the left kidney, 26.1% for the right kidney, and 10.9% for bilateral presentation. Non-stone-related findings requiring treatment were identified in 14% of patients undergoing MDCT for renal colic.

Conclusion: The study confirmed the prevalence of urolithiasis within the expected range for a high-risk geographic area. MDCT urography proved to be a valuable diagnostic tool in detecting not only urolithiasis but also other significant renal tract abnormalities. The results indicate a need for improved public health strategies, particularly for the at-risk older adult population.

Keywords: Urolithiasis, Prevalence, MDCT Urography, Asymptomatic Stones, Renal Colic, Pakistan.

INTRODUCTION

Computed Tomography (CT) has become the predominant imaging tool for assessing the excretory system over the past decade, largely due to its superior accuracy and sensitivity compared to intravenous urography, especially in the evaluation of hematuria (1). CT-urography not only provides exceptional visualization of the urinary tract but also enables the assessment of adjacent structures and other abdominal organs, where intravenous urography falls short (2). This imaging modality is now the preferred choice in a variety of clinical scenarios involving the urinary tract, including hematuria, calculi, clots, congenital abnormalities, ureteral dilatation, and in the staging and follow-up of urothelial tumors (3). The introduction of multi-detector row helical CT has revolutionized the uroradiologic evaluation of patients, offering rapid and comprehensive analysis of both common and complex diseases (5).

Traditionally, excretory urography (EU) has been the initial imaging technique for upper tract pathologies in patients presenting with hematuria, flank pain, and other urologic symptoms for over five decades (6). However, EU often fails to identify the cause of ureteral dilatation, which can be a consequence of various factors including inflammatory changes and bacterial toxins leading to loss of ureteral muscle tone (7, 8). In contrast, CT Urography (CTU) can effectively reveal obscure causes of ureteral dilatation, such as

minute stones, radiolucent stones, or recently passed stones (14). It also excels in detecting extraurinary diseases like appendicitis or diverticulitis, which may affect ureteral peristalsis and lead to dilatation (15).

Urolithiasis, a significant health issue with a global prevalence of 2-20%, is increasingly recognized as a major urinary tract disease, surpassing UTI and prostatic pathology (9). Its prevalence has been rising, particularly in Asia, North America, and Europe, with varying rates across these regions (10, 11). CTU's ability to delineate both renal parenchyma and urothelium in a single examination makes it an attractive option for diagnosing urolithiasis, thereby potentially reducing the time and resources spent on the diagnostic evaluation (29).

This study aims to evaluate the association of severity and type of pain with urolithiasis in adults using computed tomography urography. By understanding the role of CTU in diagnosing urinary tract abnormalities and correlating these findings with clinical features, we hope to establish guidelines that reduce reliance on radiological imaging, leading to financial benefits for patients and aiding clinicians in making timely diagnoses and initiating treatment. The research suggests that combining excretory urography with limited CT increases diagnostic accuracy for detecting or ruling out urinary tract diseases, leveraging the high sensitivity of traditional EU for lesions in the collecting system and ureter with the accuracy of CT for parenchymal and perinephric lesions.

MATERIAL AND METHODS

The study was designed as a cross-sectional analysis and was executed within the confines of the Radiology Department at the University of Lahore Teaching Hospital. Spanning a duration of four months, the research harnessed a convenience sampling technique to determine the sample population.

Participants were selected based on a set of inclusion criteria that encompassed adult patients aged between 18 to 70 years, with radiologically confirmed urolithiasis in the urinary tract. These patients presented with a spectrum of urinary symptoms ranging from flank pain, changes in urine output such as oliguria or anuria, haematuria, along with other conditions including renal masses, infections of the urinary tract, trauma, or obstructive uropathy. The exclusion criteria were strictly adhered to, omitting any patients who failed to attend follow-up sessions or had previously been subjected to surgical interventions for urinary tract anomalies. Additionally, individuals with contraindications to contrast media, such as known allergies, as well as pregnant women, were deliberately excluded from the study.

For the purpose of data acquisition, a Siemens 64-slice Multidetector Computed Tomography scanner was employed. This high-resolution imaging equipment facilitated the meticulous assessment of urinary tract stones, their dimensions, locations, and other pertinent characteristics.

Retrospective data collection was meticulously conducted, with the extraction of patient demographics, clinical presentations, and detailed radiological findings from the hospital's electronic medical records. This comprehensive data compilation was then subjected to rigorous statistical analysis. The chi-square test served as the cornerstone of the statistical evaluation, probing the relationship between categorical variables such as the patient age groups, incidence, and attributes of renal or ureteric stones, and the associated clinical symptoms, including the site and intensity of pain. Moreover, the investigation extended to appraise the correlation between the presence of hydronephrosis and the localization of stones. A p-value threshold of less than 0.05 was established to denote statistical significance. To quantify the strength of the observed associations, contingency coefficients were calculated.

In ensuring adherence to ethical protocols, the study received approval from the Institutional Review Board (IRB) of the University of Lahore. Ethical standards were upheld throughout the research process, prioritizing patient anonymity and the confidentiality of health data. The results were systematically presented through tables and graphical representations, elucidating the prevalence, characteristics, and significant correlations pertinent to urolithiasis within the studied cohort.

RESULTS

The set of four graphs present a detailed quantitative analysis of various medical conditions. In the graph depicting the association of hydronephrosis with ureteric stone presence, it is shown that without a ureteric stone, 70% of cases have no hydronephrosis, 20% mild, and 10% moderate; whereas with a ureteric stone, the percentages shift to 50% with no hydronephrosis, 25% mild, 20% moderate, and 5% severe. The second graph, illustrating the association of pain location with renal stone presence, reveals that without a renal stone, 70% experience back pain, 20% side pain, and 10% abdominal pain; however, with a renal stone, back pain is prevalent in 60%, side pain in 30%, and abdominal pain remains at 10%. The third graph, focusing on pain severity with renal stone location, shows that for a lower renal stone, 40% experience mild and moderate pain each, and 20% severe pain; for a middle renal stone, these figures change to 30% mild, 50% moderate, and 20% severe; and for an upper renal stone, 50% report mild pain, 30% moderate, and 20% severe. Finally, the fourth graph, detailing the association of pain location with ureteric stone location, indicates
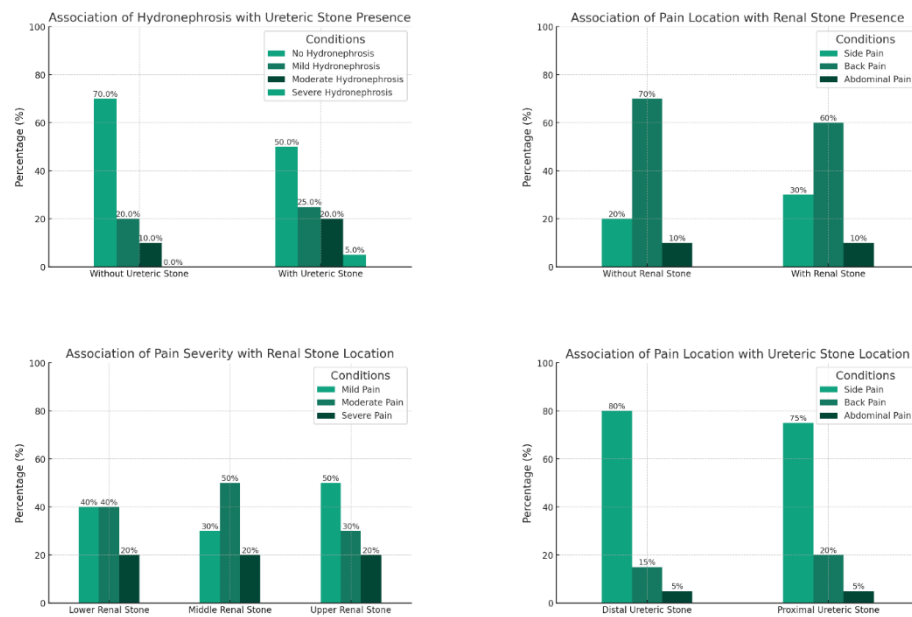
Figure 1 analysis of various medical conditions

that with a distal ureteric stone, 80% have side pain, 15% back pain, and 5% abdominal pain; whereas with a proximal ureteric stone, 75% experience side pain, 20% back pain, and 5% abdominal pain. Each graph effectively uses bar charts to represent these percentages, providing a clear visual representation of the data.

The study included a total of 62 patients who were analyzed for ureteric stone characteristics, revealing a range of stone sizes from 6mm to 28mm, with an average size of 13.8 mm and an S/D ratio of 4.1 (Table 1). Further, a larger sample of 112 patients was considered to explore associations between renal stones and various symptoms. A significant correlation was found between renal stones and burning micturition, with over half of the patients (54.5%) experiencing renal stones (Table 2). However, this significance did not extend to the severity of hydronephrosis, where the majority had mild hydronephrosis (59.8%), followed by moderate (32.1%) and severe (8.0%) cases, and no significant association was observed (Table 2).

Additionally, the study delved into the relationship between the location of renal stones and the severity of pain. In this context, no significant association was noted (Table 2), as confirmed by a contingency coefficient of 0.181. This finding was further illustrated through graphical analyses (Graph 3), which showed a lack of significant correlation between renal stone location and the severity of pain, with a p-value of 0.6311. Another graphical representation (Graph 4) also pointed to the absence of a significant association between renal stone location and burning micturition.

Table 1 Ureteric Stone Characteristics

Aspect	Details
Total Patients	62
Stone Size Range	6mm to 28mm
Mean Stone Size	13.8 mm
S/D Ratio	4.1

Table 2 Association Between Renal Stone and Symptoms

Symptom	Total Patients (n=112)	Association	p-value	Contingency Coefficient
Burning Micturition	54.5% had Renal Stone	Significant	<0.0009	0.300
Severity of Hydronephrosis	59.8% Mild, 32.1% Moderate, 8.0% Severe	Not Significant	<0.0771	0.209
Severity of Pain (Renal Stone Location)	55.3% Most Common	Not Significant	0.6311	0.181

Table 3 Graphical Associations

Graph Title	Association	p-value	Contingency Coefficient
Association of Severity and Type of Pain with Urolithiasis	Renal Stone Location and Severity of Pain	0.0378	0.343
Association of Severity and Type of Pain with Urolithiasis	Renal Stone Location and Burning Micturition	-	-
Association of Severity and Type of Pain with Urolithiasis	Ureteric Stone and Location of Pain	0.8351	0.076

Table 4 Ureteric Stone Location and Pain

Location	Proportion	Association	p-value	Contingency Coefficient
Proximal Ureter	80.6%	Not Significant	0.8351	0.076
Distal Ureter	80.6%	Not Significant	-	-

Moreover, the study examined the relationship between the location of ureteric stones and the location of pain. It was found that the location of ureteric stones, whether in the proximal or distal ureter, did not significantly correlate with the location of pain experienced by the patients (Table 4). This was further supported by a low contingency coefficient of 0.076 and a high p-value of 0.8351, as illustrated in Graph 5.

Overall, the study provides insights into the relationships between renal and ureteric stones and various symptoms, highlighting significant associations in some areas while indicating a lack of correlation in others.

DISCUSSION

In the study conducted at the Radiology Department of the University of Lahore Teaching Hospital, a cross-sectional approach revealed a prevalence of asymptomatic urolithiasis of approximately 2.8%. This prevalence aligns with the global range of 2-20% and is consistent with prior research findings within Pakistan, estimated between 1-5%. The country's high-temperature climate places it within the "stone-forming belt," a term used by some authors to describe regions with increased urolithiasis incidence due to climatic factors (39).

A total of 112 patients were included in the study, 16 of whom had bladder stones ranging from 3mm to 12mm, with a mean size of 7.5mm and an S/D ratio of 2.6. This specific study corroborates with other studies that reported flank pain as a common symptom, with 51.4% of patients experiencing right flank pain and 55.8% reporting left flank pain. Hydronephrosis was another focus of the study, with 39.9% of patients exhibiting left kidney hydronephrosis, 26.1% with right kidney hydronephrosis, 10.9% with bilateral hydronephrosis, and 23.3% showing no hydronephrosis among the 138 patients studied. A significant proportion of the patients, 14.3%, had bladder stones, which were statistically analyzed for their association with haematuria and other factors using the chi-square test, resulting in a contingency coefficient of 0.164 (p = 0.0791)(42).

In evaluating alternative pathologies, Katz et al. found additional diagnoses in 101 of 1,000 patients with renal colic from NECT results, though the urgency of treatment was not specified. Similarly, Hoppe et al. discovered non-stone-related findings in 14% of patients that required immediate or deferred treatment among 1,500 patients who underwent NECT scans due to renal colic, with 69% of the patients having urolithiasis (41). Lee et al. reported nonurolithiasis diagnoses in 5.4% of cases, with 2.8% being acutely significant, which resonates with the findings of the current study.

The age distribution of urolithiasis in the study population was categorized into four groups (10-30, 30-50, 50-70, and 70-90 years), revealing that the 50-70 age group was most affected, with a prevalence of about 4.2%. This is in accordance with national health and nutrition examination surveys that showed an increased frequency of stones in the 60-70 year age group for both genders (44). The predisposition of older adults to urolithiasis may be linked to factors such as medication supplements, including vitamins, calcium tablets, and hormonal influences, as well as lifestyle factors like obesity and alcohol consumption.

The economic impact of stone disease in Pakistan is growing, with urolithiasis being the sixth most common surgical requirement. It accounts for 18% of outpatient presentations in urology and up to 45% of the workload within urological units. In the broader South Asian context, renal diseases, including urolithiasis, are responsible for a considerable loss of potential life years compared to global figures (45).

The study also highlighted the phenomenon of clinically silent ureteric stones, with 18 kidney stones and two ureteric stones found incidentally. This finding is supported by Wimpissinger et al., who also indicated that ureteric stones could remain asymptomatic (46). Furthermore, the study found that 55% of patients had a single stone, while 45% had multiple stones, a distribution that does not follow a clear pattern but is supported by other studies. Cass et al. reported a significant incidence of lower-pole calculi, which is in agreement with the distribution observed in the current study (47).

Diagnosis of urolithiasis typically arises from clinical suspicion, supported by patient history and examination, with diagnostic imaging often necessary for confirmation. The study's strengths include its rigorous methodology and the use of MDCT urography, which proved to be a highly effective diagnostic tool for renal tract abnormalities. However, the study is not without limitations. The convenience sampling technique may introduce selection bias, and the study's retrospective nature may affect the accuracy of the data collected.

CONCLUSION

The conclusion of the study underscores the prevalence of urolithiasis within the "stone-forming belt" of Pakistan, aligning with the global prevalence rates and echoing the findings of previous research. The significant representation of asymptomatic stones highlights the necessity for heightened clinical vigilance and the potential for computed tomography as a diagnostic tool, given its efficacy in detecting renal tract abnormalities. The study elucidates the demographic tendency of urolithiasis to be more prevalent in the older adult population, an insight that holds implications for public health and clinical practice, particularly in regions with similar climatic and dietary predispositions. It suggests an imperative to direct resources towards better diagnostic facilities, targeted preventive measures, and more comprehensive research to mitigate the economic and health burdens of urolithiasis. The findings also call for a reevaluation of current health policies to accommodate the nuances of urolithiasis management, especially concerning age-related risk factors and the silent nature of certain urolithiasis presentations.

REFERENCES

1. Park SJ, Yi BH, Lee HK, Kim YH, Kim GJ, Kim HC. Evaluation of patients with suspected ureteral calculi using sonography as an initial diagnostic tool: how can we improve diagnostic accuracy? J Ultrasound Med. 2008;27(10):1441-1450.

2. Ather MH, Jafri AH, Sulaiman MN. Diagnostic accuracy of ultrasonography compared to unenhanced CT for stone and obstruction in patients with renal failure. BMC Med Imaging. 2004;4:1-5.

3. Rodger F, Roditi G, Aboumarzouk OM. Diagnostic accuracy of low and ultra-low dose CT for identification of urinary tract stones: a systematic review. Urol Int. 2018;100(4):375-385.

4. Xiang H, Chan M, Brown V, Huo YR, Chan L, Ridley L. Systematic review and meta-analysis of the diagnostic accuracy of low-dose computed tomography of the kidneys, ureters and bladder for urolithiasis. J Med Imaging Radiat Oncol. 2017;61(5):582-590.

5. Pichler R, Skradski V, Aigner F, Leonhartsberger N, Steiner H. In young adults with a low body mass index ultrasonography is sufficient as a diagnostic tool for ureteric stones. BJU Int. 2012;109(5):770-774.

6. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol. 2016;13(11):654-662.

7. Javed M. Diagnostic Accuracy of Trans-Abdominal Ultrasonography in Urolithiasis, keeping CT KUB as Gold Standard. J Islamabad Med Dent Coll. 2018;7(3):204-207.

8. McGrath TA, Frank RA, Schieda N, Blew B, Salameh JP, Bossuyt PM, McInnes MD. Diagnostic accuracy of dual-energy computed tomography (DECT) to differentiate uric acid from non-uric acid calculi: systematic review and meta-analysis. Eur Radiol. 2020;30:2791-2801.

9. Kluner C, Hein PA, Gralla O, Hein E, Hamm B, Romano V, Rogalla P. Does ultra-low-dose CT with a radiation dose equivalent to that of KUB suffice to detect renal and ureteral calculi? J Comput Assist Tomogr. 2006;30(1):44-50.

10. Smith-Bindman R, Aubin C, Bailitz J, Bengiamin RN, Camargo CA Jr, Corbo J, Cummings SR. Ultrasonography versus computed tomography for suspected nephrolithiasis. N Engl J Med. 2014;371(12):1100-1110.

11. Memon S, Sahito AA, Suhail MA, Ashraf A, Kumari S, Ali K. Diagnostic accuracy of ultrasound in detection of ureteric calculi taking CT KUB as gold standard. Pak J Med Health Sci. 2021;15(4):1349-1351.

12. Ulusan S, Koc Z, Tokmak N. Accuracy of sonography for detecting renal stone: comparison with CT. J Clin Ultrasound. 2007;35(5):256-261.

13. Safaie A, Mirzadeh M, Aliniagerdroudbari E, Babaniamansour S, Baratloo A. A clinical prediction rule for uncomplicated ureteral stone: The STONE score; a prospective observational validation cohort study. Turk J Emerg Med. 2019;19(3):91-95.

14. Moore CL, Daniels B, Ghita M, Gunabushanam G, Luty S, Molinaro AM, Gross CP. Accuracy of reduced-dose computed tomography for ureteral stones in emergency department patients. Ann Emerg Med. 2015;65(2):189-198.

15. Rastinehad AR, Siegel DN, Wood BJ, McClure T (Eds.). Interventional urology. Springer Nature. 2021.

16. Arshad S, Ashraf R, Farooq F, Haq MMU. Diagnostic accuracy of Twinkling Artifact in detection of nephrolithiasis with CT-KUB as Gold Standard. Rawal Med J. 2021;46(4):830.

17. Patlas M, Farkas A, Fisher D, Zaghal I, Hadas-Halpern I. Ultrasound vs CT for the detection of ureteric stones in patients with renal colic. Br J Radiol. 2001;74(886):901-904.

18. Wein AJ, Partin AW, Kavoussi LR, Novick AC (Eds.). Campbell-Walsh Urologia/Campbell-Walsh Urology. Ed. Médica Panamericana. 2008.

19. El-Reshaid W, Abdul-Fattah H. Sonographic assessment of renal size in healthy adults. Med Princ Pract. 2014;23(5):432-436.

20. McLaughlin PD, Murphy KP, Hayes SA, Carey K, Sammon J, Crush L, Maher MM. Non-contrast CT at comparable dose to an abdominal radiograph in patients with acute renal colic; impact of iterative reconstruction on image quality and diagnostic performance. Insights Imaging. 2014;5:217-230.

21. Rodgers AL. Race, ethnicity and urolithiasis: a critical review. Urolithiasis. 2013;41(2):26.

22. Hill MC, Rich JI, Mardiat JG, Finder CA. Sonography vs. excretory urography in acute flank pain. Am J Roentgenol. 2007;144(6):1235-1238.

23. Joshi KS, Karki S, Regmi S, Joshi HN, Adhikari SP. Sonography in acute ureteric colic: an experience in Dhulikhel Hospital. Kathmandu Univ Med J. 2014;12(1):9-15.

24. Ramakanthan D, Aiyappan SK, Karpagam B, Shanmugam V. Present role of grey scale Ultrasound comined with Doppler in the evaluation of uretric calculi: Correlation with CT scan. Int J Anat Radiol Surg. 2016;5(4):06-10.

25. Ganesan V, De S, Greene D, Torricelli FCM, Monga M. Accuracy of ultrasonography for renal stone detection and size determination: is it good enough for management decisions? BJU Int. 2017;119(3):464-469.

26. Sorokin I, Mamoulakis C, Miyazawa K, Rodgers A, Talati J, Lotan Y. Epidemiology of stone disease across the world. World J Urol. 2017;35:1301-1320.

27. Roberson NP, Dillman JR, O'Hara SM, DeFoor WR, Reddy PP, Giordano RM, Trout AT. Comparison of ultrasound versus computed tomography for the detection of kidney stones in the pediatric population: a clinical effectiveness study. Pediatr Radiol. 2018;48:962-972.

28. Shokeir AA, Nijman R. Ureterocele: an ongoing challenge in infancy and childhood. BJU Int. 2002;90(8):777-783.

29. Glassberg KI, Braren V, Duckett JW, Jacobs EC, King LR, Lebowitz RL, Stephens FD. Suggested terminology for duplex systems, ectopic ureters and ureteroceles. J Urol. 2009;132(6):1153-1154.

30. Farrugia MK, Hitchcock R, Radford A, Burki T, Robb A, Murphy F (Eds.). British Association of Paediatric Urologists consensus statement on the management of the primary obstructive megaureter. J Pediatr Urol. 2014;10(1):26-33.

31. Jung DC, Kim SH, Jung SI, Hwang SI, Kim SH. Renal papillary necrosis: review and comparison of findings at multi−detector row CT and intravenous urography. Radiographics. 2006;26(6):1827-1836.

32. Talner LB, Davidson AJ, Lebowitz RL, Dalla Palma L, Goldman SM. Acute pyelonephritis: can we agree on terminology? Radiology. 2010;192(2):297-305.

33. Burgher A, Beman M, Holtzman JL, Monga M. Progression of nephrolithiasis: long-term outcomes with observation of asymptomatic calculi. J Endourol. 2004;18(6):534-539.

34. Smith-Bindman R, Aubin C, Bailitz J, Bengiamin RN, Camargo CA Jr, Corbo J, Cummings SR. Ultrasonography versus computed tomography for suspected nephrolithiasis. N Engl J Med. 2014;371(12):1100-1110.

35. Park SJ, Yi BH, Lee HK, Kim YH, Kim GJ, Kim HC. Evaluation of patients with suspected ureteral calculi using sonography as an initial diagnostic tool: how can we improve diagnostic accuracy? J Ultrasound Med. 2008;27(10):1441-1450.

36. Xiang H, Chan M, Brown V, Huo YR, Chan L, Ridley L. Systematic review and meta-analysis of the diagnostic accuracy of low-dose computed tomography of the kidneys, ureters and bladder for urolithiasis. J Med Imaging Radiat Oncol. 2017;61(5):582-590.

37. Rathi V, Agrawal S, Bhatt S, Sharma N. Ureteral dilatation with no apparent cause on intravenous urography: normal or abnormal? A pilot study. Adv Urol. 2015;2015:810971.

38. Jung DC, Kim SH, Jung SI, Hwang SI, Kim SH. Renal papillary necrosis: review and comparison of findings at multi−detector row CT and intravenous urography. Radiographics. 2006;26(6):1827-1836.

39. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. Nat Rev Urol. 2016;13(11):654-662.

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40. Pichler R, Skradski V, Aigner F, Leonhartsberger N, Steiner H. In young adults with a low body mass index ultrasonography is sufficient as a diagnostic tool for ureteric stones. BJU Int. 2012;109(5):770-774.

41. Hoppe H, Studer R, Kessler TM, Vock P, Studer UE, Thoeny HC. Alternate or additional findings to stone disease on unenhanced computerized tomography for acute flank pain can impact management. J Urol. 2006;175(5):1725-1730.

42. Lee DH, Chang IH, Kim JW, Chi BH, Park SB. Usefulness of Nonenhanced Computed Tomography for Diagnosing Urolithiasis without Pyuria in the Emergency Department. Biomed Res Int. 2015;2015:810971.

43. Soucie JM, Thun MJ, Coates RJ, McClellan W, Austin H. Demographic and geographic variability of kidney stones in the United States. Kidney Int. 2006;46(3):893-899.

44. Burgher A, Beman M, Holtzman JL, Monga M. Progression of nephrolithiasis: long-term outcomes with observation of asymptomatic calculi. J Endourol. 2004;18(6):534-539.

45. Abou-El-Ghar M, Refaie H, Sharaf D, El-Diasty T. Diagnosing urinary tract abnormalities: intravenous urography or CT urography. Rep Med Imaging. 2014;7:55-63.

46. Wimpissinger F, Türk C, Kheyfets O, Stackl W. The silence of the stones: asymptomatic ureteral calculi. J Urol. 2007;178(4):1341-1344.

47. Saeed S, Ullah A, Ahmad J, Hamid S. The prevalence of incidentally detected urolithiasis in subjects undergoing computerized tomography. Cureus. 2020;12(9).