RESEARCH PAPER

Epidemiological and Anatomical Characterization of Urinary Tract Calculi Using Non-Contrast Computed Tomography of Kidney, Ureter and Bladder Imaging.

Mohammad Ayan[1], Mohd Abdullah Siddiqui[2]

[1]*MSc Medical Imaging Technology, Department of paramedical Sciences, Jamia Hamdard, New Delhi, India*
Email id: mohammadayan.research@gmail.com
ORCID ID: 0009-0003-9018-3962
[2]*Faculty, Department of Paramedical Sciences, Jamia Hamdard, New Delhi, India*
Email id: mohdabdullahsiddiqui@gmail.com

ABSTRACT

Background: Ct scan of kidneys, ureter and bladder is a specialized procedure in radiology used to assess the urinary tract for condition like calculi, infections, tumors, obstruction and structural abnormalities. We can also use USG for the diagnosis but for our concern USG can only detect larger stones and hydronephrosis, may fail to detect smaller stones or radiolucent ones.

Objectives: Our main objectives to discuss will be: to analyze the gender-based distribution of urinary tract calculi, to map the positional distribution of urinary tract calculi, to determine the presence of urinary tract calculi across different age groups.

Methodology: We have taken total of 160 patients of CT KUB both males and females of all age group, out of which 45 showed us the normal findings and 115 shows us abnormal findings. For age-wise distribution, patients were divided into six groups: 10–20 years (12 patients), 21–30 years (24 patients), 31–40 years (33 patients), 41–50 years (27 patients), 51–60 years (13 patients), and 61–70 years (5 patients). The age group of 31 to 40 years old had the highest incidence of calculi, suggesting that middle aged people are more likely to have urolithiasis.

Result:A total of 160 patients underwent non-contrast computed tomography of kidneys, ureters and bladder CT KUB for suspected urinary tract calculi. Out of these 115 patients (71.9%) demonstrated evidence of calculi on imaging, while 45 patients (28.1%) had normal scans with no detectable stones

Discussion: The high detection rate of urolithiasis in this study reinforces the diagnostic superiority of non-contrast CT KUB, which effectively overcomes limitations of USG such as operator dependency and reduced sensitivity for small or radiolucent stones.

Conclusion.: The observed demographic and anatomical pattern emphasize the need for targeted preventive strategies such as hydration and dietary modification in young males prone to calcium oxalate stones and urinary alkalization or metabolic assessment in older females at risk for uric acid stones**..**

Keywords: CT stands for computed tomography, HU for Hounsfield Unit, NCCT for non-contrast computed tomography, KUB for kidneys ureters and bladder, VUJ for Vesicoureteric junction and USG for ultrasonography

How to cite this article: Ayan M, Siddiqui MA., Epidemiological and Anatomical Characterization of Urinary Tract Calculi Using Non-Contrast Computed Tomography of Kidney, Ureter and Bladder Imaging. Int J Drug Deliv Technol. 2026;16(3s): 311-316; DOI: 10.25258/ijddt.16.3s.40

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Computed Tomography is an advanced imaging modality that integrates X-ray technology with computer processing to generate highly detailed cross-sectional and 3D images of internal body structures, including bones, soft tissues, and blood vessels. Unlike conventional X-rays that provide only 2D projections, CT offers superior spatial resolution and diagnostic precision.(1)

CT scan of the kidneys, ureters, and bladder (CT KUB) is a specialized examination used to assess the urinary tract for conditions such as calculi, infections, tumors, obstructions, and structural abnormalities. Compared to plain X-ray KUB, CT provides enhanced image clarity and can detect even small stones or lesions that might otherwise go unnoticed. NCCT KUB is particularly effective for identifying renal and ureteric calculi, as calcium-containing stones appear hyperdense and are easily distinguished from surrounding tissues. CT can accurately detect and characterize both radiolucent and radio-opaque stones, offering near-complete sensitivity and specificity in the diagnosis of urolithiasis.(2)

**Author for Correspondence: mohdabdullahsiddiqui@gmail.com*

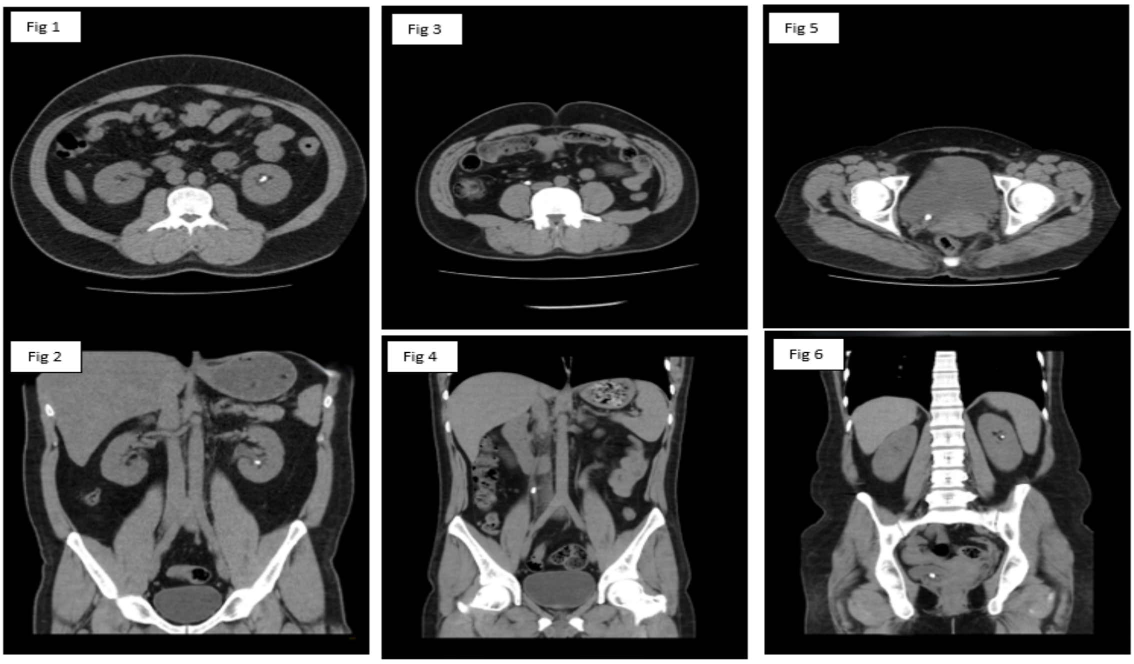


Fig 1 and 2 shows the presence of Calculi in the lower pole of left Kidney.
Fig 3 and 4 shows the presence of Calculi at the Right mid Ureter.
Fig 5 and 6 shows the presence of calculi in the Urinary Bladder.

Based on how visible they are on imaging; kidney stones are categorised as either radiolucent or radio-opaque. Calcium oxalate, calcium phosphate and struvite stones are examples of radio-opaque stones that are easily visible on x-rays and CT scans. Uric acid and other radiolucent stones. Xanthine stones are calcium-free and invisible on X-rays, but they are easily identified on CT scans. Although USG is helpful for detecting larger stones and hydronephrosis, it may miss small or radiolucent stones due to limitations such as bowel gas, patient body habitus, and operator dependency.(3)

Although USG serves as a valuable, non-invasive screening tool for larger stones and hydronephrosis, it is limited by patient body habitus, bowel gas, and operator dependency, and may fail to detect smaller or radiolucent stones. CT provides comprehensive visualization of the entire urinary tract and can identify associated complications or alternative causes of flank pain. Despite involving radiation exposure and relatively higher cost, advances in low-dose CT protocols have minimized these concerns, establishing CT as the preferred and most reliable imaging modality for the evaluation and management of kidney stones.(4)

Kidney stone is a common problem around the world and affect both men and women at different ages. Past studies often put people into big age groups, such as 40 to 70 years, which can miss important details. In this study, we use CT KUB scans and split patients into smaller age groups: 10-20, 21-30, 31-40, 41-50, 51-60 and 61-70. By studying age, gender and calculi location together, we hope to get clear patterns.(5)

METHODOLOGY

This retrospective observational study was conducted on patients who underwent CT KUB examination for suspected urolithiasis. A total of 160 patients were included in the study, out of which 45 patients showed normal findings, while 115 patients demonstrated abnormal findings on CT KUB.

All patients included in the study had clinical suspicion of renal or ureteric calculi were referred for CT KUB examination. Both male and female patients across various age groups were considered eligible. Patients with a history of previous renal surgery, urinary tract malignancy, or stent placement, as well as pregnant females, were excluded from the study to avoid confounding factors.

For age-wise distribution, patients were divided into six groups: 10–20 years (12 patients), 21–30 years (24 patients), 31–40 years (33 patients), 41–50 years (27 patients), 51–60 years (13 patients), and 61–70 years (5 patients). The highest incidence of calculi was noted in the 31–40 years age group, indicating a predominance of urolithiasis in the middle-aged population.

All CT scans were performed using a multidetector CT scanner. Non-contrast CT KUB was performed in all cases, with patients positioned supine. The scanning range extended from the upper poles of the kidneys to the base of the urinary bladder. The scanning parameters typically included a tube voltage of 120 kVp with automatic mA modulation and a slice thickness of 5 mm, with thin-section reconstructions as required. No intravenous contrast was administered in routine cases.

The acquired images were evaluated for the presence, size, number, and location of calculi within the kidneys, ureters, and bladder. The attenuation values (measured in Hounsfield Units) and density patterns of the calculi were assessed, along with associated findings such as hydronephrosis, perinephric fat stranding, and other structural abnormalities. Data were analyzed to determine the distribution of urolithiasis in relation to age, gender, and anatomical site of involvement. Descriptive statistical analysis was performed, and results were expressed in terms of frequency and percentage distribution.

RESULT

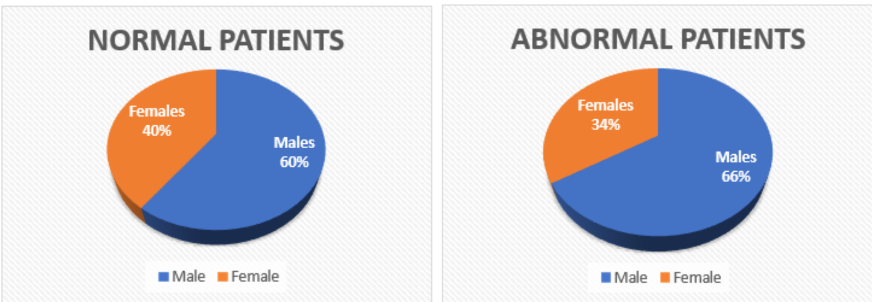
A total of 160 patients underwent non-contrast computed tomography of kidneys, ureters and bladder CT KUB for suspected urinary tract calculi. Out of these 115 patients (71.9%) demonstrated evidence of calculi on imaging, while 45 patients (28.1%) had normal scans with no detectable stones. This high detection rate shows the diagnostic superiority of non-contrast CT KUB in identifying Urolithiasis, particularly in acute settings where rapid and accurate localization is critical.

Gender Based Distribution of Urinary Tract Calculi

In my study, Gender analysis shows a clear male dominance among patients with calculi. Out of 115 abnormal cases, 76 were males (66.1%) and 39 were females (33.9%), generating a male to female ratio of 1.95:1. This finding aligns with global epidemiology trends indicating higher stone formation in males, possibly due to difference in urinary biochemistry, hormonal influence and dietary patterns. The higher prevalence in males was consistent across nearly all age groups, with only minor fluctuations in the extremes notably in the 31–40-year age group, males constituted 70% of cases with calculi, suggesting an early peak in male susceptibility during young adulthood.

This gender difference may reflect increased urinary supersaturation with calcium oxalate and uric acid in males influenced by higher muscle mass, protein intake and lower citrate excretion. Although females showed lower overall prevalence, a relative increase was observed in the 41–50-year group, potentially linked to postmenopausal hormonal changes affecting calcium metabolism.

This table shows the distribution of calculi in different locations.



This graph shows the comparison between Normal and Abnormal patients between Males and Females.

In Normal Patients graph the total no for patients is 45. The male patients are 27 (60%) and female patients are 18 (40%).

In Abnormal Patients graph the total number of patients is 115. The male patients are 76 (66%) and female patients are 39 (34%).

Positional Distribution of Urinary Tract Calculi

Detailed mapping of stone location was performed using standardized anatomical landmarks on CT KUB. Among the 115 patients with calculi, a total of 145 distinct stone locations were identified (due to 30 patients having multiple stones). The distribution is shown in table bellow

Distal ureter	38 sites (26.2%) most common location
Upper ureter	32 sites (22.1%)
Renal calyces (lower, upper & middle)	35 sites (24.1%)
Renal pelvis	28 sites (19.3%)
Mid ureter	12 sites (8.3%)
Bladder	0 sites (0%)

The distal ureteric stones emerged as the dominant site 33.0%, had at least one stone here. Consistent with the natural anatomical narrowing at the ureterovesical junction, which acts as a physiological obstruction point promoting stone impaction.

Upper ureteric stones were the second most common in 27.8% of patients, often larger in size (mean 11.2mm) and more likely to cause hydronephrosis. Calyceal stones 30.4% of patients were typically smaller (mean 5.8mm) and multiple, suggesting a staghorn calculus or gravel forming tendency in some individuals.

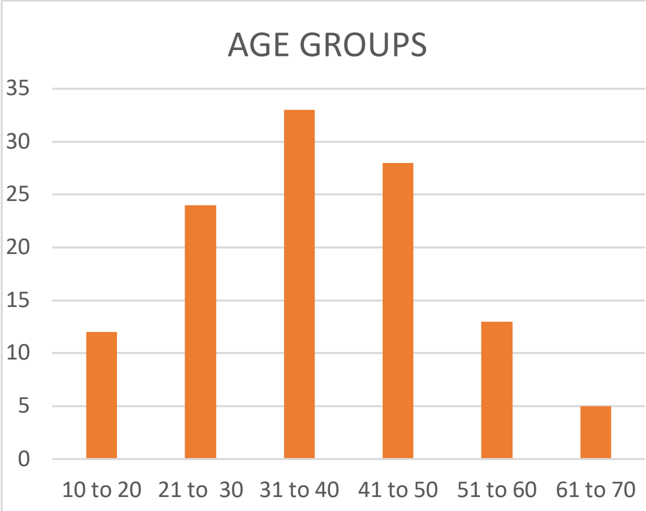
Renal pelvic stones 24.3% were notably larger (mean 16.4mm) with several exceeding 20 mm, raising concerns for obstruction and requiring urological intervention.

Notably 30 patients, 26.1% had multisite calculi with combinations such as renal pelvis + calyx (n=120, upper + distal ureter (n=8) and bilateral involvement (n=7).

Bilateral calculi were present in 11 patients (9.6%), indicating a systematic metabolic predisposition rather than localized obstruction.

Presence of Urinary Tract Calculi Across Different Age Groups

Patients were stratified into 10 years age intervals to enable granular analysis as shown in graph below:



This graph shows the highest number of patients in different Age groups.

The highest presence was observed in 31-40 years of age group 33 patients representing a clear peak in stones disease. This decade showed not only the highest proportion of affected individuals.

Prevalence remained consistently high (>75%) across all age groups, with no significant decline even in the 61–70-year cohort (80%). This challenges the conventional notion of a unimodal peak in middle age and instead suggests a sustained high risk throughout adulthood when fine age stratification is applied. The 31–40 and 41–50 groups showed nearly identical rates, forming a plateau of maximum disease expression during prime working years.

Stone size increased with age in renal locations: mean calyceal stone size was 4.1 mm in 10–20 years vs. 7.8 mm in 51–60 years, while ureteric stones showed no significant age-related size variation, supporting the hypothesis that ureteric stones represent acute migration events, whereas renal stones accumulate over time.

Hounsfield unit (HU) analysis (available in 98 cases) revealed:

Mean HU: 842 ± 482 (range 91–1972)

<500 HU (likely uric acid): 28%

500–1000 HU (mixed/calcium oxalate): 42%

>1000 HU (calcium phosphate/struvite): 30%

Lower HU stones (<500) were more common in older females (50+ years), consistent with uric acid Lithogenesis in metabolic syndrome, while higher HU stones dominated in younger males, reflecting calcium-based pathology.

In summary, this study demonstrates:

Strong male predominance (2:1) in urolithiasis. Distal ureter/VUJ as the most frequent stone site, followed by calyces and upper ureter. Peak prevalence in 31-40 years with sustained high rates (>75%) across all decades when using 10-year age bins.

These findings validate the enhanced resolution of fine age stratification and provide actionable insights for age- and gender-specific screening, prevention (e.g., alkalization in older females, hydration in young males), and procedural planning in CT KUB interpretation.

DISCUSSION

The present retrospective study evaluates the distribution pattern of urinary tract calculi with respect to gender, age and anatomical location using non contrast CT KUB. Out of 160 patients, 115 (71.9%) showed calculi, reaffirming the high diagnostic sensitivity of CT KUB for detecting Urolithiasis. This result is in line with earlier studies that demonstrates how non-contrast CT offers almost 100% sensitivity and specificity in identifying urinary tract calculi, compared to conventional radiography and ultrasonography.(6)

A distinct male predominance was observed, with 76 males accounting for 66.1% and 39 females accounting for 33.9%, yielding a male to female ratio 1.95:1. This pattern corresponds with global epidemiological trends indicating that urolithiasis is more prevalent in males (7). The higher prevalence in males may be attributed to increased muscle mass, higher dietary protein and sodium intake and lower urinary citrate excretion which collectively promote calcium oxalate and uric acid crystal formation (8). The relative rise in female cases in the 41-50 years age group observed in this study could be related to postmenopausal hormonal changes influencing calcium metabolism and urinary saturation level(9).

Age wise analysis demonstration shows that the highest prevalence of calculi 31-40- and 41-50-years groups, representing the peak incidence of urolithiasis in the early to mid-adult population. However, unlike earlier reports that suggest a single midlife peak but the present study revealed consistently high prevalence (>75%) across all adult decades, including the 61-70 years cohort. These findings indicate that once risk factors are established, stone formation continues throughout adulthood (10). Furthermore, stone size showed a gradual increase with age in renal locations, suggesting that renal stones tend to enlarge over time, while ureteric stones likely represent acute migration events.

The distal ureter, particularly near the Vesicoureteric junction, emerged as the most frequent site of calculi (33%), followed by calyceal (30.4%) and upper ureteric stones (27.8%). This distribution aligns with physiological ureteral constriction points where stone impaction commonly occurs(11). A notable proportion of patients (26.1%) exhibited multiple or bilateral stones, suggesting a systematic metabolic predisposition rather than localized obstruction. These findings shows the importance of metabolic evaluation and follow-up in recurrent stone formers.

CT attenuation values, expressed in Hounsfield Units (HU), provided insight into the likely stone composition. Stones with HU <500, suggestive of uric acid, were more common among older females while higher density stones (>1000HU), corresponding to calcium-based calculi, predominated in younger males (12).

The high detection rate of urolithiasis in this study reinforces the diagnostic superiority of non-contrast CT KUB, which effectively overcomes limitations of USG such as operator dependency and reduced sensitivity for small or radiolucent stones(13). The observed demographic and anatomical pattern emphasize the need for targeted preventive strategies such as hydration and dietary modification in young males prone to calcium oxalate stones and urinary alkalization or metabolic assessment in older females at risk for uric acid stones.

CONCLUSION

The present retrospective study highlights the diagnostic value of NCCT of KUB in evaluating urinary tract calculi. Among 160 patients examined, 115 (71.9%) demonstrated positive findings for urolithiasis, confirming CT KUB as an exceptionally accurate imaging tool for stone detection and characterization. The study revealed a clear male predominance (66.1%) consistent with global epidemiological trends, suggesting that biological, hormonal and lifestyle factors contribute significantly to this disparity. The highest prevalence was observed in the 31-40 and 41-50 years of age group, indicating that stone formation peaks during the most active years of life, possibly due to increased metabolic activity, occupational dehydration and dietary habits.

The analysis of stone location showed that the Distal Ureter and Vesicoureteric junction were the most common sites of impaction, followed by Renal Calyces and the Upper Ureter. This pattern reflects natural anatomical narrowing that predispose these sites to obstruction. The study also identified that a significant number of patients had a multiple or bilateral calculi, suggesting underlying metabolic abnormalities requiring further biochemical evaluation and preventive management.

NCCT KUB offers major advantages over USG and X-ray radiography by providing precise localization, accurate size measurement and density estimation through HU analysis. This information not only facilitates appropriate clinical management such as predicting the likelihood of spontaneous passage or need for intervention but also offers clues to stone composition. The high detection rate in this study reinforces CT KUB as the gold standard imaging modality for urinary stone disease.

Hence Urolithiasis continues to be a significant health concern with rising incidence across age groups. The findings emphasize the need for targeted preventive measures like hydration awareness, dietary counseling and metabolic evaluation especially among high-risk populations. Future studies combining radiological, biochemical and lifestyle data across larger and multicentric cohorts will be essential for understanding of stone pathogenesis and improve management outcomes..

REFERENCE

1. Kalender WA. X-ray computed tomography. Phys Med Biol [Internet]. 2006 Jun 20 [cited 2025 Oct 15];51(13):R29. Available from: https://iopscience.iop.org/article/10.1088/0031-9155/51/13/R03

2. Johnston R, Lin A, Du J, Mark S. Comparison of kidney-ureter-bladder abdominal radiography and computed tomography scout films for identifying renal calculi. BJU Int [Internet]. 2009 Sep 1 [cited 2025 Oct 15];104(5):670–3. Available from: /doi/pdf/10.1111/j.1464-410X.2009.08542.x

3. Graumann O, Osther SS, Spasojevic D, Osther PJS. Can the CT planning image determine whether a kidney stone is radiopaque on a plain KUB? Urol Res [Internet]. 2012 Aug 18 [cited 2025 Oct 15];40(4):333–7. Available from: https://link.springer.com/article/10.1007/s00240-011-0411-9

4. Comparison Between Computed Tomography and Ultrasonography in Detection of Urinary Tract Calculi | Journal of Karnali Academy of Health Sciences [Internet]. [cited 2025 Oct 15]. Available from: https://jkahs.org.np/jkahs/index.php/jkahs/article/view/319

5. Scales CD, Smith AC, Hanley JM, Saigal CS. Prevalence of Kidney Stones in the United States. Eur Urol [Internet]. 2012 Jul 1 [cited 2025 Oct 21];62(1):160–5. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0302283812004046

6. Malaki M. The comparison of ultrasound and non-contrast helical computerized tomography for children nephrolithiasis detection. Urol Ann [Internet]. 2014 Mar 1 [cited 2025 Oct 24];6(4):309. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC4216536/

7. Scales CD, Smith AC, Hanley JM, Saigal CS. Prevalence of kidney stones in the United States. Eur Urol [Internet]. 2012 Jul [cited 2025 Oct 25];62(1):160–5. Available from: https://pubmed.ncbi.nlm.nih.gov/22498635/

8. Pak CYC, Poindexter JR, Adams-Huet B, Pearle MS. Predictive value of kidney stone composition in the detection of metabolic abnormalities. American Journal of Medicine [Internet]. 2003 [cited 2025 Oct 25];115(1):26–32. Available from: https://pubmed.ncbi.nlm.nih.gov/12867231/

9. Kok DJ, Khan SR. Calcium oxalate nephrolithiasis, a free or fixed particle disease. Kidney Int [Internet]. 1994 [cited 2025 Oct 25];46(3):847–54. Available from: https://pubmed.ncbi.nlm.nih.gov/7996806/

10. Sorokin I, Mamoulakis C, Miyazawa K, Rodgers A, Talati J, Lotan Y. Epidemiology of stone disease across the world. World J Urol [Internet]. 2017 Sep 1 [cited 2025 Oct 25];35(9):1301–20. Available from: https://pubmed.ncbi.nlm.nih.gov/28213860/

11. [Correlation between urinary stones and urinary tract infections] [Internet]. [cited 2025 Oct 25]. Available from: https://www.researchgate.net/publication/264248727_Correlation_between_urinary_stones_and_urinary_tract_infections

12. Mitterberger M, Aigner F, Pallwein L, Pinggera GM, Neururer R, Rehder P, et al. Sonographic detection of renal and ureteral stones. Value of the twinkling sign. Int Braz J Urol [Internet]. 2009 Sep [cited 2025 Oct 25];35(5):532–9. Available from: https://pubmed.ncbi.nlm.nih.gov/19860931/

13. Kalra MK, Maher MM, Toth TL, Hamberg LM, Blake MA, Shepard JA, et al. Strategies for CT radiation dose optimization. Radiology [Internet]. 2004 Mar [cited 2025 Oct 25];230(3):619–28. Available from: https://pubmed.ncbi.nlm.nih.gov/14739312/

.