A Comparative Study on Diagnostic Accuracy of Ultrasound and CT in Nephrolithiasis

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Abstract: ***Introduction**: Nephrolithiasis, commonly known as kidney stone disease, is a condition characterized by the formation of renal calculi due to an imbalance between the solubility and precipitation of salts in the urinary tract and kidneys. For diagnosis and treatment to be successful, renal and ureteric calculi must be accurately detected. Even though computed tomography urography (CTU) is thought to be very sensitive and specific, ultrasonography (USG) is still a popular non - invasive, radiation - free option. By analyzing USG's sensitivity and specificity in identifying urinary calculi, this study seeks to evaluate the diagnostic performance of the procedure. **Material and Methods**: A prospective study was performed on 120 patients with suspected nephrolithiasis, where each patient underwent both USG and CTU, with CTU serving as the gold standard. The diagnostic performance of USG, including sensitivity, specificity, and accuracy, was evaluated by comparing it to CTU findings in detecting renal calculi based on size and location. **Results**: USG demonstrated a sensitivity of 58% and specificity of 88% for renal calculi. For ureteric and bladder calculi, sensitivity was 25% and 55%, respectively. The mean size of calculi missed by USG was 3.2 mm ± 1.9 mm. Smaller stones (≤5 mm) had a detection rate of 34%, while larger stones (5.1–10 mm) were detected 52% of the time. In contrast, computed tomography urography (CTU) demonstrated perfect sensitivity, specificity, and accuracy at 100%. **Conclusion**: Although CTU is more accurate, USG provides a reliable level of specificity for initial screening, especially for renal calculi. The effectiveness of USG in detecting stones varies depending on their size and location.***

Keywords: Nephrolithiasis, Ultrasound, CT Urogram, Sensitivity, diagnostic accuracy.

1. Introduction

Nephrolithiasis is most common in Caucasian men, especially in those between the ages of 20 and 30. The overall prevalence of nephrolithiasis was 10.1%, according to the 2013–2014 National Health and Nutrition Examination Survey (NHANES). Because it is more common in industrialized countries, nephrolithiasis is frequently categorized as a disease of affluence, much like obesity, type 2 diabetes, and hypertension. [1] Dehydration or a genetic predisposition to discharge extra stone - forming ions can cause urine to become supersaturated with insoluble substances, mainly calcium oxalate (CaOx) and calcium phosphate (CaP). An estimated 5–10% of Indians are genetically predisposed to nephrolithiasis, according to studies. [2]

Because ultrasound (USG) is accessible, radiation - free, reproducible, affordable, and non - invasive, it is a commonly utilized imaging modality for the initial evaluation of nephrolithiasis. However, an unenhanced computed tomography urogram (CTU) may be required for additional examination if the USG results for calculi are negative. [3]

With benefits including increased accuracy, avoiding intravenous contrast material, and the capacity to assess secondary symptoms of blockage and pinpoint additional possible sources of pain, CTU is thought to be extremely sensitive and specific for diagnosing ureteric calculi. But the unavoidable radiation dose associated with CTU raises questions regarding its widespread use, especially when USG results are unclear. [4] Few studies explicitly evaluate the effectiveness of USG and CTU in detecting urolithiasis, despite the diagnostic advantages of both tests. [5] This study attempts to evaluate the sensitivity and specificity of USG in detecting urinary tract calculi, with CTU being the gold standard.

2. Materials and Methods

This prospective observational study was carried out at a tertiary care hospital with consent from the Institutional Ethics Committee. Through successive sampling, 120 patients between the ages of 25 and 79 who presented with flank pain, hematuria, or dysuria were chosen. Based on earlier research [6] assessing the diagnostic precision of computed tomography urograms (CTU) and ultrasounds (USG) for nephrolithiasis, the sample size was established, guaranteeing sufficient statistical power to identify meaningful variations. Individuals with a BMI of greater than 35 kg/m2, a history of nephrectomy, renal transplants, or pregnancy were not included. Prior to inclusion, written informed consent was acquired, and each participant had both USG and CTU for the examination of nephrolithiasis.

In addition to other findings like hydronephrosis, ultrasound tests were performed to measure the existence, size, and location of renal and ureteric calculi. A Siemens SCT scanner, which served as the benchmark for comparison, was used for CTU. To avoid bias, radiologists evaluating CTU data were blinded to USG findings.

Imaging results, clinical symptoms, and patient demographics were among the information gathered. Using CTU as the gold standard, the sensitivity, specificity, positive predictive value

(PPV), and negative predictive value (NPV) of USG in identifying nephrolithiasis were computed. Bland - Altman analysis was used to evaluate the agreement between stone size measurements on USG and CTU, and statistical tests were performed using SPSS version 24.0. A p - value of less than 0.05 was deemed statistically significant. Throughout the investigation, patient confidentiality was preserved and ethical standards were closely adhered to IHEC standards.

3. Results

60% of the participants in the study are men (n=72), and 40% are women (n=48). In terms of co - morbidities, 3.33% have gout, 7.5% have diabetes, and 14.1% have hypertension. The age distribution has shown that 40% of the group were in between 25–39, 35% of the group aged 40–59, and 25% of the group aged 60–79. Furthermore, 21.7% of individuals report having a good dietary lifestyle (26), compared to 78.3% who report having a poor dietary lifestyle (94).

Table 1: Patient Demographics in the study

Gender		
Male	72	60%
Female	48	40%
Co - Morbidities		
HTN	17	14.1%
DM	9	7.5%
Gout	4	3.33%
Age Group		
25 - 39 Yrs	48	40%
40 - 59 Yrs	42	35%
60 - 79 Yrs	30	25%
Dietary Lifestyle		
Poor	94	78.3%
Good	26	21.7%

In a comparison between Ultrasound (USG) and CTU, USG demonstrated a sensitivity of 58%, specificity of 88%, and accuracy of 72%, while CTU showed perfect scores with 100% sensitivity, specificity, and accuracy.

Table 2: Renal Calculi Detection

	Ultrasound	CTU	95% CI
True Positive (n)	35	52	-
False Negative (n)	17	0	-
Sensitivity (%)	58%	100%	47 - 63%
Specificity (%)	88%	100%	81 - 95%
Accuracy (%)	72%	100%	57 - 87%

The analysis shows a significant association between stone size and detection on ultrasound (USG) with a p - value of 0.00027. Smaller stones (≤5 mm) were mostly missed (82%), while larger stones (5.1–10 mm) had higher detection rates (52%).

Table 3: Size Distribution of Renal Calculi

Size in mm	Detected in USG (%)	Missed on USG (%)	Chi – square value	p - value
≤5	12 (34%)	28 (82%)	16.40	0.00027
5.1–10	18 (52%)	5 (15%)		
>10	5 (14%)	1 (3%)		
Mean size detected on USG			6.5 mm ± 3.2 mm	
Mean size missed on USG:			3.4 mm ± 1.9 mm	

The mean size of detected stones was 6.5 mm, while missed stones averaged 3.4 mm, highlighting that smaller stones are more likely to be missed.

Table 4: Ureteric and Bladder Calculi

Location	Sensitivity	Specificity	Accuracy
Ureteric	25%	98%	82%
Bladder	55%	100%	97%

The diagnostic performance of ultrasound (USG) for detecting stones in different locations shows variation in sensitivity, specificity, and accuracy. For ureteric stones, the sensitivity is 25%, specificity is 98%, and accuracy is 82%. In contrast, for bladder stones, the sensitivity is significantly higher at 55%, with perfect specificity at 100% and accuracy of 97%.

4. Discussion

In our study, USG worked poorly for ureteric (25%) and bladder (55%) stones, but it had overall reasonable sensitivity (58%) for renal calculi. According to a study by Kanno et al. (2014), using non - contrast enhanced computed tomography (NCCT) as the reference standard, ultrasonography (US) has a sensitivity of 70.0% and a specificity of 94.4% for detecting renal stones. Stone sizes as determined by US showed a positive correlation with those determined by CTU, and the detection rate rose with stone size. [7]

Verhagen et al. (2019) assessed the effectiveness of US in identifying renal calculi in children in a meta - analysis. Using CT as the gold standard, the study discovered that US has an 80% sensitivity and a 100% specificity for identifying kidney stones. [8] By utilizing a single observer for every instance, bias was removed before analysis, but the study did notice that operator experience and reporting criteria affected the diagnostic performance of US.

USG often missed smaller calculi (<5 mm), which is in line with previous research. Research has shown that USG's sensitivity in identifying stones smaller than 5 mm varies; some studies have reported sensitivity as low as 18.8% when utilizing grayscale imaging alone. [9] Twinkling artifact (TA) and posterior acoustic shadowing (AS) can increase detection rates, however they are less effective for smaller stones. [10] The sensitivity levels for identifying stones of 0–3.5 mm, 3.6–5 mm, 5.1–10 mm, and higher than 10 mm were 55.8%, 73.9%, 71.7%, and 89.4%, respectively, in a study that examined stone sizes. This indicates that smaller stones are more likely to be overlooked. [6]

Kanno et al. (2014) found that USG had a 57.3% sensitivity, 97.5% specificity, and 81.3% accuracy for ureteric stones, which is comparable to our study. On the other hand, bladder stones showed a 20% sensitivity and 100% specificity, yielding a 98% accuracy rate. [7]

These diagnostic results can be affected by a number of variables, such as the location, size, and presence of hydronephrosis of the stone. USG is better at detecting larger stones and those linked to hydronephrosis. CTU is the gold standard because to its greater spatial resolution and lack of operator dependency. [11] However, because of its

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affordability and safety, USG is still useful for preliminary evaluation. A two - month maximum gap between USG and CTU was one of the limitations, which might have impacted the stone migration results.

5. Conclusion

Ultrasound (USG) serves as a valuable imaging modality for detecting renal calculi, offering a non - invasive alternative to more radiation - intensive methods. However, its diagnostic performance varies based on stone location and size. Incorporating adjunct imaging modalities, such as Doppler twinkling artifact and computed tomography urography, may enhance diagnostic accuracy, particularly for smaller or more challenging - to - detect stones.

References

[1] Stamatelou K, Goldfarb DS. Epidemiology of kidney stones. Healthcare (Basel) [Internet].2023; 11 (3): 424. Available from: http: //dx. doi. org/10.3390/healthcare11030424

[2] Alelign T, Petros B. Kidney stone disease: An update on current concepts. Adv Urol [Internet].2018; 2018: 1–12. Available from: http: //dx. doi. org/10.1155/2018/3068365

[3] Vijayakumar M, Ganpule A, Singh A, Sabnis R, Desai M. Review of techniques for ultrasonic determination of kidney stone size. Res Rep Urol [Internet].2018; 10: 57–61. Available from: http: //dx. doi. org/10.2147/rru. s128039

[4] Andreucci M, Solomon R, Tasanarong A. Side effects of radiographic contrast media: Pathogenesis, risk factors, and prevention. Biomed Res Int [Internet].2014; 2014: 1–20. Available from: http: //dx. doi. org/10.1155/2014/741018

[5] Alshoabi S, Alahmadi A, Aljuhani F, Aloufi K, Alsharif W, Alamri A. The gap between ultrasonography and computed tomography in measuring the size of urinary calculi. J Family Med Prim Care [Internet].2020; 9 (9): 4925. Available from: http: //dx. doi. org/10.4103/jfmpc. jfmpc_742_20

[6] Ahmed F, Askarpour M - R, Eslahi A, Nikbakht H - A, Jafari S - H, Hassanpour A, et al. The role of ultrasonography in detecting urinary tract calculi compared to CT scan. Res Rep Urol [Internet].2018; 10: 199–203. Available from: http: //dx. doi. org/10.2147/rru. s178902

[7] Kanno T, Kubota M, Sakamoto H, Nishiyama R, Okada T, Higashi Y, et al. The efficacy of ultrasonography for the detection of renal stone. Urology [Internet].2014; 84 (2): 285–8. Available from: http: //dx. doi. org/10.1016/j. urology.2014.04.010

[8] Verhagen MV, Watson TA, Hickson M, Smeulders N, Humphries PD. Acoustic shadowing in pediatric kidney stone ultrasound: a retrospective study with non - enhanced computed tomography as reference standard. Pediatr Radiol [Internet].2019; 49 (6): 777–83. Available from: http: //dx. doi. org/10.1007/s00247 - 019 - 04372 - x

[9] 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 [Internet].2017; 119 (3): 464–9. Available from: http: //dx. doi. org/10.1111/bju.13605

[10] Hanafi M, Fakhrizadeh A, Jaafaezadeh E. An investigation into the clinical accuracy of twinkling artifacts in patients with urolithiasis smaller than 5 mm in comparison with computed tomography scanning. J Family Med Prim Care [Internet].2019; 8 (2): 401. Available from: http: //dx. doi. org/10.4103/jfmpc. jfmpc_300_18

[11] Alshoabi SA. Association between grades of Hydronephrosis & detection of urinary stones by ultrasound imaging. Pak J Med Sci Q [Internet].2018; 34 (4). Available from: http: //dx. doi. org/10.12669/pjms.344.14602.