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# Diagnostic Accuracy of Ultrasonography in Detecting Kidney Stones Using Computed Tomography of Kidneys, Ureters, and Bladder (CT KUB) as a Gold Standard

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## ABSTRACT

***Objective:*** To determine the diagnostic accuracy of Color Doppler ultrasonography (USG) and compare it with CT KUB as the gold standard in detecting kidney stones.

***Study Design:*** Cross-sectional study

***Place and Duration of study:*** Department of Radiology, Bolan Medical Complex Hospital, Quetta, Pakistan, from Jun to Dec 2022.

***Methodology:*** Two hundred and twenty-eight (228) patients of nephrolithiasis were selected by using a non-probability consecutive sampling technique. Patients (both male and female), fulfilling the inclusion criteria, were included in the study. Ultrasonography (USG) and Computed tomography (CT), done by separate experienced radiologists, of all patients were carried out, and the required findings were noted. Data was compiled and analyzed with SPSS version 23.0.

***Results:*** As per the comparison between USG and CT-KUB findings, the results of our study revealed that US had a sensitivity and specificity of 92.6% and 100.0%, respectively. While positive predictive value, negative predictive value, and accuracy of US were 100%, 74.1%, and 93.9%, respectively, with a *p*-value < 0.001.

***Conclusion:*** Despite limitations in the diagnosis of urinary stones, US can be used as an initial assessment tool. The sensitivity and specificity of US for diagnosis of renal, ureteric stones, and hydronephrosis are variable. Moreover, size of the stone, stone type, and location also affect it.

**Keywords:** Computed tomography, Hydronephrosis, Ultrasonography

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## INTRODUCTION

The term nephrolithiasis is used for kidney stones, also known as renal calculi. Crystallization of concretions in the kidneys or urinary tract leads to formation of these stones. Kidney stones can be of different sizes. Smaller stones may leave the body easily, causing slight discomfort or none. Larger stones can get stuck in the urinary tract, thus blocking urinary flow and causing unbearable pain[1].

Nephrolithiasis is the most common condition affecting the urinary system.[2] It has a prevalence of 5% to 15%, with a yearly incidence of 0.5% in Europe and North America. The lifetime risk of kidney stone formation has been reported to be 10-12% in males and 6-8% in females. The prevalence of nephrolithiasis has been rising over the past two decades. The prevalence of renal calculi in Pakistan is approximately 16%.[3] While in India, it has been reported to be 12%.[4] Men are affected more than women.[5]

Ureteric stones lead to dilatation of the proximal ureter and renal pelvis, thus causing severe pain, which is known as renal colic. Patients with kidney stones have an increased risk of chronic kidney disease, cardiovascular disease, diabetes, and hypertension.[6] Kidney stone formation is multifactorial, which includes inadequate urinary volume, hypercalciuria, hyperoxaluria, hyperuricosuria, recurrent urinary tract infections, and hypocitraturia.[7] People with obesity, family history of kidney stones, hypertension, diabetes, and /or irritable bowel syndrome are at increased risk for the formation of urinary tract stones. These patients present with different symptoms like renal colic, painful urination, or hematuria [8].

Detailed history, physical examination, laboratory investigations, and imaging modalities help in the diagnosis of renal calculi. Imaging modalities like X-ray KUB, USG, and CT-KUB are used for the diagnosis.[9] A plain X-ray KUB can help in the diagnosis of urinary tract stones, but 10-20% of renal

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calculi are not picked up by X-ray KUB because of radiolucency. Moreover, X-ray KUB provides little information about hydronephrosis and anatomy of kidneys. Stone visualization is also affected by the bony pelvis, bowel gas, and abdominal viscera. USG is less sensitive (60-76%) than a CT scan for detecting calculi that are smaller than 5 mm, but USG can detect hydronephrosis and can provide evidence about obstruction. Moreover, USG is also the modality of choice for the evaluation of kidney stones during pregnancy. Diagnostic accuracy of combined X-ray KUB and USG for an obstructing stone is 90%, with sensitivity and specificity of 88 % and 93 %, respectively. USG is a non-invasive imaging modality, radiation-free, readily available at most places, and cost-effective. That's why it is used as an imaging technique for the diagnosis of urinary tract stones, especially in healthcare setups of peripheries.[10]

CT KUB is the most sensitive test for detecting urinary stones. It has a sensitivity of 98% and a specificity of 100 %. Resultantly, the gold standard for detecting nephrolithiasis/urolithiasis remains a non-enhanced CT scan. However, frequent CT scans expose patients to ionizing radiation. Secondly, a CT scan has a higher cost, and it is not available in the peripheries of Balochistan province. The objective of this research was to compare the diagnostic accuracy of USG with CT scan in detecting nephrolithiasis, because of the lower radiation dose and easy availability of USG in the peripheries.

## METHODOLOGY

The cross-sectional study was carried out after getting the approval from the Ethical Committee (No. 783) at the Department of Radiology, Bolan Medical Complex Hospital, Quetta, Pakistan, from Jun to Dec 2022. The Sample Size calculated was 228 using the Epi Info calculator with a prevalence of Kidney Stones at 16%[11] along with the non-response rate at 10% of the actual sample size. A non-probability consecutive sampling technique was used to enroll the participants in the study.

**Inclusion Criteria**: Patients between ages of 20 and 65 years, presenting for Radiological Investigations in the Department of Radiology with clinical features of renal stones, were inducted in the study.

**Exclusion Criteria**: Patients with a history of abdominal surgery and already diagnosed cases of nephrolithiasis were excluded.

Patients were informed about the procedure in detail, and informed written consent was taken before undergoing the procedures. USG of the patients presenting with symptoms of kidney stones was done by a consultant radiologist, using Ecoste Mylab 7 Color Doppler machine with 3.5, 5 and 7.5 MHz probes. Doppler was used for stone assessment in urinary bladder, kidneys, and ureter. Any hyper-echoic focus in the kidneys was taken as a calculus. CT scan was also done for all patients undergoing US. The following protocol was adopted while carrying out the CT scan by Siemens CT Somatom Sensation 64. Patients were placed under a CT scan machine with urinary bladder full of urine and in a supine position. Images were constructed at a distance of 5 mm gap. Any hyperdense focus in the kidneys was taken as a calculus. The CT was reported by another radiologist not doing the USG KUB, who had 05 years of experience in the relevant field. All patients having positive and negative findings on both USG and CT scans were entered in the data sheet.

Statistical Package for Social Sciences version 23 was used to analyze the data. The Shapiro-Wilk test was used to check the normality of quantitative variables. Quantitative variables with non-normal distribution were expressed as Median and interquartile ranges (IQR), while quantitative variables with normal distribution were expressed as Mean±SD and qualitative variables were expressed as frequency and percentages. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated by using 2x2 tables. Chi-Square test was applied to check the statistical significance between US KUB and CT KUB findings.

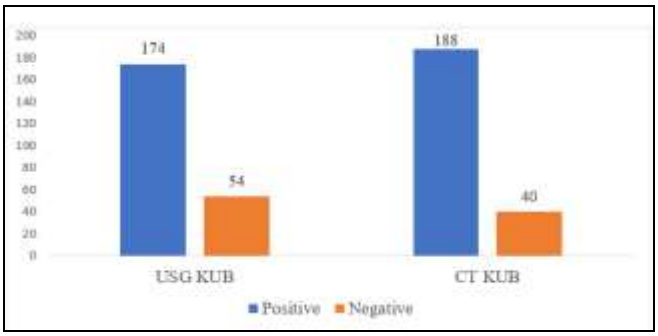


**Figure: Frequency of Positive/Negative Findings on Ultrasonography and Computed Tomography of Kidneys, Ureters, and Bladder (n=228)**

## RESULTS

During our research period, 228 participants were selected. Among these 228 participants, 174(76.3%) had positive while 54(23.7%) had negative findings on USG for nephrolithiasis, while on the other hand, 182(82.5%) had positive while 40 (17.5%) had negative findings on CT KUB procedure. (Figure) Out of all included participants, 89(39%) were females, while 139(61%) were males. Median age was 28 years with an interquartile range (IQR) of 36-25 years. Median height was 5.5 feet with Inter quartile range (IQR) of 5.6-5.5 feet, Median weight was 82 kg with Inter quartile range (IQR) of 84-66 kg, while mean BMI was 28.00±3.90 kg/m$^2$

Out of 188 (82.5%) patients who were diagnosed with nephrolithiasis on Gold Standard CT KUB, 174 were also positive on USG KUB, showing the sensitivity of USG KUB as 92.6%, while 40 (17.5%) patients who were negative on Gold Standard CT KUB, all 40 were also negative on USG KUB, showing the specificity of USG KUB as 100%. Results of our study showed positive predictive value, negative predictive value, and accuracy of USG KUB, keeping the CT KUB as the gold standard was 100%, 74.1% and 93.9%, respectively. (Table-I). Statistical test was applied to check for the statistical significance between qualitative outcome variables, i.e. findings of USG KUB and CT KUB.

**Table-I: Contingency table and Diagnostic Parameters for Ultrasonography versus Computed Tomography of Kidneys, Ureters, and Bladder (n=228)**

| | CT KUB | |
|---|---|---|
| | **Positive** | **Negative** |
| USG KUB | | |
| Positive | 174 (76.32%) | 0 (0%) |
| Negative | 14 (6.14%) | 40 (17.54%) |

Sensitivity= True Positive/(True Positive +False Negative)= 92.6%
Specificity= True Negative / (True Negative +False Positive) = 100%
Positive Predictive Value= True Positive/ (True Positive+ False Positive) = 100%
Negative Predictive Value= True Negative/ (True Negative +False Negative) = 74.1 %
Diagnostic Accuracy= (True Positive +True Negative)/All Patients = 93.9%

**USG – Ultrasonography, CT - Computed Tomography, KUB Kidneys, Ureters, and Bladder*

## DISCUSSION

In this study, as comparison between US findings and CT-KUB findings for kidney stone, study results showed that ultrasound had a sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of 92.6%, 100%, 100%, 74.1%, and 93.9%, respectively, with a $p$-value < 0.001.

Nephrolithiasis is a serious concern in Pakistan.[12] There is an increasing incidence of renal/ureteric calculi, and the inadequate diagnostic facilities in the peripheries result in delayed diagnosis. Unfortunately, despite advances in modalities of diagnosis, the incidence of complicated nephrolithiasis is on the rise in Pakistan.[13] Nephrolithiasis has remained a major problem in Pakistan, especially asymptomatic and neglected stones, which can precipitate renal failure. Although most stones are effectively treated by stent placement, extracorporeal shockwave lithotripsy (ESWL), urethrotomy (URS), percutaneous nephrostolithotomy, open pyleolithotomy, and retrograde lithoplexy modalities, there remains the problem of neglected, asymptomatic large and/or staghorn stones associated with renal failure.[5]

Unenhanced CT is the gold standard imaging modality for the diagnosis of suspected renal stones. It has a specificity of 100%, sensitivity of 98%, and a negative predictive value of 97%.[11] This imaging modality helps in localizing the stone and calculating its size. Moreover, it also provides information regarding associated hydronephrosis, hydroureter, and/or ureteral edema. Martijn *et al.,* reported in their study that the sensitivity of CT was 70% (95% confidence interval [CI] 56-80%) and the specificity was 100% (95% CI 56-100%).[13] Grivas *et al.,* concluded in their study that, CT had very high specificity (96–100%) and sensitivity (97–100%) in diagnosing urinary tract stones.[14] As per the latest updated data in Medscape, CT has a sensitivity of 95-100 % and superior specificity and accuracy when compared with intravenous pyelography.[15] A Systematic Review conducted by Saikiran et al., found the sensitivity of CT KUB to be 80-99%, and the specificity ranged from 88-100%, while the diagnostic accuracy was 96.1%.[16]

Roberson *et al.,* reported that, for detecting renal calculi, US had a sensitivity of 66.7% and specificity of 97.4%. Positive predictive value of US was 95.2%, and 79.2 % was its negative predictive value with a positive likelihood ratio of 26.0.[17] Sensitivity and specificity of US depend on different factors like the ultrasound machine, radiologist and patient position. Different international studies like Robinson *et al.,* showed that the specificity and sensitivity of CT were reported to be as high as 67–90% and 95–100%, respectively18. Another study by Ashraf *et al.,* showed

that US for renal stone diagnosis had a sensitivity and specificity was 84.8%, while CT indicated 86% accuracy.[19] A study conducted by Ahmed *et al.*, reported that the US had a specificity and sensitivity of 88% and 45%, respectively, for renal tract stones.[20]

Moreover, literature has supported that ultrasound had a sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 91.2%, 95.7%, 98.7%, 75.2% and 92.2% respectively[8] and therefore, consistent results of US concluded in this study, where, as per comparison between US findings and CT-KUB findings for kidney stone, study results showed that ultrasound had a sensitivity and specificity of 92.6% and 100% respectively while positive predictive value, negative predictive value and accuracy of US was 100%, 74.1% and 93.9% respectively with $p$ value < 0.001.

The results of this study were consistent with the findings of the literature, thus reinforcing the concept of using CT KUB as the gold standard in diagnosing kidney stones.

## LIMITATION OF STUDY

Besides a single-centre study, the relatively limited sample size may have affected the precision of the estimated diagnostic accuracy measures. Additionally, variations in CT scanner technology and radiologist interpretation could have introduced measurement bias in the assessment of CT KUB findings.

## CONCLUSIONS

Ultrasound is often the first-line imaging modality for renal stones due to its easy accessibility and availability in emergencies. So, easy accessibility, cost effectiveness, and no contraindications also favor ultrasonography as an initial diagnostic modality. However, CT KUB is superior to US KUB in diagnosing and delineating renal stones.

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**Authors' Contribution**

Following authors have made substantial contributions to the manuscript as under:

KB & MAK: Data acquisition, data analysis, critical review, approval of the final version to be published.

NA & IA: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

TS: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

## REFERENCES

1. Leslie SW, Sajjad H, Murphy PB. Renal Calculi, Nephrolithiasis. [Updated 2024 Apr 20]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK442014/
2. Kakkar M, Kakkar R. A 13 year hospital based study on the Trend of Urinary Stone Disease in Uttarakhand, India. Nepal J Epidemiol. 2021; 11(1): 949-958. https://doi.org/10.3126/nje.v11i1.35896
3. Halinski A, Bhatti KH, Boeri L, et al. Stone composition of renal stone formers from different global regions. Arch Ital Urol Androl 2021; 93(3): 307-312. https://dx.doi.org/10.4081/AIUA.2021.3.307
4. Guha M, Banerjee H, Mitra P, Das M. The demographic diversity of food intake and prevalence of kidney stone diseases in the Indian continent. Foods 2019; 8(1): 37. https://doi.org/10.3390/foods8010037
5. Rao A, Toor A, Fatima M, Noor J, Sabir R, Rose S, et al. Diagnostic Accuracy of Ultrasound for the Evaluation of Ureteric Calculi Taking Non-enhanced Computed Tomography as a Gold Standard. Asian J Med 2021; 90(04): 2021. https://doi.org/10.7176/JHMN/90-04
6. Gandhi A, Hashemzehi T, Batura D. The management of acute renal colic. Br J Hosp Med 2019; 80(1): C2-C6. https://doi.org/10.12968/hmed.2019.80.1.C2
7. Kominsky HD, Rose J, Lehman A, Palettas M, Posid T, Caterino JM, et al. Trends in Acute Pain Management for Renal Colic in the Emergency Department at a Tertiary Care Academic Medical Center. J Endourol 2020; 34(11): 1195-1202. https://doi.org/10.1089/end.2020.0402
8. Agenosov MP, Kagan OF, Kheyfets VK. Features of urolithiasis in patients of advanced and senile age. Adv Gerontol 2018; 31(3): 368-373. https://doi.org/10.1038/s41592-018-0290-0
9. Leslie SW, Sajjad H, Murphy PB. Bladder Stones. [Updated 2025 Mar 27]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/sites/books/NBK441944/
10. Thungkatikajonkit P, Wongwaisayawan S, Wibulpolprasert A, Viseshsindh W, Kaewlai R. Is Combined Ultrasound with Radiography Sufficient for the Diagnosis of Obstructive Ureteric Stone in Patients with Acute Flank Pain? J Med Ultrasound 2020; 28(2): 86-91 https://doi.org/10.4103/JMU.JMU_49_19
11. Wahab M, Tariq K, Ishtiaq M, Ahmad K, Aslam M, Khan S. Diagnostic accuracy of ultrasound in detecting ureteric stone keeping non-enhanced CT as gold standard. Ann Punjab Med Coll 2021; 13(3): 223- 225. https://doi.org/10.29054/apmc/2019.752
12. Bashir A, Zuberi SK, Musharraf B, Khan H, Ather MH. Perception of Dietary Influences on Renal Stone Formation Among the General Population. Cureus 2022; 14(6): e26024. https://doi.org/10.7759/cureus.26013
13. Martijn V, Verhagen, Watson T, Hickson M, Smeulders N, Humphries P. Acoustic shadowing in pediatric kidney stone ultrasound: a retrospective study with non-enhanced computed tomography as reference standard. Radiol 2019; 49(6): 777-783. https://doi.org/10.1007/s00247-019-04401-8
14. Grivas N, Thomas K, Drake T et al. Imaging modalities and treatment of paediatric upper tract urolithiasis: a systematic review and update on behalf of the EAU urolithiasis guidelines panel. J Pediatr Urol 2020; 16(5): 612–624 https://doi.org/10.1016/j.jpurol.2020.07.003

15. Chirag ND, Seema M, Kristen M, Sugandh S, et al. Nephrolithiasis: Treatment & Management – Approach Considerations, Emergency Management of Renal Colic, Surgical Care [Internet]. New York (NY): Medscape; 2024 [cited 2024 Jun 12]. Available from: https://emedicine.medscape.com/article/437096-treatment#d1
16. Saikiran Pendem. Effectiveness of Low Dose Over Standard dose CT for Detection of Urolithiasis: A Systematic Review. Indian J Forensic Med Toxicol 2026; 14(4): 4447-4451. https://doi.org/10.37506/ijfmt.v14i4.12341
17. Roberson NP, Dillman JR, O'Hara SM, DeFoor WR Jr, Reddy PP, Giordano RM, et al. Comparison of ultrasound versus computed tomography for the detection of kidney stones in the pediatric population: a clinical effectiveness study. Pediatr Radiol 2018; 48(7): 962-972. https://doi.org/10.1007/s00247-018-4189-2
18. Robinson C, Shenoy M, Hennayake S. No stone unturned: the epidemiology and outcomes of paediatric urolithiasis in Manchester, United Kingdom. J Pediatr Urol 2020; 16(3): 372.e1–372.e7 https://doi.org/10.1016/j.jpurol.2020.03.009
19. Ashraf H, Saulat S, Qadri S, Amin D, Ayub Kiani N, Ejaz M. All That Glitter is not Gold: Computed Tomography-Kidney Ureter Bladder (CT-KUB) is not necessary for a Safe Percutaneous Nephrolithotomy. Pak J Med Health Sci 2024; 11(2): 36-43.https://doi.org/10.36283/pjmd11-2/0020
20. Ahmed F, Askarpour MR, Eslahi A, Nikbakht HA, Jafari SH, Hassanpour A, et al. The role of ultrasonography in detecting urinary tract calculi compared to CT scan. Res Rep Urol 2018; 10: 199-203 https://doi.org/10.2147/RRU.S185989

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