Original Article

Comparative analysis of ultrasound and Computed tomography; A focus on diagnostic accuracy in the patients of urolithiasis

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Abstract

Objective: An analysis of ultrasound and computed tomography focusing on their diagnostic accuracy in patients with urolithiasis

Study design: It was a descriptive cross sectional study.

Place and duration of study: The study was conducted at Sonex Diagnostic Centre, in Rawalpindi, from April to September 2024.

Material and Methods: A total of 113 patients were studied for the research purpose. Detailed examinations were performed including USG and CT.

Results: The results of study showed that out of 113 patients, 78 (69.02%) patients were male and 35(30.97%) were female. Out of total 113 patients, those in the age group 31-40 years were more likely diagnosed with disease. In this study, the positive and negative results obtained from ultrasound diagnostics were evaluated across different anatomical locations (N/L, V/L, U/L, PUJ, and VUJ). To understand the effectiveness of ultrasound, the positive ultrasound results were compared to CT scan findings, which were considered the reference standard. Ultrasound detected 48 positive cases of nephrolithiasis and missed 17 cases (negative on ultrasound but potentially positive on CT). The nephrolithiasis site had the highest number of positive findings. For V/L (Vesicle Lithiasis), 5 cases were identified as positive, with only 1 false negative. For U/L (Ureterolithiasis), ultrasound detected 15 positive cases, while 11 cases were missed. For VUJ (Vesicoureteric Junction), 6 positive cases were detected, with no negatives recorded. Out of 113 patients, 9 patients were negative on both USG and CT, while 1 patient was suspected of having ureterolithiasis on USG but was not confirmed to have a stone on CT.

Conclusion: The ultrasound's performance varies significantly across different anatomical regions, indicating that it may be more effective for certain locations and less reliable for others. Overall, ultrasound shows high sensitivity for detecting positive cases in the N/L and VUJ regions. It may not always provide the necessary accuracy for diagnosing all types of urinary tract stones, particularly in areas like the PUJ and U/L. The overall sensitivity and specificity of CT are greater than US technique. Therefore, a combined approach using CT scanning as the reference standard may improve the diagnostic accuracy, especially for patients with symptoms or risk factors for stones in regions where ultrasound sensitivity is limited. This highlights the importance of using ultrasound in conjunction with other imaging modalities to ensure a thorough and accurate assessment of urological conditions.

Keywords: Urolithiasis, Computed Tomography, Ultrasound, Nephrolithiasis, Urinary tract.

1. Introduction

Urolithiasis refers to the presence of calculi in any part of the urinary tract. It is a widespread condition affecting individuals across different geographical, cultural, and racial groups.(1) Urolithiasis is the most common urinary tract disease. According to the National Health and Nutrition Examination Survey (NHANES), the prevalence of kidney stones is 6.3% in men and 4.1% in women.(2) Globally, the prevalence and recurrence rates of kidney stone disease are rising, with limited availability of effective drug treatments. The condition affects all ages, sexes, and races, with risk factors including obesity, reduced fluid intake, advanced age, Caucasian ethnicity, lower socioeconomic status, diabetes, gout, and conditions like inflammatory bowel disease, pancreatitis, short bowel syndrome, and hyperparathyroidism contribute to an increased risk of stone formation due to the metabolic disturbances they cause.

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Initially, kidney stones are asymptomatic, but as they progress, symptoms vary based on their location in the kidney, ureter, or bladder. Common signs and symptoms include renal colic (intense cramping pain), flank pain, hematuria (blood in urine), obstructive uropathy, urinary tract infections, urinary flow blockage, and hydronephrosis (kidney swelling). These conditions may also result in nausea and vomiting. Asymptomatic stones should be monitored with periodic imaging and removed if they grow, cause symptoms, obstruct urine flow, lead to recurrent infections. All patients with kidney stones should undergo an evaluation for the risk of recurrence, which includes a review of their medical history, basic laboratory tests, and imaging.[3] Diagnostic tools include high-speed or dual-energy computed tomography (CT) scans, which can detect even small stones, and ultrasonography. Blood tests may identify elevated calcium or uric acid levels providing insight into kidney health. Additionally, a 24-hour urine collection can reveal excessive stone-forming minerals or insufficient stone-preventing substances. For this test, patients may need to provide urine samples over two consecutive days. While urinalysis is not diagnostic, it may be used in conjunction with other assessments.[4]

Ultrasound (US) is a commonly used imaging technique that utilizes high-frequency sound waves to assess the anatomical tissues. It is the preferred first-line imaging modality for diagnosing and managing urolithiasis (kidney stones) due to its advantages, including low cost, absence of radiation, and wide availability.[5] While US is effective at determining the size of kidney stones, it is less accurate in assessing their location and the severity of associated hydronephrosis. It is particularly suitable for children and pregnant patients, as it avoids exposure to ionizing radiation. Trans-abdominal imaging uses curvilinear probes to visualize between the ribs, whereas transvaginal imaging employs intracavitary probes to assess the distal ureters. Although US has lower sensitivity and specificity compared to CT, it is safer, more affordable and increasingly used as the initial imaging method for evaluating kidney stones.[6]

Computed tomography (CT) is the imaging method of choice for diagnosing and managing urinary tract stones, or urolithiasis. Despite the increasing availability of ultrasound (US) units for renal colic, their usage remained relatively stable from 2000 to 2008, while the use of CT scans rose significantly.[7] CT is highly sensitive and specific, with sensitivity reported at 95% or higher and specificity at 96%. It can detect stones as small as 1–2 mm and measure stone density in Hounsfield Units (HU), which aids in predicting of stone composition. High-resolution CT has the potential to determine stone composition at the time of diagnosis.[8] CT is valuable for determining appropriate treatment by assessing the stone's size, location, and density. Unlike other imaging methods, it does not require intravenous contrast. Additionally, CT can detect signs of obstruction, such as hydronephrosis or hydroureter.

With a sensitivity of up to 98% and specificity ranging from 96–100%, CT is the preferred initial imaging modality for suspected urinary stones. Its advantages include widespread availability, speed, ease of image acquisition, no need for contrast media, and the ability to identify extra-urinary conditions such as appendicitis, diverticulitis, or gynecological pathologies like hemorrhagic cysts or ovarian torsion.[9] Advanced CT techniques, such as dual-energy CT (DECT), further enhance diagnostic capabilities by characterizing stone composition before to treatment.

A cross-sectional study conducted in the Department of Radiology at Sharif Medical City, Lahore, in 2023 by Talha Khalid and Syed Muhammad Yousef Farooq included 197 patients with nephrolithiasis, selected through non-probability convenient sampling. The participants had a mean age of 50.3 years (±14 years), with ages ranging from 20 to 60 years. Ultrasound demonstrated a sensitivity of 85.19% for diagnosing ureteric stones, meaning it correctly identified the condition in 85.19% of cases where it was present. However, the specificity was lower at 48.57%,

indicating that it correctly ruled out the condition in only 48.57% of those without it.The overall accuracy of ultrasound was 78.68%, indicating its ability to correctly identify both true positives and true negatives. Despite its lower specificity, ultrasound remains advantageous due to its widespread availability, affordability, and no radiation exposure compared to CT. [10]

Additionally, a retrospective observational study was conducted in the Department of Radiology and Imaging at Patan Hospital, Nepal, analyzing CT KUB reports of patients with suspected urolithiasis over a three-year period (January 2017 to January 2020). Ethical approval was obtained for the study. Out of a total 414 CT KUB reports, 230 (55.6%) were from male patients. Among these, 314 patients underwent ultrasound before CT KUB. Using CT KUB as the gold standard for diagnosing urolithiasis, the sensitivity of ultrasound was 94.09%, specificity was 27.9%, and overall accuracy was 85.03%. The association between ultrasound and CT KUB findings was analyzed using the Chi-square test, with a p-value of <0.05 considered statistically significant. The study emphasized that ultrasound, despite its lower specificity, is a valuable initial diagnostic tool for urolithiasis when compared to CT KUB. [11]

2. Materials & Methods

Data was collected from a private diagnostic setup in Rawalpindi after taking written consent. The radiology staff was provided with a questionnaire. The radiology staff included radiologists, technologists, nurses and technicians of the CT. Patients of both genders were included in this research. Patients of all age groups were included in this research. Non cooperative patients and patients with mental health problems were excluded from this research.

3. Results

The results of study showed that out of 113 patients 78(69.02%) patients were male and 35(30.97) were female. Out of total 113 patients, patients with age group 31-40 years were diagnosed with disease. In this study, the positive and negative results obtained from ultrasound diagnostics were evaluated across different anatomical locations (N/L, V/L, U/L, PUJ, and VUJ). To understand the effectiveness of ultrasound, the positive ultrasound results were compared to CT scan findings, which were considered the reference standard. Ultrasound detected 48 positive cases of nephrolithiasis and missed 17 cases (negative on ultrasound but potentially positive on CT). The nephrolithiasis site had the highest number of positive findings. V/L (Vesicolithiasis): 5 cases were identified as positive, with only 1 false negative. At VUJ (Vesicoureteric Junction): 6 positive cases were detected, with no negatives recorded.

Cases of nephrolithiasis

N/L		
	Frequency	Percentage
Positive	48	73.84615
Negative	17	26.15385

U/L (Ureterolithiasis): Ultrasound detected 15 positive cases, while 11 cases were missed.

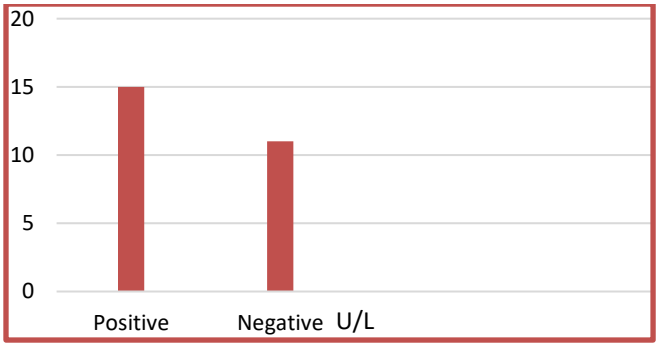

Fig. 1 Graph of Ureterolithiasis.

4. Discussion

Urolithiasis refers to the presence of calculi anywhere along the urinary tract. It is a universal problem, affecting patients across geographical, cultural, and racial boundaries. The American guidelines recommend a CT scan as the first choice for diagnosing ureteric stones, while the European guidelines suggest ultrasound as the initial modality. A larger proportion of patients in our study was in age range of 30 to

40years (69.90%) than those observed by Maryam et al. in which 46.9% of patients were in 31-45 years who conducted study in year 2018. [12] In my study, male patients accounted for 78 (69.02%), which was more than female patients, who accounted for 35 (30.97%). This finding aligns with the study conducted by Mehboob-ul-Wahab in 2019. [12]

This study showed that the sensitivity and specificity of ultrasound for urolithiasis is 71.70% and 92.0% respectively. The sensitivity and specificity of CT is 85.71% and 99.85%respectively.

This study correlates with the findings of Hao Xiang et al., who conducted a study in 2023 and reported a sensitivity of 93.13% and a specificity of 96%.

Conclusion:

The ultrasound's performance varies significantly for different anatomical regions, suggesting that it may be more effective for certain locations and less reliable for others. Overall, ultrasound demonstrates high sensitivity for detecting positive cases in the N/L and VUJ regions. It may not always provide the necessary accuracy for diagnosing all types of urinary tract stones, particularly in areas like the PUJ and U/L. Therefore, a combined approach with CT scanning as the reference standard may improve diagnostic accuracy, especially for patients with symptoms or risk factors for stones in regions where ultrasound sensitivity is limited. This highlights the importance of using ultrasound in conjunction with other imaging modalities to ensure a thorough and accurate assessment of urological con

Future Directions:

Future directions for enhancing the diagnostic accuracy of ultrasound (US) and computed tomography (CT) for urolithiasis will likely focus on improving their effectiveness, safety, and accessibility. Potential developments and areas for exploration may include:

Potential developments may include advancements in imaging technologies, the use of advanced ultrasound techniques, and the implementation of low-dose CT scans. For better results, the study can include a larger number of patients and extend over a period longer than six months. Additionally, since this study is one hospital-based, incorporating more hospitals could help achieve more comprehensive and reliable results.

Disclosure /Conflict of interest:

Authors declare no conflict of interest.

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