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Comparison of Diagnostic Accuracy of Colour Doppler Twinkling Artefact with Computed Tomography of the Kidney, Ureters, and Bladder in Detection of Nephrolithiasis in Emergency Setup–Point of Care Ultrasonography

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ABSTRACT

Objective: To Compare the Diagnostic Accuracy of the Colour Doppler twinkling artefact with Computed Tomography of the Kidney, ureters, and bladder in the detection of Nephrolithiasis - Point of Care Ultrasonography.

Study Design: Comparative prospective study.

Place and Duration of Study: Department of Diagnostic Radiology, Combined Military Hospital, Pakistan, from Jan 2023 to Apr 2023.

Methodology: A total of 370 patients referred from hospital emergency for evaluation of renal colic of the age group 18-65 years were evaluated. Greyscale ultrasound and Colour Doppler TA were performed at the emergency department as a point-of-care ultrasonography. All patients were subsequently referred for Computed Tomography of the Kidney, ureters.

Results: Diagnostic yield of Colours Doppler TA was comparable to CT KUB and slightly greater GSU. The sensitivity, Specificity, Positive predictive value, Negative predictive value and Accuracy for TA and GSU was 99.33%, 92.01%, 96.92%, 83.64%,92.97% and 89.63%, 88.0%, 95.28%,75.86% 89.19% respectively. The mean time required for GSU / Colour Doppler TA diagnosis was 39.32 ± 9.36 Minutes and 27.87 ± 15.45 hours for CT KUB.

Conclusion: The diagnostic yield of colour Doppler twinkling artefact is comparable to Computed Tomography of the kidney, ureters, and bladder in diagnosing acute renal colic. It is a reliable alternative to GSU and CT-KUB in emergency setups as a point-of-care ultrasonography.

Key Words: Diagnostic imaging tomography, X-Ray computed ultrasonography, Doppler, Color ultrasonography, Artifacts.

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INTRODUCTION

Nephrolithiasis is a common disease worldwide with the lifetime risk of approximately 12% in male and 8% in female gender.[1] The prevalence of nephrolithiasis has risen over the past few decades, resulting in more disease burden on healthcare setups.[2] The estimated prevalence of this disease in Pakistan is approximately 16 per cent.[3] The recent rise in disease is causing a significant economic burden on our hospitals.[4] The rising trend is seen more commonly in children and young adults, especially those aged 19-25 years.[5] Imaging studies, including ultrasonography and Computed Tomography of the Kidney/ureter/bladder (CT KUB), play a key role in diagnosing nephrolithiasis. CT KUB is a gold standard investigation which not only detects nephrolithiasis but also diagnoses complications of nephrolithiasis with sensitivity and specificity approaching 93 % and 100 %.[6] However, CT KUB has a few limitations, such as being expensive, exposing the patient to ionising radiation, contraindications in pregnancy and limited use in children.[7] Ultrasound, on the other hand, is less expensive, readily available, has no harmful radiation, and has a reliable diagnostic role in children and pregnant females.[8] Greyscale ultrasound (GSU) detects calculi as small echogenic foci causing posterior acoustic shadowing; however, many small calculi do not cause posterior acoustic shadowing, thus increasing the number of false negative results.[9,10]

A comprehensive review of the literature revealed limited data on this subject within a developing country. Hence, this study aimed to establish the role of cost-effective modality for diagnosis of acute renal colic. Grey scale ultrasonography is a readily available and convenient diagnostic tool, but the incorporation of colour Doppler twinkling artefact improves the accuracy of ultrasonography manifolds.

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METHODOLOGY

The comparative prospective study was conducted at the Department of Diagnostic Radiology, Combined Military Hospital, Lahore Pakistan from January to April 2023 after approval from the Hospital ethical review committee (CMH Lahore IRB no. 426 /2023 dated 12 Jan 2023). The sample size was estimated using the WHO Sample size calculator with a prevalence of nephrolithiasis at 8%.[11]

Inclusion Criteria: Patients aged 18-65 years presenting to the Emergency Department with acute flank pain or being investigated for renal colic were included.

Exclusion Criteria: Patients with comorbidities like hypertension, diabetic nephropathy, chronic kidney disease and obstructive nephropathy were excluded. Patients with pregnancy and a prior history of surgical intervention for nephrolithiasis and malignancy were also excluded.

The non-probability consecutive sampling technique was used. Informed written consent was acquired from all the patients. The procedure and purpose of the study were explained to all study participants. Grey scale ultrasonography (GSU) and Colour Doppler were done, using 3.5 MHz curvilinear probes, for all patients to elicit twinkling artefacts (TA) as a point of care ultrasonography in-hospital emergencies (Figure).

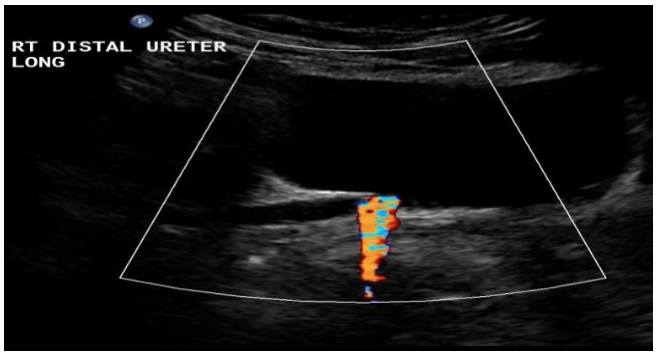

Figure: Colour Doppler Twinkling Artefact–Right Ureter

Subsequent appointment for CT KUB was given, and patients were followed up for results. Non-contrast enhanced CT KUB was done using a multi-planar 64-slice CT machine with a slice thickness of 2mm and was reported by a separate team of radiologists, and results of GSU and colour Doppler TA were blinded from that team. The time required for diagnosis by each investigation mentioned above was documented. Patients' data on data collection performance was gathered, and contact numbers were taken for future correspondence.

Statistical analysis was done using Microsoft Excel 365. Quantitative variables like age, Stone size and investigation time were depicted as mean and standard deviation. Qualitative variables like gender, number and position of stones detected by each modality were expressed in frequencies and percentages. Sensitivity, specificity, positive predictive value, negative predictive value and accuracy were determined to compare diagnostic tests.

RESULTS

Data from 370 patients being referred for evaluation of acute renal colic was analysed in this study. Patients with alternate diagnoses like acute appendicitis, pelvic inflammatory disease and surgical abdomen having negative findings on GSU, colour Doppler TA and CT KUB for nephrolithiasis were considered as a control group. The mean age was calculated to be 46.79±14.4 years. Among the total study population, 253(68.38%) were males, and 117(31.62%) were females. Renal Calculi were detected in 254 (68.65%) patients by GSU, in 261(70.54%) patients by colour Doppler TA and 270(72.97%) by CT KUB in the study group. In apprx 204 patients (75.5%), stones were found in the kidneys/proximal ureters, and 67 patients had (24.8%) stones located in the mid to distal ureters. The average stone size detected by GSU/ colour Doppler TA was 0.88 cm (±0.94) Furthermore, 0.86 cm (±0.99) was detected by CT KUB (Table–I).

Table–I: Patient Characteristics (n= 370)

Patient Variables	n(%)
Age (Years) Mean ± SD	46.79±14.4
Gender	
Males	253(68.38%)
Females	117(31.62%)
Stone Detection	
Grey scale Ultrasound	254 (68.65%)
Colours Doppler Twinkling Artefact	261 (70.54%)
Computed Tomography Kidney,	
Ureters , Bladder	270 (72.97%)
Stone Position	
Kidney+Proximal ureter	204(75.5%)
Mid+Distal Ureter/Urinary Tract	67(24.8%)
Stone Size (Mean)	
Grey scale Ultrasound (cm) Mean±SD	0.88±0.94
Computed Tomography Kidney, Ureters, Bladder (cm) Mean±SD	0.86±0.99
Time Period for Investigation	
Grey scale Ultrasound /Colour Doppler Twinkling Artefact-(Minutes)	39.32±9.36
Computed Tomography Kidney,Ureters, Bladder (Hours) Mean±SD	27.87±15.45

The mean time required for establishing GSU/colour Doppler TA diagnosis was 39.32±9.36 minutes and 27.87±15.45 hours for CT KUB. The colour Doppler TA was superior to GSU in the detection of nephrolithiasis with sensitivity 93.33%, Specificity 92.0%, Positive predictive value 96.92%, negative predictive value 83.64, Accuracy 92.97% versus Sensi-tivity 89.63%, Specificity 88.0%, Positive predictive value 95.28%, negative predictive value 75.86 % and Accuracy 89.19% (Table–II).

Table–II: Comparison of Diagnostic Parameters

Diagnostic Modality	Sensitivity (%)	Specificity (%)	Positive Predictive value (%)	Negative predictive value (%)	Accuracy (%)
Grey scale Ultrasound	89.63	88.0	95.28	75.86	89.19
Colour Doppler Twinkling Artefact	93.33	92.01	96.92	83.64	92.97

DISCUSSION

The purpose of this study was to prospectively compare the diagnostic accuracy of Doppler ultrasound TA with CT KUB in the diagnosis of nephrolithiasis as a point-of-care ultrasonography in emergency setups. CT KUB is the gold standard/Diagnostic investigation of choice in nephrolithiasis. The documented sensitivity of this test is greater than 99%, with specificity more than 94%.[12] However, in developing countries like Pakistan, the availability and cost-effectiveness of CT KUB in emergency setups is a major issue. CT-KUB as the point of care diagnosis is not feasible in many cases. The overall prevalence and recurrence of renal calculus have increased over the last few years, and thus, patients are frequently advised to repeat CT KUB for diagnosis of small renal stones, leading to a greater risk of radiation exposure.[13,14] It is also a major limitation in pregnant patients. Ultrasonography is an efficient diagnostic tool important in diagnosing nephrolithiasis. It is a safe and cost-effective diagnostic tool which can also be used as a point-of-care ultrasonography in emergency setups.[15] Results in our study depicted that although the CT KUB is the most sensitive investigation, our Doppler TA has greater sensitivity, specificity, PPV, NPV, and accuracy than grey scale ultrasonography. Our results are supported by recent studies conducted in Pakistan.

Patients having ureteral calculi lodged in the middle and lower regions of the ureters have difficulty in holding urine/bladder filling due to severe pain and lower urinary tract symptoms.[16,17] Moreover, intestinal gas shadows/distended gut makes diagnosing difficult with GSU. Therefore, colour Doppler TA can be more effective in making a diagnosis of renal and ureteric calculi. It is easy to elicit and readily available in most emergency setups.[18-20] The average time of diagnosis of nephrolithiasis by colour Doppler TA was 39.32±9.36 minutes compared to 27.87±15.45 hours required for CT KUB.

Abid *et al.* documented that colour Doppler TA has a sensitivity of 91.2% and a specificity of 95.2% with an accuracy of 92.2%.[21] Liu *et al*. also suggested that colour Doppler TA has a performance comparable to CT KUB in the diagnosis of acute renal colic with a sensitivity of 96.3%, specificity of 90.7%, PPV of 99.5% and NPV of 34.4%.[14]

Therefore, it is not only a cost-effective modality but also significantly decreases the time required for diagnosis, reducing the burden of emergency setups. Colour Doppler TA also determines the location, size and margins of stone, which helps differentiate it from the echo effect of a mass in the same anatomical region. Integration of colour Doppler TA in routine GSU as a point-of-care ultrasonography can accurately diagnose nephrolithiasis with a considerable reduction in diagnosis time. Despite the high sensitivity and specificity of GSU and colour Doppler TA, CT KUB's high negative predictive value still makes it a gold standard investigation.

LIMITATION OF STUDY

This study was conducted in the emergency department of a single tertiary care setup. Extending the scope of this study to other emergency care setups with a larger sample size will further improve the diagnostic yield of colour Doppler TA.

CONCLUSION

The diagnostic yield of colour Doppler twinkling artefact is comparable to Computed Tomography of the kidney, ureters, and bladder (CTK UB) and slightly superior to grey scale ultrasonography (GSU) in diagnosing acute renal colic. It is a reliable alternative to GSU and CT KUB in emergency setups as a point-of-care ultrasonography. It reduces the time required to diagnose acute renal colic and initiate treatment, thus reducing the burden on the emergency department.

Conflict of Interest: None.

Authors' contributions

Following authors have made substantial contributions to manuscript as under:

RT & SFN: Concept of study, Study design, data analysis, critical review and approval of final version to be published

HBT & AZH: Study design, drafting of manuscript, approval of final version

AI & WK: Data Analysis, interpretation, critical review and approval of final version to be published

Authors agree to be responsible 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.

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