The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 1, 2025

DIAGNOSTIC ACCURACY OF TWINKLING ARTIFACT FOR URINARY TRACT STONES TAKING NON-CONTRAST COMPUTED TOMOGRAPHY AS STANDARD

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DOI: https://doi.org/10.5281/zenodo.18694181

Keywords
Artifact, doppler, twinkling, stones, urinary

Article History
Received: 16 November 2024
Accepted: 16 January 2025
Published: 31 January 2025

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Abstract

Objective: *To study the sensitivity and specificity of Doppler scan twinkling artifact in diagnosis of urinary tract stones and comparing it non-contrast computed tomography (CT) of the kidney ureter bladder (KUB) as the gold standard*

Study Design: *Prospective observational study*

Place and Duration of Study: *Department of Radiology, Pak-Emirates Military Hospital, Rawalpindi from July 2023 to June 2024*

Methodology: *A total of 170 patients were analyzed in the final study protocol. All patients included with clinical suspicion of urinary tract stones had to undergo both the Doppler ultrasound and non-contrast computed tomography (CT) of the kidney, ureter and bladder. Primary variables studied were sensitivity and specificity of the Doppler ultrasound in diagnosing urinary tract stones when compared with gold standard non-contrast CT scan.*

Results: *Doppler ultrasound with the presence of a twinkling artifact showed a total sensitivity of 85.4% when compared with the gold standard non-contrast CT scan with a specificity of 92.5%. It had a positive predictive value of 97.4% while the negative predictive value was 66.1%. The diagnostic accuracy of the test in detecting stones in the kidney and urinary tract was 87.0%*

Conclusion: *We conclude that twinkling artifact on Doppler ultrasound offers good sensitivity and specificity in diagnosis of urinary tract stones when compared with gold standard non-contract computed tomography (CT) in patients.*

INTRODUCTION

Urolithiasis is one of the commonest presentations for radiological diagnosis in recent years. The formation of kidney stones is a common diagnosis in the later years of life, and it is reported that the estimated lifetime prevalence is around 10% in men and 5% in women[1]. Important risk factors affecting the prevalence include advancing age, processed diets, male gender, sedentary lifestyle and type of occupation[2, 3]. With improvements in the diagnostic radiological modalities in the past decade, aiding in the diagnosis of urinary tract stones has seen multiple modalities being used according to accuracy, availability and cost. These include digital radiography, ultrasonography (USG), pyelourethrography and non-contrast CT[4]. While all these radiological tests are available at centers of excellence, availability in resource constrained setups and rural areas of the

country is very limited and selective. The trained required for operating certain equipment is also a factor[5].

Non-contrast computed tomography (CT) is presently the gold standard for diagnosis of urinary tract stones with reported sensitivity and specificity being 98% and 96-100% respectively[6]. While the test is available at major setups in the country, patient burden, cost effectivity and exposure to radiation is a concern. Many patients with concomitant issues (pregnancy etc.) cannot undergo the procedure citing exposure of radiation and resulting complications. With low cost, portable ultrasound machines being widely available even in developing countries, the focus has shifted to using the option for diagnosis of urinary tract stones. The classical presence of a hyperechoic lesion with a posterior acoustic shadow fulfills the general criteria for diagnosis. With studies reporting limited sensitivity for detection, using Doppler settings in the USG has been reported to increase the sensitivity and specificity for diagnosis[7]. It is also helpful in diagnosing small stones not visualized through the conventional ultrasound technique and 60% of the stones are reported to be <5 mm. The twinkling artifact is generated by a strong reflecting medium and appears as a rapid alternating red and blue color Doppler signal. It has more sensitivity for small stones and in areas with good reflectors such as the ureters and prostate[8]. We aim to study the sensitivity and specificity of Doppler scan twinkling artifact in diagnosis of urinary tract stones and comparing it non-contrast computed tomography (CT) of the kidney ureter bladder (KUB) as the gold standard.

METHODOLOGY:

This prospective observational study was carried out at the Department of Radiology, Pak-Emirates Military Hospital, Rawalpindi from July 2023 to June 2024 after approval from ethical review board vide letter no. The sample size was calculated keeping the confidence interval at 95%, margin of error at 5% with the maximum population prevalence of urinary tract stones in both genders at 10%[9]. Minimum sample size using the WHO calculator came out to be 139 patients. We included 170 patients in the final analysis according to the inclusion criteria furnished for the study protocol.

Inclusion criteria included all male and female patients ages 18-75 years of age referred with clinical suspicion of urinary tract stones

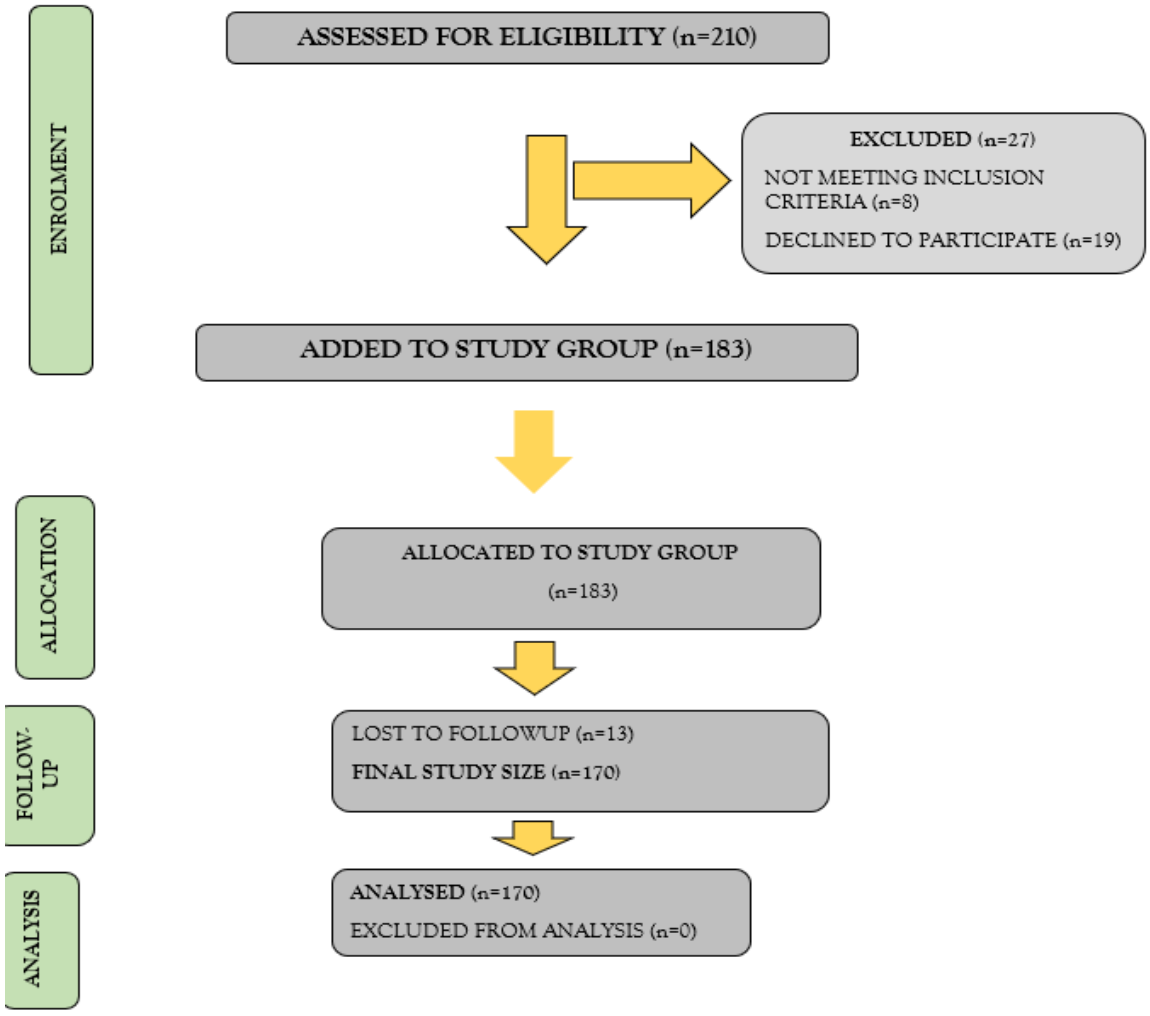
Exclusion criteria included patients with advanced cardiac and respiratory disease, patients with known cancer or metastatic disease, patients having undergone a CT scan in the last 3 months, patients lost to follow-up and patients unwilling to be included in the study

The study method included data collection after individuals were added to the study group as per the inclusion criteria furnished. A written informed consent was taken from all participants. For comparison according to the study design, all patients included had to undergo both the Doppler ultrasound and CT KUB. Patients were counselled in detail regarding both procedures and were explained about radiation exposure and risks involved. Ethical concerns were addressed and patients willing for both procedures were added to the study protocol. They were not made aware of the study outcomes and variables of study to ensure procedural blinding. Since the study design could not be affected by subjective patient issues, confounding factors were minimum. Doppler ultrasound was done in all patients by a consultant radiologist with at least 5 years of ultrasound experience, who was unaware of the study outcomes but was directed to report the presence or absence of the twinkling artifact. All ultrasounds were done on a Toshiba Xario 100 3D Ultrasound machine with Doppler capability using a curved probe. To improve and optimize detection, settings of the ultrasound machine were adjusted keeping the focal zone below the rough interface, increasing the color white priority, reducing the grey scale and reducing the pulse repetition frequency. Results were endorsed by the consultant and were then collected by a resident radiologist and submitted to the analysis team which were to report results of the USG reports. All patients were then

advised to report for CT scan assessment with appointments in the next 5-7 days. Non-contrast CT scan using a 5 mm helical approach with a pitch of 1.5:1 or less and low dose protocol was used. Results were done by two independent radiologists for reporting and were collected by a resident radiologist and submitted to another independent analysis team different from those compiling the USG results to ensure binding and prevent bias. Final results were submitted to a statistician for final analysis and comparison.

Primary variables studied were sensitivity and specificity of the Doppler ultrasound in diagnosing urinary tract stones when compared with gold standard CT scan. Demographic data were statistically described in terms of mean and SD, frequencies, and percentages when appropriate. Independent samples t-test was used to compare demographic means and frequency variables compared using the Chi-square test. A p value of ≤0.05 was considered statistically significant. All statistical calculations were performed using Statistical Package for Social Sciences 26.0.

FIGURE-I: PHASES OF THE STUDY



RESULTS:

A total of 210 patients were assessed for eligibility. 08 did not meet the inclusion criteria and 19 patients declined to participate in the study. 183 patients were then allocated to the study group from which 13 patients were lost to follow-up or did not present for the radiological tests making the final analysis sample of 170 patients. Mean age of patients was 47.04±5.73 years and mean weight was 74.72±4.29 kilograms. Gender distribution revealed 130 (76.5%) males and 40 (23.5%) females. 134 (78.8%) patients had stone size less than 5 mm when detected on Doppler by twinkling artifact and confirmed on CT scan while 36 (21.2%) had stone sizes greater than 5 mm. Location of stone detection showed that 113 (66.5%) were in the kidney, 54 (31.8%) in the ureters while 03 (1.8%) were located in the bladder region. Previous history taken of the patients showed that 49 (28.8%) had previous history of kidney and urinary tract stones while 121 (71.2%) patients had no previous history or symptoms of the disease (Table-I).

Doppler ultrasound with the presence of a twinkling artifact showed a total sensitivity of 85.4% when compared with the gold standard non-contrast CT scan with a specificity of 92.5%. It had a positive predictive value of 97.4% while the negative predictive value was 66.1%. The diagnostic accuracy of the test in detecting stones in the kidney and urinary tract was 87.0% (Table-II).

TABLES

TABLE-I DEMOGRAPHIC DATA AND CLINICAL CHARACTERISTICS (n=170)

VARIABLE	
MEAN AGE (YEARS)	47.04±5.73
MEAN WEIGHT (KG)	74.72±4.29
GENDER DISTRIBUTION	
• MALE	130 (76.5%)
• FEMALE	40 (23.5%)
MEAN TIME WITH CLINICAL SYMPTOMS (DAYS)	18.59±4.18
SIZE OF STONE IDENTIFIED (ON DOPPLER USG)	
• SMALL (< 5 MM)	134 (78.8%)
• LARGE (> 5 MM)	36 (21.2%)
AREA WHERE STONE WAS DETECTED (ON DOPPLER USG)	
• KIDNEY	113 (66.5%)
• URETER	54 (31.8%)
• BLADDER	03 (1.8%)
PREVIOUS HISTORY OF URINARY TRACT STONES (< 01 YEAR)	
• YES	49 (28.8%)
• NO	121 (71.2%)

TABLE-II SENSITIVITY, SPECIFCITY, POSITIVE AND NEGATIVE PREDICTIVE VALUE FOR DOPPLER USG WHEN COMPARED WITH CT SCAN FINDINGS (n=170)

VARIABLE	
SENSITIVITY	85.4%
SPECIFICITY	92.5%
POSITIVE PREDICTIVE VALUE	97.4%
NEGATIVE PREDICTIVE VALUE	66.1%
DIAGNOSTIC ACCURACY	87.0%

DISCUSSION:

Our study was carried out with the aim to look for cheap, alternative and safer methods for diagnosis of urinary tract stones in our demographic setups. Our institute is a center of excellence with smaller setups throughout the country where the modality of CT scan is not available readily. Our study was able to confirm a good sensitivity and specificity for the Doppler ultrasound confirming a twinkle artifact to be good in diagnosing urinary tract stones. The twinkling artifact (TA) on Doppler studies was first reported by Rahmouni et al in 1996 and was reported to show good diagnostic capability for urinary tract stones[10]. Laher et al did a meta-analysis on the pooled sensitivity and specificity of the Doppler ultrasound and twinkling artifact and found sensitivity to be around 88.16% and specificity to be around 79.22%[11]. The reported sensitivity is closer to our study while the reported specificity is higher in our study and other studies done by Letafati et al and N Liu et al[12, 13]. The reason for this is that Laher et al included studies where the sonographic technique and the model and quality of the ultrasound machines differed for patients. This could lead to observer bias and difference in the results. Further studies noted followed our study protocol by performing the tests on one standard, high quality machine with a senior consultant decreasing both the operator as well as equipment issues in diagnosing urinary tract stones. This has been reported as an important factor in the heterogenicity of the results reported for twinkling artifact and diagnosis of stones[14, 15]. Secondly, while the twinkling artifact shows good sensitivity and specificity is observer issues are controlled, the negative predictive value of the test is below satisfactory. Studies have also reported that the negative predictive value of the test especially for small stones less than 5 mm in size[16].

Our study reported that the age of diagnosis for urinary tract stones was in the early to late forties between both genders. Studies have reported that median ages for men and women varied between 44 years for males and 40 years for females[17]. This demographic finding is in line with results of our study. Gender distribution also shows a predilection towards the male gender with males affected twice as more as females[3]. Majority of the stones detected were small in size (< 5 mm) with more than 60% present in the kidneys and around 40% present in the ureters. Our study reported a mean time of diagnosis from onset and presentation of symptoms in patients to the time of diagnosis between 2-3 weeks. Since we had to do a confirmatory CT scans in all patients, this time was prolonged. We aim to lessen this time by using twinkling artifact (TA) as an important tool for which the time required for the appointment, procedure and reporting is far less than is required for CT scan modalities in our demographic setups and resource constraint centers[18].

RECOMMEDATIONS:

The study recommends the use of Doppler ultrasound using twinkling artifact (TA) as a good alternative as well as a complimentary diagnostic option for detecting urinary tract stones

CONCLUSION:

We conclude that twinkling artifact on Doppler ultrasound offers good sensitivity and specificity in diagnosis of urinary tract stones when compared with gold standard non-contract computed tomography (CT) in patients.

LIMITATIONS:

The limitations are that the study is single center only.

CONFLICT OF INTEREST:

None

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