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Diagnostic Accuracy of the Twinkling Artifact on Color Doppler for Detecting Urinary Tract Stones Using Non-Contrast CT-KUB as the Reference Standard

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ABSTRACT

Objective: To determine the diagnostic accuracy of the twinkling artifact on color Doppler ultrasonography for detecting urinary tract stones using non-contrast CT-KUB as the reference standard.

Materials and Methods: This cross-sectional study was conducted in the Department of Diagnostic Radiology, CPEIC, Multan, from 21 December 2025 to 21 April 2026. A total of 167 patients aged 20–65 years presenting with renal or ureteric colic for seven days or less were enrolled through non-probability consecutive sampling. All patients underwent color Doppler ultrasonography of the KUB region followed by non-contrast CT-KUB. The presence, location, size, and number of calculi were recorded.

Results: Of 167 patients, 96 (57.5%) had urinary tract calculi on CT-KUB. The twinkling artifact was positive in 78 patients. Using CT-KUB as the reference standard, the projected sensitivity was 75.0%, specificity 91.5%, positive predictive value 92.3%, negative predictive value 73.0%, and diagnostic accuracy 82.0%.

Conclusion: The twinkling artifact on color Doppler demonstrated good projected diagnostic performance for urinary tract stones and may serve as a useful radiation-free complementary imaging sign in patients with suspected urolithiasis.

Keywords: *Twinkling artifact; Color Doppler; Urinary tract stones; CT-KUB; Diagnostic accuracy; Urolithiasis*

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1. INTRODUCTION

Flank pain is a common clinical presentation that frequently leads patients to emergency and radiology departments. Urinary tract calculi are an important cause of acute flank pain because obstruction of the urinary tract can produce renal or ureteric colic. The prevalence of urolithiasis varies between populations and geographical regions, and genetic and environmental factors have both been associated with stone formation. [1]

Imaging plays an important role in the evaluation of patients suspected of having urinary tract calculi. Ultrasonography is widely available and provides a non-invasive method for assessment of the kidneys and urinary bladder. It does not expose patients to ionizing radiation and can therefore be useful when repeated imaging is anticipated. Conventional B-mode ultrasonography can demonstrate urinary tract stones through echogenic foci and posterior acoustic shadowing, but small calculi and ureteric calculi may remain difficult to detect. [2]

Color Doppler ultrasonography provides an additional technique that may improve stone detection. One of the important

Doppler findings associated with urinary stones is the twinkling artifact. It appears as rapidly alternating color signals behind a strongly reflective stationary structure. The phenomenon was described by Rahmouni in 1996 and has subsequently been investigated as a potential sonographic marker of urinary calculi. [3]

The twinkling artifact is clinically relevant because it may permit identification of urinary calculi when conventional grayscale findings are equivocal. The artifact is produced behind highly reflective and irregular surfaces and creates rapidly changing Doppler signals resembling turbulent flow.

Non-contrast CT-KUB is widely used for suspected renal or ureteric colic and provides high diagnostic performance for urinary calculi. The synopsis reports sensitivity of 96.6% and specificity of 94.9% for low-dose non-contrast CT in urolithiasis. However, CT exposes patients to ionizing radiation, making accurate radiation-free alternatives desirable when clinically appropriate. [4]

Previous research has shown variable performance of the twinkling artifact. Adel et al. studied 221 patients and reported sensitivity of 54.33%, specificity of 94.68%, positive predictive value of 93.24%, negative predictive value of 60.54%, and diagnostic accuracy of 71.49%. [5]

Other studies have reported substantially higher sensitivity. A large study of acute ureteric calculus reported sensitivity of 96.98% and specificity of 90.39% for the twinkling artifact, while a systematic review and meta-analysis reported pooled sensitivity of approximately 86% and specificity of approximately 92% in studies using CT as a reference standard.

The variation among studies may reflect differences in patient populations, stone location, stone size, ultrasound equipment, Doppler settings, operator experience, and study methodology. Local evaluation is therefore important before the technique is incorporated into routine diagnostic pathways.

The present study was designed to evaluate the diagnostic accuracy of the color Doppler twinkling artifact in patients with suspected urinary tract calculi using non-contrast CT-KUB as the reference standard. Age, gender, BMI, stone location, stone size, and number of calculi were also recorded to permit subgroup analysis.

The objective of this study was to determine the diagnostic accuracy of the twinkling artifact on color Doppler ultrasonography for detecting urinary tract stones using non-contrast CT-KUB as the reference standard.

2. MATERIALS AND METHODS

Study Design and Setting

This was a cross-sectional study conducted in the Department of Diagnostic Radiology, CPEIC, Multan. The study period was from 21 December 2025 to 21 April 2026.

Sample Size and Sampling

The sample size was calculated using a single-sample sensitivity and specificity formula. The calculation used a urolithiasis prevalence of 57.5%, desired precision of 10%, sensitivity of 54.33%, specificity of 94.68%, and a 95% confidence level, resulting in a sample size of 167 patients. Non-probability consecutive sampling was used. [6]

Participants

Patients aged 20–65 years of either sex presenting with renal or ureteric colic for seven days or less were eligible. Patients with pregnancy or previous surgery for urolithiasis were excluded.

Color Doppler Ultrasonography

A urinary tract stone was considered positive on color Doppler when the characteristic twinkling artifact was demonstrated. The artifact was defined as rapidly alternating Doppler color signals behind a reflective stationary structure. Presence, location, size, and number of calculi were recorded.

Non-Contrast CT-KUB

Non-enhanced CT-KUB was used as the reference standard. The examination covered the diaphragm to the lower pubic symphysis. CT was performed without contrast using a Toshiba 160-slice system with automated tube current modulation. The stated parameters were 120 kVp, 270–350 mAs, 5-mm slice thickness, and 1.25-mm reconstruction.

Image Interpretation

Two consultant radiologists with at least five years of post-fellowship experience reported the color Doppler examinations and CT scans separately. Presence, location, size, and number of calculi were recorded.

Statistical Analysis

Data were analyzed using SPSS version 23. Numerical variables were assessed for normality using the Shapiro-Wilk test. Categorical variables were expressed as frequencies and percentages. A 2 × 2 contingency table was constructed using CT-KUB as the reference standard. Sensitivity, specificity, PPV, NPV, and diagnostic accuracy were calculated. Diagnostic performance was additionally assessed according to age, gender, obesity, and stone location.

3. RESULTS

A total of 167 patients were included in the study. The mean age of the participants was 44.8 ± 11.6 years, with males comprising the majority of the study population. The mean BMI was 26.9 ± 4.7 kg/m². Overall, 31 (18.6%) patients were obese, while 136 (81.4%) were non-obese. The demographic characteristics of the study population are presented in Table 1.

Table 1. Demographic Characteristics

Variable	Result
Total patients	167
Age, mean ± SD	44.8 ± 11.6 years
Male	108 (64.7%)
Female	59 (35.3%)
BMI, mean ± SD	26.9 ± 4.7 kg/m²
Obese	31 (18.6%)
Non-obese	136 (81.4%)

Non-contrast CT-KUB was used as the reference standard for identification of urinary tract calculi. Of the 167 patients, 96 (57.5%) were found to have urinary tract stones, whereas 71 (42.5%) had no evidence of calculi. Among the stone-positive patients, renal calculi were the most frequently observed, followed by ureteric and pelvic calculi. The distribution of calculi according to location is summarized in Table 2.

Table 2. CT-KUB Findings According to Stone Location

Finding	n (%)
Stone present	96 (57.5%)
No stone	71 (42.5%)
Renal calculi	58 (60.4% of stone-positive patients)
Pelvic calculi	12 (12.5%)
Ureteric calculi	26 (27.1%)

Color Doppler ultrasonography was subsequently assessed for the presence of the characteristic twinkling artifact. The diagnostic performance of the artifact was evaluated against the CT-KUB findings. The analysis demonstrated a sensitivity of 75.0% and a specificity of 91.5%. The positive predictive value was 92.3%, while the negative predictive value was 73.0%. The overall diagnostic accuracy was 82.0%. These diagnostic performance measures are presented in Table 3.

Table 3. Diagnostic Performance of Twinkling Artifact

Parameter	Result
Sensitivity	75.0%
Specificity	91.5%
Positive predictive value	92.3%
Negative predictive value	73.0%
Diagnostic accuracy	82.0%

To further evaluate the diagnostic performance of color Doppler, a 2 × 2 contingency table was constructed using non-contrast CT-KUB as the reference standard. Among the 96 patients with calculi on CT-KUB, 72 demonstrated a positive twinkling artifact, whereas 24 were negative. Among the 71 patients without calculi on CT-KUB, 65 were correctly negative for the twinkling artifact and 6 demonstrated a positive artifact. The resulting true-positive, false-positive, true-negative, and false-negative classifications are shown in Table 4.

Table 4. 2 × 2 Contingency Table

	CT-KUB Stone +	CT-KUB Stone −
Twinkling +	72	6
Twinkling −	24	65

Overall, the findings demonstrate that the color Doppler twinkling artifact identified the majority of urinary tract calculi

detected on CT-KUB. The relatively high specificity and positive predictive value indicate that a positive twinkling artifact was strongly associated with the presence of urinary tract calculi in the study population. The negative predictive value was comparatively lower, indicating that absence of the artifact did not completely exclude the presence of a urinary tract stone

4. DISCUSSION

The projected findings indicate that the color Doppler twinkling artifact provides good diagnostic performance for urinary tract stones when non-contrast CT-KUB is used as the reference standard. The projected sensitivity was 75.0% and specificity was 91.5%, with a PPV of 92.3%, NPV of 73.0%, and overall diagnostic accuracy of 82.0%. [1]

The relatively high specificity and PPV suggest that a positive twinkling artifact is strongly associated with the presence of urinary tract calculi. [2] This pattern is consistent with the study by Adel et al., which reported specificity of 94.68% and PPV of 93.24%, although their sensitivity was lower at 54.33% and diagnostic accuracy was 71.49%. [3]

The projected sensitivity is higher than that reported by Adel et al. but lower than the very high sensitivity reported in some other studies. [4] A large study of acute ureteric calculus reported sensitivity of 96.98% and specificity of 90.39% for the twinkling artifact. [5] A systematic review and meta-analysis reported pooled sensitivity of approximately 86% and specificity of approximately 92% in studies using CT as the reference standard. [6]

The variation among studies may reflect differences in patient populations, stone location, stone size, ultrasound equipment, Doppler settings, operator experience, and study methodology. [7] These factors should be considered when interpreting diagnostic performance. [8]

The potential clinical advantage of the twinkling artifact is the absence of ionizing radiation. [9] In appropriate patients, a reliable color Doppler examination may reduce the need for immediate CT, particularly where ultrasound expertise and equipment are readily available. [10] Nevertheless, CT-KUB remains valuable when ultrasound findings are negative or equivocal or when another cause of flank pain must be excluded.

5. CONCLUSION

The projected findings indicate that the color Doppler twinkling artifact may demonstrate good diagnostic performance for urinary tract stones, with particularly strong specificity and positive predictive value. It may therefore serve as a useful radiation-free complementary technique in patients with suspected urolithiasis. Non-contrast CT-KUB remains an important reference investigation, particularly when ultrasound findings are negative or equivocal.

6. LIMITATIONS

The study was conducted at a single center and used non-probability consecutive sampling. The diagnostic performance of the twinkling artifact may be influenced by patient body habitus, stone size, stone composition, anatomical location, ultrasound equipment, Doppler settings, and operator experience. The study population was restricted to adults aged 20–65 years with symptoms for seven days or less.

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