DIAGNOSTIC ACCURACY OF TWINKLING ARTIFACT OF DOPPLER ULTRASOUND IN PREDICTING URINARY TRACT CALCULI TAKING CT SCAN AS GOLD STANDARD

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ABSTRACT

OBJECTIVES

This study aims to determine the diagnostic accuracy of the twinkling artifact of Doppler ultrasound in predicting urinary tract calculi by taking a CT scan as the gold standard in the patients presenting to the radiology department at Hayatabad Medical Complex Peshawar.

METHODOLOGY

A cross-sectional study was conducted in the Radiology Department of Hayatabad Medical Complex Peshawar in the duration of 22nd April 2021 to 22nd October 2021

A total of 206 suspected of having urinary tract calculi were included in the study consecutively and subjected to Doppler ultrasound followed by CT KUB.

RESULTS

The mean age of the sample was 42.3 + 9.1 years. 67% of the sample was male, and 33% were female. The mean duration of symptoms in our group of samples was 4.1 + 1.3 weeks. On twinkling artifacts with Doppler US, urinary tract calculi were observed in 53.4% of patients. In contrast, on follow-up CT KUB scans, urinary tract calculi were recorded in 73.3% of patients. The sensitivity of twinkling artifacts with Doppler US was found to be 71.5%, and the specificity was found to be 96.4%. The positive predictive value of the twinkling artifacts with Doppler US is 98.2%, and the negative predictive value is 55.2%.

CONCLUSION

Twinkling artifact on Doppler US has an acceptable sensitivity and specificity for detecting urinary tract calculi. As such, it is a useful radiological tool for diagnosing urinary tract stones in adults, and further studies are recommended to confirm its usefulness, particularly considering other explanatory effect modifiers.

KEYWORDS: *Urinary Tract Calculi, Doppler Ultrasound, Computed Tomography, Twinkling Artifacts*

INTRODUCTION

Flank pain due to urinary tract stones is one of the leading causes of emergency department visits. Renal colic is the acute onset of flank pain, often radiating to the groin. The prevalence of renal colic varies, ranging from 5% to 15% across different regions.[1] The prevalence of urolithiasis in the Pakistani population is 12%.[2] Various environmental and genetic factors contribute to the formation of renal stones. Ultrasonography is the most commonly used imaging method for identifying urinary tract stones, as it is widely accessible and free of ionizing radiation. The sensitivity and specificity of ultrasound for detecting renal stones are 84% and 53%, respectively.[3] Ultrasonography operates in B mode (grayscale) and Doppler mode, which uses color flow imaging. The twinkling artifact, first identified in 1996, is primarily associated with renal stones and occurs due to a highly reflective surface on Doppler ultrasonography.[4] The twinkling artifact refers to rapidly fluctuating Doppler signals observed behind particular strongly reflective, irregular objects. It demonstrates high sensitivity and positive predictive value in diagnosing renal stones.[5] A study reported that the Doppler twinkling artifact has a sensitivity of 54.33% and a specificity of 90.39%.[6] Non-contrast CT is regarded as the gold standard for diagnosing renal stones, with its use increasing in recent years. It is highly effective in identifying both renal and ureteric calculi.[7] Non-contrast CT has a sensitivity of 96.6% and a specificity of 94.9% for detecting urolithiasis.[8] However, increased exposure to ionizing radiation is a concern with non-contrast CT. Therefore, this study aims to assess the positive predictive value of the Doppler ultrasound twinkling artifact for diagnosing renal stones, using non-contrast CT as the gold standard. Since limited research exists on this topic within the local population, the findings will assist radiologists and clinicians in selecting appropriate imaging techniques for detecting urinary tract stones while minimizing exposure to harmful ionizing radiation.

METHODOLOGY

A cross-sectional study was conducted in the Radiology Department of Hayatabad Medical Complex Peshawar in the duration of 22nd April 2021 to 22nd October 2021. A total of 206 suspected of having urinary tract calculi were included in the study consecutively and subjected to Doppler ultrasound followed by CT KUB. The hospital's ethics and research committee consented before the study could be carried out. After obtaining written informed permission, patients in the radiology department of the Hayatabad Medical Complex who met the study's inclusion criteria were enrolled in the research. Since the patient was recruited before having a CT scan, it was uncertain during the sonographic evaluation whether or not a calculus was present. The GE Logiq S8 ultrasound machine was used for Doppler ultrasonography and equipped with a 2-5 MHz convex probe capable of color Doppler imaging. The 128-slice CT scanner was used to perform the CT scan. A radiologist, blinded to the sonographic results, analyzed the CT scan to detect kidney, ureter, and bladder stones. These patients underwent a restricted sonographic scan of their kidneys, ureters, and bladder while awaiting their CT scan. An ultrasonographer with training conducted this test using a device capable of color Doppler imaging. Both greyscale and color Doppler ultrasound were used to evaluate the urinary tract. Color Doppler ultrasonography was performed using a red and blue color map to detect the twinkling artifact. The Pulse Repetition Frequency (PRF) was adjusted just above the threshold for color mapping of renal vessels. For ureteric and bladder calculi, PRF was set just above the threshold of the surrounding ships of the ureter and bladder to optimize the detection of twinkling artifacts. The sonographer, who was also blinded to the CT scan results, described the calculus's location in the tract and whether or not a twinkling artifact was present on the color Doppler scan.

Figure 1 The grayscale ultrasound image (left) reveals a hyperechoic focus accompanied by posterior acoustic shadowing. The middle image, utilizing color Doppler, highlights the twinkling artifact, appearing as a color mosaic pattern over the stone. The unenhanced CT scan (right) confirms the presence of a small renal calculus, ensuring diagnostic accuracy.

Version 23 of the Statistical Package for Social Sciences (SPSS) was used to enter and analyze the data. The mean and standard deviation were addressed about quantitative outcome factors like age and duration of symptoms. Gender was indicated as a qualitative outcome variable in frequency and percentage. Using CT scan results as the gold standard, contingency tables were used to determine the diagnostic accuracy, including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the twinkling artifact.

RESULTS

A study was conducted on 206 patients suspected of urinary tract calculi, with a mean age of 42.3 years (range 25-54). The sample comprised 67% males and 33% females. The average symptom duration was 4.1 weeks. Twinkling artifacts with Doppler US detected calculi in 53.4% of patients, while follow-up CT KUB scans confirmed calculi in 73.3%. The sensitivity of Doppler US twinkling artifacts was 71.5%, and specificity was 96.4%. The positive predictive value was 98.2%, and the negative predictive value was 55.2%. Subsequent tables detail sensitivity and specificity across different demographics and symptom durations.

Table 1: Demographic Parameters of the Study Population (N=206)

Patient Variables	n (%)
Age, Mean +/- SD (years)	42.3+/-9.1 (years)
Gender	
Male	138 (67%)
Female	68 (33%)
Stone Site	
Kidney and Proximal ureter	155(75.5%)
Mid and Distal Ureter or Urinary Tract	51(24.8%)
Stone Size	
Greyscale Ultrasound (cm) Mean±SD	0.88±0.94
Computed Tomography Kidney, Ureters, Bladder (cm) Mean±SD	0.86±0.99
Duration of symptoms	
2-4 weeks	138(67%)
>4-6 weeks	68(33%)
Calculi on twinkling artifact	
Yes	110 (53.4%)
No	96 (46.6%)
Frequency of urinary tract calculi on CT	
Yes	151(73.3%)
No	55(26.77%)

Table 2: Twinkling Artifact on Us & CT Scan 2 X2 Table (N = 206)

		Calculi on CT		Total
		Yes	No	
Calculi on twinkling artifact	Yes	108	2	110
	No	43	53	96
Total		151	55	206

Table 3: Sensitivity and Specificity of Us in Different Age Groups

Age Groups	Sensitivity	Specificity	PPV	NPV	Accuracy
25-35 years	39.6%	100%	100%	27.5%	50.8%
>35-45 years	89.9%	100%	100%	88.9%	94%
>45-54 years	85.9%	92.9%	97.3%	68.4%	87.6%

Table 4: Sensitivity and Specificity of Us in Gender

Gender	Sensitivity	Specificity	PPV	NPV	Accuracy
Male	68%	94.3%	97.2%	50%	74.6%
Female	79.2%	100%	100%	66.7%	85.3%

Table 5: Sensitivity and Specificity According to the Duration of Symptoms

Duration of symptoms	Sensitivity	Specificity	PPV	NPV	Accuracy
2-4 weeks	70%	97.4%	98.6%	55.2%	77.5%
>4-6 weeks	74.5%	94.1%	97.4%	55.2%	79.4%

DISCUSSION

The study evaluated the sensitivity and specificity of computed tomography (CT) and ultrasound in diagnosing ureteral colic in 250 patients with lumbar pain. It found CT to be the most effective for detecting renal stones, while ultrasound offered a radiation-free alternative but struggled with accurate identification of ureteric stones. Ultrasound efficacy is limited by factors like operator skill, obesity, and patient compliance, necessitating plain CT (KUB) for patients with renal colic.[9] Ultrasound is widely available and reliable for assessing flank discomfort, with 100% specificity and 95% sensitivity, but its sensitivity is limited. CT should be used as a follow-up investigation.[9] The mean age in our study was 42.3 years, which coincided with the age found by Maryam et al., which was 35.69 ± 5.91 years.[10] In our study, females made up 33% and males 67% of the sample. The twinkling artifact on Doppler ultrasound showed sensitivity of 71.5%, specificity of 96.4%, PPV of 98.2%, NPV of 55.2%, and accuracy of 55.2%. Toru et al. reported sensitivity of 78.9% and specificity of 83.7% in a similar study of 856 patients, aligning with our findings. Maryam et al. found a sensitivity of 69.64%, specificity of 66.6%, PPV of 82.92%, NPV of 48.48%, and accuracy of 68.75%, which are comparable to our results.[10] In a retrospective investigation, Fowler et al. found renal stones with a sensitivity of 24% and specificity of 90% during a 30-day interval, while the US detected only 24 of 101 stones detected by NCCT.[11] Patlas et al. compared US and NCCT for the detection of ureteric stones in 62 patients, yielding a sensitivity of 93% and specificity of 95%.[12] The low specificity of this study may stem from using tones near renal sinus fat, vascular calcifications, knowledge of urinary tract anatomy, and bowel gas, which can obscure ureteral calculi. Additionally, measuring stones in multiple planes impacts reproducibility, and artifacts like vascular calcifications can be mistaken for rocks, reducing specificity.[2,6,13,14] Kanno et al. found that the US-detected stone sizes were almost identical to those detected by NCCT.[15] A prior study looked at the parameters that influence the accuracy of US for the diagnosis of urinary stones. Goertz observed that the rising degree of HDN was related to an increase in the detection of ureteric stones by the US.[16] Kanno et al. reported that the stone size in the US was associated with the detection rate of the renal stone.[15] Pichler et al. reported that age and body mass index affected the diagnosis of ureteral stones in the US.[17] In contrast, our findings imply that the detection rate of urinary tract stones is unrelated to age or BMI. Ray et al. found that greater skin-to-stone distance was substantially linked with US and NCCT discordance.[14] The twinkling artifact, or the color comet-tail artifact, is a Doppler sonographic focus of alternate colors behind a reflecting item (such as calculi) that shows turbulent blood flow. The signal remains persistent even when the pulse repetition frequency (PRF) is increased and no wave appears in pulse wave mode. Gliga et al. conducted a study on 113 patients in Romania. They found that the sensitivity, specificity, positive predictive value, and negative predictive value of twinkling artifacts in detecting renal stones smaller than 5 mm were 99.12%, 90.91%, 99.12%, and 90.91%, respectively, similar to our findings.[18] In another study conducted in Austria in 2009, Mitterberger et al. included 77 urinary tract stones in 41 participants. Their findings revealed that twinkling artifacts on the color Doppler US are substantially associated with urolithiasis. Interestingly, their findings demonstrated that the use of twinkling artifact in color Doppler US is more accurate than the presence of posterior shadowing for the identification of urolithiasis (97% vs. 66%).[19] Masch et al. studied 85 patients and found that isolated sonographic twinkling artifacts had a sensitivity of 78%, specificity of 40%, and a positive likelihood ratio of 1.30 for detecting renal calculi. Specificity and likelihood ratios improved with the addition of posterior shadowing and echogenic focus. The lower sensitivity compared to other studies might be attributed to operator skill and imaging protocols, with operator blinding not being addressed. Another study by Dillman et al. examined the diagnostic accuracy of the twinkling artifact. In this study, twinkling artifacts' sensitivity and positive predictive value in detecting renal stones were lower (55% and 78%, respectively). This artifact's true-positive and false-positive rates were 49% and 51%, respectively.[20] The variations between the two investigations might be attributed to imaging procedures; Dillman et al. employed solely Doppler, whereas our work included gray-scale imaging. Sorensen et al. examined 32 stones in 18 kidneys and discovered that twinkling artifacts had lower sensitivity, specificity, and predictive values than previously reported (56%, 74%, 62%, and 68%). This disparity may be due to the short sample size.[21] Winkel et al. evaluated 105 individuals with renal stones in Denmark and discovered sparkling artifacts in 74% of the renal stones observed in B-mode US. The combination of the grey scale and color Doppler US for identifying urolithiasis has a sensitivity, specificity, positive predictive value, and negative predictive value of 55%, 99%, 67%, and 98%, respectively.[22] The variations in studies may stem from differences in operator skill or stone characteristics. Our study found no factors affecting the accuracy of the twinkling artifact, although the limited sample size and lack of consideration for all characteristics may have played a role. Other studies similarly overlook anatomical locations of stones and the effects of stone composition. While our research highlights the diagnostic potential of the twinkling artifact in Doppler ultrasound for detecting urinary tract calculi, further investigation is needed. Future studies should explore how different stone compositions affect the twinkling artifact's presence and intensity, and assess the clinical outcomes of patients diagnosed via ultrasound compared to CT to better evaluate ultrasound's effectiveness as a primary diagnostic tool.

LIMITATIONS

The twinkling artifact in Doppler ultrasound is operator-dependent and may produce false positives and negatives. Detection varies with stone size, composition, and location, with mid-ureteral stones being challenging. Interference from bowel gas, vascular calcifications, and patient factors like obesity affects accuracy. Compared to CT, ultrasound may miss clinically insignificant stones, leading to spectrum bias.

CONCLUSIONS

Twinkling artifact on Doppler US has an acceptable sensitivity and specificity for detecting urinary tract calculi. As such, it is a useful radiological tool for diagnosing urinary tract stones in adults, and further studies are recommended to confirm its usefulness, particularly considering other explanatory effect modifiers.

CONFLICT OF INTEREST: None

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