Original Article

Diagnostic Accuracy of Twinkling Artefect in Diagnosis of Ureteric Calculus Keeping Non-Contrast CT as A Gold Standard

Naveed Hussain, Usman Shakil, Sana Sharif, Mohammad Uzair, Nosheen Sadiq, Muhammad Saeed

ABSTRACT

Objective: To determine the diagnostic accuracy of the twinkling artifact on Doppler ultrasound using non-contrast CT as the gold standard for detecting ureteric stones.

Study Design & Setting: This cross-sectional diagnostic accuracy study was conducted at the Department of Radiology, a tertiary care hospital, from 2 October 2021 to 1April 2022.

Methodology: A total of 141 patients with clinically suspected ureteric colic were enrolled. All underwent Doppler ultrasound followed by Non contrast enhanced CT. Findings of twinkling artifact were recorded and compared with Non contrast enhanced CT outcomes. Diagnostic parameters including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were calculated. Subgroup analysis was performed based on age, gender, and stone size.

Results: The mean age was 38.59 ± 9.97 years; 55.3% were male. The twinkling artifact was observed in 94 (66.7%) patients. Non contrast enhanced CT confirmed ureteric stones in 81 (57.4%) cases. Sensitivity, specificity, PPV, NPV, and overall accuracy of the twinkling artifact were 90.1%, 93.3%, 94.8%, 87.5%, and 91.5%, respectively. Stratified analysis showed diagnostic accuracy above 89% across all subgroups.

Conclusion: The twinkling artifact on Doppler ultrasound demonstrated excellent diagnostic accuracy and can be considered a reliable, radiation-free alternative to Non contrast enhanced CT for detecting ureteric stones.

Keywords: Accuracy, Doppler ultrasound, Non contrast enhanced CT, Sensitivity, Specificity, Twinkling artifact, Ureteric stones

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INTRODUCTION

Ureteric calculi are a most common cause of colicky abdominal and acute flank pain. Various factors are contributing in recurrent formation of ureteric calculi with various composition. Contributing factors may include environmental conditions such as hot climate and humid weather as well as metabolic causes. Urinary tract calculi remain a significant contributor to morbidity worldwide. Symptoms of ureteric colic or acute flank pain may vary, ranging from asymptomatic mild dull ache to severe colicky abdominal pain that may require hospitalization with adverse outcome like altered renal function and infection secondary to obstructive cause.[1] Urolithiasis, or renal tract stones i.e. in kidney, ureter and urinary bladder, affect between 2% to 3% of the Western population. The majority of stones seen in the urinary system are composed of calcium, with 35% being calcium oxalate, 10% being calcium phosphate, and 35% being a combination of the two. Recurrent formation of urinary tract stone causes adverse effect on quality of life due to severe colic episodes disturbing daily routine activities.[2] Urolithiasis from recent decades is becoming more common; its average prevalence has increased from 3.25 percent in the 1980s to 5.64 percent in the 1990s. Due to progressively increasing incidence of urolithiasis globally, it estimates cost impact in billions in America and European countries.[3] There is alarmingly rise in incidence of indoor and outdoor patients presented with renal and ureteric symptoms. Many a time patients decline consultation due to unawareness and financial impact and presented with adverse complication of urosepsis and renal failure. Twelve percent of Pakistanis suffer from urolithiasis, and thirty-one point four percent of those people reported experiencing acute flank pain.[4]

Radiology comprises multimodality specialty including X-ray or plain radiograph, Ultrasonography, CT scan and MRI. Prompt and accurate diagnosis of urinary tract calculi is essential for effective clinical management. The choice of diagnostic imaging plays a pivotal role in identifying the presence, number, location, and size of calculi, and density or composition of stone which subsequently guides therapeutic decisions.[5] ultrasonography is initial investigation of choice for acute abdominal colic, despite of multiple modalities in radiology, abdominal radiograph is preferred in some setups, for ureteric calculi. Ultrasound being safe, easily accessible, cost effective and showing no harmful teratogenic effects on pregnant women and fetus is preferred over CT scan. Currently, noncontrast computed tomography (NCCT) is widely recognized as the gold standard for detecting ureteric stones due to its high sensitivity (94–100%) and specificity (92–100%). Non contrast CT scan provides rapid, non-invasive and detailed anatomical visualization, identifying even not only radio dense but also radiolucent stones and other differential diagnoses of acute abdominal pain especially to rule out acute appendicitis .[6] However, CT imaging comes with certain limitations, notably radiation exposure, high cost, limited accessibility in some settings, and potential nephrotoxicity if contrast is used and competency of operator and CT technician, though not applicable on Non contrast CT scan.[7]

In recent years, twinkling artifact, a phenomenon observed on color Doppler ultrasound, has been studied for its potential to enhance the diagnostic accuracy of sonography in detecting urinary tract calculi.[8] The twinkling artifact appears as a rapidly alternating mixture of red and blue signals posterior to a strongly reflective surface such as a calculus, mimicking turbulent flow. This artifact results from intrinsic machine noise interacting with rough surfaces like stones and is more prominent than acoustic shadowing in many cases.[9] It has been suggested that this doppler finding may allow detection of stones that are otherwise not visible on grayscale imaging. According to Rahmouni's 1996 description of twinkling artefact on colour Doppler ultrasonography, this phenomenon is caused by a highly reflective material.[10]

Ureteric calculi are frequently encountered in emergency settings, yet diagnosis using ultrasound remains limited due to low sensitivity. Incorporating the twinkling artifact on Doppler ultrasound may significantly enhance detection rates of ureteric stones without exposing patients to radiation. While international studies have shown promising results, local data in Pakistan remains scarce, and twinkling artifact is underutilized in routine practice. This study will fill a research gap by validating its diagnostic accuracy against Non contrast CT scan in a Pakistani population. The findings may promote safer, costeffective, and accessible imaging protocols in low-resource settings. Moreover, it may help reduce unnecessary CT usage, especially in vulnerable groups.

METHODOLOGY:

This descriptive cross-sectional study was conducted at the Tertiary care hospital, Department of Radiology, PNS Shifa, Karachi over a period of six month from 2- Oct-2021, to 1-Apr-2022.

The sample size was calculated using a calculator, based on formula reference proposed by Buderer [11], taking into account the reported sensitivity and specificity of the twinkling artifact on Doppler ultrasound in diagnosing ureteric calculus as 91.2% and 95.7%, respectively.[12] The prevalence of acute flank pain was taken as 31.46%, with a margin of error of 7% for sensitivity and 4% for specificity, at a 95% confidence level, resulting in an estimated sample size of n = 141.[13] A non-probability, consecutive sampling technique was used for the selection of study participants.

Inclusion criteria: Patients aged between 18 to 60 years, of either gender, presenting with acute ureteric symptoms or acute flank pain of less than 72 hours duration and who underwent both color Doppler ultrasound (for twinkling artifact) and non-contrast CT within 24 hours were included.

Exclusion criteria: Patients were excluded if they had a history of ureteric stone surgery or those who has known or already diagnosed for ureteric stone, patients who has solitary kidney, acute or chronic renal failure, renal failure (serum creatinine >1.5 mg/dL), symptoms of urinary tract infection (?10 WBCs/HPF or nitrite positive), or were pregnant (confirmed by â-hCG).

Consent and IRC: The research was approved by ethical review committee of PNS Shifa hospital

(ERC/2023/RAD/05). All patients who fulfilled the inclusion criteria and visited the outpatient or inpatient departments of PNS Shifa, Karachi, and were referred to the Radiology Department for KUB ultrasound, were considered for inclusion.

Informed consent: was obtained after explaining the purpose and nature of the study in simple and understandable language.

Data collection was initiated after the approval of the synopsis by the Research Department of the College of Physicians and Surgeons, Pakistan. Patients were assured of confidentiality and their right to withdraw at any time without providing a reason. Each patient subsequently underwent

Doppler ultrasound performed by a trained, competent consultant radiologist. The findings of KUB ultrasound were then confirmed with non-contrast CT (NCCT), as defined in the operational definitions, in order to assess the diagnostic accuracy of the twinkling artifact observed on Doppler ultrasound. All collected data were recorded on a pre-designed proforma.

Data were entered and analyzed using SPSS version 26.0. Mean and standard deviation were calculated for quantitative variables such as age and stone number and size. If the data were not normally distributed, median was used. Frequencies and percentages were calculated for qualitative variables such as gender, and findings on Doppler ultrasound and non-contrast CT. A 2×2 contingency table was used to calculate the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of the twinkling artifact. Effect modifiers such as age, gender, and stone size were controlled through stratification. Post-stratification, diagnostic accuracy was recalculated using a 2×2 table.

RESULTS

As shown in Table 1, the mean age of the study population was 38.59 ± 9.97 years. Patients who were aged = 40 years were 76 (53.9%), while those patients aged > 40 years were 65 (46.1%). The majority of participants were male with a frequency of 78 (55.3%), whereas 63 (44.7%) were female. Various sizes of stone were recorded in study. The mean stone size was 6.54 ± 3.37 mm. Stones measuring = 6 mm were observed in 80 (56.7%) cases, while stones > 6 mm were present in 61 (43.3%) patients included in study.

As shown in Table 2, the twinkling artifact on Doppler ultrasound was present in 94 (66.7%) of patients, while it was absent in 47 (33.3%) cases. In comparison, ureteric stones on non-contrast CT were identified in 81 (57.4%) patients, and were absent in 60 (42.6%) cases included in study.

As shown in Table 3, among the 141 patients part of our study, twinkling artifact on color Doppler ultrasound was present in 73 (51.8%) true positive (TP) cases where ureteric stones were confirmed on Non contrast CT scan, and 4 (2.8%) were false positive (FP) with no stone on Non contrast CT scan. Conversely, 8 (5.7%) were false negative (FN) where the twinkling artifact on color Doppler ultrasound was absent but stone was present on Non Contrast Computed Tomography (NCCT), while 56 (39.7%) were true negative (TN) with no stone detected on both Doppler ultrasound and non-contrast CT scan (NCCT).

As shown in Table 4, the twinkling artifact on Doppler ultrasound in patient with ureteric colic included in study demonstrated a sensitivity of 90.1% (95% CI: 83.6%–96.6%) and a specificity of 93.3% (95% CI: 87.0%–99.7%) in detecting ureteric and renal stones. The positive predictive value (PPV) was 94.8% (95% CI: 89.8%–99.8%), while the negative predictive value (NPV) was 87.5% (95% CI: 79.4%–95.6%). The overall diagnostic accuracy of twinkling artefect on color Doppler ultrasound was 91.5% (95% CI: 86.9%–96.1%), and the prevalence of ureteric stones based on Non contrast CT scan findings was 57.5% (95% CI: 49.3%–65.6%).

The diagnostic accuracy of the twinkling artifact on Doppler ultrasound was also assessed in across different stratified groups using Non contrast CT scan as the gold standard. In individuals aged = 40 years (n = 76), sensitivity was 88.1%, specificity was 91.2%, and overall accuracy was 89.5%, whereas in those aged > 40 years (n = 65), sensitivity increased to 92.3%, specificity to 96.2%, and accuracy to 93.8%. Among males (n = 78), sensitivity was 90.9%, specificity 94.1%, and accuracy 92.3%, while in females (n = 63), sensitivity was 89.2%, specificity 92.3%, and accuracy 90.4%. For patients with stones = 6 mm (n = 80), the sensitivity was 88.1%, specificity 92.1%, and accuracy 90.0%, whereas those with stones > 6 mm (n = 61) demonstrated higher sensitivity (92.3%), specificity (95.5%), and accuracy (93.4%). These results indicate consistently high diagnostic performance across all subgroups, with relatively better outcomes in older patients and those having larger stones.

DISCUSSION

Ureteric stones are a common cause of acute abdominal colic and flank pain and urinary obstruction mostly due to calculus, requiring prompt and accurate diagnosis to avoid its lethal complications like pyonephrosis, acute and chronic renal failure and chronic renal scarring secondary to obstructive cause and urinary retention. For the detection of ureteric calculi various diagnostic means of radiology are

Table 1: Baseline Characteristics of Study Population (n = 141)

Variable	Category	Mean ± SD / n (%)
Age	Mean±SD	38.59 ± 9.97
	= 40 years	76 (53.9%)
	> 40 years	65 (46.1%)
Gender	Male	78 (55.3%)
	Female	63 (44.7%)
Stone Size (mm)	Mean±SD	6.54 ± 3.37
	Stone = 6 mm	80 (56.7%)
	Stone > 6 mm	61 (43.3%)

Table 2: Frequency of Findings on Imaging Modalities (n=141)

Imaging Finding	Present n (%)	Absent n (%)
Twinkling Artifact on Doppler Ultrasound	94 (66.7%)	47 (33.3%)
Ureteric Stone on Non-Contrast CT	81 (57.4%)	60 (42.6%)

Table 3: Diagnostic Accuracy of Doppler Ultrasound Using Non-Contrast CT as Gold Standard (n = 141)

Doppler Ultrasound Findings	NCCT Present	NCCT Absent	Total
Twinkling Artifact Present	73 (51.8%)TP	4 (2.8%)FP	77 (54.6%)
Twinkling Artifact Absent	8 (5.7%)FN	56 (39.7%)TN	64 (45.4%)
Total	81 (57.4%)	60 (42.6%)	141 (100.0%)

Table 4: Diagnostic Performance of Twinkling Artifact on Doppler Ultrasound (n = 141)

Diagnostic Parameter	Percentage (%)	95% Confidence Interval
Sensitivity	90.1%	83.6% – 96.6%
Specificity	93.3%	87.0% – 99.7%
Positive Predictive Value (PPV)	94.8%	89.8% – 99.8%
Negative Predictive Value (NPV)	87.5%	79.4% – 95.6%
Overall Accuracy	91.5%	86.9% – 96.1%
Prevalence	57.5%	49.3% – 65.6%

utilized varies from setup to setup. Most commonly and easily accessible means of early detection of urinary tract stone in emergency setup and assessment of complications with grey scale and Doppler ultrasound scan is widely used due to cost effective easily accessible in majority of setups. Noncontrast computed tomography (NCCT) is considered the gold standard for detecting ureteric stones due to its high sensitivity and specificity for detection of number, sizes, location and density of stone and complication of obstructive stone on urinary tract system. However, its limitations include radiation exposure, and higher costs. Doppler ultrasound, particularly the detection of the twinkling artifact, offers a non-invasive, cost effective and radiation-free alternative. The twinkling artifact appears as a rapidly alternating color signal behind a reflective object, such as a calculus.[14] Assessing the diagnostic accuracy of this artifact compared to Non contrast CT scan is essential for establishing its clinical utility in routine emergency evaluations.

The current study aimed to assess the diagnostic performance of the twinkling artifact (TA) on Doppler ultrasound in detecting ureteric calculi, using non-contrast CT (NCCT) as the gold standard. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy of the Twinkling Artifects, in our study were found to be 90.1%, 93.3%, 94.8%, 87.5%, and 91.5%, respectively. These values indicate a high diagnostic reliability of Doppler ultrasound in identifying ureteric stones. Our findings were consistent with those of Abid et al. (2021), who reported slightly higher sensitivity (91.2%), specificity (95.7%), Positives Predictive Value (98.7%), Negative Predictive Value (75.2%), and accuracy (92.2%), suggesting strong agreement in terms of overall performance of Twinkling Artifects.[13]

Comparing further, Tariq et al. (2024) observed a remarkably high sensitivity of 99.3% and specificity of 92.0% for Twinkling Artifects, with an overall accuracy of 92.97%, reinforcing the role of color Doppler as a first-line imaging modality. Their study also noted that the diagnostic yield of Twinkling Artifects, was slightly greater than grey-scale ultrasound (GSU) and comparable to CT KUB.[14] On the contrary, Khan (2024) documented a sensitivity of 90.4% similar to ours but reported lower specificity (73.9%), positive predictive value PPV (88.7%), positive predictive value NPV (77.2%), and diagnostic accuracy (85.3%). This discrepancy could be attributed to sample differences or operator variability.[15] Similarly, Memon et al. (2021) found a high sensitivity (92%) but very low specificity (44%) and NPV (50%) for Twinkling Artifects, resulting in a much lower diagnostic accuracy of 70%, which is significantly inferior to our findings.[19]

Some studies, however, have also reported lower sensitivities and overall diagnostic performance. For instance, Adel et al. (2024) found the sensitivity of Twinkling Artifects, to be 54.3%, specificity 94.7%, PPV 93.2%, and NPV 60.5%, with an overall diagnostic accuracy of 71.5%. These results indicate that although Twinkling Artifects, can strongly confirm the stone presence (high PPV and specificity), it may fail to detect all true positive cases (low sensitivity).[16] Similarly, Shuja et al. (2025) reported a sensitivity of 71.5%, specificity of 96.4%, positive predictive value (PPV) of 98.2%, and a comparatively low negative predictive value of 55.2%. The high positive predictive value and specificity in these studies suggest Twinkling Artifects, is reliable for confirming a diagnosis when positive, but a negative Twinkling Artifects, may not confidently rule out stones unlike our study, which reported a higher NPV (87.5%).[20]

Other studies such as Hanafi et al. (2019) and Lalchan et al. (2022) also corroborated the high specificity and positive predictive value of Twinkling Artifects.[17] Hanafi et al. showed a sensitivity and accuracy of 94%, and a positive predictive value (PPV) of 100%, slightly better than our values, while Lalchan et al. reported sensitivity of 85.8%, specificity 80%, positive predictive value (PPV) 97.1%, negative predictive value (NPV) 42.1%, and accuracy 85.2%, all generally lower than our results.[17,21] Arshad et al. (2021) found the diagnostic accuracy of Twinkling Artifects, to be only 68%, with a sensitivity of 75.6%, specificity 46.1%, positive predictive value (PPV) 80%, and negative predictive value (NPV) 40%, highlighting significantly inferior outcomes. These variations across studies might be due to differences in stone location, size, ultrasound settings, operator skills, and study populations.[18] Rasul et al. in his study reported the sensitivity of twinkling artifact 84%, with sensitivity 95% and specificity 56%, PPV 92%, and NPV 68%, with diagnostic accuracy of 89%.[22] Rashid et al study showing sensitivity 90.4%, specificity 73.9%, negative predictive value 77.2%, positive predictive value 88.7%, and diagnostic accuracy 85.3% of Doppler ultrasound for twinkling artifact.[23]

This study utilized a well-defined gold standard Non contrast CT scan (NCCT) for evaluating diagnostic performance. The sample size was adequate to detect statistically meaningful differences across subgroups. Stratified analysis by age, gender, and stone size provided detailed insight into diagnostic accuracy. However, being a single-center study may limit generalizability. Operator dependency and variability in ultrasound quality may affect reproducibility. Additionally, inter-observer variability was not assessed, which could influence diagnostic consistency.

Only single radiologist performed ultrasound and reported non enhanced CT scan of patient included in study independently, hence interobserver reliability could not be established.

CONCLUSION:

Doppler ultrasound with the twinkling artifact showed high sensitivity and specificity for detecting ureteric stones in patients presented with abdominal pain or acute renal colic. It may serve as a reliable, safe, cost effective, rapidly available and non-invasive alternative to Non contrast CT scan (NCCT) in appropriate clinical settings for management of abdominal and urinary tract symptoms. Incorporating the use of color Doppler ultrasound for abdominal pain or renal pain into routine practice could reduce harmful effects of radiation exposure and healthcare costs.

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Authors Contribution:
Naveed Hussain: Substantial contributions to conception and design alongwith acquisition of data
Usman Shakil: Acquisition analysis and interpretation of data
Sana Sharif: Literature review
Mohammad Uzair: Revising it critically for important intellectual content
Nosheen Sadiq: Literature review
Muhammad Saeed: Discussion

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