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Diagnostic Accuracy of Doppler Twinkling Artifact for Identifying Urinary Tract Calculi

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Abstract

The twinkling artifact was first described by Rahmouni et al in 1996 as a focus of changing colors on Doppler studies behind reflective surfaces like calcifications giving turbulent flow. The objective of this study was to ascertain the accuracy of Doppler twinkling artifact in the diagnosis of urinary tract calculi keeping plain Computed Tomography of kidney, ureter, and urinary bladder (CT KUB) as a gold standard, and whether it can replace CT KUB or not. The study design was cross- sectional retrospective study carried out in Radiology Departments, Institute of Kidney Diseases and Hayatabad Medical Complex, Peshawar from April 2019 to April 2020. Both male and female patients below and above 40 years of age were included in the study. Sonography was performed on Aplio 300 Color Doppler ultrasound machine. Patient was then referred to Radiology Department, Hayatabad Medical Complex for CT KUB. Data was entered in SPSS version 20. Study included 90 cases presenting with flank pain and dysuria. There were 32(35.6%) females and 58(64.4%) males and males to female ratio was 2.21: 1. The sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy of Doppler twinkling artifact was estimated to be 58.14%, 95.74%, 92.59%, 71.43% and 77.78% respectively. Our study concluded that Doppler twinkling artifact is a reliable sign for diagnosis of urinary tract calculi, but still its sensitivity is inferior and suboptimal to Plain CT KUB.

Keywords: *Diagnostic Accuracy, Doppler Twinkling Artifact, Urolithiasis, Computed Tomography of Kidney, Ureter and Bladder (CT KUB).*

Introduction

The incidence and prevalence of urolithiasis has acquired rising trends throughout the world. About 12% of world population is suffered from renal stones at some stage in their life. The prevalence of renal stones is

12% in our population (Knoll, 2010). Symptoms are characterized by sudden onset of lumbar pain associated with nausea, vomiting and hematuria (gross/ microscopic) (Li, Kennedy, Levine, Kumar, & Mullen, 2001). Plain CT KUB is the modality of choice for urolithiasis specially for ureteric calculi due to its high specificity and sensitivity (Shokeir & Abdulmaaboud, 2001) but at the same time its high radiation dose and cost should be kept in mind (Grisi et al., 2000). Ultrasonography is an easy, cost effective and radiation free tool to assess urogenital anatomy and pathology, though its sensitivity is inferior to non-contrast computed tomography. On ultrasound urolithiasis appears as bright focus with posterior shadowing, but in tiny calculi this shadowing may not be present resulting in inaccurate diagnosis (Mitterberger et al., 2009).

The twinkling artifact was first described by Rahmouni et al in 1996 as a focus of changing colors on Doppler studies behind reflective surfaces like calcifications giving turbulent flow. This artifact persists even at high pulse repetition frequency and lacks generation of any wave pattern on pulse wave mode (Nagafuchi et al., 2013; Ozan, Atac, & Gundogdu, 2016). However, now there is a trend to move towards recent technique of non-contrast computed tomography which is more accurate and reliable for renal and ureteric calculi having sensitivity of 96.6% and specificity of 94.9% but at the cost of ionizing radiation exposure.

Literature is available regarding twinkling artifact in renal calculi, but no such study has been conducted in our setup on this topic. This is the only kidney institute in province where the diagnosis of renal calculi is assumed mostly on ultrasonography.

The rationale behind this study was to ascertain the accuracy of Doppler twinkling artifact in the diagnosis of urinary tract calculi keeping Plain CT KUB as a gold standard, and to assess whether Doppler study can replace CT KUB or not.

Materials and Methods

Approval of the study was taken from ethical committee of the Institute of Kidney Diseases. The study design was cross- sectional retrospective carried out in Radiology Departments, Institute of Kidney Diseases and Hayatabad Medical Complex, Peshawar from April 2019 to April 2020. Both male and female patients of below and above 40 years of age, presenting with flank pain and dysuria were included in the study. Already diagnosed cases of urolithiasis and renal failure were excluded. Informed consent was taken from the patients, and all patients underwent sonography by the same qualified radiologist. Sonography was performed on Aplio 300 Color Doppler ultrasound machine with convex probe of low frequency using both grey scale and color Doppler study. Presence or absence of twinkling artifact was documented. Patient was then referred to Radiology Department, Hayatabad Medical Complex for plain CT KUB by 128 slice CT of GE company. All CT KUB were reported by same qualified radiologist for urolithiasis, who was blind to ultrasound study. Absence or presence of twinkling artifact on ultrasound and absence or presence of urinary tract calculi on CT were recorded on proforma. Data was entered in SPSS version 20 for statistical analysis. Sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of twinkling artifact were calculated keeping CT KUB as gold standard as follows Plain CT KUB (Gold Standard).

Table No1

	Plain CT KUB (Gold Standard)		
Doppler Twinkling Artifact		Positive	Negative
	Positive	A	B
	Negative	C	D

True Positive =a, False Positive =b, False Negative=c, true negative =d

Sensitivity of Doppler twinkling artifact : (a/a+c) X 100

Specificity of Doppler twinkling artifact: (d/b+d) X 100

PPV for Doppler twinkling artifact : (a/a+b) X 100

NPV for Doppler twinkling artifact : (d/c+d) X 100

Accuracy of Doppler twinkling artifact: (d+a) / overall patients

Results

Our study included 90 cases presenting with flank pain and dysuria. Majority of our study sample comprised of male patients having male to female ratio of 2.21:1. The details of demographic variables are summarized in Table 2.

In this study no renal calculi were observed on ultrasound in 63 cases (70%) with negative Doppler twinkling artifact, while in 27 cases (30%) renal calculi were revealed with positive Doppler twinkling artifact. Plain CT KUB showed renal calculi in 43 (47.8%) cases, while 47(52.2%) cases were negative for renal calculi. In this study 25 cases (27.8%) were true positive, 45 cases (50%) were true negative, 18 cases (20%) were false positive, while 2 cases (2.2%) were false negative as shown in Table 2.

The sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of Doppler twinkling artifact with CT KUB as gold standard is given in Table3.

Table 2: Demographic Variables(N=90)

		Count	%
Gender	Male	58	64.4%
	Female	32	35.6%
Age(in years)	Up to 40	41	45.6%
	Above 40	49	54.4%

Table 3: Doppler Twinkling Artifact and Plain CTKUB Results(N=90)

		Plain CT KUB		Total
		Positive	Negative	
Doppler TwinklingArtifact	Positive	25	2	27
	Negative	18	45	63
Total		43	47	90

Table 3: Sensitivity, Specificity, Positive Predictive Value, Negative Predictive Value and Diagnostic Accuracy of Doppler twinkling artifact with CT KUB as gold standard.

Table No 4

Sensitivity	25 / (25+18)	58.14%
Specificity	45 / (2+45)	95.74%
Positive Predictive Value	25 / (25+2))	92.59%
Negative Predictive Value	45 / (45+18)	71.43%
Diagnostic Accuracy	(25+45) / 90	77.78%

Discussion

Mankind has been affected by urolithiasis for centuries, accounting it to be the most frequent disease of urinary tract. Once treated, the other issue of human health regarding urinary tract calculi is its prevention which is based on better understanding of its mechanism of formation (Khan et al., 2016; Mikawlrawng, Kumar, & Vandana, 2014). It is also one of the common presentation of patients to emergency department with hematuria and groin pain affecting one in 11 people in their life, occurring twice in men as compared to women. Pathogenesis behind it is either low urine volume or increased amount of excretion of stone forming components in urine. Low levels of urinary citrate or high pH may be the culprit of the disease (Reesink et al., 2018).

Imaging plays a captious role in the diagnosis, management and follow-up of urinary tract calculi. Plain CT KUB is regarded as a gold standard for it, preferred over radiography and intravenous urography; which was first introduced in 1990s. Non-contrast CT is superior than rest of the modalities due to its easy availability, high sensitivity (> 95%) and specificity(>96%), rapid acquisition and absence of intravenous contrast (Dhar & Denstedt, 2009; Pfister et al., 2003). Ultrasound is a useful, easily available modality for urolithiasis specially in the setting of pediatric, pregnant and repeated surveillance patients due to its non-ionizing nature (Reddy, 2008). Ultrasound can detect tiny calculi as a foci of echogenicity with posterior acoustic shadowing on gray scale. Color Doppler study can further aid the accuracy with twinkling artifact which is produced due to intrinsic noise of machine (Rubens, Bhatt, Nedelka, & Cullinan, 2006). [15]

In our study we included 90 patients comprising of 58 males and 32 females. We are intended to asses the diagnostic accuracy of doppler twinkling artifact in urinary tract calculi. The sensitivity, specificity , positive predictive value, negative predictive value and diagnostic accuracy turned out to be 58.14%, 95.74%, 92.59%, 71.43% and 77.78% respectively. In a study by Dillman et al the sensitivity of twinkling artifact was estimated as 55% when compared to Plain CT KUB as a gold standard which is similar to our result of 58%, revealing that results of Doppler twinkling artifact are not as much reliable when compared with CT KUB (Dillman et al., 2011). On the other hand, it is lower as compared to reported by Masch WR et al, with high specificity (Masch et al., 2016). This difference can be explained on the basis of the fact that ultrasound is quite an operator-dependent technique and results vary with doppler settings.

In current study the false positive rate of twinkling artifact was high and shows similar results as reported by (Kielar, Shabana, Vakili, & Rubin, 2012). These false positive cases may be assumed due to its similar perception with arterial calcifications, echogenic renal sinus fat or due to variation in chemical composition of calculi. The positive predictive value of our study was also comparable to Kielar AZ et al, which was mentioned lower in previous studies(Dillman et al., 2011) due to the reason that twinkling artifact is dependent on competency of sonologist as well as on the technique adopted by the sonologist. Our study revealed low diagnostic accuracy i.e. 77.78% which is similar to (Adel, Sattar, Rahim, Aftab, & Adil, 2019) labelling Doppler twinkling artifact as suboptimal modality in comparison to CT KUB.

There were few weaknesses of our study i.e. small sample size, use of a single color Doppler Aplio 300 ultrasound machine and lack of inter and intra observer variation in opinions. Our study is implicated on radiologists and urologists who can benefit from the fact that addition of Doppler twinkling artifact to gray scale study improves the diagnostic accuracy of ultrasound in urinary tract calculi.

Further research is advised on the suggestion to evaluate the technique or variables by which we can increase the sensitivity of Doppler twinkling artifact comparable to CT KUB and thus can replace the ionizing effects of CT with radiation free Doppler sonography.

Conclusions

Our study concluded and acknowledged that twinkling artifact is a reliable sign for diagnosis of urinary tract calculi which increases the sensitivity of gray scale findings with Doppler study. The parameters like sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy of twinkling artifact was established as 58.14%, 95.74 %, 92.59%, 71.43% and 77.78% respectively. But still its sensitivity is inferior and suboptimal to Plain CT KUB.

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