

DOPPLER PARAMETERS IN ELICITATION OF TWINKLING ARTEFACTS IN SUSPECTED CASES OF RENAL CALCULI

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ABSTRACT

AIM

To find out the optimal colour Doppler parameters for eliciting twinkling artefact in cases of renal calculi.

METHODS AND MATERIALS

A total of 50 patients were included in this prospective study. Each patient was evaluated using grey-scale ultrasonography and colour Doppler using 2 MHz and 2.7 MHz.

RESULTS

Use of colour Doppler twinkling artefact with different frequencies has increased the detection rate of renal calculi. The positive predictive value was 100% for both Doppler frequencies of 2 MHz and 2.7 MHz. Sensitivity for lower frequencies of 2 MHz (49 calculi) and 2.7 MHz (34 calculi) was 98% and 68% respectively. By using lower frequency (2 MHz), the twinkling artefact intensity and sensitivity was found to be higher when compared to higher frequency (2.7 MHz).

CONCLUSION

In our study, the colour Doppler twinkling artefact evaluation of renal calculi with low and high frequencies of 2 and 2.7 MHz gave us better sensitivity and positive predictive value in detecting smaller calculi (3 mm). At 2 MHz, the twinkling artefact grading found to be high with long tail compared to medium and low tail with 2.7 MHz frequencies.

KEYWORDS

Colour Frequency, Twinkling Artefact and Renal Calculi, MHz.

HOW TO CITE THIS ARTICLE: Shivaprasad VR, Govardhanan, Vuyyuru VR, et al. Doppler parameters in elicitation of twinkling artefacts in suspected cases of renal calculi. J. Evid. Based Med. Healthc. 2016; 3(57), 2958-2961.

DOI: 10.18410/jebmh/2016/644

INTRODUCTION: Ultrasonography is an excellent imaging modality for detecting urinary tract stones because it is readily available, inexpensive and does not emit radiation.¹ However, ultrasound detection of urinary stones obscured by renal sinus fat, mesenteric fat and bowel gas is sometimes problematic.² Colour Doppler ultrasound facilitates the detection of urinary stones. Specifically, the presence of a "twinkling artefact" is suggestive of the presence of urinary stones.³ The twinkling artefact, also called the "colour comet tail artefact", is a colour Doppler phenomenon that appears as a rapid change of colour immediately behind a stationary object. This sign is diagnostically useful especially in urolithiasis.⁴

First described by Rahmouni et al. in 1996⁵, the colour Doppler artefact presents as a rapidly changing mixture of red and blue behind a reflecting object.

Two theories had been proposed to explain the twinkling Doppler artefact. The first was offered by Rahmouni et al⁵ who suggested that this artefact is generated by a strongly reflecting medium with a rough interface. They explained that when an incidental ultrasound beam is reflected by a flat interface, the acoustic waves are reflected by the interface at the same time, and so it results in production of short-wave sound signals. When the incidental beam is reflected on a rough interface, the acoustic wave is split into a complex beam pattern caused by multiple reflections in the medium, resulting in prolonged pulse duration of the transmitted sound signal and this result the Doppler units interpret this as movement and thus is assigned different colours. The second theory was offered by Kamaya et al⁶ who proposed that a twinkling artefact is caused by a narrow band of intrinsic sonographic machine noise, referred to as phase (or clock) jitter," which may be generated by slight random time fluctuations in the path lengths of transmitted and reflected acoustic waves. Also it

Financial or Other, Competing Interest: None.

Submission 28-06-2016, Peer Review 06-07-2016,

Acceptance 11-07-2016, Published 16-07-2016.

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DOI: 10.18410/jebmh/2016/644

was proposed its occurrence at a reflector with a rough interface, these slight time fluctuations are amplified to produce aliasing.

Detection of urinary stones on ultrasound (US) may be problematic when the stones are obscured by ultrasonic beam-attenuating tissue, such as renal sinus fat, mesenteric fat, and bowel, or when their posterior acoustic shadowing is weak.⁷

High sensitivity and specificity makes nonenhanced CT the imaging modality of choice for the evaluation of acute renal colic from kidney stones.⁸ Recently, there have been concerns about associated radiation doses and consequent cancer risks.⁹ Thus, an imaging modality that does not deliver ionising radiation would be particularly beneficial for patients with nephrolithiasis. B-mode diagnostic ultrasonography is an alternative to CT without ionising radiation; however, its adoption has been hindered by lower sensitivity (19%–93%) and specificity (84%–100%) for the detection of urinary calculi.¹⁰

Several studies have demonstrated the dependence of the twinkling artefact on ultrasound machine settings and stone composition.¹¹ The twinkling artefact has been observed in 83% to 96% of stones seen on B-mode ultrasonography.¹²

It is possible that this finding can be used to increase the sensitivity and specificity of ultrasound in the diagnosis of nephrolithiasis.

Twinkling artefact in the setting of nephrolithiasis is associated with an increased contrast-to-noise ratio when compared with posterior acoustic shadowing,¹³ another finding that has been attributed to renal calculi on grey-scale sonographic images.¹⁴ Twinkling artefact appears to be unaffected by poor focusing of the ultrasound beam and is likely frequency independent.

Twinkling artefact is likely to be at least partly dependent on a number of US parameters, including colour-write priority, grey-scale gain, and pulse repetition frequency.⁶ To date, only a few studies have been performed to assess the clinical importance of the renal colour Doppler twinkling artefact in humans.¹⁵ In these prior investigations, researchers used abdominal radiography, excretory urography or grey-scale sonography as the reference standard.

METHODS AND MATERIALS: Our prospective study included 50 patients with known calculous disease who were referred to the department of Radiodiagnosis for ultrasound evaluation during the period Oct 2015-Mar 2016. Those patients who were not comfortable or in pain due to calculi or any other ailment were not included as they can't tolerate additional examine time required for preparing the study.

All patients underwent Doppler ultrasound with Siemens Acuson X300 which was equipped with 2-5 MHz convex transducer. Colour frequencies available in the machine were 2,2.5 and 2.7 MHz. In our study 2 and 2.7 MHz were used for eliciting the twinkling artefact. PRF was adjusted to a value such that the maximum velocity covered was in the range of 50 to 60 cm/sec approximately, on either direction.

Hence eliminating colour aliasing in arteries of kidney and also to provide clean colour window to analyse the calculi. Colour gain was kept just below the threshold level over which leaks/artefacts/ noise start appearing. All cases had colour gain, ranging between -1 to +1 dB. Grey-scale gain was kept at a slightly lower level.

RESULTS: The demographic characteristics are shown in the table 1, 42 patients were male and 8 patients were female. Twinkling artefact for different frequencies were shown in table 2, Low frequency colour box (2 MHz) 49 calculi and high frequency colour box (2.7 MHz) 34 calculi. The grading of twinkling artefact is shown in table 3.

	No. of patients
Age (years)	
≤30	28
31-50	12
>50	10
Sex	
Males	42
Females	08

Table 1: Demographics Characteristics

	Twinkling Present	Twinkling Absent
Low frequency colour box (2 MHz)	49	1
High frequency colour box (2.7 MHz)	34	16

Table 2: Twinkling Artefact

	High with Tail	Medium with short tail	Low
Low frequency colour box (2 MHz)	10	23	16
High frequency colour box (2.7 MHz)	2	16	18

Table 3: Twinkling Grading



Fig. 1: Renal Calculi with Twinkling Artefact a. Long Tail with 2 MHz. b. Medium Tail with 2.7 MHz



Fig. 2: Right VUJ Calculi with Twinkling Artefact a. Long tail with 2 MHz. b. Low tail with 2.7 MHz



Fig. 3: Renal Calculi with Twinkling Artefact
a. Medium tail with 2 MHz. b. Low tail with 2.7 MHz

DISCUSSION: The diagnosis of urinary stones using grey-scale ultrasonography depends on echogenicity of the stone and its ability to produce a posterior acoustic shadow.^{16,17} However, in many cases it is difficult to determine whether a urinary stone is present because of its indistinct echogenicity and indiscrete posterior acoustic shadowing. Indistinct echogenicity of stones results from surrounding echogenic tissue, such as prominent renal sinus fat, mesenteric fat, and bowel.

When a renal stone is poorly distinguished from echogenic renal sinus fat and has an indiscrete posterior acoustic shadowing, it may be difficult to determine its presence on US. In one prior study, three radiologists interpreted 31 ultrasonograms with a sensitivity of 81% and a specificity of 86% for detecting renal stones.¹⁸

Non-contrast spiral CT is the gold standard for detecting urinary stones.¹⁹ Compared with non-contrast spiral CT, the detection sensitivity of grey-scale ultrasonography is relatively low.²⁰

Plain X-ray of the urinary tract remains an effective and widely used method for identifying stones in the urinary tract because of its accessibility and low cost. However, the image is affected by body size, gas in the intestines, and requires preparation of the patient prior to the exam. Non-contrast spiral CT is highly accurate for the diagnosis of both radiopaque and radiolucent stones, but its use is limited by its cost and the relatively high radiation dose to patients, particularly pregnant women.²¹

In a study by Turrin et al,¹⁵ the twinkle sign on colour Doppler was more frequently seen in patients with stone disease than those without stone disease (95.5% vs. 9.0%, $P < 0.001$).

Shabana et al¹³ stated that the twinkling artefact is a useful method for detecting renal calculi.

Lee²² demonstrated that 83% of urinary stones showed the twinkling sign on colour Doppler examination. Tchelepi and Ralls²³ stated that visualisation of the colour comet tail artefact could improve diagnostic confidence in a wide spectrum of clinical conditions encountered in sonographic practice.

In a study in which Aytaç and Ozcan²⁴ used a new-generation US system, 72 (96%) of 75 urinary tract calculi demonstrated the twinkling artefact. Aytaç and Ozcan concluded that this artefact can "help differentiate a very small stone from other small echogenic structures."

Grey-scale imaging with low gain setting to reduce renal sinus fat brightness/posterior acoustic enhancement posterior to bladder, which will show the calculus alone hyperechoic with posterior acoustic enhancement has been

traditional way of picking up calculus by ultrasound. But imaging advancements such as routine use of cross beam imaging achieving enhanced reflectivity of renal sinus fat has made ultrasound less sensitive for picking up calculi of smaller size. Spatial compounding also adds to that. So picking up calculi was difficult in grey-scale imaging in higher end machines and now even in lower end.

This scenario has increased the value of twinkling artefact heavily in picking up renal calculi and lower ureteric calculi. But not much of research is available in getting technique optimised. RSNA article²⁵ published on twinkling in 2011 doesn't mention optimal colour frequency setting or lay any importance to it. This article has dealt with mainly PRF setting that is optimal for twinkling and also has reported much low sensitivity and false positivity of twinkling to pick up calculi when using CT as gold standard. While we have seen twinkling with linear frequency, colour box has much more sensitivity in picking up even calculi smaller than 4 mm in our experience during last 4 years we have documented though, so we went to compare high and low frequency colour boxes in producing twinkling from calculi (each calculi examined was tested with two colour boxes) ignoring the low sensitivity/false positivity reported in article.²⁵ We, in our experience, have found twinkling artefact with optimal (lower frequency box + high PRF) to be much satisfying when adequate time was given for each kidney for small calculi too.

CONCLUSION: B-mode when used alone is more sensitive, but twinkling artefact is more specific in detecting kidney stones. In our study, the colour Doppler twinkling artefact evaluation of renal calculi with low and high frequencies of 2 and 2.7 MHz gave better sensitivity and positive predictive value in detecting even smaller calculi (3 mm).

At 2 MHz, the twinkling artefact grading was found to be high with long tail compared to medium and low tail with 2.7 MHz frequencies.

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