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DOPPLER ULTRASONOGRAPHY OF THE KIDNEYS IN UROLITHIASIS

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Abstract. Urolithiasis is one of the most pressing clinical problems in urology, as the incidence of the disease increases annually, this disease is diagnosed in 12% of the world's population, being the most common disease of the urinary tract. This increase can be explained by many factors, including missed cases of small stones, sedentary lifestyle, high BMI, lack of physical activity and poor nutrition. In addition, a significant contribution to the formation of urolithiasis can be made by an increase in the incidence of comorbidities such as diabetes, dyslipidemia, infections and multiple surgeries on the urinary tract. Kidney stones have been shown to exhibit a “twinkle artifact” (TA) on color Doppler ultrasound. Although this technique has better specificity than conventional B-mode imaging, it has lower sensitivity. To improve the overall performance of TA as a diagnostic tool, the Doppler output parameters were optimized in vitro . The data collected support the previous hypothesis that TA is caused by random vibrations of micron-sized bubbles trapped in the cracks and crevices of kidney stones. A set of optimized parameters was implemented such that MI and TI remained within FDA-approved limits. Several clinical renal scans were performed with the optimized settings and stones were detected with improved SNR compared to the default settings.

Key words: ultrasound, diplography, kidney stones, flicker artifact detection, optimization, urolithiasis.

The aim of this study was to conduct a comprehensive meta-analysis to evaluate the overall diagnostic value of Doppler flickering for the diagnosis of urolithiasis.

Introduction. Urolithiasis is a common problem in general practice. Prevalence rates range from 7 to 13% in North America, 5 to 9% in Europe, and 1 to 5% in Asia. Nephrolithiasis is influenced by many factors including genetic predisposition, age, gender, diet, occupation, and lifestyle. Nephrolithiasis is more common in men than in women. Kidney stone formation is a common urological problem with a lifetime prevalence of approximately 10% in men and 6% in women, and its prevalence is increasing in many developed countries, with a recurrence rate of almost 60% within 10 years of initial treatment.

Many diagnostic modalities are considered helpful in identifying urolithiasis, including plain radiography, intravenous pyelourethrography, ultrasonography (US), and computed tomography (CT). Non-contrast CT is widely considered the current gold standard for diagnosing urolithiasis. Non-contrast CT is the most sensitive (up to 98%) and specific (96–100%) method for detecting urinary stones. A history of nephrolithiasis with onset of flank pain should prompt non-contrast CT of the abdomen and pelvis to evaluate for urinary stones. Moreover, because of its ability to detect non-urologic causes of abdominal pain, CT has become the primary imaging modality for confirming urinary stones. However, one of the limitations of CT is that the associated radiation exposure is increasingly recognized as a public health issue, as radiation exposure can damage the genetic material in cells and lead

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to radiation-induced cancers years later or to hereditary diseases in the offspring of exposed individuals, and this can lead to various developmental outcomes under certain conditions. In contrast, abdominal ultrasound does not involve radiation and has been shown to detect urinary stones using the common criterion of seeing a hyperechoic lesion with posterior acoustic shadowing. Hydroureteronephrosis also significantly improves the detection of urinary stones using B -mode ultrasound imaging. However, this phenomenon used alone has limited sensitivity, particularly for small stones (53% of stones are less than 5 mm in size).

Ultrasound examination using Doppler flicker (TA) artifacts is considered an effective tool for detecting urinary tract stones. The flicker artifact was first described by the French radiologist Rahmouni and can be seen with color Doppler ultrasound, which appears as a rapidly changing mixture of red and blue colors behind a rough interface object such as a calcification [19]. Moreover, the chemical composition of the stone is related to the creation of the artifact. It is found that calcium oxalate dihydrate and calcium phosphate stones always give the TA sign , while stones composed of calcium oxalate monohydrate and urate do not have the TA sign . The validity of TA as a diagnostic tool for the presence of urolithiasis using a systematic review and meta-analysis. The TA sign may be useful as an additional tool in the diagnostic work-up of patients with suspected urolithiasis.

Materials and methods. Ultrasound is a widely used imaging method in the primary diagnostics of the urinary tract in urolithiasis. This method has several advantages over other diagnostic methods, such as noninvasiveness and absence of radiation exposure. Ultrasound examination (ultrasound) is also used in the primary diagnostics of children and pregnant women with suspected urolithiasis. Ultrasound allows diagnosing stones in the kidneys, pelvic ureteral segment, and upper ureter. The limitations of the ultrasound method include variability in sensitivity in detecting kidney stones within 12% to 93%, lack of reliable assessment of the presence of some stones in the ureters, low (about 13%) sensitivity in detecting stones less than 3 mm, and a tendency to overestimate the size of the stone. During ultrasonography, a calculus is defined as a hyperechoic structure in the lumen of the ureter giving an acoustic shadow. The ureter above the stone is dilated in most cases, its diameter does not exceed the transverse size of the stone. Dilation of the ureter below the calculus should suggest the presence of an additional cause of obstruction. Also, with Color Doppler mapping in ultrasound, a "flickering" artifact appears: in the form of a linear strip of inconsistent rapid color change to a highly reflective surface, this artifact is also known as a "comet tail" artifact.

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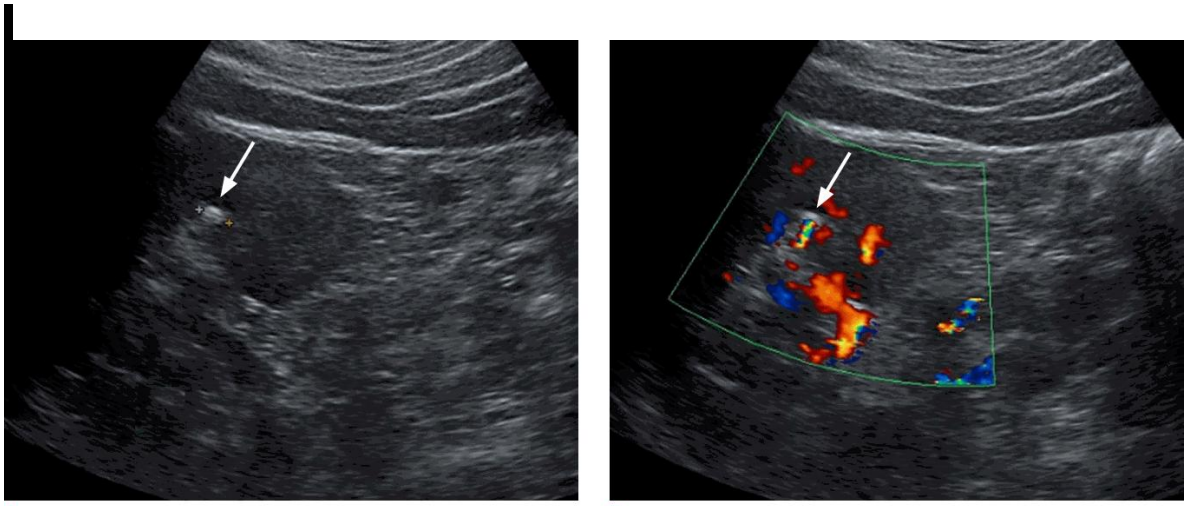

A B

A flickering artifact (FA) is a zone of rapid, random color change on an ultrasound image in the Doppler mode. This artifact occurs when there are solid inclusions in the imaging area, such as kidney stones and other concretions. The color range in the flickering mosaic spot covers the entire palette of encoded blood flow velocities: from extremely high "positive" ones, conventionally orange, to "negative" ones, conventionally violet. FA appears in those areas of the image where blood movement is obviously absent. In the spectral mode, FA is manifested by a wide "white" spectrum, often located vertical lines, and is audible as high-intensity noise. The "gold standard" in the diagnosis of kidney stones is computed tomography (CT), which has high sensitivity (80–99%); however, it exposes patients to ionizing radiation [1]. B-mode ultrasound does not expose patients to ionizing radiation, but imaging sensitivity varies widely (19–93%) because accurate stone detection is highly dependent on operator skill and stone type.

The flickering artifact allows to detect 43–96% of kidney stones [3–13] and can help to differentiate kidney stones from surrounding tissues (Fig. 1). This circumstance indicates the importance of studying and using AM to improve algorithms for ultrasound visualization of stones.

Ultrasonography of the ureter can detect not only stones, but also salt conglomerates. The latter look like elongated stones with a length-to-thickness ratio of more than 2:1. The passage of salts along the ureter occurs quite quickly, sometimes the salt conglomerate reaches the lower third of the ureter already 2–3 hours after the onset of renal colic. Such a "stone", clearly defined in the ureter during ultrasonography, seems to dissolve when it enters the bladder, leaving behind only salts in laboratory urine tests. Ultrasound is also used for dynamic monitoring, especially in patients with a history of renal colic and urolithiasis.

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Conclusion. Doppler twinkling artifact has great diagnostic value for the diagnosis of urolithiasis and should be used as an additional tool in the diagnosis of urolithiasis.

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