

COLOUR DOPPLER EVALUATION OF ACUTE RENAL COLIC

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ABSTRACT

AIMS

Can Doppler index–RI be a predictor of renal colics impending obstruction in acute and emergency clinical settings. To compare the results of RI in cases of obstructive, nondilated and normal kidneys.

METHODS

A total of 90 patients were included in this prospective study. The patients were grouped into three categories based on the clinical settings. Group 1 with acute unilateral obstruction were 44, group 2 who were presented with flank pain without stone disease were 26 and group 3 were 20 patients with sonologically normal kidneys.

Grey scale ultrasonography and colour Doppler study carried out in all the groups and index – RI value were compared.

RESULTS

The study showed differences in RI values among the groups (0.726±0.04, 0.63±0.039 and 0.608±0.03 respectively).

CONCLUSION

In acute and emergency clinical setting, grey scale ultrasonography and interrogation with colour Doppler index– RI improved the assessment and detection of impending obstructive uropathy.

KEYWORDS

Doppler Ultrasound, Renal Colic, Resistive Index (RI), Stone Disease.

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INTRODUCTION: Real-time ultrasound has become a widely available investigation technique. Ultrasound, being a safe, cheap, non-invasive and relatively simple investigation, has been adopted as the diagnostic aid where available and possible. For urinary tract diseases, plain x-ray of the abdomen and excretory urography have been the main line of investigation for a long time. Urolithiasis is the most common urological ailment, and renal colic is among the most common problems met in urology practice.¹ Renal obstruction due to urolithiasis is the most frequent cause.²

The frequency of RC in the general population ranges from 2% to 12%, and it accounts for 30-35% of all urological emergencies. The incidence is higher in men (10-20% vs 3-5% in women), and 30-40% of all patients experience symptomatic recurrence within 5 years.

In most cases, the colic is caused by ureteral spasm in response to the passage of a calculus, but in rare cases the pain stems from the transit of a blood clot (secondary to trauma or neoplastic disease), fibrin (caused by infection),

tissue fragments (urinary tract tumours or acute renal necrosis), or other factors.

Regardless of the cause, patients with RC are at risk for acute urinary obstruction (partial or complete) leading to hydronephrosis. The frequency of this complication ranges from 33% to 68.3%. Hydronephrosis is a serious clinical problem because it can produce progressive deterioration of renal function over time. If the obstruction is caused by urolithiasis, spontaneous resolution can occur, more or less rapidly. The frequency of this outcome depends on the size of the stone. If the latter is less than 2 mm in diameter, all cases generally resolve spontaneously within 4 weeks; the frequency drops to 80% for calculi 2-4 mm, to 50% for those 4-6 mm, and to 10% for those larger than 6 mm. If the calculus has not been expelled after 4-5 weeks, renal function impairment can become severe and sometime irreversible.

Early and accurate diagnosis is essential to minimise the devastating effects of obstruction on urinary tract structure and function³. Though, Intravenous Urography (IVU) is considered the standard investigation, it is not always available and an abdominal x-ray kidney, ureter, bladder (KUB) coupled with ultrasonography of the urinary tract is performed as an alternative method in many hospitals.⁴

It is emphasised that complimentary use of sonography in conjunction with high-dose urography can provide pathognomonic information in many cases when the singular

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application of either modality could render only equivocal data. Correlation of nephrosonography with excretory urography will frequently obviate the necessity of performing retrograde pyelography or angiography.

Plain abdominal radiograph has very low sensitivity for the detection of urolithiasis. Small calculi are usually obscured by bowel gases or faecal matter. In addition, ribs, transverse process and sacrum may obscure the urinary tract calculi.⁵

Because of high cost, radiation dose and high workload of CT,⁶ US should be modified to enhance its diagnostic efficacy to detect obstructive uropathy and Doppler US can be used to overcome this problem.

Renal arterial Resistive Index (RI) is most commonly used from among Doppler indices.⁷

Doppler US can non-invasively provide useful information about renal haemodynamics and make diagnosis of obstructive uropathy more accurate. When the collecting system is acutely obstructed, the pressure of renal calyces increases with changes in renal blood flow resulting in increased RI (RI >0.7).⁸

The RI sensitivity reported in literature is 75.5% and specificity 92.5%.⁹

Doppler ultrasound can improve the clinical utility of US in patients with urinary obstruction by using a resistive index (RI) to quantify changes in intrarenal arterial Doppler US waveforms [RI= peak systolic velocity-end diastolic velocity/peak systolic velocity]. The non-invasive nature of the measurement of renal RI gives it considerable appeal in its potential application to patients with obstructive uropathy.

Duplex Doppler helps to differentiate between obstructive and non-obstructive uropathy.¹⁰

Doppler study detects states of vascular resistance and promising in distinguishing between obstructive and non-obstructive forms of dilatation. Decreased renal blood flow and increase in renovascular resistance are found to be the hallmarks of significant obstructive uropathy.¹¹

METHODS: Our prospective study included 70 patients with flank pain who were referred to the department of Radiodiagnosis for ultrasound evaluation and 20 healthy individuals without any urological symptoms. The patients were then grouped into group 1 (G1) patients with flank pain and stone disease, group 2 (G2) comprised patients with absence of stone with flank pain, group 3 (G3) control with sonologically normal kidneys. The patients who had unilateral renal colic were included in the study. The inclusion criteria were both the male and the female with the history of flank pain in acute clinical settings (within 48 hours). The exclusion criteria were paediatric age group and known cases of renal parenchymal disease and previous history of calculi. This study is conducted during the period Feb 2015-Sep 2015.

All patients have undergone Doppler ultrasound with Siemens ACUSON X300 which was equipped with 2-5 MHz convex transducer.

The Doppler time velocity, spectrum of segmental and interlobar arteries were studied using 2-4 mm Doppler gate. The early systolic to end diastolic Doppler shifts were measured for RI. Low pulse repetition frequency (PRF) without aliasing, highest gain and lowest wall filter settings used.

Multiple Doppler signals tracings were taken. Average RI calculated from 3-5 waveforms and RI from contralateral kidneys were compared.

Few technical difficulties which we encountered during the process of our study were bowel gas shadows and patients who were not adequately hydrated.

Statistical analysis was performed using the one-way ANOVA test. A p-value <0.05 was considered statistically significant. All data were expressed as mean ± standard deviation.

RESULTS: The demographic characteristics are shown in the table 1, 62 patients were male and 28 patients were female. The distribution of symptoms and RI values are shown in table 2. The RI values in patients who had flank pain and haematuria were significantly higher than those in control group. Stone size and location were shown in table 3. The mean RI values for patients in G1 (n=44), G2 (n=26), G3 (n=20) were 0.726±0.04, 0.63±0.039 and 0.608±0.03 respectively. The mean RI for G1 was found to be higher than that for G2 and G3 are shown in table 4. Figure 1, 2 and 3 showing the RI values of normal kidney and that of obstructive kidney.

	No. of patients
Age (years)	
≤30	35
31-50	40
>50	15
Sex	
Males	62
Females	28
Table 1: Patient Demographics	

	Total patients	Mean RI±SD
Flank pain		
Present	70	0.720±0.04
Absent	20	0.619±0.03
Haematuria		
Present	38	0.729±0.04
Absent	32	0.631±0.04
Table 2: Associated Symptoms and RI Values		

	No. of patients
Stone location	
Right kidney	34
Left kidney	36
Stone size	
<5 mm	24
5-10 mm	14
>10 mm	06
Table 3: Stone Size and Location	

Group	Total patients	Mean RI±SD
G1	44	0.726±0.04
G2	26	0.63±0.039
G3	20	0.608±0.03

Table 4: Mean RI of All Groups

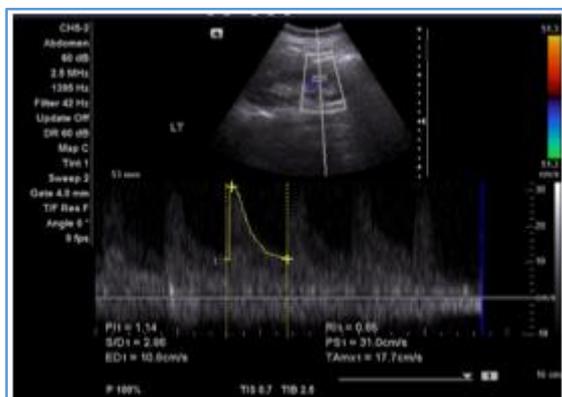


Fig. 1: Showing Normal RI Value in a Healthy Individual

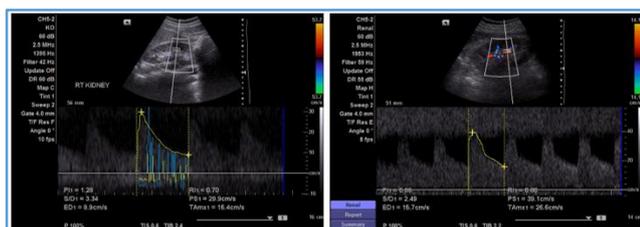


Fig. 2: Right Image Showing Increase RI Value in Obstructive Kidney, Left Image Showing Normal RI in Contralateral Kidney

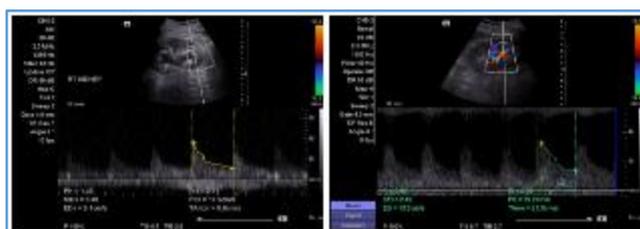


Fig. 3: Right Image Showing Increase RI Value in Obstructive Kidney, Left Image Showing Normal RI in Contralateral Kidney

DISCUSSION: Renal Doppler US is a highly sensitive and specific test that can be useful in the diagnosis of acute unilateral renal obstruction.¹²

Doppler US can be used to measure renal blood flow as well as to calculate RI. The RI is a ratio of peak systolic velocity and end diastolic velocity derived from the Doppler spectrum.¹³

It is a physiological parameter that ensures indirect measurement of the degree of resistance within intrarenal vessels.¹⁴

Previous animal and human studies have determined that the threshold RI (measured at the arcuate or interlobar arteries) to identify obstructive uropathy is 0.70. Above this value, the dilation can be considered to be of obstructive

origin, with a 93% sensitivity and 100% specificity due to a lack of homogeneity in these studies.¹⁵

By allowing direct assessment of haemodynamic response in intrarenal arteries, Doppler ultrasonography has increased the possibility of early detection of obstruction. Obstruction causes increase in renal vascular resistance leading to drop in diastolic flow, being the predominant change in Doppler wave form.¹⁶

Doppler US with measurement of the RI in the intrarenal arteries is very useful, as obstruction (except in the peracute stage) leads to intrarenal vasoconstriction, with a consecutive increase of the RI above the upper limit of 0.7; however, the case is different for non-obstructive dilatation. Clinicians differentiate physiological hydronephrosis from urinary tract obstruction using the RI.¹⁷

Prolonged renal obstruction induces hormonal alterations and thereby causes diffused vasoconstriction of the vascular bed, the visualisation of different patterns of blood flow is helpful in differentiating the obstructive from the non-obstructive pyelocaliectasis.

Intravenous Urography (IVU) and USG are still the most commonly performed investigations in renal disorders. IVU thus has been a cornerstone in detecting obstruction in the urinary tract. IVU is necessary for differentiating and for detecting obstructing lucent stones. At the same time, it provides information regarding the degree of obstruction present. The diagnostic accuracy of urogram is extremely high in patients with acute flank pain secondary to an obstructing stone - 85%.¹⁸ Complimentary use of both modalities can provide pathognomonic information in many cases where either modality used is equivocal. In case of renal obstruction, conventional B-mode USG combined with colour flow Doppler can be used to detect the change in the blood flow pattern produced due to obstruction long before structural abnormalities become evident.

US is an alternative method to IVU, as it does not involve ionising radiation or intravenous contrast; however, it is less accurate than IVU for both diagnosis of obstruction and lithiasis. Although non-contrast helical CT has become the gold standard for the diagnosis of ureterolithiasis, it is not used widely due to its inaccessibility and the radiation exposure involved.¹⁹

Doppler US is a non-invasive, painless, readily available and relatively easy to apply, and it entails no radiation exposure. It would be especially useful in patients in whom intravenous contrast agent administration must be avoided (Pregnancy, contrast agent allergy and renal dysfunction).²⁰

As the sensitivity of RI drops substantially after 48 hours, renal Doppler US is useful for diagnosing acute renal obstruction 6–48 hours after the onset of symptoms.²¹

Theories have suggested that RI is found to be persistently higher over a period of 48 hours. In our study, we choose the patients who were referred with complaints of colicky pain on a random basis and hence were examined within 48 hours. In these cases, the Resistive index was found to be persistently higher.

False Positives: Renal arterial calcifications or ureteral stents may be misinterpreted as renal pelvis calculi. Vascular walls that are parallel to the transducer surface may appear as linear echogenic foci and would be confused for calculi, but these should not shadow or show twinkle artefact.

Literature has found that twinkling artefact alone has a false positive rate of 51% when compared with non-contrast CT.

False Negatives: The sensitivity of ultrasound in detecting calculi increases to 74% when hydronephrosis is also included as positive sign for diagnosis of renal calculi.

Similarly, a resistive index of >0.70 may indicate obstruction but the presence of intrinsic renal disease can also elevate the resistive index. Moreover, partial obstruction may not result in elevated resistive index.

The use of non-steroidal anti-inflammatory drugs for treatment of pain control and antecedent intravenous contrast may also alter the resistive index.

CONCLUSION: RI index is a simple, non-invasive method that furnishes acceptably precise information on the evolution of obstructive urinary tract lesions in patients with unilateral renal colic. In this study, the colour Doppler interrogation in acute renal colics with flank pain is useful in predicting the impending obstructive ureteropathy. Patients with flank pain, haematuria with stone disease showed significant and persistent increase of RI values compared to the contralateral kidneys and in patients with non-stone disease. Routine use of colour Doppler ultrasonography in the emergency department should be a useful supplement to ultrasonography, especially when there are contraindications for methods that involve radiation exposure (pregnancy, allergies, renal failure, etc.) or intravenous administration of iodinated contrast material (urography, CT).

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