

DIAGNOSTIC ACCURACY OF RENAL ARTERIAL RESISTIVE INDEX (RI) IN ACUTE RENAL COLIC

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ABSTRACT:

Objective: To determine accuracy of resistive index in the detection of renal calculi confirmed by intravenous urography.

Methods: This study was conducted at Department of Diagnostic Radiology, Khyber teaching Hospital Peshawar. This was a cross sectional (validation) study which was conducted for a period of 6 months. All patients were subjected to Doppler ultrasound to detect renal calculi on the basis of resistive index of more than +0.70. After that intravenous urography (IVU) was done in all patients to confirm the presence or absence of renal calculi.

Results: The mean age was 30 years with SD ± 1.26 . 65% patients were male and 35% patients were female. In intravenous urography, renal calculi were detected in 92% patients. While using renal resistive index, renal calculi were detected in 87% patients.

Conclusion: Doppler Ultrasound is a sensitive and highly specific test that can contribute significantly to the diagnosis and management of acute unilateral renal obstruction, particularly in situations in which IVU is undesirable.

Key Words: Resistive index, Renal calculi, Intravenous urography.

INTRODUCTION

Urolithiasis is the most common urological ailment, and renal colic is among the most common problems met in urology practice¹. Renal obstruction due to urolithiasis is the most frequent cause². This disease is prevalent in our country and 12% of Pakistani population has urolithiasis³. Early and accurate diagnosis is essential to minimize the devastating effects of obstruction on urinary tract structure and function. Imaging of the urinary tract is pivotal in the diagnosis, management, and follow-up of patients with urolithiasis. Urologists have used a variety of imaging modalities, including plain radiography of the kidneys, ureters and bladder (KUB), intravenous urography (IVU), ultrasound (US), magnetic resonance urography (MRU) and computed tomography (CT)⁴.

Conventional abdominal (kidney, ureter, bladder [KUB]) radiography as the sole imaging modality for the evaluation of nephrolithiasis is limited by several factors, including bowel gas, extrarenal calcification, and large patient habitus. In addition, ribs, transverse process and sacrum may obscure the urinary tract calculi. These factors diminish the sensitivity of KUB radiography⁵.

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Urinary tract ultrasonography (US) is a widely used imaging method as it is safe, rapid, comfortable to patients, and relatively of low cost compared to the IVU and the computerized tomography (CT) scan. The sensitivity of US for detection of urinary calculi is widely variable in the literature depending on the site and size of calculus, and on the patient morphology⁶. Intravenous urography (IVU) was considered the radiological method of choice for a long time in patients with acute renal colic as it allows both morphological and functional evaluation of the urinary system. However, it is a semi-invasive technique with potential risks of radiation exposure and contrast material toxic and adverse allergic reactions. Moreover, a significant percentage of patients with urolithiasis have renal failure, which is a contra-indication for the use of IV contrast⁷. Traditionally, plain KUB and US have been used in patients with renal failure.

By the end of last century, unenhanced helical CT scan (UHCT) was introduced as a new imaging modality by Smith et al⁸ for depiction of urinary stones, and was well accepted as an alternative method to IVU. Nowadays, it is considered as the imaging modality of choice for this clinical entity^{9,10}. Radiation dose, accessibility, and high cost compared to US represent main limitations of this technique.

Doppler US 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. $[RI = (\text{peak systolic velocity} - \text{end diastolic velocity})/\text{peak systolic velocity}]$. It is a physiological parameter that ensures indirect measurement of the degree of resistance within intrarenal vessels. Previous animal and human studies have determined that the threshold RI (measured at the arcuate or inter-

lobular arteries) to identify obstructive uropathy is 0.70. Above this value, the dilatation can be considered to be of obstructive origin, with 93% sensitivity and 100% specificity¹¹.

Hence, this study was done to determine the accuracy of renal resistive index by doppler ultrasound as the first line of imaging method in suspected acute renal colic as it is non invasive, inexpensive, readily available, without side effects and relatively easy to apply.

MATERIAL AND METHODS:

After taking approval from institutional ethical and research committee, this study was conducted at the Department of Radiology, Khyber Teaching Hospital, Peshawar, from 1st July 2013 to 31st December 2013. Taking accuracy (measured as renal calculi detected by resistive index and then confirmed by IVU) as 87.5% of Doppler in the diagnosis of renal calculi by resistive index, margin of error 5% and 95% confidence interval, a minimum of 170 patients were required as the sample size.

All patients referred to the radiology department through OPD/Emergency Department meeting the inclusion criteria were enrolled and a written informed consent was taken. Those excluded were patients with renal insufficiency, hypertension and diabetes mellitus, pregnant ladies and patients with history of surgical intervention and trauma. All patients underwent doppler ultrasound to detect renal calculi on the basis of resistive index of more than +0.70. All patients were examined by single machine. Doppler waveforms were recorded from interlobar and arcuate arteries at the upper, middle and lower portions first over the obstructed then over the contra lateral kidney. The lowest possible pulse repetition frequency without aliasing and the highest possible gain were used. The Doppler sample width was set at 2-5mm. The renal RI was calculated by subtracting the peak diastolic velocity from the peak systolic velocity and dividing the result by the peak systolic velocity. A renal RI >0.7 was considered diagnostic of obstructive uropathy. Subsequently, intravenous urography was performed in all patients which was taken as the gold standard with which Doppler sonography findings were compared.

All the above mentioned information was recorded in a pre designed proforma. The collected data was entered and analyzed through SPSS version 10. Frequency and percentage was calculated for categorical variables like gender and accuracy. Mean \pm SD was calculated for continuous variables like age. Accuracy was stratified among the age and gender to see the effect of modifiers.

RESULTS

Overall, the mean age of the 170 patients was 30 \pm 1.26 years. There were 110 (65%) males and 60 (35%) females (tables 1&2). Table no 3 shows the fre-

TABLE NO 1. AGE DISTRIBUTION (N= 170)

AGE	FREQUENCY	PERCENTAGE
< 20 years	17	10%
21-30 years	110	65%
31-40 years	43	25%
Total	170	100%

TABLE NO 2. GENDER DISTRIBUTION (N= 170)

GENDER	FREQUENCY	PERCENTAGE
Male	110	65%
Female	60	35%
Total	170	100%

TABLE NO 3. FREQUENCY OF RENAL CALCULI IN INTRAVENOUS UROGRAPHY (N= 170)

RENAL CALCULI in IUUV	FREQUENCY	PERCENTAGE
Yes	156	92%
No	14	8%
Total	170	100%

TABLE NO 4. FREQUENCY OF RENAL CALCULI IN RESISTIVE INDEX (N= 170)

RENAL CALCULI	FREQUENCY	PERCENTAGE
Yes	148	87%
No	22	13%
Total	170	100%

quency of renal calculi detected by intravenous urography. RI was found to be >0.70 in 148 (87%) patients as shown in table no 4. By taking RI value of > 0.70 as a discriminatory level for obstruction, the overall sensitivity of RI was 87%.

DISCUSSION

There are numerous reports in the literature showing that colour doppler ultrasound (CDUS) with measurement of the RI is useful in the diagnosis of acute urinary tract obstruction in patients with recent onset (6-48 h) unilateral renal colic (RC). The RI is easy to calculate; it can even be provided automatically by the scanner itself. It represents an indirect estimate of the resistance present in the intrarenal vessels. An acute urinary tract obstruction can increase the RI because this parameter is directly correlated with the pressure within the collection system. Indeed, dilatation of the excretory ducts causes progressive compression of the renal parenchyma and renal vessels, and resistance within these vessels increases^{12,13}.

The RI is a ratio of peak systolic velocity and end

diastolic velocity derived from the Doppler spectrum. It is a physiological parameter that ensures indirect measurement of the degree of resistance within intrarenal vessels. Early clinical studies produced contradictory results regarding the value of the supplementary information furnished by CDUS (compared with gray-scale ultrasound alone) and by measurement of the RI itself in the diagnosis of acute urinary tract obstruction. In the 1980s Platt¹⁴ and Sauvain¹⁵ reported that RIs > 0.70 were indicative of acute ureteral obstruction; since then, numerous studies conducted in animals and humans have confirmed this finding and attributed more or less high sensitivity and specificity to CDUS measurement of the RI^{1,2,10,13}.

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. 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 symptoms¹⁶.

This study confirms the findings of others that RI can predict the onset of acute dilatation with higher sensitivity, specificity, accuracy, and diagnostic efficiency than gray-scale US¹⁰⁻¹⁷. In view of these findings and the temporal advantage it offers, we feel that the RI could be a useful prognostic marker for planning and monitoring responses to treatment for acute urinary tract obstruction. If an RI of >0.70 is indicative of obstruction with increased intrarenal pressures, patients with RI in this range need prompt urinary tract decompression to prevent irreversible damage, as confirmed by the more or less rapid RI normalization seen in our cohort and others once the obstruction has been eliminated.

Despite the encouraging results that emerged from our study and others, it is important to recall that this method has certain limitations. Above all, the RI has been shown to be influenced by a number of factors, including the patient's age, plasma renin levels, and the concomitant presence of diabetes, hypertension, heart disease, and many renal disorders. These factors can cause the RI to rise even in the absence of renal obstruction¹³. The population we studied was selected to minimize the effects of these variables. It was characterized by a well-defined age range and the absence of metabolic, cardiologic, renal, and urological disease.

It is also important to stress that the sensitivity and specificity of the RI varies in cases of partial obstruction. Data in the scientific literature confirm that this marker is more sensitive in the diagnosis of complete rather than partial obstructions^{18,19}. de Toledo et al²⁰, for example, reported a sensitivity of 91.8% in patients with complete obstruction but only 48.1% in those with partial obstruc-

tion. In the latter case, the intraureteral pressure is not high enough to increase intrarenal vascular resistance.

In accordance with the findings of Shokeir et al¹², Piazzese et al²¹, and other authors, we found no significant correlation between the RI and the level of ureteral obstruction, whereas de Toledo et al²⁰ reported that proximal obstructions were associated with higher RIs than distal obstructions.

Some authors have found that the RI increase associated with acute urinary tract obstruction is time-dependent and that the increase in RI occurs after at least 6 h of clinical obstruction^{10,21,22}. This finding is supported by previous laboratory research that in the earliest stage of obstruction there is vasodilatation, with which a normal RI would be expected^{23,24}. In such a situation, although the RI may not be high, a RI of >0.6 suggests unilateral obstruction before the RI reaches the 0.70 threshold. We were unable to investigate the shortest duration of acute renal obstruction that can cause elevation of RI, as all the present patients presented with renal colic of >6 h duration.

The most common reason for obtaining a normal RI in the presence of significant obstruction is a technical error that is simple to correct. The use of the correct scale (pulse-repetition frequency) to expand the wave form size to fill as much of the available display as possible, without aliasing, is crucial.⁸⁹ With this strategy, errors in measurements of RI are reduced and flow at the end of diastole generally can be differentiated from background machine noise and the wall filter. Failure to make this simple technical correction results in minute waveforms barely deviating from the baseline; when measured, these waveforms invariably result in an RI that is calculated to lie within the normal range, even when a true state of elevated renal arterial resistance is present.

CONCLUSION

In conclusion, DU is a sensitive and highly specific test that can contribute significantly to the diagnosis and management of acute unilateral renal obstruction, particularly in situations in which IVU is undesirable.

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