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Intrarenal Resistive Index in Color Doppler Sonography as Predictor in Differentiating Obstructive Uropathy from Non-Obstructive Uropathy Taking Contrast Enhanced Computed Tomography as Gold Standard Imaging Modality

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Abstract

Objective:

To determine the diagnostic accuracy of renal arterial resistive index on Doppler ultrasound in patients with acute renal colic to diagnose obstructive uropathy taking contrast enhanced helical computed tomography as the gold standard.

Study Design and Setting:

The cross-sectional study is conducted at Department of Radiology of Bolan Medical Complex Hospital, Quetta, from June 10, 2019 to February 09, 2020.

Methodology:

320 patients with complaint of renal colic were evaluated with ultrasound and subsequently contrast enhanced computed tomography scan of kidney, ureter and bladder was performed. Data was collected on prescribed proforma and analyzed using SPSS 20.

Results:

The sensitivity of the index was 76.23%, specificity was 88.13%. The positive predictive value was 91.6%, and negative predictive value was calculated to be 68.42%. The diagnostic accuracy of the test was 80%.

Conclusion:

Renal Doppler ultrasound can determine altered renal perfusion before pelvicalyceal system dilatation and can distinguish obstructed and non-obstructed kidneys.

Keywords: intrarenal; resistive index; color doppler sonography; obstructive uropathy; non-obstructive uropathy; contrast enhanced CT Scan

Introduction:

Flank pain due to urolithiasis is a common ailment in patients presenting to the emergency department. Radiology plays a vital role in the work-up of these patients. Obstructive uropathy due to urolithiasis is the utmost repeated cause. [2,3] Prevalence of this disease in Pakistani population is 12%. [4] A population-based study showed that overall prevalence of kidney stone in Iran is 5.7%, with slightly increased frequency in male 6.1%, while it was 5.3% in females. [5] Prompt and accurate diagnosis is vital to reduce the upsetting effects of obstruction on urinary tract morphology and physiology. [6] 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. [2,7]

Plain abdominal radiograph has very low sensitivity for the detection of urolithiasis. Small calculi are usually obscured by bowel gases or fecal matter. [8] In addition, ribs, transverse process and sacrum may obscure the urinary tract calculi. [8] Ultrasonography (US) is a delicate method of distinguishing dilatation of the renal collecting system and therefore has been suggested for investigating renal colic. Nevertheless, its use in the diagnosis of acute renal obstruction is partial when dilatation has not developed. It fails to determine dilatation of the renal collecting system in acute obstruction of the kidney in 50% of the cases. [6] Also US deficiencies

capability to offer significant physiologic data on renal status and occasionally cannot distinguish obstructive and nonobstructive dilatation of the kidney. US has sensitivity of 37% for ureteric calculi (direct visualization), [9] therefore, non-enhanced helical computed tomography (CT) has become the chief radiological investigation for the evaluation of urolithiasis and is used as the gold standard for urolithiasis. [10] CT has sensitivity of 95% and specificity of 98%. [11]

Cost effectiveness, dose of radiation and high workload of CT compel the use of US in acute renal obstruction. [12] With the advent of Doppler US new insight into the physiology of the kidney has emerged, enabling the detection of subtle renal blood flow changes associated with various pathophysiological conditions. Intrarenal Resistive Index (RI) is utmost frequently used from among Doppler indices. [13] Recent work has documented significant elevation in the intrarenal resistive index (RI) in established renal obstruction. In acutely obstructed kidneys, the pressure of renal calyces' upsurges with changes in renal blood flow resulting in increased RI (RI >0.7). [2,7,14-16] The RI sensitivity reported in literature is 75.5% and specificity 92.5%. [3]

Similar works has been done at international and national levels previously. Mean RI of obstructed kidney was found to be more than 0.7 by Geavlete et al,3 Amin et al, [17] Ashraf et al, [18] Platt et al [19] and De Toledo [20] et al. Sauvian et al [21] found it to be 0.7, whereas Hyder et al, [22] Onur et al1 and Skokeir et al [23] found it to be below 0.7. Sensitivity and specificity of mean RI of more than 0.7 was also calculated by various researchers (Table-1).

	Resistive Index	Sensitivity	Specificity
Geavlete et al[3]	0.76	75.5%	92.5%
Ashraf et al[18]	>0.70	87.5%	85%
Platt et al[19]	>0.70	92%	88%
De Toledo et al[20]	>0.70	91.8%	92.8%
Amin et al[17]	0.77		
Hyder et al[22]	0.69		
Onur et al[1]	0.69		
Skokeir et al[23]	0.69		
Sauvian et al[21]	0.70		

Table 1: Platt et al reported RI of 0.70 to be a good discriminatory level for obstruction with accuracy of9 0%.[19]

This study focuses on the value of duplex Doppler US and the sensitivity of RI for the diagnosis of renal obstruction caused by ureteral calculi and to see whether CT scan can be replaced by Doppler US, especially in patients with recurrent renal calculi, pediatrics and pregnant patients in view of reducing radiation dose to such patients.

Material & Method:

After taking approval from institutional review board and ethics committee we evaluated intra renal RI of 320 patients who presented to the emergency department with renal colic using duplex Doppler sonography between June 10, 2019 to February 09, 2020. Taking alpha at 5%, power 80%, sensitivity as 92% and specificity of 88%.

After presenting to the emergency department, routine longitudinal and transverse images on US of both kidneys were obtained for assessment of pelvicalyceal dilatation, the presence of calculi or other morphological abnormality. Subsequently, Contrast Enhanced CT Scan, which was taken as the gold standard, [6, 12] was performed. The sampling technique was non-probability, purposive sampling.

Patients of either gender, between 18-55 years of age, who gave informed consent for the study and had unilateral renal colic, were included. Patients under 18 years of age (because of CT radiation risks), patients older than 55 years (because of increased risk of atherosclerosis that affects Doppler findings), patients having bilateral flank pain, pregnant patients, patients with known renal disease, known case of urolithiasis, patients having solitary kidney, and transplanted kidney were excluded.

Doppler US was performed with a Xario-200 US machine using a curvilinear transducer of 3.5 MHz. The intrarenal vessels were then identified using color flow Doppler, and Doppler signals were obtained from arcuate arteries at the corticomedullary junctions and interlobar arteries along the border of medullary pyramids 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.

All patients afterward underwent Contrast Enhanced CT KUB examination within 12 hours of the Ultrasound examination. Scanning was done on Toshiba Aquillion 16 CT Scanner. A subject was taken as negative when no ureteric calculus was seen and was considered positive when a hyperdense ureteric calculus was distinguished along with altered parenchymal enhancement (striated nephrogram). CT scan findings were considered the gold standard with which Doppler findings were compared. Data was initially collected on a proforma which was then shifted to SPSS 20. Descriptive statistics were expressed as mean ± standard deviation for continuous variables like age, while frequency and percentage were calculated for categorical variables like gender, side of renal colic and presence of ureteric calculus. Age and gender-wise stratification was done to control effect modulation

After analyzing the data, sensitivity, specificity, negative and positive predictive values (NPV and PPV) and accuracy of Doppler US for obstructive uropathy was calculated by corresponding with Contrast Enhanced CT KUB examination using 2/2 table.

RI was measured using following formula and taking mean RI of upper, middle and lower segments of kidney; [RI = (peak systolic velocity - end diastolic velocity)/peak systolic velocity]. RI more than 0.7 was taken as indicator of obstructive uropathy along with altered parenchymal enhancement (striated nephrogram).

CT was taken as positive if there was calculus in the ureter.

True Positive was defined as obstructive uropathy diagnosed on Doppler US and also found on Contrast Enhanced CT KUB.

True Negative was defined as obstructive uropathy not diagnosed on Doppler US and also not found on CT KUB.

Obstructive uropathy diagnosed on Doppler US, but not found on Contrast Enhanced CT KUB was taken as False Positive, while obstructive uropathy not diagnosed on Doppler US, but found on Contrast Enhanced CT KUB was defined as False Negative.

Sensitivity was equal to: True Positive/True Positive + False Negative x 100; while Specificity was equal to: True Negative/False Positive + True Negative x 100.
True Positive / True Positive + False Positive x 100, and NPV as, True Negative / False Negative + True Negative x 100. The Diagnostic Accuracy was calculated by the formula: True Positive + True Negative / True Positive + False Positive + False Negative + True Negative x 100.

Results:

Overall, the mean age of the 320 patients was 34±8.5 years (range: 18-55 years). There were 206 (64.4%) males and 114 (35.6%) females. Of the total, 182 patients presented with right-sided pain and 138 with left-sided pain. Calculi were noted predominantly on the right side (n=142; 70.2%), while 60 (29.8%) had them on the left side. Ureteric calculus was noted on CT scan in 202 (63.1%) patients, and it was not present in 118(36.8%) (Table-2).

RI of affected kidney on color doppler ultrasound	Ureteric calculus seen on Contrast Enhanced CT KUB	Ureteric calculus not seen on Contrast Enhanced CT KUB
>0.7	154(TP)	14(FP)
≤0.7	48(FN)	104(TN)

Table-2: 2 x 2 table of study
RI: Resistive Index. CT KUB: Computed Tomography of Kidney, Ureter and Bladder. TP: True Positive. FP: False Positive. TN: True Negative. FN: False Negative.

Of the 206 male patients, calculus was found in 128 (62.1%) patients and of the 114 female patients, ureteric calculus was identified in 74 (64.9%).
RI was found to be >0.70 in 168(52.2%) patients. Calculus was seen on CT scan in 154 (91.6%) of these 168 patients, so these patients were True Positive and constituted 48.1% of the total sample. In the remaining 14 (8.3%) of these 168 patients, calculus was not seen on CT scan. These False Positive patients constituted 4.3% of the total sample.
RI was found to be >0.70 in 152 (47.5%) of the 320 patients. Ureteric calculus was seen on CT scan in 48 (31.5%) of these patients, who were False Negative and constituted 15% of the total sample. In 104 (68.4%) of these 152 patients, ureteric calculus was not seen on CT scan, so they were True Negative and constituted 32.5% of the total sample. Other causes of loin pain seen on CT scan were appendicitis in 34 (10.6%) patients, diverticulitis in 28 (8.75%), spondylolysis in 16 (5%), while no cause of pain was seen in 26 (8.12%).
By taking RI value of > 0.70 as a discriminatory level for obstruction, the overall sensitivity of RI was 76.23% and specificity was 88.13%. The PPV of RI was 91.6% and NPV was 68.42%. The diagnostic accuracy of the test was 80%.

Discussion:

Usually, the indication of renal obstruction provided by US has been indirect, and reliant on on the "anatomical" criterion of dilatation of the pelvicalyceal system and ureter proximal to the level of obstruction. But initial in the sequence of ureteral obstruction, hydronephrosis may be vague or only of negligible severity. CT Scan and gray-scale sonography have been the two most shared imaging modalities used in patients with acute renal colic to distinguish calculi and obstruction. [6,7] As protracted renal obstruction tempts hormonal modifications and thereby causes diffuse vasoconstriction of the vascular bed, the visualization of different patterns of blood flow is helpful in differentiating the obstructive from the non-obstructive pyelocaliectasis. [1,2,6] The accessibility of Doppler sonography is seemingly an attractive and well-reproducible adjunct to the partly invasive diagnostic procedures commonly used in the radiological assessment of renal obstruction. [21] Recently Doppler US techniques have been used to obtain functional information in suspected renal obstruction. Doppler waveform studies are noninvasive, painless, readily available, and relatively easy to perform and learn. In addition, Doppler US prevents the need for ionizing radiation and intravenous contrast material administration in situations in which they may be unwanted, such as pregnancy, allergy and renal insufficiency.
The resistive index is a physiological parameter imitating the grade of renal vascular resistance. Hence, it is hypothetically pertinent for perceiving kidney disease related with increased or decreased resistance of the intrarenal vasculature.
There has been much argument on the role of Doppler US in the analysis of acute obstructive uropathy, and the sensitivity and specificity of this method have varied considerably among series. The causes for the inconsistency in the results in the literature regarding the sensitivity of duplex Doppler US in the diagnosis of urinary obstruction are linked to these factors: variable discriminatory thresholds used for RI, degree of obstruction and quality of Doppler examination. In the past two decades, previous investigators have reported somewhat conflicting results regarding the additional information from duplex Doppler sonography over grey-scale sonography, allowing the diagnosis of acute urinary tract obstruction. [3,6] Many researchers have reported an elevated RI in the setting of acute ureteric obstruction.1,6 Various mean RI values have been reported in obstructed kidneys (Table-1). Our study is comparable with works of Geavlete et al, [3] Amin et al, [17] Ashraf et al, [18] Platt et al [19] and De Toledo et al [20] who found mean RI of above 0.70 in obstructed kidneys. Elevated RI of more than 0.7 was found to be 76.23% sensitive and 88.13% specific in this study which is also comparable with the results of previous studies using RI of more than 0.70 as indicator of obstructed kidney due to ureteric calculus.

Conclusion:

This study complements the prevailing evidence that, in acutely obstructed kidneys, renal Doppler recording can determine altered renal perfusion before pelvicalyceal system dilatation and distinguish obstructed and unobstructed kidneys evaluated with suspicion of renal colic.

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