



A ULTRASONOGRAPHIC STUDY OF MEAN RESISTIVE INTRARENAL INDEX AS A PROGNOSTIC TOOL FOR HYDROURETRONEPHROSIS IN PATIENTS WITH ACUTE UNILATERAL RENAL COLIC

Radiology

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ABSTRACT

BACKGROUND: Acute renal colic due to ureteric obstruction is one of the leading causes of morbidity. Ureteric obstruction predisposes to urinary infection, renal damage and failure. Uretolithiasis is one of the most common cause of urinary tract obstruction which leads to the admission into the emergency ward. The detection of urolithiasis or acute renal colic is by the radiography, conventional ultrasonography (US) and intravenous urography (IVU). A colour Doppler USG measures this change as a resistive index (RI) of the arcuate arteries at interlobar arteries.

METHODS: 50 patients between the ages 21-65 years, who were admitted to the Emergency department of our hospital with unilateral renal colic were included into our study. Detailed demographic data was collected from all the patients and they were all subjected to a thorough physical and clinical examination. Bladder ultrasound was taken along with color Doppler for all the patients at the time of admission for every 6 hours. Thus, an increased RI index signifies an obstruction without a dilatation.

RESULTS: Most of the patients were presented with vomiting or nausea and dysuria and all of them were positive for mean RI. The specificity with the mean resistive index with color Doppler was 91%, while the sensitivity was 100%. Around 96% of the prediction was accurate with mean resistive index, with more than 91% efficiency.

CONCLUSIONS: The mean resistive index is a very good tool for the diagnosis of hydronephrosis, with a very high level of specificity and sensitivity.

KEYWORDS

Acute renal colic, Doppler sonography Hydronephrosis, Mean resistive index, unilateral ureteric obstruction.

INTRODUCTION

Uretolithiasis is one of the most common cause of urinary tract obstruction which leads to the admission into the emergency ward^{1,2}. The most common symptoms include severe pain in the abdomen, decrease of urine flow and output, which can eventually lead to acute or chronic renal failure³. The renal colic basically begins with a lower flank pain radiating to the hypochondrium or the groin. It is known to come in waves due to the ureteric peristalsis, although at times the pain is constant. Although, this is one of the most severe pains known to man, there is no permanent damage. In severe cases, such as large stones, there may be a requirement of surgery. The cause of the renal colic is mainly due to the presence of a kidney stone, although rarely a movement of a blood clot due to a trauma or neoplastic disease may also cause this pain. Other rare reasons can be urinary tract tumors or acute renal necrosis^{4,5}. Ultrasound is a sensitive detector of pelvicalyceal dilatation. This is important because minor dilatation is a well-recognized finding in some patients with severe obstruction, particularly those with acute ureteric obstruction caused by a calculus. Even with very careful technique, ultrasound may miss renal obstruction in a small proportion of patients in whom an obstructed pelvicalyceal system is not dilated. The obstructed pelvicalyceal system fails to dilate presumably because of low diuresis resulting from dehydration, underlying renal parenchymal disease and intermittent obstruction by calculus or decompression of the pelvicalyceal system through a tear of a calyceal fornix.

In the diagnosis of renal obstruction, the sensitivity of ultrasound is much better than its specificity. Ultrasound is less specific than excretory urography because it shows less detail of the pelvicalyceal anatomy, visualizes the dilated ureter incompletely, makes a poorer assessment of upper tract drainage and provides none of the functional information furnished by contrast medium excretion during urography⁶.

One problem relates to the fact that ultrasound can image a fluid filled collecting system, which may not necessarily be pathological. These situations include a baggy extra-renal type of pelvis, a compound upper pole calyx and an over-distended urinary bladder. Fluid within

the collecting system is often visualized during active diuresis after an overload of oral fluids. A similar situation arises during the osmotic diuresis induced after intravenous injection of hypertonic contrast medium for urography. In addition, ultrasound visualizes a variety of dilated but non-obstructed systems, especially in reflux, or other non-obstructive causes of calyceal dilatation e.g. papillary necrosis, mega calyces, TB, infection and residual dilatation due to previous stone or surgery.

Acute complete ureteric obstruction is associated with changes in renal blood flow as well as with an increase in renal pelvic pressure. In the first few hours, renal blood flow increases, most likely because of afferent arteriolar dilatation. After three to five hours, renal blood flow decreases, probably because of afferent arteriolar vasoconstriction produced by prostaglandins and other vasoactive substances⁷.

Decreased renal blood flow persists after 24 hrs, at a time when the pressure within the collecting system is returning towards normal. The decrease in renal blood flow during obstruction can be demonstrated with Doppler ultrasound using the resistive index (RI). The time course of the RI changes is exactly as might be predicted from knowledge of the pathophysiology - increasing approximately six hours after acute calculus obstruction and remaining at its peak from 6 to 48 hours. Subsequently, the RI remains elevated but less markedly so⁸.

Platt⁹ *et al* found that obstructed pelvicalyceal systems were associated with RI greater than 0.7, whereas kidneys with dilated non-obstructed systems had RI less than 0.7. A difference greater than 0.06 to 0.10, in RI values between the two kidneys (Δ RI) is considered to be a significant indicator of unilateral obstruction⁹.

Duplex sonography is a modality that is reliable, inexpensive, easily available, non-invasive, has no adverse effect and has good patient acceptability.

The present study was conducted to evaluate the utility of intrarenal arterial Doppler study in ureteric obstruction.

AIMS AND OBJECTIVES

1. To compare intrarenal arterial doppler change (RI value) in patients with ureteric obstruction and non obstructed ureters.
2. To evaluate the diagnostic accuracy and utility of intrarenal arterial Doppler study (RI value) in ureteric obstruction.

MATERIALS AND METHODS

This study was conducted by the department of Radiology at father muller medical college hospital 50 patients, in the age group of 21 to 65 yrs, presenting with acute ureteric colic as a result of unilateral ureteric calculus obstruction confirmed by gray scale sonography based on intrarenal arterial Doppler study over a period of one year from September 2017- August 2018. All patients with acute ureteric colic as a result of unilateral ureteric obstruction due to calculus (confirmed with gray scale USG), in the age group of 21 to 65yrs. Patients with history of renal parenchymal disease ,chronic renal obstruction ,renal trauma,bilateral renal calculi ,patients on dialysis and patients having a single kidney or congenital anomaly of the kidneys were excluded. Detailed history taking and clinical examination were taken. Intrarenal Doppler evaluation of the kidney with obstructed ureter and comparison of Doppler indice resistivity index (RI) with those of the contralateral non- obstructed kidney were taken and recorded. In this study ultrasound was performed using Ultrasound machine PHILIPS IU22. PHILIPS AFFINITY 50 , PHILIPS HD7 AND TOSHIBHA XARIO using 3.5 MHz curvilinear transducer.

The study required a noninvasive investigation to be conducted on patients. Hence an ethical clearance was obtained from father muller medical college and hospital ethics committee.

RESULTS

Total number of patients: 50 (100 kidneys)
 Cases: 50 obstructed kidneys
 Controls: 50 non-obstructed contralateral kidneys
 Range of age: 21-65 years
 Sex incidence: Male - 33
 Female - 17

Table no 1 showing mean PSV in Obstructed and non obstructed kidney.

	Mean PSV (cm/s)	Mean EDV (cm/s)
Obstructed kidney	34.86 ± 5.78	9.71 ± 1.74
Non-obstructed kidney	23.99 ± 5.25	8.94 ± 1.98

Table no 2 showing RI valuen in normal and obstructed kidney.

	Number	Minimum	Maximum	Mean
RI- Normal kidney	50	0.56	0.67	0.63
RI- Obstructed kidney	50	0.64	0.78	0.72

Table no 3 showing RI Value at different time interval .

	0-5 hrs	6-12hrs	13-18hrs	19-24hrs
	n=2	n=27	n=14	n=7
Obstructed kidney (RI)	0.65±0.01	0.73±0.02	0.72±0.02	0.7±0.01
Non-obstructed (RI)	0.58±0.02	0.64±0.02	0.63±0.02	0.60±0.02

Table no 4 showing site of obstruction.

Site of obstruction	Kidney	
	Obstructed (RI)	Non-ostructed (RI)
Distal	0.72 ± 0.03	0.63 ± 0.02
Proximal	0.71 ± 0.01	0.61 ± 0.02

Majority of the men came under the 30 to 39 years age group (30%) and majority of the women came under the 20 to 29 years age group (12%).

The mean peak systolic velocity (PSV) value were lower in the obstructed kidney as compared to the non-obstructed kidney. The mean intra-renal Resistivity Index (RI) in the 50 kidneys which had a ureteric calculus downstream was 0.72. The mean RI of the contralateral normal kidney in the 50 patients was 0.63. The mean intra-renal RI in obstructed kidneys was significantly higher than in unobstructed kidneys (0.72 Vs 0.63).RI was higher in obstructed kidneys in all the cases. The difference in RI between obstructed and non-obstructed kidney ranged from 0.04 to 0.14 .(Table 1 and 2)

Most of the patients (54%) were evaluated between 6-12hrs, 28% within 13-18hrs, 14% within 19-24hrs and 4% within 0-5hrs after the onset of symptoms. Slightly higher RI values were noted in patients evaluated between 6-12hrs and the least was noted in patients

evaluated between 0-5hrs. (Table no 3)

The site of obstruction was distal in 46 (92%) cases and proximal in 4 (8%) cases. The mean RI of the obstructed kidneys with distal obstruction was higher (0.72 ± 0.03), than in the kidneys with proximal obstruction (0.71 ± 0.01) .(Table no 4)

Pelvicalyceal system (PCS) dilatation was observed in 48 (96%) patients while it was absent in 2 (4%) patients. RI values were similar in both groups. Calculus was noted in the vesicoureteric junction in both the cases. Doppler USG was useful in diagnosing acute renal obstruction even in those cases, where PCS dilatation was absent on USG.

Taking 0.70 as the threshold for abnormality as reported by Platt *et al* RI was found to have a sensitivity of 92% in patients with acute unilateral ureteric obstruction. If the mean RI value of 0.72 is taken as the threshold (as found in this study), the sensitivity calculated is 50%.

DISCUSSION

Intravenous urography (IVU) and grey-scale ultrasound are the two most common imaging examinations used in patients with acute renal colic to determine whether renal obstruction is present. Evaluation with ultrasonography (USG) is particularly useful in conditions when IVU is contraindicated, e.g. pregnancy, a history of reaction to contrast material, renal impairment and repeated episodes of renal colic. However, conventional USG is an inaccurate test for obstruction because dilatation of the collecting system is often seen in unobstructed kidneys and may not occur or may occur late in obstructed kidneys.

Traditionally, the evidence of renal obstruction provided by USG has been indirect and dependent on the „anatomical“ criterion of dilatation of the PCS and ureter proximal to the level of obstruction. However, USG fails to reveal hydronephrosis in acute obstruction of the kidney in up to 35% of cases. More direct „functional“ evidence of obstruction has usually required scintigraphy but recently, Doppler US techniques have been used to obtain functional information in suspected renal obstruction.

USG imaging may miss the diagnosis of obstruction in a variety of situations. Mild dilatation may be overlooked or considered clinically insignificant. Some patients with obstructive renal failure may show no PCS dilatation. The reasons for this are unclear; in some patients it may relate to dehydration or to decompression of the pelvicalyceal system by rupture of a calyceal fornix.PCS dilatation may be missed if the PCS system is filled with blood clot, calculus, tumor or pus. Intermittent ureteric obstruction, particularly caused by ureteric calculi, may also lead to a failure to visualize the collecting system with USG.

On the contrary, in an attempt not to miss the diagnosis of obstruction in patients with only mild PCS dilatation, the false positive rate of diagnosis may be as high as 26%. Causes of a false-positive diagnosis include: (i) Visualization of a normal PCS system, when there are anatomical variants such as extrarenal pelvis, when the bladder is distended or under conditions of diuresis (ii) Visualization of a dilated but unobstructed system when there is vesico-ureteric reflux (VUR), a distensible system after previous obstruction or infection, dilated calyces (e.g. in papillary necrosis or reflux nephropathy) or during normal pregnancy (iii) Central renal fluid collections other than the PCS, including normal vessels, renal artery aneurysm and peripelvic cysts.

Acute unilateral ureteric obstruction results in a complex sequence of changes in renal blood flow and ureteric pressure. In the first two hours, the renal blood flow increases, because of afferent arteriolar vasodilatation and the ureteric pressure increases. From two to six hours after obstruction, the renal blood flow decreases, secondary to vasoconstriction of the efferent arterioles and the ureteric pressure remains elevated. Subsequently, at six to eighteen hours, the renal blood flow remains reduced, because of vasoconstriction of the afferent arterioles and the ureteric pressure decreases. With bilateral ureteric obstruction, the initial pattern of blood flow change is slightly different, but the resultant decrease in renal blood flow by 24hrs is similar to that in unilateral ureteric obstruction.The role of renal Doppler US in the evaluation of acute renal obstruction has been vigorously debated. Rodgers PM *et al* found an elevated RI in acutely

obstructed kidneys, especially when compared with the RI in normal contralateral kidneys and with a control group of healthy subjects. Similar results were obtained by Platt JF *et al* in 23 patients with acute unilateral ureteric obstruction. However, others reported that duplex Doppler sonography is highly insensitive for detecting acute ureteric obstruction.

The application of an adequate Doppler sonographic technique is essential for obtaining accurate results. 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-PRF) to expand the waveform size to fill as much of the available display as possible, without aliasing, is crucial. With this strategy, errors in measurement 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.

In our study, the RI was ≥ 0.70 in 46 cases (out of a total of 50). If 0.72 (the mean RI value obtained in our study) is taken as the threshold, then 25 cases out of 50 were equal to or above this level. Only two cases with unilateral ureteric calculus had RI values ≤ 0.65 (mean RI of 0.65 and 0.64 respectively). The increase in RI was also demonstrated in two cases that had equivocal dilatation of the pelvicalyceal system. This observation is important in showing that duplex Doppler sonography can reveal urinary obstruction earlier than conventional sonography, which can miss cases of urinary obstruction without collecting system dilatation. The same observation has been made by Opendakker L *et al*¹⁰.

Previous investigators (Ryan P *et al*¹¹, Murphy G *et al*¹², Moody T *et al*¹³, Badr K *et al*¹⁴ and Klahr S *et al*¹⁵) have shown that a short period (<2 hrs) of likely prostaglandin-mediated vasodilatation occurs immediately after obstruction. After this period, renal blood flow decreases, and renal vascular resistance increases. In our study, two patients presented with renal colic at 3hrs and 4hrs duration respectively. Only the patient with 4hrs duration of renal colic had shown change in the inter-renal resistive index ($\Delta RI=0.10$) whereas the mean RI was 0.65. Thus, according to our study, the shortest duration of acute renal obstruction that can cause elevation of RI is 4hrs.

The mean peak systolic velocity (PSV) value and the end diastolic velocity (EDV) value were lower in the obstructed kidney as compared to the non-obstructed kidney and was statistically significant ($p < 0.05$). We divided our patients into four groups (0-5hrs, 6-12hrs, 13-18hrs and 19-24hrs) based on the duration of the renal colic. Slightly higher RI values were noted in patients evaluated between 6-12hrs. We agree with Platt *et al* and Shokeir *et al*¹⁶ that kidneys obstructed for more than 12h do not have a higher RI than those with obstruction of shorter duration.

We also studied the effect of the level of obstruction on RI values. In our study the level of ureteric obstruction (proximal v/s distal) had no significant impact on the values of RI, in agreement with Platt *et al*⁹ and Shokeir AA *et al*¹⁶. Statistical analysis showed that the sensitivity of RI in the diagnosis of complete urinary obstruction was 92% if a threshold value of 0.70 (as suggested by Platt JF *et al*⁹) is taken as the abnormal value.

Several studies have demonstrated that RI is affected by factors other than renal vascular resistance, such as vascular compliance, age of the patient, hypertension, diabetes mellitus and other renal diseases¹⁰. These factors may explain the absence of significant ΔRI in four cases with unilateral ureteric calculus. One additional factor that could potentially affect renal arterial resistance is clinical management. Ureteric colic is usually accompanied by considerable pain, the severity of which mandates administration of narcotics and non-steroidal anti-inflammatory drugs (NSAIDs). The use of NSAIDs (Indomethacin, Toradol) has been shown in animal models to reverse both the early vasodilatation and subsequent vasoconstriction of acute ureteric obstruction. Thus, their use may mask the expected changes in the renal arterial RI.

ABBREVIATIONS

cm/s Centimetre(s) per second

EDV	End diastolic velocity
Hrs	Hours
HYN	Hydronephrosis
HUN	Hydroureteronephrosis
IVU	Intravenous urography
LK	Left Kidney
LT	Left
MHz	Mega Hertz
M	Obstructed
NO	Nonobstructed.
NSAID	Non steroidal anti inflammatory drugs
PCS	Pelviccalyceal system
PSV	Peak systolic velocity
PUJ	Pelvi-ureteric junction
RI	Resistive index
RK	Right Kidney
RT	Right
S.Cr	Serum creatinine
USG	Ultrasonography
VUJ	Vesico-ureteric junction
VUR	Vesico-ureteric reflux
yrs	Years

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