

THE USEFULNESS OF INTER-RENAL RESISTIVE INDEX DIFFERENCE IN DIAGNOSING ACUTE UNILATERAL URETERIC OBSTRUCTION DUE TO CALCULUS

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ABSTRACT

Objectives: To evaluate the usefulness of inter-renal resistive index difference in diagnosis of acute unilateral ureteric obstruction due to calculus.

Study design: Case Control Study

Place and Duration of Study: Study was conducted in Department of Radiology, Combined Military Hospital Lahore, from August 2005 to February 2006.

Subjects and Methods: Sixty patients were divided in two groups of 30 each group I, 30 patients with unilateral acute ureteric colic due to ureteric calculus; and group II, 30 patients having no symptoms and with a normal ultrasound (as controls).

Interlobar arteries were examined by Colour Doppler ultrasound in upper, mid and lower renal pole with a two to five millimetre sample volume to calculate average resistive index. Inter-renal resistive index difference (Δ RI) was then calculated.

Results: Statistically significant difference was observed in the inter-renal resistive index difference (Δ RI) measurements with mean value in the case group of 0.09 compared to 0.021 in controls. Average intrarenal resistive index measurement in the obstructed kidney was .69 compared to 0.58-0.59 in the control group.

Conclusion: Measurement of inter-renal resistive index difference in patients with ureteric colic improves diagnostic accuracy of ultrasound in distinguishing between obstructive and non-obstructive dilatation.

Keywords: Color Doppler ultrasonography, ureteral calculi, hydronephrosis

INTRODUCTION

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 urography [1].

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 substances [2]. 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 so [3].

Platt [4] 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 obstruction [5]. An increase in RI is not however specific for obstruction, as it increases in a variety of renal parenchymal diseases. In infants normal RI values are higher and in the first year of life it often

exceeds 0.7, which may persist up to the age of four years [6].

The null hypothesis was that there is no difference in Δ RI in the patients with unilateral ureteric calculus and those who are normal.

PATIENTS AND METHODS

Case Control Study was conducted in the Department of Radiology, Combined Military Hospital Lahore, using Color and Power Doppler Ultrasound machine ALOKA SSD-5500 from 19th August 2005 to 19th February 2006. Sixty patients were studied in two groups:

Group I: Thirty patients with acute ureteric colic and unilateral ureteric obstruction due to calculus (confirmed with IVU later on).

Group II: Thirty patients having no symptoms and with a normal ultrasound (as controls).

All cases (group I) were more than four years of age with duration of complaints more than or equal to six hours and up to five days.

Patients with history of renal parenchymal disease, chronic renal obstruction, renal trauma and patients on dialysis were excluded. Similarly, patients having a single kidney or those with a congenital anomaly of the kidneys, children less than four years of age and pregnant females were also excluded.

The RI of the interlobar arteries was measured in the cases using multifrequency 3-5 MHz convex probe. Examination of each kidney was carried out with the patient lying on his side. Patients were asked to empty the urinary bladder prior to the examination.

Measurements were made at three sites in the kidney in the upper, mid and lower pole. A 2-5 mm sample volume was used and angle correction was not applied. Waveforms

were optimized for measurement using the lowest pulse repetition frequency without aliasing (to maximize waveform size), the highest gain without background noise, and the lowest wall filter. Three to five waveforms were recorded at each site and the average RI was calculated. This was done on the afflicted kidney as well as the contra lateral normal kidney to obtain the Δ RI. Similar measurements were made in the patients included as controls who had no abnormality in either kidney.

The results were subjected to descriptive statistics that were performed using SPSS version 11 software package. Descriptive statistics were used to describe the data.

Independent samples t-test were used to compare the mean Δ RI values in cases and controls. P-value <0.05 was considered as significant.

RESULTS

Mean age of patients was 38 years (range, 17-70 years) while mean age of the controls was 39 years (range 21-71). Twenty two patients were males and 8 were females in the case group. The duration of complaints in the cases was on an average 5 days.

The mean intra-renal RI in the 30 kidneys which had a ureteric calculus downstream was 0.69 (Fig.1). The mean RI of the contralateral normal kidney in the 30 patients was 0.60 (range 0.51 - 0.68). 15 of the obstructed kidneys had mean RI values more than or equal to 0.7 while none of the normal contralateral kidneys in the cases had RI values exceeding 0.68 (Tab-1).

The mean inter-renal RI difference (Δ RI) in the 30 cases (with unilateral ureteric calculus) was 0.09. Five patients showed a Δ RI value less than 0.05 (Fig.2).

Of the 30 patients with urinary obstruction, 28 had sonographic evidence of hydronephrosis (mild to moderate). There

were two cases of ureteric calculus not producing any obstructive dilatation in the kidney. Two cases, out of 30 with unilateral ureteric calculus, had an RI of less than 0.65 (average RI of 0.55 and 0.62 within the affected kidney with Δ RI of 0.04 and 0.02 respectively).

In the control group of 30 individuals, the average RI calculated of the normal right kidney was 0.58, ranging from 0.51 to 0.64 (Fig.3). Mean RI of the normal left kidney was 0.59 (range: 0.52 to 0.66).

Mean Δ RI value (Fig. 4) was found to be 0.021 in the controls (range: 0.00 - 0.05). These patients were asymptomatic at the time of the study and had no previous history of renal disease.

Mean Δ RI in controls was significant lower than that in the cases ($p < 0.05$). The null hypothesis was thus significant.

Taking 0.70 as the threshold for abnormality as reported by Platt 3, 4, RI was found to have a sensitivity of 50% in patients with acute unilateral ureteric obstruction (case-group).

If the mean RI value of 0.69 is taken as the threshold (as found in this study), the sensitivity calculated is 60%. By using the inter-renal RI difference with a value above 0.05 as abnormal, the sensitivity rises to 83% as only 5 patients out of 30 patients presenting with unilateral ureteric calculus had an RI difference from the contra lateral normal kidney of less than 0.05.

DISCUSSION

IVU and grey-scale US are the two most common imaging examinations used in patients with acute renal colic to determine whether renal obstruction is present. Evaluation with US 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 US 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.

The role of renal Doppler US in the evaluation of acute renal obstruction has been vigorously debated. Rodgers PM [1] 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 [2] in 23 patients with acute unilateral ureteric obstruction. However, others reported that duplex Doppler sonography is highly insensitive for detecting acute ureteric obstruction [3, 5].

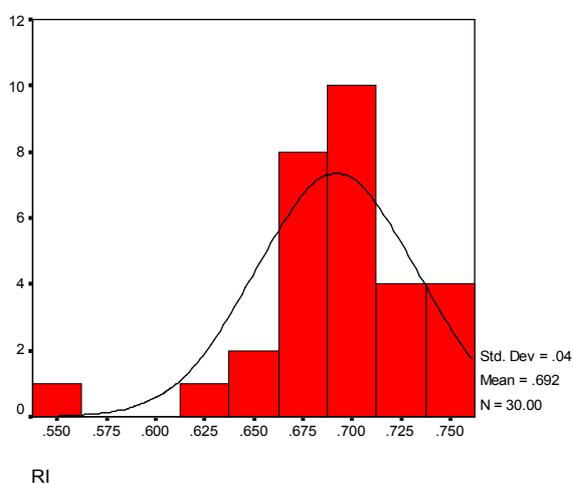
With acute urinary obstruction, there is an elevation of the pressure in the intra-renal collecting system. This can induce reduction in renal blood flow as a result of increased renovascular resistance. An increase in intra-renal vascular resistance is responsible for a diminished diastolic blood flow velocity in

Table-1: Descriptive Statistics - Cases

	Number	Minimum	Maximum	Mean	Standard Deviation
Resistive index normal kidney	30	0.51	0.68	0.60	0.04
Resistive index in kidney affected by ureteric calculus	30	0.55	0.75	0.69	0.04
Inter-renal resistive index difference	30	0.01	0.16	0.09	0.04

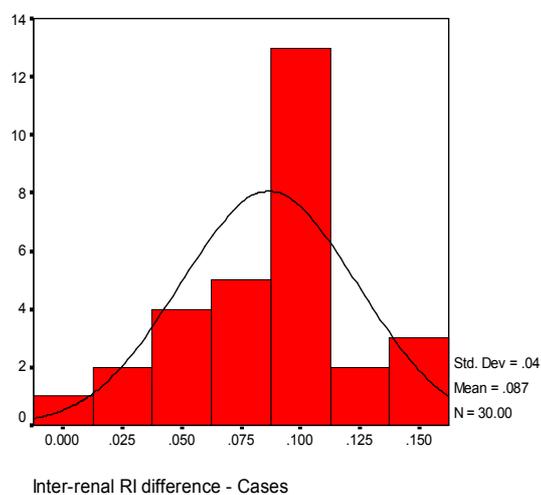
Table-2: Descriptive Statistics - Controls

	Number	Minimum	Maximum	Mean	Standard deviation
Resistive index right kidney	30	0.51	0.64	0.58	0.03
Resistive index left kidney	30	0.52	0.66	0.59	0.03
Inter-renal resistive index difference	30	0.00	0.05	0.02	0.01



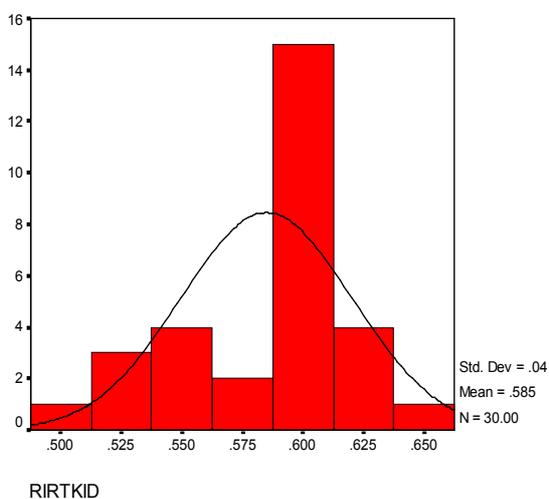
Key: RI = Resistive index
 Std. Dev = Standard deviation
 N = Sample size

Figure.1: Resistive index of affected kidney (with ureteric calculus)

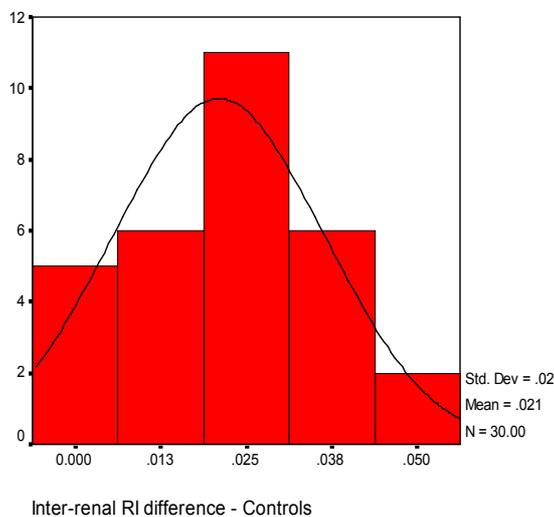


Key: Std. Dev = Standard deviation
 N = Sample size
 RI = Resistive index

Figure.2: Inter-renal resistive index difference - Cases



Key: RIRTKID = Resistive index right kidney
 Std. Dev = Standard deviation



Key: Std. Dev = Standard deviation
 N = Sample size

the intra-renal arteries, and accordingly, the RI will be increased. In our study, the RI was ≥ 0.70 in 15 cases (out of a total of 30). If 0.69 (the mean RI value obtained in the case group) is taken as the threshold, then 18 cases out of 30 were equal to or above this level. Only two cases with unilateral ureteric calculus had RI values < 0.65 (mean RI of 0.55 and 0.62 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 other authors [6, 7].

Statistical analysis showed that the sensitivity of RI in the diagnosis of complete urinary obstruction was 50% if a threshold value of 0.70 (as suggested by Platt JF [2, 4]) is taken as the abnormal value. However, if we take the threshold value as 0.69 (the mean RI of the 30 cases in this study), the sensitivity rises to 60%. When inter-renal RI difference (Δ RI) of 0.06 or above is used to analyze the effect of ureteric obstruction, only five cases with unilateral ureteric calculus exhibited values less than 0.05, raising the sensitivity to 83%. These findings suggest that inter-renal resistive index difference (Δ RI) is the most significant measurement to be made in acute unilateral ureteric obstruction.

In the control group, the mean RI of both kidneys was found to be significantly lower than those presenting with ureteric calculus (0.58 in right kidney and 0.59 on left side). Mean Δ RI in the controls was 0.021, significantly lower than that in the cases with unilateral ureteric calculus (mean Δ RI: 0.09).

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 diseases [8, 13-21]. These factors may explain the absence of significant Δ RI 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 [8-11]. Thus, their use may mask the expected changes in the renal arterial RI.

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.

Based on the values obtained in this study, it is reasonable to assume that the discriminatory thresholds published by Platt

et al for RI (0.70 and Δ RI of 0.10) is relatively high. The mean RI and Δ RI in our control group of healthy individuals were 0.58-0.59 and 0.021. Thus, the discriminatory threshold for RI should be taken as 0.69 and Δ RI as >0.05 , in all cases suspected of having acute unilateral ureteric colic due to ureteric obstruction by a calculus.

The measurement of Δ RI should always be undertaken in all cases presenting with acute unilateral ureteric colic as it significantly increases the sensitivity of duplex Doppler sonography in diagnosing obstruction (sensitivity of 83% in this study). This indicates the importance of calculating the Δ RI in all cases presenting with unilateral ureteric colic, even when collecting system dilatation is absent on conventional sonography.

CONCLUSION

As conventional sonography is the first imaging modality used in many centers to evaluate patients presenting with acute ureteric/renal colic, it should be complemented by duplex Doppler sonography in all patients, even when collecting system dilatation is not present. Duplex Doppler sonography concentrating mainly on the measurement of inter-renal resistive index difference is a very useful examination in patients presenting with unilateral ureteric colic, especially where pelvic/cecal dilatation is not present on the symptomatic side and in those cases where IVU is not possible or contraindicated.

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