

# Renal Resistive Index in Unilateral Obstructive Nephropathy – A Study to Assess Current Role and Future Possibilities

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## Abstract

**Introduction:** Gray scale ultrasonography is the initial investigation for the anatomical assessment of the renal system. CTIVU and diuretic renogram are the investigations of choice for functional assessment of the kidneys. Recently, the role of color Doppler to determine renal resistive index (RI) and RI ratios (RIRs) has been suggested for functional assessment of kidneys at the time of disease presentation as well as for follow-up after corrective surgeries.

**Aims:** This study aims to determine the role of RI and RI ratio in the functional assessment, diagnosis, and follow-up of unilateral hydronephrotic/obstructive kidney.

**Materials and Methods:** Thirty patients who presented to our outpatient department/emergency department with unilateral hydronephrosis were selected and pre-operative RI of diseased and normal kidneys and RIR were determined. Individualized surgical interventions were performed for the relief of hydronephrosis in these patients and 3 months post-operative, the RI and RIR were measured again. The values of the RI in normal and hydronephrotic kidneys, pre-operative and post-operative RI and RIR were compared. Student's t-test was applied to determine the *P* value.

**Results:** The value of RI in hydronephrotic kidneys was significantly higher as compared to normal kidneys, but when the established cutoff of 0.7 was used, the sensitivity was found to be very low. There was also a significant decrease in the pre- and post-operative RI values of the abnormal kidneys.

**Conclusions:** Even though color Doppler is much cheaper and readily available technique, it is user dependent and the sensitivity to determine functional compromise of the kidney is not high, especially in mild-to-moderate hydronephrosis. It may have a role as an adjuvant investigation but not as an alternative of diuretic renogram.

**Key words:** Colour doppler, Obstructive hydronephrosis, Renal resistive index ratio, Renal resistive Index

## INTRODUCTION

Gray scale ultrasonography has been the most routinely performed investigation for the evaluation of renal pathologies. In spite of marked improvement in the technology, it gives us the information regarding the anatomy of kidney and dilatation of the pelvicalyceal

system. Functional assessment of the renal units cannot be performed through it.

Thus, the use of Doppler sonography was established to provide better diagnostic information as well as the functional status of the kidneys. With the calculation of the renal resistive index (RI), one can show the degree of resistance within the renal vasculature. Its use has been indicated in the diagnostic evaluation and follow-up of various renal pathologies, including obstructive diseases. At present, diuretic renography is the most widely accepted non-invasive procedure to assess renal function in an obstructed pathology of kidney. However, it has the disadvantages of being expensive, it uses ionizing radiation and having 10–15% rate of false-positive and indeterminate

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results. The non-invasive and non-radiation nature of measurement and easy availability of Doppler give RI considerable appeal in potential application to patients with obstructive uropathy.

## MATERIALS AND METHODS

A prospective study was conducted at a tertiary center. A total of 30 cases which underwent treatment for unilateral hydronephrosis were included in the study.

All patients who presented to the emergency department and surgery outpatient department above the age of 12 years with the clinical symptoms of renal colic (flank pain, nausea, vomiting, hematuria, and burning micturition) were evaluated by proper history taking, physical examination, and thereafter, blood investigations (complete blood count and renal function test) and radiological investigations such as ultrasound of the KUB region and plain radiograph KUB. Those patients diagnosed clinically with unilateral hydronephrosis (either due to a calculus or pelviureteric junction [PUJ] obstruction) with a normal contralateral kidney were included in the study. After explaining the details of the study including the benefits and risks, those patients that gave informed and written consent were selected for the study. The patients with contralateral kidney involvement, patients with single kidney, patient lost to follow-up, and those who refused to undergo surgical intervention for their cause of hydronephrosis were excluded from the study.

Patients were further evaluated by performing renal color Doppler of both kidneys and thus determining the pre-intervention renal RI of normal and abnormal kidneys and RI ratio. Other investigations such as CTIVU and DTPA were conducted in a few patients with severe hydronephrosis. Depending on the functional status of the kidney and the level and type of obstruction in the urological tract, individualized interventions were planned for each patient such as percutaneous nephrostomy, percutaneous nephrolithotomy, and open or laparoscopic pyeloplasty. On recovery, the patients were discharged and asked to come for follow-up. Three months post-operative, each of these patients was asked to undergo the basic blood investigations and ultrasound with renal color Doppler again. Post-operative RI of both the kidneys was noted and RIR calculated. The pre-operative RI of normal and obstructive kidneys and pre- and post-interventional renal RIR were compared in every patient. Student's *t*-test was applied to determine *P* value.

## RESULTS

In this research, we have endeavored to study renal vascular resistance in terms of Doppler waveforms in

renal obstruction. The study comprises 30 patients, aged from 12 to 60 years, and eventually planned for surgery for diagnosed PUJ obstruction, either from an anatomical or physiological defect or secondarily from calculi.

In our study, the mean age of presentation was 33.7 years with the mean age of PUJ obstruction cases being 30.23 years and PUJ calculus group being 36.35 years. Out of 30 subjects, 20 were males making 66.66% of total patients, while 10 were female making 33.33% of the total. PUJ obstruction, either from an anatomical or physiological defect, was the cause of pathology in 13 out of 30 patients (43.33%), while obstructive calculus at pelvic-ureteric junction/upper ureter was the cause in the rest 17 (56.66%). While the left kidney was pathologically affected in 46.66% of cases (14 patients), the right kidney was affected in the rest 53.33% (16 patients).

The calculation of RI of both the renal systems was done by color Doppler technique.

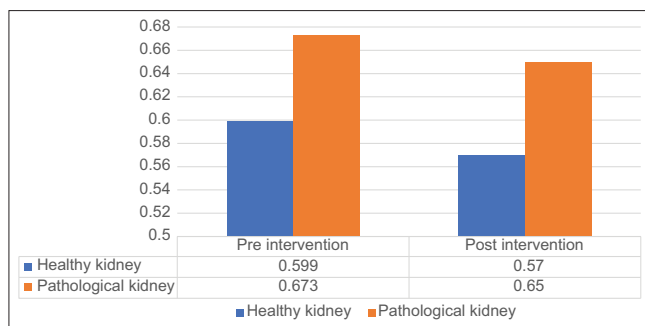
Preoperatively, the mean RI in healthy kidney was 0.599 while in the pathological kidney was 0.673 [Figure 1]. This difference between the two was found to be statistically significant. However, if we take into account the established threshold value for RI in pathological kidney of 0.7, then the sensitivity came out to be only 20% and specificity was 100%.

Postoperatively, the mean RI in healthy kidney was measured as 0.57 and in the pathological kidney was measured as 0.65 [Figure 1]. This decrease in mean RI values of pathological kidneys was found to be statistically significant ( $P < 0.001$ ) on applying paired *t*-test.

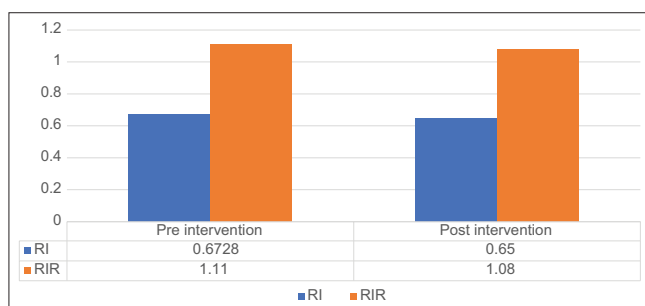
Preoperatively, the mean RIR in this study of 30 patients was 1.11. This value was reduced to 1.08 postoperatively [Figure 2], the difference was found to be significant on applying paired *t*-test. However, if the threshold value of 1.1 is being considered, then the sensitivity was found to be only 56.66% in this study.

## DISCUSSION

The hemodynamic changes that occur in an obstructed kidney have been studied extensively. The initial phase of increase in the renal blood flow is due to pre-glomerular vasodilation followed by the second phase in which decline in flow is observed.<sup>[1,2]</sup> The extent of the blood flow changes is dependent on the extent or severity of obstruction. In case of chronic obstruction, the renal blood flow may reduce or may be essentially the same as that of a normal kidney,<sup>[3]</sup> the reasons for which are unclear. These hemodynamic responses can be measured by the renal RI.



**Figure 1: Bar chart comparing mean resistive index in pre- and post-operative healthy and pathological kidneys**



**Figure 2: Bar chart comparing pre- and post-operative resistive index in pathological kidneys and pre- and post-operative renal index ratio values**

Various studies have been done on the usefulness of this index and its reliability in studying functional compromises of an obstructed kidney.

0.70 being considered the upper limit for a normal mean intrarenal RI,<sup>[4,5]</sup> the sensitivity of RI to differentiate between obstructive and non-obstructive hydronephrosis was 92% and 100% in the series of Platt *et al.*<sup>[4]</sup> and Gottlieb *et al.*,<sup>[5]</sup> respectively. Brkljacić *et al.*<sup>[6]</sup> found RI <0.70 in six of 21 unilaterally obstructed kidneys (28.6%), the sensitivity was 71.4% when RI ~0.70 was used as a cutoff value in diagnosing obstruction.

With this upper limit, the sensitivity was found to be only 20% in our study. Many other studies failed to show a high sensitivity of RI in obstructive pathologies. Chen *et al.*<sup>[7]</sup> found a sensitivity of 52% in their study, which they attributed to the fact that mildly obstructed kidneys had little change in the RI values. Tublin *et al.*<sup>[8]</sup> observed a sensitivity of 44% in their study. They concluded that when the RI is elevated and one is suspecting acute obstruction clinically it is highly specific. However, if one relies solely on an elevated RI to diagnose obstruction, the sensitivity is such that many cases of obstruction would be missed.

Deyoe *et al.*<sup>[9]</sup> found that only three obstructed kidneys out of 10 showed an elevation in RI. None of the partially obstructed systems had an increase in RI. Only 30% of their

patients with complete obstruction exhibited an elevated or asymmetric RI. de Toledo *et al.*<sup>[10]</sup> reported a sensitivity of 91.8% in patients with complete obstruction but only 48.1% in those with partial obstruction. Li *et al.*<sup>[11]</sup> concluded in their study that pre-operative RI and post-operative decrease in RI were not independent predictors of renal functional recovery in their patients. Elevation of pre-operative RI was associated with poor recovery of post-operative renal function. Their study was the first to use RI to predict the recoverability of post-operative renal function in patients with chronic hydronephrosis. They demonstrated that lower pre-operative RI and a greater decline in post-operative compared with pre-operative RI were associated with better outcomes in patients younger than 35 years.<sup>[11]</sup>

In acute obstruction, the sensitivity of RI drops substantially after 48 h, renal Doppler US is useful for diagnosing acute renal obstruction 6–48 h after the onset of symptoms.<sup>[12]</sup> In unilateral hydronephrosis, a RI ratios (RIR) of >1.1 indicates obstruction and is predictive of the need for surgery.<sup>[13]</sup> This index is of more significance in children as compared to adults, since unlike the RI, it is unaffected by the age of the child.<sup>[14]</sup> Brkljacić *et al.*<sup>[6]</sup> showed that RI comparison between obstructed and contralateral kidneys in a patient with unilateral obstruction is more useful than the application of a 0.70 RI threshold value in diagnosing urinary tract obstruction. In our study, the sensitivity of RIR when the upper limit of 1.1 was considered was found to be 56.66%. In contrast, Ulrich *et al.*<sup>[15]</sup> reported an RI ratio of 1.15 to be 100% sensitive and specific for acute obstruction.

There are many limitations of our study, one being a very small sample size, too small to define a threshold RI value for renal obstruction. We also did not perform the Whitaker test; so the significance of obstruction could not be accurately assessed on the basis of ultrasonographic findings. Another limitation of RI is that its value may be affected by various other factors such as hypertension, diabetes mellitus, arteriosclerosis, or pulmonary system diseases, which may also affect its efficiency and feasibility for predicting postoperative renal function.<sup>[16]</sup> Even though, currently, the role of RI is limited and only has a supportive role, it can be of help in situations in which intravenous contrast administration is undesirable such as pregnancy, contrast agent allergy, and renal dysfunction. Furthermore, it has a role in assessing the presence of obstruction and if functional compromise is present in pyelocaliectasis of a symptomatic kidney.

In institutions at which sonography is used as a primary technique for evaluating acute renal colic, the addition of a Doppler study will improve the sensitivity for early obstruction and will provide functional information regarding an obstructed kidney.

## CONCLUSIONS

Renal obstruction produces a change in the Doppler waveform causing elevation of RI by causing increase in renal vascular resistance. Duplex Doppler sonography is an insensitive technique for the detection of patients with renal obstruction. Multiple factors that directly or indirectly affect renal arterial resistance limit its use as a screening examination. Decrease of a previously elevated RIR to significant values can be used as an early indicator that recovery of renal function is likely and hence helps in evaluating the success of surgical intervention. After relief of obstruction, renal function is regained that is associated with decrease in mean RI and RIR. RI and RIR values provide corroboration of the initial diuretic renogram and can be used as a non-invasive modality for monitoring the dilated collecting system. Doppler ultrasound being a physiological investigation cannot be used to determine precise anatomical details and should not be used alone to evaluate a patient with hydronephrosis. However, it can be used for monitoring hydronephrotic kidney under observation obviating the need for frequent radioisotope scintigraphy. The non-invasive nature of renal color Doppler gives it considerable appeal in the diagnosis and follow-up of patients with hydronephrosis. This method provides a non-invasive modality for monitoring patients after reconstructive surgery of the upper urinary tract. More work needs to be conducted to establish the role of RI and RIR in diagnosing and follow-up cases of renal obstruction in adults.

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