

The Role of Renal Resistance Index in Diabetes and Hypertension Diagnosis

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ABSTRACT

Introduction: Both macrovascular and microvascular complications have been linked to diabetes and hypertension. Various cardiovascular-related diseases are examples of macro-vascular disorders. Diabetic neuropathy, retinopathy and nephropathy are examples of these microvascular consequences of diabetes. Diabetic retinopathy is the major cause of blindness in those not born with vision problems, while diabetic nephropathy is the primary cause of kidney failure. Diabetic foot ulceration and peripheral vascular disease account for all non-traumatic amputations.

Aim: The goal of the current study was to develop a more quantitative differential diagnostic model and investigate the potential importance of the Renal Resistant Index in the differential diagnosis of diabetes and hypertension.

Materials & Methods: For patients with renal colic, Doppler ultrasonography was utilized to establish the existence of renal calculi, in addition to laboratory testing such as serum creatinine, total cholesterol, glycosylated hemoglobin, and microalbuminuria. **Results:** In this study, total obstruction had higher RI values than partial obstruction. The patient group's blood creatinine, total cholesterol, glycosylated hemoglobin, and microalbuminuria profiles were documented.

Conclusion: The study might predict the course of sickness in patients, particularly diabetic and hypertensive nephropathies, by assessing the intra-renal resistive index.

Keywords: Diabetes, Kidney disease, Resistance index, Differential diagnosis, Diabetes mellitus

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INTRODUCTION

Non-invasive methods such as ultrasound and Doppler assess the kidney in various illnesses [1]. Using ultrasound to examine the kidneys has the added benefit of avoiding ionizing radiation and its potentially hazardous consequences [2]. Renal sonography has been used a lot on people with azotemia to rule out obstructive uropathy, get an idea of how big the kidneys are, and see how echogenic the kidney tissue is [3,4]. Duplex ultrasonography has made it easy and painless to study the blood flow in the kidneys (renal hemodynamics)

[5,6]. Only a few systemic illnesses for which Doppler indicators like the resistive index have recently gained much attention [7].

One of the most prevalent disorders seen in the emergency room is Renal Colic (RC). It causes 30%–35% of urological crises and affects 2%–12% of the population. 40% of patients have a symptomatic recurrence within five years, and males are more likely than women (10-20% vs 3-5%) [8]. any obstruction of urine drainage from the kidney (renal calyces or renal pelvis), ureter, or bladder is referred to as obstructive uropathy [9]. Hydro nephrosis is a sign of obstructive uropathy in which the renal pelvis and calyces seem dilated or swollen [10]. Stones in the kidneys (nephrolithiasis), ureter (ureterolithiasis), or any place in the urinary system (urolithiasis) are the most prevalent causes of obstructive uropathy [11,12]. Diabetes and hypertension are two of the most prevalent chronic non-communicable illnesses and are major risk factors for end-stage renal disease, coronary heart disease, and stroke. Syndrome X

is a combination of diabetes mellitus and hypertension [12,13]. Diabetes now affects over 40 million people in India, which is expected to increase by 2030 [14,15].

India has been called the "diabetes capital of the world" in anticipation of a pandemic such as a rise in diabetic patients [16]. Over the previous three decades, the prevalence of diabetes has climbed from 1.2 percent to 11 percent [17]. Hypertension affects around one billion individuals globally, and it is predicted that up to 2 billion will be hypertensive by 2025 [18–20]. Therefore, the current research was carried out to examine the possible significance of the Renal Resistant Index in the differential diagnosis between diabetes and hypertension and build a better-quantified differential diagnostic model.

METHODS

Study type (prospective study)

Two groups of patients are used in this prospective study. Group 1 individual with unilateral acute renal colic who present to the emergency medical division, outpatients, and patients with obstructive uropathy. Group 2 includes diabetes and hypertension patients (newly diagnosed, between 5 and 10 years, and above ten years) with complications related to both diseases (nephropathies).

Source of information

Patients referred from various departments of Bhaarith Medical College and Hospital, Chennai, would be the primary data source for this study.

Sample size

A total of 120 people participated in the research.

Study duration

Two years were committed to the research. The Institute's Scientific and Ethics Committee gave its stamp of approval to the study. Serum creatinine, random blood sugar and lipid profile (total serum cholesterol), and glycosylated hemoglobin (HbA1c) levels were investigated.

Technique

Renal Resistive Index samples are obtained at the arcuate or interlobar arteries near the medullary pyramids. The following formula is used to determine an RRI:

$$RRI = (\text{peak systolic velocity} - \text{end-diastolic velocity}) / \text{peak systolic velocity}.$$

Statistical analysis

The mean and standard deviation are used to express the results. The Fisher exact test was used to compare categorical variables that were provided as a number (%). The difference between the two means was evaluated using a student's t-test for paired and unpaired data. The "p" value of less than 0.05 was considered statistically significant.

RESULTS

A total of 120 patients were included in this study: 50 patients with unilateral acute renal colic, 35 patients with diabetes mellitus, and 35 patients with hypertension. In all cases, Doppler ultrasonography was used, as well as intravenous pyelography for patients with renal colic, to confirm the presence of renal calculi and laboratory tests such as serum creatinine, total cholesterol, glycosylated hemoglobin, and microalbuminuria. First, we'll look at the findings in individuals with unilateral acute renal blockage. There are 37 men and 13 girls among the 50 patients (the sex of the patient was statistically not significant). Most patients were assessed four to twenty-four hours following the beginning of symptoms. The duration of the onset of symptoms had little effect on the resistive index values.

To compare the variance in resistive index value in blocked and unobstructed control kidneys, unobstructed contralateral kidneys are used as controls (Table 1). The difference in Resistive Index (RI) between obstructed and unobstructed kidneys was 0.09. The mean RI in obstructed kidneys was substantially greater than in unobstructed kidneys (0.70 Vs 0.61). Compared to unobstructed kidneys, all blocked kidneys had a greater RI. Patients were separated into two groups based on the location of blockage: proximal obstruction (25 patients) and distal obstruction (25 patients). The obstructed kidneys with proximal blockage had a higher RI (0.72) than those with distal obstruction (0.66). When proximally obstructed kidneys are compared to contralateral normal kidneys, RI in proximally obstructed kidneys is higher (0.11) than in distally obstructed kidneys (0.06).

This research included 16 patients with full blockage and 34 with partial obstruction. Completely clogged kidneys had a higher RI value (0.71) than moderately obstructed kidneys (0.67). Even in moderately blocked kidneys, RI was considerably greater when compared to contralateral normal kidneys. This demonstrates that the degree of blockage has a significant impact on the RI value.

The effects of chronic medical renal disorders, particularly diabetic and hypertensive nephropathy will be examined next. There are 70 individuals in this study, including 35 diagnosed instances of diabetes mellitus and 35 diagnosed hypertensives. A total of 35 diabetic individuals are split into two groups. Group 1 had a RI value of 0.7 (25 patients), while group 2 had a RI value of 0.7 (25 patients) (10 patients). The difference in age between patients in groups 1 and 2 was not statistically

Table 1: Comparison of RI values based on site and degree of obstruction.

Obstruction	Number	RI In The Obstructed Kidney	RI In Control Kidney	Δ RI
Proximal	25	0.72	0.61	0.11
Distal	25	0.66	0.6	0.06
Complete	16	0.71	0.62	0.09
Partial	34	0.67	0.6	0.07

significant. There was no discernible difference in diabetes duration. After a year, all of the patients were followed up. The value of the RI is related to the glycosylated hemoglobin levels and serum creatinine.

After a year of follow-up, patients' mean RI had increased significantly (0.64 Vs 0.71). The RI difference was 0.06 (Table 2). All patients are split into three categories based on the length of their diabetes: Group 1 has diabetes for less than five years, Group 2 has diabetes for five to ten years, and Group 3 has diabetes for more than ten years. For newly diagnosed individuals, a random blood sugar measurement is considered. For Group 2 and Group 3 patients, the HbA1c levels and serum creatinine are considered. After a year of follow-up, the RI in group 1 patients was 0.06, and the rise in serum creatinine (creatinine) was 1.5 mg/dl. The RI was 0.07 in group 2 individuals, and the increase in serum creatinine (S.cr) was 1.7 mg/dl. The change in RI in group 3 patients with a duration of more than ten years was 0.08 (0.65 Vs 0.73), which is statistically significant in our investigation.

Twenty five of the 35 hypertension patients are confirmed cases, ranging from recently diagnosed to more than ten years old. The remaining ten instances are suspected cases of high blood pressure or high total serum cholesterol levels, and confirmation is pending. The average age of girls (48.12) is somewhat greater than that of males (41.15), as shown in Table 3.

This information is not statistically significant. Females also have a longer average duration of hypertension than males. The 35 patients are separated into groups 1 (24 patients) with a RI larger than 0.7 and 2 (24 patients) with a RI less than 0.7. (11in number). In our study, the difference in RI between the two groups is 0.05, which is statistically significant. Serum cholesterol and creatinine levels are significantly higher in group 1 than in group 2 patients.

This study aimed to see how the intrarenal resistive

index affected individuals with unilateral acute renal obstruction, diabetes mellitus, and hypertension at various phases of illness development shown in Table 4.

DISCUSSION

In diabetic nephropathy, conventional ultrasonography and Doppler are non-invasive techniques for evaluating the kidneys. After hydro nephrosis has been ruled out, conventional ultrasonography assessment of the kidneys in renal disorders is of little utility. A few researchers have attempted to diagnose and describe renal medical illness using real-time sonographic measures such as relative echogenicity and renal size [21]. This study aimed to see how the intrarenal resistive index affected individuals with unilateral acute renal obstruction, diabetes mellitus, and hypertension at various phases of illness development. The study comprised 120 individuals (60 with unilateral acute renal calculus, 35 diabetics, and 35 hypertensives).

Renal Doppler Ultrasonography is a sensitive and specific technique that may diagnose acute unilateral renal obstruction and compute RI [22]. It can also be used to monitor renal blood flow and calculate RI. The RI is calculated as a ratio of peak systolic velocity to end-diastolic velocity using Doppler ultrasonography. RI is a physiological characteristic that allows for the indirect evaluation of intrarenal vascular resistance [23]. Numerous previous types of research have shown that Color Doppler Ultrasonography with RI measurement is beneficial in identifying acute urinary tract blockage in individuals with unilateral Renal Colic of recent onset (6-48 h) [24]. Because this measure is closely connected with the pressure within the collecting system, an acute urinary tract blockage might raise the RI. It's also worth noting that in circumstances of partial blockage, the RI's sensitivity and specificity vary. According to scientific evidence, this marker is more sensitive in identifying total blockages than partial obstructions [25].

Table 2: Comparison of RI changes and serum creatinine value in diabetic patients

Duration	Initial		Followup after one year		Δ values	
	RI	S.cr	RI	S.cr	ΔRI	ΔS.cr
< 5 years	0.62	1.5mg/dl	0.68	3.5mg/dl	0.06	2mg/dl
5 – 10 years	0.64	2.07mg/dl	0.71	3.5mg/dl	0.07	1.5mg/dl
>10 years	0.65	2.1mg/dl	0.73	4.2mg/dl	0.08	2.1mg/dl

Table 3: Comparison of RI changes and serum creatinine value in hypertensive patients.

Duration	Initial		Followup after one year		Δ values	
	RI	S.cr	RI	S.cr	ΔRI	ΔS.cr
< 5 years	0.6	1.3mg/dl	0.70	2.3mg/dl	0.1	1mg/dl
5 – 10 years	0.66	2.14mg/dl	0.72	3.64mg/dl	0.06	1.5mg/dl
>10 years	0.67	2.54mg/dl	0.72	4.76mg/dl	0.05	2.2mg/dl

Table 4: Predictive and p-values of the renal resistive index.

Disease	Positive predictive value	Negative predictive value	'P' value
Renal obstruction	100	83.3	<0.0001
Hypertension	91.6	72.7	<0.0001
Diabetes	87.5	63.6	<0.0001

In this research, the RI value for total obstruction is higher than for partial obstruction. The sensitivity was 87.5 percent, and the specificity was 57.7%, which is consistent with earlier research [26]. Doppler US with intrarenal artery RI measurement is highly beneficial because obstruction (unless in the acute stage) causes intrarenal vasoconstriction, with a subsequent increase in the RI over the upper limit of 0.7; however, the case is different for non-obstructive dilatation. Using the RI, clinicians can distinguish between normal hydro nephrosis and urinary tract blockage [27]. Renal Doppler Ultra Sonography is beneficial for identifying acute renal obstruction 6–48 hours after the beginning of symptoms since the sensitivity of RI declines significantly beyond 48 hours. Platt discovered that the RI is not substantially greater in individuals who have had an obstruction for 12 hours than in those who have had a more recent blockage [28].

These variations are likely linked to the length of the blockage and its clinical progression. The elevation in RI occurred before dilatation in all patients with hydro nephrosis, according to our findings (at least 6-12 h in 93 percent of the cases) [29]. De Toledo stated that proximal obstructions were related to larger RIs than distal obstructions; however, Shokeir and other writers observed no significant association between the RI and the amount of ureteral blockage [30]. According to our research, when proximally obstructed kidneys are compared to distally obstructed kidneys, resistive index values are higher in proximally obstructed kidneys [31]. Ultrasonography provides non-ionizing radiation and an intravenous contrast-free alternative to intravenous urography (IVU); nonetheless, it is less reliable for blockage and urolithiasis diagnosis than IVU [32]. Doppler Ultrasonography is non-invasive, painless, widely available, and reasonably simple to use, and it does not expose you to radiation [33]. It would be especially advantageous for individuals unable to receive intravenous contrast agents [34]. According to the findings of our study, RI is effective for early detection with 80% sensitivity and 100% specificity, especially for those who must avoid radiation and contrast chemicals.

Diabetes mellitus causes diabetic nephropathy, which is a common microvascular consequence. A few years after the commencement of the illness, functional and structural problems may be observed. Doppler ultrasonography has given a simple and non-invasive approach to examining renal hemodynamics in recent decades. The renal resistive index measures vascular resistance within the kidneys [35]. Increased RI values in patients with impaired renal function have uncertain mechanisms. Elevated RI levels can be caused by increased interstitial fibrosis. Taniwaki et al. recently investigated the effect of Renin-angiotensin system (RAS) blockade on intra-renal hemodynamic alterations in normotensive individuals with type 2 diabetes by examining changes in RI [36]. They discovered that RI levels after the test were considerably lower in diabetes patients than baseline values, although this was not the

case in healthy people. HbA1c and baseline plasma renin activity both had a substantial and independent effect on the amount of the drop in RI values following captopril administration in diabetic individuals, according to multiple regression analysis.

In nondiabetic patients, intrarenal arteriosclerosis, rather than other kinds of renal impairment, is an independent risk factor for an elevated intrarenal RI. People with diabetes had a higher intrarenal RI than those with nondiabetic renal disease. Ohta et al. recently investigated the connection between RI and arterial stiffness (PWV, a measure of arterial stiffness that indicates atherosclerosis) in 245 individuals to see if renal RI was altered based on the underlying renal illness [37]. They discovered that in individuals with Diabetic Nephropathy, the RI of the primary renal arteries was much greater than in other patients. In Diabetic Nephropathy, intrarenal vascular resistance appears to rise more rapidly. Their findings suggest that a higher RI in the renal arteries is linked to the degree of systemic atherosclerosis. In a recent series of studies, the potential of Doppler ultrasonography as a valuable complement for assessing renal illness was pushed. Renal RI was explored in individuals with chronic tubulointerstitial nephritis by Boddi et al. [38]. They discovered that using RI measurements, both normotensive and hypertensive individuals with chronic TIN may be identified early while their renal function remains intact. Renal RI values were shown to be proportional to uricaemia and filtration ratio. In a recent study, Heine et al. found that intrarenal RI increased linearly with progressive degradation of renal function in individuals with chronic kidney disease and that it can independently represent both local renal damage and systemic vascular illness [39].

We followed up on the patients for a year in this research. This investigation is part of a larger longitudinal study in which we follow individuals with diabetes and diabetic nephropathy to see if serial periodic RI measurements may predict disease progression better than well-established clinical or laboratory criteria. With 84 percent sensitivity and 70 percent specificity, the current investigation demonstrates a very excellent association between RI and renal functioning measures, consistent with prior findings. Even in the absence of overt nephropathy, hypertensive individuals had considerably higher RI values than normotensive controls. Lower RI levels, on the other hand, were linked to reduced renal and target organ damage [40]. This is not unexpected because people with early-stage hypertension have steady function for lengthy periods. This is especially true when blood pressure is well controlled with antihypertensive drugs, which may provide extra protection beyond blood pressure management. According to our findings, the RI of intrarenal arteries might be a valuable measure for early organ injury and a predictor of future CV issues in hypertensive individuals.

CONCLUSION

In the case of unilateral acute renal obstruction, Doppler Ultrasonography is a valuable diagnostic technique. Gray scale Ultrasonography was shown to have a sensitivity of 77.5 percent for identifying blockage. Even when Ultrasonography results were normal, Doppler Ultrasonography helped determine blockage. The RI values in acute renal obstruction were unaffected by the length of symptoms at presentation or the location of the obstruction. The RI values of patients with total blockage were substantially higher than those with partial obstruction. The partly blocked kidneys had significantly higher RI values than the normal kidneys on the opposite side. When applying the discriminating threshold value of RI 0.70, Doppler Ultrasonography had an overall sensitivity of 87.5 percent and specificity of 90 percent in diagnosing acute renal obstruction. When choosing a RI of 0.06 as a threshold value, the sensitivity was 95%, and the specificity was 100%. As RI grew, sensitivity declined while specificity remained consistent.

In patients with advanced clinical diabetic nephropathy, Duplex Doppler Ultrasonography provides a quick, non-invasive assessment of the intrarenal vasculature. It can be utilized as a readily accessible measure of progression and prediction. Doppler ultrasound should be utilized regularly in patients with severe renal parenchymal disease. The RI values collected from the interlobar arteries and the major renal arteries were shown to have a statistically significant relationship, which grew stronger as the disease stage progressed. Any rise in RI values obtained from the major renal and interlobar arteries should raise concerns about the probability of progressive renal injury and progression to chronic medical renal disease. We found that hypertension patients with higher RI scores had more damage to target organs. Current hypertension treatment recommendations emphasize the importance of RI evaluation since it may be used to foresee impending damage and provide an accurate estimate of overall risk. European guidelines for managing hypertension from 2003 define high normal blood pressure as readings considered high in those at high risk and thus need treatment with antihypertensive drugs.

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