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ORIGINAL ARTICLE

Assessment of Intra Renal Arterial Resistivity Index (RI) in Primary Hypertensive Patients and Its Correlation with Those of Normotensive Population

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Abstract

Background: ***The rising prevalence of primary hypertension (HTN) necessitates the development of novel indicators for the early identification of hypertensive nephropathy. Doppler sonography offers non-invasive techniques to study renal hemodynamics.***

Objectives: ***This research aimed to assess the resistivity index (RI) in the renal arteries of individuals with primary HTN and determine its connection with RI values in the normotensive population.***

Methods: ***This research used a case-control cross-sectional analytical observational design and included a sample of 60 individuals, ranging in age from 35 to 70, of both genders, who had primary HTN and normotensive individuals. The patients were separated into two equal groups: one group (the control group) consisted of healthy individuals. Two groups of patients were submitted to the ultrasonography unit.***

Results: ***There was a significantly higher mean value of resistive index "RI" in the patients' group than in the control group, with a p-value (p=0.006). There was a highly significant positive correlation between the resistive index of the patients' group according to their duration of HTN "years," during the age insignificant correlation. There was no correlation between the resistive index of the control group and age.***

Conclusion: ***The mean renal RI increases significantly in primary hypertensive patients when compared with normal control ones. RI increases with the duration of HTN. Renal Doppler is a useful noninvasive method for early detection of hypertensive nephropathy and investigating renal hemodynamics alteration, so we considered renal duplex an important prognostic and diagnostic tool for essential HTN.***

Keywords: Intra Renal Arterial RI; Primary Hypertensive Patients; Normotensive Population

1. Introduction

The continual rise in the prevalence of primary hypertension (HTN) has necessitated the development of novel indicators for the early identification of hypertensive nephropathy. HTN ranks as the second most common cause of end-stage renal disease (ESRD) after diabetes.[1] The precise significance of Doppler sonography in evaluating renal vascular resistance in primary HTN remains unclear. Identifying target organ damage is crucial in assessing the total risk and managing individuals with primary HTN. [2]

Increased renal vascular resistance in persons with HTN may suggest the initiation of hypertensive nephrosclerosis, resulting in renal failure. The renal vascular resistance index (RI) provides a new noninvasive method for monitoring persons with essential HTN. Elevated renal resistance index (RRI) indicates increased cardiovascular risk in primary HTN.[3]

Moreover, an elevated RRI has been used to forecast the occurrence of diabetes mellitus in individuals with primary HTN[5]. Doppler sonography enables the use of noninvasive techniques to study the blood flow in the kidneys. The RRI is an indicator of the resistance inside the kidney's blood vessels.[4]

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Ultrasound and Doppler imaging have been used to assess chronic renal disease. They can identify both large-scale and small-scale vascular anomalies in the kidneys. Evaluating the vascular resistance of renal parenchyma may reveal any functional or anatomical changes in the kidneys and can provide important diagnostic and prognostic information. Doppler-derived indices may effectively detect the existence of arteriolosclerosis and interstitial fibrosis, both of which impact vascular distensibility. [5]

Doppler sonography may be used to evaluate renal vasculature in many situations, such as renal obstruction, urinary tract infections, reno-vascular HTN, acute or chronic renal failure, and diabetic renal complications. Renal illness often presents with hemodynamic disturbances inside the kidneys, which may be assessed by renal blood flow measurements, such as the RRI. [6]

This research aimed to evaluate the renal artery RI in persons with primary HTN and investigate its correlation with RI values in the normotensive population.

2. Patients and methods

This research used a case-control cross-sectional analytical observational design, with a sample of 60 individuals between the ages of 35 and 70, of both genders, who were diagnosed with primary HTN and those with normal blood pressure. This research was conducted under the agreement of the Ethical Committee at Alhussin Hospital Radiology Department at Alazhar University and the National Institute of Urology and Nephrology at Al-Mataria, Cairo, Egypt. Each patient also provided verbal informed consent. The patients were divided into two groups: Group A consisted of 30 healthy people of similar age who acted as the control group. Group B was designated as the ultrasonography unit. The exclusion criteria included those younger than 35 years old or older than 70 years old and those with DM. We thoroughly assessed all the patients by gathering comprehensive medical history. We used B-mode ultrasonography to examine both kidneys and locate them accurately. Additionally, we did color and pulsed wave Doppler ultrasonography to examine the intra-renal arteries using a 3.5 MHZ convex transducer.

A real-time color-coded scanner connected to a 3.5 MHz transducer was used to scan the participants. The subject was placed on the examination couch in a supine position. After applying sufficient coupling gel to the region of interest to allow sound conduction, the transducer was positioned, and the patient was scanned in a supine and lateral posture. Color mapping was used to see the kidneys' blood flow during a comprehensive evaluation of the kidneys. Before moving on to the region of interest (the interlobar arteries), the primary renal artery was examined for the presence or absence of stenosis. Three Doppler waveforms were obtained from each kidney by sampling either the interlobar artery (situated at the boundary of medullary pyramids) or the arcuate arteries (placed at the corticomedullary junction) of the superior, middle, and inferior regions of the kidney. The average value was manually calculated due to the possibility of variation between observers when measuring the RRI. To minimize this fluctuation, an average of three observations were taken.

The velocity waveform was acquired using an ideal insonation angle of less than 60° to provide a clear picture of the first systolic peak. A Doppler tracing was acquired and recorded by positioning a gate measuring 2-4 mm (modified as needed) above the interlobar artery. A low-pass filter was used, and the minimal scale necessary to exhibit the flow without aliasing was adopted. The magnitude of the Doppler waves was increased to enhance measurement accuracy. While the user was not breathing, a sequence of 3-5 successive Doppler waves with similar properties were seen, suggesting a discernible pattern. The RI was then calculated using the sonography device's internal calipers and analytical software. The RIs derived from these five waveforms were averaged to give the mean RI values for each kidney. The acquired value was derived by summing the RI from the intrarenal arteries in the upper, middle, and lower poles and dividing the sum by 3. Each patient had comparable patterns and data in both kidneys. A single examiner conducted the Doppler exams to minimize inter-observer variability. A normal RRI number typically falls between 0.50 and 0.70, with 0.70 as the upper normality threshold.

Renal RI: The RI may be calculated by subtracting the end-diastolic velocity (EDV) from the peak systolic velocity (PSV) and then dividing the result by the PSV.

The main objectives were to evaluate the resistance index of intrarenal arteries in both hypertensive and normotensive individuals. The secondary objectives were to identify the association between renal RI in hypertensive patients and normotensive individuals and examine other characteristics such as age, sex, duration of HTN, and medication status.

Statistical Analysis:

We used IBM's SPSS v26 software based in Chicago, IL, USA, to do statistical analysis. Numbers were defined in terms of means and standard deviations (SD). For this reason, we compared the two data sets using an unpaired Student's t-test. Depending on the conditions, the qualitative variables were examined using the Chi-square or Fisher's exact test, with frequency and

percentage (%) provided as inputs. A statistically significant result was defined as a two-tailed P value below 0.05.

3. Results

There was statistically significantly higher mean value of resistive index "RI" in patients' group than control group. Table 1

Table 1. Comparison of RI in all studied groups

	PATIENTS GROUP (N=30)	CONTROL GROUP (N=30)	P-VALUE
RI	0.70 ± 0.04	0.67 ± 0.04	0.006*

Data are presented as Mean ± SD. *p-value <0.05 is significant.

There is no notable link between the gender of patients and the resistive index (RI) in either the patient group or the control group. Table 2

Table 2. Association between RI and sex among patients and control groups

		PATIENTS GROUP (N=30)	CONTROL GROUP (N=30)
RESISTIVE INDEX	Male (n=14)	0.7 ± 0.04	0.67 ± 0.03
	Female (n=16)	0.7 ± 0.05	0.67 ± 0.04
P-VALUE		0.861	0.921

Data are presented as Mean ± SD.

15 patients (50%) were taking treatment, while the range of duration of HTN 0.25-35 years with mean 9.66 ± 8.43 years. Table 3

Table 3. Treatment and duration of HTN among patients' group

	PATIENTS GROUP N=30
TREATMENT	15 (50%)
DURATION OF HTN (YEARS)	9.66 ± 8.43

Data are presented as Mean ± SD or number (%).

No statistically significant differences were seen between groups when analyzed by age and gender. Table 4

Table 4. Comparison of age and sex in all studied groups

		PATIENTS GROUP (N=30)	CONTROL GROUP (N=30)	P-VALUE
AGE (YEARS)		51.10 ± 11.45	51.87 ± 11.55	0.797
SEX	Male	14 (46.7%)	17 (56.7%)	0.438
	Female	16 (53.3%)	13 (43.3%)	

Data are presented as Mean ± SD or number (%). p-value >0.05 is insignificant.

There was a significantly higher mean value of resistive index "RI" in non-treated group than treated group among patients' group. Table 5

Table 5. Compression of RI in all studied groups

	NON-TREATED (N=15)	TREATED (N=15)	P-VALUE
RI	0.71 ± 0.03	0.68 ± 0.05	0.027*

Data are presented as Mean ± SD.*p-value <0.05 is significant.

The resistive index of the patients' group had a positive correlation with the duration of HTN, measured in years, and this relationship was shown to be statistically significant. Since the p-value is above 0.05, we can confidently exclude the possibility of any link between age and the resistive index. No association was seen between age and the resistance index of the control group. Table 6

Table 6. Correlation between RI with age and duration of HTN, using Pearson Correlation Coefficient among patients and control groups

	RESISTIVE INDEX (RI)	
	r	p-value
PATIENTS' GROUP		
AGE (YEARS)	0.304	0.102
DURATION OF HTN (YEARS)	0.671	<0.001**
CONTROL GROUP		
AGE (YEARS)	0.653	<0.001**

r-Pearson Correlation Coefficient. p-value >0.05 is insignificant; **p-value <0.001 is highly significant.

Case 1:

Clinical data: A 40 -year- old female patient presented with HTN for 10 yrs. Figure 1, Table 6

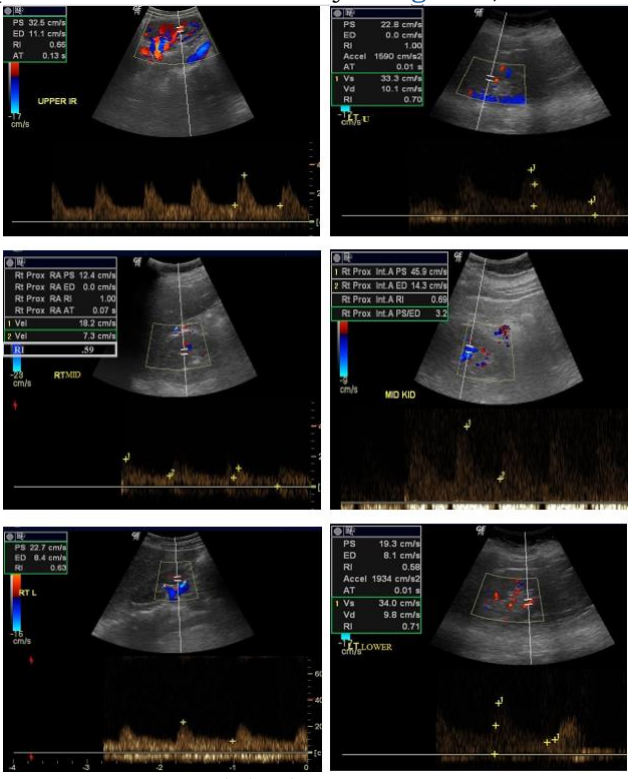

Figure 1. Renal duplex

Table 7. Renal duplex

RIGHT UPPER INTERLOBAR ARTERY RI	0.66
RIGHT MID INTERLOBAR ARTERY RI	0.59
RIGHT LOWER INTERLOBAR ARTERY RI	0.63
RIGHT MEAN RI	0.62
LEFT UPPER INTERLOBAR ARTERY RI	0.70

LEFT MID INTERLOBAR ARTERY RI	0.69
LEFT LOWER INTERLOBAR ARTERY RI	0.71
LEFT MEAN RI	0.7
MEAN RI OF BOTH KIDNEYS	0.66

Conclusion: Early nephrosclerosis with an elevated RI compared to a normal age matched individual.

Case 2:

Clinical data: A 75 -year- old Male patient presented with HTN for 20 years. Figure 2,Table 7

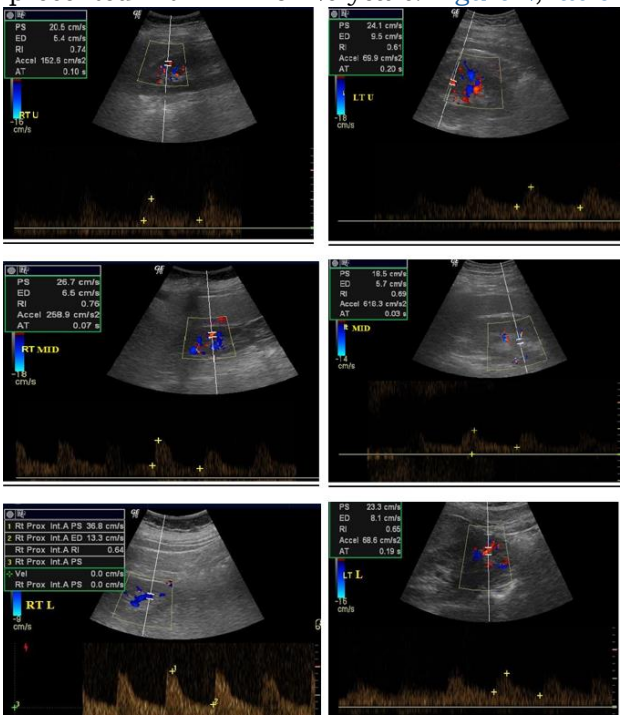

Figure 2. Renal duplex

Table 8. Renal duplex

RIGHT UPPER INTERLOBAR ARTERY RI	0.74
RIGHT MID INTERLOBAR ARTERY RI	0.76
RIGHT LOWER INTERLOBAR ARTERY RI	0.64
RIGHT MEAN RI	0.71
LEFT UPPER INTERLOBAR ARTERY RI	0.61
LEFT MID INTERLOBAR ARTERY RI	0.69
LEFT LOWER INTERLOBAR ARTERY RI	0.65
LEFT MEAN RI	0.65
MEAN RI OF BOTH KIDNEYS	0.68

Conclusion: Early nephrosclerosis with an elevated RI compared to a normal age matched individual.

4. Discussion

The increasing prevalence of primary hypertensive nephropathy necessitates the development of novel indicators for the timely identification of hypertensive nephropathy. HTN is positioned as the second major etiologic of ESRD, following diabetes.[1] Identifying target organ damage is essential for evaluating the overall risk and treating individuals with primary HTN. Doppler sonography enables the use of noninvasive techniques to study the blood flow in the kidneys. The RRI, as evaluated by Doppler ultrasonography, indicates the resistance level in the blood vessels inside the kidney. [4]

The patients' mean age ranged from 35 to 70 years, and their mean duration of HTN was 9.66±8.43 years, according to our research. The average RRI was substantially greater in persons with primary HTN compared to healthy individuals of the same age (0.70±0.04) versus (0.67±0.04). The results align with those of Galesić et al.[7], who discovered a strong positive relationship between essential HTN and intrarenal RI. In their study, the average RI in hypertensive patients was 0.66 ±0.05, whereas in healthy controls it was 0.60 ±0.03 (p = 0.0001). According to their findings, the RI may be a helpful indicator for evaluating the hemodynamic patterns of blood flow in the kidneys and the arteries surrounding the kidneys in individuals suffering from essential HTN. Renal failure may occur in HTN individuals if their renal vascular RI increases, which may be an indication of hypertensive nephrosclerosis. The renal vascular RI offers a novel, non-invasive approach for monitoring patients with essential HTN.

Pontremoli et al. and Terry et al.[3,8] reported that Renal resistance is influenced by two well-recognized factors: HTN and age. Stavros and Harshfield et al.[9] The possible reason for the modest rise in renal insufficiency in patients with advanced hypertensive vascular lesions might be attributed to the impact of arteriolosclerosis, which may diminish vascular compliance to a level where Doppler measures no longer accurately represent hemodynamic alterations. The Doppler waveform exhibits a reduction in the late systolic peak, enabling an accurate interpretation of the Doppler data. Pontremoli et al. and Doi et al.[3,10] also found that Patients with essential HTN and normal renal function saw increased RRI. Doi et al.[10] found that the mean RRI in patients with primary HTN is 0.62 for men and 0.67 for females.

Pontremoli et al. & Ratto et al.[3,11] considered the elevated RRI to be an indicator of atherosclerotic damage to blood vessels.

Hashimoto and Ito et al.[12] supported our results and found a positive relationship between RRI and primary HTN. They emphasized that abnormal renal hemodynamics are characterized by elevated peripheral resistance and/or enhanced flow pulsation.[12]

This matches the hypothesis approved by Afsar et al.[13] that RRI is affected by age, pulse pressure, greater systemic 24-hour blood pressure load, and increased sympathetic activity. The correlation between RRI and primary HTN was previously investigated by Derchi et al.[14], who found an increased parenchymal impedance to blood flow in primary hypertensive patients.

Pearce et al.[15] Examined the correlations between Doppler-derived renal parenchymal RI parameters and cardiovascular morbidity and death in individuals with primary HTN. Cardiovascular events are more common in hypertensive patients and may be associated with increased intrarenal stiffness and resistance to blood flow, according to the results. Left ventricular hypertrophy (LVH) and other forms of hypertensive and atherosclerotic organ damage are indicated by an increased RRI.[10] Elevated RRI is regarded as a marker of heightened cardiovascular risk profile in primary HTN.[3] Various papers have provided RRI threshold values for renal impairment and poor prognostic renal outcome, which range from 0.60 to 0.79. Our research results align with these findings, as the mean RRI in primary HTN was measured to be between 0.66 and 0.74, with an average of 0.70±0.04.[16,17,18,19] Messerli considered peripheral arterial resistance the hallmark for hemodynamic changes to detect the severity of arterial HTN. [20]

Multiple studies have been reported about the importance of duplex Doppler ultrasonography in evaluating renal vascular impedance in individuals with primary HTN.[21,22,23]

In the Galesic et al.[7] study, RRI in primary HTN was significantly elevated compared to normal subjects, which is also our study's result.

They studied 80 patients with essential HTN, who had a mean age of 45 years ranging from 24-76 years, and 65 normal controls with a mean age of 43.2 ranging from 19-75 years. They reported that RRI in primary hypertensive is higher than their normal control with p-value < 0.01.

They explained the increase in RRI caused by hypertensive arteriolar alteration and diminished renal blood flow due to arteriolar constriction during the early stage of primary HTN.

They considered renal duplex an important diagnostic tool for essential HTN. [24]

Aleksander et al.[25] found a significant positive correlation between RRI and primary HTN, where the RRI in true resistant primary HTN was 0.62 ± 0.05 and in well-controlled HTN was 0.60 ± 0.05.

The rise in RRI indicates alterations in intra-renal blood flow and systemic hemodynamics and the existence of subclinical atherosclerosis. [26, 27]

Our research found a notable association between the average RRI (R-R interval) and the duration of HTN. However, we did not observe a significant link between the average RRI and the patient's age.

Aleksander et al.[27] discovered a correlation between elevated RRI and age in individuals with primary HTN. Patients exhibiting elevated RRI were distinguished by a higher mean age of 52.2 ± 4.9, with a statistically significant p-value of 0.006, in contrast to our findings, which yielded a p-value of 0.102.

Galesić et al. found that RRI is correlated to the duration with a value < 0.02, matching our study. However, the correlation between RRI and the age of patients was significant as a p-value < 0.0001, which does not match our results, p-value> 0.05. [7, 24]

4. Conclusion

The average RRI in persons with primary HTN is much higher than in normal control participants, with statistical significance. There is a positive correlation between the duration of HTN and the RRI. Renal Doppler is an important non-invasive method used to examine alterations in renal blood flow and detect first indications of hypertensive nephropathy. Hence, renal duplex is regarded as an essential prognostic and diagnostic instrument for severe HTN.

Disclosure

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