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Original Article

Frequency of Diabetic Nephropathy Using Renal Resistive Index in Type 2 Diabetics with Normal Albuminuria

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Abstract

Objective: To assess the prevalence of diabetic nephropathy using the renal resistive Index in patients with Type 2 diabetes and normal albuminuria.

Methodology: This cross-sectional study was conducted in the Department of Medicine, Karachi Teaching Hospital, from October 2025 to March 2026. A total of 280 individuals with type 2 diabetes of both genders and different age groups, with no known diabetic nephropathy and albuminuria below 30mg/g were included. We recorded gender, age, smoking, hypertension, diabetes duration, creatinine, eGFR, UACR, BMI, RRI, glucose, HbA1c, and ultrasonography findings. RRI >0.70 indicated high resistance. Data were analyzed using SPSS 23.

Results: We enrolled 280 individuals with type 2 diabetes mellitus and normal albuminuria, whom whom 165 (59%) were male and 115 (41%) were female. The mean age was 51 years, with elevated RRI (>0.70) in 23.2% (65 participants). Higher RRI was associated with longer diabetes duration, poorer glycaemic control, increased creatinine, lower eGFR, and greater overweight/obesity. Hypertension, smoking, and sex were not statistically significant.

Conclusion: This study concluded that renal resistive index can play a vital role in the early diagnosis of diabetic nephropathy in individuals with type 2 diabetes and normal albuminuria. The frequency of diabetic nephropathy (RRI >0.70) was 23.2%. The renal resistive index significantly correlated with fasting blood glucose, diabetes duration, HbA1c, serum creatinine, GFR, and lipid profile.

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Introduction

Diabetes mellitus is gradually increasing globally, posing a significant health concern. It affects around 537 million people worldwide and is expected to reach 783 million by 2045. This increased prevalence is associated with unhealthy lifestyles (e.g., low nutrition quality, lack of physical exercise), advanced age, and obesity. Low- and middle-income countries have the highest illness burden[1]. Diabetes mellitus affects 33 million people in Pakistan, with a prevalence of 26.7%. It is characterized by persistent hyperglycemia caused by insulin deficiency or resistance. Type 2 diabetes accounts for over 90% of all cases of DM[2]. Diabetes mellitus is a chronic hyperglycemic condition caused by insulin secretion, resistance, or both. Type 2 diabetes mellitus accounts for over 90% of all DM cases[3]. Chronic diabetes causes serious consequences in practically every human organ. Atherosclerosis, myopathy, neuropathy, stroke, Coronary heart disease, nephropathy, retinopathy, osteoporosis, and arthropathy are some of these medical conditions. The disease is associated with a significant mortality rate; a higher percentage of these fatalities are related to renal and cardiac disorders[4]. Diabetic nephropathy is the primary cause of renal diseases, including chronic kidney disease (CKD) and end-stage renal disease, worldwide. After 10 years of diabetes, around 40% develop diabetic nephropathy. Early identification and appropriate treatment are crucial to prevent progression of diabetic nephropathy and improve patient outcomes[5]. Diabetic nephropathy is diagnosed when GFR is less than 60 ml/min per 1.73 m² and urine albumin-to-creatinine ratio is more than 30 mg/g. These tests cannot detect disease in its early stages and only deviate from normal limits when structural or functional abnormalities are present[6]. A solid, sensitive, and safe approach is needed for early diagnosis of diabetic nephropathy.⁵ The renal resistive index can help to diagnose diabetic nephropathy early. Doppler ultrasonography can measure resistance in blood flow inside the renal arteries. It assesses renal vascular problems, including perfusion[7]. Conventional diagnostic approaches focus solely on glomerular function, but RRI examines changes in the renal parenchyma's vascular system [8]. A literature review found that the renal resistive index is a reliable, safe, and accurate early diagnostic tool for diabetic nephropathy. This approach is very efficient, even for patients with normal albuminuria levels[9]. There have been limited studies conducted in Pakistan on the role of RRI in diagnosing diabetic nephropathy in type 2 DM[10].

Materials and method

This cross-sectional study was conducted in the Department of Medicine, Karachi Teaching Hospital, from October 2025 to March 2026. After approval from the hospital research committee. The sample size was calculated using the WHO calculator with a 95% confidence level, a 3% margin of error, and an expected frequency of diabetic nephropathy with RRI >0.70 of 7.0%.¹⁰ Nonprobability consecutive sampling technique was used for data collection. A total of 280 individuals with type 2 diabetes of both genders and different age groups (above 18 years) with no known diabetic nephropathy and albuminuria below 30mg/g were included. Patients with a history of renal stones, known CKD, GFR <60ml/min/1.73 m², and Pregnant women were excluded from the study. We recorded all data, including gender, age, smoking, hypertension, diabetes duration, serum creatinine, eGFR, UACR, BMI, renal resistive index, fasting blood glucose, HbA1c, and renal ultrasonography findings, on a well-designed proforma. Once the patient was adequately prepared, we performed renal Doppler ultrasonography. We collected intrarenal arterial waveforms from representative areas of both kidneys. We computed RRI as (peak systolic velocity - end-diastolic velocity) / peak systolic velocity. We categorized RRI>0.70 as high.¹¹ Data were analyzed using SPSS version 23. We described continuous values as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. We used the chi-square test for categorical variables and the independent-samples t-test for uniformly distributed continuous variables. We used logistic regression to identify independent variables associated with high RRI. We considered $p < 0.05$ statistically significant.

Results

We enrolled 280 individuals with type 2 diabetes mellitus and normal albuminuria; 165 (58.9%) were male, and 115 (41.1%) were female. The mean age of the study participants was 51 years, and the majority were aged ≤ 60 years (245, 87.5%). hypertension was seen in 99(35.45) individuals and most of the individuals were overweight 194(69.1%). 56(20%) of the individuals were smoker and in 168(60%) individuals the duration of diabetes was ≤ 5 years while 112(40.0%) had diabetes for more than five years. We recorded family history of diabetes in 191 (68.2%) individuals, as shown in Table 1. Overall, 65 (23.2%) had elevated RRI (> 0.70). Individuals with elevated RRI had statistically higher UACR; however, all individuals had normal albuminuria.

Participants with increased RRI were older and had diabetes for a longer period of time. The average duration of diabetes was 8.0 ± 5.2 years, in contrast to 4.3 ± 3.7 years in those individuals with normal RRI. Glycemic control was similarly lower in the high-RRI group. The average HbA1c was $8.1 \pm 1.4\%$, compared to $7.2 \pm 1.1\%$ in the normal-RRI group. Patients with higher RRI had higher serum creatinine and lower eGFR, as shown in Table 2. Hypertension, smoking, and sex showed no statistical significance; however, hypertension was more prevalent in individuals with increased RRI. Overweight/obesity was also considerably higher in the higher-RRI population (89.2% vs. 76.7%, $p=0.024$). Diabetes duration showed the greatest clinical association. Among participants with increased RRI, 42 (64.6%) had diabetes for over five years, compared to 70 (32.6%) with normal RRI ($p < 0.001$), as shown in Table 3.

Table 1. Clinical and Demographic Characteristics of the Study Population (n = 280)

Variable	Frequency (n)	Percentage (%)
Age, years		
≤60	245	87.5
>60	35	12.5
Sex		
Male	165	58.9
Female	115	41.1
Duration of diabetes, years		
≤5	168	60.0
>5	112	40.0
Smoking status		
Yes	56	20.0
No	224	80.0
Hypertension		
Yes	99	35.4
No	181	64.6
Body mass index (BMI), kg/m ²		
Normal	57	20.4
Overweight	194	69.3
Obese	29	10.4
Family history of diabetes		
Yes	191	68.2
No	89	31.8

Table 2. Biochemical Parameters and Renal Resistive Index According to RRI Classification

Parameter	Normal RRI ≤0.70 (n = 215)	Elevated RRI >0.70 (n = 65)	p-value
Age, years	47.3 ± 9.6	54.1 ± 10.7	<0.001
Duration of diabetes, years	4.3 ± 3.7	8.0 ± 5.2	<0.001
Body mass index, kg/m ²	26.5 ± 3.1	28.3 ± 4.0	0.001
Fasting blood glucose, mg/dL	145.1 ± 37.8	163.7 ± 45.1	0.001
HbA1c, %	7.2 ± 1.1	8.1 ± 1.4	<0.001
Serum creatinine, mg/dL	0.88 ± 0.13	0.97 ± 0.18	<0.001
eGFR, mL/min/1.73 m ²	89.4 ± 13.8	80.6 ± 15.6	<0.001
UACR, mg/g	12.5 ± 6.3	16.1 ± 7.5	<0.001
Total cholesterol, mg/dL	181.7 ± 34.7	194.6 ± 39.6	0.009
Triglycerides, mg/dL	152.8 ± 58.2	176.4 ± 66.4	0.006
Mean RRI	0.65 ± 0.04	0.73 ± 0.02	<0.001

Renal resistive index; HbA1c: glycated hemoglobin; eGFR: estimated glomerular filtration rate; UACR: urinary albumin-to-creatinine ratio. Values are presented as mean ± standard deviation.

Table 3. Clinical Characteristics According to Renal Resistive Index Classification

Clinical characteristic	Normal RRI ≤0.70, n (%)	Elevated RRI >0.70, n (%)	p-value
Age, years			
≤60	196 (91.2)	49 (75.4)	0.001
>60	19 (8.8)	16 (24.6)	
Sex			
Male	129 (60.0)	36 (55.4)	0.518
Female	86 (40.0)	29 (44.6)	
Duration of diabetes, years			
≤5	145 (67.4)	23 (35.4)	<0.001
>5	70 (32.6)	42 (64.6)	
Hypertension			
Yes	70 (32.6)	29 (44.6)	0.081
No	145 (67.4)	36 (55.4)	
Smoking status			

Yes	39 (18.1)	17 (26.2)	0.154
No	176 (81.9)	48 (73.8)	
Body mass index			
Overweight/obese	165 (76.7)	58 (89.2)	0.025
Normal	50 (23.3)	7 (10.8)	

Renal resistive index. Values are presented as frequency and percentage.

Discussion

Diabetes mellitus is a disease of the poor in advanced nations, but an illness of the rich in underdeveloped countries. It affects a large portion of the global population, more than 220 million people, and is expected to affect around 440 million by 20303. Many issues in the form of organ damage owing to DM are occurring. Diabetes affects the body at both the micro- and macrovascular levels, causing blood pressure to fluctuate and the patient to become hypertensive[11]. Retinopathy, neuropathy, and nephropathy are the primary consequences, identified at the micro- and macrovascular levels [12,13]. Diabetic nephropathy (DN) is one of the most common microvascular problems caused by fibrosis and sclerosis of the renal arteries and parenchyma.DN results from glomerular basement membrane damage and tissue injury due to hypoxia, and it causes not only arteriole narrowing but also lower and upper urinary tract infections [14]. This damage produces kidney hypertrophy and afferent arteriole dilation. Afferent arteriole dilation raises glomerular filtration pressure and causes more injury to glomerular capillaries. Increased pressure also increases local shearing forces, contributing to mesangial cell hypertrophy and extracellular matrix secretion, initially of the basement membrane [15]. At this level, damage occurs when large protein molecules (primarily albumin) leak into the urine; this is called proteinuria (albuminuria) and can occur at the micro- or macrolevel, indicating initial kidney injury [16]. A total of 280 individuals with type 2 diabetes mellitus with normal albuminuria were enrolled in this study to determine the frequency of diabetic nephropathy using the renal resistive index. In our study, 65 (23.2%) had diabetic nephropathy (RRI >0.70). Our findings are similar to those of Shahid et al., who reported a similar frequency of DN [17]. A recent Pakistani study found that 64 (21.3%) of patients with T2DM with normal albuminuria had an increased RRI of ≥0.70[18]. This finding implies that even in the absence of conventional albuminuria, a significant number of normoalbuminuric diabetic individuals may exhibit abnormal renal vascular resistance. One of the most significant findings was the relationship between diabetes duration and RRI. In the

current study, 64.6% of those with high RRI had diabetes for over five years, compared to 32.6% of individuals with normal RRI. These results are physiologically plausible because chronic hyperglycemia can cause endothelial dysfunction, microvascular damage, vascular remodeling, and increased arterial stiffness. These modifications may raise intrarenal vascular resistance prior to traditional measures like albuminuria becoming problematic[19]. A recent study also found a substantial link between RRI and diabetes duration, supporting our findings [18].In our study, the high-RRI group had lower glycemic control. The average HbA1c was 8.1 ± 1.4%, compared to 7.2 ± 1.1% in the normal-RRI group. Chronic hyperglycemia is a significant cause of diabetic microvascular problems. Poor glucose management may thus contribute to renal vascular anomalies that Doppler can detect before significant clinical albuminuria occurs. These findings are similar to those reported by Joseph and Kharadi [19,20]. These findings suggest that a high RRI may occur in one-fifth to one-quarter of normoalbuminuric T2DM patients. In contrast, variations in patient selection, ultrasonography methodology, RRI measurement, and population variables can influence prevalence. As a result, the available information suggests that RRI should be investigated further as an early marker. Importantly, take the evidence cautiously, since RRI is affected by a variety of vascular and hemodynamic variables and is not limited to diabetic nephropathy.

Conclusion

The present study concluded that renal resistive index can play a vital role in the early diagnosis of diabetic nephropathy in individuals with type 2 diabetes and normal albuminuria. The frequency of diabetic nephropathy (RRI >0.70) was 23.2%. The renal resistive index significantly correlated with fasting blood glucose, diabetes duration, HbA1c, serum creatinine, GFR, and lipid profile.

Informed Consent

We obtained written informed consent from all participants before enrollment. Participants were informed of the study purpose, the voluntary nature of participation, confidentiality, and their right to withdraw without affecting their medical care.

Funding: This study received no external funding.

Conflict of Interest

The authors declare that they have no competing interests or conflicts of interest related to this study.

Ethical Approval

Ethical approval was obtained from the Karachi Institute of Medical Sciences & Ethics Review Committee (Approval Code/Ref. No. KIMS-PA-2024/186; Date of Approval: 12 September 2024).

Authors' Contributions

Sellal Ahmed: Conceptualization, study design, participant recruitment, data collection, data analysis, manuscript drafting, and critical revision of the manuscript.

Ajmaal Jami: Conceptualization, supervision, interpretation of findings, critical revision of the manuscript, and final approval of the version to be published.

Mahnoor Khan: Literature review, participant recruitment, data collection, data organization, data analysis, and manuscript revision.

Arshad Ali: Literature review, data organization, manuscript drafting and revision, reference verification, and final approval of the version to be published.

All authors: Reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work in accordance with ICMJE authorship criteria.

Data Availability

The data generated during this study are not publicly available because they contain potentially identifiable participant information. Relevant information may be made available by the corresponding author upon reasonable request, subject to ethical and confidentiality requirements.

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