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A Comprehensive Analysis of Resistive Index and Biochemical Parameters in Type-II Diabetes-Induced Nephropathy

Dr. Himarshi Upadhyay[1], Dr. Himalaya Hareshkumar Raval[2], Sandeep U[3], Dr. Parth R. Patel[4]

[1]Assistant Professor, Department of General Medicine, GMERS Medical Collegeand Hospital, Vadnagar, Gujarat, India

[2]Senior Resident, Department of General Medicine, Banas Medical College and Research Institute, Palanpur, Gujarat, India

[3]Assistant Professor, Department of General Medicine, Karuna Medical College Hospital, Chittur, Palakkad, Kerala, India

[4]Senior Resident, Department of General Medicine, GMERS Medical College and Hospital, Vadnagar, Gujarat, India

Corresponding Author: Dr. Parth R. Patel

Email ID: parth4632.pp@gmail.com

Abstract

Introduction: Among diabetic patients, diabetic nephropathy emerges as the most frequent microvascular complication, affecting approximately 30% of individuals with diabetes. Microalbuminuria is recognized as a risk factor for the progression to macroalbuminuria and overt nephropathy in the later stages of the disease. The resistive index (RI) has been identified as a non-invasive diagnostic measure, robustly indicating the outcome of renal function in patients with type 2 diabetes.

Material and Methods: A cross-sectional study was conducted with a sample size of 67 patients, including individuals diagnosed with type 2 diabetes mellitus. Patients with chronic kidney disease secondary to other causes were excluded from the study. Relevant biochemical investigations were obtained, and renal artery RI was recorded using USG. Statistical analysis was performed using the SPSS program, considering a p-value <0.05 as statistically significant.

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Results: In patients with diabetes mellitus, the mean RI was significantly higher in those with albuminuria compared to those without albuminuria. RI demonstrated significant associations with the duration of the disease and serum creatinine ($p < 0.01$).

Conclusion: The development of small vessel abnormalities in the kidneys is multifactorial in type 2 diabetes, reflecting vascular damage. The consequential elevation of renal RI serves as an indirect marker for diagnosing the severity of renal disease in diabetic patients.

Key Words: Diabetes, Nephropathy, Resistive Index, Albuminuria

Introduction

Diabetes mellitus has become one of the most prevalent non-communicable diseases worldwide. Characterized by hyperglycemia and glucose intolerance due to insulin deficiency, impaired insulin effectiveness, or a combination thereof, diabetes comprises a diverse group of disorders. Diabetic nephropathy, a predominant microvascular complication affecting approximately 30% of diabetic patients, underscores the severity of the disease [1].

Microalbuminuria, defined as the excretion of 30-300mg/day of albumin, serves as a pivotal risk factor for the progression to macroalbuminuria and subsequent development of overt nephropathy in the later stages of diabetes [2]. The pathogenesis of diabetic nephropathy involves hemodynamic alterations, including intraglomerular hypertension, heightened renal vascular resistance, and ischemic nephropathy [2]. Studies have demonstrated a significant correlation between the Resistivity Index (RI) of renal arteries and key parameters such as effective renal plasma flow, renal vascular resistance, and filtration fraction in chronic renal failure patients. Specifically, individuals with renal dysfunction secondary to type 2 diabetes mellitus exhibit a notably elevated RI compared to those with non-diabetic renal disease. RI, serving as a noninvasive diagnostic tool, robustly predicts renal function outcomes in type 2 diabetes patients, even when glomerular filtration rate patterns remain within the normal range.

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Notably, RI is significantly higher in type 2 diabetes patients with albuminuria compared to those without albuminuria [3, 4].

This study aims to evaluate the correlation between intrarenal artery resistive index and 24-hour albumin excretion, duration of illness, serum creatinine, and serum cholesterol in individuals diagnosed with type 2 diabetes mellitus.

Material and Methods

This cross-sectional study included a sample of 67patients diagnosed with type 2 diabetes mellitus, as per the American Diabetes Association criteria, within the age range of 18-70 years. Patients with renal artery stenosis and chronic kidney disease secondary to other causes were excluded. Informed consent was obtained from all participating patients.

The initial evaluation encompassed a detailed clinical history, biochemical investigations, urinalysis, and measurement of 24-hour urine albumin excretion. Albuminuria status was classified as per the American Diabetes Association standards: normal (<30 μg/mg), microalbuminuria (30–299 μg/mg), or macroalbuminuria (≥300 μg/mg) [5].

Blood investigations included measurements of serum creatinine and serum total cholesterol. Patients underwent ultrasound and Doppler assessment. Renal artery RI was recorded using a ultrasound machine. A curved array transducer (2-5Hz) was employed for intra-renal RI recording. Color and spectral Doppler were utilized to measure RI, automatically by the equipment. The average RI of the right and left kidneys was recorded.

67 patients with complete data were enrolled for statistical analysis. SPSS 19.0 was employed for data analysis, while Microsoft Word and Excel were used for graph generation. The relationship between the dependent variable, RI, and independent variables (24-hour albumin

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excretion, diabetes duration, lipid values, creatinine) was assessed using multiple regression analysis. The significance level was set at 5%, and statistical significance.

Results

A statistically meaningful distinction in RI was observed between the categories of patients with normoalbuminuria and those with albuminuria (0.62 ± 0.03 vs. 0.66 ± 0.04; P<0.05). Positive correlations were identified between RI and levels of 24-hour urinary albumin concentration when comparing normoalbuminuric, microalbuminuric, and macroalbuminuric patients. Notably, among the RI values of these three groups, the highest RI was observed in patients with macroalbuminuria, and the differences among these three groups were statistically significant (Figure 1).

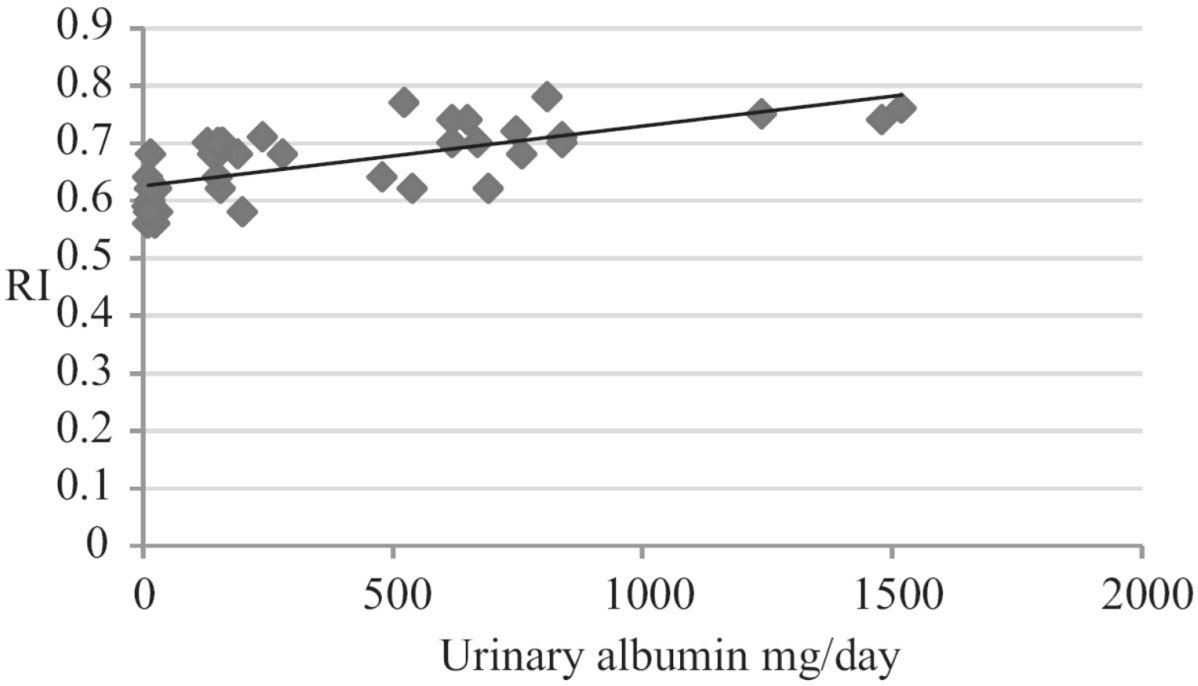

Figure 1: Correlation between RI and daily albumin excretion

Out of 67 patients, this study group comprised 37 subjects with a duration of 0-5 years and 30 patients with a duration exceeding 5 years. A statistically significant difference in RI was observed between the two groups, with 0-5 years patients showing a value of 0.69±0.07 and >5 years patients having a value of 0.718±0.05 (P<0.05) (Figure-2).

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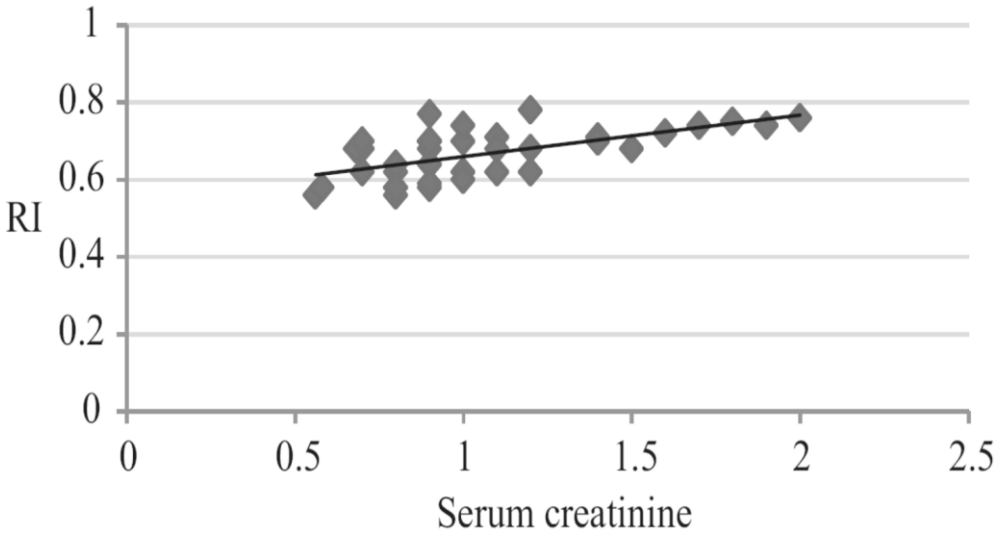

Figure 2: Correlation between RI and chronicity of disease

Out of 67 patients, this study group included 55 subjects with a creatinine level <1.2mg/dl and 12 patients with a creatinine level of >1.2mg/dl. A statistically significant difference in RI was observed between the two groups, with those having a creatinine level <1.2mg/dl showing a value of 0.67±0.05, and those with a creatinine level >1.2mg/dl having a value of 0.718±0.03 (P<0.05) (Figure-3).

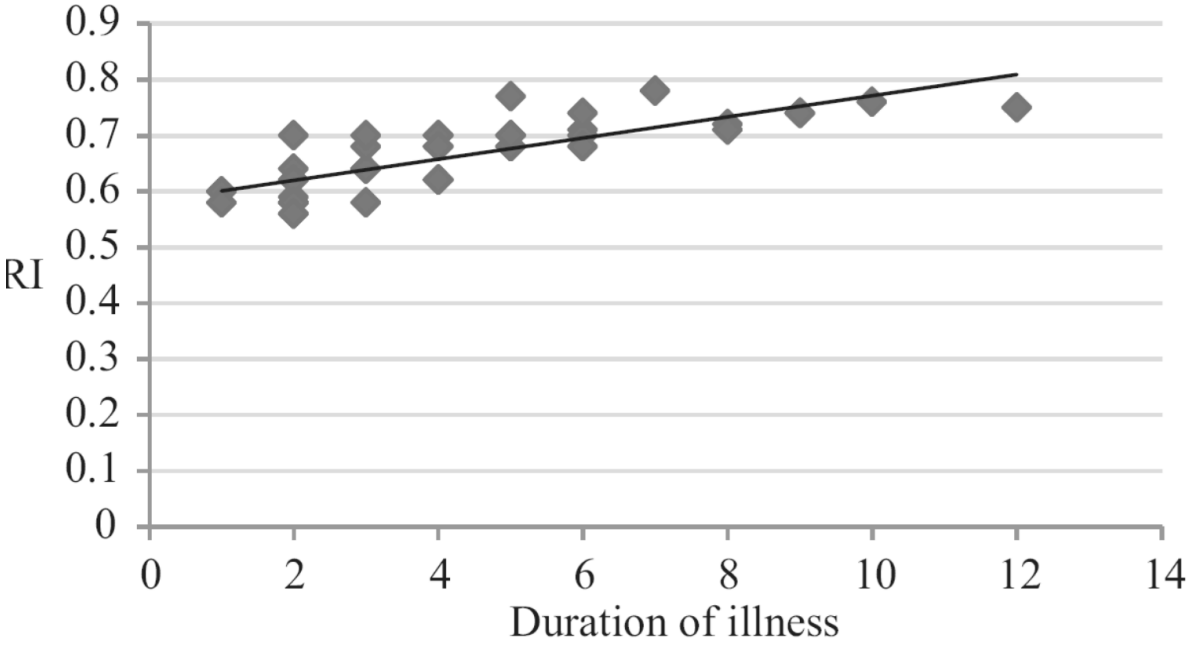

Figure 3: Correlation between RI and S. creatinine (mg/dl)

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Discussion

Microalbuminuria stands out as an early predictor for the onset and progression of diabetic nephropathy [6]. In the diagnosis of renal diseases, a comprehensive approach involves the patient's clinical history, physical examination, laboratory tests, diagnostic imaging, scintigraphy, and histopathology. Persistent microalbuminuria, defined by an albumin excretion rate of 20–200 μg/min or 30–300 mg/24 h, indicates early diabetic nephropathy. Overt diabetic nephropathy is characterized by proteinuria exceeding 500 mg/24 h or albuminuria surpassing 300 mg/24 h, with a decreased estimated glomerular filtration rate (eGFR) <60 ml/min/1.73 m^2 as another manifestation. Color and power Doppler offer a morphological and functional assessment of intraparenchymal vascularity, with the intrarenal RI being a sensitive parameter measured on renal parenchymal arteries, providing pathophysiological insights into nephropathy. An elevated intra-renal artery RI (≥0.7) predicts decreasing renal function in diabetic patients with micro or macroalbuminuria. This study investigated the association between intrarenal RI, albuminuria, duration of illness, serum creatinine, and serum cholesterol in type II diabetic mellitus patients [7].

The resistive index, as measured in parenchymal vessels, demonstrated higher mean RI values in those with albuminuria in our study. These findings align with studies indicating higher RI values in diabetic patients with renal dysfunction, positioning RI as a potential marker for diabetic nephropathy, even preceding the appearance of microalbuminuria. The study further revealed significantly higher RI in patients with macroalbuminuria, indicating a positive correlation between the severity of diabetic nephropathy and RI values. Notably, Doppler was identified as useful in the early diagnosis of diabetic nephropathy, showing a significant positive correlation between intra-renal RI and diabetic nephropathy, consistent with this study [8].

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While RI was suggested as an estimator for 24-hour urine protein, the absence of albuminuria in some diabetics with renal dysfunction highlights the complexity of this relationship. Regardless of albuminuria status, glomerular filtration rate is considered a risk factor for diabetic nephropathy, correlating with RI. Previous studies have established a significant correlation between RI and serum creatinine values in patients with microalbuminuria and clinically evident proteinuria, consistent with the current study's findings in patients with increased serum creatinine levels. The study also identified risk factors influencing kidney disease progression, including age, duration of illness, serum cholesterol, glycemic control, and blood pressure. Diabetics with a duration of illness >5 years showed significantly higher RI values compared to those with <5 years of duration [9-11].

Cholesterol and LDL-cholesterol levels are recognized predictors for atherosclerotic changes in diabetes [12]. However, serum cholesterol did not exhibit a statistically significant correlation with RI in this study. The development of small vessel abnormalities in the kidney, indicative of widespread vascular damage in type 2 diabetes, may result in an elevation of intrarenal resistive index. Most studies report RI values in diabetic patients ranging from 0.65 to 0.72, with a significant positive correlation with albuminuria, duration of illness, and creatinine, consistent with the current study. However, serum cholesterol did not exhibit a significant correlation with RI in type II diabetes mellitus patients in this study. Elevated RI was observed in type 2 diabetic patients with diabetic nephropathy and albuminuria, with duration of illness and serum creatinine identified as statistically significant covariables influencing RI.

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Conclusion

The RI holds promise as a valuable renal prognostic marker. The promptness and safety afforded by this investigation may facilitate the timely assessment of renal exacerbations, leading to more effective treatment interventions.

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