

Correlation of Renal Resistive Index, Serum Creatinine and Albuminuria in Patients with Diabetic Nephropathy

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ABSTRACT

Objective: To evaluate the correlation between renal resistive index (RI), serum creatinine and urinary albumin in patients with diabetic nephropathy.

Study Design: Prospective Analytical Study.

Place and Duration of Study: Department of Radiology, Combined Military Hospital, Multan Pakistan, from Jan to Aug 2025.

Methodology: This study was conducted on 80 patients with diabetic nephropathy. Renal Doppler ultrasound was used to measure RI, while serum creatinine and 24-hour urinary albumin were analyzed biochemically. Data normality was assessed using Shapiro-Wilk test and correlations were tested with Spearman's rank correlation. Post-stratification analysis was performed for age, gender, obesity, smoking, hypertension, diabetes duration and control. Significance was set at p -value ≤ 0.05 .

Results: Mean age of participants was 55.79 ± 8.05 years; 60% were males and 40% females. Median BMI was 27.80 (IQR 4.3) with obesity observed in 12.5%. Hypertension was present in 51.2% and smoking in 25%. Median serum creatinine was 1.40 mg/dL, urinary albumin 425 mg/24h and RI 0.71. RI showed significant positive correlation with serum creatinine ($r=0.506$, $p<0.001$) and urinary albumin ($r=0.354$, $p=0.001$). These correlations persisted across most stratified subgroups.

Conclusion: RI demonstrated strong positive correlation with both serum creatinine and urinary albumin, highlighting its role as a valuable, non-invasive imaging biomarker for early assessment of diabetic kidney disease.

Keywords: Creatinine, Diabetic Nephropathies, Doppler Ultrasonography, Renal Artery/Ultrasonography.

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INTRODUCTION

Diabetes mellitus (DM) represents one of the most significant global health challenges of 21st century with estimates suggest that around 537 million individuals were managing the disease worldwide in 2021 and approximately 14% of adults over the age of 18 living with this condition. DM contributes substantially to global mortality with an estimated 1.6 million deaths annually.¹ In Pakistan, type 2 diabetes affects nearly 33 million adults with a prevalence of 31.4% among individuals over the age of 18.² Diabetic nephropathy (DN) represents a serious long-term consequences of disease with significant morbidity and mortality.³ Diabetics are at a substantial risk of progressing to end-stage renal disease, nearly 40% of patients experience this complication during course of their illness.⁴ DN is characterized by the progressive renal failure, hypertension, and proteinuria.⁵ It is recommended to perform certain tests including urinary albumin, serum creatinine levels, urine microscopy and creatinine clearance.⁶

Resistive index (RI) by Doppler ultrasound is non-invasive modality which plays an important role in serious renal illnesses.⁷ It aids in assessing how well the kidneys are functioning. The typical RI value of intrarenal artery ranges from 0.53 to 0.68. An abnormal RI value is defined as 0.70 or greater.⁸ Duplex doppler ultrasound is better than conventional ultrasound in diagnosing kidney abnormalities in asymptomatic as well as symptomatic cases with DN.⁹ RI values rise in diabetic patients even prior to development of microalbuminuria.¹⁰

With the global prevalence of diabetes continuing to rise, early recognition of DN is crucial, as timely intervention can delay or prevent progression to end-stage renal disease. This study aimed to assess the correlation of renal resistive index (RI) measured by doppler ultrasound with albuminuria and serum creatinine, in order to evaluate its role in the early detection and monitoring of DN in our local population.

METHODOLOGY

This prospective analytical study was performed in department of Radiology, Combined Military

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Hospital Multan, Pakistan. Study was performed over a duration of eight months from Jan 2025 to Aug 2025 after obtaining permission from Institutional ethical committee (ERC No 10/2025 dated 2 Jan 2025). The sample size was estimated using the WHO calculator considering expected correlation between renal resistive index and serum creatinine ($r = 0.37$),¹¹ α value of 0.05 (two-sided) and power of 90%, our sample size came to 73 participants. The final target sample size was increased to 80. Patients were recruited through non-probability consecutive sampling.

Inclusion Criteria: Patients of either gender between the ages of 30 and 70, who were diagnosed cases of diabetes mellitus for at least five years and who had diabetic nephropathy (persistent albuminuria (>30 mg/day) which had been checked on minimum two occasions with interval of 4-6 months) were included.

Exclusion Criteria: Individuals with one kidney, pregnant women, renal artery stenosis (proven through medical record) and those currently receiving ACE inhibitor therapy were excluded.

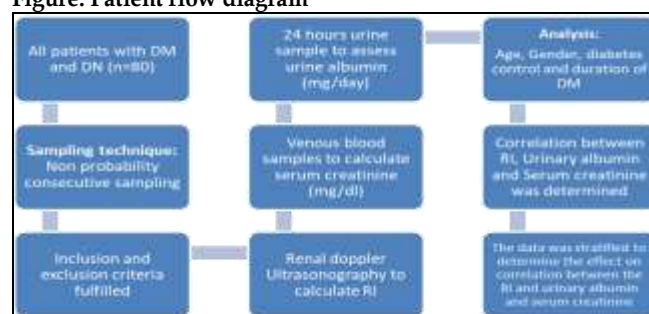
Following informed consent, 80 patients who met enrollment criteria and were referred to diagnostic radiology department for Ultrasound Kidney Ureter Bladder (KUB) were enrolled. Age, gender, BMI, obesity, diabetes duration, diabetes control, hypertension and smoking were among patient variables that were documented. BMI was measured by formula – weight in kg/height in meter² and a BMI of ≥ 30 kg/m² was taken as obese. Diabetes was labelled controlled if HbA1c <7% and uncontrolled if HbA1c $\geq 7\%$. Hypertension was deemed positive if patient is a known case of hypertension on antihypertensive therapy for ≥ 1 -year. A current smoker who has smoked ≥ 10 cigarettes /day for two years was labelled as smoker.

All patients then underwent Renal doppler ultrasonography in supine position (or lateral if needed), using LogiqS7 ultrasound machine (curvilinear 2-5 MHz and linear 6-10 MHz transducers). Kidneys were initially viewed using a real-time B-scan for assessing size, shape and echogenicity of kidneys. Using color doppler, spectral pattern of intrarenal arteries was obtained and for accurate measurement, velocity was taken with an angle. Renal resistive index (RI) was calculated by machine using a preset formula. RI was determined in intralobar or arcuate arteries of both kidneys. There were at least three readings from the upper, middle

and lower intrarenal arteries of each kidney. An average of all RI values was taken as final reading. All scan were performed by a consultant radiologist with more than 10 years post fellowship experience. Radiologist was not aware of results of serum creatinine and urinary albumin.

All patients then submitted blood sample for serum creatinine levels. Serum creatinine (mg/dl) was measured in laboratory using Jaffe's reaction achieved while performing alkaline sodium picrate method. Urine albumin (mg/day) was measured by 24-hour urine sample. All the data obtained was recorded on proforma. Patient flow diagram is shown in Figure.

Figure: Patient flow diagram



Data was examined through Statistical Package for Social Sciences version 25. Normality of numerical data was assessed through Shapiro-Wilk test. Age, duration of diabetes, renal RI, serum creatinine levels and albumin in urine were described as Mean $\pm$ SD if normally distributed (median and interquartile range if not normally distributed). Gender, obesity, hypertension, diabetes control and smoking were summarized as frequency and percentage. The correlation (r) between RI and urinary albumin and serum creatinine levels was examined with Spearman's rank correlation analysis. Data was stratified on age groups, gender, diabetes duration, diabetes control, hypertension, obesity and smoking to determine effect on correlation between the RI and urinary albumin and serum creatinine. Post-stratification Spearman's correlation (r) was calculated. A p -value ≤ 0.05 was taken as significant.

RESULTS

Our study included 80 participants with a mean age of 55.79 ± 8.05 years. The median (IQR) of BMI was 27.60 (3.9). In our study 10(12.5%) patients were classified as obese. The cohort comprised 48(60%) males and 32(40%) females as shown in Table-I.

Mean duration of diabetes mellitus was 10.68 ± 3.11 years. Hypertension was present in 41(51.2%) and absent in 39(48.8%) patients. Additionally, 20(25%) of patients were smokers and adequate glycemic control was observed in 37(46.3%) of study population as shown in Table-II. Renal parameters, including median (IQR) of serum creatinine, urinary albumin and renal resistive index are also shown in Table-II.

Table-I: Demographics of study participants (n=80)

Parameter(s)		Value n(%)
Age (years) -Mean $\pm$ SD		55.79 $\pm$ 8.05
Gender	Male	48(60%)
	Female	32(40%)
BMI in kg/m ² - Median (IQR)		27.80 (24.75-29.07)
Obesity	Yes	10(12.5%)
	No	70(87.5%)

Table-II: Clinical and renal metrics of Patients(n=80)

Parameter(s)		Value n(%)
Duration of Diabetes Mellitus (years) (Mean $\pm$ SD)		10.86 $\pm$ 3.11
Hypertension	Yes	41(51.2%)
	No	39(48.8%)
Smoking	Yes	20(25%)
	No	60(75%)
Glycemic control	Adequate	37(46.3%)
	Inadequate	43(53.7%)
Urinary albumin in mg/24 hour -Median (IQR)		425(399-457)
Serum creatinine in mg/dl -Median (IQR)		1.40 (1.19-1.50)
Renal resistive index -Median (IQR)		0.71 (0.65-0.73)

Table-III: Stratified Analysis of correlation between RI and serum creatinine (n=80)

Variable(s)	Subgroup	Correlation coefficient value (r)	p-value
Age (years)	≤ 50	0.388	0.112
	> 50	0.510	< 0.001
Gender	Male	0.553	< 0.001
	Female	0.437	0.012
BMI (kg/m ²)	≤ 30	0.555	< 0.001
	> 30	0.116	0.767
Duration of Diabetes Mellitus (years)	≤ 10	0.466	0.006
	> 10	0.523	< 0.001
Diabetic control	Inadequate	0.474	0.001
	Adequate	0.528	0.001
Hypertension	No	0.486	0.002
	Yes	0.512	0.001
Smoking	No	0.552	0.001
	Yes	0.403	0.078

Serum creatinine, urinary albumin and RI were not normally distributed and Spearman's rank correlation analysis demonstrated a moderate association between RI and both serum creatinine and urinary albumin. The correlation between RI and

serum creatinine was $r=0.506$ ($p<0.001$). RI and urinary albumin showed correlation of $r=0.354$ ($p=0.001$). Data was stratified on age groups, BMI, gender, diabetes duration, diabetes control, hypertension, obesity and smoking to determine the effect on correlation between RI and serum creatinine (Table-III).

Table-IV: Stratified Analysis of correlation between RI and urinary albumin (n=80)

Variable(s)	Subgroup	Correlation coefficient value (r)	p-value
Age (years)	≤ 50	0.562	0.015
	> 50	0.264	0.038
Gender	Male	0.372	0.009
	Female	0.362	0.042
BMI (kg/m ²)	≤ 30	0.418	< 0.001
	> 30	-0.376	0.319
Duration of Diabetes Mellitus (years)	≤ 10	0.346	0.049
	> 10	0.418	0.003
Diabetic control	Inadequate	0.561	< 0.001
	Adequate	0.058	0.733
Hypertension	No	0.292	0.072
	Yes	0.394	0.011
Smoking	No	0.305	0.018
	Yes	0.562	0.010

Table-IV demonstrates the effect of data stratification on correlation between RI and Urinary albumin. Subgroup analysis revealed a consistently positive correlation between urinary albumin and renal resistive index, with stronger associations observed in patients aged ≤ 50 years, males, those with BMI ≤ 30 , shorter diabetes duration, inadequate glycemic control, hypertensives and smokers.

DISCUSSION

The findings of this study demonstrate that renal resistive index is significantly associated with key markers of renal function, including serum creatinine and urinary albumin excretion, in patients with diabetes mellitus. Pakistan ranks among top ten countries worldwide in terms of diabetes prevalence and harbors one of the largest populations of individuals living with disease. Our study found that RI was significantly positively correlated with serum creatinine and urinary albumin levels. Lotfinejad et al. studied data on 82 patients with diabetes (aged between 17-67 years old).¹¹ They observed that correlation between RI and urinary albumin in patients with diabetes was 0.75, while between RI and Creatinine level, it was 0.37, which was significant. Their study reported a stronger correlation of RI with urinary albumin than ours, while our findings demonstrated a comparatively higher correlation

between RI and serum creatinine. Shirin *et al.*, evaluated renal RI by doppler ultrasound to detect renal abnormalities in 53 diabetic cases. RI ≥ 0.7 was found in 73% cases who had diabetes and mean RI was 0.7 ± 0.04 .¹² Positive correlation between RI with creatinine levels in serum ($r=0.58$) and albuminuria ($r=0.725$) was observed. Similar to our study, they observed RI ≥ 0.7 in a large proportion of diabetic patients, though their correlation coefficients with creatinine and albuminuria were stronger than those seen in our cohort.

Fatima *et al.*, studied patients with diabetic nephropathy, correlation analysis demonstrated significant associations between the RI and renal function markers.¹³ RI showed a moderate positive correlation with serum creatinine ($r = 0.490$, $p < 0.001$), indicating impaired renal function with higher values. A weak but significant negative correlation was noted between RI and urinary albumin excretion ($r = -0.257$, $p < 0.001$). In contrast to our results, they reported a negative correlation between RI and urinary albumin, whereas our study demonstrated a significant positive association with albuminuria. Another study established Patients with intrarenal RI ≥ 0.80 had a faster increase of serum creatinine levels compared to those with RI < 0.80 .¹⁴ A significant positive correlation was observed between RI and serum creatinine ($r = 0.438$, $p < 0.001$). RI also showed a positive association with microalbuminuria ($r = 0.245$, $p = 0.05$). Similar to our study, they confirmed a positive correlation between RI and both serum creatinine and microalbuminuria, although strength of correlation with albuminuria was weaker than in our results.

A study conducted by Krishna *et al.*, demonstrated RI showed a negative correlation with GFR ($r = -0.02$, $p = 0.001$) and a positive correlation with 24-hour urinary albumin excretion ($r = 0.03$, $p = 0.04$).¹⁵ These findings suggest that greater albuminuria and disease severity are associated with elevated RI values in diabetic nephropathy. Theerta *et al.*, studied RI as a marker of histopathological damage in chronic kidney disease and found that histopathological indices demonstrated a significant positive correlation with renal resistive index in diabetic patients, with the strongest association observed for tubulo-interstitial score.¹⁶ This established that RI may serve as a non-invasive marker of histological injury in diabetic kidney disease and its inclusion in routine evaluation of chronic kidney disease could improve assessment of intrarenal damage.

Mahashabde *et al.*, in their study concluded that RI could detect early kidney impairment in patients with diabetes and, when used alongside standard diagnostic tests, may improve detection and monitoring of diabetic kidney disease.¹⁷ Their conclusion that RI can detect early diabetic kidney damage is in line with our findings, supporting its utility as a non-invasive tool for early nephropathy detection. Ali *et al.*, found in their study that at a cutoff of > 0.68 , RI demonstrated an AUC of 1.0, perfectly distinguishing T2DM patients with diabetic nephropathy from those without, achieving 100% sensitivity, specificity, positive predictive value and negative predictive value ($p < 0.001$).¹⁸ While our study showed moderate predictive ability of RI, their results demonstrated exceptionally high diagnostic accuracy (AUC 1.0), suggesting possible differences in study design, population or sample size.

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LIMITATION OF STUDY

This study has several limitations that should be considered when interpreting results. First, it was conducted at a single center with a modest sample size, which may limit the generalizability of findings to broader populations. Second, while stratified analysis was performed to assess effect of demographic and clinical factors on the correlation between renal resistive index (RI), serum creatinine and albuminuria, some subgroups contained a small number of participants, potentially reducing statistical power and reliability of subgroup-specific correlations. Third, although RI measurements were performed by an experienced radiologist using standardized protocols, inter-observer variability and lack of blinding may have influenced measurements.

CONCLUSION

This study demonstrates that renal resistive index is significantly associated with key markers of renal function, including serum creatinine and urinary albumin excretion, in patients with diabetes mellitus. This indicates its potential as an early, non-invasive indicator of diabetic kidney injury. Top of Form

Conflict of Interest: None.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

MI & AL: Data acquisition, data analysis, critical review, approval of the final version to be published.

AH & NUK: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

AB: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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