

Comparison of Renal Doppler Indices in Normal Kidney and in Diabetic Nephropathy

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ABSTRACT

Objective: To assess and compare renal Doppler indices in normal and diabetic nephropathic kidneys to facilitate early diagnosis and intervention in diabetic nephropathy.

Study Design: Comparative Cross-sectional Study.

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

Methodology: Patients within the age range of 35 to 70 years with diagnosed diabetes mellitus for at least 10 years, referred for renal ultrasound as well as non-diabetic, normotensive patients of same age serving as controls were included in study. All individual were kept in two groups in a 2:1 ratio with Diabetic patients in Group-A, while non-diabetic, normotensive in Group-B (controls). Resistive Index (RI) and Renal-Aortic Ratio (R-AR) were recorded by Doppler ultrasound in both groups. ROC curve calculated with AUC value for differentiating diabetic Nephropathic kidney from normal kidney using RI and R-Ar as measures of diagnostic accuracy.

Results: Two hundred and forty six patients participated in this study, comprising 164 patients with diabetes and 82 non-diabetic patients with median age of 56.00(15.00) and 53.50(17.00) years respectively ($p=0.162$). Diabetic patients had significantly higher RI median 0.71(0.17) compared to control group 0.54(0.09) ($p<0.001$). Similarly, R-Ar was significantly elevated in diabetic patients 3.45(0.48) compared to controls 3.11(0.60) ($p<0.001$). The optimal RI cut-off value 0.635 provided sensitivity (72.6%), specificity (90.2%), PPV (93.7%), and NPV of 62.2%. The optimal R-AR cut-off 3.215, demonstrated sensitivity (79.9%), specificity (72.2%), PPV (85.1%), and NPV (64.1%).

Conclusion: Overall results indicated renal Doppler indices were significantly elevated in diabetic patients compared to controls, with strong diagnostic performance.

Keywords: Diabetes Mellitus, Diabetic Nephropathy, Microalbuminuria, Renal-Aortic Ratio, Renal Indices, Renal Resistive Index.

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INTRODUCTION

Diabetes mellitus (DM), has 28.5% prevalence in Pakistan and leads to micro as well as macro-vascular complications.¹ Diabetic nephropathy (DN) usually occurs due to microangiopathy of renal glomerular capillaries secondary to intra and extra renal atherosclerosis.² DN prevalence in our population reaches upto 30% in type-1 and 38% in type-2 diabetes mellitus.³ Microalbuminuria is an early indicator of diabetic nephropathy followed by macro-albuminuria and ultimately leading to reduced eGFR.⁴ Renal indices are also early independent predictors of developing diabetic kidney disease. In Diabetic patients, eGFR is sometimes reduced without presence of microalbuminuria, hence, renal indices are more accurate predictors for preemptive assessment of DN.⁵

Renal indices including Renal Resistive index (RRI) and Renal-Aortic ratio (R-AR) are well-

recognized markers of renal vascular and interstitial damage, corresponding to overall cardiovascular adverse events.⁶ RI reflects the flow resistance in renal parenchymal circulation especially small arteries and arterioles leading to scarring and interstitial fibrosis contributing to diabetic nephropathy. RI of >0.70 predicts renal dysfunction in diabetic patients.⁷ The RI is measured by renal Doppler ultrasound, a non-invasive and cost-effective tool which represents renal arteriosclerosis and an early indicator of diabetic nephropathy.⁸ Renal-Aortic ratio (R-Ar) describes the objective measure of renal artery diameter which directly correlates with renal perfusion and higher R-Ar >3.45 indicates renal atherosclerosis or aortic stenosis often due to DM.⁹

In a resource-constrained settings like ours, where access to advanced diagnostics may be limited at times, Doppler ultrasound offers a practical and affordable modality for the early detection of diabetic renal damage. The objective of this study was to compare renal Doppler indices in normal kidneys and diabetic nephropathic kidneys to facilitate early

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diagnosis and intervention in diabetic nephropathy. Incorporating such into routine diabetic care could significantly reduce the disease burden and associated complications in vulnerable populations.

METHODOLOGY

This study was conducted as a comparative cross-sectional study in the Department of Radiology, Combined Military Hospital, Multan Pakistan from January 2025 to September 2025, over a period of 9 months, following approval from the Institutional Ethical Committee (ERC 017/2025 dated 03 Jan 2025). The sample size was calculated using the OpenEpi online sample size calculator taking 95% confidence interval, 5% margin of error and power of the test 80%. Using the reported Odds ratio of 5.32 having a higher RI at a cut-off 0.66 in diabetic kidney disease patients with more than 5 years versus those with lesser duration, as reported by Li *et al.*, a sample size of 62 patients was estimated. However, 246 patients with diabetes were included in the study and were distributed in a 2:1 ratio between diabetic patients and non-diabetic controls.¹⁰

Inclusion Criteria: Patients aged 35 to 70 years with a diagnosis of diabetes mellitus for at least 10 years, referred for renal ultrasound as well as non-diabetic, normotensive patients aged 35 to 70 years referred to the radiology department for abdominal ultrasonography for non-renal indications, serving as controls were included in study.

Exclusion Criteria: Patients aged below 35 or above 70 years or having coexisting hypertension, heart failure, HIV, chronic Hepatitis B or C infection, polycystic kidney disease, traumatic kidney injury, or a history of surgical kidney intervention were all excluded from study.

Renal Doppler ultrasound was performed using standardized protocol parameters on all eligible patients. Diabetic patients referred for ultrasound of the abdomen and KUB were included in Group-A, while non-diabetic, normotensive individuals undergoing abdominal ultrasound for other clinical indications comprised Group-B (controls). Total 376 individuals (diabetic and non-diabetic) referred to radiology department for USG abdomen/KUB screened and 244 individuals fulfilling inclusion criteria were included as in 2:1 ratio after scrutiny. During assessment and data collection, 8 diabetic patients found to have associated HTN or IHD or renal artery stenosis and 11 individuals from control had undiagnosed DM, HTN or CKD were all excluded

from study. Hence, 164 diabetic and 82 non-diabetic control individuals were included in final analysis (Figure-1).

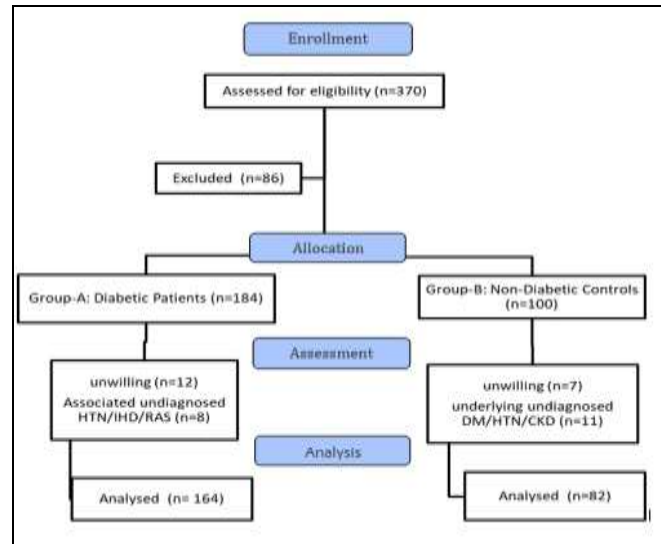


Figure-1: Patient Enrollment & Assessment Flow Diagram

Informed written consent was obtained from all patients at the time of inclusion in the study, and confidentiality of patient data was ensured at every step of the study. All ultrasound examinations were performed using a high-resolution ultrasound machine with a convex 3–5 MHz transducer. Patients were scanned in the supine and lateral decubitus positions after adequate hydration. A grayscale ultrasound was initially used to assess renal morphology and size. For Doppler evaluation, the segmental, interlobar, and arcuate arteries were assessed at the upper, mid, and lower poles of both kidneys. Doppler ultrasound parameters recorded included the Resistive Index (RI) and Renal-Aortic Ratio (R-AR).

The Resistive Index (RI) was calculated using the formula: $RI = \frac{\text{Peak Systolic Velocity} - \text{End Diastolic Velocity}}{\text{Peak Systolic Velocity}}$. Three measurements were taken from each kidney, and the average RI was recorded. An RI >0.70 considered indicative of increased intrarenal resistance. The Renal-Aortic Ratio (R-Ar) calculated by dividing the Peak Systolic Velocity of the renal artery by that of the abdominal aorta at the level just above the renal arteries. A standardized insonation angle of less than 60 degrees was maintained to ensure accuracy. These indices were calculated by two senior radiologists to ensure coherence and uniformity in measurements and were compared between the diabetic and control groups.

Variables including age, gender, fasting blood sugar (BSF), HbA1c, serum creatinine, renal size, RI, and R-AR were collected and analyzed using Statistical Package for Social Sciences software (SPSS v25.00). The normality of data checked using Kolmogorov-Smirnov test which revealed that the data was not normally distributed. Categorical data (gender) were presented as frequency and percentage, and continuous variables like age, BSF, HbA1c, serum creatinine, renal size, RI and R-Ar were summarized as median (interquartile range). Chi-square test was used to analyze categorical variables, while Mann-Whitney U test was applied to continuous variables. Correlation between RI / R-AR and serum creatinine was checked using Spearman correlation. ROC curve analysis was also done with AUC value for differentiating diabetic Nephropathic kidney from normal kidney using RI and R-Ar as measures of diagnostic accuracy. A p -value of ≤ 0.05 was considered statistically significant.

RESULTS

Two hundred and forty six patients enrolled including 164 patients with diabetes (Group-A) and 82 non-diabetic control participants (Group-B). The median age of diabetic patients were 56.00(15.00) years and control group had median age of 53.50(17.00) years ($p=0.162$). Gender distribution in both groups were statistically insignificant. The median BSF and HbA1c in diabetic groups were 145.30(27.10) mg/dL and 9.40(1.40) % respectively. The demographic and clinical characteristics of both groups are summarized in Table-I.

Table-I: Demographic and Clinical Characteristics of Study Participants (n=246)

Variable(s)	Group-A (Diabetic) (n=164)	Group-B (Control) (n=82)	p - value
Age (years) [Median(IQR)]	56.00(15.00)	53.50(17.00)	0.162
Gender	Male n(%)	85(51.8%)	0.360
	Female n(%)	44(53.6%)	
Fasting Blood Sugar (mg/dL) [Median(IQR)]	145.30(27.10)	99.98(13.90)	<0.001
HbA1c (%) [Median(IQR)]	9.40(1.40)	5.10(0.80)	<0.001
Serum Creatinine (mg/dL) [Median(IQR)]	95.50(59.00)	78.50(27.00)	<0.001
Renal Size (cm) [Median(IQR)]	9.50(1.70)	9.80(1.20)	0.03

The comparison of renal Doppler indices between the two groups revealed significant differences. Diabetic patients had a significantly higher Resistive Index (RI) with a median(IQR) of 0.71(0.17) compared to the control group with a median(IQR) of 0.54(0.09)

($p<0.001$). Similarly, the Renal-Aortic Ratio (R-AR) was significantly elevated in diabetic patients 3.45(0.48) compared to controls who had R-AR of 3.11(0.60) ($p<0.001$) (Table-II).

Table-I: Comparison of Renal Doppler Indices between Diabetic and Control Groups (n=246)

Doppler Index	Group-A (n=164)	Group-B (n=82)	p -value
Resistive Index (RI)			
Median (IQR)	0.71(0.17)	0.54(0.09)	<0.001
RI >0.70, n(%)	88(53.65%)	0 (0.0%)	<0.001
Renal-Aortic Ratio (R-AR)			
Median (IQR)	3.45(0.48)	3.11(0.60)	<0.001
R-AR ≥ 3.5 , n(%)	70(42.68%)	5(6.09%)	<0.001

Receiver Operating Characteristic (ROC) analysis for distinguishing diabetic nephropathy using the Resistive Index (RI) yielded an area under the curve (AUC) of 0.876 (95% CI: 0.834–0.918, $p<0.001$). The optimal cut-off value derived from ROC analysis for RI was 0.635, providing a sensitivity of 72.6%, specificity of 90.2%, positive predictive value (PPV) of 93.7%, and negative predictive value (NPV) of 62.2%.

Similarly, the ROC analysis for the Renal-Aortic Ratio (R-AR) indicated an AUC of 0.836 (95% CI: 0.783–0.889, $p<0.001$). The optimal cut-off for R-AR was 3.215, demonstrating sensitivity of 79.9%, specificity of 72.2%, positive predictive value (PPV) of 85.1%, and negative predictive value (NPV) of 64.1% (Figure-2).

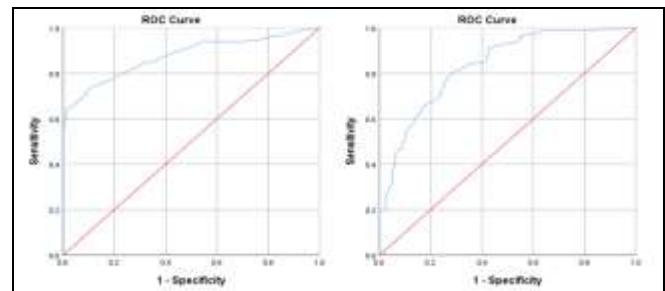


Figure-2: ROC Curves for Resistive Index (AUC = 0.876) and Renal-Aortic Ratio (AUC = 0.836)

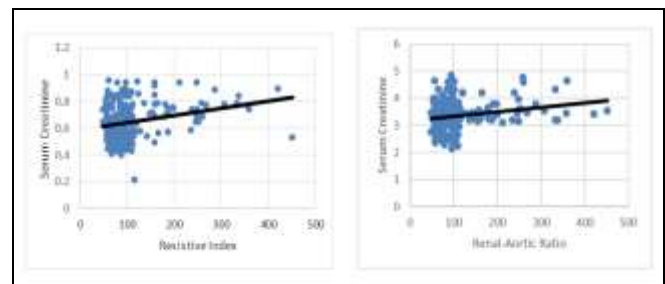


Figure-3: Scatter plots showing Linear relationship between Serum Creatinine and RI/RAR

A weak but statistically significant positive association between renal resistive index and serum creatinine was observed ($\rho=0.179$, $p=0.005$). For R-AR, a weak but statistically significant positive relationship between serum creatinine and renal aortic ratio was seen ($\rho=0.177$, $p=0.005$) (Figure-3). However, overall analyses indicate that renal Doppler indices are significantly elevated in diabetic patients compared to controls, with strong diagnostic performance.

DISCUSSION

This study demonstrated that intra-renal Doppler indices were markedly elevated in patients with long-standing diabetes mellitus compared to non-diabetic normotensive controls. Diabetic subjects exhibited a median resistive index of 0.71 (IQR 0.17) versus 0.54 (IQR 0.09) in controls ($p<0.001$), and a median renal-aortic ratio of 3.45 (IQR 0.48) versus 3.11 (IQR 0.60) in controls ($p<0.001$). In a study, Li *et al.*, studied the changes in renal indices in diabetic kidney disease and noticed significantly higher RI in the diabetic patients as compared to non-diabetic individuals (0.70 vs. 0.63, $p<0.001$) with RI cutoff value of 0.66 for predicting diabetic kidney disease with sensitivity and specificity of 69.2% and 80.9% respectively.¹⁰ Another study concluded similar findings that mean intra-renal RIs were comparatively higher in diabetic patients with nephropathy (0.61 ± 0.04) and without nephropathy (0.60 ± 0.04) in comparison to control healthy non-diabetic individuals (0.56 ± 0.04) ($p=0.02$).¹¹

It was observed that renal indices were significantly higher in diabetic patients and were correlated with duration of diabetes and glycemic control as well. Afsar *et al* reported similar results that diabetic patients tend to have higher RI which is indirect indicator of renal atherosclerosis leading to diabetic nephropathy with higher positive predictor value.¹²

ROC analyses underscored the strong discriminative capacity of these indices, yielding an AUC of 0.876 for RI (optimal cutoff 0.635; 72.6% sensitivity, 90.2% specificity) and an AUC of 0.836 for R-AR (optimal cutoff 3.215; 79.9% sensitivity, 72.2% specificity). These results suggested that both RI and R-AR had served as reliable sonographic markers for detecting diabetic nephropathy in routine ultrasound settings. Khairallah *et al.*, observed that diabetic patients with diabetic nephropathy (DN) had longer duration of diabetes (10.45 ± 1.11 vs. 4.09 ± 0.56 years, $p<0.001$) and higher RI as compared to DM patients without DN (0.89 ± 0.11 vs. 0.49 ± 0.18 , $p<0.001$). He also

concluded that at cutoff point >0.73 , RI had 82.5% diagnostic accuracy for prediction and diagnosis of DN with AUC of 0.837.¹³ El-Dayem *et al.*, reported that RI had high sensitivity (75.5%) and specificity (92.5%) along with high PPV (100%) and NPV (80.1%) indicating renal indices role as screening test for early kidney disease in patients with DM.¹⁴

In this study, the Renal-Aortic Ratio (R-AR) was noted to be significantly elevated in patients with DM median R-AR 3.45(0.48) compared to non-diabetic controls 3.11(0.60) having AUC of 0.836 (95% CI: 0.783–0.889, $p<0.001$). These findings were in accordance with other studies as Cardoso *et al.*, explained in a cohort study that raised renal-aortic ratio >3.30 and increased aortic stiffness (HR=1.16, 95% CI: 1.00–1.34, $p=0.05$) were indirect indicators of underlying Diabetic kidney disease and independent predictors of development or progression of diabetic nephropathy (DN).¹⁵ Vollema *et al.*, also reported patients having renal dysfunction and deteriorating GFR had higher R-AR and moderate to severe aortic stiffness with positive predicting value for CKD.¹⁶

Despite their diagnostic performance, the weak correlations observed between Doppler indices and serum creatinine ($\rho\approx0.18$ for both RI and R-AR, $p=0.005$) indicated that these hemodynamic measures had captured early microvascular alterations rather than overt declines in glomerular filtration. In another study by Nasir *et al.*, it was concluded that in the background of diabetes mellitus, renal RI had positive correlation with serum creatinine ($r=0.438$, $p<0.001$) and microalbuminuria ($r=0.245$, $p=0.05$). He also observed strong association of RI with HbA1c levels ($r=0.162$, $p=2.17$) and statistically significant association with duration of DM ($r=0.312$, $p=0.015$).¹⁷ As other studies also proved that early screening for CKD in diabetic patients is necessary, renal indices were independent and early predictors of diabetic kidney disease.¹⁸

Others studies also suggested that renal Doppler ultrasound with renal indices (RI & R-AR) allows it to predict and diagnose DN earlier than conventional markers of early kidney damage such as microalbuminuria and eGFR.¹⁹ Similarly, Darabont *et al* concluded that higher RI on renal Doppler ultrasound in patients with chronic kidney disease points towards underlying diabetic nephropathy as a causative factor of chronic kidney disease.²⁰

The findings of this study, highlighted renal indices potential utility in identifying subclinical renal

injury before significant biochemical impairment occurred, while also cautioning against relying on Doppler parameters in isolation for staging disease severity. It was inferred that combining RI and R-AR with established biomarkers such as estimated glomerular filtration rate and albuminuria could have enhanced early detection and risk stratification of diabetic kidney disease.

It is proposed that subsequent research should have tracked changes in RI and R-AR over time in relation to glycemic control and renoprotective treatments, to determine their value as monitoring tools. Moreover, it is also suggested that integrating Doppler indices into composite risk algorithms alongside emerging serum and urinary biomarkers might have further improved the early identification of diabetic nephropathy.

LIMITATION OF STUDY

Authors are well aware of limitation of current study foremost being the limited sample size and single center study. In this study, Type-1 and type-2 diabetics were not differentiated and renal indices were not compared between different types of diabetes. The effect of other diseases on renal indices including HTN, Dyslipidemia, CLD, IHD and PCKD were not studied in current study. Given the single-center, cross-sectional nature of the work, the investigators recognized that multicenter and longitudinal studies would have been required to validate these findings and define normal reference ranges across populations before implementing these findings on general population.

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CONCLUSION

The results indicate that renal Doppler indices were significantly elevated in diabetic patients compared to controls, with strong diagnostic performance. In diabetic patients, Renal RI directly correlates with HbA1c, duration of diabetes and with rising serum creatinine levels. Therefore, increased RI and R-AR serve as early and independent predictor of developing or ongoing diabetic nephropathy.

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Authors' Contribution

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

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

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

NS: 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.

REFERENCES

1. Azeem S, Khan U, Liaquat A. The increasing rate of diabetes in Pakistan: A silent killer. *Ann Med Surg* 2022; 79: 103901. <https://journals.lww.com/10.1016/j.amsu.2022.103901>
2. Selby NM, Taal MW. An updated overview of diabetic nephropathy: Diagnosis, prognosis, treatment goals and latest guidelines. *Diabetes Obes Metab* 2020; 22(S1): 3–15. <https://doi.org/10.1111/dom.14007>
3. Hussain S, Chand Jamali M, Habib A, Hussain MS, Akhtar M, Najmi AK. Diabetic kidney disease: An overview of prevalence, risk factors, and biomarkers. *Clin Epidemiol Glob Health* 2021; 9: 2–6. <https://doi.org/10.1016/j.cegh.2020.05.016>
4. Ceccarelli Ceccarelli D, Paleari R, Solerte B, Mosca A. Re-thinking diabetic nephropathy: Microalbuminuria is just a piece of the diagnostic puzzle. *Clin Chim Acta* 2022; 524: 146–153. <https://doi.org/10.1016/j.ccca.2021.11.009>
5. Sistani SS, Alidadi A, Moghadam AA, Mohamadnezhad F, Ghahderijani BH. Comparison of renal arterial resistive index in type 2 diabetic nephropathy stage 0–4. *Eur J Transl Myol* 2019; 29(4): 8364–8366. <https://doi.org/10.4081/or.2019.8364>
6. Ali N, Khalaf-Awad AM, Hm F, Hashim AEA, Abd ElRazik GM. Role of Renal Resistive Index in early detection of Diabetic Nephropathy in Type II Diabetic Patients. *SVU-Int J Med Sci* 2024; 7(1): 1011–1021. <https://doi.org/10.21608/svuijm.2023.236371.1700>
7. Maksoud AAA, Sharara SM, Nanda A, Khouzam RN. The renal resistive index as a new complementary tool to predict microvascular diabetic complications in children and adolescents: a groundbreaking finding. *Ann Transl Med* 2019; 7(17): 422–422. <http://dx.doi.org/10.21037/atm.2019.08.65>
8. K.C. T, Das SK, Shetty MS. Renal Resistive Index: Revisited. *Cureus* 2023; 15(3): e36091. <https://doi.org/10.7759/cureus.36091>
9. Majos M, Polguy M, Stefańczyk L, Derlatka-Kochel M, Wachowski M, Majos A. Renal-aortic ratio as an objective measure of renal artery diameter a computed tomography angiography study. *BMC Cardiovasc Disord* 2019; 19(1): 181. <https://doi.org/10.1186/s12872-019-1163-7>
10. Li H, Shen Y, Yu Z, Huang Y, He T, Xiao T, et al. Potential Role of the Renal Arterial Resistance Index in the Differential Diagnosis of Diabetic Kidney Disease. *Front Endocrinol* 2022; 12: 731187. <https://doi.org/10.3389/fendo.2021.731187>
11. Olanrewaju Jinadu Y, Raheem Raji Y, Oluwole Ajayi S, Lawal Salako B, Arije A, Kadiri S. Resistivity index in the diagnosis and assessment of loss of renal function in diabetic nephropathy. *Cardiovasc J Afr* 2022; 33(1): 28–34. <https://doi.org/10.5830/CVJA-2021-032>
12. Afsar B, Elsurur R. Increased renal resistive index in type 2 diabetes: Clinical relevance, mechanisms and future directions. *Diabetes Metab Syndr Clin Res Rev* 2017; 11(4): 291–296. <https://doi.org/10.1016/j.dsx.2016.08.019>

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13. Khairallah MK, Sobh MA, Mansour E, Ibrahim R, Mostafa MH. Renal Resistive Index as a Promising Tool in Early Identification of Diabetic Nephropathy. *Egypt J Hosp Med* 2023; 90(1): 1983–1987. <https://doi.org/10.21608/ejhm.2023.284774>
 14. Abd El Dayem SM, El Bohy AEM, Hamed M, Ahmed S. Follow Up of Value of the Intrarenal Resistivity Indices and Different Renal Biomarkers for Early Identification of Diabetic Nephropathy in Type 1 Diabetic Patients. *Open Access Maced J Med Sci* 2017; 5(2): 188–192. <https://doi.org/10.3889/oamjms.2017.034>
 15. Cardoso CRL, Leite NC, Salles GC, Ferreira MT, Salles GF. Aortic stiffness and ambulatory blood pressure as predictors of diabetic kidney disease: a competing risks analysis from the Rio de Janeiro Type 2 Diabetes Cohort Study. *Diabetologia* 2018; 61(2): 455–665. <https://doi.org/10.1007/s00125-017-4484-z>
 16. Vollema EM, Prihadi EA, Ng ACT, Gegenava T, Ajmone Marsan N, Bax JJ, et al. Prognostic Implications of Renal Dysfunction in Patients With Aortic Stenosis. *Am J Cardiol* 2020; 125(7): 1108–1110. <https://doi.org/10.1016/j.amjcard.2019.12.040>
 17. Nasir M, Maryam S, Qadir SA, Fatima M. Correlation Between Renal Artery Resistive Index and Renal Function Tests in Type II Diabetic Patients. *Avicenna J Health Sci* 2024; 1(3): 62–66.
 18. Christofides EA, Desai N. Optimal Early Diagnosis and Monitoring of Diabetic Kidney Disease in Type 2 Diabetes Mellitus: Addressing the Barriers to Albuminuria Testing. *J Prim Care Community Health* 2021; 12. <https://doi.org/10.1177/21501327211003683>
 19. Levey A, Inker L. Assessment of Glomerular Filtration Rate in Health and Disease: A State of the Art Review. *Clin Pharmacol Ther* 2017; 102(3): 405–419. <https://doi.org/10.1002/cpt.729>
 20. Darabont R, Mihalcea D, Vinereanu D. Current Insights into the Significance of the Renal Resistive Index in Kidney and Cardiovascular Disease. *Diagnostics* 2023; 13(10): 1687–1689. <https://doi.org/10.3390/diagnostics13101687>
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