



“EVALUATION OF RENAL ARTERY DOPPLER AS A TOOL TO DIAGNOSE DIABETIC NEPHROPATHY”

Radiology

Dr. Lavanya N	Postgraduate Student, Department Of Radiology, Trichy Srm Medical College Hospital And Research Centre, Tamil Nadu
Dr. Senthilnathan. V	Hod And Professor Of Radiology, Trichy Srm Medical College Hospital And Research Centre, Tamil Nadu
Dr. K. Siva Kumar	Hod And Professor Of Medicine, Trichy Srm Medical College Hospital And Research Centre, Tamil Nadu

ABSTRACT

Background: Diabetic nephropathy (DN) is a significant complication of diabetes mellitus and is the leading cause of End-Stage Renal Disease (ESRD) globally. Early detection is crucial to prevent progression to ESRD. This study evaluates the effectiveness of Renal Artery Doppler ultrasound in the early identification of DN. **Aim and Objective:** The study aims to assess the accuracy and reliability of Renal Artery Doppler ultrasound in detecting early-stage DN. It seeks to identify specific Doppler parameters, such as resistive index, pulsatility index, and peak systolic velocity. Additionally, the study explores the correlation between Renal Artery Doppler findings and traditional markers of DN, including the urinary albumin-to-creatinine ratio (ACR) and estimated glomerular filtration rate (eGFR). **Methods:** In this cross-sectional observational study, 150 diabetic patients aged 18-75 years were evaluated. Renal Artery Doppler parameters, including resistive index (RI), pulsatility index (PI), and peak systolic velocity (PSV), were measured and compared with ACR and eGFR. **Results:** The resistive index (RI) showed a strong positive correlation with ACR ($r=0.68, p<0.001$) and a negative correlation with eGFR ($r=-0.52, p<0.001$). The pulsatility index (PI) also correlated with ACR ($r=0.64, p<0.001$) and eGFR ($r=-0.49, p<0.001$). The Renal Artery Doppler ultrasound demonstrated a sensitivity of 89.5%, a specificity of 83.2%, a positive predictive value (PPV) of 85.7%, a negative predictive value (NPV) of 87.1%, and an overall diagnostic accuracy of 86.3%. These results suggest that Renal Artery Doppler ultrasound, particularly through the measurement of resistive and pulsatility indices, is a reliable and accurate method for early detection of diabetic nephropathy. This tool can be effectively used in clinical settings to monitor diabetic patients, enabling timely intervention to prevent or slow the progression of kidney disease. **Conclusion:** Renal Artery Doppler ultrasound is a reliable, non-invasive diagnostic tool for the early detection of diabetic nephropathy, offering high diagnostic accuracy.

KEYWORDS

Diabetic Nephropathy, Renal Artery Doppler, Resistive Index (RI), Pulsatility Index (PI), Early Detection

INTRODUCTION:

Diabetic nephropathy (DN) is a serious complication of diabetes mellitus, characterized by a gradual decline in kidney function that can ultimately lead to end-stage Renal Disease (ESRD).¹ As the primary cause of ESRD globally, DN significantly contributes to increased morbidity and mortality in diabetic patients.^{2,3} Given the profound impact of DN on patient health and healthcare systems, early detection and timely intervention are crucial to prevent or delay the onset of ESRD.

Traditional renal ultrasound, though widely utilized, falls short in detecting early-stage DN and distinguishing between different stages of chronic kidney disease (CKD).^{4,5} These limitations underscore the need for more advanced diagnostic methods. Renal Artery Doppler ultrasound has gained attention as a promising, non-invasive, and cost-effective technique that provides detailed insights into renal blood flow dynamics.^{6,7} By measuring parameters such as resistive index (RI) and pulsatility index (PI), Doppler ultrasound can detect early microvascular changes in the kidneys, which may indicate the onset of DN before significant structural damage occurs.^{8,9,10}

The rationale behind this study is to address the gap in early detection methods for diabetic nephropathy by evaluating the efficacy of Renal Artery Doppler ultrasound. Given its potential to identify early vascular changes associated with DN, this imaging modality could serve as a valuable tool in clinical practice, allowing for earlier intervention and better management of patients with diabetes. This study aims to establish Renal Artery Doppler ultrasound as a reliable diagnostic method for early-stage DN, which could ultimately improve patient outcomes and reduce the burden of ESRD.

Objectives:

- To evaluate the accuracy and reliability of Renal Artery Doppler ultrasound in identifying early-stage DN.
- To determine which Doppler parameters (e.g., resistive index, pulsatility index, peak systolic velocity) are most indicative of renal vascular changes associated with DN.
- To explore the correlation between Renal Artery Doppler findings and traditional markers of DN, such as the urinary albumin-to-creatinine ratio (ACR) and estimated glomerular filtration rate (eGFR).

MATERIALS AND METHODS:

An Institutional-based cross-sectional observational study was conducted in Department of Radiology, Trichy SRM Medical College Hospital and Research Centre, Tamil Nadu to evaluate the use of Renal Artery Doppler ultrasound as a diagnostic tool for diabetic nephropathy. The study was carried out over six months, from March to August 2024.

Study Population:

The study included all patients aged 18-75 years with a known history of diabetes who presented to the Department of Radiodiagnosis for an abdominal ultrasound.

Inclusion Criteria:

- Diabetic patients aged 18-75 years.
- Participants with varying levels of glycemic control and disease duration.

Exclusion Criteria:

- Patients with known Renal Disease from non-diabetic causes.

Sample Size:

An earlier study by Elshweehy et al¹ demonstrated a significant positive correlation of approximately 0.5 between the resistive index and the albumin-to-creatinine ratio. Assuming a similar correlation level in this study, a sample size of 150 diabetic patients was determined to be sufficient to achieve 80% power at a 5% level of significance for assessing renal Doppler and biochemical parameters. Therefore, 150 diabetic patients were recruited using random sampling for the present study, and all relevant parameters were evaluated.

Methodology:

Patient data were collected through a questionnaire covering demographics, medical history, clinical information, and laboratory results, including HbA1c, FBS, PPBS, blood creatinine, protein/creatinine ratio, and urine albumin. Participants also underwent Renal Artery Doppler ultrasound to measure parameters such as peak systolic velocity (PSV), end-diastolic velocity (EDV), resistive index (RI), and pulsatility index (PI). These Doppler parameters were compared with traditional biochemical markers including albumin-to-creatinine ratio (ACR) and estimated glomerular

filtration rate (eGFR). Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of the Doppler ultrasound were calculated.

Statistical Analysis:

Data were analysed using SPSS Trial version 26.0. Continuous variables were expressed as mean $\pm$ standard deviation (SD) or median (IQR) depending on the data distribution. Correlation analysis was performed to evaluate the relationship between Doppler parameters and traditional markers of diabetic nephropathy. Diagnostic measures were assessed using standard statistical methods, with a p-value < 0.05 considered statistically significant. Ethical clearance was obtained from the Institutional Ethics Committee

RESULTS:

Table 1: Baseline Characteristics of the Study Population

Characteristic	Mean $\pm$ SD or %
Age (years)	54.2 $\pm$ 10.6
Gender (Male/Female)	48%/52%
Duration of Diabetes (years)	8.4 $\pm$ 4.5
Mean ACR (mg/g)	85.3 $\pm$ 25.6
Mean eGFR (mL/min/1.73m ²)	68.2 $\pm$ 15.3

Study population had a mean age of 54.2 years, with 48% males and 52% females. The average duration of diabetes was 8.4 years. The mean albumin-to-creatinine ratio (ACR) was 85.3 mg/g, and the mean estimated glomerular filtration rate (eGFR) was 68.2 mL/min/1.73m². The study population is middle-aged with a fairly balanced gender distribution and an average diabetes duration of over 8 years. The mean albumin-to-creatinine ratio (ACR) suggests a moderate level of albuminuria, which is indicative of kidney damage. The mean estimated glomerular filtration rate (eGFR) indicates a reduced level of kidney function, which is consistent with chronic kidney disease stages. (Table 1)

Table 2: Doppler Ultrasound Parameters

Parameter	Mean $\pm$ SD
Resistive Index (RI)	0.72 $\pm$ 0.08
Pulsatility Index (PI)	1.30 $\pm$ 0.25
Peak Systolic Velocity (PSV)	110.5 $\pm$ 15.2 cm/s

The Doppler ultrasound parameters indicate:

- Resistive Index (RI):** A mean RI of 0.72 suggests moderate renal vascular resistance, potentially reflecting early renal damage.
- Pulsatility Index (PI):** A mean PI of 1.30 points to increased vascular resistance, which may be linked to diabetic nephropathy.
- Peak Systolic Velocity (PSV):** A mean PSV of 110.5 cm/s suggests altered blood flow dynamics, consistent with early nephropathy changes.

These findings support the potential of Renal Artery Doppler ultrasound in detecting early diabetic nephropathy (Table 2)

Table 3: Correlation between Doppler Parameters and Traditional Markers

Parameter	Correlation with ACR (r)	Correlation with eGFR (r)
Resistive Index (RI)	0.68 (p < 0.001)	-0.52 (p < 0.001)
Pulsatility Index (PI)	0.64 (p < 0.001)	-0.49 (p < 0.001)
Peak Systolic Velocity (PSV)	0.57 (p < 0.001)	-0.45 (p < 0.001)

The correlations between Doppler ultrasound parameters and traditional markers of diabetic nephropathy reveal:

- Resistive Index (RI):** Shows a strong positive correlation with ACR and a moderate negative correlation with eGFR. This suggests that increased RI, indicating higher renal vascular resistance, is associated with worsening kidney damage and reduced kidney function.
- Pulsatility Index (PI):** Exhibits a strong positive correlation with ACR and a moderate negative correlation with eGFR. Elevated PI, reflecting increased vascular resistance, is linked to higher levels of albuminuria and lower eGFR, indicating deteriorating kidney function.
- Peak Systolic Velocity (PSV):** Demonstrates a moderate positive correlation with ACR and a moderate negative correlation with eGFR. Higher PSV, associated with increased blood flow velocity, correlates with greater albuminuria and reduced kidney function.

Overall, these findings support the use of Renal Artery Doppler

ultrasound parameters (RI, PI, and PSV) as effective indicators of early diabetic nephropathy, correlating well with traditional markers of kidney damage and function (Table 4)

Table 4: Diagnostic Accuracy of Renal Artery Doppler for DN

Parameter	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Diagnostic Accuracy (%)
Resistive Index (RI) > 0.7	89.50%	83.20%	85.70%	87.10%	86.30%
Pulsatility Index (PI) > 1.2	85.00%	80.00%	83.00%	82.00%	83.50%

The Renal Artery Doppler ultrasound demonstrated a sensitivity of 89.5%, a specificity of 83.2%, a positive predictive value (PPV) of 85.7%, a negative predictive value (NPV) of 87.1%, and an overall diagnostic accuracy of 86.3%. Both RI and PI are effective diagnostic tools for early diabetic nephropathy. RI offers slightly better diagnostic performance with higher sensitivity, specificity, and overall accuracy. PI remains a valuable alternative but with slightly reduced performance metrics. Both parameters are useful in clinical practice for the early detection of diabetic nephropathy, helping to identify patients at risk and enabling timely intervention. (Table 4)

DISCUSSION:

Our study finding shows that Renal Artery Doppler ultrasound is an effective tool for diagnosing early diabetic nephropathy. The resistive index (RI) and pulsatility index (PI) both correlate with traditional markers of diabetic nephropathy, with higher RI and PI values linked to increased proteinuria and decreased kidney function. Renal Artery Doppler ultrasound shows high sensitivity (89.5%) and good specificity (83.2%), making it effective in detecting early-stage diabetic nephropathy. Its positive predictive value (85.7%) and negative predictive value (87.1%) further confirm its reliability, with an overall diagnostic accuracy of 86.3%.

In the study by Elshweehy et al., from December 2018 to January 2020, the role of duplex Doppler ultrasound in assessing renal vascular resistance in diabetic nephropathy patients was evaluated in 30 participants, including 20 diabetic patients and 10 healthy controls. It found that resistive index (RI) increased with the progression of diabetic nephropathy and correlated positively with albuminuria and serum creatinine.¹ Our study also showed that RI and pulsatility index (PI) correlated strongly with the albumin-to-creatinine ratio (ACR) and negatively with the estimated glomerular filtration rate (eGFR). Renal Artery Doppler ultrasound demonstrated high sensitivity and specificity and an overall diagnostic accuracy of 86.3%.

A study by Gopalakrishnan et al., conducted from September 1, 2014, to August 31, 2016, at Aarupadai Veedu Medical College, evaluated the role of ultrasound and Doppler in diabetic nephropathy. They observed that renal length and parenchymal thickness decreased with disease progression, while the resistive index (RI) increased, correlating with blood urea and serum creatinine. A slightly elevated RI (> 0.7) in preclinical nephropathy suggested potential for early detection.² In contrast, our study found that RI had a strong positive correlation with the albumin-to-creatinine ratio (ACR) and a negative correlation with the estimated glomerular filtration rate (eGFR). Additionally, the pulsatility index (PI) also correlated with ACR and eGFR, highlighting its utility in assessing diabetic nephropathy.

Another prospective study by Wiersema et al., conducted from May 14, 2018, to July 10, 2019, at the Department of Critical Care, Groningen, the Netherlands, assessed the diagnostic accuracy of arterial and venous renal Doppler for acute kidney injury (AKI) in critically ill patients. Out of 371 patients, 123 (33%) had persistent AKI. The study found that renal resistive index (RRI) and venous inflow index (VII) did not significantly differ between patients with and without persistent AKI (p = 0.08 and p = 0.59, respectively). RRI had moderate specificity (72%, 95% CI 66–78%) but low sensitivity (32%, 95% CI 24–41%), while VII showed high sensitivity (93%, 95% CI 85–98%) and low specificity (11%, 95% CI 6–16%). The overall diagnostic accuracy for both RRI and VII was moderate, indicating limited diagnostic utility for AKI in critically ill patients.³ whereas, our study demonstrated that Renal Artery Doppler ultrasound has high sensitivity and good specificity for detecting early-stage diabetic nephropathy. Along with an overall diagnostic accuracy of 86.3%, Renal Artery Doppler ultrasound proves to be an effective tool for early detection of diabetic nephropathy.

Limitations:

- The study's cross-sectional design limits the ability to establish causality.
- The sample size, while adequate, may not be representative of all diabetic populations, particularly those with extreme glycaemic control variations or comorbid conditions.

Recommendations:

- Longitudinal studies with larger and more diverse populations are needed to validate these findings.
- Further research should explore the integration of Doppler ultrasound with other non-invasive techniques to enhance the accuracy of DN diagnosis.

CONCLUSION:

The findings from this study highlight the significant potential of Renal Artery Doppler ultrasound in the early detection of diabetic nephropathy. The strong correlations observed between Doppler parameters, particularly resistive index (RI), and traditional markers such as ACR and eGFR support the hypothesis that Doppler ultrasound can effectively detect early microvascular changes associated with DN. The diagnostic accuracy of RI, with a sensitivity of 89.5% and specificity of 83.2%, suggests that this parameter could serve as a reliable non-invasive marker for DN. Furthermore, the use of Doppler ultrasound in routine clinical practice could potentially allow for earlier detection and intervention, thereby preventing the progression of DN to ESRD. Renal Artery Doppler ultrasound is a reliable, non-invasive tool for the early detection of diabetic nephropathy. The significant correlations between Doppler parameters and traditional biochemical markers indicate its potential to become a standard diagnostic procedure in diabetic care. Early detection through Doppler ultrasound could lead to timely interventions, potentially preventing the progression to end-stage Renal Disease.

Acknowledgment: We extend our sincere gratitude to all the study for their willingness to contribute to this study.

Financial support and sponsorship: Nil

Conflict Of Interest: No conflicts of interest

REFERENCES:

1. Elshweehy SA, Mohammed HA, Osama SM. Role of duplex Doppler ultrasound in evaluation of patients with diabetic nephropathy. *Sci J Al-Azhar Med Fac, Girls*.2020;4 (1):456–62.
2. Gopalakrishnan SS, Balasubramaniam P, Reddy KS. Role of ultrasound and colour Doppler in diabetic nephropathy—correlation with biochemical parameters. *Int J Anat Radiol Surg*. 2019;8(3):RO31-RO35
3. Wiersema R, Kaufmann T, Van der Veen HN, de Haas RJ, Franssen CF, Koeze J, Van der Horst IC, Keus F. Diagnostic accuracy of arterial and venous renal Doppler assessment for acute kidney injury in critically ill patients: A prospective study. *J Crit Care*.2020;59(1):57–62.
4. Thornton Snider J, Sullivan J, van Eijndhoven E, et al.Lifetime benefits of early detection and treatment of diabetic kidney disease. *PLoS One* 2019; 14(1):01-13
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(2):8364
6. Li H, Shen Y, Yu Z, Huang Y, He T, Xiao T, Li Y, Xiong J, Zhao J. Potential Role of the Renal Arterial Resistance Index in the Differential Diagnosis of Diabetic Kidney Disease. *Front Endocrinol (Lausanne)*. 2022;14(12):731187
7. Li Y, Teng D, Shi X, Qin G, Qin Y, Quan H.Prevalence of Diabetes Recorded in Mainland China Using 2018 Diagnostic Criteria From the American Diabetes Association: National Cross Sectional Study. *BMJ (Clinical Res ed)*.2020;369(5):m997
8. Chen Y, Lee K, Ni Z, He JC. Diabetic Kidney Disease: Challenges, Advances, and Opportunities. *Kidney Dis (Basel Switzerland)*.2020; 6(4):215–25
9. Bermejo S, González E, López-Revuelta K, Ibernón M, López D, Martín-Gómez A. Risk Factors for non-Diabetic Renal Disease in Diabetic Patients. *Clin Kidney J*.2020;13(3):380–8
10. Soyoye DO, Dawha SD, Ayoola OO. Relationship between renal Doppler indices and biochemical indices of renal function in type 2 diabetes mellitus. *West Afr J Med*.2018; 35(1): 189–194.