Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

ROLE OF DUPLEX DOPPLER ULTRASOUND IN ASSESSMENT OF RENAL ARTERY IN DIABETIC NEPHROPATHY PATIENTS

Minahil Shahzad
Faculty of Allied Health Sciences, Superior University Lahore, Pakistan
Madiha Naheed
Faculty of Allied Health Sciences, Superior University Lahore, Pakistan
Dr. Fahmida Ansari
Faculty of Allied Health Sciences, Superior University Lahore, Pakistan
Dr. Hafiz Shehzad Muzamil
Faculty of Allied Health Sciences, Superior University Lahore, Pakistan
Anum Noreen
Faculty of Allied Health Sciences, Superior University Lahore, Pakistan

Author Details

Keywords:
Chronic kidney disease, end-stage renal disease, glycated hemoglobin.

Received on 08 Mar 2026
Accepted on 20 Apr 2026
Published on 05 May 2026

Corresponding E-mails & Authors*:
Minahil Shahzad
E-mail: mminahil999@gmail.com

Abstract

Background: Diabetic nephropathy is a serious complication of diabetes and it is one of the primary source of renal failure. Duplex Doppler ultrasound is reliable and effective diagnostic tool for evaluating renal blood flow by using renal Doppler indices including peak systolic velocity, end diastolic velocity and resistive index.

Objectives: The aim of this study is to evaluate the role of duplex Doppler ultrasound in assessment of renal artery in diabetic nephropathy patients.

Methods: Total number of 43 patients were included in this descriptive cross-sectional study. A non-probability sampling technique was used for this study. Data were collected based on the questionnaire included patient's age, gender, medical history, laboratory findings, grey-scale ultrasound and Doppler ultrasound parameters. Data were analyzed and verified using Statistical Package for the Social Sciences (SPSS) software. Pearson's correlation test was applied and a p-value (< 0.05) was considered statistically significant.

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

Results: Females predominated 64.7% with mean age 55.49±6.19 years. A positive correlation was found between the renal resistive index and serum creatinine, serum urea, BUN, uric acid (r= 0.970-0.989, p <0.001), along a strong negative correlation with estimated glomerular filtration rate (r= -0.993 to -0.994, p <0.001). Increased resistive index positively associated with the long-term duration of diabetes (14.02 ± 4.31), hypertension (9.70±3.17) and chronic renal failure (5.16±2.00), (r= 0.972-0.978, p< 0.001). Progressive renal parenchymal damage often characterized on grey-scale ultrasound by increased echogenicity (Grades III/IV) and reduced renal length.

Conclusion: There is positive correlation between elevated renal resistive index and biochemical markers including uric acid, BUN, urea, serum creatinine and decreased estimated glomerular filtration rate. The association between higher renal resistive index, longer disease duration and structural changes like reduced renal length confirms its utility in assessing the progression of diabetic nephropathy.

INTRODUCTION

Diabetes is referred to as metabolic syndrome defined by persistently high blood sugar levels (hyperglycemia). Glucose level rises because it cannot be broken down in the body's cells due to insulin resistance and the impaired cellular response to insulin production by the pancreas[1]. Diabetic nephropathy is a chronic renal disease that is related to the prolonged duration of diabetes and is the leading cause of renal failure with a major global health concern. Nephropathy is a heterogeneous disease distinguished through the macroalbuminuria (albumin –to-creatinine ratio ≥ 300 mg/g), rapid loss in rate of estimated glomerular filtration (< 60mL/min/1.73m^2) and also a major driver of hypertension in type 1 diabetes mellitus[2,3,4].DN is linked to the genetic material and traits influenced by hereditary markers and the molecular signaling pathways[5]. It is also the major cause of renal failure in patients starting renal replacement therapy and evolves most commonly in up to 40% of both type I and type II diabetes mellitus patients[6].

Chronic kidney disease is categorized into five stages; varying from stage 1-normal, 2-mild, 3(a)-mild to moderate and 3(b)-moderate to severe, 4-severe and 5-end-stage renal disease. These stages are

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

based on estimated glomerular filtration rate (mL/min/1.73m^2) because it measures the filtration rate of blood. As the glomerular filtration rate decreases the renal function starts to decline[7]. Renal disease must be controlled at the early stage through the prevention of proteinuria. Blockade of renin-angiotensin-aldosterone system(RAAS) helps to reduce intraglomerular pressure which gradually protects the kidney's filtration and it can prevent the progression to end-stage renal disease. Recent advancements in antidiabetic agents, especially sodium-glucose transport protein 2 (SGLT2) inhibitors and glucagon-like peptide-1 (GLP-1) agonists have positive effects on diabetic kidney disease patients. These drugs effectively help reduce the blood glucose levels and provide protection against kidney and cardiovascular diseases[8]. Although proteinuria is a major driver of progression and a target for treatment, corresponding to kidney disease: improving global outcomes (KDIGO) stage A1. Stage A2/A3 have therapeutic interventions for patients with diabetic renal disease[9]. CKD is strongly linked to mortality rates. As renal disease expanded the mortality rate in diabetic patients up to 31.1% and it rises as the disease progresses[10].

Doppler ultrasound is an effective tool in evaluating diabetic nephropathy, particularly in analyzing the severity and monitoring the progression of the disease. Beyond detecting structural changes, it helps in evaluating renal hemodynamics such as blood flow rate and resistance within the intrarenal vessels[11]. Renal resistive index, a non-intrusive Doppler ultrasound assessment helps in predicting functional activity of kidneys in diabetic patients. The prompt diagnosis of developing albuminuria is indicated through the elevated resistive index. The increased vascular resistive index shows positive correlation with reduced glomerular filtration rate and elevated creatinine (serum)[12].

The rationale for the Role of duplex Doppler ultrasound in assessment of the renal artery in diabetic nephropathy patients is to evaluate the structural, vascular changes and hemodynamics of both kidneys, which can be affected by the diabetic kidney disease(DKD). This assessment helps in the early detection of abnormalities, monitoring of disease progression, and potentially guiding treatment strategies for diabetic nephropathy patients.

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

METHODOLOGY

The descriptive cross-sectional study of 43 patients was conducted for 6 months at the nephrology and dialysis department of Jinnah Hospital, Lahore. A non-probability sampling technique was used for this study with the specific inclusion criteria to select the participants consisted of, patients aged between 25-80 years with a diagnosis of type 1 or type 2 diabetes mellitus and the evidence of diabetic nephropathy based on elevated creatinine(serum) and on reduced estimated glomerular filtration rate (eGFR). Informed consent was provided to undergo renal duplex Doppler ultrasound. Prior treatment history including hypertensive and diabetic drugs were also included. Exclusion criteria were applied to patients with known renal artery stenosis of non-diabetic origin. Those who were pregnant or breastfeeding and patients with the history of recent hospitalization or surgery. A history of cancer or other serious disease that may have affected the participant's ability to complete the study and the use of certain medications that may have interfered with the study results or posed a risk to the participant.

Data were collected according to the variables in the questionnaire including patient's age, gender and medical history. Laboratory investigations were conducted, focusing on serum uric acid, Blood Urea Nitrogen (BUN), urea(serum), serum creatinine and estimated glomerular filtration rate (mL/min/1.73m^2). Grey-scale ultrasound parameters including renal length, renal parenchymal echogenicity and parenchymal thickness were measured. Doppler parameters; peak systolic velocity (PSV), end diastolic velocity (EDV) and resistive index (RI) of the main renal arteries and segmental renal arteries were assessed. Patients were instructed to fast (NPO) for 6-8 hours prior to the examination to reduce bowel gas. A duplex Doppler ultrasound of both kidneys was performed by using Toshiba Aplio 500 prime high- resolution machine equipped with a 3-5MHz curvilinear probe. The examination was conducted with the patient in supine and oblique positions to optimize visualization. In grey-scale ultrasound longitudinal and transverse images were obtained to measure renal size and parenchymal characteristics, followed by color and spectral Doppler ultrasound to evaluate vascular flow.

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

The data were analyzed and verified through the Statistical Package of Social Sciences (SPSS) software, using descriptive statistics to summarize demographic data. Quantitative variables were expressed as mean ± standard deviation. Qualitative variables were expressed as frequency and percentages. The normality of data was assessed using the Shapiro-Wilk test with a p –value (Sig.) > 0.05 indicating a normal distribution. Pearson's correlation test was used to evaluate relationships between the variables and a p-value (< 0.05) was considered statistically significant.

RESULTS

In this study of 43 patients, females included 64.7% whereas males 32.6%. The mean age was 55.49±6.19 years with minimum and maximum age of 45 to 66 years (Table 1). Increased renal resistive index positively associated with the long-term mean duration of diabetes 14.02±4.31, mean duration of hypertension 9.70±3.17 and mean duration of chronic renal failure 5.16±2.00 in (Table 2), r= 0.972 to -0.978, p< 0.001in (Table 6). Mean serum uric acid was calculated as 8.29±1.25, mean blood urea nitrogen (BUN) 39.91±11.35, while mean serum urea 84.81±24.39, mean serum creatinine 2.93±1.05 and mean eGFR 29.40±14.43 was recorded in (Table 3).

Table 1: Baseline Demographic Data of the Study Population.

Variable	Category	Frequency(n)	Percentage(%)
Gender	Male	14	32.6%
	Female	29	67.4%

Variable	Mean ± SD	Minimum-Maximum
Age (years)	55.49 ± 6.19	45-66

Table 2: Baseline Clinical Data of the Study Population.

Variable	Mean ± SD	Minimum-Maximum
Duration of Diabetes Mellitus(y)	14.02 ± 4.31	7-22
Duration of Hypertension(y)	9.70 ± 3.17	4-16
Duration of Renal Failure(y)	5.16 ± 2.00	2-9

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

Table 3: Laboratory Findings (Renal Function Tests) of the Study Population.

Variable	Mean ± SD	Minimum-Maximum
Serum Uric acid(mg/dL)	8.29 ± 1.25	6.2-10.5
BUN(mg/dL)	39.91 ± 11.35	22-60
Serum Urea(mg/dL)	84.81 ± 24.39	48-130
Serum Creatinine(mg/dL)	2.93 ± 1.05	1.4-5.0
Estimated Glomerular Filtration Rate (mL/min/1.73m^2)	29.40 ± 14.43	9-58

Mean right renal length was calculated as 8.77±0.91and mean left renal length 8.63±0.87. Grade-I, parenchymal changes were present in 18.6% of cases, Grade-II in 20.9%, Grades-III and IV both equally in 30.2% (combined 60.4%). Progressive renal parenchymal damage often characterized on grey-scale ultrasound by increased parenchymal echogenicity (Grades-III/IV) and reduced renal length (Table 4).

Mean resistive index of right main renal artery was calculated as 0.77±0.09, mean resistive index of left main renal artery 0.77±0.10 and mean resistive index of right renal segmental artery 0.74±0.09, mean resistive index of left renal segmental artery 0.73±0.09 were recorded in (Table 5).

Table 4: Grey-Scale Ultrasound Findings of the Study Population.

Variable	Mean ± SD	Minimum-Maximum
Right Renal Length (cm)	8.77 ± 0.91	7.3-10.4
Left Renal Length(cm)	8.63 ± 0.87	7.2-10.2

Variable	Category	Frequency(n)	Percentage(%)
Right and left Renal Parenchymal Echogenicity	I=Mild	8	18.6
	II=Moderate	9	20.9
	III=Severe	13	30.2
	IV=ESRD	13	30.2
	I=Mild Reduction(1.2-	8	18.6

Vol. 5 No. 2 (2026)
Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387 Print ISSN 3007-2379
Shahzad et al - 2026
DOI: http://doi.org/10.5281/zenodo.20066574

Right and left Renal Parenchymal Thickness	1.4cm)		
	II=Moderate(0.9-1.1cm)	9	20.9
	III=Severe(0.6-0.8cm)	13	30.2
	IV=ESRD(< 0.6cm)	13	30.2

Table 5: Doppler Ultrasound Findings of the Study Population.

Variable	Mean ± SD	Minimum-Maximum
Resistive Index of Right Main Renal Artery	0.77 ± 0.09	0.59-0.91
Resistive Index of Left Main Renal Artery	0.77 ± 0.10	0.58-0.91
Resistive Index of Right Segmental Renal Artery	0.74 ± 0.09	0.60-0.88
Resistive Index of Left Segmental Renal Artery	0.73 ± 0.09	0.59-0.88

Table 6 shows a very strong positive correlation ($r > 0.97$) between the right and left renal resistive index and clinical, biochemical parameters of renal insufficiency including age, duration of diabetes mellitus, hypertension, renal failure and serum creatinine, uric acid (serum), urea(serum), BUN. A very strong negative association ($r < -0.99$) exists between the renal resistive index (RRI) and both estimated glomerular filtration rate and renal length. It indicates that as renal function declines and kidney size decreases, the resistive index increases proportionally. All observed correlations were statistically significant ($p<0.001$). These findings suggest that RI is a non-invasive Doppler parameter that mirrors progressive renal parenchymal damage.

Vol. 5 No. 2 (2026)
Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387 Print ISSN 3007-2379
Shahzad et al - 2026
DOI: http://doi.org/10.5281/zenodo.20066574

Table 6: Pearson's Correlation of Doppler Ultrasound with Clinical, Laboratory, Grey-Scale Ultrasound Parameters.

Variable	Right Main Renal Artery Resistive Index (r, p-values)	Left Main Renal Artery Resistive Index (r, p-values)
Age(y)	0.971, <0.001	0.970, <0.001
Duration of Diabetes Mellitus(y)	0.978, <0.001	0.978, <0.001
Duration of Hypertension(y)	0.977, <0.001	0.976, <0.001
Duration of Renal Failure(y)	0.972, <0.001	0.970, <0.001
Creatinine(mg/dL)	0.970, <0.001	0.973, <0.001
Glomerular Filtration Rate (mL/min/1.73m^2)	-0.993, <0.001	-0.994, <0.001
Uric acid(mg/dL)	0.987, <0.001	0.985, <0.001
BUN(mg/dL)	0.986, <0.001	0.989, <0.001
Urea(mg/dL)	0.981, <0.001	0.984, <0.001
Right and Left Renal Length(cm)	-0.996, <0.001	-0.997, <0.001

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

Shahzad et al - 2026
DOI: http://doi.org/10.5281/zenodo.20066574

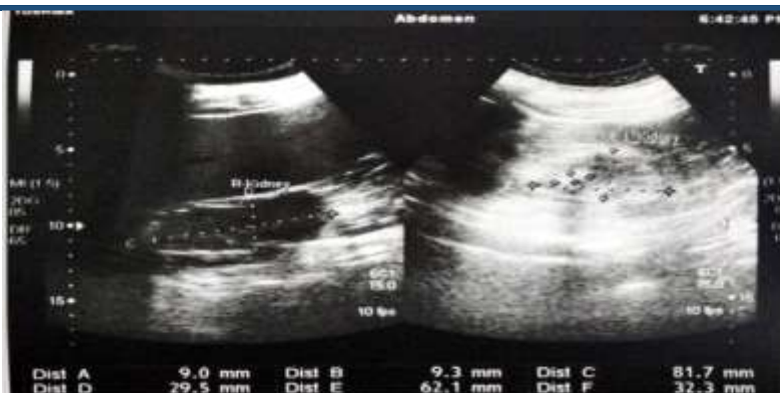

Figure 1: Grey-scale ultrasound shows renal parenchymal changes Grade-III.

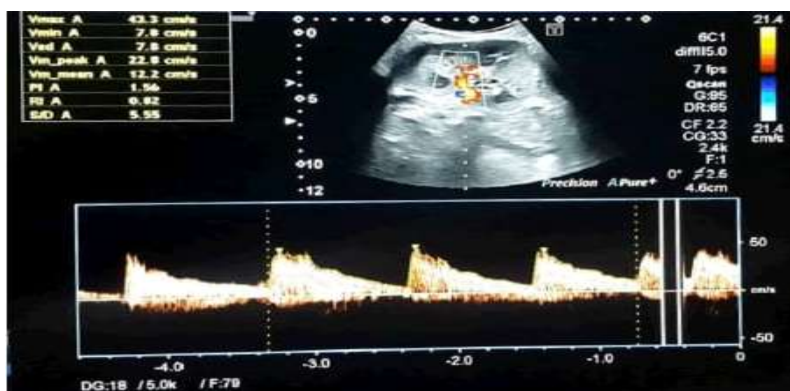

Figure 2: Doppler ultrasound image of a stage 4 chronic kidney disease with high resistive index of 0.82.

DISCUSSION

The study was conducted to diagnose renal structural and functional changes in diabetic patients using grey-scale and Doppler ultrasound with laboratory parameters.

A study conducted by Azza Gamal Mubarak Khalifa, et al: in (2025) on renal ultrasound and renal duplex ultrasonography for prediction of diabetic nephropathy in correlation to biochemical markers and glomerular filtration rate. The left resistive index corresponded both actively and vigorously with albuminuria, urea(serum), creatinine(serum) and HbA1c with high statistical significance ($p < 0.001$). Maham Nasir, et al: conducted a study in (2024) on relationship between renal function tests and resistive index of renal artery in type II diabetic patients. Patients with high

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

serum creatinine levels results in increased renal artery resistive index. A strong positive association of p-value was observed among resistive index and serum creatinine levels. There was also a positive correlation between resistive index and microalbuminuria. Our findings are consistent with previous studies which demonstrate that Doppler-derived renal resistive index is a prominent, non-intrusive indicator for evaluating chronic renal disease progression in patients with high-risk vascular diseases such as diabetes mellitus and hypertension. It shows a strong positive correlation with serum creatinine, BUN, urea and uric acid ($r= 0.97$, $p< 0.001$). This is consistent with earlier research that increasing resistive index is a dynamic benchmark of declining renal function rather than just an absolute marker[13,14].

Kritika Sharma, et al: conducted a study in (2023) on assessment of renal hemodynamics by Doppler ultrasound in diabetes mellitus: Relationship with HbA1c and creatinine(serum). Doppler parameters demonstrated a crucial relationship with participants age, duration of diabetes also with the laboratory tests; glycated hemoglobin and creatinine(serum). This study is consistent with earlier findings that show a strong correlation between the duration of diabetes and hypertension with elevated resistive index. The results suggest that constant, chronic systemic renal disease results in vascular changes within the renal parenchyma including glomerulosclerosis and interstitial fibrosis. These structural changes restrict diastolic flow, leading towards higher resistive index which indicates that hypertension and diabetic nephropathy both increase intra-renal pressure[15].

Azza Gamal Mubarak Khalifa, et al: conducted a study in (2025) on renal ultrasound and renal duplex ultrasonography for prediction of diabetic nephropathy in correlation to biochemical markers and glomerular filtration rate. Statistically significant inverse relationship was found between the left RI and eGFR ($r= -0.68$, $p< 0.001$). Khushal Markanday, et al: conducted a study in (2025) on patients with presence of proteinuria demonstrated elevated values of resistive index relative to those individuals with normal urine. Moreover, rise in resistive index values was observed with worsening nephropathy severity and inversely associated with eGFR. New findings are consistent with prior studies that depicted a negative association between the renal resistive index

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387 Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

and the estimated glomerular filtration rate (r= -0.99, p< 0.001). This indicates that an increased resistive index is highly predictive of a decrease in the glomerular filtration rate. When the renal parenchyma becomes more fibrotic, the elasticity of the vessels decreases, leading to higher blood pressure and less forward flow. Thus it is a crucial sign of structural damage[13,16].

Fekadu H Getaneh, et al: conducted a study in (2025) on components of diagnostic ultrasound and its association with estimated glomerular filtration rate in patients with chronic renal disease. A facility-based cross-sectional study. The statistical value of estimated glomerular filtration rate was high (34.47±15.81 mL/min/1.73m^2) as compare to the normal value. For average renal length the mean 8.97±1.42. Statistical value of parenchymal thickness 1.36±0.45 and the cortical thickness 0.85±0.27 correspondingly. It seems a prominent association between the estimated glomerular filtration rate and the average renal length, relative renal length and parenchymal thickness. An inverse relationship was identified between parenchymal echogenicity and estimated glomerular filtration rate which was statistically significant (p< 0.001). Md. Jahangir Alam Prodhan, et al: conducted a study in (2024) on role of diagnostic ultrasound in diagnosing chronic renal disease. Statistical value of serum creatinine levels across echogenicity grades was observed with significant variance of p-value. Similar trends were noted for the renal grey-scale parameters like renal length, parenchymal thickness and corticomedullary differentiation. These grey-scale indices have the same p-value (p=0.0005). Our study is consistent with earlier research that demonstrates the prevalence of renal parenchymal echogenicity Grades-III and IV along with reduced cortical thickness complements the Doppler data. Increased echogenicity indicates parenchymal fibrosis and renal tubular atrophy while decreased mean renal length 8.77±0.91 shows a strong negative correlation with the resistive index (r= -0.996 to -0.997, p< 0.001), demonstrates severe, irreversible renal atrophy. The study concludes that an increase in resistive index specifically associated with renal parenchymal changes of Grades III-IV is a crucial sign of chronic, irreversible damage and can work as a diagnostic tool to evaluate chronic kidney disease, especially when glomerular filtration rate 29.40 ±14.43, (r=

Vol. 5 No. 2 (2026)
Pakistan Journal of Medical & Cardiological Review
https://pakjmcr.com/index.php/1/about
Online ISSN 3007-2387 Print ISSN 3007-2379
Shahzad et al - 2026
DOI: http://doi.org/10.5281/zenodo.20066574

-0.993 to -0.994, p< 0.001) and grey-scale ultrasound (p< 0.001) markers show severe dysfunction[17,18].

CONCLUSION

This study validates duplex Doppler ultrasound as a highly valuable, non-invasive diagnostic modality for the early detection and monitoring of renal involvement in patients with diabetes mellitus. There is strong positive correlation between elevated renal resistive index (RRI) and biochemical markers including uric acid, BUN, urea, creatinine(serum) and decreased estimated glomerular filtration rate. Furthermore, the association between higher renal resistive index, longer disease duration and structural changes like reduced renal length confirms its utility in assessing the progression of diabetic nephropathy.

LIMITATIONS OF STUDY

This study is primarily limited by its single-group, cross-sectional design which precludes establishing causal relationships between renal resistive index and subject outcomes. Furthermore, the small sample size, one-time data collection and reliance on operator-dependent Doppler ultrasound introduce potential selection bias and measurement variability, limiting generalizability.

RECOMMENDATIONS

Future studies implement longitudinal, multi-center prospective studies with larger, diverse cohorts to establish causality. Include a control group to allow for comparison and validated assessment of the renal resistive index. Standardize Doppler techniques such as use of consistent settings, operator-independent and ensuring standard to reduce variability. Integrate resistive index with additional diagnostic modalities including histopathological findings for a comprehensive analysis.

REFERENCES

1. Mobasseri M, Shirmohammadi M, Amiri T, Vahed N, Hosseini Fard H, Ghojazadeh M. Prevalence and incidence of type 1 diabetes in the world: a systematic review and meta-analysis. Health Promot Perspect. 2020 Mar 30;10(2):98-115.

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387

Print ISSN 3007-2379

Shahzad et al - 2026

DOI: http://doi.org/10.5281/zenodo.20066574

2. Pelle MC, Provenzano M, Busutti M, Porsu CV, Zaffina I, Stanga L, Arturi F. Update on diabetic nephropathy. Life. 2022 Aug 8;12(8):1202.

3. Mlynarska E, Bulawska D, Czarnik W, Hajdys J, Majchrowicz G, Prusinowski F, et al. Novel insights into diabetic kidney disease. Int J Mol Sci. 2024 Sep 23;25(18):10222.

4. Jung CY, Yoo TH. Pathophysiologic mechanisms and potential biomarkers in diabetic kidney disease. Diabetes Metab J. 2022 Mar 24;46(2):181-197.

5. Joumaa JP, Raffoul A, Sarkis C, Chatrieh E, Zaidan S, Attieh P, et al. Mechanisms, biomarkers, and treatment approaches for diabetic kidney disease: current insights and future perspectives. J Clin Med. 2025 Jan 23;14(3):727.

6. Natesan V, Kim SJ. Diabetic nephropathy: a review of risk factors, progression, mechanism, and dietary management. Biomol Ther (Seoul). 2021 Apr 23;29(4):365-372.

7. Selby NM, Taal MW. An updated overview of diabetic nephropathy: diagnosis, prognosis, treatment goals and latest guidelines. Diabetes Obes Metab. 2020 Apr 8;22(1):3-1.

8. Sinha SK, Nicholas SB. Pathomechanisms of diabetic kidney disease. J Clin Med. 2023 Nov 27; 12(23):7349.

9. Sindhu D, Sharma GS, Khumbala D. Management of diabetic kidney disease: where do we stand?: A narrative review. Medicine(Baltimore). 2023 Mar 31;102(13): e33366.

10. Hussain S, Jamali MC, Habib A, Hussain MS, Akhtar M, Najmi AK. Diabetic kidney disease: an overview of prevalence, risk factors, and biomarkers. Clin Epidemiol Glob Health. 2021 Mar; 9:2-6.

11. Elshweehy S, Mohammed H, Osama S. Role of duplex Doppler ultrasound in evaluation of patients with diabetic nephropathy. Sci J Al-Azhar Med Fac Girls. 2020 Sep;4(3):456-462.

12. Samsu N. Diabetic nephropathy: challenges in pathologies, diagnosis, and treatment. BioMed Res Int. 2021 Jul 9;2021(1):1497449.

13. Khalifa AGM, Sweed IM, Shalaby AMI, ElAlfy AKE. Renal ultrasound and renal duplex ultrasonography for prediction of diabetic nephropathy in correlation to biochemical markers & glomerular filtration rate. Egypt J Hosp Med. 2025;99(1):1744.

Vol. 5 No. 2 (2026)

Pakistan Journal of Medical & Cardiological Review

https://pakjmcr.com/index.php/1/about

Online ISSN 3007-2387
Print ISSN 3007-2379

DOI: http://doi.org/10.5281/zenodo.20066574

14. 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 Sep 30;1(3):62-66.

15. Sharma K, Thakur MK, Mahela S, Konwar R, Varma D, Ullah IK, et al. Role of renal Doppler ultrasonography in evaluating renal haemodynamics in diabetic patients and its correlation with laboratory parameters (Serum HbA1C and Serum Creatinine). Int J Res Med Sci. 2023 May 10;11(6):2174.

16. Markanday K, Kumar PG, Radhakrishnan B, Rafath S. Estimation of renal resistive index as an early marker of diabetic nephropathy. APIK J Intern Med. 2025 Sep;13(3):205-209.

17. Getaneh FH, Kassa BF, Amha LG, Getanah FB. Ultrasound characteristics and correlation with estimated glomerular filtration rate in patients with chronic kidney disease: a facility-based cross-sectional study. J Int Med Res. 2025 Mar 27;53(3):03000605251327484.

18. Nickavar A, Safaeian B, Zaeri H, Gharib MH, Chaharnaei T. Usefulness of Doppler ultrasound for the early diagnosis of diabetic nephropathy in type 1 diabetes mellitus. J Ultrasound. 2022;25(1):79-82.