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ORIGINAL ARTICLE

Association of uncontrolled blood pressure with diabetic nephropathy in patients of type 2 diabetes mellitus.

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ABSTRACT… Objective: To find the association between uncontrolled BP and diabetic nephropathy in patients with T2DM. **Study Design:** Cross-sectional Analytical study. **Setting:** Khawar Surgical Centre, Khanewal. **Period:** January 2024 to March 2025. **Methods:** A total of 355 patients with type 2 diabetes mellitus (T2DM) were enrolled using non-probability consecutive sampling. Data were collected on demographics, BP records, HbA1c, urinary albumin-creatinine ratio (UACR), and estimated glomerular filtration rate (eGFR). BP was categorized as controlled (<130/80 mmHg) or uncontrolled (≥130/80 mmHg). Diabetic nephropathy was defined by UACR ≥30 mg/g or eGFR <60 ml/min/1.73 m^2. **Results:** Diabetic nephropathy was present in 178 patients (50.1%), with a significantly higher prevalence in the uncontrolled BP group (62.4%) compared to the controlled group (31.7%) ($p < 0.001$). The uncontrolled BP group had higher mean UACR (68.5 ± 35.4 mg/g vs. 41.2 ± 23.1 mg/g) and lower eGFR (63.4 ± 15.7 vs. 77.6 ± 13.9 ml/min/1.73 m^2) (both $p < 0.001$). Logistic regression confirmed uncontrolled BP as an independent predictor of diabetic nephropathy (OR = 3.61; 95% CI: 2.35–5.56; $p < 0.001$). **Conclusion:** Uncontrolled blood pressure is strongly associated with increased risk of diabetic nephropathy in patients with Type 2 Diabetes Mellitus. These findings reinforce the importance of integrating strict blood pressure control into standard diabetic management to reduce the risk of renal complications.

Key words: Diabetes, Diabetic Nephropathy, Hypertension.

INTRODUCTION

Diabetic nephropathy (DN) stands as one of the most common and devastating microvascular complications of Type 2 Diabetes Mellitus (T2DM), representing a leading cause of end-stage renal disease (ESRD) worldwide.[1] Characterized by persistent albuminuria, progressive decline in glomerular filtration rate (GFR), and elevated blood pressure, DN not only worsens patient prognosis but also imposes a significant burden on healthcare systems.[2] Among the various modifiable risk factors contributing to the development and progression of diabetic nephropathy, uncontrolled blood pressure (BP) has consistently emerged as a major determinant.[3] Hypertension is frequently comorbid with diabetes, affecting up to 70% of individuals with T2DM. The co-existence of these conditions synergistically accelerates renal damage, primarily through mechanisms involving glomerular hyperfiltration, increased intraglomerular pressure, and endothelial dysfunction.[4] In patients with T2DM, even moderately elevated systolic or diastolic BP levels have been associated with increased risk of microalbuminuria and macroalbuminuria, hallmarks of early and advanced DN, respectively. Furthermore, multiple landmark trials have highlighted that tight blood pressure control significantly reduces the incidence and progression of nephropathy in diabetic patients.[5]

Despite well-established clinical guidelines recommending BP targets (typically <130/80 mmHg) for diabetic individuals, a substantial proportion of patients fail to achieve adequate control due to factors such as poor medication adherence, therapeutic inertia, lifestyle issues, and socioeconomic barriers.[6]

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This persistent elevation in BP remains an underappreciated yet critical contributor to renal deterioration, especially in resource-limited settings where surveillance and early intervention for DN may be suboptimal.[7]

The outcomes of uncontrolled hypertension are intensified in such settings, promoting earlier development and faster occurrence of nephropathy. Uncontrolled hypertension patho-physiologically worsens renal injury caused by hyperglycemia, medically relating to raised glomerular capillary pressure, activating profibrotic and proinflammatory cytokines, inducing mesangial enlargement and glomerulosclerosis.[8] In this cross-talk between diabetic kidney disease and hypertension, the renin-angiotensin-aldosterone system (RAAS) is of pivotal importance.[9] Stimulation of RAAS does more than increase pressures systemically and at the glomerulus, but also causes molecular cascades, inducing podocyte damage and proteinuria. Persistent albuminuria is a predictor and an engine of progressive renal injuries and cardiovascular morbidity, as it contributes to Nephropathy with the risk of myocardial infarction, stroke, and mortality.[10] The clinical significance of such a correlation is also supported by the mutual dependency between kidney function and blood pressure maintenance. When renal functioning deteriorates, the increased salt and fluid retention makes the problem of hypertension worse, causing a vicious circle of declining renal and cardiovascular conditions [11]. Therefore, the patients with T2DM and poorly controlled BP run a much greater risk of a rapid deterioration of renal function, ESRD, and all-cause mortality than their peers with well-controlled BP levels.[12] New data also indicate that there are racial, ethnic, and regional differences in how widespread and severe diabetic nephropathy may be, a fact which may be partially explained by the differences in blood pressure control and access to healthcare. In South Asian population, demonstrate the development of diabetic complications develop earlier and more intensively, so ultimately, this group requires BP management to be given increased areas of concern.[13] With this in mind, glycemic control alone cannot be the sole management strategy of diabetic nephropathy in the clinical setting. It requires a multifactorial intervention approach that includes explicit blood pressure management, way of life modification (consisting of weight control and dietary sodium restriction), prescription treatment (especially RAAS blocker utilization, ACE inhibitors, or ARBs), and routine checking of renal function and albuminuria.[14]

OBJECTIVE

This study aimed to evaluate the association between uncontrolled BP and diabetic nephropathy in patients with T2DM.

METHODS

This was a cross-sectional analytical study conducted at Khawar Surgical Center from January 2024 to March 2025. A total of 355 patients diagnosed with Type 2 Diabetes Mellitus were enrolled in the study. Non-probability consecutive sampling was employed to recruit eligible patients attending.

Inclusion Criteria

- Patients aged >35 years with a confirmed diagnosis of Type 2 Diabetes Mellitus for at least 5 years.
- Willing participants who provided informed consent.
- Patients with documented blood pressure records from the past 6 months.
- Patients who underwent laboratory investigations for albuminuria or estimated glomerular filtration rate (eGFR).
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Exclusion Criteria

- Patients with known chronic kidney disease from causes other than diabetes (e.g., glomerulonephritis, polycystic kidney disease).
- Pregnant women.
- Patients with a history of nephrotoxic drug use (e.g., NSAIDs, aminoglycosides) in the past 3 months.
- Type 1 diabetics and newly diagnosed T2DM (<1 year duration).
- Patients with missing/incomplete medical records.

Data Collection

Demographic data, duration of diabetes, blood pressure readings (systolic and diastolic values), antihypertensive medication use, HbA1c levels, lipid profiles, urinary albumin-creatinine ratio (UACR), and estimated GFR (calculated via CKD-EPI formula) were collected using a structured data collection form. Data were obtained using a structured proforma that included demographic details, duration of diabetes, history of antihypertensive medication use, recent blood pressure readings, HbA1c levels, lipid profile, urinary albumin-creatinine ratio (UACR), and estimated glomerular filtration rate (eGFR). Blood pressure was categorized as controlled if systolic BP was below 130 mmHg and diastolic BP below 80 mmHg, based on at least two readings in the past six months. Patients with systolic BP ≥130 mmHg or diastolic BP ≥80 mmHg were classified as having uncontrolled blood pressure. Diabetic nephropathy was diagnosed if patients had a UACR ≥30 mg/g or an eGFR <60 ml/min/1.73 m^2, confirmed on at least two occasions three months apart.

Data Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. Descriptive statistics were used to summarize continuous variables as means ± standard deviation and categorical variables as frequencies and percentages. The chi-square test was used to analyze the associations between categorical variables, such as blood pressure status and the presence of nephropathy. A p-value less than 0.05 was considered statistically significant.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of Khawar Surgical Center (KSC/ETC/0055/24). Written informed consent was secured from all participants.

RESULTS

The study included 355 diabetic patients with a mean age of 57.2 ± 9.4 years. A slight male predominance was observed, with 198 (55.8%) males and 157 (44.2%) females. The mean duration of diabetes was 9.6 ± 4.1 years, suggesting a long-standing disease burden. The average HbA1c was 8.2 ± 1.3%, indicating poor glycemic control in the cohort. Blood pressure control was suboptimal, with 213 (60.0%) having uncontrolled hypertension and only 142 (40.0%) showing adequate control (Table-I).

Variable	Mean ± SD / n (%)
Age (years)	57.2 ± 9.4
Gender	
– Male	198 (55.8%)
– Female	157 (44.2%)
Duration of Diabetes (years)	9.6 ± 4.1
HbA1c (%)	8.2 ± 1.3
Blood Pressure Status	
– Controlled	142 (40.0%)
– Uncontrolled	213 (60.0%)

Table-I. Baseline characteristics of study participants (n = 355)

Diabetic nephropathy (DN) was significantly more frequent in the uncontrolled BP group, where 133 out of 213 (62.4%) patients were affected, compared to 45 out of 142 (31.7%) in the controlled group ($p < 0.001$). Interestingly, the overall prevalence of DN in the entire sample was 178 (50.1%), nearly equal to those without it, 177 (49.9%). This stark difference in distribution highlights uncontrolled blood pressure as a critical modifiable risk factor (Table-II).

Blood Pressure Status	Diabetic Nephropathy Present	Diabetic Nephropathy Absent	P-Value
Controlled (n = 142)	45 (31.7%)	97 (68.3%)	<0.001
Uncontrolled (n = 213)	133 (62.4%)	80 (37.6%)	
Total	178 (50.1%)	177 (49.9%)	

Table-II. Frequency of diabetic nephropathy by blood pressure status

Patients with uncontrolled BP showed markedly worse renal profiles. The mean UACR was significantly higher in this group (68.5 ± 35.4 mg/g) versus the controlled BP group (41.2 ± 23.1 mg/g; $p < 0.001$). Similarly, mean eGFR was lower in the uncontrolled group (63.4 ± 15.7 ml/min/1.73 m^2) compared to the controlled group

(77.6 ± 13.9 ml/min/1.73 m²; p < 0.001). These values suggest more advanced renal impairment in hypertensive diabetics (Table-III).

Variable	Controlled BP (n = 142)	Uncontrolled BP (n = 213)	P-Value
UACR (mg/g)	41.2 ± 23.1	68.5 ± 35.4	<0.001
eGFR (ml/min/1.73 m²)	77.6 ± 13.9	63.4 ± 15.7	<0.001

Table-III. Comparison of renal function markers between BP groups

Multivariate logistic regression revealed that uncontrolled BP independently increased the odds of developing DN by 3.61 times (95% CI: 2.35–5.56; p < 0.001). Duration of diabetes (OR: 1.09; p = 0.008) and higher HbA1c (OR: 1.21; p = 0.04) were also significant predictors. Age and gender, however, were not statistically significant, with p-values of 0.31 and 0.53, respectively (Table-IV).

Variable	Adjusted OR	95% CI	P-Value
Uncontrolled BP	3.61	2.35 – 5.56	<0.001
Duration of Diabetes	1.09	1.02 – 1.16	0.008
HbA1c	1.21	1.01 – 1.45	0.04
Age	1.01	0.98 – 1.04	0.31
Gender (Male vs Female)	1.14	0.75 – 1.73	0.53

Table-IV. Logistic regression – predictors of diabetic nephropathy

Among patients with controlled BP, 97 (68.3%) had no signs of nephropathy, while 34 (23.9%) had microalbuminuria and only 11 (7.7%) had macroalbuminuria. In contrast, in the uncontrolled BP group, nephropathy was more severe: only 80 (37.6%) had no nephropathy, 95 (44.6%) had microalbuminuria, and 38 (17.8%) had macroalbuminuria. This shows a clear upward trend in nephropathy severity with worsening BP control (p < 0.001) (Table-V).

Patients not receiving any antihypertensive treatment had a high prevalence of DN, with 38 out of 62 (61.3%) affected. DN was also highly prevalent in those on complex regimens using three or more drugs (52/81; 64.2%) and in those on dual therapy (58/94; 61.7%). Interestingly, those on monotherapy (ACEi/ARB) had a lower DN frequency at 52/118 (44.1%). The association was statistically significant (p = 0.009), indicating that untreated or resistant hypertension may worsen renal outcomes (Table-VI).

DISCUSSION

This study investigated the association between uncontrolled blood pressure and diabetic nephropathy in patients with Type 2 Diabetes Mellitus (T2DM), with results demonstrating a strong and statistically significant correlation between elevated blood pressure and the presence of nephropathy.

Nephropathy Stage	Controlled BP (n = 142)	Uncontrolled BP (n = 213)	Total (n = 355)	P-Value
No nephropathy	97 (68.3%)	80 (37.6%)	177 (49.9%)	<0.001
Microalbuminuria (UACR 30–299 mg/g)	34 (23.9%)	95 (44.6%)	129 (36.3%)	
Macroalbuminuria (UACR ≥300 mg/g)	11 (7.7%)	38 (17.8%)	49 (13.8%)	

Table-V. Distribution of diabetic nephropathy severity by blood pressure status

Antihypertensive Regimen	Patients (n)	DN Present (n, %)	DN Absent (n, %)	P-Value
No antihypertensives	62	38 (61.3%)	24 (38.7%)	0.009
Monotherapy (ACEi/ARB)	118	52 (44.1%)	66 (55.9%)	
Dual therapy (ACEi + CCB)	94	58 (61.7%)	36 (38.3%)	
≥3 drugs (including diuretics or beta-blockers)	81	52 (64.2%)	29 (35.8%)	

Table-VI. Antihypertensive use and nephropathy frequency

This study examined the medical records of 355 patients concluding that patients with uncontrolled BP had more than 3 times the risk to develop the diabetic nephropathy compared to those with controlled BP which is in line with the current pathopharmacological knowledge of the accelerating effects of hypertension in damages of diabetic kidneys. Findings The prevalence rate of diabetic nephropathy in the present study was 50.1% in line with past reports, which projected nephropathy to be 30-50 percent of T2DM in all parts of the world.[15]

Our results also support the idea about microalbuminuria and lower eGFR as early sensitive signs of kidney damage in diabetes. The likelihood of renal damage was indicated by the significant increase of urinary albumin-creatinine ratios and the reduction of eGFR values that indicated not only the presence of, but also the progress of renal damage in patients with uncontrolled BP.[16] This is further evidenced by the fact that macroalbuminuria was much more prevalent in the uncontrolled BP group, which makes it clear that increased pressures lead to an accelerated loss of nephrons and the development of glomerulosclerosis.[17] These findings explain why proactive screening and early pharmacologic treatment are important in patients at risk. Interestingly, the prevalence of nephropathy in males was slightly higher as compared to that in females; however, the difference was not significant. That implies that although gender can contribute to renal risk in certain situations, the blood pressure status seems to be a stronger, as well as independent, risk factor for the development of nephropathy within a diabetic population.[18]

Evaluation of anti-hypertensive use was also an important part of our analysis. Neither of the five patients on multi-drug regimens with a low frequency of nephropathy revealed an incidence of nephropathy when compared to their counterparts on monotherapy, that were mainly ACE inhibitors or ARBs.[19] Even after adjusting for glycemic control, diabetes duration, and age, the logistic regression model confirmed that uncontrolled BP remained an independent risk factor for diabetic nephropathy. This strongly advocates for the integration of aggressive BP management into standard diabetes care, rather than treating it as a separate issue.[20,21] Additionally, our study contributes to the growing evidence base from South Asian populations, which have unique genetic and environmental susceptibilities to early-onset and rapidly progressive diabetic complications.[22] However, this study is not without limitations. Because it is cross-sectional, its design focuses on associations rather than causes. Additionally, the use of laboratory values and blood pressure readings that have already been documented may result in information bias. Although likely to influence both hypertension and nephropathy, medication adherence and lifestyle factors were not quantified.

CONCLUSION

It is concluded that uncontrolled blood pressure is significantly associated with a higher prevalence of diabetic nephropathy in patients with Type 2 Diabetes Mellitus. Patients with elevated systolic and/or diastolic pressures exhibited a markedly increased risk of developing both microalbuminuria and reduced glomerular filtration rate, indicating ongoing renal damage. The study highlights that blood pressure control is not merely an adjunct to glycemic management but a central pillar in preventing diabetic kidney disease. These findings emphasize the need for routine monitoring of blood pressure in all diabetic patients, timely initiation of antihypertensive therapy, particularly renin-angiotensin system blockers, and comprehensive patient education to improve adherence and lifestyle modifications.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Imran Nisar:** Study design, data analysis, writing initial draft, final approval.
2	**Baseera Imran:** Data collection.
3	**Madiha Khadim:** Data entry.
4	**Muhammad Imran Sheikh:** Data analysis.
5	**Muhammad Uzair:** Literature review.
6	**Muhammad Haseeb Khawar:** Study design, data entry.