International Journal of Advances in Medicine
Orchi P et al. Int J Adv Med. 2025 Jul;12(4):362-365
http://www.ijmedicine.com
pISSN 2349-3925 | eISSN 2349-3933
DOI: https://dx.doi.org/10.18203/2349-3933.ijam20251932

Original Research Article

Progression of diabetic nephropathy in patients with uncontrolled type 2 diabetes mellitus: a cross-sectional study

Proma Orchi[1]*, Mourin Binte Zaman[2], Farah Binte Faruque[3], Samiha Jabin Susmita[4], Tasnim Jannat Begh[4]

[1]Department of Internal Medicine, Enam Medical College and Hospital, Savar, Dhaka, Bangladesh
[2]Kurmitola General Hospital, Dhaka, Bangladesh
[3]Department of Internal Medicine, Sir Salimullah Medical College and Mitford Hospital, Dhaka, Bangladesh
[4]Department of Internal Medicine, Dhaka Medical College and Hospital, Dhaka, Bangladesh

Received: 09 April 2025
Accepted: 20 May 2025

***Correspondence:**
Dr. Proma Orchi,
E-mail: promaorchi49@gmail.com

ABSTRACT

Background: Diabetic nephropathy (DN) is a major complication of uncontrolled type 2 diabetes mellitus (T2DM), leading to chronic kidney disease (CKD) and end-stage renal disease (ESRD). This study aimed to assess the progression of DN in patients with uncontrolled T2DM and its association with clinical and biochemical parameters.
Methods: A cross-sectional study was conducted on 147 T2DM patients aged 45-60 years at Enam medical college, Sir Salimullah medical college, and Dhaka medical college from March 2024 to December 2024. Purposive sampling technique was applied in sample selection Patients were categorized into two groups: poorly controlled diabetes (HbA1c≥7%) and controlled diabetes (HbA1c<7%). Data were analyzed by using SPSS version 23.0 program.
Results: This study of 147 T2DM patients found 53.1% had poorly controlled diabetes (HbA1c≥7%), associated with higher urinary ACR, reduced eGFR, and elevated serum creatinine. Advanced CKD (eGFR<60 mL/min/1.73 m^2) was present in 67.3%, with 33.3% microalbuminuria and 19.7% macroalbuminuria. Grade 2 hypertension (HTN) (43.5%) was significantly linked to renal impairment, highlighting the need for better glycemic and blood pressure (BP) control.
Conclusions: Poor glycemic control and HTN significantly accelerate DN progression in T2DM patients. Early intervention targeting glycemic control, BP management, and regular renal screening is essential to mitigate renal complications and improve outcomes.

Keywords: Chronic kidney disease, Diabetic nephropathy, HbA1c, HTN, eGFR, Type 2 diabetes mellitus, Proteinuria

INTRODUCTION

Diabetic nephropathy (DN) is one of the most severe microvascular complications of T2DM, contributing significantly to the global burden of CKD and ESRD.[1] It is estimated that approximately 30-40% of patients with T2DM develop DN, making it a leading cause of renal failure worldwide.[2,3] The progression of DN is closely linked to poor glycemic control, HTN, and the duration of diabetes, highlighting the need for early intervention and effective management strategies.[4] The pathophysiology of DN involves a complex interplay of metabolic, hemodynamic, and inflammatory factors. Persistent hyperglycemia leads to the formation of advanced glycation end-products (AGEs), oxidative stress, and activation of protein kinase C (PKC) pathways, resulting in glomerular hypertrophy, podocyte injury, and tubulointerstitial fibrosis.[5] HTN, a common comorbidity in T2DM, exacerbates renal damage by increasing intraglomerular pressure and accelerating the decline in glomerular filtration rate (GFR).[6] These mechanisms collectively contribute to the progression from microalbuminuria to macroalbuminuria and, ultimately, to ESRD.[7] Glycemic control, as measured by hemoglobin

A1c (HbA1c), is a critical determinant of DN progression. Studies have shown that patients with HbA1c levels ≥7% are at a significantly higher risk of developing albuminuria and CKD compared to those with better-controlled diabetes.[8,9] Additionally, the duration of diabetes plays a pivotal role, with longer disease duration associated with more advanced renal impairment.[10] Early detection of DN through biomarkers such as urinary albumin-to-creatinine ratio (ACR) and estimated GFR (eGFR) is essential for timely intervention and slowing disease progression.[11] Despite advances in diabetes management, the prevalence of DN remains high, particularly in low- and middle-income countries where access to healthcare and diabetes education is limited.[12] This underscores the importance of understanding the clinical and biochemical correlates of DN in diverse populations. However, there is a paucity of data on the progression of DN in patients with uncontrolled T2DM, especially in the context of varying degrees of HTN and proteinuria. This cross-sectional study aimed to evaluate the progression of DN in patients with uncontrolled T2DM, focusing on the association between glycemic control, renal function, and HTN. By classifying CKD stages based on eGFR levels and analyzing the distribution of proteinuria, this study provides valuable insights into the factors driving DN progression. Findings may inform targeted interventions to reduce the burden of DN and improve outcomes in patients with T2DM.

Objectives

The primary objective of this study was to evaluate the progression of DN in patients with uncontrolled T2DM and to assess its association with clinical and biochemical parameters, including glycemic control, renal function, and HTN. Specifically, the study aimed to: Compare the severity of DN between poorly controlled (HbA1c≥7%) and well-controlled (HbA1c<7%) T2DM patients. Classify CKD stages based on eGFR levels. Analyze the distribution of proteinuria (microalbuminuria, macroalbuminuria, and normal renal function) in relation to glycemic control. Examine the association between HTN severity and the progression of DN.

METHODS

A cross-sectional study was conducted on 147 patients with T2DM, aged 45-60 years, at Enam medical college, Sir Salimullah medical college, and Dhaka medical college from March 2024 to December 2024. Participants were selected using a purposive sampling technique and categorized into two groups based on glycemic control: poorly controlled diabetes (HbA1c≥7%) and controlled diabetes (HbA1c<7%). Clinical and biochemical parameters were assessed, including BP, duration of diabetes, HbA1c levels, serum creatinine, urinary ACR, and eGFR. CKD stages were classified according to eGFR levels, and proteinuria was categorized as microalbuminuria, macroalbuminuria, or normal renal function. HTN was graded using American heart association (AHA) guidelines. Data were analyzed using SPSS version 23.0. Continuous variables were expressed as mean±SD and categorical variables were presented as frequencies and percentages. Statistical tests were used to evaluate associations between glycemic control, renal function, and HTN. Ethical approval was obtained, and informed consent was secured from all participants.

RESULTS

The study included 147 patients with T2DM, comprising 98 males (66.7%) and 49 females (33.3%), with a mean age of 55±4.3 years. Participants were categorized into two groups based on glycemic control: poorly controlled diabetes (HbA1c≥7%) and controlled diabetes (HbA1c<7%). The mean duration of diabetes among participants was 10.2±3.1 years. Poorly controlled diabetes (HbA1c≥7%) was observed in 78 patients (53.1%), with a mean HbA1c level of 8.1±1.2%, while 69 patients (46.9%) had controlled diabetes (HbA1c<7%), with a mean HbA1c level of 6.2±0.5% (Table 1). Renal function assessment based on eGFR levels revealed the following distribution of CKD stages: 44 patients (29.9%) had stage 1 CKD (eGFR≥90 ml/min/1.73 m^2), 29 patients (19.7%) had stage 2 CKD (eGFR 60-89 ml/min/1.73 m^2), 49 patients (33.3%) had stage 3 CKD (eGFR 30-59 ml/min/1.73 m^2), and 25 patients (17.0%) each had stage 4 (eGFR 15-29 ml/min/1.73 m^2) and Stage 5 CKD (eGFR <15 ml/min/1.73 m^2) (Table 2). Proteinuria distribution showed that 49 patients (33.3%) had microalbuminuria, 29 patients (19.7%) had macroalbuminuria, 44 patients (29.9%) had normal renal function, and 25 patients (17.0%) had ESRD (Figure 1). HTN grading according to American heart association (AHA) guidelines indicated that 64 patients (43.5%) had grade 2 HTN, 44 patients (29.9%) had grade 1 HTN, and 39 patients (26.5%) were normotensive (Figure 2). Statistical analysis revealed significant associations between poorly controlled diabetes (HbA1c≥7%) and adverse renal outcomes. Poorly controlled diabetes was associated with higher urinary ACR, reduced eGFR, and elevated serum creatinine levels ($p<0.05$). Additionally, grade 2 HTN was more prevalent in patients with advanced CKD stages ($p<0.01$) (Table 3).

Table 1: Demographic and clinical characteristics of study participants.

Variables	Total	Poorly controlled, (n=78)	Controlled, (n=69)
Age (in years)	55±4.3	56±4.1	54±4.5
Male, N (%)	98 (66.7)	52 (66.7)	46 (66.7)
Female, N (%)	49 (33.3)	26 (33.3)	23 (33.3)
Duration of diabetes (in years)	10.2±3.1	11.1±2.9	9.3±3.2
HbA1c (%)	7.3±1.2	8.1±1.2	6.2±0.5

Table 2: Distribution of CKD stages based on eGFR levels.

CKD stage	eGFR range (ml/min/1.73 m^2)	N	Percent (%)
Stage 1	≥90	44	29.90
Stage 2	60-89	29	19.70
Stage 3	30-59	49	33.30
Stage 4	15-29	25	17.00
Stage 5	<15	25	17.00

Table 3: Association between glycemic control and renal parameters.

Parameters	Poorly controlled, (n=78)	Controlled, (n=69)	P value
Urinary ACR (mg/g)	320±150	120±80	<0.05
eGFR (ml/min/1.73 m^2)	45±15	75±20	<0.05
Serum creatinine (mg/dl)	2.1±0.8	1.2±0.5	<0.05

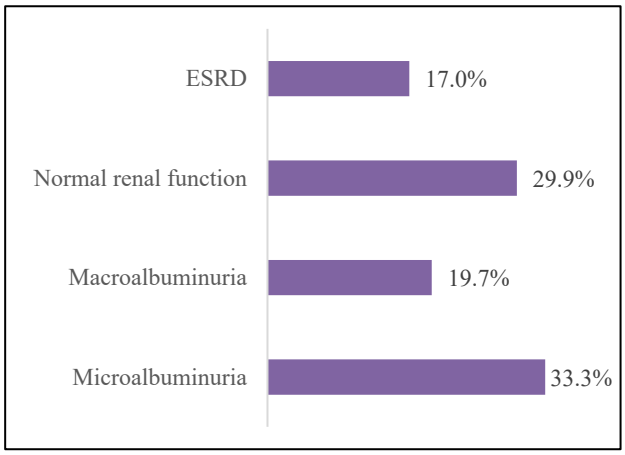

Figure 1: Distribution of proteinuria and renal function.

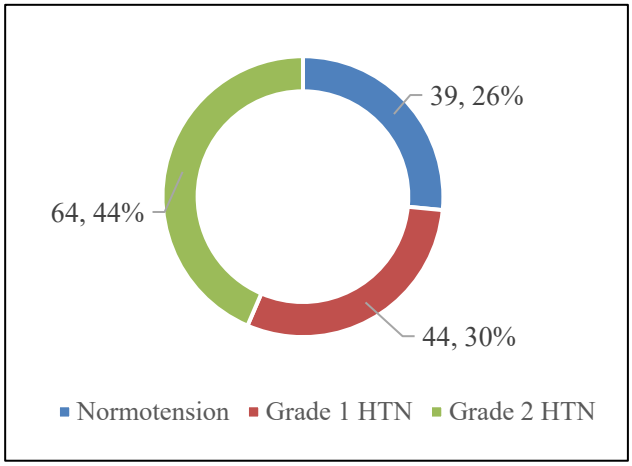

Figure 2: BP distribution according to AHA guidelines.

DISCUSSION

This cross-sectional study evaluated the progression of DN in patients with uncontrolled T2DM, highlighting the significant impact of glycemic control, HTN, and renal function on disease progression. The findings demonstrate that poorly controlled diabetes (HbA1c≥7%) is strongly associated with advanced stages of CKD, elevated urinary ACR, and reduced eGFR, consistent with previous studies.[2,13] The prevalence of CKD stages in this study aligns with global trends, where a substantial proportion of T2DM patients progress to CKD due to poor glycemic control and comorbid HTN.[4,14] The high prevalence of microalbuminuria (33.3%) and macroalbuminuria (19.7%) in our cohort underscores the role of proteinuria as an early marker of DN and a predictor of renal decline.[15] These findings emphasize the importance of regular screening for albuminuria in T2DM patients to facilitate early intervention and slow disease progression.[16] HTN, particularly grade 2 HTN, was significantly associated with advanced CKD stages, corroborating evidence that elevated BP exacerbates renal damage by increasing intraglomerular pressure and accelerating glomerulosclerosis.[6,10] The high prevalence of HTN (73.5%) in our study population highlights the need for aggressive BP management in T2DM patients, as recommended by current guidelines.[17] The strong association between poorly controlled diabetes (HbA1c≥7%) and adverse renal outcomes, including reduced eGFR and elevated serum creatinine, reinforces the critical role of glycemic control in preventing DN progression.[5,18] These findings are consistent with the UK prospective diabetes study (UKPDS), which demonstrated that intensive glycemic control significantly reduces the risk of microvascular complications, including DN.[19] However, the study has some limitations, including its cross-sectional design, which precludes the establishment of causal relationships. Additionally, the sample size, though adequate, may not fully represent the broader T2DM population. Future longitudinal studies are needed to explore the temporal relationship between glycemic control, HTN, and DN progression. This study highlights the detrimental effects of poor glycemic control and HTN on renal function in T2DM patients. Early intervention targeting glycemic control, BP management, and regular screening for albuminuria are essential to mitigate the progression of DN and improve patient outcomes.

Limitations

This study has a cross-sectional design, limiting causal inferences. The sample size, though adequate, may not fully represent the broader T2DM population. Additionally, potential confounding factors, such as medication adherence and lifestyle, were not assessed, which may influence the observed outcomes.

CONCLUSION

This study highlights significant impact of poor glycemic control and HTN on the progression of DN in patients with T2DM. Poorly controlled diabetes (HbA1c≥7%) was strongly associated with advanced CKD stages, elevated proteinuria, and reduced eGFR. Early intervention focusing on glycemic control, BP management, and regular renal screening is essential to mitigate DN progression and improve outcomes in T2DM patients.

Recommendations

Regular screening for albuminuria and eGFR is crucial for early detection of renal impairment in T2DM patients. Achieving glycemic control (HbA1c<7%) and managing HTN aggressively can prevent DN progression. Patient education on lifestyle changes and treatment adherence is vital for better outcomes.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Orchi P, Zaman MB, Faruque FB, Susmita SJ, Begh TJ. Progression of diabetic nephropathy in patients with uncontrolled type 2 diabetes mellitus: a cross-sectional study. Int J Adv Med 2025;12:362-5.