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Original Research Article

Impact of Duration of Type 2 Diabetes Mellitus on the Development of Microalbuminuria: A Predictor of Diabetic Nephropathy

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Abstract:

Background: Type 2 Diabetes Mellitus (T2DM) is a major global health concern associated with various microvascular complications. Diabetic nephropathy is one of the most serious complications, and microalbuminuria is considered the earliest detectable marker of renal damage. Early detection of microalbuminuria is important for preventing the progression to advanced kidney disease.

Aim: To evaluate the impact of the duration of Type 2 Diabetes Mellitus on the development of microalbuminuria as an early predictor of diabetic nephropathy.

Methodology: A hospital-based observational cross-sectional study was conducted in the Department of Biochemistry, Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Bihar. A total of 90 patients with diagnosed T2DM were included. Clinical data and biochemical parameters such as fasting blood sugar, postprandial blood sugar, HbA1c, blood urea, serum creatinine, and urinary microalbumin were analyzed. Statistical analysis was performed using SPSS version 27.

Results: Microalbuminuria was present in 42 (46.7%) patients and its prevalence increased with the duration of diabetes. Patients with diabetes duration >15 years showed the highest prevalence (83.3%). The mean HbA1c level was 8.2 ± 1.3%, indicating poor glycemic control among participants.

Conclusion: Longer duration of T2DM is strongly associated with increased prevalence of microalbuminuria, highlighting the need for early screening and strict glycemic control to prevent diabetic nephropathy.

Keywords: Type 2 Diabetes Mellitus, Microalbuminuria, Diabetic Nephropathy, HbA1c, Duration of Diabetes.

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Introduction

Diabetes mellitus (DM) is a chronic metabolic condition that presents itself with sustained hyperglycemia through the defects in the secretion of insulin, insulin action, or both. The disease has become one of the greatest health issues in the world because of its outstanding rising rate of prevalence and its connection with a number of chronic complications [1]. Diabetes-induced chronic hyperglycemia causes metabolic and structural alterations in various body organs, especially to the microvasculature. Consequently, diabetic nephropathy, diabetic retinopathy, and diabetic neuropathy are microvascular complications that are very likely to occur among patients with long-standing diabetes. Diabetic nephropathy is one of such complications, as it may eventually develop into end-stage renal disease (ESRD), a condition that results in a great morbidity and mortality rate among diabetic patients [2]. The role of poor glycemic control in the development and exacerbation of diabetic nephropathy is significant and sustained exposure to high blood glucose levels causes damage to the glomerular filtration barrier that causes excessive amount of protein to be secreted into the urine.

Albuminuria is commonly known to be one of the valuable parameters of renal dysfunction and the initial indicator of kidney damage in people with diabetes mellitus [3]. Albumin in the urine is an indicator of damage to the glomerular filtration barrier that prevents the excretion of large proteins like albumin into the urine. The microalbuminuria that has appeared in the initial phases of diabetic nephropathy is a moderate level of albumin excretion in the urine that cannot be identified using standard dipstick analysis. Microalbuminuria refers to the excretion of

urinary albumin between 30300mg/24hours or 20200 µg/minute [4]. Microalbuminuria is clinically significant as it is the first stage of diabetic kidney disease that can be detected and acts as a predictor in the subsequent occurrence of overt nephropathy should no action be taken to curb microalbuminuria at an early stage.

Microalbuminuria is not simply a sign of early renal involvement, but is also linked to endothelial dysfunction in the general sense. Endothelial dysfunction is a key element of the pathogenesis of microvascular and macrovascular complications of diabetes. Microalbuminuria has been associated with elevated vascular permeability, inflammation and oxidative stress, both of which lead to progressive renal damage and cardiovascular complications. Consequently, microalbuminuria can be regarded as a powerful predictor of diabetic nephropathy and a valuable risk factor of cardiovascular disease among diabetic mellitus patients. Early detection of microalbuminuria enables clinicians to take preventive measures, including better glycemic regulation, blood pressure management, and lifestyle change, which result in renal disease retardation or even prevention [5].

Long-term glycemic control is an important assessment that is instrumental in monitoring and managing diabetes mellitus patients [6]. Glycosylated hemoglobin (HbA1c) has been extensively adopted as a good predictor of mean blood glucose level over the last two or three months. HbA1c is a more consistent and precise measure of chronic glycemic exposure than the other tests of fasting blood sugar (FBS) and post-prandial blood sugar (PPBS) since it is not affected by the temporary changes in glucose levels in the blood. Continuous high HbA1c level indicates an inadequate control of glycemic regulation and corresponds with higher chances of onset of the microvascular issues such as diabetic nephropathy. It has been proven that the increased levels of HbA1c are associated with the development of microalbuminuria and onset of the renal impairment in the patients with type 2 diabetes mellitus.

Routine checking of renal activity is thus a necessary part of dealing with diabetic patients. Clinical guidelines suggest that patients with diabetes be screened annually with kidney disease measurement of urinary albumin excretion and evaluation of glycemic control with HbA1c testing. Diabetic nephropathy is a medical condition that can be prevented or slowed down through therapeutic measures; early identification of microalbuminuria will help healthcare providers to identify patients at risk of developing diabetic nephropathy [7]. Besides glycemic regulation, several other issues including hypertension, dyslipidemia, and time of diabetes conditions are important issues that contribute to diabetic kidney disease. Hence, careful assessment of such parameters is required to be effective in terms of controlling and preventing complications among diabetics.

Previous research studies have demonstrated that multiple metabolic and physiological factors work together to create microalbuminuria which develops and progresses. The rise in blood glucose levels creates a direct risk to the glomerular capillaries and basement membrane which results in increased urinary albumin excretion. The development of diabetic complications stems from two key elements which include sustained hyperglycemia and glycemic variability [8]. The progression of nephropathy accelerates due to frequent blood glucose level changes which increase oxidative stress and cause endothelial damage. The hallmark trait of type 2 diabetes mellitus known as insulin resistance has been linked to microalbuminuria through three core pathways which include inflammation and vascular dysfunction and metabolic disturbance.

Diabetes duration serves as an essential factor that determines the likelihood of developing diabetic nephropathy. Diabetic patients who experience extended periods of diabetes face increased risk for hyperglycemic episodes and metabolic disorders, which results in greater chances of developing microvascular damage. Long-standing diabetes is therefore strongly associated with a higher prevalence of microalbuminuria and other complications. The early detection of patients who have diabetes for an extended period and show poor blood sugar control enables medical professionals to implement preventive measures that protect against kidney damage.

The study examined patients with type 2 diabetes mellitus who received treatment through the Prolanis chronic disease management program at primary health care facilities. The healthcare program monitors patients through monthly tests which include fasting blood sugar (FBS) and post-prandial blood sugar (PPBS) assessments of their blood glucose levels. The detection of diabetic nephropathy through continuous monitoring proves difficult because renal damage develops without symptoms until it reaches advanced stages. The study needs to examine how glycemic control affects microalbuminuria development because researchers need to identify nephropathy risk at the earliest point to protect against permanent kidney damage.

The researchers performed their study to determine how HbA1c levels in blood tests relate to microalbuminuria development in type 2 diabetes patients. The study included assessment of glycemic control together with age, gender, fasting blood sugar (FBS), post-prandial blood sugar (PPBS), blood pressure, blood urea level, serum creatinine level, and duration of diabetes as vital assessment factors. The research investigates these variables to establish how diabetes duration and metabolic control con-

tribute to microalbuminuria development, which functions as an early indicator of diabetic nephropathy.

Methodology

Study Design: The present study was designed as a hospital-based observational cross-sectional study. The study aimed to evaluate the impact of the duration of Type 2 Diabetes Mellitus on the development of microalbuminuria and its role as an early predictor of diabetic nephropathy among diabetic patients.

Study Area: The study was conducted in the Department of Biochemistry, Bhagwan Mahavir Institute of Medical Sciences, Pawapuri, Nalanda, Bihar, India.

Study Duration: The study was carried out over a period of 7 months from March 2025 to September 2025.

Study Participants: The study participants included patients diagnosed with Type 2 Diabetes Mellitus who attended the outpatient and inpatient departments of the hospital during the study period.

Inclusion Criteria

- Patients diagnosed with Type 2 Diabetes Mellitus.
- Patients aged 18 years and above.
- Patients who were willing to participate in the study and provided informed consent.
- Patients with documented duration of diabetes.
- Patients who attended the hospital during the study period and underwent laboratory investigations.

Exclusion Criteria

- Patients with pre-existing chronic kidney disease.
- Patients diagnosed with glomerulonephritis or nephrotic syndrome.
- Patients suffering from acute or chronic inflammatory diseases.
- Patients who were smokers or chronic alcohol consumers.
- Patients receiving nephrotoxic drugs.
- Patients with primary hypertension or other systemic diseases affecting kidney function.
- Pregnant women.

Sample Size: A total of 90 patients with clinically diagnosed Type 2 Diabetes Mellitus were included in the study. The participants were selected using a convenient sampling method from patients attending the hospital during the study period.

Procedure: The participants, detailed clinical and demographic information was collected using a structured proforma. Information regarding age, gender, duration of diabetes, and relevant medical history was obtained from the patients and their medical records. The duration of diabetes was recorded based on the time since diagnosis as documented in the hospital records.

Blood and urine samples were collected from all participants for laboratory investigations. Blood samples were collected after 10–12 hours of overnight fasting while maintaining all aseptic and antiseptic precautions. Approximately 5 mL of venous blood was drawn from the antecubital vein using sterile disposable syringes. The collected samples were processed for biochemical investigations including fasting blood glucose, postprandial blood glucose, blood urea, serum creatinine, and glycated hemoglobin (HbA1c).

Urinary microalbumin levels were assessed using a urine sample collected in a sterile container. The presence of microalbuminuria was determined to evaluate early renal involvement in patients with Type 2 Diabetes Mellitus. Laboratory investigations were performed using standard biochemical methods and automated analyzers available in the Department of Biochemistry.

The patients were further categorized according to the duration of diabetes in order to assess the relationship between the length of time a patient had diabetes and the development of microalbuminuria. All clinical and laboratory findings were recorded systematically for further analysis.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 27.0. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency and percentage. Appropriate statistical tests were applied to determine the association between the duration of Type 2 Diabetes Mellitus and the presence of microalbuminuria. The level of statistical significance was considered at $p < 0.05$. The findings were presented in tables and graphs for clear interpretation.

Result

Table 1 shows the distribution of study participants according to different age groups. Out of the total 90 participants included in the study, the highest proportion belonged to the 41–50 years age group with 24 participants (26.7%). This was followed by the 51–60 years age group comprising 22 participants (24.4%). Participants aged more than 60 years accounted for 18 individuals (20%), while those in the 31–40 years age group included 16 participants (17.8%). The least number of participants were observed in the 18–30 years age group with 10 individuals (11.1%). Overall, the findings indicate that the majority of the study population was concentrated in the middle-aged and older age groups.

Table 1: Distribution of Study Participants According to Age Group (n=90)		
Age Group (Years)	**Frequency (n)**	**Percentage (%)**
18–30	10	11.1
31–40	16	17.8
41–50	24	26.7
51–60	22	24.4
>60	18	20
Total	**90**	**100**

Table 2 shows the gender distribution of the study participants included in the research. Out of the total 90 participants, the majority were males with 48 individuals, accounting for 53.3% of the study population. Females constituted 42 participants, representing 46.7% of the total sample. The findings indicate that male participant slightly outnumbered female participants in the study. However, the difference between the two groups was not very large, suggesting that both genders were fairly represented in the study population. Overall, the distribution reflects a relatively balanced participation of males and females, which helps in minimizing gender bias and allows for a more reliable interpretation of the study results.

Table 2: Gender Distribution of Study Participants (n=90)		
Gender	**Frequency (n)**	**Percentage (%)**
Male	48	53.3
Female	42	46.7
Total	**90**	**100**

Table 3 shows the distribution of participants according to the duration of Type 2 Diabetes Mellitus. Out of the total 90 participants included in the study, the majority had diabetes for 5–10 years, accounting for 34 participants (37.8%). This was followed by 26 participants (28.9%) who had diabetes for less than 5 years. Participants with a duration of 11–15 years constituted 18 cases (20%), while the smallest proportion was observed among those with diabetes for more than 15 years, comprising 12 participants (13.3%). Overall, the findings indicate that a considerable proportion of the study population had been living with diabetes for 5–10 years, highlighting a moderate duration of disease among most participants in the study.

Table 3: Distribution of Participants According to Duration of Type 2 Diabetes Mellitus		
Duration of Diabetes	**Frequency (n)**	**Percentage (%)**
<5 years	26	28.9
5–10 years	34	37.8
11–15 years	18	20
>15 years	12	13.3
Total	**90**	**100**

Table 4 shows the mean biochemical parameters of the study participants. The mean fasting blood sugar level was 152.4 ± 34.6 mg/dL, while the mean postprandial blood sugar level was 224.7 ± 48.2 mg/dL, indicating elevated blood glucose levels among the participants. The mean blood urea level was 36.5 ± 9.4 mg/dL, and the mean serum creatinine level was 1.21 ± 0.34 mg/dL, suggesting mild variations in renal function. The mean HbA1c level was 8.2 ± 1.3%, reflecting poor long-term glycemic control among the study population. Additionally, the mean urinary microalbumin level was 52.8 ± 18.6 mg/day, which indicates the presence of increased urinary albumin excretion and suggests a risk or early indication of diabetic nephropathy among individuals with type 2 diabetes mellitus.

Table 4: Mean Biochemical Parameters of Study Participants	
Parameter	**Mean ± SD**
Fasting Blood Sugar (mg/dL)	152.4 ± 34.6
Postprandial Blood Sugar (mg/dL)	224.7 ± 48.2
Blood Urea (mg/dL)	36.5 ± 9.4
Serum Creatinine (mg/dL)	1.21 ± 0.34
HbA1c (%)	8.2 ± 1.3
Urinary Microalbumin (mg/day)	52.8 ± 18.6

Table 5 shows the association between the duration of diabetes and the presence of microalbuminuria among the study participants. Out of the total 90 patients, 26 had a duration of diabetes of less than 5 years, among whom 6 patients had microalbuminuria while 20 did not show its presence. In the group with 5–10 years duration of diabetes, 14 patients had microalbuminuria and 20 patients did not. Among patients with a duration of 11–15 years, 12 showed microalbuminuria while only 6 did not. In the group with diabetes duration of more than 15 years, 10 patients had microalbuminuria whereas only 2 patients were without it. Overall, 42 patients were found to have microalbuminuria while 48 patients did not. The findings indicate that the prevalence of microalbuminuria increases with the increasing duration of diabetes.

Table 5: Association Between Duration of Diabetes and Presence of Microalbuminuria

Duration of Diabetes	Microalbuminuria Present (n)	Microalbuminuria Absent (n)	Total
<5 years	6	20	26
5–10 years	14	20	34
11–15 years	12	6	18
>15 years	10	2	12
Total	**42**	**48**	**90**

Discussion

The current research investigates how long Type 2 Diabetes Mellitus lasts until patients develop microalbuminuria, which doctors use to identify early stages of diabetic nephropathy. The study results show that people with diabetes for longer periods of time experience a growing rate of microalbuminuria. The study found that microalbuminuria occurred in 6 out of 26 patients with diabetes duration under 5 years. The study found that microalbuminuria occurred in 14 out of 34 patients with diabetes duration between 5 and 10 years. The study found that microalbuminuria occurred in 12 out of 18 patients who had diabetes for 11 to 15 years. The study found that microalbuminuria occurred in 10 out of 12 patients with diabetes duration longer than 15 years. The results show that longer diabetes duration directly increases the chances of developing kidney problems.

Thakur et al. (2019) [9] observed similar findings to their research which involved 227 Type 2 Diabetes Mellitus patients who showed that microalbuminuria occurred more frequently in patients with longer diabetes history. Their research demonstrated that people who had diabetes for more than 10 years developed microalbuminuria at higher rates than those who had diabetes for shorter periods. The current research discovered that people who had diabetes for more than 15 years experienced microalbuminuria at the highest rate of 83.3 percent. The research results demonstrate that extended periods of elevated blood sugar levels lead to the development of diabetic nephropathy.

Another study conducted by Ansar et al. (2017) [10] in Iran also reported that duration of diabetes was an independent risk factor for the development of microalbuminuria. The study showed that diabetes patients who had diabetes for a longer time period produced more urinary albumin than patients who had recently been diagnosed with the condition. Our research produces results which match the findings from their study because both studies demonstrate that microalbuminuria rates rise with longer disease duration. The study found a lower prevalence rate than what we found in our population because different groups had varying patterns of living and diabetes management and access to medical services.

Microalbuminuria serves as the first clinical indicator which shows the beginning stages of diabetic nephropathy. Early detection is important because timely intervention can slow or prevent the progression of renal damage. The present study found that diabetic patients showed increased albumin excretion through their mean urinary microalbumin level of 52.8 ± 18.6 mg/day. Pasko et al. (2013) [11] reported similar results when they discovered that routine screening for kidney involvement among Type 2 Diabetes Mellitus patients would help identify microalbuminuria which occurred at high rates. The research revealed that timely detection together with suitable treatment would help to postpone the advancement of kidney disease to its complete nephropathy stage.

The research established that study participants showed unsatisfactory blood sugar management because their average fasting blood sugar value reached 152.4 ± 34.6 mg/dL and their postprandial blood sugar result showed 224.7 ± 48.2 mg/dL and their HbA1c measurement reached 8.2 ± 1.3%. Diabetes patients experience microvascular complications because their body maintains chronic high blood sugar levels which scientists have identified as a primary cause. Kundu et al. (2013) [12] discovered that HbA1c levels showed a strong link to microalbuminuria in Type 2 Diabetes Mellitus patients. The research demonstrated that patients who did not maintain their blood sugar levels showed higher rates of microalbuminuria which indicates that extended periods of high blood sugar levels result in kidney damage.

Some research studies found that HbA1c results showed weaker connections to microalbuminuria than they had expected. Chen et al. (2014) [13] showed that poor glycemic control increased the risk of renal complications, but they established that hypertension and lipid abnormalities and genetic predisposition functioned as significant factors in the development of diabetic nephropathy. The development of microalbuminuria shows primary hyperglycemia as a major factor, yet multiple mechanisms work together to create this condition.

Diabetic nephropathy develops through multiple metabolic and hemodynamic alterations which create its pathophysiological mechanism. Persistent hyperglycemia leads to the formation of advanced glycation end products, activation of the polyol pathway, oxidative stress, and increased inflammatory responses. The processes induce structural changes which lead to kidney damage because they cause glomerular basement membrane thickening and mesangial expansion, which result in increased glomerular filtration barrier permeability and albumin leakage into urine. Parchwani and Upadhyah (2012) [14] described similar mechanisms which they found to cause diabetic patients to experience progressive kidney damage that leads to nephropathy through their study of chronic hyperglycemia.

Baig et al. (2016) [15] conducted another study which confirmed that diabetes duration affects both glycemic control and microalbuminuria. The research demonstrated a strong connection between three factors which included extended disease duration and increased HbA1c levels and elevated urinary albumin excretion among the 60 participants who had Type 2 Diabetes Mellitus. The current research results show that microalbuminuria occurs more frequently when people experience both extended diabetes duration and inadequate blood sugar management.

The study by Bagzai and Bagzai (2019) [16] found that patients with higher HbA1c levels showed more severe microalbuminuria symptoms. The study results showed that HbA1c serves as a critical indicator which doctors can use to determine diabetic nephropathy risk. The current research demonstrates that the study participants showed high HbA1c levels which reached 8.2% because their blood sugar levels remained uncontrolled over time thus increasing their chances of developing microvascular damage.

The present study results show consistency with multiple earlier studies which examined different groups of people. The results show that extended Type 2 Diabetes Mellitus duration combined with inadequate glycemic control leads to microalbuminuria development. Microalbuminuria screening should begin earlier while doctors need to establish strict glycemic control combined with proper management methods to stop diabetic nephropathy progression and decrease chronic kidney disease rates among diabetic patients.

Conclusion

The present study evaluated the relationship between the duration of Type 2 Diabetes Mellitus and the development of microalbuminuria, an early marker of diabetic nephropathy. The findings demonstrated that microalbuminuria prevalence increased progressively with longer duration of diabetes, indicating a strong association between chronic hyperglycemia and early renal damage. Patients with diabetes for more than 15 years showed the highest occurrence of microalbuminuria compared with those with shorter disease duration. The biochemical findings also revealed poor glycemic control among participants, as reflected by elevated fasting blood sugar, postprandial blood sugar, and HbA1c levels. Increased urinary microalbumin levels further indicated early renal involvement in many patients. These results highlight the importance of regular monitoring of HbA1c and urinary microalbumin in diabetic individuals. Early detection and effective glycemic management can help prevent or delay the progression of diabetic nephropathy and associated complications.

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