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Comparative Study of Microalbuminuria in Relation with Hba1c Levels in Type 2 Diabetes Mellitus

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ABSTRACT

Background: *Type 2 Diabetes Mellitus (T2DM) is associated with microvascular complications, notably diabetic nephropathy, for which microalbuminuria is an early marker. The association between glycemic control, as reflected by HbA1c, and microalbuminuria in Indian populations remains incompletely characterized.*

Aim: *To evaluate the relationship between HbA1c levels and microalbuminuria among patients with T2DM.*

Methods: *This cross-sectional study enrolled 100 adult T2DM patients at a tertiary care hospital in India over 18 months. Demographic data, clinical history, and laboratory parameters including HbA1c, fasting and postprandial blood sugars, renal function tests, and urine albumin were recorded. Participants were grouped based on HbA1c (<7.5%, 7.5–10%, >10%) and categorized according to urine albumin levels. Associations were analyzed using Pearson's correlation and chi-square test; $p < 0.05$ was considered significant.*

Results: *The mean age of participants was 53.1 ± 11.1 years; 57% were male. Most (84%) were managed with oral hypoglycemic agents. The mean HbA1c was 7.44 ± 1.18%. Microalbuminuria was present in 60% of patients, and mean urine albumin was 83.5 ± 79.2 mg/g. Patients with HbA1c <7.5% had significantly lower urine albumin levels (34.7 ± 26.2 mg/g) than those with higher HbA1c (7.5–10%: 142.7 ± 69.6 mg/g; >10%: 254.4 ± 35.6 mg/g; $p < 0.05$). A strong positive correlation was found between HbA1c and urine albumin ($r = 0.914$, $p < 0.001$). All patients with HbA1c ≥7.5% had microalbuminuria.*

Conclusion: *This study demonstrates a strong, statistically significant association between poor glycemic control and increased prevalence and severity of microalbuminuria in T2DM patients. Regular screening for microalbuminuria and maintenance of target HbA1c levels are essential strategies to prevent or delay the onset of diabetic nephropathy and reduce renal and cardiovascular risk in Indian patients with T2DM.*

Key words: *Type 2 Diabetes Mellitus, Microalbuminuria, HbA1c, Glycemic control, Diabetic nephropathy, Indian population*

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder marked by insulin resistance and progressive pancreatic β-cell dysfunction. Its complications are classified as macrovascular (e.g., cardiovascular disease, stroke, peripheral vascular disease) and microvascular (e.g., neuropathy, nephropathy, retinopathy) [1,2]. The global prevalence of diabetes is rapidly increasing, especially in developing countries, making it a major public health concern.

Diabetic kidney disease (DKD), a common microvascular complication, is the leading cause of end-stage renal disease (ESRD) worldwide, with 20–40% of diabetic patients developing DKD and up to 40% of these progressing to ESRD [3]. Novel DKD phenotypes, such as nonalbuminuric renal impairment, emphasize the importance of assessing both proteinuria and glomerular filtration rate (GFR) in clinical management [4,5].

The Kidney Disease: Improving Global Outcomes (KDIGO) guidelines have introduced a new chronic kidney disease (CKD) classification, combining GFR and albuminuria risk categories, now standard in clinical practice [6–9]. Despite advances in treatment, the risk of DKD remains substantial, highlighting the need for ongoing refinement of prevention and management strategies [6].

Microalbuminuria (urinary albumin excretion of 30–299 mg/day) is an early indicator of renal involvement in diabetes and is associated with increased cardiovascular risk and progressive renal impairment. Early detection enables timely interventions to slow nephropathy progression and improve outcomes [10–14]. Glycated hemoglobin (HbA1c) is a key marker of long-term glycemic control, with elevated levels linked to greater risk of microvascular complications, including microalbuminuria. However, the direct relationship between HbA1c and microalbuminuria is influenced by multiple factors and remains an area of active investigation [15–17].

Given the rising burden of T2DM and its complications, effective detection and management strategies are crucial. Microalbuminuria serves as both an early nephropathy marker and an independent cardiovascular risk predictor. HbA1c remains central for glycemic monitoring and risk stratification. Although early intervention improves outcomes, data on the direct correlation between HbA1c and microalbuminuria in diverse populations is limited. This study aims to address this gap by evaluating their relationship in T2DM patients [18-20]. The primary aim of this study is to investigate the relationship between microalbuminuria and glycated hemoglobin (HbA1c) levels in patients with Type 2 Diabetes Mellitus (T2DM). Specifically, the study seeks to assess HbA1c and urine albumin levels in T2DM patients and to identify the association between glycemic control, as indicated by HbA1c, and the presence of microalbuminuria.

MATERIALS AND METHODS

This cross-sectional study was conducted at Adichunchanagiri Hospital and Research Centre, B.G. Nagara, Mandya District, over an 18-month period from May 2023 to November 2024. The study recruited patients aged above 18 years with Type 2 Diabetes Mellitus (T2DM), including both known and newly diagnosed cases, who provided informed consent. Exclusion criteria included acute febrile illness, drug-induced proteinuria, malignancies, collagen vascular disorders, other systemic diseases causing proteinuria, pregnancy, chronic kidney disease (CKD) due to causes other than diabetes, and unwillingness to participate.

Based on a previous study by Juhi Aggarwal et al. in rural India, which reported a 52% prevalence of proteinuria in T2DM patients, the sample size was estimated using the formula $n = (z^2 \times p \times q) / d^2$, with $z = 1.96$ for 95% confidence, $p = 0.52$, $q = 1 - p$, and $d = 0.10$ (absolute precision), yielding a required sample size of 96, rounded to 100 T2DM patients.

After obtaining institutional ethics committee approval, eligible participants were enrolled from the Department of General Medicine, including both inpatient and outpatient services. Data collection involved detailed history-taking, physical examination, and biochemical investigations. Blood samples (5–8 mL) were collected via venous puncture, and serum was separated by centrifugation at 3000 rpm for 10 minutes. Laboratory analyses included random blood sugar (RBS), fasting blood sugar (FBS), postprandial blood sugar (PPBS), HbA1c, serum urea, and creatinine. Estimated glomerular filtration rate (eGFR) was calculated as per KDIGO 2022 guidelines, and patients were categorized according to CKD stage. Ultrasonography of the abdomen and pelvis was performed to assess corticomedullary differentiation. Only patients meeting all inclusion and exclusion criteria were considered for the study. Purposive sampling was used for patient selection.

Statistical analysis was performed using SPSS version 26.0. Descriptive statistics were employed to summarize data; qualitative variables were presented as frequencies and percentages, while quantitative variables were expressed as mean and standard deviation. The chi-square test was used to compare proportions, and Student's t-test or ANOVA was applied for comparison of means. Pearson's correlation coefficient was calculated to assess the relationship between continuous variables. A significance level of 5% ($\alpha = 0.05$) was considered for all statistical analyses.

RESULTS

The study population consisted of 100 individuals with Type 2 Diabetes Mellitus, ranging in age from 30 to 89 years, with a mean age of 53.11 ± 11.12 years. The majority of participants were in the 40–49 (27%), 50–59 (27%), and 60–69 (26%) age groups. Males comprised 57% of the cohort, while females accounted for 43%. The duration of diabetes was most commonly 1–5 years (59%), followed by 6–10 years (23%), 11–15 years (11%), and more than 15 years (7%). The mean BMI was 23.43 ± 3.5 kg/m^2. Regarding comorbidities, 23% of participants had hypertension, and 21% had ischemic heart disease (IHD).

Among the 100 study participants, the majority (84%) were managed with oral hypoglycemic agents (OHA) alone, while 12% received a combination of OHA and insulin, and only 4% were on insulin

monotherapy. The mean fasting blood sugar (FBS) was 180.77 ± 31.33 mg/dL, and the mean postprandial blood sugar (PPBS) was 255.97 ± 40.50 mg/dL. Regarding long-term glycemic control, 60% of patients had an HbA1c below 7.5%, 35% had levels between 7.5–10%, and 5% had values greater than 10%, with an overall mean HbA1c of 7.44 ± 1.18%. Renal function tests showed a mean blood urea of 29.4 ± 6.37 mg/dL and a mean serum creatinine of 1.06 ± 0.18 mg/dL. Lipid profile analysis revealed mean values of 188.34 ± 33.19 mg/dL for total cholesterol, 157.6 ± 61.33 mg/dL for triglycerides, 125.82 ± 23.68 mg/dL for LDL, and 31.0 ± 3.52 mg/dL for HDL. The mean urine albumin level was 83.51 ± 79.24 mg/g, indicating varying degrees of microalbuminuria among the study population.

Microalbuminuria was detected in 60% of participants, while 40% had normal urine albumin levels. Further stratification of urine albumin categories revealed that 40% of patients had normal albuminuria, 30% exhibited mild microalbuminuria, 18% had moderate microalbuminuria, and 12% demonstrated severe microalbuminuria, highlighting a substantial burden of renal involvement among the Type 2 Diabetes Mellitus cohort.

Analysis revealed a statistically significant association between HbA1c levels and urine albumin excretion ($p < 0.05$). Patients with HbA1c <7.5% had a mean urine albumin level of 34.73 ± 26.23 mg/g, whereas those with HbA1c 7.5–10% and >10% had markedly higher mean albumin levels of 142.72 ± 69.57 mg/g and 254.37 ± 35.63 mg/g, respectively. Microalbuminuria was present in 33.3% of patients with HbA1c <7.5%, while all patients with HbA1c ≥7.5% exhibited microalbuminuria (100%). These findings confirm a significant association between poor glycemic control and increased prevalence and severity of microalbuminuria in patients with Type 2 Diabetes Mellitus.

Table 1. Baseline Characteristics of Study Participants

Variable	Category	Frequency	Percentage
Age Group (years)	30–39	12	12%
	40–49	27	27%
	50–59	27	27%
	60–69	26	26%
	70–79	6	6%
	80–89	2	2%
Mean Age ± SD		53.11 ± 11.12	
Sex	Male	57	57%
	Female	43	43%
Duration of Diabetes	1–5 years	59	59%
	6–10 years	23	23%
	11–15 years	11	11%
	>15 years	7	7%
BMI (kg/m²)	Mean ± SD	23.43 ± 3.5	
Comorbidities	Hypertension	23	23%
	IHD	21	21%

Table 2. Clinical, Biochemical, and Treatment Characteristics of Study Participants

Variable	Category	Frequency	Percentage
Treatment	Insulin	4	4
	OHA	84	84
	Both	12	12
Fasting Blood Sugar (mg/dL)	Mean ± SD	180.77 ± 31.33	
Postprandial Blood Sugar (mg/dL)	Mean ± SD	255.97 ± 40.50	
HbA1c (%)	<7.5	60	60
	7.5–10	35	35
	>10	5	5
	Mean ± SD	7.44 ± 1.18	
Blood Urea (mg/dL)	Mean ± SD	29.4 ± 6.37	
Serum Creatinine (mg/dL)	Mean ± SD	1.06 ± 0.18	

Total Cholesterol (mg/dL)	Mean ± SD	188.34 ± 33.19
Triglycerides (mg/dL)	Mean ± SD	157.6 ± 61.33
LDL (mg/dL)	Mean ± SD	125.82 ± 23.68
HDL (mg/dL)	Mean ± SD	31.0 ± 3.52
Urine Albumin Level (mg/g)	Mean ± SD	83.51 ± 79.24

FIGURE 1. MICROALBUMINURIA

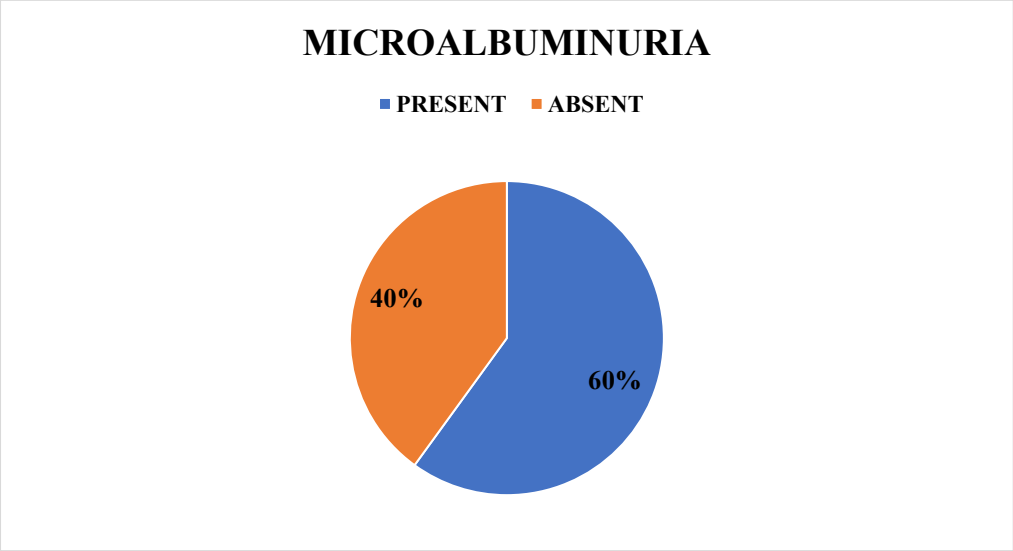


FIGURE 2. URINE ALBUMIN CATEGORY

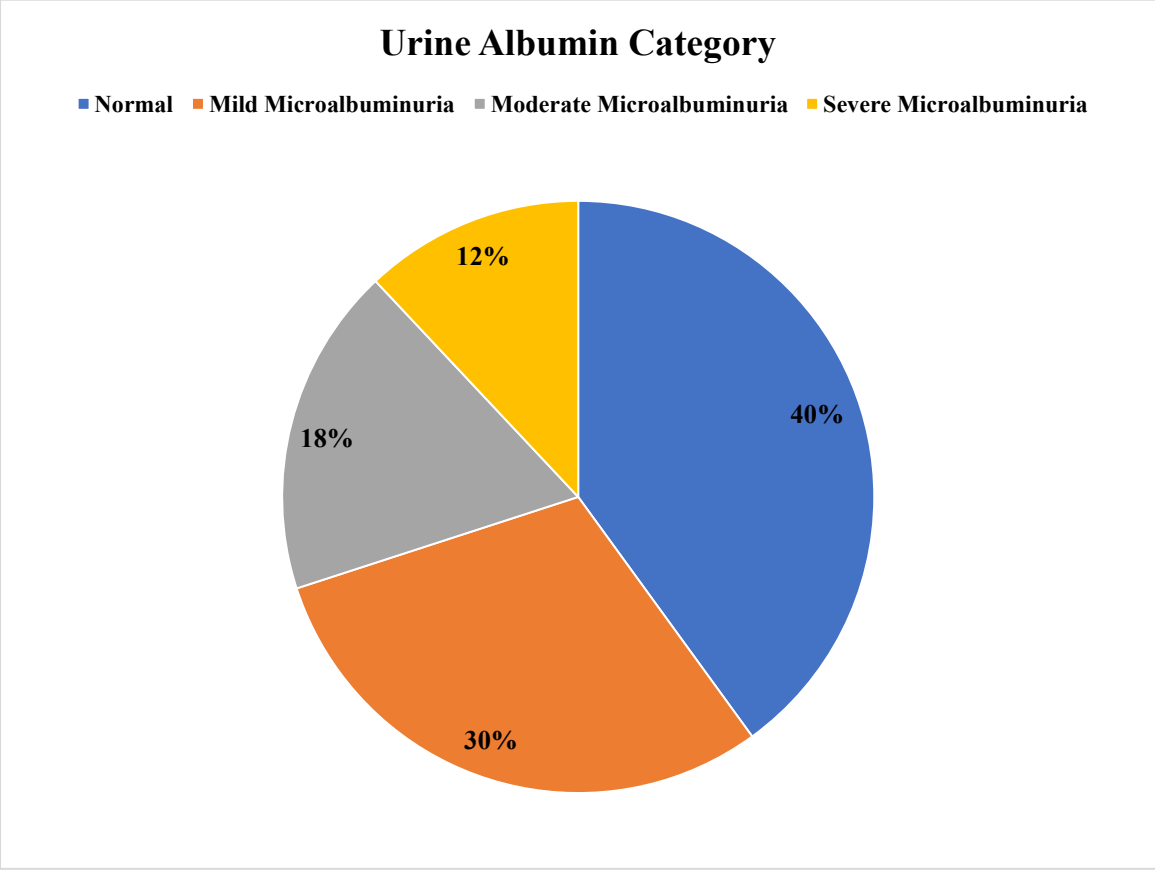


FIGURE 3. Association of Urine Albumin Level with HbA1c

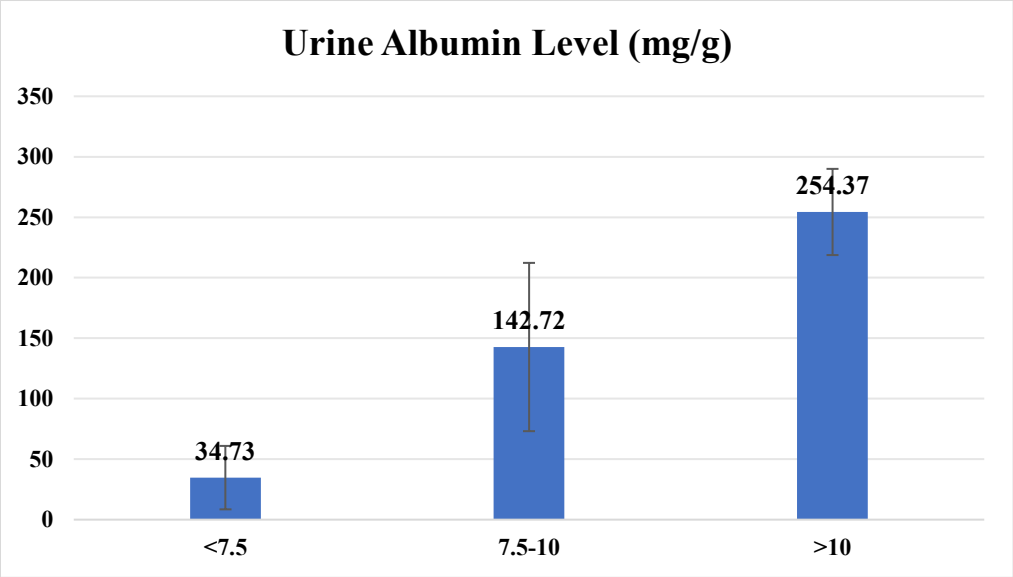
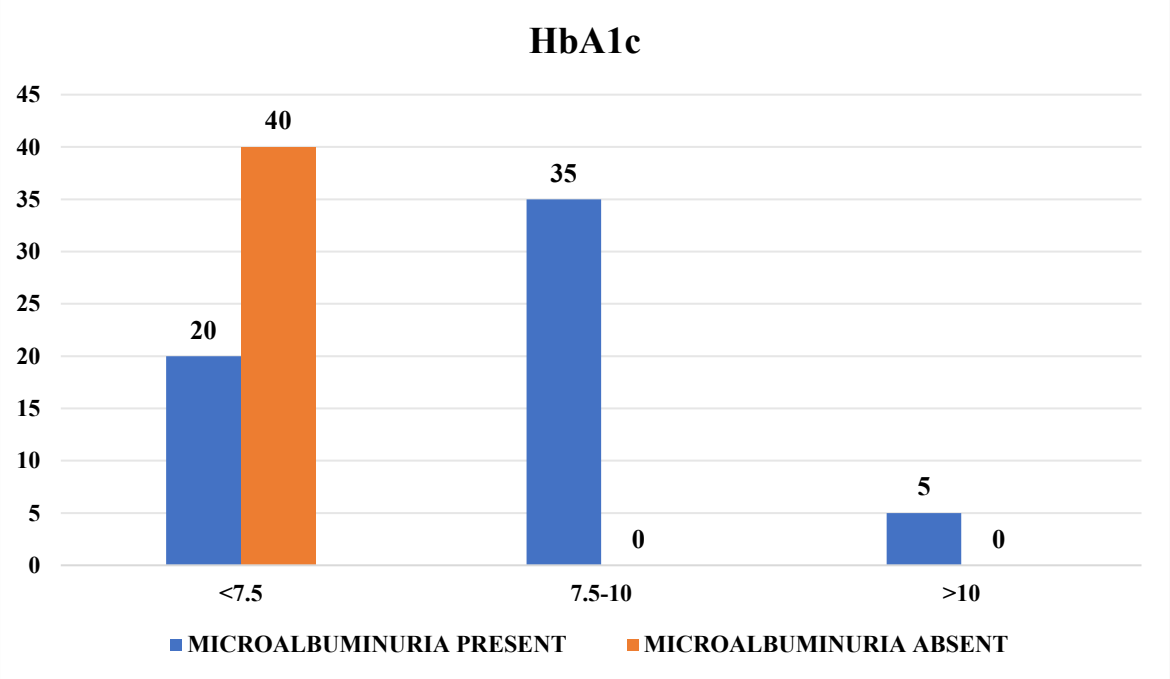


FIGURE 4. Association of Microalbuminuria with HbA1c



DISCUSSION

Variable levels of insulin resistance, decreased insulin secretion, and elevated glucose production are hallmarks of diabetes, a significant metabolic disease affecting populations worldwide. India, in particular, is one of the epicenters of the global diabetes epidemic. The prevalence of diabetes mellitus in India has escalated rapidly over the past 40 years due to socioeconomic development, demographic changes, and increased genetic susceptibility among Indians 21. By 2030, India's type 2 diabetes burden is projected to reach 87 million people, posing major public health and economic challenges 22.

Diabetic kidney disease (DKD) in the context of long-standing diabetes is defined by albuminuria, with or without a progressive decline in eGFR. An increase in urinary protein excretion is an early clinical manifestation and is associated with retinopathy 23. Even with a GFR >60 mL/min/1.73 m^2, albuminuria is a separate indicator of CKD and can be present in 20–40% of patients with type 1 or type 2 diabetes mellitus 24.

In the present study of 100 participants, the mean age was 53.11 years, with the majority (80%) aged 40–69 years, indicating that T2DM is more prevalent among middle-aged and older adults. Males constituted 57% of the cohort, similar to prior Indian studies 25, but with a slightly lower male proportion than previously reported studies. Duration of diabetes was 1–5 years in 59% of participants; a similar

distribution was reported in other Indian research 26. Most patients (84%) were managed with oral hypoglycemic agents (OHA), and only 4% required insulin alone.

Glycemic indices showed a mean fasting blood sugar (FBS) of 180.77 mg/dL and PPBS of 255.97 mg/dL, reflecting suboptimal control. The mean HbA1c was 7.44%, with 40% of patients above the ideal target. HbA1c is a marker of long-term glycemic control and is closely linked to the risk of microangiopathy in diabetics 27.

Hypertension (23%) and dyslipidemia were prevalent in our cohort, both known risk factors for DKD and cardiovascular complications 28. The mean blood urea (29.4 mg/dL) and serum creatinine (1.055 mg/dL) indicated preserved renal function for most participants, while low HDL and high LDL increased cardiovascular risk.

Microalbuminuria, an early marker of DKD, was found in 60% of participants, with a mean urine albumin level of 83.51 mg/g. Categorization showed 40% with normal albumin, 30% with mild, 18% with moderate, and 12% with severe microalbuminuria. This aligns with previous Indian studies highlighting the high prevalence of renal involvement in T2DM 29.

Our findings revealed a strong positive correlation (Pearson's $r = 0.914$, $p < 0.001$) between HbA1c and urine albumin, showing that poor glycemic control significantly increases the risk of microalbuminuria. This is consistent with multiple studies from India and worldwide, which have reported that worsening glycemic control is associated with a higher prevalence and severity of microalbuminuria 30, 31, 32. However, some Indian studies reported no significant correlation, potentially due to sample size or confounding variables 33.

Stratification showed that 66.7% of patients with HbA1c <7.5% had normal albumin levels, while all those with HbA1c ≥7.5% had microalbuminuria, echoing findings from other Indian studies 30-33. This supports that glycemic control is a key determinant in the progression of diabetic nephropathy.

Other studies in India and internationally have confirmed that maintaining HbA1c <7% is associated with lower rates of nephropathy and cardiovascular events. Microalbuminuria also predicts cardiovascular disease and adverse cardiac outcomes, as shown by Joshi PP et al 33.

Limitations:

This study is limited by its cross-sectional design, relatively small sample size, and potential confounding factors (diet, adherence, genetics) not addressed. Only a single urine albumin measurement was obtained, and intervention impacts were not evaluated.

CONCLUSION

Our study demonstrates a strong association between poor glycemic control (higher HbA1c) and increased prevalence and severity of microalbuminuria in T2DM patients. As HbA1c rises, so do urine albumin levels, highlighting the critical need for maintaining glycemic targets to prevent or delay diabetic nephropathy. Sixty percent of our participants had microalbuminuria, and its occurrence was universal among those with HbA1c >7.5%. The results underscore the importance of regular microalbuminuria screening, aggressive blood glucose management, and a comprehensive approach addressing hypertension and dyslipidemia to reduce renal and cardiovascular complications in T2DM.

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