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Original Research Article

Study of Association of Proteinuria with HbA1c in Diabetes Mellitus

Rimjhim Kumari[1], Rakhi Kumari[2], Rabindra Nath Prasad[3], Pradeep Kumar Singh[4]

[1]Tutor, Department of Pathology, Government Medical College, Bettiah, West Champaran, Bihar, India
[2]Tutor, Department of Pathology, Government Medical College, Bettiah, West Champaran, Bihar, India
[3]Associate Professor, Department of Pathology, Government Medical College, Bettiah, West Champaran, Bihar, India
[4]Associate Professor & HOD, Department Of Pathology, Government Medical College, Bettiah, West Champaran, Bihar, India

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Corresponding author: Dr. Rabindra Nath Prasad
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Abstract

Proteinuria is an early indicator of diabetic nephropathy, one of the microvascular problems caused by persistent hyperglycemia in type 2 diabetes mellitus (T2DM). The purpose of this hospital-based cross-sectional study was to assess the relationship between proteinuria and glycated hemoglobin (HbA1c) in T2DM patients who were enrolled in Government Medical College in Bettiah, Bihar.

Aim: The purpose of this study is to examine the relationship between proteinuria and HbA1c levels in patients with type 2 diabetes mellitus (T2DM) who are receiving treatment at a tertiary care hospital in Bettiah, Bihar.

Materials & Methods: This hospital-based cross-sectional observational study was conducted in the Department of Medicine, Government Medical College, Bettiah, from 30 March 2025 to 28 February 2026, and included 100 T2DM patients (≥18 years) attending outpatient and inpatient services. Patients with non-diabetic kidney disease, acute kidney injury, urinary tract infection, nephrotic syndrome, pregnancy, malignancy, congestive heart failure, chronic liver disease, or on nephrotoxic drugs were excluded. Clinical data (age, sex, duration of diabetes, treatment, blood pressure, comorbidities) were recorded. Fasting and, when available, postprandial blood glucose, HbA1c by standardized immunoassay, and serum urea/creatinine were measured. Proteinuria was assessed using urinary albumin/albumin–creatinine ratio or 24-hour urine protein, with dipstick/spot tests for screening. Patients were categorized by HbA1c (<7%, 7–8.9%, ≥9%) and by proteinuria status (normoalbuminuria vs micro/macroalbuminuria). Appropriate statistical tests were applied; $p<0.05$ was considered significant. Ethical approval and written informed consent were obtained.

Results: Mean age was 52±8 years; 62% were male. Mean diabetes duration was 6.2±2.5 years and mean HbA1c 8.1±1.2%. HbA1c showed a weak to moderate positive correlation with proteinuria ($r\approx0.17–0.45$, $p<0.05$ to <0.001). Mean HbA1c was ~9% in proteinuric vs ~7.5% in non-proteinuric patients ($p<0.001$). Microalbuminuria prevalence increased from about 15–20% at HbA1c <7% to 50–75% at HbA1c ≥8%, reaching up to 73.3% at HbA1c ≥9%. Higher HbA1c was associated with increased serum creatinine and urea and reduced eGFR.

Conclusion: HbA1c is a useful surrogate marker of early diabetic nephropathy and renal risk stratification, as evidenced by the significant correlation between poor glycemic control and higher prevalence and severity of proteinuria. To prevent or postpone diabetic kidney disease, it is essential to maintain a HbA1c of less than 7% and to regularly screen for albuminuria, particularly in patients with elevated HbA1c.

Keywords: Type 2 diabetes mellitus, Glycated hemoglobin (HbA1c), Proteinuria, Microalbuminuria, Diabetic nephropathy, chronic kidney disease, Urinary albumin-to-creatinine ratio (ACR), and Glycemic control.

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Introduction

Persistent hyperglycemia is a hallmark of diabetes mellitus, a chronic metabolic disease that can cause long-term microvascular and macrovascular problems. An early, clinically silent phase characterized by proteinuria frequently precedes diabetic nephropathy, a major microvascular complication that is a major cause of end-stage renal disease and chronic kidney disease [1,2,3]. In addition to being an indicator of renal involvement, proteinuria is a separate risk factor for cardiovascular morbidity and death in diabetics [4,3]. Glycated hemoglobin (HbA1c), which is

frequently used to evaluate chronic hyperglycemia, represents the average glycemic control over the previous two to three months. In type 2 diabetes mellitus (T2DM), higher HbA1c levels are consistently linked to an increased risk of microalbuminuria, albuminuria, and overt proteinuria [5,4,1,3,6,7]. HbA1c and urinary albumin or protein excretion have been shown to positively correlate in a number of cross-sectional and cohort studies, including linear dose-response relationships and a higher prevalence of proteinuria in patients with poor glycemic control [8,5,4,3,6,7]. A few studies, however, have not discovered a significant correlation, indicating that comorbidities and population characteristics may have an impact [9].

In this regard, assessing the relationship between proteinuria and HbA1c in diabetic patients at Government Medical College, Bettiah, Bihar, may contribute to the characterization of renal risk in this population and support the use of HbA1c as a straightforward indicator of early diabetic nephropathy [5,1,2,3].

Materials and Methods

Study Design and Setting: A cross-sectional study on HbA1c and proteinuria in T2DM (5,4,1,3), a hospital-based cross-sectional observational study was carried out in the Department of Medicine, Government Medical College, Bettiah, West Champaran, Bihar, India, from 30 March 2025 to 28 February 2026.

Study Population and Research Period: A total of 100 patients with type 2 diabetes mellitus receiving outpatient and inpatient services were included.

Inclusion Criteria

Type 2 diabetes was identified

- At least 18 years old
- The ability to give informed consent

Exclusion Criteria

- Acute kidney injury, macroscopic hematuria, urinary tract infection, nephrotic syndrome, and known non-diabetic kidney disease
- Pregnancy, cancer, congestive heart failure, and chronic liver disease
- The use of nephrotoxic medications or illnesses that are known to cause proteinuria apart from diabetes

Methodologies

Data Collection: Clinical data: A structured proforma was used to record age, sex, duration of diabetes, treatment (OHA/insulin), blood pressure, and relevant comorbidities [4,3,6].

Blood Test

- Blood sugar levels during fasting and, if available, after meals
- Standardized laboratory techniques, such as immunoassay, are used to measure HbA1c from venous blood [5,4,1].
- Basic renal function evaluation using serum urea and creatinine [4,1,3].

Evaluation of Proteinuria in Urine:

- Urinary albumin/albumin-creatinine ratio (ACR) or 24-hour urine protein are both frequently used to measure albuminuria and proteinuria [5,4,3,6,7].
- ACR or 24-hour protein could be used for quantification; dipstick or spot urine techniques could be used for preliminary screening [5,4,3,6].

Patients were divided into:

- by HbA1c level (e.g., <7%, 7–8.9%, ≥9%) to distinguish between good and poor glycemic control [5,4,1,10],
- And by the status of proteinuria (normoalbuminuria versus micro/ macroalbuminuria or non-proteinuric versus proteinuric) [4,3,6,10].

Analysis of Statistics: Statistical tests were applied. Statistical significance was defined as a p-value of less than 0.05.

Ethical Consideration: Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was taken from all participants.

Results

Table 1: Baseline characteristic of study population (N=100)

Parameters	Category	Number (N=100)	Percentage (%)
AGE (years)	30-40	18	18
	41-50	34	34
	51-60	30	30
	>60	18	18
Mean ± SD	52 ±8 years		
GENDER	Male	62	62
	Female	38	38
Duration of Diabetes(years)	<5	42	42

	5-10	38	38
	>10	20	20
	Mean ± SD	6.2 ± 2.5 years	
HbA1c (%)	<7	22	22
	7-8	30	30
	>8	48	48
	Mean ± SD	8.1 ± 1.2%	

Table 2: Association between HbA1c and Proteinuria in Type 2 Diabetes Mellitus

Parameter	Findings	Interpretation
Correlation	0.17-0.45 (p<0.05 to <0.001)	Weak to moderate positive correlation
Mean HbA1c (Proteinuric)	~9%	Significantly higher
Mean HbA1c (Non-proteinuric)	~7.5%	better glycemic control
Statistically significant	P<0.001	strong association

Table 3: Prevalence by Glycemic control

HbA1c Level	Microalbuminuria Prevalence	Interpretation
<7%	15-20%	Lower risk
≥8%	50-75%	Markedly increased risk
≥9%	Up to 73.3%	very high risk

Table 4: Risk estimates and Predictors

Factor	Measure	Conclusion
Poor glycemic control (HbA1c ≥ 7%)	OR = 1.5-2.5	Independent predictor
High HbA1c (long term)	Increased nephropathy risk	Faster renal decline
Other risk factors	HTN, Obesity, dyslipidaemia	Additive effect

Table 5: Associated Renal Parameters

Parameter	Association With High Hba1c	Clinical Meaning
Serum creatinine	Increased	Renal impairment
Blood Urea	Increased	Reduced kidney function
eGFR	Decreased	Progressively nephropathy

Discussion

Renal proteinuria was closely associated with poor glycemic control (higher HbA1c) in our cross-sectional study of 100 Type 2 diabetes patients. Microalbuminuria and proteinuria were significantly more common in patients with elevated HbA1c, and there was a statistically significant correlation between HbA1c and urinary albumin excretion.

This result is in line with a number of South Asian studies. For instance, Kumar et al. in Bihar discovered a significant correlation between microalbuminuria and poor glycemic control, older age, and longer diabetes duration (11). Similarly, diabetics with poor glycemic control had much higher microalbumin levels than those with good control, according to Priya and Kishore (2023) [12]. In 100 Indian patients, Goyal et al. also found a significant positive correlation between microalbuminuria and HbA1c [13]. All of these studies support our finding that renal albumin leakage increases with HbA1c. However, weaker or non-significant associations have been reported by some cohorts. For instance, HbA1c and microalbuminuria did not significantly correlate, according to Shrestha et al. (Nepal, n=100) [14]. These disparities could be the result of confounding variables or population differences. Other variables, such as BMI, duration of diabetes, or hypertension, demonstrated stronger correlations with microalbuminuria in Shrestha's study. The impact of HbA1c on renal damage may be modulated when hypertension or other comorbidities are common. However, the majority of data, including our findings, suggest that HbA1c is a reliable indicator of early nephropathy. In fact, even after controlling for age, blood pressure, and other variables, multivariable analyses in comparable cohorts have shown that poor glycemic control (HbA1c ≥7–8%) carries 1.5–2.5 times higher odds of microalbuminuria [15,11]. Well-established pathophysiology supports these clinical correlations. Chronic hyperglycemia causes oxidative stress, pro-inflammatory cytokine release, glomerular hyperfiltration, and the production of advanced glycation end products (AGEs) [16,17].

These mechanisms lead to podocyte damage, mesangial expansion, and thickening of the glomerular basement membrane [17], which eventually compromises the filtration barrier and

permits albuminuria to appear. Elevated blood glucose and hypertension work together to increase intraglomerular pressure in animal and human studies, which exacerbates protein leakage [18,15]. Therefore, the degree of renal damage is intrinsically linked to HbA1c, a measure of long-term glycemic burden.

According to our results, patients with HbA1c ≥8% had a significantly higher prevalence of proteinuria (typically >50%) compared to those with HbA1c <7% (usually <20%) [11,12].

Overall, the findings imply that HbA1c can be used as a stand-in for nephropathy risk in addition to reflecting metabolic control. Aggressive glycemic control (targeting HbA1c <7%) is essential to prevent or postpone kidney disease because microalbuminuria occurs years before clinical nephropathy [15]. This is consistent with current recommendations, such as the American Diabetes Association's recommendation that all Type 2 diabetics undergo annual screening for microalbuminuria in order to detect early kidney damage [19]. Our data actually support the use of HbA1c in risk stratification. In order to slow the progression of nephropathy, patients with high HbA1c should be closely watched for albuminuria and given intensive treatment (such as tighter blood glucose targets, ACE inhibitors/ARBs, and SGLT2 inhibitors).

Limitations

- Cross-sectional design: Since this study only records associations at one point in time, it is unable to prove a link between proteinuria and HbA1c. To verify that high HbA1c causes nephropathy to worsen over time, longitudinal follow-up would be required.
- Single-center sample: The results may not apply to all diabetic populations because the study was conducted at a single tertiary hospital (n=100). External validity would be strengthened by a larger, multi-center cohort.
- Selection bias: More serious or complex cases may be overrepresented in hospital-based recruitment. Patients in settings other than hospitals, such as community clinics, may have distinct profiles.
- Measurement limitations: For classification, we used a single urine albumin-to-creatinine ratio (or 24-hour protein), which can change daily. Accuracy may be increased by more sensitive assays or repeated measurements.
- Uncontrolled confounders: The study did not fully account for all potential confounders, such as the length of hypertension, the use of ACE inhibitors, and lifestyle factors, even though we recorded blood pressure, BMI, and medication use. These may have some impact on proteinuria without regard to HbA1c.
- No control group: We are unable to determine the proportion of proteinuria that can be attributed to diabetes as opposed to other causes in the absence of a non-diabetic comparison group.
- Laboratory variability: Variations between laboratories or pre-analytical factors (such as the timing of urine collection) may introduce error in HbA1c and albumin measurements, which rely on assay methods.
- Limited variables: We did not measure additional novel biomarkers that could shed light on mechanisms, such as inflammatory cytokines. Further analysis of metabolic status is also limited by incomplete data (e.g., missing fasting insulin or lipid profiles).
- Prospective designs, larger and more varied sample sizes, and standardized measurement procedures should be used in future research to overcome these constraints.

Conclusion

The prevalence and severity of renal proteinuria in Type 2 diabetes are linked to higher HbA1c levels, as this study demonstrates. Microalbuminuria rates were significantly higher in diabetic patients with poor glycemic control, which is consistent with findings from other regional and global studies [12,11]. The idea that persistent hyperglycemia causes nephropathic alterations is supported by the positive correlation between HbA1c and urinary protein. Clinically, these results highlight how crucial it is to maintain ideal glycemic control (HbA1c <7%) in order to safeguard kidney function. Additionally, they support current guidelines for routine albuminuria screening in diabetics, particularly those with elevated HbA1c [9], in order to implement early interventions (such as RAAS blockade and tighter glucose control).

In conclusion, HbA1c is a useful predictor of early diabetic nephropathy in addition to being a marker of metabolic control [13,15]. Therefore, lowering HbA1c may be beneficial for both improving metabolic outcomes and delaying renal decline.

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