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Evaluation of Microalbuminuria in Early Detection of Diabetic Nephropathy in the Population of Western Rajasthan.

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Abstract

Background: ***Objectives:*** Diabetic nephropathy (DN) is the leading cause of end-stage renal disease (ESRD) globally and constitutes a major public health burden in India, which is home to approximately 101 million diabetic individuals.[1,2] Microalbuminuria (MA) represents the earliest clinically detectable marker of incipient DN, preceding overt proteinuria by several years.[3,7] The present study aimed to evaluate the prevalence and severity of microalbuminuria in type 2 diabetic patients attending JIET Medical College & Hospital, Jodhpur, and to correlate MA levels with clinical and biochemical parameters. ***Methods:*** This prospective cross-sectional observational study was conducted over nine months (April 2025 to December 2025) at JIET Medical College & Hospital, Jodhpur. A total of 150 confirmed type 2 diabetes mellitus (T2DM) patients were recruited from the diabetic outpatient department. Spot urine samples were analyzed for albumin-to-creatinine ratio (UACR) using the immunoturbidimetric method. Fasting blood glucose (FBG), HbA1c, serum creatinine, lipid profile, and blood pressure were also measured. Statistical analysis was performed using SPSS v26. ***Results:*** Of the 150 patients studied, 48 (32%) had microalbuminuria (UACR 30–300 mg/g) and 19 (12.67%) had macroalbuminuria (UACR >300 mg/g). Microalbuminuria showed statistically significant positive correlation with HbA1c ($r = 0.684$, $p < 0.001$), duration of diabetes ($r = 0.612$, $p < 0.001$), systolic blood pressure ($r = 0.541$, $p < 0.001$), fasting blood glucose ($r = 0.498$, $p < 0.001$), and serum triglycerides ($r = 0.432$, $p < 0.001$). Patients with HbA1c > 8% showed significantly higher UACR than those with good control ($p < 0.001$). ***Conclusion:*** Microalbuminuria is highly prevalent in western Rajasthan's diabetic population and strongly associates with poor glycemic control, hypertension, and longer disease duration. Routine UACR screening in all T2DM patients at diagnosis and annually thereafter is strongly recommended for early detection and prevention of DN progression investigated in head and neck cancer, thereby maximizing treatment effectiveness.

Keywords: Microalbuminuria; Diabetic nephropathy; Type 2 diabetes mellitus; HbA1c; Albumincreatinine ratio; Western Rajasthan; UACR.

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INTRODUCTION

Diabetes mellitus (DM) is one of the most prevalent non-communicable diseases worldwide. India is home to approximately 101 million diabetic individuals as of 2023, making it the country with the highest absolute number of diabetic patients globally.[1,2] The global burden of type 2 diabetes mellitus (T2DM) is compounded by its chronic macrovascular and microvascular complications, of which diabetic nephropathy (DN) is among the most clinically significant.

Diabetic nephropathy is characterized by progressive decline in renal function, beginning with glomerular hypertension and hyper filtration, advancing through micro albuminuria to clinical proteinuria, and eventually culminating in end-stage renal disease (ESRD).[3] In India, DN accounts for nearly 30–40% of patients on dialysis programs, generating a massive economic and social burden.[19] Given the high cost of renal replacement therapy and the poor prognosis of established DN, early detection is of paramount importance.

Micro albuminuria — defined as a urinary albumin-to-creatinine ratio (UACR) of 30–300 mg/g in a random spot sample — is recognized as the earliest clinically detectable sign of incipient DN.[7,21] It reflects early endothelial dysfunction and glomerular injury, preceding overt proteinuria by several years.[3,22] Crucially, the progression from norm albuminuria to micro albuminuria is potentially reversible with intensive glycemic control, antihypertensive therapy (especially ACE inhibitors or ARBs), and lifestyle modifications.[5,10,11]

Jodhpur, located in the Thara Desert region of western Rajasthan, presents a unique demographic and environmental context. The population of this semi-arid belt faces high ambient temperatures, limited water availability, dietary patterns rich in saturated fats, and high salt intake — all factors that independently predispose to hypertension and renal injury. Moreover, limited awareness, delayed diagnoses, and poor adherence to prescribed therapy amplify the risk of DN in this region.

Despite this pressing need, published data specifically characterizing micro albuminuria prevalence and its clinical correlates in the western Rajasthan diabetic population remain sparse. The present study was therefore designed to evaluate the prevalence of micro albuminuria in T2DM patients attending a tertiary care institution in Jodhpur, and to examine its correlations with glycemic control, blood pressure, lipid profile, and duration of diabetes.

AIMS AND OBJECTIVES

The study was undertaken with the following objectives:

1. To determine the prevalence of microalbuminuria in type 2 diabetic patients attending JIET Medical College & Hospital, Jodhpur.
2. To correlate UACR with HbA1c, fasting blood glucose, duration of diabetes, and blood pressure.
3. To assess the relationship between microalbuminuria and lipid parameters (total cholesterol, LDL, HDL, and triglycerides).
4. To stratify patients by degree of albuminuria and compare biochemical profiles across groups.
5. To generate context-specific recommendations for nephropathy screening in the western Rajasthan diabetic population.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective, cross-sectional, observational study conducted at the Department of Biochemistry in association with the Diabetic OPD of JIET Medical College & Hospital, Jodhpur, Rajasthan. The study was conducted over eight months from April 2025 to November 2025.

Ethical Approval

The study was approved by the Institutional Ethics Committee (IEC) of JIET Medical College & Hospital (Ref. No. JIETMC/IEC/2025/12), and conducted in accordance with the principles of the Declaration of Helsinki (2013 revision). Written informed consent was obtained from all participants.

Study Population

A total of 150 adult patients with confirmed T2DM per ADA 2023 criteria[5] were enrolled by consecutive sampling from the Diabetic OPD during the study period.

Inclusion Criteria:

- Confirmed T2DM (ADA 2023 criteria), age 30–75 years
- Disease duration ≥ 1 year
- Willing to provide written informed consent

Exclusion Criteria:

- Known pre-existing renal disease or active urinary tract infection (UTI) at enrollment
- Type 1 DM, gestational diabetes, or secondary diabetes
- Fever, heavy physical exertion, menstruation, or cardiac failure at the time of sample collection
- Use of nephrotoxic drugs or NSAIDs within the previous two weeks
- Pregnant women

Sample Collection and Laboratory Methods

Early morning spot urine samples (10 mL) were collected in sterile containers. Urinary albumin was estimated by the immunoturbidimetric method and urinary creatinine by the modified Jaffe's kinetic method on an automated biochemistry analyzer (ERBA XL-640). The UACR was calculated and expressed in mg/g, in accordance with KDOQI guidelines.[6]

Venous blood (5 mL, 8–10 hours fasting) was collected for: (i) Fasting blood glucose (glucose oxidase-peroxidase method), (ii) HbA1c (HPLC method, Bio-Rad D-10), (iii) Serum creatinine (modified Jaffe's method), (iv) Lipid profile — total cholesterol (TC), triglycerides (TG), HDL cholesterol, and LDL cholesterol (Friedewald formula). Blood pressure was measured with a standardized mercury sphygmomanometer.

Classification of Albuminuria

Category	UACR (mg/g)	Clinical Significance
Normoalbuminuria	< 30	Normal / No nephropathy
Microalbuminuria (Incipient DN)	30 – 300	Early / Incipient nephropathy
Macroalbuminuria (Overt DN)	> 300	Overt diabetic nephropathy

Classification adapted from Mogensen et al. (1983)[7] and KDOQI 2012 guidelines.[6]

Statistical Analysis

Data were entered in Microsoft Excel 2021 and analyzed using SPSS v26.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean ± SD) were computed for continuous variables. Chi-square test was used for categorical variables. Pearson's correlation coefficient (r) was applied to assess relationships between UACR and biochemical variables. One-way ANOVA with Tukey's post-hoc test was used to compare means across albuminuria groups. A p-value < 0.05 was considered statistically significant.

RESULTS

Sociodemographic Profile

Of the 150 patients enrolled, 86 (57.3%) were male and 64 (42.7%) were female. The mean age was 52.4 ± 9.7 years (range 31–74 years). Mean duration of diabetes was 7.3 ± 4.8 years. The majority of patients (72.7%) were residents of Jodhpur and adjoining districts of western Rajasthan, including Barmer, Jaisalmer, Pali, Nagaur, and Bikaner.

Prevalence of Albuminuria

Albuminuria was categorized as follows: normoalbuminuria in 83 patients (55.33%), microalbuminuria in 48 (32%), and macroalbuminuria in 19 (12.67%). Combined, 44.67% of the diabetic patients had some degree of albuminuria, indicating a high burden of subclinical and overt renal involvement (Table 1).

Table 1: Distribution of Albuminuria Categories among Study Participants (n=150)

Albuminuria Category	UACR Range (mg/g)	Number of Patients (n=150)	Percentage (%)
Normoalbuminuria	< 30	83	55.33%
Microalbuminuria	30 – 300	48	32.00%
Macroalbuminuria	> 300	19	12.67%
Total	—	150	100%

Comparison of Clinical and Biochemical Parameters

Statistically significant differences were observed across all three albuminuria groups for most parameters (Table 2). HbA1c, fasting blood glucose, systolic and diastolic blood pressure, duration of diabetes, serum creatinine, and triglycerides increased progressively from normoalbuminuria to macroalbuminuria. HDL cholesterol showed an inverse trend.

Table 2: Comparison of Clinical & Biochemical Parameters across Albuminuria Groups (mean ± SD). One-way ANOVA with Tukey post-hoc test. FBG = Fasting Blood Glucose; BP = Blood Pressure.

Parameter	Normoalbuminuria (n=83)	Microalbuminuria (n=48)	Macroalbuminuria (n=19)	p-value
Age (years)	50.8 ± 9.2	53.6 ± 10.1	56.2 ± 8.4	0.048
Duration of DM (years)	5.1 ± 3.6	8.9 ± 4.2	13.4 ± 5.1	< 0.001
FBG (mg/dL)	142.3 ± 28.4	178.6 ± 34.7	212.4 ± 41.3	< 0.001
HbA1c (%)	7.2 ± 0.9	8.9 ± 1.1	10.6 ± 1.4	< 0.001

Serum Creatinine (mg/dL)	0.89 ± 0.18	1.08 ± 0.24	1.54 ± 0.38	< 0.001
Systolic BP (mmHg)	128.4 ± 12.1	142.8 ± 14.6	158.6 ± 16.3	< 0.001
Diastolic BP (mmHg)	80.2 ± 8.4	88.6 ± 9.2	96.4 ± 10.8	< 0.001
Total Cholesterol (mg/dL)	186.4 ± 32.1	208.7 ± 36.4	231.8 ± 42.6	< 0.001
Triglycerides (mg/dL)	148.2 ± 42.1	189.6 ± 48.3	228.4 ± 54.7	< 0.001
LDL Cholesterol (mg/dL)	112.4 ± 28.6	138.2 ± 34.1	162.8 ± 38.4	< 0.001
HDL Cholesterol (mg/dL)	48.6 ± 8.4	42.3 ± 7.2	36.8 ± 6.4	< 0.001
UACR (mg/g)	14.2 ± 7.1	84.6 ± 52.3	518.4 ± 212.6	< 0.001

Correlation of UACR with Biochemical Parameters

Pearson's correlation analysis (Table 3) revealed highly significant positive correlations between UACR and HbA1c ($r = 0.684$), duration of diabetes ($r = 0.612$), systolic blood pressure ($r = 0.541$), fasting blood glucose ($r = 0.498$), triglycerides ($r = 0.432$), and LDL cholesterol ($r = 0.386$) — all with $p < 0.001$. A significant negative correlation was observed with HDL cholesterol ($r = -0.361$, $p < 0.001$).

Table 3: Pearson's Correlation of UACR with Clinical and Biochemical Variables. *** p < 0.001.

Parameter	**Pearson's r**	**p-value**	**Significance**
HbA1c (%)	0.684	< 0.001	***
Parameter	**Pearson's r**	**p-value**	**Significance**
Duration of Diabetes (years)	0.612	< 0.001	***
Systolic Blood Pressure (mmHg)	0.541	< 0.001	***
Fasting Blood Glucose (mg/dL)	0.498	< 0.001	***
Triglycerides (mg/dL)	0.432	< 0.001	***
LDL Cholesterol (mg/dL)	0.386	< 0.001	***
Total Cholesterol (mg/dL)	0.342	< 0.001	***
Diastolic BP (mmHg)	0.318	< 0.001	***
Serum Creatinine (mg/dL)	0.294	< 0.001	***
HDL Cholesterol (mg/dL)	−0.361	< 0.001	***

Gender Distribution of Microalbuminuria

Among patients with microalbuminuria, 27 (56.25%) were male and 21 (43.75%) were female. Among macroalbuminuric patients, 12 (63.16%) were male and 7 (36.84%) were female. The difference did not reach statistical significance (chi-square = 1.84, $p = 0.174$).

DISCUSSION

The present study documents a high prevalence of microalbuminuria (32%) and macroalbuminuria (12.67%) in T2DM patients attending a tertiary care hospital in Jodhpur. These findings are comparable to prior Indian studies: Varghese et al.[8] reported microalbuminuria in 36.3% of south Indian T2DM patients, while Datta et al.[9] found a prevalence of 29.4% in eastern India. The somewhat higher prevalence in the present series may reflect the unique dietary patterns, water hardness, and greater burden of uncontrolled hypertension in the Thar Desert belt of western Rajasthan.

HbA1c emerged as the strongest biochemical predictor of microalbuminuria ($r = 0.684$, $p < 0.001$), consistent with the well-established causal link between sustained hyperglycemia and glomerular endothelial damage. Advanced glycation end products (AGEs), activation of protein kinase C, and increased polyol pathway flux collectively contribute to podocyte injury and increased glomerular permeability.[4] The landmark UKPDS[11] and DCCT/EDIC[12] trials convincingly demonstrated that intensive glycemic control significantly reduces the incidence and progression of microalbuminuria.

Duration of diabetes was the second strongest correlate ($r = 0.612$, $p < 0.001$). Adler et al.[16] in the UKPDS 64 follow-up study showed that each decade of disease duration was associated with a 3–4-fold increase in nephropathy risk. Patients with disease duration exceeding 10 years should be considered at particularly high risk and screened at least biannually for microalbuminuria.

The strong correlation of UACR with systolic blood pressure ($r = 0.541$) highlights the bidirectional relationship between hypertension and microalbuminuria. Systemic hypertension amplifies glomerular capillary pressure, accelerating endothelial damage and albumin leak. The renin-angiotensin-aldosterone system (RAAS) plays a central mechanistic role, and RAAS blockade with ACE inhibitors or ARBs has been shown to reduce urinary albumin excretion independently of blood pressure reduction.[10,13,14]

The dyslipidemia observed in macroalbuminuric patients — elevated LDL, triglycerides, and reduced HDL — is consistent with the concept of the cardiorenal metabolic syndrome.[20] Lipidmediated mesangial injury and tubular lipotoxicity may independently accelerate glomerulosclerosis. The negative correlation of HDL with UACR ($r = -0.361$) suggests that reduced reverse cholesterol transport may contribute to renal endothelial oxidative stress.[22]

From a regional public health perspective, early identification of microalbuminuria offers an affordable, non-invasive opportunity to initiate RAAS blockade, intensify glycemic control, and implement lifestyle modifications that could defer or prevent ESRD.[15,19] The cost of a UACR test (approximately Rs. 150–250 at most institutional laboratories) is negligible compared to the lifetime cost of dialysis or renal transplantation. The NKF PARADE statement[21] and ADA Standards of Care 2024[5] both emphasize the centrality of annual UACR screening in all T2DM patients.

We acknowledge several limitations. First, the cross-sectional design precludes inference about causality or temporal progression. Second, repeat UACR measurements (two additional samples over three months, as recommended by ADA) were not performed in this observational study. Third, the single-centre hospital-based sample may not fully represent the broader community. Future longitudinal, multicentre studies with follow-up UACR and GFR data are needed from this region.

CONCLUSION

Microalbuminuria is highly prevalent in the type 2 diabetic population of western Rajasthan, affecting nearly one in three patients in this cohort. It is significantly associated with HbA1c, duration of diabetes, hypertension, and dyslipidemia — all modifiable risk factors. Given the established reversibility of microalbuminuria with aggressive glycemic and blood pressure control,[11,12,13] UACR measurement must be integrated into routine diabetic care protocols from the time of diagnosis.

This study reinforces the urgent need for structured diabetes management programs with mandatory annual nephropathy screening in western Rajasthan, and provides a robust data foundation for regional health policy formulation.

DECLARATIONS

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Conflict of Interest:
The authors declare no conflict of interest.

Author Contributions:
Dr. Patil Prashant Hari: Conceptualization, study design, protocol development, data analysis, manuscript writing, and final approval. Dr. Gangani Jai P.: Patient recruitment, clinical examination, maintenance of documentation, taking consent, manuscript review, and final approval. Dr. Srividhya N.: Patient recruitment, sample collection coordination, laboratory analysis, data entry, manuscript review.

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Ethical Approval:
Institutional Ethics Committee, JIET Medical College & Hospital, Jodhpur, Rajasthan (Ref. No. JIETMC/IEC/2025/12). Conducted in accordance with the Declaration of Helsinki, 2013 revision..

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