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Original Article

Early Kidney Damage Detection in Diabetes Using Urine Albumin-Creatinine Ratio: A Diagnostic Yield Study

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ABSTRACT

Background: Diabetic kidney disease may begin silently, and serum creatinine can remain normal during early renal injury. Urine albumin-creatinine ratio is a practical screening test for detecting early albuminuria before routine renal function markers become abnormal. Objective: To determine the diagnostic yield of urine albumin-creatinine ratio for detecting microalbuminuria among adult diabetic patients with normal serum creatinine and to assess its association with diabetes duration and blood pressure control. Methods: This diagnostic yield study was conducted at a tertiary-care hospital in Bahawalpur, Punjab, Pakistan. A total of 180 adult diabetic patients with normal serum creatinine were included through consecutive sampling. Patients with known chronic kidney disease, raised serum creatinine, urinary tract infection, pregnancy, fever, heart failure, or acute severe illness were excluded. Microalbuminuria was defined as urine albumin-creatinine ratio of 30–300 mg/g. Associations with diabetes duration and blood pressure control were assessed using chi-square tests. Results: Microalbuminuria was detected in 62 of 180 patients, giving a diagnostic yield of 34.4% with a 95% confidence interval of 27.9–41.6%. Microalbuminuria increased with diabetes duration, from 20.7% in patients with duration below 5 years to 50.9% in those above 10 years. It was also more frequent in patients with uncontrolled blood pressure than controlled blood pressure, 48.6% versus 24.5%. Both associations were statistically significant. Conclusion: Urine albumin-creatinine ratio identified early albuminuria in a substantial proportion of diabetic patients with normal serum creatinine. Longer diabetes duration and uncontrolled blood pressure were associated with higher microalbuminuria frequency. Keywords: Diabetes mellitus; microalbuminuria; urine albumin-creatinine ratio; diabetic kidney disease; serum creatinine; diagnostic yield; Pakistan.

INTRODUCTION

Diabetes mellitus is a major and expanding public health burden worldwide, with increasing prevalence projected across both high-income and low- and middle-income countries (1). In Pakistan, national and pooled estimates indicate a substantial burden of diabetes and prediabetes among adults, creating sustained pressure on outpatient services, hospital systems, household finances, and long-term complication care (2–4). Among the chronic complications of diabetes, diabetic kidney disease is particularly important because early renal injury may remain clinically silent and may not be detected through routine serum creatinine testing alone.

Diabetic kidney disease develops through progressive metabolic, hemodynamic, inflammatory, and microvascular injury to the renal glomerulus. In the early stages, glomerular filtration may remain preserved, and serum creatinine may stay within the laboratory reference range despite ongoing renal endothelial and basement membrane dysfunction. This creates a diagnostic gap in routine diabetic care, because reliance on serum creatinine alone may delay recognition until kidney impairment is more advanced. Contemporary kidney and diabetes guidelines therefore recommend assessment of both kidney filtration and kidney damage, including estimated glomerular filtration rate and albuminuria testing, for risk classification and early detection in patients with diabetes (5–8).

Urine albumin-creatinine ratio is a practical, non-invasive marker of urinary albumin excretion that can detect early glomerular injury before overt proteinuria or creatinine elevation becomes apparent. Albuminuria also has prognostic value beyond renal disease alone, as it is associated with future chronic kidney disease progression, cardiovascular events, and mortality in patients with diabetes and chronic kidney disease risk states (9–13). The traditional term microalbuminuria, generally corresponding to a urine albumin-creatinine ratio of 30–300 mg/g, remains widely used in clinical studies to describe moderately increased urinary albumin excretion and has long been recognized as an early warning marker for subsequent proteinuria and adverse outcomes in diabetes (14–17).

The burden of albuminuria among patients with diabetes is particularly relevant in Asian and South Asian populations, where diabetes is common, follow-up may be irregular, and complications are often detected late. The Micro Albuminuria Prevalence Study in Asian patients with type 2 diabetes reported a high prevalence of albuminuria, supporting the need for active screening in routine diabetic care (18). Hospital-based evidence from India has similarly shown that microalbuminuria is frequent among patients with type 2 diabetes, reinforcing the relevance of albuminuria testing in regional clinical settings (19). Pakistani studies have also reported a considerable burden of microalbuminuria among patients with type 2 diabetes and have linked albuminuria with clinical and metabolic factors such as diabetes duration, glycemic control, uric acid levels, and other diabetic complications (20–25).

Despite this evidence, albuminuria screening is not always performed consistently in routine diabetic clinics, particularly when serum creatinine is normal. This is clinically important because patients may be falsely reassured by normal serum creatinine despite having early renal involvement. In resource-constrained outpatient settings, a diagnostic-yield approach can help quantify how many additional patients with possible early diabetic kidney damage are identified when urine albumin-creatinine ratio is added to routine assessment. Local evidence from tertiary-care settings in Punjab remains useful because patient profiles, access to follow-up, blood pressure control, and screening practices may differ from those reported in larger international cohorts.

Blood pressure control is another key factor in diabetic kidney protection. Hypertension can increase intraglomerular pressure, accelerate endothelial injury, and worsen urinary albumin leakage in patients with diabetes. Patients with both diabetes and poor blood pressure control therefore represent a clinically important group for early renal risk assessment. Similarly, longer diabetes duration increases cumulative exposure to hyperglycemia and related microvascular injury, making duration of disease a practical clinical variable for identifying patients who may require closer renal surveillance.

This study was conducted to determine the diagnostic yield of urine albumin-creatinine ratio for detecting microalbuminuria among adult diabetic patients with normal serum creatinine in a tertiary-care setting in Bahawalpur, Punjab, Pakistan. The study also assessed the association of microalbuminuria with duration of diabetes and blood pressure control. The primary objective was to estimate the proportion of diabetic patients with normal serum creatinine who had microalbuminuria on urine albumin-creatinine ratio testing, while the secondary objective was to evaluate whether longer diabetes duration and uncontrolled blood pressure were associated with a higher frequency of microalbuminuria.

MATERIAL AND METHODS

This diagnostic yield study was conducted in a tertiary-care hospital setting in Bahawalpur, Punjab, Pakistan, among adult patients with diabetes mellitus who attended the medical outpatient department, diabetic clinic, and medical wards during a six-month study period. The study was designed to determine the proportion of diabetic patients with normal serum creatinine who had microalbuminuria detected by spot urine albumin-creatinine ratio testing, and to assess whether microalbuminuria was associated with duration of diabetes and blood pressure control. The diagnostic-yield design was selected because the purpose was not to validate urine albumin-creatinine ratio against a reference diagnostic standard, but to quantify the additional detection of early albuminuria among patients who would otherwise appear to have preserved renal status on serum creatinine assessment.

A total of 180 eligible diabetic patients were enrolled through non-probability consecutive sampling. All adult patients aged 18 years or above with previously diagnosed diabetes mellitus and serum creatinine within the normal laboratory reference range were considered eligible. Both male and female patients were included, and patients with type 1 or type 2 diabetes were eligible if they fulfilled the serum creatinine criterion and were willing to provide clinical information and a urine sample for albumin-creatinine ratio testing. Patients were excluded if they had previously diagnosed chronic kidney disease, raised serum creatinine, nephrotic syndrome, urinary tract infection, fever, pregnancy, menstruation at the time of urine collection, heart failure, acute severe illness, or any clinically suspected condition likely to cause transient albuminuria. These exclusions were applied to reduce false-positive albuminuria findings and improve the clinical interpretability of urine albumin-creatinine ratio results.

Eligible patients were recruited consecutively until the required sample was completed. After informed consent, data were collected using a structured proforma. Recorded variables included age, sex, residence, type of diabetes, duration of diabetes, history of hypertension, treatment history, blood pressure status, serum creatinine level, and urine albumin-creatinine ratio value. Duration of diabetes was categorized as less than 5 years, 5–10 years, and more than 10 years to allow clinically interpretable comparison across increasing duration of disease. Blood pressure was measured with the patient seated after at least five minutes of rest using a standard blood pressure apparatus. When the initial reading was elevated, a second reading was obtained and the average value was recorded. Blood pressure status was categorized as controlled or uncontrolled according to routine diabetic-care targets used in clinical assessment.

Serum creatinine was measured from a venous blood sample in the hospital laboratory when a recent valid report was not available. Only patients whose serum creatinine was within the laboratory's normal reference range were included in the final analysis. For urine albumin-creatinine ratio testing, a spot urine sample was collected from each participant, with early morning urine preferred where feasible. Patients were instructed to provide a clean-catch midstream urine sample in a sterile container. Urinary albumin and urinary creatinine were measured from the same specimen, and urine albumin-creatinine ratio was reported as mg/g creatinine. A urine albumin-creatinine ratio below 30 mg/g was considered normal, 30–300 mg/g was classified as microalbuminuria, and values above 300 mg/g were classified as macroalbuminuria. For the purpose of the present diagnostic-yield analysis, the primary positive finding was microalbuminuria among diabetic patients with normal serum creatinine.

The primary outcome was the diagnostic yield of urine albumin-creatinine ratio, defined as the number of patients with microalbuminuria divided by the total number of eligible diabetic patients tested, multiplied by 100. The main explanatory variables were diabetes duration and blood pressure control. Additional demographic and clinical variables were recorded to describe the study population. Data quality was maintained through use of a standardized data-collection proforma, consistent eligibility screening, exclusion of common transient causes of albuminuria, standardized blood pressure measurement procedures, and laboratory-based measurement of serum creatinine and urine albumin-creatinine ratio. Completed records were reviewed for completeness before entry into the final dataset.

Data were entered and analyzed using SPSS version 26. Quantitative variables, including age, duration of diabetes, serum creatinine, blood pressure, and urine albumin-creatinine ratio, were summarized as mean and standard deviation where appropriate. Categorical variables, including sex, diabetes type, hypertension history, blood pressure control, diabetes-duration category, and albuminuria status, were summarized as frequencies and percentages. The diagnostic yield of urine albumin-creatinine ratio was calculated as the proportion of patients with microalbuminuria among all included diabetic patients with normal serum creatinine. Associations between microalbuminuria and categorical clinical variables, including diabetes-duration category and blood pressure control, were assessed using the chi-square test. A p-value below 0.05 was considered statistically significant. Records with incomplete essential outcome data were not included in the final diagnostic-yield analysis.

The study was conducted after obtaining informed consent from all participants. Patient confidentiality was maintained during data collection, data entry, analysis, and reporting. Identifiable patient information was not included in the final dataset used for analysis or in the manuscript. The study followed standard ethical principles for observational clinical research, including voluntary participation, confidentiality, and use of collected data only for the stated research purpose.

RESULTS

A total of 196 diabetic patients were assessed for eligibility during the study period. Sixteen patients were excluded because they did not fulfil the selection criteria, and 180 patients with normal serum creatinine underwent final analysis. The mean age of the study population was 52.4 ± 9.8 years. Most participants were male, and type 2 diabetes mellitus was the predominant diabetes type. The mean duration of diabetes was 7.6 ± 4.2 years. A history of hypertension was present in 82 patients, while 74 patients had uncontrolled blood pressure at assessment or in the recent clinical record.

Table 1. Baseline Characteristics of the Study Population

Variable	Result
Patients assessed, n	196
Patients excluded, n	16
Patients analyzed, n	180
Age, years, Mean ± SD	52.4 ± 9.8
Male, n (%)	102 (56.7)
Female, n (%)	78 (43.3)
Type 2 diabetes mellitus, n (%)	172 (95.6)
Type 1 diabetes mellitus, n (%)	8 (4.4)
Duration of diabetes, years, Mean ± SD	7.6 ± 4.2
Diabetes duration <5 years, n (%)	58 (32.2)
Diabetes duration 5–10 years, n (%)	67 (37.2)
Diabetes duration >10 years, n (%)	55 (30.6)
History of hypertension, n (%)	82 (45.6)
Controlled blood pressure, n (%)	106 (58.9)
Uncontrolled blood pressure, n (%)	74 (41.1)
Serum creatinine, mg/dL, Mean ± SD	0.86 ± 0.18

The final analyzed sample included 180 diabetic patients with normal serum creatinine. The sex distribution showed 102 males and 78 females, while type 2 diabetes mellitus accounted for 172 patients. Diabetes duration was distributed across clinically relevant categories, with 58 patients having diabetes for less than 5 years, 67 for 5–10 years, and 55 for more than 10 years. Blood pressure was controlled in 106 patients and uncontrolled in 74 patients, providing a basis for evaluating the association between blood pressure status and microalbuminuria.

Table 2. Diagnostic Yield of Urine Albumin-Creatinine Ratio for Microalbuminuria

UACR Category	n	%	95% CI
Normal UACR	118	65.6	—
Microalbuminuria	62	34.4	27.9–41.6
Total	180	100.0	—

UACR: urine albumin-creatinine ratio; CI: confidence interval. Microalbuminuria was defined as UACR 30–300 mg/g. The 95% CI for diagnostic yield was calculated using the Wilson method.

Urine albumin-creatinine ratio testing identified microalbuminuria in 62 of 180 diabetic patients with normal serum creatinine, giving a diagnostic yield of 34.4% with a 95% confidence interval of 27.9–41.6%. Normal UACR was observed in 118 patients. These findings indicate that approximately one-third of diabetic patients who appeared to have preserved renal status on serum creatinine testing had albuminuria detectable by UACR.

Table 3. Association of Microalbuminuria With Diabetes Duration and Blood Pressure Control

Variable	Category	Total n	Microalbuminuria Present, n (%)	Microalbuminuria Absent, n (%)	χ^2	df	p-value
Diabetes duration	<5 years	58	12 (20.7)	46 (79.3)	11.54	2	0.003
Diabetes duration	5–10 years	67	22 (32.8)	45 (67.2)	—	—	—
Diabetes duration	>10 years	55	28 (50.9)	27 (49.1)	—	—	—
Blood pressure control	Controlled	106	26 (24.5)	80 (75.5)	11.23	1	0.001
Blood pressure control	Uncontrolled	74	36 (48.6)	38 (51.4)	—	—	—

χ^2: chi-square statistic; df: degrees of freedom. Chi-square tests were used for categorical comparisons.

Microalbuminuria increased progressively with longer diabetes duration. It was present in 12 of 58 patients with diabetes duration below 5 years, 22 of 67 patients with duration of 5–10 years, and 28 of 55 patients with duration above 10 years. The association between diabetes-duration category and microalbuminuria was statistically significant. Blood pressure control also showed a significant association with microalbuminuria. Among patients with uncontrolled blood pressure, 36 of 74 had microalbuminuria, compared with 26 of 106 patients with controlled blood pressure.

Table 4. Crude Odds Ratios for Microalbuminuria According to Diabetes Duration and Blood Pressure Control

Exposure Category	Reference Category	Crude OR	95% CI	p-value
Diabetes duration 5–10 years	Diabetes duration <5 years	1.87	0.83–4.23	0.131
Diabetes duration >10 years	Diabetes duration <5 years	3.98	1.74–9.08	0.001
Uncontrolled blood pressure	Controlled blood pressure	2.91	1.54–5.50	0.001

OR: odds ratio; CI: confidence interval. Odds ratios were calculated from the reported aggregated 2×2 counts.

Compared with patients who had diabetes for less than 5 years, patients with diabetes duration of 5–10 years had higher crude odds of microalbuminuria, although the confidence interval crossed unity. Patients with diabetes duration greater than 10 years had nearly fourfold higher crude odds of microalbuminuria compared with those with duration below 5 years. Uncontrolled blood pressure was also associated with almost threefold higher crude odds of microalbuminuria compared with controlled blood pressure. These findings support the observed pattern that longer diabetes duration and uncontrolled blood pressure were associated with a higher frequency of early albuminuria among diabetic patients with normal serum creatinine.

Overall, the results demonstrate that UACR testing detected early albuminuria in a clinically meaningful proportion of diabetic patients whose serum creatinine remained normal. The diagnostic yield was substantial, and the burden of microalbuminuria was higher among patients with longer diabetes duration and uncontrolled blood pressure. These findings support the clinical utility of UACR screening as an additional renal risk-assessment tool in diabetic patients who may not yet show abnormal serum creatinine values.

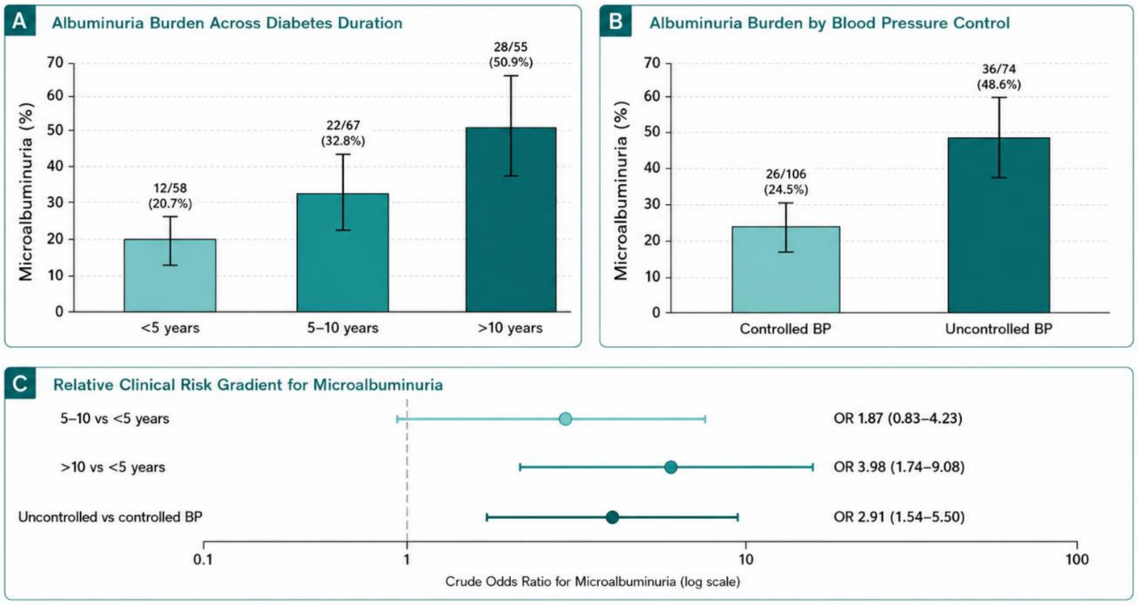

Figure 1. Early Albuminuria Detection in Diabetic Patients With Normal Serum Creatinine. Panel A shows a progressive increase in microalbuminuria across diabetes-duration categories, rising from 20.7% in patients with diabetes duration below 5 years to 32.8% in those with 5–10 years and 50.9% in those with more than 10 years. Panel B shows a higher burden of microalbuminuria among patients with uncontrolled blood pressure compared with those with controlled blood pressure, 48.6% versus 24.5%, respectively. Panel C demonstrates the crude risk gradient, with patients having diabetes for more than 10 years showing higher odds of microalbuminuria compared with those below 5 years, OR 3.98, 95% CI 1.74–9.08, while uncontrolled blood pressure was associated with higher odds compared with controlled blood pressure, OR 2.91, 95% CI 1.54–5.50. The 5–10-year diabetes-duration group showed a weaker and statistically imprecise association, OR 1.87, 95% CI 0.83–4.23. Overall, the figure highlights that longer diabetes duration and uncontrolled blood pressure identify clinically higher-risk subgroups among diabetic patients whose serum creatinine remains normal.

DISCUSSION

This diagnostic yield study found that urine albumin-creatinine ratio identified microalbuminuria in 34.4% of diabetic patients whose serum creatinine remained within the normal laboratory range. This finding is clinically important because it demonstrates that a substantial proportion of patients may have early albuminuric kidney involvement despite apparently preserved renal status on routine serum creatinine assessment. Serum creatinine is an insensitive marker of early diabetic kidney injury because it may remain normal until a meaningful decline in filtration has occurred. The present findings therefore support the use of UACR as an early renal risk-assessment tool in diabetic patients, consistent with contemporary recommendations that kidney assessment in diabetes should include albuminuria evaluation in addition to filtration-based measures (5–8).

The diagnostic yield observed in this study indicates that approximately one in three diabetic patients with normal serum creatinine had microalbuminuria. This proportion is clinically meaningful in routine diabetic care because patients with albuminuria require closer monitoring, stricter cardiovascular and renal risk reduction, and optimization of glycemic and blood pressure control. Previous evidence has shown that albuminuria is not only a marker of renal injury but also an important prognostic indicator for kidney disease progression, cardiovascular outcomes, and mortality (11–13). Earlier longitudinal evidence also established microalbuminuria as a predictor of later clinical proteinuria and adverse outcomes in diabetes (14). The present study adds local relevance by showing that this hidden burden is detectable in a tertiary-care diabetic population in Punjab even when serum creatinine is normal.

The study findings are also consistent with previous regional and Pakistani evidence. The MicroAlbuminuria Prevalence Study reported a high prevalence of albuminuria among Asian patients with type 2 diabetes, highlighting the importance of screening in populations with substantial diabetes burden (18). Similar findings have been reported in hospital-based South Asian studies, where microalbuminuria was common among patients with type 2 diabetes (19). Pakistani studies have also shown a considerable frequency of microalbuminuria and have reported associations with clinical and metabolic risk factors, including diabetes duration, glycemic status, uric acid, and diabetic complications (20–25). The current study aligns with this body of evidence but focuses specifically on patients with normal serum creatinine, a subgroup in whom early kidney involvement may otherwise be overlooked.

A significant association was observed between longer duration of diabetes and microalbuminuria. Patients with diabetes for more than 10 years had the highest proportion of microalbuminuria, and the crude odds of microalbuminuria were markedly higher in this group compared with patients who had diabetes for less than 5 years. This pattern is biologically plausible because longer diabetes duration reflects prolonged exposure to hyperglycemia, oxidative stress, endothelial dysfunction, and glomerular basement membrane injury. Over time, these processes may increase glomerular permeability and lead to urinary albumin leakage. Previous studies have similarly reported that longer diabetes duration is associated with higher risk of diabetic kidney disease and albuminuria (16,17,21). In clinical practice, duration of diabetes is easy to record and may help identify patients who require more consistent renal screening.

Uncontrolled blood pressure was also significantly associated with microalbuminuria. Nearly half of the patients with uncontrolled blood pressure had microalbuminuria compared with approximately one-quarter of those with controlled blood pressure, and the crude odds were almost three times higher in the uncontrolled blood pressure group. This association is clinically relevant because hypertension can increase intraglomerular pressure, worsen endothelial injury, and accelerate albumin leakage in patients with diabetes. Guideline recommendations emphasize blood pressure control in diabetic patients with kidney disease risk because reducing hemodynamic stress is central to slowing renal progression and lowering cardiovascular risk (6–8). The current findings reinforce the need to integrate routine BP assessment and albuminuria screening in diabetic follow-up rather than treating creatinine alone as an adequate marker of renal safety.

The findings have practical implications for diabetic clinics in Pakistan and similar resource-constrained settings. Serum creatinine is commonly ordered because it is inexpensive and widely available, but the present study shows that it may fail to identify early albuminuric renal involvement. UACR is a non-invasive urine-based test that can be incorporated into outpatient screening workflows and may identify higher-risk patients earlier. Earlier detection creates an opportunity for intensified lifestyle counseling, improved glycemic control, stricter blood pressure management, review of kidney-protective therapy where clinically indicated, and closer follow-up. In tertiary-care hospitals receiving patients from both urban and rural communities, this approach may be particularly useful because many patients present late or have inconsistent long-term monitoring.

This study should be interpreted in view of its limitations. It was conducted at a single tertiary-care hospital using non-probability consecutive sampling, which may limit generalizability to the broader diabetic population. UACR was measured using a spot urine sample, and repeat testing was not included; therefore, persistent albuminuria could not be confirmed. Although patients with common transient causes of albuminuria, including urinary tract infection, fever, pregnancy, menstruation, heart failure, and acute severe illness, were excluded, biological variability in albumin excretion remains possible. The study did not report estimated glomerular filtration rate, HbA1c, body mass index, smoking status, diabetes treatment, use of renin-angiotensin system blockers, sodium-glucose cotransporter-2 inhibitors, or lipid parameters, all of which may influence albuminuria risk. The analysis was based on crude associations and did not include multivariable adjustment, so residual confounding cannot be excluded.

Despite these limitations, the study provides clinically useful evidence that UACR detects a considerable burden of early albuminuria among diabetic patients with normal serum creatinine. The associations with longer diabetes duration and uncontrolled blood pressure are consistent with established pathophysiology and prior literature. The findings support routine incorporation of UACR screening into diabetic care pathways, particularly for patients with longer disease duration or suboptimal blood pressure control, while also highlighting the need for larger multicenter studies with repeated UACR testing, eGFR assessment, glycemic indicators, medication data, and adjusted statistical modeling.

CONCLUSION

Urine albumin-creatinine ratio detected microalbuminuria in a substantial proportion of diabetic patients who had normal serum creatinine, indicating that serum creatinine alone may miss early albuminuric kidney involvement. Microalbuminuria was more frequent among patients with longer diabetes duration and uncontrolled blood pressure, suggesting that these clinical factors should prompt closer renal surveillance during routine diabetic follow-up. In tertiary-care settings of Punjab and similar resource-limited clinical environments, routine UACR screening may improve early identification of diabetic kidney disease risk and support timely optimization of glycemic control, blood pressure management, and kidney-protective care before progression to more advanced renal impairment.

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