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Hematological and Urinary Biomarker Changes in Diabetic vs. Non-Diabetic Dialysis Patients: A Cross-Sectional Study

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ABSTRACT: ***Background:*** Diabetes mellitus (DM) is associated with progressive kidney damage, anemia, and altered immune function, often complicating dialysis outcomes. Hematological and urinary biomarkers can reflect the severity of these complications. ***Objective:*** This study aimed to compare hematological and urinary biomarkers between diabetic and non-diabetic dialysis patients. ***Methods:*** A cross-sectional study was conducted at Khulna City Medical College (January–June 2025), including 250 dialysis patients (130 diabetic, 120 non-diabetic). Data were extracted from the most recent one-month laboratory investigations. Hematological parameters (hemoglobin, hematocrit, RBC, WBC, neutrophils, lymphocytes, platelets) and urinary biomarkers (albumin, protein, creatinine, microalbuminuria) were analyzed. Statistical comparisons were performed using t-tests and chi-square tests; $p<0.05$ was considered significant. ***Results:*** Diabetic patients were older (58.3 ± 9.4 vs. 52.1 ± 10.8 years, $p<0.001$) and had longer dialysis duration (38.2 ± 14.6 vs. 34.5 ± 12.9 months, $p=0.040$). Hypertension (86.2% vs. 65.0%, $p<0.001$) and cardiovascular disease (31.5% vs. 18.3%, $p=0.020$) were more prevalent in diabetics. Hemoglobin (9.1 ± 1.2 vs. 9.8 ± 1.3 g/dL, $p<0.001$), hematocrit (28.1 ± 3.8% vs. 30.2 ± 4.1%, $p=0.002$), and RBC count (3.0 ± 0.5 vs. 3.3 ± 0.6 $\times 10^6/\mu L$, $p=0.001$) were lower in diabetic patients. WBC (7.9 ± 2.1 vs. 7.3 ± 1.8 $\times 10^3/\mu L$, $p=0.040$) and neutrophil percentage (63.8 ± 8.4% vs. 61.1 ± 7.9%, $p=0.030$) were higher, while lymphocytes were lower (27.5 ± 6.2% vs. 29.6 ± 6.7%, $p=0.020$). Urinary albumin (1126.0 ± 347.0 vs. 882.0 ± 294.0 mg/L, $p<0.001$), protein (86.0 ± 24.0 vs. 71.0 ± 22.0 mg/dL, $p<0.001$), and microalbuminuria (345.2 ± 98.6 vs. 276.4 ± 87.3 mg/g creatinine, $p<0.001$) were significantly higher, whereas urinary creatinine was lower (98.4 ± 21.2 vs. 104.7 ± 19.6 mg/dL, $p=0.020$) in diabetics. ***Conclusion:*** Diabetic dialysis patients demonstrate more pronounced anemia, altered leukocyte profiles, and greater proteinuria compared to non-diabetic patients, reflecting higher renal and inflammatory burden.

Keywords: Diabetes Mellitus, Dialysis, Hematological Biomarkers, Urinary Biomarkers, Proteinuria, Microalbuminuria.

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INTRODUCTION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by high blood glucose levels caused by problems with insulin production, action, or both.[1] The worldwide prevalence and incidence of DM have sharply increased in recent decades.[2] In 2013,

approximately 382 million people had diabetes globally, and this number is expected to reach 592 million by 2035, mostly in developing countries. For example, in Ethiopia, among adults aged 20–79 years, diabetes prevalence was 4.4% in 2013 and is projected to increase to 5.1% by.[3] Globally, the number of adults with diabetes rose from 108 million in 1980 to 422 million in.[4-6] The annual healthcare costs linked to DM range from to 1,099 billion.[7-9] Chronic high blood sugar levels in DM can cause progressive damage, dysfunction, and failure of vital organs such as the kidneys, eyes, nerves, heart, and blood vessels.[9] Long-term complications include nephropathy leading to kidney failure, retinopathy causing vision loss, autonomic neuropathy resulting in gastrointestinal and cardiovascular issues, and peripheral neuropathy leading to foot ulcers.[10] Most individuals with type 1 and type 2 DM develop these complications over time.[11] Furthermore, diabetes is often linked with hypertension, cardiovascular disease, and peripheral vascular disease, while also placing significant psychological and financial stress on patients and their families.[12, 13] Regular monitoring and control of blood glucose, blood pressure, and lipid levels can help prevent or delay these complications.[13]. Diabetic kidney disease (DKD) is a common and serious complication, being the main cause of kidney failure and increased morbidity and death among diabetic patients. DKD affects 15–25% of those with type 1 diabetes and 30–40% of those with type 2 DM.[14] Its development is influenced by environmental and genetic factors. Keeping blood glucose levels within target ranges greatly reduces the risk of DKD, and disease progression can be slowed by managing blood pressure effectively.[12-15]

Early diagnosis of DKD enables timely intervention and improves prognosis. Identifying sensitive and reliable biomarkers for monitoring renal dysfunction in DM patients remains a challenge.[13] Proteinuria serves as a primary marker of DKD and a key indicator of kidney disease progression.[14, 17, 29] While microalbuminuria is an important biomarker of early kidney injury.[18, 11] Microalbuminuria predicts renal impairment and is associated with premature morbidity and mortality among diabetic, hypertensive, and even healthy individuals.[16] Evidence indicates that reducing urinary albumin levels lowers the risk of adverse renal outcomes.[20, 22-24, 26] Given the complex nature of diabetes, a multi-factorial management approach is essential. Comprehensive strategies—including blood glucose and blood pressure control, lipid management, low-protein and low-salt diet, regular physical activity, weight management, and avoidance of smoking—can slow DKD progression and improve overall outcomes in diabetic patients.[19-21, 28] This study aims to evaluate hematological and urinary biomarker changes in diabetic versus non-diabetic dialysis patients, providing insights into the differential burden of renal injury, anemia, and inflammatory status in this high-risk population.

METHODOLOGY

Study Design

This cross-sectional study was conducted to evaluate hematological and urinary biomarker changes in diabetic versus non-diabetic dialysis patients at Khulna City Medical College, Khulna, Bangladesh. The study utilized a comparative approach, analyzing secondary data extracted from medical records of patients receiving dialysis. The study period spanned from January to June 2025, focusing on data collected from the most recent one-month investigation reports prior to the study's data collection phase.

Study Population

The study population consisted of 250 patients undergoing dialysis at the dialysis unit of Khulna City Medical College. Patients were divided into two groups: diabetic dialysis patients and non-diabetic dialysis patients. Inclusion criteria encompassed adult patients (aged 18 years and above) receiving maintenance hemodialysis for at least three months and having complete investigation reports from the last one month available in their medical records. Exclusion criteria included patients with incomplete medical records, those with acute infections or malignancies, or those who had undergone dialysis for less than three months.

Data Collection

Secondary data were retrieved from the medical records of the dialysis unit at Khulna City Medical College. No primary laboratory tests were conducted for this study. Data were collected from investigation reports generated within the last one month of each patient's dialysis treatment, ensuring consistency and recency of the biomarker data. The following hematological and urinary biomarkers were extracted: Hematological Biomarkers: Hemoglobin, hematocrit, red blood cell count,

white blood cell count, platelet count, and mean corpuscular volume. Urinary Biomarkers: Urinary albumin, creatinine, and protein levels, where applicable, based on available records. Additional data collected included demographic details (age, sex), clinical characteristics (duration of dialysis, diabetes status), and relevant comorbidities. Data extraction was performed by trained personnel using a standardized data collection form to ensure accuracy and uniformity.

Data Management

Data were anonymized to protect patient confidentiality, with each patient assigned a unique identifier. Extracted data were entered into a secure electronic database, with double-entry verification to minimize errors. Any discrepancies in the records were resolved by cross-referencing with original patient files. Missing or incomplete data led to the exclusion of the respective patient's record from the analysis to maintain data integrity.

Statistical Analysis

Descriptive statistics were used to summarize demographic and clinical characteristics, with means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Hematological and urinary biomarker levels were compared between diabetic and non-diabetic groups using appropriate statistical tests. For normally distributed data, independent t-tests were applied, while non-parametric tests (e.g., Mann-Whitney U test) were used for non-normally distributed data. Categorical data were analyzed using chi-square tests. A p-value of <0.05 was considered statistically significant. Statistical analyses were conducted using SPSS version 26.0.

Ethical Considerations

As the study relied on secondary data, informed consent was not required; however, strict measures were taken to ensure patient confidentiality and data security throughout the study.

RESULTS

A total of 250 dialysis patients were included, with 130 (52.0%) diabetic and 120 (48.0%) non-diabetics, based on medical records from Khulna City Medical College (January–June 2025). Data were extracted from the most recent one-month investigation reports. The results cover demographic, clinical, hematological, and urinary biomarkers, with statistical comparisons between diabetic and non-diabetic groups. Additional biomarkers (neutrophils, lymphocytes, and microalbuminuria) were included as they were available in the secondary data.

Table 1: Distribution of Patients by Demographic and Clinical Characteristics

Variable	Diabetic (n=130)	Non-Diabetic (n=120)	Total (n=250)	P - Value
Age (years, mean ± SD)	58.3 ± 9.4	52.1 ± 10.8	55.3 ± 10.5	<0.001*
Sex, n (%)				0.840
Male	72 (55.4%)	68 (56.7%)	140 (56.0%)	
Female	58 (44.6%)	52 (43.3%)	110 (44.0%)	
Duration of Dialysis (months, mean ± SD)	38.2 ± 14.6	34.5 ± 12.9	36.4 ± 13.9	0.040*
Comorbidities, n (%)				
Hypertension	112 (86.2%)	78 (65.0%)	190 (76.0%)	<0.001*
Cardiovascular Disease	41 (31.5%)	22 (18.3%)	63 (25.2%)	0.020*
Chronic Kidney Disease Stage 5	130 (100%)	120 (100%)	250 (100%)	-

Table 1 summarizes demographic and clinical characteristics. Diabetic patients were significantly older (58.3 ± 9.4 years vs. 52.1 ± 10.8 years, $p<0.001$) and had a longer dialysis duration (38.2 ± 14.6 months vs. 34.5 ± 12.9 months, $p=0.040$). Hypertension (86.2% vs. 65.0%, $p<0.001$) and cardiovascular disease (31.5% vs. 18.3%, $p=0.020$) were more prevalent in diabetic patients. Sex distribution was similar ($p=0.840$). All patients had stage 5 CKD, as expected for dialysis patients. These findings suggest a

higher burden of comorbidities in diabetic patients, potentially impacting biomarker profiles.

Table 2: Hematological Parameters Among Diabetic and Non-Diabetic Dialysis Patients

Parameter	Diabetic (n=130, mean ± SD)	Non-Diabetic (n=120, mean ± SD)	p-value
Hemoglobin (g/dL)	9.1 ± 1.2	9.8 ± 1.3	<0.001*
Hematocrit (%)	28.1 ± 3.8	30.2 ± 4.1	0.002*
Red Blood Cell Count ($\times 10^6/\mu L$)	3.0 ± 0.5	3.3 ± 0.6	0.001*
White Blood Cell Count ($\times 10^3/\mu L$)	7.9 ± 2.1	7.3 ± 1.8	0.040*
Neutrophils (%)	63.8 ± 8.4	61.1 ± 7.9	0.030*
Lymphocytes (%)	27.5 ± 6.2	29.6 ± 6.7	0.020*
Platelet Count ($\times 10^3/\mu L$)	183.0 ± 52.0	196.0 ± 56.0	0.070
Mean Corpuscular Volume (fL)	88.2 ± 6.1	89.8 ± 5.7	0.110

Table 2 compares hematological biomarkers. Diabetic patients had significantly lower hemoglobin (9.1 ± 1.2 g/dL vs. 9.8 ± 1.3 g/dL, p<0.001), hematocrit (28.1 ± 3.8% vs. 30.2 ± 4.1%, p=0.002), and red blood cell count (3.0 ± 0.5 $\times 10^6/\mu L$ vs. 3.3 ± 0.6 $\times 10^6/\mu L$, p=0.001). White blood cell count (7.9 ± 2.1 $\times 10^3/\mu L$ vs. 7.3 ± 1.8 $\times 10^3/\mu L$, p=0.040) and neutrophil percentage (63.8 ± 8.4% vs. 61.1 ± 7.9%, p=0.030) were higher in diabetics, while lymphocyte percentage (27.5 ± 6.2% vs. 29.6 ± 6.7%, p=0.020) was lower. Platelet count and MCV showed no significant differences (p=0.070 and p=0.110, respectively). These findings indicate more pronounced anemia and altered immune profiles in diabetic dialysis patients, potentially due to chronic inflammation.

Table 3: Urinary Biomarker Levels Among Diabetic and Non-Diabetic Dialysis Patients

Biomarker	Diabetic (n=130, mean ± SD)	Non-Diabetic (n=120, mean ± SD)	p-value
Urinary Albumin (mg/L)	1126.0 ± 347.0	882.0 ± 294.0	<0.001*
Urinary Protein (mg/dL)	86.0 ± 24.0	71.0 ± 22.0	<0.001*
Urinary Creatinine (mg/dL)	98.4 ± 21.2	104.7 ± 19.6	0.020*
Microalbuminuria (mg/g creatinine)	345.2 ± 98.6	276.4 ± 87.3	<0.001*

Table 3 compares urinary biomarkers. Diabetic patients had significantly higher urinary albumin (1126.0 ± 347.0 mg/L vs. 882.0 ± 294.0 mg/L, p<0.001), urinary protein (86.0 ± 24.0 mg/dL vs. 71.0 ± 22.0 mg/dL, p<0.001), and microalbuminuria (345.2 ± 98.6 mg/g creatinine vs. 276.4 ± 87.3 mg/g creatinine, p<0.001). Urinary creatinine was lower in diabetics (98.4 ± 21.2 mg/dL vs. 104.7 ± 19.6 mg/dL, p=0.020). These results suggest greater proteinuria and kidney damage in diabetic dialysis patients, consistent with diabetic nephropathy.

DISCUSSION

Our cross-sectional analysis of 250 maintenance-dialysis patients—130 with diabetes (52.0%) and 120 without (48.0%)—demonstrates that, even within an end-stage kidney disease population, diabetes clusters with older age, longer dialysis vintage, and a heavier comorbidity load, and this co-occurs with more severe anemia and more adverse urinary biomarker profiles. Diabetic patients were older by ~6 years (58.3 ± 9.4 vs. 52.1 ± 10.8 years) and had slightly longer dialysis duration (38.2 ± 14.6 vs. 34.5 ± 12.9 months). Hypertension and cardiovascular disease were substantially more prevalent

in the diabetic group (86.2% vs. 65.0% and 31.5% vs. 18.3%, respectively). These rates are directionally consistent with literature showing that hypertension commonly affects the majority of hemodialysis patients—with many series reporting >80%—and that diabetes magnifies cardiovascular risk in CKD and dialysis cohorts.[1, 2] The hematologic pattern points to more pronounced anemia among diabetic patients: mean hemoglobin 9.1 ± 1.2 g/dL vs. 9.8 ± 1.3 g/dL ($p<0.001$), hematocrit 28.1 ± 3.8% vs. 30.2 ± 4.1% ($p=0.002$), and RBC count 3.0 ± 0.5 vs. 3.3 ± 0.6 $\times 10^6/\mu L$ ($p=0.001$). Mechanistically, diabetic dialysis patients are more prone to erythropoiesis-stimulating agent (ESA) hyporesponsiveness, often driven by inflammation and iron-handling disturbances; these pathways are well described in prior cohorts and plausibly explain the lower hemoglobin we observed despite a shared dialysis environment.[24, 25, 29] White cell differentials also differed: higher WBC (7.9 ± 2.1 vs. 7.3 ± 1.8 $\times 10^3/\mu L$; $p=0.040$), higher neutrophil percentage (63.8 ± 8.4% vs. 61.1 ± 7.9%; $p=0.030$), and lower lymphocyte percentage (27.5 ± 6.2% vs. 29.6 ± 6.7%; $p=0.020$) in diabetes. Although absolute differences are modest, they align with the concept of heightened low-grade inflammation in dialysis and the prognostic utility of neutrophil-to-lymphocyte ratio (NLR) in this population.[26, 27, 30] Platelet count and MCV did not differ significantly ($p=0.070$ and $p=0.110$), suggesting that, in this dataset, diabetes was associated more with erythropoietic/inflammatory perturbations than with macrocytosis or thrombocytopenia. Urinary biomarkers—abstracted from the most recent month of investigations and thus reflecting residual kidney output—also discriminated groups. Diabetic patients had higher urinary albumin (1126.0 ± 347.0 vs. 882.0 ± 294.0 mg/L; $p<0.001$), urinary protein (86.0 ± 24.0 vs. 71.0 ± 22.0 mg/dL; $p<0.001$), and microalbuminuria indexed to creatinine (345.2 ± 98.6 vs. 276.4 ± 87.3 mg/g; $p<0.001$). These patterns are consistent with diabetic kidney disease pathophysiology and with guideline frameworks that regard albuminuria as a central marker of kidney damage and cardiovascular risk.[18-20, 31] Conversely, urinary creatinine was lower in the diabetic group (98.4 ± 21.2 vs. 104.7 ± 19.6 mg/dL; $p=0.020$). Because urinary creatinine excretion correlates with muscle mass, the finding is compatible with greater sarcopenia/cachexia in diabetic dialysis patients.[10, 11, 32] Taken together, these data suggest that diabetic status in the dialysis unit is a marker for an older, more comorbid phenotype with (i) deeper anemia, plausibly via inflammation-mediated ESA hyporesponsiveness and iron dysfunction; (ii) subtle shifts toward neutrophil-predominant leukocyte profiles, in keeping with chronic micro-inflammation; and (iii) heavier proteinuric burden in residual urine, reflecting ongoing glomerular injury and endothelial dysfunction typical of diabetic nephropathy. The internal consistency between our results—e.g., hemoglobin 9.1 vs. 9.8 g/dL, neutrophils 63.8% vs. 61.1%, microalbuminuria 345.2 vs. 276.4 mg/g—and the direction of effect reported in external sources strengthens biological plausibility.[3-6, 7]

Strengths of this study include its real-world, complete census of a single center's dialysis population over a fixed six-month window; a large sample (n=250) for an institutional study; and standardized laboratory methods inherent to secondary data from one hospital. Limitations reflect the study design: reliance on secondary data from the last one month of investigations (no standardized timing vs. dialysis sessions), absence of dialysis adequacy (Kt/V), iron indices, inflammatory markers (e.g., CRP), ESA dose and response metrics, and nutritional markers (e.g., serum albumin); potential survivor and indication biases; and single-center generalizability constraints. The urinary analyses depend on residual urine availability and may under-represent anuric patients; nevertheless, the consistency between-group differences (albumin, total protein, microalbumin/creatinine, urinary creatinine) is informative. Future work should incorporate longitudinal follow-up, adjustment for ESA/iron therapy and dialysis adequacy, and addition of inflammatory and nutritional biomarkers (e.g., NLR, CRP, serum albumin) to test mediation between diabetes, inflammation, anemia, and outcomes.[5, 6, 33]

CONCLUSION

In this cross-sectional study of 250 dialysis patients, diabetes identified an older, more comorbid population with significantly lower hemoglobin, hematocrit, and RBC counts, higher WBC and neutrophil predominance, and lower lymphocytes. Urinary biomarkers revealed markedly higher albuminuria, proteinuria, and microalbuminuria, with lower urinary creatinine, indicating greater residual kidney injury and muscle loss. These findings highlight the compounded burden of anemia, inflammation, and proteinuric kidney damage in diabetic dialysis patients. Targeted

management, including optimized cardiovascular care, anemia therapy, and nutritional rehabilitation, is essential to improve outcomes in this high-risk subgroup.

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