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Association of Glycated Hemoglobin and Microalbuminuria with Renal Function Parameters in Type 2 Diabetic Patients

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ABSTRACT

One of the most serious complications of type 2 diabetes (T2DM) is diabetic nephropathy, which can eventually lead to kidney failure. While microalbuminuria is commonly used to detect early kidney damage, relying on it alone may not be enough. Additional markers could help improve early detection and timely treatment. **Objectives:** To look at how HbA1C levels, a key indicator of blood sugar control, relate to microalbuminuria in people with T2DM. Also, to explore how HbA1C correlates with other markers of kidney function, including the albumin-to-creatinine ratio (ACR), serum urea, creatinine, fasting blood sugar (FBS), and random blood sugar (RBS). **Methods:** The study included 250 participants: 200 patients with T2DM and 50 healthy individuals matched by age and sex. Those with hypertension, kidney disease, urinary tract infections, or other health issues were excluded. Blood and urine samples were collected. Hemoglobin A1C was measured using high-performance liquid chromatography (HPLC), and A1C was calculated. Data were analyzed using SPSS-20, and correlations were assessed with Pearson's coefficient. **Results:** Compared to healthy controls, diabetic patients had significantly higher levels of FBS, RBS, HbA1C, serum urea, creatinine, and microalbuminuria. Higher HbA1C levels were linked with worse kidney function, suggesting that poor blood sugar control may signal early kidney damage. **Conclusions:** It was concluded that monitoring both HbA1C and microalbuminuria offers a better chance of catching kidney problems early in T2DM patients.Adding both markers to routine screenings could help delay or prevent serious kidney issues.

INTRODUCTION

T2DM is a highly prevalent chronic metabolic disorder worldwide, and its prevalence is continuously increasing, so are its complications [1, 2]. The number of adult diabetic patients worldwide has exceeded more than 500 million, out of which 20% have end-stage renal damage, which is a major health issue [3]. Approximately 537 million persons worldwide were expected by the International Diabetes Federation (IDF) to have diabetes by 2021, with type 2 diabetes accounting for more than 90% of these cases [4]. The prevalence is particularly concerning in Pakistan, where, according to the IDF, 26.7% of people had diabetes in 2022, ranking it third in the world behind China and India. "The News," one of the leading newspapers of Pakistan, published an article on diabetes, according to which Pakistan ranked third in the prevalence list of diabetes worldwide after India and China [5]. T2DM is the most common metabolic syndrome caused by disturbed carbohydrate metabolism, impaired insulin secretion, or, most of the time, insulin resistance due to blocking antibodies, resulting in hyperglycemia. In the absence of glucose, the tissue starts producing energy by lipolysis or proteolysis [6]. Simultaneous production of energy by

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sources other than glucose in T2DM leads to an increased production of various dangerous byproducts like advanced glycation end products, ketones, and free radicals. The microvasculature of T2DM patients is the first organ to be affected by these byproducts, resulting in microvascular disorders, especially neuropathy, nephropathy, and retinopathy [7-9]. Diabetic nephropathy is one of the feared complications of T2DM, causing progressive damage to renal tissues resulting in end-stage renal disorder, and patients ultimately go for dialysis or renal transplant. Due to the high prevalence of DM, diabetic nephropathy cases have exceeded other causes of renal damage, e.g. immune immune-mediated renal disorders [10]. Diabetic kidney disease (DKD) is predicted to develop in 20–50% of persons with type 2 diabetes [11]. According to research, the prevalence of chronic kidney disease (CKD) in diabetic people in Pakistan ranges between 12.5% to 29.9% [12]. Furthermore, 88% of diabetic individuals in a Lahore research had albuminuria, suggesting a substantial burden of renal problems [13]. The diagnosis of diabetic nephropathy is mainly based on microalbuminuria and estimated glomerular filtration rate. But it has been observed that in those diabetic patients who have disturbed glucose metabolism for a long time, the detection of microalbuminuria alone does not reflect the true picture of renal damage. This group of patients must be advised to have their HbA1C along with microalbuminuria to better assess the extent of renal damage. HbA1c is a significant test for monitoring glycemic control, and it accurately provides a pattern of glucose control for the last couple of months. HbA1C is a steadfast measure of chronic hyperglycemia, and it is also well associated with the development of long-term complications of DM [14-16].

This study aims to assess the diagnostic value of microalbuminuria and HbA1c in the early identification of nephropathy in patients with type 2 diabetes. In order to enable prompt interventions to stop the progression to end-stage renal disease (ESRD), we aim to correlate these indicators in order to identify patients at risk of developing DN at an earlier stage.

METHODS

This analytical case-control study was conducted at Life Care Molecular Lab, Karachi, from March 2023 to March 2024 in collaboration with Fazaia Ruth Pfau Medical College. Ethical approval was obtained from the Institutional Review Board of Fazaia Ruth Pfau Medical College (IRB Ref: FRPMC/003/IRB/23). The sample size of 250 participants was calculated using OpenEpi software, considering a correlation coefficient (r) of 0.2 between microalbuminuria and serum creatinine, with 80% power and 95% confidence level. A non-probability purposive sampling technique was employed. Among the 250 participants, 200 were diagnosed cases of type 2 diabetes mellitus (T2DM) for at least 10 years and aged above 30 years, while the remaining 50 were age-matched healthy individuals serving as controls with no history of diabetes or renal disease. Diabetic patients were further stratified into two groups based on the urine albumin/creatinine ratio (ACR): Group 1 with normal ACR (<30 mg/g) and Group 2 with microalbuminuria (30–299 mg/g), as per National Kidney Foundation (NKF) guidelines. In addition, T2DM patients were stratified based on HbA1C levels into well-controlled (HbA1C <7.0%) and poorly controlled (HbA1C ≥7.0%), and by disease duration into two categories: 10–15 years and more than 15 years. This stratification was done to better understand the relationship between glycemic control, severity/duration of diabetes, microalbuminuria, and progression of nephropathy. The controls were selected based on normal fasting blood sugar (FBS), random blood sugar (RBS), and HbA1C levels, with no known renal or systemic illnesses. To ensure homogeneity of the sample, the following exclusion criteria were applied to diabetic patients: those with acute or chronic kidney disease from non-diabetic causes, hypertension, cardiovascular diseases, chronic infections, malignancies, autoimmune disorders, pregnancy, or use of nephrotoxic drugs were excluded. Patients with urinary tract infections or any systemic disease were also not included in the diabetic group. All participants were instructed to fast overnight for 12 hours before sample collection. A total of 7 mL of venous blood was collected under aseptic conditions. The samples were processed accordingly: 2 mL in EDTA tubes for HbA1C analysis using high-performance liquid chromatography (HPLC), which was chosen over immunoassay or enzymatic methods due to its superior analytical precision, reproducibility, and ability to detect hemoglobin variants, making it a gold-standard method for HbA1C measurement in clinical and research settings. Additionally, 2 mL in fluoride tubes was used for FBS measurement, 1 mL in a separate fluoride tube for RBS, and the remaining in gel tubes for estimation of serum urea and creatinine using chemiluminescence. Spot urine samples were collected for the assessment of microalbumin and creatinine, and the ACR was calculated by dividing albumin (mg) by creatinine (g). The primary outcome variables included microalbuminuria (defined by ACR 30–299 mg/g), HbA1C level, serum urea, and serum creatinine, while secondary variables included age, sex, duration of diabetes, FBS, and RBS. Microalbuminuria was considered an early marker of diabetic nephropathy. Data were recorded using a structured proforma and entered into Microsoft Excel. Statistical analysis was performed using SPSS version 20. Mean and standard deviation (SD) were calculated for continuous variables. Independent sample t-tests and ANOVA were applied to compare means between diabetic and control groups. Pearson correlation analysis was performed among diabetic patients to explore

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relationships between HbA1C, ACR, and serum creatinine. A p-value of <0.05 was considered statistically significant throughout the study.

RESULTS

The study included 250 participants, divided into three groups: Group A (Control group): 50 healthy individuals, Group B: 100 T2DM patients with normoalbuminuria, Group C: 100 T2DM patients with microalbuminuria Results summarize the mean values ± SD of various biochemical parameters across the three groups and demonstrates statistically significant differences in all parameters as nephropathy progresses. The mean values of glycemic (HbA1C, FBS, RBS) and renal parameters (urea, creatinine) significantly increased with worsening albuminuria status among diabetic patients (Table 1).

Table 1: Comparison of Biochemical Parameters Among Study Groups

Parameter	Group A (Control)	Group B (Normoalbuminuria)	Group C (Microalbuminuria)	p-value (ANOVA)
FBS (mg/dL)	88.00 ± 10.00	165.00 ± 35.00	205.00 ± 40.00	<0.001
RBS (mg/dL)	130.00 ± 15.00	250.00 ± 45.00	300.00 ± 50.00	<0.001
Urea (mg/dL)	30.00 ± 5.00	48.00 ± 10.00	62.00 ± 15.00	<0.001
Creatinine (mg/dL)	1.00 ± 0.20	1.70 ± 0.80	2.50 ± 1.10	<0.001
HbA1C (%)	5.20 ± 0.40	7.20 ± 1.00	10.10 ± 2.00	<0.001
Microalbumin (mg/dL)	15.00 ± 5.00	25.00 ± 4.00	120.00 ± 50.00	<0.001

The following table presents the correlation coefficients of microalbuminuria with glycemic and renal markers in diabetic patients (Groups B and C combined). Findings show a strong correlation of microalbuminuria with serum creatinine, and a moderate correlation with HbA1C, confirming the relationship between poor glycemic control and progressive renal impairment in T2DM patients (Table 2).

Table 2: Correlation Between Microalbuminuria and Biochemical Markers in T2DM Patients

Parameter	Pearson's r	p-value	Interpretation
FBS	0.190	0.0001	Mild positive correlation
RBS	0.240	0.001	Mild Positive Correlation
Urea	0.155	0.020	Weak But Significant
Creatinine	0.799	<0.0001	Strong Positive Correlation
HbA1C	0.659	<0.0001	Moderate Positive Correlation

DISCUSSION

Diabetic nephropathy is a serious and most feared complication of diabetes mellitus affecting the microvasculature of the kidneys, resulting in end-stage renal disease. Worldwide data from the International Diabetes Federation states that almost 30-40% of diabetic patients may develop chronic kidney damage, resulting in renal failure. Likewise, 80% of diabetics with hypertension lead to end-stage renal failure [17, 18]. Diabetic patients are ten times more prone to have chronic kidney disease, accompanied by increased morbidity and mortality among diabetic patients [19]. The prevalence of diabetic nephropathy is increasing as the diabetic pool is expanding worldwide, and it needs marked improvement in strategic plans for the prevention of diabetic nephropathy [20, 21]. Microalbuminuria is an early indicator of diabetic nephropathy. About 30-40% of diabetic patients may develop microalbuminuria-related nephropathy within ten years, and the majority of these patients develop end-stage renal disease. Estimation of HbA1C provides accurate and precise information about glycemic status, and it accurately defines the cumulative glycemic history of the preceding two to three months. Besides, it is well correlated with the increasing risk of diabetic complications, especially nephropathy [22]. In our study, FBS, RBS in the control group are found to be 80 mg/dl and 120 mg/dl, respectively, with HbA1C below 6.0 %. While group 1 and group 2 have increased FBs and RBs levels with HbA1C more than 6.2 %. Similarly, urea and Creatinine were also found to be within normal range with normal HbA1C, while Group 1 and Group 2 showed increased levels of both urea and Creatinine with increased HbA1C. Microalbuminuria also showed a significant direct proportional relationship with HbA1C in both diabetic groups. These findings are by the results given by [23, 24]. The present study also showed a significant correlation of microalbuminuria with HbA1C (p-value=0.0001) and (r=0.65) as shown by [25]. Similar results were given by [26], which also showed a significant correlation between Microalbuminuria and HbA1C. The strong point of our study is the precise and accurate measurement of HbA1C and microalbuminuria, and it proves that good glycemic control by HbA1C can minimize microalbuminuria detection through resulting in the decreased progression of diabetic nephropathy. Even though our research shows a strong link between high HbA1C levels and microalbuminuria, it's crucial to take into account possible confounding factors like obesity, hypertension, dyslipidemia, and nephrotoxic medication use that could also play a role in the onset and progression of diabetic nephropathy. To reduce the impact of these confounders. According to our predetermined exclusion criteria, patients with hypertension were not allowed to participate in the study. Because hypertension is a known risk factor for renal impairment and may have led to higher microalbuminuria levels on its own, skewing the

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correlation with HbA1C, this was crucial [1]. Another significant confounding factor is obesity, which can worsen kidney disease by encouraging glomerular hyperfiltration and insulin resistance. Although not specifically mentioned in our study, anthropometric measurements (waist circumference, BMI) should be used in future studies to account for the possible impact of obesity [27]. Our study's strength is the precise measurement of HbA1C using HPLC and the detection of microalbuminuria using chemiluminescence, both of which support the idea that strict glycaemic management helps prevent early renal involvement in diabetes patients. We recommend adding regular HbA1C and microalbuminuria tests to the routine clinical follow-up of all type 2 diabetic patients according to our results. Although annual or biennial microalbuminuria screening may help in early detection of renal impairment, HbA1C must be assessed every three months to monitor long-term glycaemic control. Ultimately, this holistic approach will reduce the burden of diabetic nephropathy by allowing for timely intervention and early detection of high-risk patients.

CONCLUSIONS

It was concluded that the consequences of T2DM are becoming more sensitive in terms of healthcare expenditure in Pakistan, particularly concerning diabetic renal disease.The damage to kidney tissue must be identified early to avoid end-stage renal failure.This research proves that both urine microalbuminuria and glycosylated hemoglobin (HbA1C) are critical markers for the optimal control of diabetes and nephropathy detection in diabetes. Due to their interdependent relationship, the evaluation of these two parameters can be beneficial for both newly diagnosed and long-standing diabetic patients. The routine performance of these tests by healthcare providers will dramatically improve the management of advanced renal complications in diabetes patients.

Authors Contribution

Conceptualization: AR
Methodology: NQ, SZ, I
Formal analysis: RFM
Writing review and editing: SE, ZI, SS
All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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REFERENCES

[1] Wagnew F, Eshetie S, Kibret GD, Zegeye A, Dessie G, Mulugeta H *et al*. Diabetic Nephropathy and Hypertension in Diabetes Patients of Sub-Saharan Countries: A Systematic Review and Meta-Analysis. BioMed Central Research Notes.2018Dec;11: 1-7.doi:10.1186/s13104-018-3670-5.

[2] Abdul Basith Khan M, Hashim MJ, King JK, Govender RD, Mustafa H, Al Kaabi J. Epidemiology of Type 2 Diabetes—Global Burden of Disease and Forecasted Trends. Journal of Epidemiology and Global Health. 2020 Mar; 10(1): 107-11. doi: 10.2991/jegh.k.191028.001.

[3] Asghar S, Asghar S, Mahmood T, Bukhari SM, Mumtaz MH, Rasheed A. Microalbuminuria as the Tip of the Iceberg in Type 2 Diabetes Mellitus: Prevalence, Risk Factors, and Associated Diabetic Complications. Cureus. 2023Aug;15(8).doi:10.7759/cureus.43190.

[4] Arshad MS, Alqahtani F, Rasool MF. The Economic Burden of Type 2 Diabetes Mellitus in Pakistan: A Cost of Illness Study.In Healthcare.2024Sep;12(18):1826. doi:10.3390/healthcare12181826.

[5] Azeem S, Khan U, Liaquat A. The Increasing Rate of Diabetes in Pakistan: A Silent Killer.Annals of Medicine And Surgery.2022Jul;79.doi:10.1016/j.amsu.2022.103901.

[6] Nasir M, Razzaque R, Afzal S. Epidemiology of Diabetes Mellitus, Pre-Diabetes, Undiagnosed and Uncontrolled Diabetes in Pakistan.World Journal of Pharmaceutical Research.2023;12(9):162-169.

[7] Campos-Pastor MM, Escobar-Jimenez F, Mezquita P, Herrera-Pombo JL, Hawkins-Carranza F, Luna JD *et al.* Factors Associated with Microalbuminuria in Type 1 Diabetes Mellitus: A Cross-Sectional Study.Diabetes Research and Clinical Practice.2000Apr;48(1):43-9. doi: 10.1016/S0168-8227(99)00133-3.

[8] Prakash S and Yadav K. Mi-croalbuminuria in Diabetes. Letters In Health and Biological Sciences. 2017; 2(1).

[9] Basavaraj RG and Malladad R. Correlation of Glycosylated Hemoglobin with Urinary Albuminuria for Early Detection and Progression of Nephropathy in Patients with Type 2 Diabetes Mellitus.Indian Journal of Pathology and Oncology.2023Jan;8(4):433-6.doi: 10.18231/j.ijpo.2021.090.

[10] Thethi TK and Batuman V. Challenging the Conventional Wisdom on Diabetic Nephropathy: Is Microalbuminuria The Earliest Event? Journal of Diabetes and Its Complications.2019Mar;33(3):191-2. doi: 10.1016/j.jdiacomp.2018.12.006.

[11] Hoogeveen EK. The Epidemiology of Diabetic Kidney Disease. Kidney and Dialysis.2022Aug;2(3):433-42. doi: 10.3390/kidneydial2030038.

[12] Khan A, Cheema MF, Fatima R, Cheema SS, Butt Z, Gillani S *et al.* Prevalence of Chronic Kidney Disease in A High-Risk Population in Urban Lahore, Pakistan: A Cross-Sectional Study.Cureus. 2024Jun;16(6).doi: 10.7759/cureus.63296.

[13] Munir A, Gulzar S, Afzal A, Zahid MA, Khan MA, Khan NU *et al.* Prevalence of Diabetic Nephropathy among Patients of Type 2 Diabetes at Tertiary Care Hospital

DOI: https://doi.org/10.54393/pjhs.v6i5.2988

Lahore.Journal of Health and Rehabilitation Research .2024Jun;4(2):1607-11.doi:10.61919/jhrr.v4i2 .1108.
[14] Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c Test in Diagnosis and Prognosis of Diabetic Patients.Biomarker Insights.2016Jan;11:BMI-S38440.doi:10.4137/BMI.S38440.
[15] Gluhovschi C, Gluhovschi G, Petrica L, Timar R, Velciov S, Ionita I *et al.* Urinary Biomarkers in the Assessment of Early Diabetic Nephropathy.Journal of Diabetes Research.2016;2016(1):4626125.doi:10.1155/2016/4626125.
[16] Mukherjee S, Ray SK, Jadhav AA, Wakode SL. Multi-Level Analysis of HbA1c in Diagnosis and Prognosis of Diabetic Patients.Current Diabetes Reviews.2024 Sep;20(7):85-92.doi:10.2174/0115733998262501231015051317.
[17] Sulaiman MK. Diabetic Nephropathy: Recent Advances in Pathophysiology and Challenges in Dietary Management.Diabetology and Metabolic Syndrome.2019Dec;11:1-5.doi:10.1186/s13098-019-0403-4.
[18] Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS *et al.* Global Prevalence of Chronic Kidney Disease–A Systematic Review and Meta-Analysis.PLOS ONE.2016Jul;11(7):e0158765.doi:10.1371/journal.pone.0158765.
[19] Valencia WM and Florez H. How to Prevent the Microvascular Complications of Type 2 Diabetes Beyond Glucose Control. British Medical Journal.2017 Jan; 356. doi: 10.1136/bmj.i6505.
[20] Yadav D, Kochar B, Mathur A, Chougle A. Prevalence of Microalbuminuria in Type 2 Diabetes Mellitus: A Hospital-Based Study. International Journal of Research-Granthaalayah.2017;5(12):217-22.doi:10.29121/granthaalayah.v5.i12.2017.496.
[21] Dereje D. Using Microalbuminuria as Early Screening Tool for Prevention of Renal Disease Progression in Diabetes Mellitus: A Review Article of Current Insights. EC Microbiol. 2021; 17: 35-40.
[22] Sung JY, Chen CI, Hsieh YC, Chen YR, Wu HC, Chan L *et al.* Comparison of Admission Random Glucose, Fasting Glucose, and Glycated Hemoglobin in Predicting the Neurological Outcome of Acute Ischemic Stroke: A Retrospective Study.PeerJ.2017Feb;5:e2948.doi:10.7717/peerj.2948.
[23] Chawla S, Trehan S, Chawla A, Jaggi S, Chawla R, Kumar V *et al.* Relationship Between Diabetic Retinopathy Microalbuminuria and Other Modifiable Risk Factors. Primary Care Diabetes.2021Jun;15(3):567-70. doi: 10.1016/j.pcd.2021.01.012.
[24] Chowdhury SK, Datta S, Mohith MT, Roy S, Hossain MJ, Zafrin N *et al.* Study of Relationship Between HbA1c and Microalbuminuria of Diabetic Patients. Annals of International Medical and Dental Research.2022 ;8(2):99-108. doi: 10.53339/aimdr.2022.8.2.14.
[25] Mohammed O, Alemayehu E, Bisetegn H, Debash H, Gedefie A, Ebrahim H *et al.* Prevalence of Microalbuminuria Among Diabetes Patients in Africa: A Systematic Review and Meta-Analysis.Diabetes, Metabolic Syndrome and Obesity.2023Dec:2089-103.doi:10.2147/DMSO.S409483.
[26] Mohammad P and Khan EH. Unnoticed Microalbuminuria Is Substantially Prevalent in Patients of Type-2 Diabetes Mellitus in Peshawar. Journal of Saidu Medical College.2019Jun;9(1).
[27] Maric C and Hall JE. Obesity, Metabolic Syndrome and Diabetic Nephropathy.Contributions to Nephrology. 2011Jun;170:28.doi:10.1159/000324941.