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Interest of Measuring Microalbuminuria and Glycated Hemoglobin in Type 2 Diabetes in Mali Hospital

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Abstract: Introduction: Diabetes is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Objective: The objective of this study was to investigate the correlation between microalbuminuria and glycated hemoglobin in the monitoring of patients with type 2 diabetes mellitus. Methods : This was a cross-sectional, descriptive, and analytical study conducted simultaneously in the Endocrinology Department and the Medical Biology Laboratory of Mali Hospital from February 1 to September 31, 2022. The study population consisted of patients with type 2 diabetes aged between 30 and 70 years. Results: A total of 160 patients with type 2 diabetes were included. Females predominated, with a male-to-female ratio of 0.74. The mean age of participants was 54.63 ± 10.16 years. The most prevalent diabetes risk factors were advanced age, overweight/obesity, hypertension, family history of diabetes, and dyslipidemia, with respective frequencies of 90.6%, 62.5%, 47.5%, 46.8%, and 35.6%. The mean biochemical parameters were 1.94 ± 0.93 g/L for fasting plasma glucose, 9.58 ± 3.19% for glycated hemoglobin, and 91.96 ± 119.19 mg/L for microalbuminuria. A statistically significant correlation was found between elevated fasting plasma glucose and the presence of microalbuminuria ($p = 0.013$). Microalbuminuria was also significantly higher in patients with elevated glycated hemoglobin levels ($p = 0.01$). Conclusion: Poor glycemic control and persistent positive microalbuminuria appear to be predictive markers for the development of microvascular complications in patients with type 2 diabetes.

Keywords: Type 2 Diabetes, Microalbuminuria, Glycated hemoglobin, Mali Hospital

INTRODUCTION

Diabetes is a chronic and serious condition characterized by elevated blood glucose levels resulting from insufficient insulin production (insulin deficiency) or impaired insulin utilization (insulin resistance) [1]. With the global prevalence of diabetes steadily increasing, the International Diabetes Federation (IDF) has declared it a true pandemic due to its rapid expansion [1]. The total number of people living with diabetes is projected to rise by 129%, reaching 55 million by 2045. Africa is not exempt from this trend, with rising prevalence and incidence rates. Diabetes was responsible for 416,000 deaths in Africa, and over half (54%) of affected individuals remain undiagnosed [1].

In sub-Saharan Africa, the prevalence and number of new diabetes cases were estimated at 4.8% and 19.1 million in 2015, and are expected to reach 5.7% and 41.4 million by 2035, respectively [2]. In Mali, a recent hospital-based study reported a prevalence of 10.12%, with type 2 diabetes accounting for 95% of all cases [3].

Uncontrolled diabetes leads to metabolic disturbances and is associated with cardiovascular complications and increased risk of premature mortality. Common complications include hypertension, stroke, kidney failure, minor wounds, limb amputation, and vision loss [4]. Cardiovascular complications, in particular, have been shown to correlate with elevated glycated hemoglobin (HbA1c) levels, with each 1% increase above a baseline HbA1c of 6.5% conferring a 15–20% higher risk of cardiovascular events [5].

HbA1c is widely recognized as an objective marker of long-term glycemic control in diabetic patients. It reflects the non-enzymatic attachment of glucose to hemoglobin during chronic hyperglycemia and represents the average blood glucose levels over the preceding 60 days, complementing point-of-care glucose measurements [6]. Diabetes is generally considered well-controlled when HbA1c levels are ≤7% [7]. Elevations above this threshold indicate a heightened risk of cardiovascular complications, underscoring the importance of regular HbA1c monitoring, typically on a quarterly basis.

At this stage, metabolic disturbances may also manifest as microalbuminuria, a strong predictor of hypertension and peripheral neuropathy. Microalbuminuria is defined as urinary albumin excretion of 30–300 mg/24 h in a 24-hour collection, 20–200 µg/min in a timed sample, or 30–300 µg/mg in a spot urine sample with creatinine measurement [3]. In type 2 diabetic patients, early renal involvement and vascular risk can be detected through routine monitoring of this parameter [8]. Poor glycemic control, generally indicated by HbA1c levels above 7%, is a major factor contributing to increased urinary albumin excretion [3], highlighting the importance of assessing both HbA1c and microalbuminuria in type 2 diabetes management. To date, no study in Mali has examined the correlation between microalbuminuria and HbA1c, despite their relevance in predicting vascular and renal complications in type 2 diabetes. Management of these patients is multidisciplinary, encompassing therapeutic education, lifestyle modifications, and pharmacological interventions [9]. Given the complexity of care, this study was undertaken at Mali Hospital to investigate the following research question:

How can the measurement of microalbuminuria and HbA1c improve the management of patients with type 2 diabetes?

METHODS

Ethical Aspects

The study was conducted in accordance with the ethical standards set out in the Declaration of Helsinki (1983) and approved by the ethics committee of the Faculty of Medicine, Pharmacy, and Dentistry (FMPOS) of the University of Sciences, Techniques, and Technologies of Bamako (USTTB) under number 2016/05/CE/FMPOS dated January 18, 2016. A documented, free, and informed verbal consent from patients was obtained before their inclusion in the study. The information provided by each patient was kept completely confidential and cannot be disclosed. It was used solely for research purposes. Personal information regarding each patient was coded with a number that would not allow the

identification of the patient in the publication of the study's results. Good social, medical, and laboratory practices were adhered to and disseminated.

Study Design and Setting

This was a descriptive, analytical, and prospective study conducted over a nine-month period, from February 2022 to September 2022, at Mali Hospital. The study population consisted of patients with type 2 diabetes who attended outpatient consultations or were regularly followed at the hospital during the study period.

Sample Collection

For urinary analysis, patients were instructed to empty their bladder, consume approximately 250 mL of water, and collect all urine passed during the following three hours. Morning fresh urine samples were collected in sterile containers and centrifuged at 3000 rpm for 15 minutes. The resulting supernatant was used for microalbumin determination.

Venous blood samples were collected after an overnight fast between 8:00 and 10:00 a.m. from the antecubital vein. Blood was drawn into appropriate tubes according to the required analyses: EDTA tubes for glycated hemoglobin (HbA1c), fluoride tubes for fasting plasma glucose, and heparinized tubes for serum creatinine and lipid profile measurements. Samples were centrifuged at 3000 rpm for 15 minutes to obtain plasma for biochemical analyses.

Biochemical Analyses

Fasting plasma glucose was measured using the enzymatic glucose oxidase–peroxidase (GOD-POD) method on an automated ultraviolet-visible spectrophotometric analyzer. In this method, glucose is oxidized by glucose oxidase to gluconic acid and hydrogen peroxide. The hydrogen peroxide reacts, in the presence of peroxidase, with a chromogenic substrate to form a colored compound. The absorbance measured is directly proportional to the glucose concentration.

HbA1c was determined using high-performance liquid chromatography (HPLC). This chromatographic technique separates the different hemoglobin fractions and quantitatively measures HbA1c as a percentage of total hemoglobin. HbA1c reflects the average blood glucose concentration over the previous three months.

Microalbuminuria was assessed using an immunoturbidimetric method based on antigen–antibody reaction. Urine samples were mixed with a reagent containing Tris buffer and specific anti-human albumin antibodies, resulting in turbidity proportional to the albumin concentration. This method enables early detection of glomerular dysfunction and assessment of renal and cardiovascular risk.

Serum creatinine was measured using the sarcosine oxidase method. Creatinine is converted into creatine and subsequently into sarcosine. Oxidation of sarcosine produces hydrogen peroxide, which reacts with a chromogen to form quinoneimine. The absorbance

measured at 546 nm is directly proportional to the creatinine concentration, allowing evaluation of renal function.

The lipid profile included total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides. Total cholesterol was measured using the cholesterol oxidase–peroxidase (CHOD-POD) method. HDL and LDL cholesterol were determined using direct enzymatic colorimetric assays following selective fraction separation. Triglycerides were measured using the enzymatic glycerokinase–peroxidase method, in which triglycerides are hydrolyzed and the resulting glycerol is oxidized to produce a measurable colored compound.

Variables Explored in the Study

The variables analyzed included age and sex. Fasting plasma glucose was considered normal within the range of 0.7–1.1 g/L. Glycated hemoglobin (HbA1c) was categorized as follows :

< 7%: good glycemic control; 7–9%: poor glycemic control; 9% : high risk of complications.

Serum creatinine normal values were defined as 71–115 µmol/L for men and 53–106 µmol/L for women. Glomerular filtration rate (GFR) was classified as ≥ 90 mL/min/1.73 m^2 (Stage 1).

The lipid profile included measurements of total cholesterol, HDL cholesterol (HDL-C), LDL cholesterol (LDL-C), and triglycerides in order to evaluate dyslipidemia in relation to HbA1c levels.

Univariate Statistical Analysis

Survey data were entered using Microsoft Excel 2021 and analyzed using SPSS version 22.0. Descriptive statistics were calculated, including arithmetic means and standard deviations. Statistical significance was set at $p < 0.05$ with a confidence level corresponding to $\alpha = 0.05$ (95% confidence interval). The Chi-square test was used to compare proportions. Data entry and document processing were performed using Microsoft Word 2021.

RESULTS

The study included 160 patients with type 2 diabetes mellitus. The sex ratio was 0.74 in favor of females, who represented 57.5% of the study population, compared to 42.5% males. The mean age was 54.63 ± 10.17 years, with extremes ranging from 30 to 70 years. Among the cardiovascular risk factors, age over 40, high blood pressure, dyslipidemia, and a sedentary lifestyle were the most common, with respective frequencies of 90.6%, 47.5%, 35.6%, and 14.4%. Overweight/obesity was 62.5% with an average BMI of 26.69±5.914 kg/m^2. Tea, smoking, and alcoholism were consumed by 84.4%, 4.4%, and 0.6% of the patients, respectively. Regarding fasting plasma glucose, 70.6% of patients presented with hyperglycemia, with a mean level of 1.94 ± 0.93 g/L. The mean HbA1c level was 9.58 ± 3.196%, and 43.8% of patients had poor glycemic control. Patients with good glycemic control had a mean HbA1c of 5.90 ± 0.75%. Those with poor glycemic control had a mean HbA1c of 8.01 ± 0.61%. Patients with uncontrolled diabetes and high risk of complications had a mean HbA1c of 12.50 ± 2.50%. Urinary albumin excretion was observed in 57.5% of

patients, with a mean albumin excretion of 91.96 ± 119.19 mg/L. Regarding renal clearance, 33.1% of patients had impaired renal function. The mean GFR was 111.12 ± 54.54 mL/min/1.73 m² according to the MDRD equation. **Note:** In this study, the lipid profile was not performed in 32 patients. Total cholesterol was elevated in 33.6% of patients with with type 2 diabetes mellitus, with a mean total cholesterol level of 4.47 ± 1.58 mmol/L. HDL-C was decreased in 22.7% of patients, with a mean HDL-C level of 1.13 ± 0.53 mmol/L. LDL-C was elevated in 46.1% of patients, with a mean LDL-C level of 3.144 ± 1.36 mmol/L. Hypertriglyceridemia was observed in 20 patients (15.6%), with a mean triglyceride level of 1.17 ± 0.51 mmol/L.

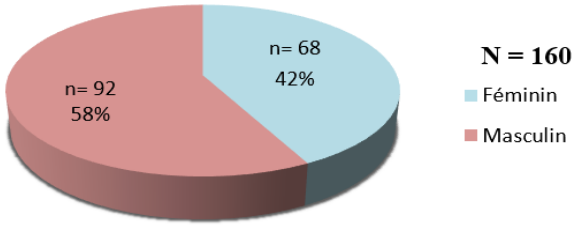

Figure 1: Distribution by gender

Among the 160 patients, 92 (57.5%) were female, which makes a sex ratio of 0.74.

Table I : Distribution of patients according to biochemical markers

Biochemical markers	N	Average ± EC	[Min-Max]
Fasting plasma glucose (g/L)	160	1,9433±0,93630	[0,67-5,20]
HbA1c (%)	160	9,5843±3,19686	[4,20-19,5]
Microalbuminuria (mg/L)	160	91,9675±119,1975	[0,11-740]
Creatinine (µmol/L)	160	91,9877±90,67028	[24,30-872,26]
GFR (ml/min/1.73m²) MDRD	160	111,12±54,54	[1,80-385,51]
GFR (ml/min/1.73m²) CKD-EPI	160	96,8337±32,74064	[0,45-167,29]
Cholesterol-T (mmol/L)	128	4,4753±1,58536	[0,87-8,37]
HDL-Cholesterol (mmol/L)	128	1,133±0,53580	[0,13-3,61]
LDL-Cholesterol (mmol/L)	128	3,1448±1,36951	[0,36-6,68]
Triglyceridemia (mmol/L)	128	1,1750±0,51335	[0,41-2,90]

This table shows the distribution of various biochemical markers measured in our diabetic patients. The different concentrations are expressed as averages ± standard deviation and as minimum and maximum concentrations in a total of 160 type 2 diabetic patients. However, for the lipid markers, 32 patients did not have these tests done.

Table II: Distribution of Type 2 Diabetes Patients by Fasting Plasma Glucose Level.

Glycémie à jeun (g/L)	Number (n)	Frequency (%)
Decreased (< 0.7)	1	0.6
Normale ([0.7 - 1.26 [)	46	28.8
Increased (≥ 1.26)	113	70.6
Total	160	100.0

In our study population, 70.6% of patients presented with hyperglycemia, with a mean fasting plasma glucose level of 1.94 ± 0.93 g/L.

Table III: Distribution of type 2 diabetic patients according to glycated hemoglobin (HbA1c) levels

HbA1c (%)	Number (n)	Frequency (%)
Good glycemic control (HbA1c < 7%)	30	18.7
Suboptimal glycemic control (HbA1c 7–9%)	60	37.5
Poor glycemic control with high risk of complications (HbA1c > 9%)	70	43.8
Total	160	100.0

In our study, 43.8% of patients had poor glycemic control with a high risk of complications based on HbA1c levels, with a mean HbA1c of 9.58 ± 3.196%.

Table IV: Distribution of type 2 diabetic patients according to urinary albumin excretion

Microalbuminuria (mg/L)	Number (n)	Frequency (%)
Normoalbuminuria (< 30)	56	35.0
Microalbuminuria (30 – 300)	92	57.5
Macroalbuminuria (> 300)	12	7.5
Total	160	100.0

More than half of the patients in our study (57.5%) had positive microalbuminuria, with a mean urinary albumin excretion of 91.96 ± 119.19 mg/L. The mean urinary albumin excretion levels in the normoalbuminuric and microalbuminuric groups were 12.016 ± 6.302 mg/L and 98.606 ± 73.104 mg/L, respectively.

Table V: Distribution of type 2 diabetic patients according to glomerular filtration rate (GFR) estimated by MDRD and CKD-EPI equations.

Classification (ml/min/1.73m^2)	DFG	
	According to MDRD (%)	According to CKD-EPI (%)
Stade 1 (≥ 90)	107 (66.9)	103 (64.4)
Stade 2 (60-89)	34 (21.2)	32 (20.0)
Stade 3A (45-59)	10 (6.2)	15 (9.4)
Stade 3B (30-44)	3 (1.9)	3 (1.9)
Stade 4 (15-29)	4 (2.5)	5 (3.1)
Stade 5 (< 15)	2 (1.3)	2 (1.2)
Total	160 (100.0)	160 (100.0)

A proportion of 33.1% of the type 2 diabetic patients in our study had impaired renal function, with a mean estimated glomerular filtration rate (*e*GFR) of 111.12 ± 54.54 mL/min/1.73 m^2 according to the MDRD equation. In addition, 35.6% of patients had impaired renal function, with a mean eGFR of 96.83 ± 32.74 mL/min/1.73 m^2 according to the CKD-EPI equation.

Table VI: Correlation between Fasting Blood Glucose and Microalbuminuria

Fasting Blood Glucose	Microalbuminuria			Total (%)
	< 30 (%)	30 – 300 (%)	> 300 (%)	
< 0,7	0 (0.0)	1 (0.6)	0 (0.0)	1 (0.6)
[0,7 - 1,26]	24 (15.0)	20 (12.5)	2 (1.2)	46 (28.8)
≥ 1,26	32 (20.0)	71 (44.4)	10 (6.3)	113 (70.6)
Total	56 (35.0)	92 (57.5)	12 (7.5)	160 (100.0)

Pearson's test = 9.072; df = 4; p = 0.013.

We observed a proportional increase in microalbuminuria with rising fasting blood glucose levels, as well as a statistically significant association between fasting blood glucose and microalbuminuria.

Table VII: Correlation between HbA1c and Microalbuminuria.

HbA1c %	Microalbuminuria			Total (%)
	< 30 (%)	30 – 300 (%)	> 300 (%)	
< 7	18 (11.3)	11 (6.9)	1 (0.6)	30 (18.7)
7 – 9	17 (10.6)	35 (21.9)	8 (5.0)	60 (37.5)
> 9	21 (13.1)	46 (28.7)	3 (1.9)	70 (43.8)
Total	56 (35.0)	92 (57.5)	12 (7.5)	160 (100.0)

Fisher's exact test = 13.365; df = 4; p = 0.010.

We observed a higher concentration of patients with microalbuminuria in the HbA1c class above 9%.

Table VIII: Correlation between *e*GFR (MDRD) and Microalbuminuria.

DFG (MDRD)	Microalbuminuria			Total (%)
	< 30 (%)	30 – 300 (%)	> 300 (%)	
Stade 1	51 (31.9)	53 (33.1)	3 (1.9)	107 (66.9)
Stade 2	4 (2.5)	28 (17.5)	2 (1.3)	34 (21.2)
Stade 3A	1 (0.6)	7 (4.4)	2 (1.3)	10 (6.2)
Stade 3B	0 (0.0)	1 (0.6)	2 (1.2)	3 (1.9)
Stade 4	0 (0.0)	2 (1.3)	2 (1.2)	4 (2.5)
Stade 5	0 (0.0)	1 (0.6)	1 (0.6)	2 (1.3)
Total	56 (35.0)	92 (57.5)	12 (7.5)	160 (100.0)

Fisher's exact test = 42.573; df = 10; $p < 10^{-3}$.

We observed that *e*GFR (MDRD) was inversely proportional to microalbuminuria. Its decline was correlated with an increase in microalbuminuria, showing a highly statistically significant relationship between eGFR (MDRD) and microalbuminuria.

Tableau IX: Correlation between *e*GFR (CKD-EPI) and Microalbuminuria.

*e*DFG (CKD-EPI)	Microalbuminuria			Total (%)
	< 30mg (%)	30 – 300mg (%)	> 300mg (%)	
Stade 1	51 (31.9)	50 (31.2)	2 (1.3)	103 (64.4)
Stade 2	4 (2.5)	25 (15.6)	3 (1.9)	32 (20.0)
Stade 3A	1 (0.6)	11 (6.9)	3 (1.9)	15 (9.4)
Stade 3B	0 (0.0)	2 (1.3)	1 (0.6)	3 (1.9)
Stade 4	0 (0.0)	3 (1.9)	2 (1.2)	5 (3.1)
Stade 5	0 (0.0)	1 (0.6)	1 (0.6)	2 (1.2)
Total	56 (35.0)	92 (57.5)	12 (7.5)	160 (100.0)

Fisher's exact test = 43.437; df = 10; $p < 10^{-3}$.

We observed an inverse relationship between *e*GFR and microalbuminuria, as well as a statistically significant association between *e*GFR (CKD-EPI) and microalbuminuria.

DISCUSSION

This was a prospective, descriptive, and analytical study conducted over a nine-month period at the Hospital of Mali. Data from patients with type 2 diabetes were collected during consultations in the endocrinology department, and laboratory analyses were performed at the medical biology laboratory. Although the initially planned sample size was 140 patients, a total of 160 were ultimately included during the study period.

In our study, females predominated (57.5%), with a sex ratio of 0.74, similar to the findings reported by Kamissoko (2017) and Diawara *et al.*, (2019) [9, 10], who reported sex ratios of 0.73 and 0.76, respectively. This female predominance may be explained by urbanization-related lifestyle changes that promote overweight and insulin resistance among women. Other contributing factors may include pregnancy-related obesity, the use of contraceptives and corticosteroids, and menopause, which reduces insulin sensitivity [11]. Furthermore, women tend to seek medical care more frequently, as shown by data from the endocrinology department of the Hospital of Mali, where 66.4% of consultations involved female patients.

Participants were aged between 30 and 70 years, with a mean age of 54.63 ± 10.16 years. The most represented age group was 50–59 years (33.1%). These findings are comparable to those reported by Sangaré *et al.*, (2021), in which the predominant age group was also 50–59 years, with a mean age of 53.26 ± 9.69 years [12]. Diao (2020) reported similar values, with a mean age of 54.82 ± 11.93 years [13], while Kahina *et al.*, (2015) found a mean age of 54.59 ± 4.87 years in the same age group [14]. Additionally, the AMAR-AFO study (2013), conducted in Senegal and Ivory Coast, reported a mean age of 53.2 ± 9.6 years among participants, confirming the trend observed in African studies [15].

These findings reflect metabolic disturbances associated with known risk factors for the disease and are consistent with evidence that the prevalence of type 2 diabetes increases significantly after the age of 40 in both sexes [16]. In contrast, in developed countries, the mean age of patients with diabetes is higher. The ENTRED study in France reported a mean age of 65 years [17], and in Quebec in 2019, 80% of diabetic patients were diagnosed after the age of 50, with 43% diagnosed after 65 years. This difference can be

explained by the more pronounced population aging in these countries, attributable to medical advances and improved living conditions [18].

In our study, only 18.7% of patients achieved good glycemic control (mean HbA1c 5.90 ± 0.75%), a proportion lower than the 23% reported by Diao A (2020) [13]. More than 81% of patients had HbA1c levels above the normal range, with a mean of 9.58 ± 3.19%. Mossi *et al.,* (2019) in Togo reported similar findings, with 87.65% of patients presenting elevated HbA1c levels (9.19 ± 3.26%) [19].

In developed countries, therapeutic adherence appears to be better, as reflected by mean HbA1c levels of 6.34 ± 1.0% in the study by Dawson C. in Colorado [20] and 7.01% in France (ENTRED study) [17], where 70% of patients had HbA1c levels below 7.0%. The International Diabetes Federation (IDF) attributes this difference to better access to medications in high-income countries.

In our study, 57.5% of patients had microalbuminuria, with a mean value of 91.96 ± 119.19 mg/L, which is higher than the 48.7% reported by Diouf *et al.,* (2015) in Senegal [21]. This predominance may be attributed to poor glycemic control and irregular follow-up in some patients. A significant association was found between duration of diabetes and microalbuminuria (P = 0.004), consistent with the findings of Chowta *et al.,* (2009) and Kundu *et al.,* (2013), who also reported a positive correlation between these factors [22,23]. Moreover, a statistically significant correlation was observed between microalbuminuria and fasting plasma glucose (P = 0.013), in line with the results of Jatoi *et al.,* (2020) and Kahina et al. (2015) [14,24]. We also observed an association between microalbuminuria and systolic hypertension (P = 0.002), with 63.2% of hypertensive patients presenting microalbuminuria, a proportion lower than the 87.8% reported by Diarra M. (2009) [25].

With a mean serum creatinine level of 91.98 ± 90.67 µmol/L, the mean estimated glomerular filtration rate (*e*GFR) was 111.12 ± 54.54 mL/min/1.73 m^2 according to the MDRD formula and 96.83 ± 32.74 mL/min/1.73 m^2 according to the CKD-EPI equation. A significant association was established between *e*GFR and microalbuminuria (P < 0.001), consistent with another study reporting a correlation (P = 0.0063) between these two parameters. However, we did not find a statistically significant association between *e*GFR and HbA1c, in contrast to other studies, such as Lee et al. (2013), which demonstrated a correlation between increased HbA1c levels and decreased eGFR (P = 0.0001) [26].

We found a significant correlation between microalbuminuria and HbA1c (P = 0.010), confirming the role of poor glycemic control in the development of microalbuminuria, as also demonstrated by Abdelwahid *et al.,* (2022), Kare *et al.,* (2021), and Diouf *et al.,* (2015). According to these studies, a 1% increase in HbA1c is associated with an increase of 39.7 mg/L in microalbuminuria [27,28]. Finally, the prevention of microalbuminuria in patients with type 2 diabetes relies on strict glycemic control (HbA1c < 7%) and effective management of hypertension, as recommended by studies including more than 25,000 patients [29].

CONCLUSION

Type 2 diabetes represents a major public health challenge due to its serious vascular complications. Measurement of glycated hemoglobin (HbA1c) remains the most reliable indicator for assessing glycemic control and preventing cardiovascular complications.

Microalbuminuria, a predictive marker of renal impairment and cardiovascular risk, was associated in our study with poor glycemic control, longer duration of diabetes, elevated systolic blood pressure, and decreased glomerular filtration rate. These findings highlight the importance of enhancing patient education, performing regular microalbuminuria assessments, maintaining strict glycemic control with quarterly HbA1c measurements, and addressing cardiovascular risk factors. Combined with lifestyle and dietary modifications, these measures aim to prevent or slow the progression of diabetic nephropathy. A nationwide study would help to generalize these conclusions to the broader population.

What is known about this subject?

- It is a public health problem

What's news about your study:

- Our findings support the routine combined assessment of HbA1c and microalbuminuria as affordable and practical biomarkers for the early detection of diabetic nephropathy and the prevention of microvascular complications in resource-limited healthcare settings.
- It provides valuable local epidemiological data on the prevalence of microalbuminuria among Malian patients with type 2 diabetes, filling an important evidence gap in sub-Saharan Africa.
- This study provides one of the first comprehensive evaluations from Mali demonstrating a significant association between glycated hemoglobin (HbA1c) and microalbuminuria among patients with type 2 diabetes, highlighting poor glycemic control as a marker of early diabetic kidney damage.

Conflicts of interest: The authors declare no conflicts of interest.

Author Contributions: All authors participated in the development of the study clinically than biologically, in the statistical analysis and in the writing.

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REFERENCES

1. International Diabetes Federetion. Diabetes around the world in 2021. IDF Diabetes Atlas, 10th edn. Brussels, Belgium: 2022.
2. Diop SN, Diédhou D. Diabetes Mellitus in Sub-Saharan Africa: Epidemiological and Socioeconomic Aspects. Médecine des Maladies Métaboliques. 2015; Vol. 9(2): 123–129.
3. Sy S, Samaké M, Sy D, Coulibaly M, Diallo D, Yattara H et al., Prevalence of Micro- and Macroalbuminuria in Type 2 Diabetic Patients at the Point G University Teaching Hospital in Bamako. Health Sci. Dis. 2020; Vol. 21(3): 61–64.
4. WHO. Global Report on Diabetes: Executive Summary, 2016.
5. Diabetes Magazine. Links between Glycated Hemoglobin and Cardiovascular Disease. 2019.

6. Goulle J-P, Lacroix C, Bouige D. Glycated Hemoglobin: A Marker of Choice in Forensic Toxicology. Annals of Analytical Toxicology. 2000; Vol. XII, No. 3.

7. French Federation of Diabetics. HbA1c or Glycated Hemoglobin. 2010.

8. Weir MR. Microalbuminuria in type 2 diabetics: an important, overlooked cardiovascular risk factor. J Clin Hypertens (Greenwich). 2004 Mar;6(3):134-41.

9. Kamissoko K-F. Therapeutic Aspects of Type 2 Diabetes in the Internal Medicine and Endocrinology Department of the Mali Hospital [Medical Thesis]. Bamako: FMPOS Library; 2017.

10. Diawara MS, Cissé MM, Kane Y, Koney AK, Faye M, Fall K et al., Chronic Kidney Disease in the Thiès Region: Epidemiological, Clinico-Paraclinical, Therapeutic and Evolutionary Aspects: About 86 Cases Collected from 2013 to 2017. Health Sci Dis. 2019; 20(6): 58–62.

11. Yazdkhasti M, Jafarabady K, Shafiee A, Omran SP, Mahmoodi Z, Esmaeilzadeh S et al., The association between age of menopause and type 2 diabetes: a systematic review and meta-analysis. Nutr Metab (Lond). 2024;21(1):87.

12. Drissa S, Doumbia N, Coulibaly M, Cissé S, Mangara S, Berthé B et al., Epidemiological and Clinical Aspects of Diabetes Mellitus at the Internal Medicine Unit of Fousseyni Daou Hospital in Kayes, Mali. SAS J Med. Nov 2021; 7(11): 603–609.

13. Diao A. Assessment of Glycemic Control by Glycated Hemoglobin in Type 2 Diabetic Patients Followed in the Diabetology Unit of the Reference Health Center of Commune I of Bamako District [Medical Thesis]. Bamako: FMOS Library; 2020.

14. Kahina H, Asma M. Value of Microalbuminuria Measurement in the Early Diagnosis of Diabetic Nephropathy [Biology Thesis]. People's Democratic Republic of Algeria; 2015.

15. Diop SN, Wade A, Lokrou A, Diédhiou D, Adoueni VK, et al., Management of type 2 diabetes in routine medical practice in sub-Saharan Africa: results of the AMAR-AFO study in Senegal and Côte d'Ivoire. Médecine des Maladies Métaboliques. 2013;7(4):363-367.

16. Ricordeau P, Weill A, Vallier N, Bourrel R, Fender P, Allemand H. Epidemiology of diabetes in metropolitan France. Diabetes Metab. 2000;26(Suppl 6):11-24.

17. French National Authority for Health (HAS). Pharmacological strategy for glycemic control in type 2 diabetes: excerpt from the scientific rationale. Chapter: Epidemiology and cost of type 2 diabetes in France. Saint-Denis: HAS; 2013.

18. Robert P, O'Connor S, Perron L, Dubé M, Trépanier PL, Leclerc J. Overview of diabetes in the Quebec population aged one year and over from 2001 to 2019. Quebec: National Institute of Public Health of Quebec (INSPQ); 2022. (Chronic Disease Surveillance; No. 39).

19. Mossi KE, Balaka A, Tchamdja T, Djagadou KA, Sama HD, Apeti S, et al., Prevalence of complications of diabetes mellitus at the medical-surgical clinic of Sylvanus Olympio University Hospital in Lomé. Revue Africaine de Médecine Interne. 2019; 6(1-3):42-48.

20. Dawson C. Type II Diabetes Mellitus self-management: relating diabetes distress, social support, self-efficacy, and performance of diabetes self-care activities. [For the Degree of Master of Science]. Colorado State University. Fort Collins ; Colorado Spring 2020.

21. Diouf NN, Lo G, Sow-Ndoye A, Djité M, Diégane JAT, Diatta A. Evaluation of microalbuminuria and lipid profile in patients with type 2 diabetes. Rev Med Brux. 2015;36:10-13.

22. Kundu D, Roy A, Mandal T, Bandyopadhyay U, Ghosh E, Ray D. Relation of microalbuminuria to glycosylated hemoglobin and duration of type 2 diabetes. Nigerian Journal of Clinical Practice. 2013; Vol 16 : 2.

23. Chowta NK, Pant P, Chowta MN. Microalbuminuria in diabetes mellitus: Association with age, sex, weight, and creatinine clearance. Indian J Nephrol. 2009; 19 (2) : 53-6.

24. Jatoi NA, Said AH, Al-Ghamdi MS, Al-Abdulmhsin MF, Bin-Jaban RA, Al-Tayeb JA et al., Prevalence of Microalbuminuria and Cardiovascular Risk Factors in Patients With Diabetes Mellitus Type-II in Al-Khobar, Kingdom of Saudi Arabia. Cureus. 2022 ; 14 (10) : e29808.

25. Diarra M. Value of microalbuminuria measurement in the early diagnosis of diabetic nephropathy in the diabetology department of Gabriel Touré University Hospital. [Medical thesis]. Bamako (Mali): Faculty of Medicine, Pharmacy and Odontology (FMPOS); 2009.

26. Lee CL, Li TC, Lin SY, Wang JS, Lee IT, Tseng LN et al., Dynamic and dual effects of glycated hemoglobin on estimated glomerular filtration rate in type 2 diabetic outpatients. Am J Nephrol. 2013; 38 (1) : 19-26.

27. Abdelwahid HA, Dahlan HM, Mojemamy GM, Darraj GH. Predictors of microalbuminuria and its relationship with glycemic control among Type 2 diabetic patients of Jazan Armed Forces Hospital, southwestern Saudi Arabia. BMC Endocr Disord. 2022 ; 22 (1) : 307.

28. Kare S, Reddy VN, Mahamkali T. A study to assess the correlation between HbA1c and microalbuminuria among diabetics. International Journal of Advances in Medicine. 2021; 8 (1) : 2349-3933.

29. Coca SG, Ismail-Beigi F, Haq N, Krumholz HM, Parikh CR. Role of intensive glucose +control in development of renal end points in type 2 diabetes mellitus : systematic review and meta-analysis intensive glucose control in type 2 diabetes. Arch Intern Med. 2012; 172 (10) : 761-9.