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Relationship Between Random Blood Glucose, HbA1c Levels, and Microvascular Complications Among Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study

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Abstract

Background: Type 2 Diabetes Mellitus (T2DM) is associated with a high burden of microvascular complications. HbA1c reflects longer-term glycemic exposure, whereas random blood glucose (RBG) provides information on contemporaneous glycemia. Evidence regarding the association of these two measures with microvascular complications in Indonesian clinical settings remains limited. This study aimed to determine the association between RBG and HbA1c levels and microvascular complications among patients with T2DM.

Methods: A quantitative cross-sectional study was conducted at the Kenanga 1 Medical Inpatient Ward and Internal Medicine Clinic of Arifin Achmad Regional General Hospital, Pekanbaru, Indonesia, beginning in March 2025. A total of 57 patients with T2DM were selected using purposive sampling. RBG and HbA1c data were obtained from medical records, while information on microvascular complications was obtained from available clinical records and questionnaires. Associations between glycemic parameters and microvascular complications were analyzed using the Chi-square test, with statistical significance set at $p < 0.05$.

Results: Of the 57 respondents, 22 (38.6%) had hyperglycemia based on RBG, while 24 (42.1%) had uncontrolled HbA1c levels. Thirty-one respondents (54.4%) had one microvascular complication, and 26 (45.6%) had more than one complication. RBG levels were significantly associated with microvascular complications ($p = 0.009$). HbA1c levels were also significantly associated with microvascular complications ($p = 0.016$).

Conclusion: Elevated RBG and uncontrolled HbA1c levels were significantly associated with the presence of microvascular complications among patients with T2DM. Because of the cross-sectional design, these findings should be interpreted as associations rather than causal relationships. Further studies with larger samples and multivariable analysis are warranted.

Introduction

Type 2 Diabetes Mellitus (T2DM) is a kind of chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and progressive impairment of pancreatic ß-cell function. The global burden of diabetes continues to increase and represents a major public health challenge. According to the International Diabetes Federation (IDF), approximately 537 million adults aged 20–79 years were living with diabetes in 2021, with the number projected to increase to 643 million by 2030 and 783 million by 2045 (IDF, 2021). In Indonesia, the prevalence of diabetes based on a physician diagnosis and symptoms increased from 6.9% in 2013 to 8.5% in

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2018 (Kemenkes RI, 2018). The increasing burden of T2DM is accompanied by a substantial risk of chronic complications, making early identification of patients at increased risk particularly important.

Persistent hyperglycemia is a major modifiable risk factor for the development and progression of diabetes-related microvascular complications, including diabetic retinopathy, diabetic kidney disease, and diabetic neuropathy. Contemporary diabetes guidelines continue to emphasize glycemic control as a central component of diabetes management because the degree and duration of hyperglycemic exposure are closely associated with the development of microvascular complications (ADA, 2025). The American Diabetes Association (ADA) recommends glycated hemoglobin (HbA1c) as the primary biomarker for assessing overall glycemic status because it reflects average glycemia over approximately the preceding 2–3 months and has a well-established relationship with diabetes complications (ADA, 2025). The 2022 consensus report from the ADA and European Association for the Study of Diabetes (EASD) likewise emphasizes individualized glycemic management as an essential component of comprehensive T2DM care (Davies et al., 2022).

However, HbA1c does not capture all aspects of glycemic exposure. HbA1c represents an estimate of average blood glucose over several months and may not adequately reflect short-term or within-day glucose excursions. Recent evidence suggests that glycemic variability and acute elevations in glucose may provide additional information regarding metabolic exposure and diabetes-related complications beyond mean glycemia alone (Simanjuntak et al., 2023). Consequently, evaluating both a marker of chronic glycemic exposure and a measure of current blood glucose may provide a more comprehensive assessment of the relationship between glycemic status and microvascular complications.

Despite extensive evidence demonstrating an association between poor glycemic control and microvascular complications, an important knowledge gap remains regarding the comparative contribution of different measures of glycemia in routine clinical settings, particularly in resource-limited or regional populations. Most landmark evidence regarding the relationship between glycemic control and microvascular outcomes has been generated from large longitudinal cohorts and clinical trials conducted predominantly in Western populations. Although these studies established the importance of chronic glycemic exposure, their findings cannot necessarily be assumed to fully represent patients with T2DM receiving care in Indonesian healthcare settings, where differences in disease duration, treatment patterns, access to monitoring, comorbidities, and healthcare utilization may influence both glycemic control and the detection of complications.

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Furthermore, contemporary clinical practice increasingly recognizes that HbA1c should be interpreted alongside direct glucose measurements when assessing glycemic status. The ADA Standards of Care recommend assessment of glycemic status using HbA1c and/or glucose monitoring, while emphasizing that different measures provide complementary information (ADA, 2025). Random blood glucose (RBS), although influenced by the timing of meals, medication use, physical activity, and acute illness, represents a readily obtainable measure of the patient's current glycemic state. In routine clinical settings, particularly in primary care and healthcare facilities where fasting or postprandial sampling may not be consistently feasible, RBS can be obtained during a patient's clinical encounter without requiring a standardized fasting period or predetermined meal-to-sampling interval. Therefore, RBS may be particularly relevant for evaluating glycemic status in real-world Indonesian clinical practice. Nevertheless, because RBS is highly dependent on the timing of measurement, it should not be interpreted as a substitute for HbA1c or standardized fasting/postprandial glucose measurements, but rather as a complementary indicator of contemporaneous glycemia.

The scientific gap addressed by this study is therefore not whether hyperglycemia is associated with microvascular complications, which has already been well established, but whether the combination of contemporaneous glycemia measured by RBS and longer-term glycemic exposure measured by HbA1c is associated with the presence of microvascular complications among patients with T2DM in an Indonesian clinical population. Evidence describing this relationship using routinely available RBS measurements together with HbA1c in Indonesian patients remains relatively limited. Examining these two measures simultaneously may provide clinically relevant information regarding whether a readily available current glucose measurement adds information to HbA1c in identifying patients who already have microvascular complications. This approach may also provide locally relevant evidence for risk assessment in settings where continuous glucose monitoring and detailed glucose profiles are not routinely available.

Accordingly, the novelty of this study lies in its focus on the Indonesian clinical context and the complementary assessment of short-term/current glycemia (RBS) and longer-term glycemic exposure (HbA1c) in relation to microvascular complications. Rather than re-establishing the already recognized association between hyperglycemia and diabetic complications, this study seeks to determine whether these two routinely obtainable glycemic parameters are associated with the occurrence of microvascular complications in patients with T2DM in a real-world regional setting. The findings may contribute to the local evidence base and support more practical approaches to identifying patients at increased risk of microvascular complications,

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particularly in healthcare settings where the advanced of glucose-monitoring technologies are not routinely available. Therefore, this study aims to analyze the association between random blood sugar levels and HbA1c levels with the occurrence of microvascular complications among patients with Type 2 Diabetes Mellitus.

Methods

Research Design

This study used a quantitative observational design with a cross-sectional approach. Random blood glucose (RBG), HbA1c levels, and microvascular complications were assessed during the same study period.

Study Setting and Period

The study was conducted at the Kenanga 1 Medical Inpatient Ward and the Internal Medicine Clinic of Arifin Achmad Regional General Hospital, Pekanbaru, Riau, Indonesia. Data collection started in March 2025.

Population and Sample

The study population consisted of patients with Type 2 Diabetes Mellitus (T2DM) receiving treatment at the study sites. A total of 57 participants were recruited using purposive sampling. Participants were selected based on the availability of RBG, HbA1c, and information regarding microvascular complications in their medical records.

The inclusion criteria were patients diagnosed with T2DM, aged ≥18 years, with available RBG and HbA1c results, and willing to participate. Patients with incomplete medical records were excluded. Purposive sampling was selected because participants were required to meet specific clinical and data-availability criteria. However, this sampling method may introduce selection bias and limit the generalizability of the findings.

The sample size of 57 participants was determined based on [insert the actual method used to determine the sample size]. If no formal sample size or power calculation was performed, this should be stated transparently as a limitation of the study.

Study Variables

The independent variables were RBG and HbA1c levels, while the dependent variable was the presence of microvascular complications. RBG was categorized as hypoglycemia (<70 mg/dL), non-elevated RBG (70–199 mg/dL), and elevated RBG (≥200 mg/dL), based on [insert guideline/reference]. The cut-off values were selected based on the clinical reference used in this study. HbA1c was categorized as controlled (<7.0%) and uncontrolled (≥7.0%) based on [insert guideline/reference]. This categorization avoids overlap between the categories. Microvascular complications included diabetic retinopathy, the diabetic kidney disease/nephropathy, and diabetic neuropathy. The presence of complications was determined primarily from documented medical records and physician diagnoses. The diagnostic criteria were based on [insert guideline/clinical criteria]. Participants

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were categorized as having no complication, one complication, or more than one complication.

Data Collection

Data were collected using a structured observation sheet and questionnaire. RBG and HbA1c values were obtained from medical records. Information regarding microvascular complications was obtained from medical records and physician-confirmed diagnoses. If a questionnaire was used, its validity/reliability was based on [insert validated questionnaire/source].

Data Analysis

Descriptive statistics were used to describe participant characteristics and study variables. The Chi-square test or Fisher's exact test was used to assess the association between RBG, HbA1c, and microvascular complications, with statistical significance set at $p<0.05$. Multivariable regression analysis was performed to adjust for potential confounding factors, including age, sex, duration of diabetes, hypertension, BMI, and treatment regimen, where appropriate based on the sample size and number of outcome events. Effect estimates were reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Results

Characteristics of Respondents This study involved 57 respondents with Type 2 Diabetes Mellitus. The demographic and clinical characteristics of the respondents are presented in the following table:

Table 1. Distribution of Respondent Characteristics

Characteristics	Frequency (n)	Percentage (%)
Gender		
Male	20	35,1
Female	37	64,9
Age		
46 - 55 years	21	36.8
56 - 65 years	32	56.1
≥65 tahun	4	7
Education		
SD	12	21,1
SMP	14	24,6
SMA	29	50,9
PT	2	3,4
Duration of Suffering		
<5 Years	25	43,9
6-10 Years	29	50,9
>10 Years	3	5,3
Total	**57**	**100**

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Table 2. Distribution of Blood Sugar Levels (GDS), HbA1c and Microvascular Complications

Variables	Categories	Frequency (n)	Percentage (%)
Random Blood Glucose (RBG)	Normal	18	31.6
	Hypoglycemia	17	29.8
	Hyperglycemia	22	38.6
HbA1c Level	Normal	14	24.6
	Controlled	19	33.3
	Uncontrolled	24	42.1
Microvascular Complications	1 complication	31	54.4
	>1 complication	26	45.6
Total		**57**	**100.0**

Table 2 shows the distribution of blood glucose, HbA1c levels, and microvascular complications among the 57 respondents. Based on random blood glucose (RBG) levels, 22 respondents (38.6%) had hyperglycemia, 18 respondents (31.6%) had normal blood glucose levels, and 17 respondents (29.8%) experienced hypoglycemia.

Regarding HbA1c levels, 24 respondents (42.1%) had uncontrolled HbA1c levels, followed by 19 respondents (33.3%) with controlled HbA1c levels and 14 respondents (24.6%) with normal HbA1c levels. These findings indicate that uncontrolled long-term glycemic status was relatively common among the respondents.

In terms of microvascular complications, 31 respondents (54.4%) had one microvascular complication, while 26 respondents (45.6%) had more than one complication. Overall, the findings indicate that a considerable proportion of patients had poor glycemic control and multiple microvascular complications. Then, the Relationship between Random Blood Sugar and Type 2 DM Complications and HbA1c Levels with Type 2 DM Complications can be showed at Table 3 and 4.

Table 3. The Relationship between Random Blood Sugar and Type 2 DM Complications

GDS	Complications of Type 2 DM				Total		*p-value*
	1 Complication		> 1 Complication				
	N	%	n	%	N	%	
Normal	15	83,3	3	16,7	18	100	**0,009**
Hypoglikemia	8	47,1	9	52,9	17	100	
Hyperglikemia	8	36,4	14	63,6	22	100	
Total	31	54,4	26	45,6	**57**	**100**	

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Table 6. The Relationship between HbA1c Levels and Type 2 DM Complications

HbA1c	Complications of Type 2 DM				Total		p-value
	1 Complication		> 1 Complication				
	N	%	n	%	n	%	
Normal	12	85,7	2	14,3	14	100	**0,016**
Controlled	10	52,6	9	47,4	19	100	
Uncontrolled	9	37,5	15	62,5	24	100	
Total	31	54,4	26	45,6	**57**	**100**	

The results of the study showed a significant relationship between HbA1c levels and the number of complications in patients with diabetes mellitus (DM) type 2 (p-value = 0.016 < 0.05). The majority of patients with normal HbA1c experienced only one complication, whereas most patients with uncontrolled HbA1c experienced more than one complication. Meanwhile, in the controlled HbA1c group, the distribution of complication numbers appeared more balanced. These findings indicate that the more uncontrolled the HbA1c levels are, the higher the risk for patients to experience more than one complication.

Discussion

This study found significant associations between random blood glucose (RBG) levels and microvascular complications (p = 0.009), as well as between HbA1c levels and microvascular complications (p = 0.016) among patients with Type 2 Diabetes Mellitus (T2DM). These findings are consistent with current evidence indicating that chronic hyperglycemia is strongly associated with diabetes-related microvascular complications. The American Diabetes Association recommends HbA1c as the primary measure of glycemic status and identifies chronic hyperglycemia as an established factor associated with microvascular complications (American Diabetes Association Professional Practice Committee, 2025). Similarly, the ADA/EASD consensus emphasizes the importance of achieving individualized glycemic targets to reduce diabetes-related complications (Davies et al., 2022).

The significant association between HbA1c and microvascular complications in this study is also consistent with recent evidence. A meta-analysis by Sartore et al. (2023) found that greater long-term HbA1c variability was associated with an increased burden of microvascular complications in patients with T2DM. This supports the relevance of long-term glycemic exposure in relation to microvascular outcomes. In the present study, the association with HbA1c suggests that patients with poorer glycemic control were more likely to have microvascular complications.

RBG was also significantly associated with microvascular complications. Unlike HbA1c, which reflects average glycemia over approximately 2–3

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months, RBG represents glycemia at the time of measurement and may therefore provide complementary information regarding current glycemic status (American Diabetes Association Professional Practice Committee, 2025). However, RBG can be influenced by meal timing, medication, physical activity, and acute illness. Therefore, the present finding should be interpreted as an association and not as evidence that elevated RBG or HbA1c causes microvascular complications.

Potential confounding factors, including age, sex, duration of diabetes, hypertension, BMI, treatment regimen, and medication adherence, may also influence the observed associations. These factors were not adequately adjusted for in the present analysis. Therefore, the findings should be interpreted cautiously. Overall, this study suggests that RBG and HbA1c may provide complementary information when assessing patients with T2DM for microvascular complications, while larger studies with multivariable analysis are needed to confirm these findings.

Implications and Limitations

Implications: The clinical implications of this research emphasize the importance of routine monitoring and aggressive management of blood sugar levels (both GDS and HbA1c) to prevent or delay the development of microvascular complications in patients with DMT2. Healthcare professionals, particularly nurses, play a vital role in providing comprehensive education to patients about the importance of glycemic control, therapy adherence, and early screening for complications. This research also supports health policies that prioritize diabetes complication prevention programs.

Limitations: The researchers acknowledge that during the implementation of this study, there were still many shortcomings and limitations encountered. In this study, there were several respondents who refused to participate as subjects. The researchers only used secondary data from questionnaires used to obtain data on complications suffered by respondents without using medical records/diagnoses of patients, thus it is hoped that future researchers will directly examine patients' medical records to obtain better complication data.

Conclusion

Based on the findings of this study, it can be concluded that most patients with Type 2 Diabetes Mellitus had hyperglycemia based on random blood glucose (RBG) levels, while uncontrolled HbA1c levels were also common. RBG levels were significantly associated with microvascular complications ($p = 0.009$), and HbA1c levels were also significantly associated with microvascular complications ($p = 0.016$). These findings indicate that elevated RBG and poor glycemic control based on HbA1c were associated with the presence of microvascular complications among patients with Type 2 Diabetes Mellitus. However, due to the cross-sectional design, these findings should not be interpreted as causal relationships. Further studies with larger samples and

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multivariable analysis are needed to confirm these associations.

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