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The Relationship between HbA1c Levels and Random Blood Glucose in Patients with Type 2 Diabetes Mellitus

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Abstract

Diabetes mellitus is a chronic metabolic disease characterized by hyperglycemia resulting from impaired insulin secretion, insulin action, or both. Assessment of glycemic control is essential in the management of diabetes mellitus, and two commonly used laboratory parameters are Hemoglobin A1c (HbA1c), which reflects the average blood glucose level over the previous 2–3 months, and random blood glucose (RBG), which represents the blood glucose level at the time of examination. This study aimed to determine the relationship between HbA1c levels and RBG levels in patients with hyperglycemia. An observational analytic study with a cross-sectional design was conducted using medical record data from August 2025, including patients aged ≥18 years who had complete HbA1c and RBG examination results. Data analysis was performed using the Spearman rho correlation test. The results showed that HbA1c levels ranged from 5.75% to 14.0%, while RBG levels ranged from 50 to 357 mg/dL. The correlation analysis demonstrated a strong positive relationship between RBG and HbA1c levels, with a correlation coefficient of r = 0.87. In conclusion, there is a strong relationship between random blood glucose and HbA1c levels in patients with hyperglycemia, indicating that RBG is associated with long-term glycemic control, although HbA1c remains the primary parameter, and patient adherence to dietary management, healthy lifestyle, and regular monitoring plays an important role in achieving optimal glycemic control.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disease characterized by hyperglycemia resulting from insulin resistance and impaired insulin secretion (American Diabetes Association [ADA], 2025). T2DM has become a global health problem due to its continuously increasing prevalence over the years (International Diabetes Federation [IDF], 2021). The International Diabetes Federation reported that in 2021 there were 537 million adults worldwide living with diabetes, of whom approximately 90–95% had T2DM (IDF, 2021). Poorly controlled hyperglycemia in patients with T2DM can lead to microvascular and macrovascular complications, including nephropathy, neuropathy, and cardiovascular disease (World Health Organization [WHO], 2016).

Routine monitoring of blood glucose levels is an essential component of T2DM management to reduce the risk of long-term complications (ADA, 2025). One of the parameters used to assess long-term glycemic control is glycated hemoglobin (HbA1c) (Nathan et al., 2008). HbA1c reflects the average blood glucose level over the previous 8–12 weeks, as it is formed through a non-enzymatic glycation process between glucose and hemoglobin (Nathan et al., 2008). The American Diabetes Association defines an HbA1c level of ≥ 6.5%

as a diagnostic criterion for diabetes and recommends its use in evaluating the effectiveness of therapy in patients with T2DM (ADA, 2025).

In addition to HbA1c, random blood glucose (RBG) testing is a commonly used method in clinical practice because it is simple, rapid, and does not require specific preparation related to meal timing (WHO, 2016). RBG testing provides a snapshot of blood glucose levels at a particular time point and is frequently used in primary healthcare settings for initial assessment as well as routine monitoring (Powers et al., 2020). However, random blood glucose levels reflect only short-term glycemic status and can be influenced by various factors such as dietary intake, physical activity, and stress (Powers et al., 2020).

Several studies have demonstrated a relationship between HbA1c levels and random blood glucose levels in patients with T2DM. Descriptive studies have reported a significant positive linear correlation between HbA1c and random blood glucose, indicating that higher random blood glucose levels are associated with increased HbA1c values (Saxena et al., 2014; Ansari et al., 2023). Other studies have also shown a positive correlation between HbA1c and random blood glucose, although the strength of this correlation varies when compared with other glucose parameters such as fasting or postprandial blood glucose (Ansari et al., 2023). Understanding the relationship between HbA1c and random blood glucose is important in clinical practice, particularly in healthcare settings where routine HbA1c testing is not readily available. Knowledge of this relationship may assist healthcare providers in better evaluating patients' glycemic control and making appropriate clinical decisions.

METHOD

This study employed an observational analytic cross-sectional design conducted in August 2025 at a Type C hospital in Sidoarjo, Indonesia. The study population consisted of all patients diagnosed with Type 2 Diabetes Mellitus (T2DM) who underwent laboratory examinations during the study period. A total sampling technique was applied, including all patients who met the eligibility criteria. Patients aged ≥18 years with complete laboratory results for glycated hemoglobin (HbA1c) and random blood glucose (RBG) obtained within the same examination period were included in the study. Patients with conditions that could affect HbA1c levels, such as severe anemia, acute bleeding, pregnancy, or incomplete medical records, were excluded.

The independent variable in this study was random blood glucose level (mg/dL), while the dependent variable was HbA1c level (%). Random blood glucose was measured using serum samples obtained from venous blood and analyzed by the enzymatic GOD-PAP method according to standard laboratory procedures. HbA1c was measured using whole blood samples collected in EDTA tubes and analyzed using the immunoturbidimetric method, which reflects average blood glucose levels over the previous 2–3 months. All laboratory examinations were conducted in accordance with standard operating procedures to ensure data validity and accuracy. Random blood glucose levels were categorized as normal (<140 mg/dL) and elevated (≥140 mg/dL), while HbA1c levels were categorized as normal (<6%) and elevated (≥6%) based on clinical standards.

Data analysis was performed at the final stage of the study. Descriptive statistics were used to summarize HbA1c and random blood glucose levels. The relationship between HbA1c and random blood glucose was analyzed using the Spearman rho correlation test. If the data met the assumptions of normality, an appropriate parametric correlation test was applied. Statistical analysis was conducted using SPSS version 26, with a significance level of $p < 0.05$.

RESULTS AND DISCUSSION

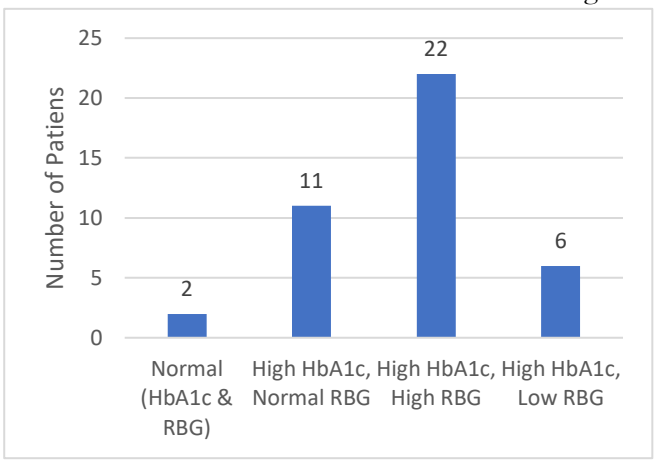
The distribution of HbA1c and random blood glucose (RBG) levels among patients with Type 2 Diabetes Mellitus (T2DM) reflects substantial variability in both short-term and long-term glycemic control. The predominance of patients with elevated HbA1c (≥6%) accompanied by increased RBG (>140 mg/dL) indicates persistent hyperglycemia, which is pathophysiologically associated with insulin resistance and progressive β-cell dysfunction. These metabolic abnormalities represent the fundamental mechanisms underlying T2DM and have been consistently documented across diverse populations (American Diabetes Association [ADA], 2025; Selvin et al., 2011).

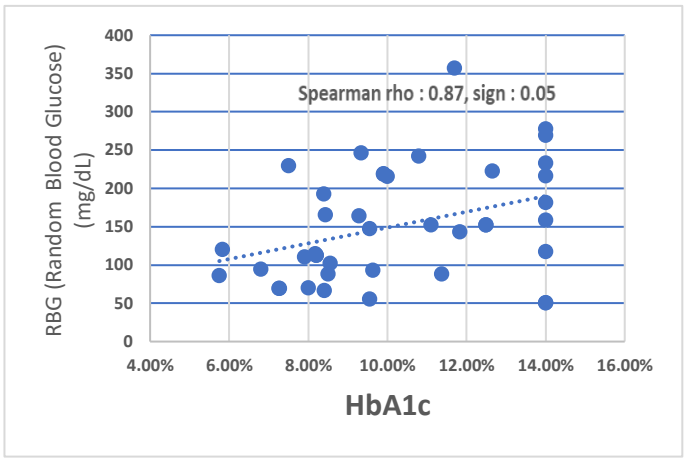
Elevated HbA1c levels carry significant clinical implications due to their strong association with chronic complications of diabetes. The UK Prospective Diabetes Study (UKPDS) demonstrated that each 1% increase in HbA1c is associated with a 37% higher risk of microvascular complications and a 14% increased risk of myocardial infarction (Stratton et al., 2000). Accordingly, patients presenting with HbA1c values exceeding

8% in this study may be considered at heightened risk for long-term vascular complications, particularly when elevated HbA1c is accompanied by high RBG values.

The presence of patients with elevated HbA1c but normal RBG highlights the limitations of relying on random blood glucose measurements as a sole indicator of glycemic control. HbA1c reflects average plasma glucose concentrations over the preceding 8–12 weeks, whereas RBG represents glycemic status at a single point in time and is influenced by recent food intake, physical activity, stress, and medication timing (Nathan et al., 2008). Rohlfing et al. (2002) reported a linear relationship between HbA1c and mean blood glucose; however, substantial intra-day glucose variability may occur without proportionally altering HbA1c values. This phenomenon explains the discordance observed between HbA1c and RBG in certain patients.

Conversely, the identification of patients with elevated HbA1c and low RBG (<70 mg/dL) suggests the occurrence of hypoglycemic episodes within a background of chronic hyperglycemia. Such patterns are commonly observed in patients receiving intensive insulin therapy or combination antidiabetic regimens. Evidence from the Advance trial indicates that severe hypoglycemia is independently associated with increased risks of cardiovascular events and mortality in individuals with T2DM (Zoungas et al., 2010). Therefore, marked fluctuations in blood glucose levels may indicate suboptimal therapeutic balance and warrant careful reassessment of treatment strategies.





The correlation analysis revealed a strong positive association between HbA1c and RBG (rho = 0.87), indicating that higher random blood glucose levels tend to coincide with increased HbA1c values. This finding aligns with previous studies reporting significant correlations between HbA1c and random glucose measurements, although the strength of correlation varies across studies. Saxena et al. (2014) and Sherwani et al. (2016) observed that HbA1c correlates more strongly with fasting and postprandial glucose levels than with random glucose; nevertheless, RBG remains a clinically useful parameter, particularly in settings where access to HbA1c testing is limited.

Variability in the strength of correlation between HbA1c and RBG may be attributed to daily glycemic fluctuations. Monnier et al. (2006) demonstrated that acute glucose excursions contribute more significantly to oxidative stress than sustained chronic hyperglycemia. This finding underscores the importance of assessing both long-term glycemic exposure and short-term glucose variability, as both contribute to the pathogenesis of diabetic complications.

From a clinical perspective, the combined use of HbA1c and RBG provides complementary information for the evaluation of glycemic control in patients with T2DM. HbA1c serves as a robust indicator of long-term glycemic exposure and risk of complications, while RBG facilitates the detection of acute hyperglycemia or hypoglycemia requiring immediate intervention. This integrative approach aligns with international clinical guidelines advocating multimodal glycemic assessment to optimize diabetes management and improve patient outcomes (ADA, 2025; World Health Organization [WHO], 2016).

CONCLUSION

Based on the results of this study, a very strong and statistically significant positive relationship was observed between HbA1c levels and random blood glucose in patients with Type 2 Diabetes Mellitus, indicating that higher HbA1c values tend to be accompanied by increased random blood glucose levels.

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