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THE RELATIONSHIP BETWEEN GLYCEMIC CONTROL AND THE TRIGLYCERIDE-TO-HDL RATIO AS A PREDICTOR OF CARDIOMETABOLIC RISK IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Atherogenic dyslipidemia is one of the major risk factors for cardiometabolic complications in patients with type 2 diabetes mellitus (T2DM). The triglyceride-to-high-density lipoprotein cholesterol (TG/HDL) ratio is commonly used as an indicator of cardiometabolic risk. However, the association between the degree of glycemic control and the TG/HDL ratio remains inconsistent. To determine the association between the degree of glycemic control (HbA1c) and the TG/HDL ratio as a predictor of cardiometabolic risk in patients with T2DM. This cross-sectional study included 84 T2DM patients attending the internal medicine outpatient clinic at a hospital. Data were analyzed using Chi-square test, Spearman correlation, logistic regression, and Kruskal–Wallis test. There was no significant association between glycemic control categories and the TG/HDL ratio (p=0.702). Logistic regression analysis also revealed no significant result (p=0.703). The Spearman correlation between HbA1c and the TG/HDL ratio was not statistically significant (r = -0.062; p = 0.574). The Kruskal–Wallis test yielded a p-value of 0.890. No significant association was found between the degree of glycemic control and the TG/HDL ratio as a predictor of cardiometabolic risk in patients with T2DM. Further studies with better control of confounding variables and larger sample sizes are warranted.

Keywords: Type 2 Diabetes Mellitus, Glycemic Control, Hba1c, TG/HDL Ratio, Cardiometabolic Risk, Atherogenic Dyslipidemia.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic disease characterized by hyperglycemia and insulin resistance. According to the International Diabetes Federation (IDF) (2021), the prevalence of T2DM continues to rise, with cardiovascular complications being the leading cause of morbidity and mortality among diabetic patients, making it a major public health concern. According to the 2018 Basic Health Research (Riskesdas), the prevalence of diabetes in Indonesia was 10.9%. However, the 2018 Riskesdas findings increased to 11.7% in the 2023 Indonesian Health Survey (SKI).

T2DM is known to be a major risk factor for macrovascular complications, particularly cardiovascular diseases such as coronary artery disease and stroke, which remain the leading causes of death among diabetes sufferers. T2DM patients commonly experience

hyperglycemia and lipid metabolism abnormalities or dyslipidemia, which contribute to worsening cardiometabolic risk (Yudha et al., 2021; Anggraini et al., 2025). Atherogenic dyslipidemia, observed in T2DM patients, is characterized by elevated triglyceride (TG) levels and reduced high-density lipoprotein (HDL) cholesterol levels. The TG/HDL ratio is now recognized as an important marker for assessing cardiometabolic risk as it reflects the underlying metabolic conditions driving atherogenesis (Lumbantobing et al., 2021).

Dyslipidemia, marked by high triglyceride (TG) levels and low high-density lipoprotein (HDL) levels, is common in T2DM populations. The TG/HDL ratio has been identified as an important indicator for assessing cardiometabolic risk. Several studies, particularly in Asian populations, which tend to have an atherogenic lipid profile despite normal LDL levels, have found that the TG/HDL ratio strongly correlates as a predictor of metabolic syndrome and cardiovascular disease (Rusdiana et al., 2020).

Blood glucose control, assessed through glycated hemoglobin (HbA1c) levels, plays a crucial role in managing T2DM. However, the relationship between the degree of blood glucose control and the TG/HDL ratio is not yet fully understood. Therefore, it is important to explore whether there is a connection between glycemic control (based on HbA1c) and the TG/HDL ratio as a predictor of cardiometabolic risk. This ratio reflects the lipid metabolism imbalance often underlying insulin resistance, which is the central pathophysiology of T2DM. Although poor glycemic control, as assessed by HbA1c levels, has long been recognized as an independent predictor of microvascular and macrovascular complications, the specific relationship between the degree of blood glucose control (HbA1c) and the TG/HDL ratio as a marker of cardiometabolic risk still requires further exploration. Recent studies have emphasized that the TG/HDL ratio is strongly correlated with insulin resistance and the risk of cardiometabolic disease (Gedikli et al., 2022; De Almeida-Pitotto et al., 2024). Specifically, this ratio tends to increase as glycemic control worsens, as reflected in the rise in HbA1c levels (Gedikli et al., 2022). Recent studies suggest that poor glycemic control (HbA1c >7%) correlates with an increase in the TG/HDL ratio, worsening the risk of metabolic syndrome (Chen et al., 2022).

While the triglyceride to HDL ratio can serve as a simple yet powerful indicator for predicting insulin resistance and cardiovascular disease risk in both the general population and T2DM patients, research in Indonesia remains limited. Moreover, the specific relationship between the degree of blood glucose control (HbA1c) and the TG/HDL ratio in T2DM patients in Indonesia needs further investigation, considering the unique genetic variation and dietary patterns in this population. This study aims to analyze the relationship between the degree of blood glucose control (HbA1c) and the TG/HDL ratio in patients with Type 2 Diabetes Mellitus.

LITERATURE REVIEW

Diabetes Mellitus is a disease caused by a hormonal disorder that prevents the body's cells from absorbing glucose from the blood. This disease occurs when there is insufficient insulin in the blood or when the body's cells cannot react normally to the insulin in the blood.

Diabetes Mellitus is usually characterized by elevated blood glucose levels, or blood sugar levels that exceed normal levels and tend to be high (>200 mg/dL), known as hyperglycemia (Suryati, 2021).

This type of diabetes occurs due to a progressive disruption in insulin secretion, leading to insulin resistance. In this case, insulin is present in sufficient quantities but cannot function optimally, causing blood sugar levels to rise. Type II diabetes usually occurs in adults and the elderly due to unhealthy lifestyle factors, such as lack of exercise and being overweight. An unhealthy lifestyle causes the body's cells to become resistant or less sensitive to the hormone insulin. This condition, also known as insulin resistance, results in the body's cells being unable to process blood glucose into energy, resulting in glucose accumulation in the blood. In terms of gender, women are more at risk because physically, women have a higher chance of increasing their BMI (Body Mass Index) (Permadi, 2025).

Diabetes mellitus occurs due to progressive abnormalities in insulin secretion and insulin resistance. In patients with type II diabetes mellitus (NIDDM), the disease has a strong, familiar pattern. Type II diabetes is characterized by abnormalities in both insulin secretion and insulin action. Initially, there appears to be resistance in target cells to insulin action. Insulin initially binds to specific cell surface receptors, then an intracellular reaction occurs that increases glucose transport across the cell membrane (Setyawati, 2024).

RESAERCH METHOD

This study is an observational analytical study with a cross-sectional research design aimed at evaluating the relationship between the degree of blood glucose control and the triglyceride to HDL ratio as an indicator of cardiometabolic risk in patients with Type 2 Diabetes Mellitus (T2DM). The population in this study includes all patients diagnosed with T2DM who undergo examination and follow-up at the internal medicine clinic of Hospital "X". The sample was selected using consecutive sampling, with inclusion criteria being patients aged 18 years or older with a diagnosis of T2DM, who regularly undergo control for at least 6 months, and have undergone laboratory tests for HbA1c, triglycerides (TG), and HDL cholesterol. Exclusion criteria included patients with advanced-stage chronic kidney disease, anemia, pregnant or breastfeeding women, and patients with incomplete laboratory data.

The independent variable in this study is the degree of blood glucose control, which is measured using glycated hemoglobin (HbA1c) levels, categorized into good (HbA1c <7%), moderate (7-9%), and poor (>9%) according to ADA recommendations (2021). Meanwhile, the dependent variable is the triglyceride to HDL ratio (TG/HDL), which is the ratio of triglyceride levels to HDL levels in mg/dL, divided into two categories: poor category with a ratio ≥2.5, considered as increased cardiometabolic risk (high risk), and good category with a ratio <2.5 mg/dL (low risk). Data were obtained from medical records and laboratory results, which were then recorded in a structured form. The examination was conducted after patients fasted for at least 8 hours. Laboratory tests for HbA1c and levels of triglycerides and HDL were performed at the hospital laboratory using enzymatic methods and standardized and accredited

procedures, ensuring valid and reliable results.

Data analysis was performed using SPSS version 22.0 statistical software. Data normality was assessed using the Kolmogorov-Smirnov test. Chi-Square tests were used to evaluate the relationship between HbA1c control categories and TG/HDL ratio categories. Spearman's correlation test was used to assess the relationship between HbA1c values and TG/HDL ratios numerically. Furthermore, the Kruskal-Wallis test was employed to observe differences in TG/HDL ratio values across HbA1c categories, and binary logistic regression analysis was used to examine the effect of blood glucose control on the likelihood of an increased TG/HDL ratio risk. The significance level used in all statistical analyses was $p<0.05$.

This study refers to similar designs and approaches used by Gedikli et al. (2022), whose research showed a significant positive relationship between HbA1c levels and the TG/HDL ratio, with the ratio increasing in patients with poor glycemic control.

RESEARCH RESULT

This study involved a total of 84 patients diagnosed with Type 2 Diabetes Mellitus who underwent examinations at the internal medicine clinic. Based on gender characteristics, the majority of the subjects were female (58 respondents, 69%), while 26 respondents (31%) were male. The average age was 57.13 ± 8.6 years, with the youngest being 26 years old and the oldest being 81 years old. The HbA1c values in the patients showed a wide range, with an average value of 8.72 ± 2.41%, although the values were fairly evenly distributed. Meanwhile, the triglyceride to HDL ratio was found to be on average 6.03 ± 3.18 mg/dL.

Table 1. Demographic Characteristics

Parameter	Results
Gender	
Woman	58 (69%)
Man	26 (31%)
Age (years)	57.13 ± 8.62
HbA1C (%)	8.72 ± 2.41
HDL/TG ratio	6.03 ± 3.18

Based on the blood glucose control categories determined through HbA1c levels, as shown in Table 2, it was found that out of the total 84 patients, 26 patients (31%) had good blood glucose control with HbA1c levels < 7%. A total of 21 patients (25%) were classified in the moderate control category with HbA1c levels between 7–9%. Meanwhile, the majority of patients, 37 individuals (44%), fell into the poor control category with HbA1c levels > 9%. These findings suggest that the majority of Type 2 Diabetes Mellitus patients in this study have suboptimal blood glucose control, which may increase the risk of cardiometabolic complications.

Table 2. HbA1c Categories

	< 7% (Good)	7-9% (Medium)	>9% (Poor)
HbA1C	26 (31%)	21 (25%)	37 (44%)

Based on Table 3, the results of the grouping of the triglyceride to HDL ratio (TG/HDL-C) indicate that the majority of patients have a high cardiometabolic risk. A total of 76 patients (90.5%) were found to have a TG/HDL ratio ≥ 2.5, which is categorized as high risk for cardiometabolic complications. Meanwhile, only 8 patients (9.5%) had a TG/HDL ratio < 2.5, placing them in the low-risk category. These findings suggest that the majority of Type 2 Diabetes Mellitus patients in this study are in a state of atherogenic dyslipidemia, which can increase the risk of cardiovascular disorders in the future.

Table 3. TG/HDL-C Ratio Categories

	Ratio ≥2.5 (High Risk)	Ratio < 2.5 (Risk Low)
TG/HDL-C ratio	76 (90.5%)	8 (9.5%)

The results of the study show that there is no statistically significant relationship between the degree of blood glucose control and the triglyceride to HDL ratio as a predictor of cardiometabolic risk in Type 2 Diabetes Mellitus patients. The statistical test results are shown in Table 4. The Chi-Square test revealed a p-value of 0.702, indicating that there is no significant relationship between the blood glucose control categories and the TG/HDL ratio categories. Furthermore, the binary logistic regression test showed a p-value of 0.703, suggesting that the HbA1c category does not significantly affect the risk of an increased TG/HDL ratio (≥2.5).

The Spearman correlation test between HbA1c values and the TG/HDL ratio produced a p-value of 0.574, indicating no significant relationship between these two numerical variables. Meanwhile, the Kruskal-Wallis test, used to assess differences in the TG/HDL ratio across the three HbA1c categories (good, moderate, poor), also yielded an insignificant result with a p-value of 0.890.

Table 4. Statistical Analysis

Statistical Test	Tested Variables	Results (p-value)
Chi-Square	Blood sugar control category vs. category TG/HDL ratio	0.702
Binary Logistic Regression	Influence HbA1c category against risk improvement TG/HDL ratio (≥2.5)	0.703

Statistical Test	Tested Variables	Results (p-value)
Spearman Correlation	Connection HbA1c value and TG/HDL ratio (variables numeric)	0.574
Kruskal-Wallis	Difference TG/HDL ratio based on HbA1c categories (good , moderate , bad)	0.890

DISCUSSION

This study aimed to analyze the relationship between the degree of blood glucose control, measured through HbA1c levels, and the triglyceride to HDL (TG/HDL) ratio as a predictor of cardiometabolic risk in Type 2 Diabetes Mellitus patients. Although there is a theoretical connection between poor glycemic control and an increased risk of atherogenic dyslipidemia, the results of this study show that no significant relationship exists between HbA1c categories and the TG/HDL ratio.

Based on the Chi-Square test, no significant relationship was found between blood glucose control categories (good, moderate, poor) and TG/HDL ratio categories (high or low) (p=0.702). These results indicate that changes in HbA1c levels do not directly correlate with the distribution of TG/HDL risk categories. This is consistent with the findings of Imayanti and Pusparini (2024), who stated that while high HbA1c levels are often associated with dyslipidemia, not all lipid parameters show a significant relationship with glycemia.

The binary logistic regression test also showed that HbA1c categories did not significantly affect the likelihood of an increased TG/HDL ratio (≥2.5) (p=0.703). This suggests that although most patients with poor blood glucose control tend to have high TG/HDL ratios, the relationship is not statistically strong enough. Previous studies, such as by Ezquerra et al. (2018), have shown that factors such as insulin resistance, central obesity, and dietary patterns have a more dominant effect on the TG/HDL ratio compared to HbA1c levels themselves (Yang,2019).

Next, the Spearman correlation test was used to assess the relationship between numerical values of HbA1c and the TG/HDL ratio. The results showed no significant correlation between these two variables (p=0.574), indicating that an increase in HbA1c levels is not always accompanied by an increase in the TG/HDL ratio in Type 2 DM patients. This finding aligns with several studies that state the relationship between glycemic control and dyslipidemia is complex and can be influenced by various other factors such as insulin resistance, lifestyle, and pharmacological therapy (Petersen & Titchenell, 2017; Leavens & Birnbaum, 2011). Even in patients with relatively controlled HbA1c levels, lipid abnormalities can still occur due to other metabolic factors.

The Kruskal-Wallis test, conducted to assess whether there were differences in the TG/HDL ratio across the three blood glucose control categories, also yielded insignificant results (p=0.890). Thus,

no meaningful difference was found in the median TG/HDL ratio values between patients with good, moderate, and poor blood glucose control. This may be due to the homogeneity of dyslipidemia patterns in Type 2 DM patients, where most patients are already in a metabolic condition that tends to have a high risk.

Overall, the results of this study show that HbA1c, both as a category and as a numerical value, does not significantly correlate with the TG/HDL ratio in Type 2 Diabetes Mellitus patients. These findings highlight the need for a multidimensional approach in assessing cardiometabolic risk, considering other factors such as obesity, blood pressure, physical activity, and dietary habits. This is important to demonstrate that evaluating cardiometabolic risk in T2DM patients should not rely solely on glycemic parameters like HbA1c, but should also incorporate other metabolic indicators, including lipid ratios. Interventions aimed at reducing cardiometabolic risk should consider a more comprehensive assessment of the patient's metabolic status, not just glucose control alone (Bays et al., 2021).

CONCLUSION

Overall, the statistical analysis results in this study indicate that there is no significant relationship between the degree of blood glucose control and the triglyceride to HDL ratio. Nevertheless, these findings still provide important scientific contributions to understanding the lipid profile characteristics in Type 2 Diabetes Mellitus patients and serve as a foundation for further research with a larger sample size, as well as consideration of other relevant confounding variables. The results of this study support the need for a multidimensional approach in managing T2DM, including the routine monitoring of the TG/HDL ratio as part of the cardiometabolic risk assessment, regardless of the patient's glycemic control status.

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