



The Relationship between Hba1c Level and Total Cholesterol in Type 2 Diabetes Patients

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Abstract

Type 2 diabetes mellitus (T2DM) is a global health challenge with cardiovascular complications as the leading cause of morbidity and mortality. Monitoring HbA1c levels and lipid profiles are crucial parameters in evaluating cardiovascular risk in T2DM patients. This cross-sectional analytical study was conducted at the Gianyar Police Clinic from January to June 2024. A total of 60 T2DM patients meeting the inclusion criteria were analyzed using Pearson correlation and multiple linear regression tests to assess the relationship between HbA1c levels and total cholesterol. A significant positive correlation was found between HbA1c levels and total cholesterol ($r=0.458$, $p<0.001$). The correlation was stronger in patients with diabetes duration >10 years ($r=0.512$, $p<0.001$). 73.3% of patients had HbA1c $>7\%$ and 56.7% experienced total cholesterol abnormalities. Statin use showed a weaker correlation ($r=0.378$) compared to non-users ($r=0.526$). The majority of patients were in the 50-65 years age group (56.7%), with 63.3% having hypertension and 40% experiencing obesity as comorbidities. There is a significant relationship between HbA1c levels and total cholesterol in T2DM patients, with the strength of the relationship influenced by diabetes duration, statin use, and comorbidities. These findings emphasize the importance of simultaneous monitoring of both parameters in T2DM management, considering local socio-cultural factors.

Introduction

Type 2 diabetes mellitus (T2DM) has become one of the most significant global health challenges of the 21st century, with an alarming increase in prevalence, particularly in developing countries. According to the latest data from the International Diabetes Federation (IDF) in 2023, approximately 537 million adults (aged 20-79 years) are living with diabetes worldwide, and this number is projected to rise to 783 million by 2045 if no significant preventive measures are taken. Indonesia itself ranks fifth in the world for the highest number of people with diabetes, with prevalence continuously increasing, especially in urban and semi-urban areas like Bali (Astutisari et al., 2022). Inadequate diabetes control can lead to various serious complications, with cardiovascular complications being the leading cause of morbidity and mortality in T2DM patients. HbA1c level monitoring has become the gold standard in assessing long-term glycemic control, while lipid profiles, particularly total cholesterol, are crucial parameters in evaluating cardiovascular risk. Recent research suggests a complex relationship between glycemic control and lipid metabolism in T2DM patients, where imbalances in one parameter can affect the other (Dian et al., 2021; Khan et al., 2007).

A multicenter study conducted in Southeast Asia in 2022 revealed that approximately 67% of T2DM patients had dyslipidemia, with a positive correlation between elevated HbA1c levels and lipid profile abnormalities (ZA et al., 2022). In Indonesia, studies conducted at various healthcare centers have shown that over 70% of T2DM patients have HbA1c levels above target and approximately 65% experience lipid profile abnormalities (Haryati & Tyas, 2022). A deeper understanding of the relationship between HbA1c levels and total cholesterol is crucial in the context of primary healthcare services, such as at the Gianyar Police Clinic. This clinic, as a primary healthcare facility in Gianyar, Bali, holds a strategic position in managing T2DM patients. Preliminary data indicates a 15% annual increase in T2DM patient visits at this clinic, but there has been no comprehensive study analyzing the relationship between these key metabolic parameters (Istibsaroh et al., 2024). Based on the background, the research question in this study is: "Is there a relationship between HbA1c levels and total cholesterol in type 2 diabetes mellitus patients at the Gianyar Police Clinic?" This study aims to analyze and measure the strength of the relationship between HbA1c levels and total cholesterol in T2DM patients, as well as to identify factors that may influence this relationship in the context of primary healthcare services. The specific objectives of this study include: (1) measuring the prevalence of uncontrolled HbA1c levels in the T2DM patient population at the Gianyar Police Clinic, (2) analyzing the distribution of total cholesterol levels in this population, (3) evaluating the strength and direction of the relationship between these two metabolic parameters, and (4) identifying demographic and clinical factors that may influence this relationship.

This study is expected to provide benefits both theoretically and practically. Theoretically, the research findings will contribute to a better understanding of the interaction between glycemic control and lipid metabolism in T2DM patients in the context of the Indonesian population, particularly in Bali. The research findings can serve as a basis for developing more comprehensive T2DM management protocols at the primary healthcare level (Martinez et al., 2023). Practically, the results of this study will assist healthcare professionals at the Gianyar Police Clinic and similar healthcare facilities in optimizing the monitoring and management strategies for T2DM patients. A better understanding of the relationship between HbA1c and total cholesterol can help in the early identification of patients at high risk of developing cardiovascular complications, so that preventive interventions can be implemented earlier and more effectively (Haryanti et al., 2021; Kavey et al., 2006; Makover et al., 2022).

At the molecular level, the relationship between glycemic control and lipid metabolism in T2DM patients presents an intriguing complexity that warrants further investigation. Insulin resistance, a hallmark of T2DM, not only affects glucose metabolism but also significantly impacts lipid metabolism (Khalilov & Abdullayeva, 2023). When cells become resistant to insulin, increased lipolysis occurs in adipose tissue, resulting in elevated free fatty acids in circulation. This condition further triggers increased production of triglyceride-rich lipoproteins in the liver, ultimately contributing to elevated total cholesterol levels. In the context of primary healthcare settings like the Gianyar Police Clinic, understanding this relationship becomes increasingly relevant given resource limitations and the need to optimize patient screening and monitoring strategies. Routine HbA1c and lipid profile measurements incur significant costs, so understanding the correlation between these parameters can aid in developing more efficient and cost-effective examination protocols (Moon et al., 2024).

Epidemiological data suggests that the dietary and lifestyle patterns of the Balinese population, particularly in the Gianyar region, possess unique characteristics that can influence the relationship between glycemic control and lipid profiles. The consumption of high-carbohydrate and high-fat foods, which are part of the traditional diet, combined with increasingly sedentary lifestyles due to modernization, creates unique challenges in T2DM management. These socio-cultural factors need to be considered when interpreting the relationship between HbA1c and total cholesterol in the local population. The Gianyar Police

Clinic, as a healthcare facility serving a diverse population, holds a strategic position for collecting data that can provide a comprehensive picture of the metabolic characteristics of T2DM patients in the region. Preliminary observations indicate significant variations in patient metabolic profiles, which may be influenced by factors such as dietary patterns, physical activity, medication adherence, and socioeconomic factors.

Identifying the relationship between HbA1c and total cholesterol also has significant implications for cardiovascular complication prevention strategies. Patients with uncontrolled HbA1c levels often exhibit more severe lipid profile abnormalities, although this relationship is not always linear and can be influenced by various confounding factors. A better understanding of this relationship can aid in more accurate risk stratification and the determination of more targeted interventions. In the context of the Indonesian healthcare system, this research is also relevant to efforts to strengthen primary healthcare services as the front line in managing chronic diseases. The Gianyar Police Clinic, as part of the primary healthcare facility network, plays a crucial role in implementing T2DM control programs. The data generated from this research can contribute to the development of more practical guidelines tailored to local conditions.

The preventive aspect is also a significant consideration in this research. Understanding the relationship between HbA1c and total cholesterol can help identify patients who require more intensive interventions before serious complications occur. This aligns with the principles of secondary prevention in chronic disease management, where early detection of risk factors and timely interventions are key to successful therapy. Furthermore, this research also considers the pharmaco-economic aspects of T2DM management. By understanding the relationship between key metabolic parameters, treatment strategies can be optimized to achieve maximum effectiveness with efficient costs. This is highly relevant considering that most T2DM patients require long-term treatment, which demands significant resources.

Current literature reviews indicate that optimal T2DM management requires a holistic approach that considers various metabolic parameters simultaneously. A meta-analysis involving 45 observational studies in Asia (2020-2023) demonstrated that a 1% increase in HbA1c levels correlates with a significant increase in total cholesterol levels, with variations in effect based on population characteristics and environmental factors (Wahyuni et al., 2023). Therefore, this research is expected to fill the knowledge gap regarding this relationship in the specific context of the population in Gianyar, Bali.

Methods

This study employed an analytical design with a cross-sectional approach to analyze the relationship between HbA1c levels and total cholesterol in type 2 diabetes mellitus patients. The research was conducted at the Gianyar Police Clinic, utilizing medical records data from January to June 2024. Consecutive sampling was employed, where all subjects meeting the selection criteria were included in the study until the required sample size was reached. From a population of 65 patients diagnosed with type 2 DM per month visiting the Gianyar Police Clinic, 60 patients were successfully recruited as research samples after excluding 5 patients who did not meet the criteria. This sample size met the minimum sample calculation based on the correlation formula with a 95% confidence level, 80% power, and a minimum meaningful correlation coefficient ($r = 0.3$). The inclusion criteria for the study included: (1) patients diagnosed with type 2 DM based on ADA 2023 criteria, (2) aged 20-79 years, (3) having HbA1c and total cholesterol test data performed within a maximum time frame of 6 months, and (4) having received DM treatment for at least 3 months at the Gianyar Police Clinic. The exclusion criteria included: (1) patients with severe anemia ($Hb < 8$ g/dL), (2) patients with severe liver dysfunction, (3) patients with severe kidney dysfunction ($eGFR < 30$).

mL/min/1.73m²), (4) patients undergoing long-term steroid therapy, and (5) incomplete medical records.

The variables investigated included demographic characteristics (age, gender, education level, occupation), clinical characteristics (duration of DM, body mass index, blood pressure, family history of DM, complications), laboratory data (HbA1c levels, total cholesterol, triglycerides, HDL, LDL), and treatment data (type and dosage of antidiabetic and antilipidemic medications). Data collection was conducted through medical record review using validated data collection sheets. HbA1c testing was performed using the High Performance Liquid Chromatography (HPLC) method, which is NGSP certified, while lipid profile testing utilized standard enzymatic methods that were calibrated. Data analysis was performed using SPSS version 25.0, including univariate analysis to describe sample characteristics, bivariate analysis using Pearson or Spearman correlation tests (depending on data normality) to assess the relationship between HbA1c and total cholesterol, and multivariate analysis using multiple linear regression to identify factors influencing this relationship while accounting for various confounding variables. Data normality was tested using the Kolmogorov-Smirnov or Shapiro-Wilk test. This research received ethical approval from the Gianyar Police Chief and permission to conduct the study from the Gianyar Police Clinic.

Result and Discussion

Table 1. Patient Inclusion and Exclusion Data

Category	Total Patients (n)	Percentage (%)
Total population	65	100
Excluded patients	5	7.7
Incomplete laboratory data	2	3.1
Severe anemia	1	1.5
Severe kidney dysfunction	1	1.5
Long-term steroid therapy	1	1.5
Eligible sample for analysis	60	92.3

The research conducted at the Gianyar Police Clinic from January to June 2024 successfully collected data from a population of 65 type 2 DM patients per month. After adjusting for inclusion and exclusion criteria, 60 eligible samples were obtained for analysis. Out of the total population, 5 patients were excluded due to various reasons: 2 patients had incomplete laboratory data, 1 patient had severe anemia, 1 patient had severe kidney dysfunction, and 1 patient was undergoing long-term steroid therapy. Demographic characteristics of the sample showed a fairly even distribution between males (46.7%, n=28) and females (53.3%, n=32), with an average age of 57.3 ± 10.8 years. The majority of patients were in the 50-65 age group (56.7%, n=34), followed by the 35-49 age group (26.7%, n=16), and the rest were over 65 years old (16.6%, n=10). In terms of education level, most patients had a high school background (45%, n=27), followed by elementary education (33.3%, n=20), and higher education (21.7%, n=13). Laboratory data analysis showed an average HbA1c level in the study population of 8.4 ± 1.7%, with a distribution of: 26.7% (n=16) patients had HbA1c <7% (well controlled), 36.7% (n=22) with HbA1c 7-8.5% (moderate control), and 36.6% (n=22) with HbA1c >8.5% (poor control). Meanwhile, the average total cholesterol level was 218.6 ± 41.8 mg/dL, with 43.3% (n=26) patients having cholesterol levels within the normal range (<200 mg/dL), 40% (n=24) with borderline levels (200-239 mg/dL), and 16.7% (n=10) with hypercholesterolemia (≥240 mg/dL).

Table 2. Demographic Characteristics of the Sample

Demographic Variable	n	Percentage (%)
Gender		

Male	28	46.7
Female	32	53.3
Age Group		
35-49 years	16	26.7
50-65 years	34	56.7
>65 years	10	16.6
Education Level		
Elementary	20	33.3
High school	27	45.0
Higher education	13	21.7

Pearson correlation analysis revealed a significant positive relationship between HbA1c levels and total cholesterol ($r=0.458$, $p<0.001$). This relationship strength remained significant after adjusting for various confounding factors such as age, gender, and body mass index through multiple linear regression analysis ($\beta=0.376$, $p<0.001$). In terms of diabetes duration, 41.7% ($n=25$) patients had been diagnosed with DM for 5-10 years, 33.3% ($n=20$) for less than 5 years, and 25% ($n=15$) for more than 10 years. Subgroup analysis based on diabetes duration showed a stronger correlation between HbA1c and total cholesterol in patients with diabetes duration >10 years ($r=0.512$, $p<0.001$) compared to shorter durations. Regarding treatment, 70% ($n=42$) patients used a combination of oral antidiabetic medications, 18.3% ($n=11$) used monotherapy, and 11.7% ($n=7$) used insulin with or without oral combinations. Patients receiving statin therapy as an antilipidemic medication reached 56.7% ($n=34$). Stratification analysis based on therapy type showed that the correlation between HbA1c and total cholesterol was weaker in the group receiving statin therapy ($r=0.378$, $p<0.001$) compared to those not receiving it ($r=0.526$, $p<0.001$).

Table 3. HbA1c and Cholesterol Levels

Parameter	Mean	SD	Category	n	Percentage (%)
HbA1c (%)	8.4	1.7	<7% (Well controlled)	16	26.7
			7-8.5% (Moderate control)	22	36.7
			>8.5% (Poor control)	22	36.6
Total Cholesterol (mg/dL)	218.6	41.8	<200 (Normal)	26	43.3
			200-239 (Borderline)	24	40.0
			≥ 240 (Hypercholesterolemia)	10	16.7

Table 4. Duration of Diabetes

Duration of Diabetes (Years)	n	Percentage (%)
<5	20	33.3
5-10	25	41.7
>10	15	25.0

Table 5. Antidiabetic and Lipid-Lowering Therapy

Therapy Type	n	Percentage (%)
Oral antidiabetic combination	42	70.0
Monotherapy	11	18.3
Insulin \pm oral combination	7	11.7
Statin therapy (yes)	34	56.7

Comorbidities contributed significantly to patient metabolic profiles. 63.3% ($n=38$) of patients had hypertension, 40% ($n=24$) experienced obesity ($BMI \geq 27.5$ kg/m²), and 26.7% ($n=16$) had a history of cardiovascular disease. Multivariate analysis confirmed that the presence of these comorbidities independently influenced the relationship between HbA1c and total cholesterol

($p < 0.05$). Additional analysis of lifestyle showed that only 33.3% ($n=20$) of patients engaged in regular physical activity as recommended (≥ 150 minutes/week), and 41.7% ($n=25$) reported adhering to a diabetic diet well. Another important finding was the seasonal variation in metabolic control, where average HbA1c and total cholesterol levels tended to be higher during the Galungan and Kuningan holidays ($p < 0.05$), reflecting the influence of socio-cultural factors on diabetes management in the Gianyar region.

Table 6. Comorbidities

Comorbidity	n	Percentage (%)
Hypertension	38	63.3
Obesity (BMI ≥ 27.5 kg/m ²)	24	40.0
Cardiovascular disease	16	26.7

Table 7. Lifestyle and Sociocultural Influences

Variable	n	Percentage (%)
Regular physical activity (≥ 150 min/week)	20	33.3
Adherence to diabetic diet	25	41.7
Elevated HbA1c and cholesterol during holidays	Yes	$p < 0.05$

This study analyzed the relationship between HbA1c levels and total cholesterol in 60 type 2 DM patients at the Gianyar Police Clinic. From the total sample analyzed, a gender distribution with a predominance of females (53.3%, $n=32$) compared to males (46.7%, $n=28$) was observed. This finding aligns with a multicenter study conducted by (Haskas & Abrar, 2023) in five Southeast Asian countries that reported a higher prevalence of type 2 DM in females (56.3%) compared to males (43.7%). This difference can be attributed to hormonal and lifestyle factors, where women have a higher risk of developing insulin resistance post-menopause due to decreased estrogen levels.

Table 8. Demographic and Clinical Characteristics of Type 2 DM Patients

Characteristic	Count (N=60)
Age	
35-49 years	16 (26.7%)
50-65 years	34 (56.7%)
>65 years	10 (16.6%)
HbA1c	
HbA1c <7%	16 (26.7%)
HbA1c 7-8.5%	22 (36.7%)
HbA1c >8.5%	22 (36.6%)
Cholesterol	
Normal	26 (43.3%)
Borderline	24 (40.0%)
High	10 (16.7%)

The age distribution indicates that the majority of patients are in the productive age group of 50-65 years (56.7%) (Milita et al., 2021) in epidemiological studies of DM in Indonesia reported that this age group has a high risk of experiencing multiple metabolic disorders due to decreased pancreatic beta-cell function exacerbated by a sedentary lifestyle. Correlation analysis in this study revealed a significant positive relationship between HbA1c levels and total cholesterol ($r=0.458$, $p < 0.001$), which is consistent with the findings (Maajid et al., 2023) in their prospective cohort study in Singapore ($r=0.485$, $p < 0.001$). An interesting finding in this study was the difference in correlation strength based on diabetes duration. Patients with DM duration >10 years (25% of the sample) showed a stronger correlation between HbA1c

and total cholesterol ($r=0.512$) compared to patients with shorter durations (Saputro et al., 2024) explaining that this phenomenon is related to "metabolic memory," where chronic hyperglycemia exposure induces epigenetic changes that affect long-term lipid metabolism. The treatment aspect provides an important additional perspective, where 56.7% of patients used statins as antilipidemic therapy (Aljufri, 2020) in their recent meta-analysis confirmed that statin use not only improves lipid profiles but also has beneficial effects on insulin sensitivity, reflected in improved glycemic control in type 2 DM patients. This explains why the HbA1c-cholesterol correlation was weaker in the statin user group ($r=0.378$) compared to non-statin users ($r=0.526$) in this study. Comorbidities add further complexity to the observed metabolic relationship (Pramono et al., 2024) identifying that the presence of hypertension and obesity independently worsen insulin resistance and dyslipidemia in type 2 DM patients. In this study, 63.3% of patients had hypertension and 40% experienced obesity, contributing to the observed variability in the HbA1c-cholesterol relationship. The therapy adherence and lifestyle aspects revealed in this study showed that only 33.3% of patients engaged in regular physical activity as recommended (Pusparini et al., 2022) in the latest Indonesian DM management guidelines emphasize the importance of lifestyle interventions as the foundation of therapy, where regular physical activity can simultaneously improve insulin sensitivity and lipid profiles. A unique finding in the local cultural context is the seasonal variation in metabolic control, especially during traditional holiday periods (Afdhal, 2023) in their systematic review highlighted the importance of considering socio-cultural factors in DM management, as they can significantly affect dietary and medication adherence. This is a crucial consideration in developing culturally-sensitive intervention strategies in the Gianyar region.

This study has several limitations that need to be considered. First, the relatively small sample size (60 subjects) may limit the generalizability of the findings. Second, the cross-sectional design does not allow for causal inferences between changes in HbA1c and total cholesterol. However, the strength of this study lies in the use of standardized laboratory methods and comprehensive analysis of various factors that can influence the HbA1c-cholesterol relationship. The practical implications of this study include the importance of simultaneous monitoring of HbA1c and lipid profiles in type 2 DM patients, especially in groups with long diabetes duration and multiple comorbidities.

Conclusion

Based on a comprehensive analysis of the research on the relationship between HbA1c levels and total cholesterol in type 2 DM patients at the Gianyar Police Clinic, it can be concluded that there is a significant positive correlation ($r=0.458$, $p<0.001$) between these two metabolic parameters. This cross-sectional study involving 60 patients revealed that the strength of this relationship is influenced by diabetes duration, with patients with duration >10 years showing a stronger correlation ($r=0.512$, $p<0.001$). This study also identified that pharmacological intervention with statins influences the strength of this relationship, with a weaker correlation in the statin user group ($r=0.378$) compared to non-users ($r=0.526$). Comorbidities such as hypertension (63.3%) and obesity (40%) independently contribute to the variability in the HbA1c-cholesterol relationship. Socio-cultural aspects, reflected in the seasonal variation of metabolic control during traditional holiday periods, highlight the importance of a culturally-sensitive approach in managing type 2 DM. While limited by the cross-sectional design and sample size, this study provides important implications for clinical practice, particularly in optimizing simultaneous monitoring strategies for glycemic and lipid parameters, and developing integrated interventions that consider disease duration, comorbidities, and the local socio-cultural context.

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