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Correlation of HbA1c with Lipid Profile in Type 2 Diabetes

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is typically in line with dyslipidaemia, which substantially increases cardiovascular risk. Glycated haemoglobin (HbA1c) reflects long-term glycaemic control and has been proposed as a potential surrogate marker for lipid abnormalities. However, evidence regarding the correlation between HbA1c and lipid profile components remains inconsistent, particularly in Southeast Asian populations. This study aimed to evaluate the correlation between HbA1c levels and lipid profile parameters among patients with T2Dm treated at a tertiary referral hospital in Indonesia.
Methods: A cross-sectional analytic study was conducted using medical record data from 68 patients with T2DM. HbA1c levels and lipid profile parameters–including total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides–were analysed. Data normality was assessed using the Kolmogorov–Smirnov test. Spearman's rank correlation test was applied to determine the correlation between HbA1c and lipid profile components.
Results: The median HbA1c level was 8.70% (range: 4.90–14.70%), indicating suboptimal glycaemic control. Median lipid profile values were 203.50 mg/dL for total cholesterol, 55.50 mg/dL for HDL cholesterol, 115.00 mg/dL for LDL cholesterol, and 138.50 mg/dL for triglycerides. Correlation analysis revealed no statistically significant association between HbA1c levels and any lipid profile component.
Conclusion: HbA1c levels were not significantly correlated with lipid profile parameters in patients with T2DM. These findings suggest that glycaemic control alone may not adequately reflect lipid-related cardiovascular risk, underscoring the need for comprehensive cardiometabolic assessment in patients with T2DM.

Keywords: *Type 2 diabetes mellitus, HbA1c, lipid profile, dyslipidaemia, cardiovascular risk*

Introduction

Type 2 diabetes mellitus (T2DM) is a long-standing metabolic disorder defined by reduced insulin sensitivity and gradual deterioration of beta-call function on pancreas, culminating in chronic elevations in blood glucose levels.[1,2] The global prevalence of T2DM continues to escalate, in parallel by a rising burden of cardiovascular morbidity and mortality associated with long-term metabolic dysregulation.[1,3,4] Dyslipidaemia, a common metabolic abnormality in T2DM, is instrumental in a pivotal role in the pathogenesis of atherosclerotic cardiovascular disease, which continues to be the principal underlying factor of mortality among patients with diabetes.[2,5]

Glycated haemoglobin (HbA1c) is extensively used as an indicator of long-term glycaemic control, reflecting the average levels of the blood glucose over the preceding two or three months.[6] Persistent hyperglycaemia has been implicated in alterations of lipid metabolism through insulin resistance, increased lipolysis, and hepatic overproduction of very-low-density lipoproteins (VLDL).[7,8] However, research findings remains inconsistent

across studies on the correlation between HbA1c levels and lipid profile parameters with several studies have identified statistically significant correlations and others have reported weak or non-significant associations between these variables.[9–13]

Variations in study design, population characteristics, disease duration, medication use, and metabolic heterogeneity may partly explain these discrepancies.[13] In particular, limited data are available from Indonesian tertiary care settings, where patients often present with advanced metabolic disturbances and diverse treatment histories.[9,14]

Therefore, among patients with T2DM treated at Universitas Andalas Hospital, this study attempted to investigate the correlation between HbA1c levels and lipid profile parameters, specifically total cholesterol, HDL cholesterol (HDL-C), LDL cholesterol (LDL-C), and triglycerides. Understanding this relationship is essential to clarify whether glycaemic control alone adequately reflects lipid-related cardiovascular risk in this population.

Methods

Study Design and Setting

A cross-sectional design was employed in this analytic observational study, using secondary data obtained from medical records. The study was organized at Universitas Andalas Hospital, a tertiary referral center in Padang, Indonesia. Data collection took place from February to November 2025, utilizing medical records from January to December 2024.

Study Population and Sampling

The study population comprised all patients diagnosed with T2DM who underwent laboratory assessment during the study period. Hospital records identified a total of 909 eligible patients. Using a consecutive non-probability sampling approach, 68 patients who complied with the predefined inclusion and exclusion criteria ultimately enrolled in the study. Gender was defined as the patient's gender identity recorded in the medical record and categorized as male or female. Age was expressed in years and documented in the medical record. Age was classified according to the Indonesian Ministry of Health criteria into two groups: adults (18–59 years) and elderly (>60 years).

Inclusion and Exclusion Criteria

Participants were deemed eligible if they had confirmation of T2DM diagnosis on the basis from the American Diabetes Association (ADA) diagnostic criteria and had complete laboratory data, including HbA1c measurement and a comprehensive lipid profile evaluation.

Patients were excluded if they had conditions known to interfere with HbA1c measurement or lipid metabolism, including haematological disorders (such as haemoglobinopathies, haemolytic anaemia, iron deficiency anaemia, thalassaemia), malaria, HIV infection, pregnancy (second or third trimester or postpartum period), prior splenectomy, blood transfusion within the preceding four months, current or previous statin therapy, or incomplete medical records.

Sample Size Determination

Cramer's V formula was used to calculate the minimum sample size, yielding a requirement of 49 subjects. After accounting for a 10% dropout rate, the required study sample increased to 54 patients. Ultimately, a total of 68 patients were included.

Variables

In this analytical observational study, HbA1c was defined as the independent variable, while lipid profile parameters, such as total cholesterol, HDL-C, LDL-C, and triglycerides served as dependent variables. HbA1c was analyzed as a continuous variable with standard cut-off values of 7.0%. Lipid parameters likewise was analyzed as continuous data according to standard cut-off values (e.g., total cholesterol ≥ 200 mg/dL, HDL-C ≥ 40 mg/dL

for female and ≥ 50 mg/dL for male, LDL-C ≥ 130 mg/dL, triglycerides ≥ 150 mg/dL). HbA1c is reported in percentage (%) and lipid parameters are expressed in milligrams per deciliter (mg/dL).

HbA1c measurement is performed using standardized methods such as high-performance liquid chromatography (HPLC). Lipid levels are determined enzymatically from fasting venous serum samples.

Statistical Analysis

SPSS version 25 software was used to perform statistical analysis. The laboratory results and demographics traits were summarized using univariate (descriptive) analysis. Data distribution was evaluated using the Kolmogorov–Smirnov test, while Levene's test was applied to evaluate variance homogeneity. As the data did not satisfy the assumption of normality, Spearman's rank correlation test was applied to ascertain the correlation between HbA1c and lipid profile parameters. The threshold for statistical significance was defined at a two-tailed p-value of 0.05.

Ethical Clearance

This study was performed following the receipt of formal ethical clearance from the Research Ethics Committee of the Faculty of Medicine, Universitas Andalas (No: 500/UN.16.2/KEP-FK/2025). All study procedures adhered strictly to institutional regulations and internationally recognized ethical principles for biomedical research.

Results

Patient Characteristic

In the study conducted at Andalas University Hospital, a total of 909 patients with T2DM were registered based on hospital medical records during the period from January to December 2024. Patien Characteristic (Tabel 1)

Table 1. Patient Characteristics

Characteristic	n (%)
Gender	
Male	28 (41.2)
Female	40 (58.8)
Age (years)	
Adult (18-59 years)	39 (57.4)
Elderly (>60 years)	29(42.6)

Among the 68 patients enrolled in the study, more than half of the patients were female, accounting for 58,8%, compared to 41,2% who were male. More than half of patients were within the adult age group (18–59 years, 57.4%), while 42.6% were aged 60 years or older.

HbA1c Levels

In this study, all 68 patients who complied with the predefined inclusion and exclusion criteria had their HbA1c levels measured. Blood samples were collected during the patients' first hospital visit, and the measurements were obtained from laboratory tests. The following table presents the distribution of the patients' HbA1c levels (Tabel 2).

Table 2. HbA1c Levels

Parameter	Minimum (%)	Maksimum (%)	Median (%)	Standar Error (%)
HbA1c levels	4.90	14.70	8.70	0.307

The median HbA1c level was 8.70% (range: 4.90–14.70%), indicating suboptimal long-term glycaemic control in most patients.

Lipid Profile

The lipid profile (Tabel 3)

Table 3. Lipid profile

Lipid Profile	Minimum (mg/dL)	Maximum (mg/dL)	Median (mg/dL)	Std. Error (mg/dL)
Total Cholesterol	95	301	203.50	6.268
HDL Cholesterol	8	109	55.50	2.318
LDL Cholesterol	24	201	115.00	4.707
Triglycerides	40	527	138.50	12.134

The lipid profile analysis showed wide variability among patients. Median levels were 203.50 mg/dL for total cholesterol, 55.50 mg/dL for HDL cholesterol, 115.00 mg/dL for LDL cholesterol, and 138.50 mg/dL for triglycerides, with triglycerides demonstrating the broadest range of values.

Correlation Between HbA1c and Lipid Profile

Spearman's correlation test was used to analyze the correlation between HbA1c levels and lipid profile parameters in patients diagnosed with T2DM, owing to the data that were not distribute normally. This non-parametric approach was applied to determine whether fluctuations in HbA1c values were statistically correlated to variations in the lipid profile parameters.

Table 4. Correlation Between HbA1c and Lipid Profile

Lipid Profile	r (HbA1c)	p (HbA1c)
Total Cholesterol	0.060	0.625
HDL Cholesterol	-0.161	0.190
LDL Cholesterol	0.159	0.196

The correlation analysis demonstrated no statistically significant correlations between HbA1c levels and any lipid profile parameters. Specifically, the correlations between HbA1c and total cholesterol, HDL cholesterol, LDL cholesterol, and triglyceride levels were not statistically significant, with p-values of 0.625, 0.190, 0.196, and 0.901, accordingly.

Discussion

This study investigated the correlation between HbA1c levels and lipid profile parameters in patients with T2DM treated at Universitas Andalas Hospital. The study population was predominantly female and largely composed of adults of productive age, reflecting an epidemiological shift toward earlier onset of T2DM. Similar sex distributions have been reported in Indonesian primary-care settings, whereas studies from Middle Eastern tertiary centres have demonstrated male predominance, highlighting the influence of population characteristics and healthcare system differences on disease demographics.[13,15,16]

The median HbA1c level exceeded recommended targets, indicating suboptimal long-term glycaemic control in most patients. This result highlights the continued challenges in managing diabetes and aligns with findings from other national studies. A persistently high HbA1c level indicates chronic hyperglycemia, which promotes the

glycation of non-enzymatic proteins and the accumulation of advanced glycation end products, both of which can contribute to vascular complications.[17–20]

Regarding lipid parameters, median total cholesterol and LDL-C levels were above reference values, while HDL and triglyceride levels remained largely within normal ranges. These findings are consistent with several regional studies. Insulin resistance reduces hepatic LDL receptor expression, impairing LDL clearance, while increased free fatty acid (FFA) flux enhances hepatic VLDL production, thereby increasing circulation cholesterol levels. Importantly, LDL particles in T2DM tend to be small and dense, conferring greater atherogenicity despite near-normal LDL concentration.[21,22]

Although median HDL levels were within normal limits, substantial interindividual variability was observed. In insulin-resistant states, HDL metabolism is altered through increased cholesterol ester transfer protein activity and glycation of apolipoprotein A-1, impairing reverse cholesterol transport and diminishing HDL functionality despite preserved concentrations. Thus, HDL quality rather than quantity may better reflect cardiovascular risk in T2DM.[20,23,24]

Inadequacy of significant correlation between HbA1c and lipid profile components indicates that glycaemic control alone does not reliably reflect abnormalities in patients with T2DM. These findings align with prior studies that found modest or non-significant associations between HbA1c and lipid markers.[13,20,25–27]

The relationship between hyperglycaemia and dyslipidaemia in T2DM is complex and multifactorial. Lipid metabolism is influenced by insulin resistance severity disease duration, dietary intake, physical activity, hormonal status, and pharmacological therapy.[28–31] Antidiabetic medications such as metformin may improve lipid profiles independently of glycaemic control, potentially attenuating observable correlations.[32]

Furthermore, conventional lipid measurements may not adequately reflect cardiovascular risk in T2DM. Emerging evidence indicates that lipid subfractions, including small dense LDL (sd-LDL) and HDL functional properties, may be more sensitive indicators of atherogenic risk than total lipid concentrations.[33,34]

Limitations

This study is subject to several limitations. Its cross-sectional nature prevents the causal inference. Important confounding variables, including disease duration, dietary intake, physical activity, anthropometric measurements, and prior lipid-lowering therapy, were not fully documented. Additionally, since the study was conducted in a tertiary care referral center, the applicability of the results to primary healthcare settings or the general population may be restricted.

Conclusions

This study demonstrates that HbA1c levels were not significantly correlated with lipid profile parameters in patients with T2DM. These findings indicate that dyslipidaemia may occur independently of long-term glycaemic control and that HbA1c alone is insufficient for assessing cardiovascular risk. Consequently, comprehensive metabolic monitoring, including routine lipid evaluation, remains essential for effective risk stratification and management in patients diagnosed with T2DM.

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Declaration concerning generative AI and AI-augmented technologies in the compositional process

In the course of preparing this paper, the authors utilized ChatGPT to enhance readability and linguistic quality. Subsequent to utilizing this tool/service, the writers assessed and amended the information as necessary and assume complete accountability for the publication's content.

Declarations of competing interest

No potential competing interest was reported by the authors.

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