

Glycemic control and serum lipid profile in type2 diabetic patients

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Dyslipidemia is a common metabolic abnormality among patients with T2DM and contributes significantly to the development of cardiovascular disease. Glycated hemoglobin (HbA1c) is widely used as a marker of long-term glycemic control and may be associated with alterations in lipid parameters.

Objective:

To investigate the association between glycemic control, assessed by HbA1c, and lipid parameters in patients with type 2 diabetes mellitus.

Patients and Methods:

This retrospective study included 100 patients with T2DM aged 40–87 years who attended the Endocrinology Center at Al-Sader Medical City, Al-Najaf, Iraq, between January 1 and September 30. The mean age of the participants was 57.71 years, and the mean HbA1c level was 8.68%. Patients were classified according to glycemic control using an HbA1c cutoff value of 6.5%. Lipid profile parameters, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), and non-HDL cholesterol, were evaluated.

Results:

Patients with HbA1c levels $\geq 6.5\%$ demonstrated significantly higher serum triglyceride and VLDL-C levels compared with those with HbA1c levels $< 6.5\%$ ($p = 0.00023$ and $p = 0.00047$, respectively). No statistically significant associations were observed between HbA1c and TC, LDL-C, HDL-C, or non-HDL cholesterol. Smoking status was not significantly associated with any lipid profile parameter.

Conclusion:

Poor glycemic control was significantly associated with elevated triglyceride and VLDL-C levels in patients with type 2 diabetes mellitus. These findings suggest that HbA1c may serve as a useful indicator for identifying diabetic patients at increased risk of hypertriglyceridemia and VLDL-C elevation. However, no significant relationship was observed between HbA1c and other lipid parameters. Further studies with larger sample sizes and prospective designs are recommended to confirm these findings and clarify the clinical utility of HbA1c as a predictor of dyslipidemia in patients with T2DM.

List of Abbreviations

Abbreviation	Definition
ATP III	Adult Treatment Panel III
cAMP	Cyclic Adenosine Monophosphate
CVD	Cardiovascular Disease
DM	Diabetes Mellitus
DKA	Diabetic Ketoacidosis
HbA1c	Glycated Hemoglobin
HDL	High-Density Lipoprotein
LDL	Low-Density Lipoprotein
NCEP	National Cholesterol Education Program
Non-HDL	Non-High-Density Lipoprotein
sRAGE	Soluble Receptor for Advanced Glycation End Products
TC	Total Cholesterol
TG	Triglycerides
UKPDS	United Kingdom Prospective Diabetes Study
VLDL	Very-Low-Density Lipoprotein
WHO	World Health Organization

Keywords: type 2 diabetes mellitus, low density lipoprotein, total cholesterol, triglyceride, high density lipoprotein.

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Introduction

Diabetes mellitus (DM) is a group of metabolic disorders characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both.(1) Diabetes has become a major global health problem, with a rapidly increasing prevalence in both developed and developing countries.(2) It is associated with substantial morbidity and mortality due to its microvascular and macrovascular complications, which significantly reduce life expectancy.(3)

Poor glycemic control has been linked to the development and progression of diabetic complications, including dyslipidemia.(4) Glycated hemoglobin (HbA1c) is widely used as a reliable indicator of long-term glycemic control, reflecting the average blood glucose level over the preceding two to three months.(5) Elevated HbA1c levels have been shown to predict the risk of diabetic complications. The United Kingdom Prospective Diabetes Study (UKPDS) demonstrated a strong association between chronic hyperglycemia and the development of diabetic complications, emphasizing the importance of maintaining good glycemic control.(6) Furthermore, the Diabetes Control and Complications Trial (DCCT) established HbA1c as the gold standard marker for assessing glycemic control and reducing the risk of diabetes-related complications.(7)

Diabetic dyslipidemia is commonly characterized by elevated triglycerides (TG), increased low-density lipoprotein cholesterol (LDL-C), and reduced high-density lipoprotein cholesterol (HDL-C). These lipid abnormalities are closely associated with poor glycemic control and contribute substantially to cardiovascular risk in patients with type 2 diabetes mellitus (T2DM).(8) In addition, elevated levels of soluble receptor for advanced glycation end products (sRAGE) have been reported in patients with T2DM and coronary artery disease, showing significant associations with both HbA1c and serum lipid parameters.(9)

Chronic hyperglycemia may lead to vascular and metabolic disturbances that increase the risk of cardiovascular disease.(10) The coexistence of dyslipidemia further amplifies this risk; however, appropriate management of both hyperglycemia and lipid abnormalities can significantly reduce cardiovascular morbidity and mortality.(11,12)

Increasing evidence suggests that diabetic dyslipidemia is largely driven by insulin resistance and related metabolic abnormalities. Enhanced free fatty acid flux, increased adiposity, and the release of pro-inflammatory adipokines and cytokines contribute to the development of lipid abnormalities in patients with T2DM.(13)

Aim of the Study

This study aimed to investigate the association between glycemic control, as assessed by HbA1c, and lipid profile parameters in patients with type 2 diabetes mellitus.

Patients and Methods

This retrospective study included 100 patients with type 2 diabetes mellitus (T2DM). Data were retrieved from the electronic records of the Endocrinology Department at Al-Sadr Medical City, Al-Najaf, Iraq, covering the period from January 1, 2021, to September 30, 2021.

The diagnosis of T2DM was based on the World Health Organization (WHO) criteria, using glycated hemoglobin (HbA1c) $\geq 6.5\%$ as the diagnostic threshold. Demographic data, including age, sex, and smoking status, were collected from the patients' records.

Exclusion Criteria

Patients were excluded if they had any of the following conditions:

- Type 1 diabetes mellitus. •
- Acute diabetic complications, including diabetic ketoacidosis (DKA) and severe hypoglycemia. •
- Severe infections. •
- Gastrointestinal disorders. •
- Severe cardiovascular or respiratory diseases. •
- Recent major surgery or trauma. •
- Pregnancy or breastfeeding. •

Lipid Profile Assessment

Low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), and non-high-density lipoprotein cholesterol (non-HDL-C) were calculated using the following equations:

$$\text{LDL-C} = \text{TC} - \text{HDL-C} - (\text{TG}/5) \quad (15) \quad \bullet$$

$$\text{VLDL-C} = \text{TG}/5 \quad (15) \quad \bullet$$

$$\text{Non-HDL-C} = \text{TC} - \text{HDL-C} \quad (16) \quad \bullet$$

Patients were categorized according to glycemic control using an HbA1c cutoff value of 6.5%. Patients with

HbA1c < 6.5% were considered to have good glycemic control, whereas those with HbA1c ≥ 6.5% were considered to have poor glycemic control.

Statistical Analysis

Statistical analysis was performed using IBM Statistical Package for the Social Sciences (SPSS), version 26.0.

Continuous variables were expressed as mean ± standard error of the mean (SEM). Pearson's correlation coefficient was used to assess the relationship between HbA1c and lipid profile parameters. Comparisons between groups were performed using the independent-samples t-test (two-tailed).

A p-value < 0.01 was considered statistically significant.

Table 1. Diagnostic Criteria for Type 2 Diabetes Mellitus was based on the World Health Organization (WHO) criteria.(14)

Parameter	Diabetes Mellitus
Fasting Plasma Glucose	≥ 7.0 mmol/L (126 mg/dL)
2-Hour Plasma Glucose after OGTT	≥ 11.1 mmol/L (200 mg/dL)
Random Plasma Glucose	≥ 11.1 mmol/L (200 mg/dL)
HbA1c	≥ 6.5%

Table 1. World Health Organization (WHO) diagnostic criteria for diabetes mellitus. Adapted from the World Health Organization and International Diabetes Federation.(14)

Results

A total of 100 patients with type 2 diabetes mellitus were included in this study. The mean age of participants was 57.7 ± 9.3 years (range: 40–87 years). The mean HbA1c level was 8.6 ± 1.8%. The study population consisted of 39 males (39%) and 61 females (61%). Smokers represented 19% of the sample.

The overall lipid profile showed elevated mean levels of total cholesterol, triglycerides, LDL-C, VLDL, and non-HDL cholesterol, with relatively lower HDL-C levels, indicating an atherogenic lipid pattern among the studied patients.

Table 2. Baseline characteristics and lipid profile of study participants (n = 100)

Parameter	Mean ± SD	Range
Age (years)	57.7 ± 9.3	40–87
HbA1c (%)	8.6 ± 1.8	4.5–13.9
Total Cholesterol (mg/dL)	197.5 ± 54.5	115–484
Triglycerides (mg/dL)	278.4 ± 80.3	90–484
LDL-C (mg/dL)	99.6 ± 50.3	13–376
VLDL (mg/dL)	55.6 ± 16.0	18–96.8
HDL-C (mg/dL)	42.1 ± 5.5	32–73
Non-HDL-C (mg/dL)	155.3 ± 49.1	82–411

Legend: Values are presented as mean ± SD.

Table 3. Lipid profile according to glycemic control (HbA1c)

Parameter	HbA1c < 6.5 (n = 19)	HbA1c ≥ 6.5 (n = 81)	P value	Interpretation
Total Cholesterol	195 ± 83	198 ± 46	0.829	Not significant
Triglycerides	175 ± 43	302 ± 66	0.00023	Significant
LDL-C	116 ± 73	95 ± 42	0.016	Not significant
VLDL	35 ± 8.6	60 ± 13.3	0.00047	Significant
HDL-C	44 ± 8.1	41 ± 4.7	0.018	Not significant
Non-HDL-C	151 ± 74	156 ± 41.5	0.61	Not significant

Legend: Data are expressed as mean ± SEM.

Table 4. Lipid profile according to gender

Parameter	Males (n = 39)	Females (n = 61)	P value	Interpretation
Total Cholesterol	201 ± 11.4	195 ± 5.1	0.133	Not significant
Triglycerides	286 ± 14.4	273 ± 9.4	0.294	Not significant
LDL-C	101 ± 10.6	98 ± 4.7	0.436	Not significant
VLDL	57 ± 2.9	54 ± 1.8	0.291	Not significant
HDL-C	42 ± 1.1	42 ± 0.5	0.439	Not significant
Non-HDL-C	158 ± 10.3	153 ± 4.6	0.317	Not significant

Table 5. Lipid profile according to age groups

Parameter	40–60 years (n = 62)	>60 years (n = 38)	P value	Interpretation
Total Cholesterol	201 ± 7.5	187 ± 7.3	0.577	Not significant
Triglycerides	279 ± 10.5	277 ± 12.4	0.516	Not significant
LDL-C	103 ± 7	91 ± 6.6	0.465	Not significant
VLDL	56 ± 2.1	55 ± 2.4	0.516	Not significant
HDL-C	43 ± 0.7	41 ± 0.7	0.461	Not significant
Non-HDL-C	159 ± 6.8	146 ± 6.4	0.593	Not significant

Table 6. Lipid profile according to smoking status

Parameter	Smokers (n = 19)	Non-smokers (n = 81)	P value	Interpretation
Total Cholesterol	193 ± 10.3	198 ± 6.2	0.114	Not significant
Triglycerides	270 ± 18	280 ± 9	0.456	Not significant
LDL-C	97 ± 9.1	100 ± 5.8	0.413	Not significant
VLDL	54 ± 3.5	56 ± 1.8	0.356	Not significant
HDL-C	41 ± 1	42 ± 0.6	0.152	Not significant
Non-HDL-C	151 ± 9.4	156 ± 5.6	0.402	Not significant

Discussion

The present study evaluated the association between glycemic control, assessed by glycated hemoglobin (HbA1c), and lipid profile parameters in patients with type 2 diabetes mellitus. The principal finding was that patients with poor glycemic control (HbA1c $\geq 7\%$) had significantly higher serum triglyceride (TG) and very-low-density lipoprotein (VLDL) levels compared with patients with better glycemic control. These findings suggest that

deterioration of glycemic control is associated with worsening abnormalities in triglyceride-rich lipoproteins, which may contribute to increased cardiovascular risk in patients with type 2 diabetes mellitus (17).

The significant association between HbA1c and TG and VLDL observed in the current study is consistent with the findings reported by Khan et al. (17), who demonstrated that HbA1c is closely related to the severity of dyslipidemia in patients with type 2 diabetes mellitus. Insulin resistance and relative insulin deficiency are considered major mechanisms underlying this relationship. Increased free fatty acid release from adipose tissue and altered adipocytokine secretion promote hepatic triglyceride synthesis and increased VLDL production, leading to elevated circulating TG and VLDL concentrations (18).

In contrast, no statistically significant association was observed between HbA1c and total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), or non-HDL cholesterol. These findings are in agreement with the study conducted by Senthilkumar et al. (22), which also reported no significant correlations between HbA1c and TC, LDL-C, or HDL-C among patients with type 2 diabetes mellitus. However, other investigators, including Yan et al. (23) and Abd Elkarim et al. (24), demonstrated significant associations between HbA1c and several lipid parameters. Such discrepancies may be attributed to differences in sample size, ethnicity, duration of diabetes, treatment regimens, and study design.

The present study also found no significant association between HbA1c and non-HDL cholesterol. Although non-HDL cholesterol has been proposed as a useful marker of atherogenic lipoproteins and cardiovascular risk in diabetic patients (25,26), its relationship with glycemic control remains inconsistent across studies. The absence of a significant association in the current study may be related to the relatively small sample size and the retrospective cross-sectional design.

With regard to demographic characteristics, no significant differences in lipid profile parameters were observed according to gender. These findings are consistent with those reported by Maqsood Ahmad et al. (30). However, Sirsikir et al. (31) reported significantly higher HbA1c levels among males, while other studies found higher cholesterol and LDL-C levels among female patients with type 2 diabetes mellitus, possibly due to differences in body fat distribution and hormonal influences (32,33).

Similarly, age was not significantly associated with any lipid profile parameter in the present study. This finding is consistent with previous reports by IK Hammed (32) and Arshad Hussain et al. (34). Although aging is frequently associated with increased insulin resistance, reduced pancreatic β -cell function, and adverse metabolic changes (35), the effect of age on lipid parameters may be influenced by multiple confounding factors, including lifestyle, dietary habits, physical activity, and medication use. Some previous studies reported higher cholesterol and triglyceride levels among older individuals with diabetes (36,37), which was not demonstrated in the current study.

Smoking status was also not significantly associated with lipid profile parameters in this study. This finding differs from several previous investigations that reported significantly higher TC, TG, LDL-C, and VLDL levels and lower HDL-C levels among smokers compared with non-smokers (40,41). Nicotine exposure may increase lipolysis and circulating free fatty acids, thereby enhancing hepatic triglyceride synthesis and VLDL production (42). The lack of significant differences observed in the current study may be explained by the relatively small number of smokers included in the study population.

Strengths and Limitations

The present study has several strengths. It evaluated multiple lipid profile parameters, including LDL-C, VLDL, HDL-C, and non-HDL cholesterol, in relation to glycemic control in patients with type 2 diabetes mellitus. In addition, the study reflects real-world clinical data obtained from a specialized endocrinology center.

However, several limitations should be considered. First, the retrospective cross-sectional design precludes the establishment of causal relationships. Second, the study was conducted in a single center and included a relatively limited sample size, which may affect the generalizability of the findings. Third, important variables such as duration of diabetes, body mass index, dietary habits, physical activity, and lipid-lowering medications were not available for analysis. Therefore, larger prospective multicenter studies are required to further clarify the relationship between glycemic control and lipid abnormalities in patients with type 2 diabetes mellitus.

Conclusion

The present study demonstrated a significant association between poor glycemic control and elevated serum triglyceride and VLDL levels in patients with type 2 diabetes mellitus. In contrast, no significant associations were found between HbA1c and total cholesterol, LDL-C, HDL-C, non-HDL cholesterol, age, gender, or smoking status. These findings suggest that HbA1c may serve as a useful indicator for identifying patients at increased risk of triglyceride-related dyslipidemia. Regular monitoring and optimization of glycemic control may contribute to improving lipid abnormalities and reducing cardiovascular risk. Further large-scale prospective studies are recommended to confirm these findings and clarify the underlying mechanisms.

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