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Original Research Article

Association of HbA1c with Lipid Profile in Type 2 Diabetes Mellitus: A Cross-Sectional Study

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Abstract:

Background: Type 2 diabetes mellitus (T2DM) is frequently associated with dyslipidemia, which significantly increases the risk of cardiovascular disease. Glycated hemoglobin (HbA1c) is a reliable marker of long-term glycemic control and may serve as an indicator of lipid abnormalities in diabetic patients.

Objective: To evaluate the association between HbA1c levels and lipid profile parameters among patients with Type 2 Diabetes Mellitus.

Methods: A hospital-based cross-sectional study was conducted among adult patients diagnosed with T2DM. Demographic data, HbA1c levels, and fasting lipid profile parameters including total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and very-low-density lipoprotein cholesterol (VLDL-C) were analyzed. Pearson correlation and statistical tests were used to determine the association between HbA1c and lipid parameters.

Results: Elevated HbA1c levels were significantly associated with increased TC, TG, LDL-C, and VLDL-C levels, whereas HDL-C demonstrated a negative correlation with HbA1c. Patients with poor glycemic control (HbA1c ≥7%) exhibited significantly higher levels of atherogenic lipids compared with patients having good glycemic control (HbA1c <7%).

Conclusion: HbA1c is significantly associated with lipid abnormalities in T2DM patients and may serve as a useful predictor of dyslipidemia and cardiovascular risk. Regular monitoring of HbA1c and lipid parameters may facilitate early identification and management of diabetic dyslipidemia.

Keywords: Type 2 diabetes mellitus, HbA1c, Dyslipidemia, Lipid profile, Cardiovascular risk, Glycemic control.

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Introduction

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by hyperglycemia resulting from insulin resistance and impaired insulin secretion. The global prevalence of diabetes has increased dramatically over recent decades, posing a major public health challenge. Chronic hyperglycemia contributes to the development of microvascular and macrovascular complications, including nephropathy, retinopathy, neuropathy, and cardiovascular disease (CVD) [1,2].

Glycated hemoglobin (HbA1c) reflects average blood glucose levels over the preceding 8–12 weeks and is widely accepted as the gold standard for assessing long-term glycemic control [3]. Elevated HbA1c levels are associated with increased risk of diabetic complications and cardiovascular morbidity [4]. Dyslipidemia is a common metabolic abnormality among patients with T2DM and is characterized by elevated triglycerides, increased low-density lipoprotein cholesterol (LDL-C), increased very-low-density lipoprotein cholesterol (VLDL-C), and reduced high-density lipoprotein cholesterol (HDL-C) [5]. Insulin resistance promotes excessive free fatty acid flux from adipose tissue to the liver, resulting in increased hepatic lipoprotein production and altered lipid metabolism [6]. Several studies have reported a significant relationship between HbA1c and lipid profile parameters, suggesting that HbA1c may be utilized as a surrogate marker for predicting dyslipidemia and cardiovascular risk in diabetic patients [7–10]. Understanding this association may improve risk stratification and clinical management of T2DM.

The present study aims to evaluate the association between HbA1c levels and lipid profile parameters among patients with Type 2 Diabetes Mellitus.

Materials and Methods

This cross-sectional study was conducted in the Department of General Medicine and Biochemistry at a tertiary care teaching hospital. A total of 200 patients diagnosed with Type 2 Diabetes Mellitus (T2DM) and aged 30 years or above were included in the study after obtaining informed consent. Patients with Type 1 diabetes mellitus, gestational diabetes, thyroid disorders, chronic liver disease, renal failure, acute infections, or those receiving lipid-lowering medications were excluded from the study. Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study.

Detailed Demographic and clinical information, including age, gender, duration of diabetes, and medical history, were collected from patient records and a structured questionnaire. After an overnight fast, venous blood samples were obtained for biochemical analysis. Fasting lipid profile parameters (TC, TG, HDL-C, LDL-C, and VLDL-C) were measured using standard enzymatic methods on an automated analyzer, while HbA1c levels were estimated by High-Performance Liquid Chromatography (HPLC).

Statistical Analysis: Statistical analysis was performed using the Statistical Package R for windows. The data expressed as mean ± SD. Normality was tested with Kolmogorov–Smirnov test. To study the association between HbA1c and lipid parameters. pearson's correlation was used. The null hypothesis was rejected at $P \leq 0.05$

Results

Baseline Characteristics of the Study Population: A total of 200 patients with Type 2 Diabetes Mellitus were included in the study. The mean age of the participants was 54.8 ± 10.2 years, with the majority of patients belonging to the age group of 50–60 years. The mean duration of diabetes was 8.3 ± 4.5 years. The overall mean HbA1c level was 8.4 ± 1.9%, indicating suboptimal glycemic control among most study participants. The mean values of lipid profile parameters revealed elevated levels of total cholesterol, triglycerides, and LDL cholesterol, suggesting a high prevalence of diabetic dyslipidemia within the study population.

Table 1: Baseline Characteristics of Study Participants

Parameter	Mean ± SD
Age (years)	54.8 ± 10.2
Duration of Diabetes (years)	8.3 ± 4.5
HbA1c (%)	8.4 ± 1.9
Total Cholesterol (mg/dL)	213 ± 42
Triglycerides (mg/dL)	198 ± 64
LDL-C (mg/dL)	132 ± 36
HDL-C (mg/dL)	39 ± 8
VLDL-C (mg/dL)	39.6 ± 12.8

Table 1shows that the mean HbA1c value of 8.4% indicates poor glycemic control in the majority of diabetic patients. According to ADA recommendations, HbA1c values above 7% are associated with an increased risk of diabetic complications. Elevated mean total cholesterol (213 mg/dL), triglycerides (198 mg/dL), and LDL cholesterol (132 mg/dL) observed in this study further indicate a high burden of dyslipidemia among patients with T2DM. The reduced mean HDL cholesterol level (39 mg/dL) suggests an increased atherogenic risk profile. These findings support the well-established association between hyperglycemia and abnormal lipid metabolism in diabetic individuals.

Table 2: Comparison of Lipid Profile According to Glycemic Status

Parameter	HbA1c <7% (n=62)	HbA1c ≥7% (n=138)	p-value
Total Cholesterol (mg/dL)	181 ± 28	227 ± 39	<0.001
Triglycerides (mg/dL)	146 ± 34	221 ± 59	<0.001
LDL-C (mg/dL)	108 ± 22	143 ± 31	<0.001
HDL-C (mg/dL)	45 ± 7	36 ± 6	<0.001
VLDL-C (mg/dL)	29 ± 7	44 ± 12	<0.001

Table 2 demonstrates that patients with poor glycemic control (HbA1c ≥7%) had significantly higher levels of total cholesterol, triglycerides, LDL-C, and VLDL-C, while HDL-C levels were significantly lower compared to patients with good glycemic control (HbA1c <7%). Triglycerides and LDL-C showed marked elevation among poorly controlled diabetics, indicating an increased risk of atherosclerosis and cardiovascular disease. The lower HDL-C levels further suggest a greater cardiovascular risk in this group. The statistically significant p-values

(<0.001) confirm a strong association between poor glycemic control and dyslipidemia.

Table 3 shows a significant positive correlation between HbA1c and total cholesterol, triglycerides, LDL-C, and VLDL-C, indicating that lipid levels increase with worsening glycemic control. The strongest correlation was observed with triglycerides (r = 0.51). In contrast, HDL-C showed a significant negative correlation with HbA1c (r = -0.31), suggesting lower HDL-C levels in patients with poor glycemic control. These findings indicate that higher HbA1c levels are associated with an unfavorable lipid profile and may serve as a useful marker for predicting dyslipidemia in patients with Type 2 Diabetes Mellitus.

Table 3: Correlation of HbA1c with Lipid Profile

Parameter	Correlation Coefficient (r)	p-value
Total Cholesterol	0.46	<0.001
Triglycerides	0.51	<0.001
LDL-C	0.43	<0.001
HDL-C	-0.31	0.002
VLDL-C	0.48	<0.001

Discussion

The present study evaluated the association between HbA1c levels and lipid profile parameters among patients with Type 2 Diabetes Mellitus. The results demonstrated a significant relationship between poor glycemic control and adverse lipid abnormalities. Elevated HbA1c levels were associated with increased concentrations of total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol, while HDL cholesterol showed a significant inverse relationship.

The mean HbA1c value of 8.4 ± 1.9% observed in the present study indicates inadequate glycemic control among the majority of participants. Similar observations have been reported by Khan et al. [7], who found that poorly controlled diabetic patients exhibited significantly higher lipid levels compared with patients having satisfactory glycemic control. The persistent hyperglycemic state reflected by elevated HbA1c contributes to metabolic disturbances that alter lipid metabolism and increase cardiovascular risk. One of the major findings of the present study was the strong positive correlation between HbA1c and serum triglyceride levels. Triglycerides demonstrated the highest correlation coefficient among all lipid parameters (r=0.51). This finding is consistent with studies by Syed et al. [10] and Kumar et al. [8], who also reported significant associations between worsening glycemic control and elevated triglyceride concentrations. Insulin resistance promotes enhanced lipolysis in adipose tissue, resulting in increased release of free fatty acids into the circulation. These fatty acids are subsequently transported to the liver, where they undergo re-esterification and contribute to increased hepatic production of triglyceride-rich VLDL particles [16].

The study also demonstrated a significant positive correlation between HbA1c and LDL cholesterol levels. Elevated LDL cholesterol is a well-established risk factor for atherosclerotic cardiovascular disease. Chronic hyperglycemia promotes non-enzymatic glycation of LDL particles, resulting in structural modifications that enhance their atherogenicity. Glycated LDL particles are less efficiently cleared by hepatic LDL receptors and remain in circulation for prolonged periods, increasing the risk of endothelial dysfunction and plaque formation [14].

Similarly, total cholesterol and VLDL cholesterol showed significant positive correlations with HbA1c. Increased hepatic synthesis of lipoproteins secondary to insulin resistance is believed to contribute to these abnormalities. These findings support previous observations by Howard et al. [15], who identified dyslipidemia as a major determinant of cardiovascular morbidity among diabetic individuals.

An important finding of the present study was the significant inverse correlation between HbA1c and HDL cholesterol. HDL cholesterol plays a protective role against cardiovascular disease by facilitating reverse cholesterol transport and exerting anti-inflammatory effects on the vascular endothelium. The reduction in HDL cholesterol observed among poorly controlled diabetic patients may further accelerate atherosclerotic processes and contribute to increased cardiovascular risk. Similar findings have been reported by Mooradian [14] and Vergès [16].

When participants were categorized according to glycemic status, patients with HbA1c levels ≥7% exhibited significantly worse lipid profiles than those with HbA1c levels <7%. Total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol were substantially higher among patients with poor glycemic control, while HDL cholesterol was significantly lower. These findings indicate that glycemic status has a direct influence on lipid metabolism and support the use of HbA1c as a predictor of dyslipidemia.

The clinical implications of these findings are significant. Measurement of HbA1c is routinely performed during diabetes management and is readily available in most healthcare settings. The demonstrated association between HbA1c and lipid

abnormalities suggests that HbA1c may serve as a simple and cost-effective indicator for identifying diabetic patients at increased cardiovascular risk. Early recognition of dyslipidemia through HbA1c monitoring may facilitate timely interventions such as lifestyle modification, dietary counseling, optimization of glycemic control, and initiation of lipid-lowering therapy. The findings of the present study are in agreement with previous investigations conducted across different populations and geographical regions, thereby strengthening the evidence supporting the relationship between glycemic control and dyslipidemia. Collectively, these studies suggest that improvement in glycemic control may contribute to favorable lipid profile changes and potentially reduce cardiovascular complications among patients with Type 2 Diabetes Mellitus.

Conclusion- HbA1c is significantly associated with lipid profile abnormalities in patients with Type 2 Diabetes Mellitus. Higher HbA1c levels correlate positively with total cholesterol, triglycerides, LDL-C, and VLDL-C and negatively with HDL-C. HbA1c may serve as a useful predictor of dyslipidemia and cardiovascular risk among diabetic patients. Routine assessment of HbA1c together with lipid profile can facilitate early detection and management of cardiovascular risk factors in T2DM.

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