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Correlation of HBA1C with Lipid Profile in Type 2 Diabetes Mellitus

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ABSTRACT
Background: Type 2 Diabetes Mellitus (T2DM) is frequently associated with dyslipidemia, which significantly increases the risk of cardiovascular morbidity and mortality. Glycated hemoglobin (HbA1c) reflects long-term glycemic control and may also serve as an indicator of lipid abnormalities in diabetic patients.
Objectives: To evaluate the correlation between HbA1c levels and lipid profile parameters in patients with Type 2 Diabetes Mellitus.
Materials and Methods: This cross-sectional observational study included 120 patients with Type 2 Diabetes Mellitus attending a tertiary care hospital. Fasting blood samples were analyzed for HbA1c and lipid profile parameters including total cholesterol, triglycerides, LDL-cholesterol, HDL-cholesterol, and VLDL-cholesterol. The correlation between HbA1c and lipid profile parameters was assessed using Pearson's correlation coefficient.
Results: The mean HbA1c level was 8.1 ± 1.3%. HbA1c showed a significant positive correlation with total cholesterol ($r = 0.48$), triglycerides ($r = 0.55$), LDL-cholesterol ($r = 0.51$), and VLDL-cholesterol ($r = 0.53$), while a significant negative correlation was observed with HDL-cholesterol ($r = -0.44$) ($p < 0.05$). Patients with poorer glycemic control demonstrated more pronounced dyslipidemia.
Conclusion: Poor glycemic control, as reflected by elevated HbA1c levels, is significantly associated with an adverse lipid profile in patients with Type 2 Diabetes Mellitus. HbA1c may serve as a useful marker for identifying diabetic patients at increased cardiovascular risk, emphasizing the need for integrated management of glycemic and lipid abnormalities.

Keywords: *Type 2 Diabetes Mellitus; HbA1c; Lipid Profile; Dyslipidemia; Cardiovascular Risk*

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INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and relative insulin deficiency. The global prevalence of T2DM has increased dramatically over the past few decades, making it one of the most significant public health challenges worldwide. According to recent estimates, the burden of diabetes is particularly high in developing countries, including India, where lifestyle changes, urbanization, and genetic susceptibility contribute to its rising incidence [1].

Cardiovascular disease is the leading cause of morbidity and mortality among patients with T2DM. Diabetic individuals are two to four times more likely to develop coronary artery disease compared to the non-diabetic population [2]. Among the various factors contributing to this increased risk, dyslipidemia plays a pivotal role. Diabetic dyslipidemia is typically characterized by elevated triglyceride levels, increased low-density lipoprotein cholesterol (LDL-C), and reduced high-density lipoprotein cholesterol (HDL-C), collectively promoting accelerated atherosclerosis [3].

Glycated hemoglobin (HbA1c) is formed by the non-enzymatic glycation of hemoglobin and reflects the average blood glucose concentration over the preceding two to three months. It is widely accepted as the gold standard for assessing long-term glycemic control in patients with diabetes mellitus [4]. Poor glycemic control, as indicated by elevated HbA1c levels, has been shown to adversely affect lipid metabolism by increasing free fatty acid flux from adipose tissue, enhancing hepatic triglyceride synthesis, and impairing lipoprotein clearance [5].

Several studies have suggested that HbA1c not only reflects glycemic status but may also serve as an indirect marker of lipid abnormalities and cardiovascular risk. Hyperglycemia induces oxidative stress and inflammation, leading to qualitative and quantitative changes in lipoproteins, particularly LDL particles, making them more atherogenic [6]. Consequently, patients with higher HbA1c levels are more likely to exhibit an unfavorable lipid profile, thereby increasing their risk of macrovascular complications.

In clinical practice, lipid profile assessment is usually performed periodically, whereas HbA1c is routinely measured to monitor glycemic control. If a significant correlation exists between HbA1c and lipid parameters, HbA1c could serve as a simple and cost-effective indicator to identify diabetic patients at higher risk of dyslipidemia and cardiovascular disease [7]. This would be particularly beneficial in resource-limited settings where frequent lipid testing may not be feasible.

The present study was undertaken to evaluate the correlation between HbA1c levels and lipid profile parameters in patients with Type 2 Diabetes Mellitus.

MATERIALS AND METHODS

Study Design

This study was conducted as a **cross-sectional observational study** to evaluate the correlation between glycemic control, assessed by glycated hemoglobin (HbA1c), and lipid profile parameters in patients with Type 2 Diabetes Mellitus (T2DM). Cross-sectional designs are commonly employed to assess associations between metabolic variables in chronic diseases such as diabetes mellitus.

Study Setting

The study was carried out in the **Department of General Medicine** in collaboration with the **Department of Biochemistry** at a tertiary care teaching hospital that caters to both urban and rural populations and provides comprehensive diabetes care services.

Study Period

The study was conducted over a period of **one year**.

Study Population

The study population comprised patients with a confirmed diagnosis of Type 2 Diabetes Mellitus attending the outpatient department or admitted to medical wards during the study period.

Sample Size

A total of **120 patients** were included in the study. The sample size was determined based on feasibility and availability of eligible patients during the study period, similar to earlier hospital-based observational studies assessing metabolic correlations in diabetes.

Inclusion Criteria

- Patients aged **30 years and above**
- Diagnosed cases of **Type 2 Diabetes Mellitus**
- Both **male and female** patients
- Patients willing to provide informed consent

Exclusion Criteria

- Patients with **Type 1 Diabetes Mellitus**
- Patients on **lipid-lowering therapy**, which could alter lipid profile values
- Known cases of **chronic kidney disease**, due to its influence on lipid metabolism
- **Chronic liver disease**
- **Hypothyroidism**, as it independently affects lipid levels
- Acute infections, inflammatory conditions, or recent hospitalization
- Pregnant women

Data Collection Procedure

After obtaining written informed consent, demographic and clinical data were collected using a pre-structured proforma. Information regarding age, gender, duration of diabetes, and treatment details was recorded. All participants were instructed to maintain an overnight fast of **8–10 hours** prior to blood sample collection, as recommended for accurate lipid estimation

Blood Sample Collection

Venous blood samples were collected in the morning under aseptic precautions. Samples were transferred into appropriate vacutainers and processed according to standard laboratory protocols to ensure accuracy and reproducibility of biochemical measurements.

LABORATORY INVESTIGATIONS

Blood Sample Collection

After an overnight fast of **8–10 hours**, venous blood samples were collected from all participants under strict aseptic precautions. Blood samples were collected in appropriate vacutainers and transported immediately to the central clinical laboratory for analysis.

Estimation of Glycated Hemoglobin (HbA1c)

Glycated hemoglobin (HbA1c) was estimated using **High Performance Liquid Chromatography (HPLC)**. HPLC is considered the reference method for HbA1c estimation due to its high precision, specificity, and standardization across laboratories. HbA1c values were expressed as percentages (%) and interpreted according to internationally accepted diagnostic and monitoring guidelines [8,9].

Estimation of Lipid Profile

Fasting lipid profile assessment included the following parameters:

- **Total Cholesterol (TC)**
- **Triglycerides (TG)**
- **High-Density Lipoprotein Cholesterol (HDL-C)**

These parameters were measured using **enzymatic colorimetric methods** on an automated biochemistry analyzer. These methods are widely used in routine clinical practice due to their reliability and reproducibility [10].

Calculation of LDL and VLDL Cholesterol

- **Low-Density Lipoprotein Cholesterol (LDL-C)** was calculated using **Friedewald's formula** in patients with triglyceride levels below 400 mg/dL [11]:

$$\text{LDL-C} = \text{Total Cholesterol} - (\text{HDL-C} + \text{Triglycerides}/5)$$

- **Very Low-Density Lipoprotein Cholesterol (VLDL-C)** was calculated as **Triglycerides/5**.

Statistical Analysis

Data were entered into **Microsoft Excel** and analyzed using the **Statistical Package for the Social Sciences (SPSS)** software. Continuous variables were expressed as **mean ± standard deviation**, and categorical variables as **frequencies and percentages**.

The relationship between HbA1c and lipid profile parameters was assessed using **Pearson's correlation coefficient**, which is appropriate for evaluating linear associations between continuous variables [20]. A **p-value < 0.05** was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the **Institutional Ethics Committee**. Written informed consent was obtained from all participants prior to enrollment. Confidentiality of patient data was strictly maintained in accordance with ethical guidelines for biomedical research involving human participants.

RESULTS

The present study included **120 patients** diagnosed with Type 2 Diabetes Mellitus.
The study population predominantly comprised middle-aged individuals, with a higher proportion of male patients as shown in table 1

Table 1: Age and Gender Distribution of Patients (n = 120)

Variable	**Number of Patients**	**Percentage**
Gender		
Male	72	60.0%
Female	48	40.0%
Age (years)		
30–40	14	11.7%

Variable	Number of Patients	Percentage
41–50	32	26.7%
51–60	42	35.0%
61–70	24	20.0%
>70	8	6.6%

Most patients demonstrated suboptimal glycemic control as shown in table 2.

Table 2: Distribution of HbA1c Levels

HbA1c Category (%)	Number of Patients	Percentage
<7.0 (Good control)	28	23.3%
7.0–8.9 (Moderate control)	54	45.0%
≥9.0 (Poor control)	38	31.7%

Mean HbA1c: ***8.1 ± 1.3%***

Patients with Type 2 Diabetes Mellitus showed an overall atherogenic lipid profile as shown in table 3.

Table 3: Mean Lipid Profile Values

Lipid Parameter	Mean ± SD (mg/dL)
Total Cholesterol	214 ± 38
Triglycerides	190 ± 45
LDL-Cholesterol	134 ± 30
HDL-Cholesterol	39 ± 8
VLDL-Cholesterol	38 ± 9

HbA1c showed significant correlation with most lipid profile components as shown in table 4.

Table 4: Correlation of HbA1c with Lipid Profile

Lipid Parameter	Correlation Coefficient (r)	p-value
Total Cholesterol	+0.48	<0.01
Triglycerides	+0.55	<0.001
LDL-Cholesterol	+0.51	<0.01
HDL-Cholesterol	−0.44	<0.01
VLDL-Cholesterol	+0.53	<0.001

Patients with poorer glycemic control demonstrated more pronounced dyslipidemia as shown in table 5.

Table 5: Mean Lipid Values Based on HbA1c Levels

Parameter	HbA1c <7%	HbA1c 7–8.9%	HbA1c ≥9%
Total Cholesterol (mg/dL)	186 ± 32	214 ± 34	238 ± 41
Triglycerides (mg/dL)	158 ± 36	188 ± 40	224 ± 48
LDL-Cholesterol (mg/dL)	112 ± 26	134 ± 28	156 ± 32
HDL-Cholesterol (mg/dL)	44 ± 7	39 ± 6	34 ± 6

Differences across groups were statistically significant ($p < 0.05$).

DISCUSSION

The present study was undertaken to evaluate the correlation between glycemic control, assessed by HbA1c levels, and lipid profile parameters in patients with Type 2 Diabetes Mellitus. The findings of this study demonstrate a significant association between poor glycemic control and an adverse lipid profile, highlighting the close interrelationship between glucose and lipid metabolism in diabetes.

Demographic Characteristics

In this study, the majority of patients were middle-aged, with a mean age of 55.1 ± 9.2 years, and a male predominance was observed. Similar demographic patterns have been reported in earlier Indian studies, where Type 2 Diabetes Mellitus commonly presents in the fifth and sixth decades of life [12]. The higher proportion of male patients may be attributed to lifestyle factors, occupational stress, and differences in healthcare-seeking behavior.

Glycemic Control Status

The mean HbA1c level in the present study was 8.1 ± 1.3%, indicating suboptimal glycemic control in a large proportion of patients. This observation is consistent with previous studies that have reported poor glycemic control among patients with Type 2 Diabetes Mellitus in developing countries [13]. Factors such as delayed diagnosis, inadequate treatment adherence, and lack of regular follow-up may contribute to persistently elevated HbA1c levels.

Lipid Profile Abnormalities in Type 2 Diabetes Mellitus

The lipid profile analysis revealed elevated levels of total cholesterol, triglycerides, LDL-cholesterol, and VLDL-cholesterol, along with reduced HDL-cholesterol. This pattern is characteristic of diabetic dyslipidemia and has been widely documented in the literature [14]. Insulin resistance leads to increased lipolysis and free fatty acid flux to the liver, resulting in enhanced hepatic triglyceride synthesis and altered lipoprotein metabolism.

Correlation Between HbA1c and Lipid Profile

A significant positive correlation was observed between HbA1c and total cholesterol, triglycerides, LDL-cholesterol, and VLDL-cholesterol, while a significant negative correlation was noted with HDL-cholesterol. These findings suggest that worsening glycemic control is associated with progressive deterioration of lipid parameters. Similar correlations have been reported in earlier studies, supporting the role of HbA1c as a surrogate marker for dyslipidemia and cardiovascular risk in patients with Type 2 Diabetes Mellitus [15,16].

Hyperglycemia promotes oxidative stress and non-enzymatic glycation of lipoproteins, particularly LDL particles, making them more atherogenic. In addition, reduced insulin activity impairs lipoprotein lipase function, leading to decreased clearance of triglyceride-rich lipoproteins and lower HDL-cholesterol levels [17].

Lipid Profile According to Glycemic Control

In the present study, patients with poor glycemic control (HbA1c ≥9%) demonstrated significantly higher levels of total cholesterol, triglycerides, and LDL-cholesterol, along with lower HDL-cholesterol, compared to patients with better glycemic control. These findings are in agreement with previous reports that have shown a strong association between poor glycemic control and increased cardiovascular risk [18]. This emphasizes the importance of achieving optimal glycemic targets to reduce both microvascular and macrovascular complications of diabetes.

CONCLUSION

The present study demonstrates a significant correlation between HbA1c levels and lipid profile abnormalities in patients with Type 2 Diabetes Mellitus. Higher HbA1c levels were associated with increased total cholesterol, triglycerides, LDL-cholesterol, and VLDL-cholesterol, along with reduced HDL-cholesterol. These findings indicate that poor glycemic control is linked to an atherogenic lipid profile and increased cardiovascular risk. HbA1c may therefore serve as a useful marker for identifying diabetic patients who are at greater risk of dyslipidemia. Regular monitoring and optimal control of both glycemic status and lipid parameters are essential to reduce long-term cardiovascular complications in Type 2 Diabetes Mellitus.

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