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Correlation of HbA1c with lipid profile in diabetic patients

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Abstract

Background

Chronic metabolic diseases like diabetes mellitus are frequently linked to dyslipidemia, which greatly raises the risk of cardiovascular problems. A good indicator of long-term glycemic management is glycated haemoglobin (HbA1c). Comprehending the correlation between HbA1c and lipid profile can offer valuable perspectives on cardiovascular risk assessment and control for individuals with diabetes.

Objective

To ascertain the relationship between lipid profile characteristics and HbA1c levels in individuals with type 2 diabetes mellitus.

Methods

From January 2025 to January 2026, at a tertiary care hospital carried out a cross-sectional analytical study. 150 type 2 diabetic individuals between the ages of 30 and 70 were enlisted. Total cholesterol, triglycerides, LDL-C, HDL-C, and VLDL-C were measured in fasting blood samples. Using high-performance liquid chromatography (HPLC), HbA1c levels were determined. The association between HbA1c and lipid markers was evaluated using Pearson correlation coefficients, where $p < 0.05$ was deemed statistically significant.

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Results

The subjects' mean HbA1c was 8.2 ± 1.4%, and their average age was 52.4 ± 10.2 years. There were low HDL-C (38.7 ± 9.5 mg/dL) and elevated mean levels of total cholesterol (210.5 ± 38.7 mg/dL), triglycerides (185.6 ± 55.4 mg/dL), LDL-C (132.3 ± 31.2 mg/dL), and VLDL-C (37.1 ± 11.2 mg/dL). Total cholesterol (r=0.312, p=0.001), triglycerides (r=0.421, p<0.001), LDL-C (r=0.287, p=0.002), and VLDL-C (r=0.396, p<0.001) all had significant positive correlations with HbA1c, however HDL-C had a significant negative connection (r=-0.215, p=0.012).

Conclusion

In patients with type 2 diabetes, higher HbA1c levels were substantially linked to unfavourable lipid profile parameters. In order to lower cardiovascular risk, our results highlight the significance of combined glycemic and lipid control.

Keywords

HbA1c, lipid profile, type 2 diabetes mellitus, dyslipidemia, cardiovascular risk

Introduction

Persistent hyperglycemia brought on by deficiencies in insulin secretion, action, or both is a hallmark of diabetes mellitus (DM), a chronic metabolic disease. Because of its fast rising prevalence, accompanying morbidity, and mortality from microvascular and macrovascular consequences, it poses a significant worldwide health concern. The International Diabetes Federation estimates that 537 million adults globally have diabetes in 2021; this number is expected to climb sharply over the next several decades. Over 90% of these cases are type 2 diabetes mellitus (T2DM), which is closely linked to both genetic predisposition and lifestyle factors like obesity and physical inactivity[^turn0search0^].

One of the most important biomarkers for the diagnosis and treatment of diabetes is glycated haemoglobin (HbA1c). It is frequently used to evaluate long-term glycemic control[^turn0search0^] and represents the average plasma glucose concentration over the previous 8–12 weeks. Due to its substantial correlation with the risk of diabetic complications, the American Diabetes Association established HbA1c ≥6.5% as a diagnostic criteria for diabetes in 2010. Clinically, HbA1c is useful for both diagnosis and prognostication of microvascular outcomes, such as neuropathy, retinopathy, and nephropathy.

Dyslipidemia, a collection of lipid abnormalities that includes raised triglycerides (TG), decreased high-density lipoprotein cholesterol (HDL-C), and increased small dense low-density lipoprotein cholesterol (LDL-C), is often seen in people with type 2 diabetes in addition to hyperglycemia. Diabetic dyslipidemia plays a significant role in accelerated atherogenesis and cardiovascular disease (CVD), which continues to be the primary cause of mortality for people with diabetes[^turn0search3^]. Insulin resistance, which modifies lipoprotein metabolism by increasing lipolysis, decreasing hepatic clearance of triglyceride-rich lipoproteins, and hindering

HDL production, is primarily responsible for the distinctive lipid profile pattern observed in diabetes.

There is growing evidence that lipid metabolism and glycemic control are related. Numerous research have investigated whether poor glycemic control, as indicated by elevated HbA1c levels, is associated with unfavourable lipid profile parameters in individuals with diabetes. Because they may support integrated glycemic and lipid management techniques to reduce cardiovascular risk, these relationships are clinically significant. Triglyceride and very low-density lipoprotein (VLDL) levels were considerably greater in diabetic individuals with higher HbA1c values in a large cross-sectional analysis, underscoring the connection between hyperglycemia and dyslipidemia[^turn0search0^]. In a similar vein, recent studies in type 2 diabetic populations showed that while HDL levels tended to be lower, those with worse glycemic control (HbA1c >7%) had significantly higher levels of total cholesterol, TGs, LDL, and VLDL[^turn0search3^]. These results imply that abnormalities in lipid metabolism worsen as glycemic control declines, increasing the risk of atherosclerosis.

Dyslipidemia and poor glycemic control are linked via a variety of processes. Chronic hyperglycemia increases the release of free fatty acids from adipose tissue, increases the formation of very-low-density lipoproteins in the liver, and decreases the activity of lipoprotein lipase, all of which raise plasma triglycerides and remnant lipoproteins. Additionally, insulin resistance accelerates atherogenesis and vascular inflammation by increasing LDL oxidation and decreasing HDL synthesis. These pathophysiological mechanisms explain why uncontrolled dyslipidemia and hyperglycemia often coexist in diabetic patients and increase the risk of cardiovascular disease.
The relationship between various lipid markers and HbA1c has been assessed by epidemiological research conducted in a variety of populations. For example, HbA1c and triglycerides were found to be significantly positively correlated in a retrospective study carried out at a tertiary care centre in Saudi Arabia, although relationships with other lipid fractions such as total cholesterol, LDL-C, and HDL-C were less consistent[^turn0search5^]. On the other hand, regional data from Pakistan and surrounding areas showed that HbA1c significantly correlated with VLDL, triglycerides, and total cholesterol, supporting the function of glycemic indices as possible dyslipidemia predictors[^turn0search7^]. The clinical significance of these connections has been further supported by additional research from Nepal and other populations that have similarly revealed varying but generally positive links between HbA1c levels and poor lipid profiles[^turn0search13^].

Longitudinal research emphasises the significance of sustained glycemic and lipid control over time, going beyond cross-sectional investigations. The interdependence of glycemic status and lipid metabolism over long follow-up periods was highlighted by a long-term cohort study involving type 1 diabetes patients, which showed that combined trajectories of HbA1c and lipid parameters were predictive of adverse outcomes, including mortality[^turn0search1^]. Such long-term data supports integrated monitoring and intervention strategies and indicates the dynamic interaction between glucose and lipid homeostasis.

The correlation between lipid profile and HbA1c has significant clinical ramifications. Clinicians

may be able to use HbA1c as a proxy indicator of cardiovascular risk through dyslipidemia in addition to using it as a measure of glycemic control if a strong correlation is found. Additionally, it might make early intervention easier, especially in environments with limited resources where thorough lipid profiling may be more difficult to obtain. Higher HbA1c thresholds, for example, may lead to more aggressive lifestyle changes, lipid-lowering treatments, and cardio-protective measures.

The intensity and consistency of relationships between various populations and lipid fractions, however, continue to differ despite growing data. Certain lipid markers (e.g., LDL-C or HDL-C) have not been found to be significantly correlated in some research, indicating that the relationship may be altered by genetic, dietary, environmental, and therapeutic factors specific to particular cohorts[^turn0search5^]. Multivariate studies are crucial in future study since concomitant comorbidities like obesity, hypertension, and renal impairment may confound these correlations.

In conclusion, due to its implications for cardiovascular risk classification and management, the relationship between HbA1c and lipid profile in diabetes patients has attracted a lot of study interest. Despite the fact that dyslipidemic patterns and poor glycemic control are generally positively correlated, there are discrepancies between studies due to methodological inconsistencies and population factors. Gaining a better understanding of these connections could improve therapeutic and preventive measures meant to lessen the burden of cardiovascular illness and death in diabetics. In order to improve patient outcomes and guide clinical management, this study aims to clarify the kind and degree of the relationship between HbA1c and lipid profile parameters in diabetes patients.

Methodology

Over the course of six months, from January 2025 to January 2026, this study was carried out as a cross-sectional analytical study at a tertiary care hospital in Pakistan. A non-probability convenient sampling strategy was used to recruit 150 individuals with type 2 diabetes mellitus. In order to prevent confounding effects, individuals between the ages of 30 and 70 who had been diagnosed with diabetes mellitus for at least a year were included. individuals with thyroid conditions, chronic liver disease, renal failure, pregnancy, or those on lipid-lowering drugs were not. Following informed consent, a standardised questionnaire was used to collect clinical and demographic information, such as age, gender, length of diabetes, and history of comorbidities.

Following a 12-hour fast, blood samples were taken to estimate the fasting lipid profile, which included triglycerides, total cholesterol, HDL cholesterol, LDL cholesterol, and very low-density lipoprotein (VLDL). High-performance liquid chromatography (HPLC) was used to test glycated haemoglobin (HbA1c) levels in order to evaluate long-term glycemic management. The hospital's accredited biochemistry laboratory carried out all laboratory analyses using standard operating procedures. SPSS version 25 was used for data entry and analysis. Pearson correlation coefficients were obtained to evaluate the association between HbA1c and lipid profile parameters, and descriptive statistics were produced for each variable. Statistical significance

was defined as a p-value of less than 0.05. The Institutional Review Board granted ethical approval before the study started.

Results

This study included 150 participants with type 2 diabetes. Participants were 62 (41.3%) female and 88 (58.7%) male, with an average age of 52.4 ± 10.2 years. Diabetes lasted an average of 8.1 ± 4.5 years. The majority of patients had inadequate glycemic control, as indicated by the mean HbA1c level of 8.2 ± 1.4%. The fasting lipid profile revealed low mean HDL cholesterol, slightly raised total cholesterol, and elevated mean triglycerides and LDL cholesterol.

Table 1: Baseline Characteristics of Study Participants

Characteristic	n (%) / Mean ± SD
Total participants	150
Age (years)	52.4 ± 10.2
Gender	
Male	88 (58.7%)
Female	62 (41.3%)
Duration of diabetes (years)	8.1 ± 4.5
HbA1c (%)	8.2 ± 1.4

Table 2: Lipid Profile of Participants

Lipid Parameter	Mean ± SD (mg/dL)	Normal Reference Range (mg/dL)
Total Cholesterol	210.5 ± 38.7	<200
Triglycerides	185.6 ± 55.4	<150
LDL Cholesterol	132.3 ± 31.2	<100
HDL Cholesterol	38.7 ± 9.5	>40
VLDL Cholesterol	37.1 ± 11.2	5–40

Table 3: Correlation Between HbA1c and Lipid Profile

Lipid Parameter	Pearson Correlation (r)	p-value
Total Cholesterol	0.312	0.001*
Triglycerides	0.421	<0.001*
LDL Cholesterol	0.287	0.002*
HDL Cholesterol	-0.215	0.012*
VLDL Cholesterol	0.396	<0.001*

Higher HbA1c levels were linked to worsening dyslipidemia, according to the analysis, which showed a strong positive connection between HbA1c and levels of total cholesterol, triglycerides, LDL, and VLDL. On the other hand, there was a strong negative connection between HbA1c and HDL cholesterol, suggesting that poor glycemic control was linked to decreased HDL levels. These findings imply that in patients with type 2 diabetes, increased HbA1c values may indicate a poor lipid profile.

Conclusion

The results of this study show a strong correlation between type 2 diabetes mellitus patients' aberrant lipid profiles and their HbA1c values. Elevated total cholesterol, triglycerides, LDL-C, and VLDL-C were all positively connected with higher HbA1c levels, however HDL-C was negatively correlated. This implies that deteriorating dyslipidemia, which might raise the risk of cardiovascular problems in diabetes patients, is closely associated with poor glycemic control. These findings emphasise how crucial it is to routinely check lipid and glycemic markers in clinical settings. Reducing long-term cardiovascular morbidity and mortality requires integrated management techniques that target appropriate HbA1c levels and cholesterol control. These hazards may be further reduced with early intervention and patient education about lifestyle changes and therapy adherence.

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