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Original Research Article

A Clinical Utility of HbA1c in Detecting Dyslipidemia among Patients with Type 2 Diabetes Mellitus in Saurashtra Region of Gujarat

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Abstract

Background: Type 2 diabetes mellitus (T2DM) often comes with dyslipidemia, a key factor in increasing cardiovascular risks. While HbA1c is commonly used to measure long-term blood sugar control, this study explored whether HbA1c could also help detect lipid abnormalities in diabetic patients, providing a more comprehensive assessment of their cardiovascular health.

Aims and Objectives: This study aimed to investigate the relationship between HbA1c levels and dyslipidemia markers in T2DM patients, to determine if HbA1c could serve as a reliable biomarker for early detection of dyslipidemia.

Methods and Materials: Participants with elevated HbA1c levels were included in the study. After obtaining informed consent, their medical histories were recorded. Diagnostic procedures included HbA1c measurement, and a detailed lipid profile analysis. Statistical analysis, including unpaired t-tests, was performed to assess the correlation between HbA1c and dyslipidemia markers.

Results: The findings showed a strong association between higher HbA1c levels and increased dyslipidemia markers, particularly elevated triglycerides and lower HDL cholesterol levels. This supported the hypothesis that HbA1c can indicate lipid abnormalities in diabetic patients ($p < 0.05$).

Discussion: These results suggest that HbA1c not only reflects glycemic control but could also be a valuable tool in predicting lipid abnormalities. Using HbA1c as a dual-purpose marker could improve cardiovascular risk assessments and lead to more personalized care for T2DM patients.

Conclusion: The study concluded that HbA1c is a promising biomarker for identifying dyslipidemia in T2DM patients. Routine inclusion of HbA1c in lipid screenings could enhance early detection and management of cardiovascular risks in diabetic care.

Keywords: HbA1c, Dyslipidemia, Type 2 Diabetes Mellitus, Lipid Profile, Cardiovascular Risk.

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Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder that results in elevated blood glucose levels due to the body's inability to produce or effectively use insulin. The most common types are type 1 diabetes, type 2 diabetes (T2DM), and several other forms such as maturity-onset diabetes of the young (MODY) and latent autoimmune diabetes in adults (LADA).

Type 1 diabetes is an autoimmune condition where the immune system destroys insulin-producing beta cells in the pancreas, often diagnosed in childhood. Type 2 diabetes, which is more prevalent, occurs when the body becomes resistant to insulin or fails to produce sufficient amounts of it, often due to factors like obesity and aging. MODY is a rare, inherited form of diabetes caused by gene mutations affecting insulin production, typically manifesting before the age of 25. LADA, sometimes referred to as "type 1.5 diabetes," shares characteristics with both type 1 and type 2 diabetes and tends to progress more slowly than type 1. [2,5]

In India, around 77 million adults live with diabetes, predominantly type 2 diabetes, which accounts for over 90% of cases. This aligns with the global trend, where approximately 1 in 11 adults has diabetes. The increasing prevalence of diabetes, particularly in low- and middle-income

countries, has made it a pressing public health issue. Diabetes is now one of the leading causes of death worldwide, significantly contributing to complications such as cardiovascular disease, kidney failure, and blindness. An essential tool in managing and diagnosing diabetes is the measurement of glycated hemoglobin (HbA1c), which provides an indication of average blood glucose levels over the previous two to three months. Since the early 2000s, HbA1c has been recommended as a standard for diagnosing diabetes and monitoring long-term glycemic control. [3,19] Additionally, dyslipidemia, marked by abnormal cholesterol and triglyceride levels, is common in diabetics and increases the risk of cardiovascular disease. Dyslipidemia can also worsen glycemic control by impairing beta-cell function in the pancreas. However, the precise relationship between HbA1c and lipid profiles in diabetes is not yet fully understood. [4,10]

This study aims to explore the correlation between HbA1c and lipid profiles in individuals with diabetes, prediabetes, and non-diabetics, with the goal of enhancing early cardiovascular risk detection and management in diabetic patients.

Materials and Methods

The present investigation was designed as a cross-sectional observational study, this study was conducted at a tertiary care centre in Gujarat, following approval from the Institute Research Committee and Ethics Committee The study took place from August 2024 – January 2025. A total of 60 individuals who provided blood samples for glucose testing and consented to participate were included. Of these, 30 were non-diabetic and 30 diagnosed with type 2 diabetes mellitus (T2DM), based on the American Diabetes Association criteria.

Inclusion Criteria

Age 30-70 male and female

- Patients diagnosed with diabetes mellitus Type 2.
- Availability of recent HbA1c levels within the last 3 months.
- Willingness to participate in the study and provide informed consent.

B. Exclusion Criteria

- Patients with secondary dyslipidemia due to conditions such as hypothyroidism, nephrotic syndrome, or hepatic disease.
- Individuals with a documented history of cardiovascular events, including myocardial infarction, cerebrovascular accident, or peripheral artery disease.
- Pregnant or lactating females.
- Patients diagnosed with chronic kidney disease (CKD).
- Subjects with recent exposure to medications known to influence lipid metabolism, such as corticosteroids or hormonal contraceptives, within the preceding three months, or those with acute illnesses or a recent history of infections.

C. Procedure and Data Collection

Venous blood samples were collected after an overnight fast, with postprandial samples taken two hours after breakfast. Samples for plasma glucose, HbA1c, and lipid profile were collected in vacutainers (gray, purple, and red caps, respectively) and analysed in the Biochemistry Laboratory of P.D.U. Government medical college. HbA1c was measured using capillary electrophoresis, while lipid profile components were analysed on an automated clinical chemistry analyser. LDL was calculated using the Friedewald equation.

Non-diabetic controls (n = 30) attending for routine blood investigations were selected based on similar tests. Demographic and medical data were obtained from clinical booklets, and all relevant information was recorded using a standardized proforma.

D. Statistical Analysis

Data were analysed using IBM SPSS Statistics v30.0.0. Continuous variables were expressed as Mean ± Standard Deviation. Normality was assessed using the Shapiro-Wilk test.

The unpaired Student's t-test was used for intergroup comparison of continuous variables. Categorical variables such as sex distribution were analysed using the Chi-square test. A two-tailed p-value < 0.05 was considered statistically significant.

Results

A total of 60 participants were included in the study, comprising 30 non-diabetics and 30 patients with type 2 diabetes mellitus. The baseline anthropometric characteristics of both groups were comparable.

Table 1: Anthropometric and Clinical Measurements.

Descriptive statistics of Various Anthropometric and Clinical Measurements					
Parameter	**Non-Diabetics (N=30)**		**Diabetics (N=30)**		
Parameter	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**	**P-value**
Age (years	50.08	8.28	51.97	7.73	0.379
Height (cm)	166.8	6.5	167	6.7	0.843
Weight (kg)	70.5	10.2	71.2	10.5	0.729
BMI	24.4	4.1	24.6	4.2	0.791

The mean age of non-diabetic participants was 50.08 ± 8.28 years, while that of diabetic participants was 51.97 ± 7.73 years, with no statistically significant difference (p = 0.379). Similarly, the mean height was 166.8 ± 6.5 cm in non-diabetics and 167 ± 6.7 cm in diabetics (p = 0.843).

The average body weight was 70.5 ± 10.2 kg in the non-diabetic group and 71.2 ± 10.5 kg in the diabetic group, which was not statistically significant (p = 0.729). Body mass index (BMI) was also comparable between the two groups, with mean values of 24.4 ± 4.1 kg/m² in non-diabetics and 24.6 ± 4.2 kg/m² in diabetics (p = 0.791). Overall, there were no statistically significant differences in baseline anthropometric parameters between the diabetic and non-diabetic groups, indicating that both groups were well matched. Glycemic status differed markedly between groups. The mean HbA1c level was significantly higher in the diabetic group (9.23 ± 1.61%) compared to the non-diabetic group (4.91 ± 0.63%), which was statistically highly significant (p = 0.001).

Regarding lipid parameters, triglyceride levels were significantly elevated in diabetics (157.8 ± 52.52 mg/dL) compared to non-diabetics (123.63 ± 45.52 mg/dL; p = 0.017). Similarly, total cholesterol was significantly higher in the diabetic group (180.02 ± 21.6 mg/dL) than in controls (166.07 ± 27.26 mg/dL; p = 0.032). Very low-density lipoprotein (VLDL) levels were also significantly elevated in diabetics (36.99 ± 9.26 mg/dL) compared to non-diabetics (29.88 ± 7.01 mg/dL), with strong statistical significance (p = 0.001).

Table 2: Comparison of Clinical and Biochemical Parameters between Non-Diabetic and Diabetic Groups

Parameters	**Non-diabetic**		**Diabetic**		**p value**
	Mean	**SD**	**Mean**	**SD**	
Age	50.08	8.28	51.97	7.73	0.379
HbA1C	4.91	0.63	9.23	1.61	0.001
TG	123.63	45.52	157.8	52.52	0.017
Total Cholesterol	166.07	27.26	180.02	21.6	0.032
HDL	49.69	5.73	46.6	6.4	0.054
VLDL	29.88	7.01	36.99	9.26	0.001
LDL	118.6	18.58	114.61	20.8	0.187

High-density lipoprotein (HDL) levels were lower in diabetics (46.6 ± 6.4 mg/dL) than in non-diabetics (49.69 ± 5.73 mg/dL); however, this difference did not reach statistical significance (p = 0.054), though it showed a declining trend.

Low-density lipoprotein (LDL) levels did not differ significantly between the two groups (118.6 ± 18.58 mg/dLin non-diabetics vs. 114.61 ± 20.8 mg/dL in diabetics; p = 0.187).

Overall, diabetic patients demonstrated significantly higher HbA1c, triglycerides, total cholesterol, and VLDL levels, suggesting a pattern of diabetic dyslipidemia.

Discussion

The present study evaluated the association between glycemic control and lipid abnormalities in patients with type 2 diabetes mellitus. The findings demonstrated significantly higher HbA1c levels in diabetic patients compared to non-diabetic controls, confirming poor glycemic control in the diabetic group. This marked difference validates appropriate group categorization and reflects chronic hyperglycemia, a hallmark of type 2 diabetes. [2,9] In the present study, diabetic patients exhibited significantly elevated triglyceride levels compared to controls. Hypertriglyceridemia is a well-recognized feature of diabetic dyslipidemia and is primarily driven by insulin resistance. [6,19] Insulin normally stimulates lipoprotein lipase activity, which facilitates the clearance of triglyceride-rich lipoproteins. In diabetes, impaired insulin action reduces lipoprotein lipase activity and increases hepatic production of very low-density lipoprotein (VLDL), leading to elevated circulating triglycerides. The observed increase in VLDL levels in the diabetic group further supports this mechanism and reflects increased hepatic lipid synthesis. [6,19].

Total cholesterol levels were also significantly higher among diabetic participants. Although the difference was modest, this finding aligns with the metabolic disturbances seen in diabetes, where altered lipid metabolism contributes to increased atherogenic burden. [4,9] Elevated total cholesterol in the presence of hyperglycemia may accelerate endothelial dysfunction and atherosclerosis, thereby increasing cardiovascular risk. [4]

High-density lipoprotein (HDL) levels were lower in diabetics compared to non-diabetics, although the difference did not reach statistical significance. However, the declining trend in HDL is clinically relevant, as reduced HDL is a known component of diabetic dyslipidemia. HDL plays a protective role through reverse cholesterol transport and anti-inflammatory actions. Even borderline reductions in HDL may contribute to increased cardiovascular susceptibility in diabetic individuals. Interestingly, low-density lipoprotein (LDL) levels did not differ significantly between groups. This observation may be explained by the qualitative rather than quantitative changes in LDL seen in diabetes. Diabetic patients often exhibit small, dense LDL particles, which are more atherogenic despite normal absolute LDL concentrations. Therefore, the lack of significant difference in LDL levels does not necessarily imply reduced cardiovascular risk. The coexistence of elevated HbA1c with adverse lipid parameters in this study highlights the close interrelationship between glucose and lipid metabolism. Chronic hyperglycemia promotes glycation of lipoproteins, oxidative stress, and hepatic lipid overproduction, all of which contribute to dyslipidemia. The simultaneous presence of hyperglycemia and lipid abnormalities underscores the concept of a common metabolic pathway linking diabetes and cardiovascular disease. [18,19] From a clinical perspective, the findings suggest that HbA1c may serve as a useful indicator not only of glycemic control but also of associated lipid abnormalities. Since HbA1c testing is routinely performed in diabetic care, its potential role as a surrogate marker for dyslipidemia could aid in early cardiovascular risk stratification, especially in resource-limited settings. [1,8,17]

The results of this study are consistent with previous reports demonstrating higher triglycerides and VLDL levels in diabetic populations, along with relatively preserved LDL concentrations but increased atherogenic potential. The near-significant reduction in HDL observed in this study further supports the classical pattern of diabetic dyslipidemia. [15,18,19]

Conclusion

A prominent dyslipidemic feature observed in the present study was hypertriglyceridemia, which emerged as the most significant lipid abnormality among diabetic individuals. This finding aligns with the classical pattern of diabetic dyslipidemia and highlights the metabolic consequences of insulin resistance. Hypertriglyceridemia in diabetes primarily results from impaired clearance of triglyceride-rich lipoproteins.

Under normal physiological conditions, insulin enhances the activity of lipoprotein lipase (LPL), an enzyme responsible for the hydrolysis of triglycerides present in chylomicrons and very low-density lipoproteins (VLDL). However, in states of insulin deficiency or resistance, reduced LPL activity leads to decreased triglyceride breakdown and subsequent elevation of circulating triglyceride levels.

Additionally, insulin resistance promotes increased lipolysis in adipose tissue, resulting in excessive release of free fatty acids into the circulation. These free fatty acids are transported to the liver, where they are re-esterified into triglycerides, further increasing hepatic VLDL production. The combined effect of impaired triglyceride clearance and enhanced hepatic lipid synthesis contributes to elevated triglyceride and VLDL levels in diabetic patients.

These metabolic disturbances emphasize the importance of routine lipid monitoring in individuals with type 2 diabetes mellitus. Early detection of hypertriglyceridemia and associated lipid abnormalities can facilitate timely therapeutic interventions, thereby reducing the risk of atherosclerosis and cardiovascular complications.

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