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THE DUAL BURDEN OF HYPERGLYCEMIA AND DYSLIPIDEMIA: CORRELATION OF HBA1C WITH SERUM 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 contributes to cardiovascular morbidity and mortality. Glycosylated Hemoglobin (HbA1c) is a well-established marker of long-term glycemic control and may also reflect lipid abnormalities and cardiometabolic risk. The aim is to evaluate the correlation between Glycosylated Hemoglobin (HbA1c) and serum lipid profile parameters in patients with Type 2 Diabetes Mellitus and assess its utility as a predictor of dyslipidemia.

Materials and Methods: This hospital-based cross-sectional observational study included 87 patients with Type 2 Diabetes Mellitus. Demographic data, anthropometric measurements, glycemic parameters, and serum lipid profile were assessed. HbA1c was estimated using standardized laboratory methods. Pearson's correlation analysis was used to determine the association between HbA1c and lipid profile parameters. A p-value <0.05 was considered statistically significant.

Results: The mean age of participants was 53.06 ± 8.23 years, and 65.5% were males. The mean HbA1c level was 10.31 ± 2.04%. HbA1c demonstrated significant positive correlations with Total Cholesterol ($r = 0.85$, $p < 0.001$), Triglycerides ($r = 0.84$, $p < 0.001$), VLDL Cholesterol ($r = 0.84$, $p < 0.001$), LDL Cholesterol ($r = 0.70$, $p < 0.001$), and Postprandial Blood Sugar ($r = 0.54$, $p < 0.001$). No significant correlation was observed with HDL Cholesterol, BMI, abdominal circumference, weight, height, or fasting blood sugar.

Conclusion: Elevated HbA1c levels are significantly associated with adverse lipid profile alterations in patients with Type 2 Diabetes Mellitus. HbA1c may serve as a useful surrogate marker for dyslipidemia and cardiometabolic risk assessment. Regular monitoring of HbA1c may facilitate early identification of patients at increased cardiovascular risk and support timely intervention.

Keywords: Type 2 Diabetes Mellitus; HbA1c; Dyslipidemia; Lipid Profile; Total Cholesterol; Triglycerides; LDL Cholesterol; Cardiometabolic Risk; Glycemic Control.

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and/or impaired insulin secretion.[1] It is one of the most common non-communicable diseases worldwide and constitutes a major public health concern because of its increasing prevalence and associated complications.[1,2] According to the International Diabetes Federation (IDF), the global burden of diabetes continues to rise, with India being among the countries most affected by the disease.[3-5] The growing incidence of T2DM is attributed to rapid urbanization, sedentary lifestyles, dietary changes, obesity, and increasing life expectancy.[3] Persistent hyperglycemia in T2DM leads to various metabolic disturbances and contributes significantly to the development of both microvascular and macrovascular complications.[1,2]

Cardiovascular disease is the leading cause of morbidity and mortality among patients with T2DM.[2] Several risk factors contribute to the increased cardiovascular risk observed in diabetic patients, among which dyslipidemia plays a crucial role.[6-9] Diabetic dyslipidemia is characterized by elevated triglycerides, increased low-density lipoprotein cholesterol (LDL-C), elevated very low-density lipoprotein cholesterol (VLDL-C), and decreased high-density lipoprotein cholesterol (HDL-C).[6-9] These lipid abnormalities accelerate the process of atherosclerosis and significantly increase the risk of coronary artery disease, cerebrovascular disease, and peripheral vascular disease.[6,8] Insulin resistance, which is the hallmark of T2DM, contributes to altered lipid metabolism through increased hepatic synthesis of triglyceride-rich lipoproteins, reduced clearance of circulating lipids, and impaired regulation of lipoprotein metabolism.[6-9]

Glycosylated 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.[10,11] It is widely accepted as a reliable marker for long-term glycemic control and has become an essential tool for monitoring diabetic patients.[1,10] Higher HbA1c levels indicate poor glycemic control and are associated with an increased risk of diabetic complications.[1,2] In addition to its role in assessing glycemic status, recent studies have suggested that HbA1c may also be associated with various metabolic abnormalities, including dyslipidemia.[12-18]

The relationship between glycemic control and lipid abnormalities has gained considerable attention in recent years.[12-18] Poor glycemic control is often accompanied by derangements in lipid metabolism, resulting in elevated serum cholesterol, triglycerides, and LDL-C levels along with reduced HDL-C concentrations.[6-9,12-18] These abnormalities contribute significantly to cardiovascular complications among diabetic patients.[2] Since HbA1c is routinely measured in clinical practice, establishing its correlation with lipid profile parameters may provide an additional advantage in identifying individuals at higher risk for cardiovascular disease.[12-18] A strong association between HbA1c and serum lipid abnormalities would suggest that HbA1c could serve as a useful predictor of dyslipidemia and cardiometabolic risk.[12-18]

Several studies have reported significant correlations between HbA1c and various lipid parameters in patients with T2DM.[12-18] Elevated HbA1c levels have been associated with increased total cholesterol, triglycerides, LDL-C, and VLDL-C levels and decreased HDL-C levels.[12-18] However, variations in study populations, ethnic backgrounds, duration of diabetes, and treatment modalities have resulted in inconsistent findings across different studies.[12-18] Therefore, further evaluation of this relationship is necessary, particularly in the Indian population where the burden of diabetes and cardiovascular disease is rapidly increasing.[3-5]

Identification of dyslipidemia at an early stage is essential for preventing cardiovascular complications and improving long-term outcomes in patients with T2DM.[2,6] If HbA1c demonstrates a strong correlation with lipid abnormalities, it may serve as a convenient and cost-effective marker for predicting dyslipidemia and identifying patients requiring early intervention.[12-18] This could facilitate comprehensive risk assessment and improve clinical management strategies aimed at reducing cardiovascular morbidity and mortality among diabetic patients.[2]

In view of the increasing prevalence of Type 2 Diabetes Mellitus and its associated cardiovascular complications, the present study is undertaken to evaluate the correlation between Glycosylated Hemoglobin (HbA1c) and serum lipid profile parameters in patients with Type 2 Diabetes Mellitus and to assess the potential role of HbA1c as a predictor of dyslipidemia and cardiometabolic risk.

Aim of the Study

The aim of the present study is to evaluate the correlation between Glycosylated Hemoglobin (HbA1c) levels and serum lipid profile parameters in patients with Type 2 Diabetes Mellitus and to assess the utility of HbA1c as a predictor of dyslipidemia and cardiometabolic risk.

Objectives of the Study

The objectives of the study are to estimate the levels of Glycosylated Hemoglobin (HbA1c) among patients with Type 2 Diabetes Mellitus; to assess serum lipid profile parameters including total cholesterol, triglycerides, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and very low-density lipoprotein cholesterol; to determine the correlation between HbA1c levels and individual lipid profile parameters; to compare lipid profile abnormalities between patients with good and poor glycemic control; and to evaluate the usefulness of HbA1c as a predictor of dyslipidemia and cardiometabolic risk in patients with Type 2 Diabetes Mellitus.

MATERIALS AND METHODS

The present study will be a hospital-based cross-sectional observational study conducted in the Department of Biochemistry in collaboration with the Department of General Medicine at a tertiary care teaching hospital. The study will be carried out over a period of 18 months after obtaining approval from the Institutional Ethics Committee. Patients diagnosed with Type 2 Diabetes Mellitus attending the Medicine Outpatient Department and those admitted to medical wards during the study period will be considered for inclusion in the study.

Adult patients aged 18 years and above with a confirmed diagnosis of Type 2 Diabetes Mellitus and willing to provide written informed consent will be enrolled. Patients with Type 1 Diabetes Mellitus, gestational diabetes mellitus, chronic liver disease, chronic kidney disease, thyroid disorders, acute infections, hereditary lipid disorders, pregnant women, and those receiving lipid-lowering medications will be excluded from the study to minimize confounding factors affecting lipid metabolism.

After obtaining informed consent, demographic details and relevant clinical information including age, sex, duration of diabetes, treatment history, body mass index, and associated comorbidities will be recorded using a structured proforma. Following an overnight fast of 8–12 hours, approximately 5 mL of venous blood will be collected under aseptic precautions. Blood samples will be divided into EDTA and plain vacutainers for estimation of HbA1c and serum lipid profile respectively.

HbA1c will be estimated using High-Performance Liquid Chromatography (HPLC) or an immunoturbidimetric method according to the laboratory protocol. Serum lipid profile including total cholesterol, triglycerides, HDL cholesterol, LDL cholesterol, and VLDL cholesterol will be analyzed using standard enzymatic methods on a fully automated biochemistry analyzer. Internal and external quality control measures will be followed to ensure accuracy and reliability of laboratory results.

Patients will be categorized based on glycemic control using HbA1c values, with HbA1c less than 7% indicating good glycemic control and HbA1c equal to or greater than 7% indicating poor glycemic control. Dyslipidemia will be defined according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) guidelines.

The collected data will be entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 26.0 or an equivalent statistical software package. Continuous variables will be expressed as mean ± standard deviation, whereas categorical variables will be expressed as frequencies and percentages. Pearson's correlation coefficient will be used to determine the relationship between HbA1c and lipid profile parameters. Appropriate statistical tests such as Student's t-test or Mann–Whitney U test will be applied for comparison between groups. A p-value of less than 0.05 will be considered statistically significant.

Confidentiality of participant information will be maintained throughout the study. Written informed consent will be obtained from all participants, and the study will be conducted in accordance with the ethical principles of the Declaration of Helsinki and institutional ethical guidelines.

RESULTS

Table 1: Age Distribution of Study Participants (n = 87)

Age Group (Years)	Frequency (n)	Percentage (%)
< 40	2	2.3
40–49	25	28.7
50–59	38	43.7
≥ 60	22	25.3
Total	87	100.0

Interpretation

The majority of study participants belonged to the age group of 50–59 years (43.7%), followed by 40–49 years (28.7%) and ≥60 years (25.3%). Only 2.3% of patients were younger than 40 years. The findings indicate that Type 2 Diabetes Mellitus was predominantly observed among middle-aged and elderly individuals.

Table 2: Gender Distribution of Study Participants (n = 87)

Gender	Frequency (n)	Percentage (%)
Male	57	65.5
Female	30	34.5
Total	87	100.0

Interpretation

Among the 87 study participants, 57 (65.5%) were males and 30 (34.5%) were females, indicating a male predominance with a male-to-female ratio of approximately 1.9:1.

Table 3: Descriptive Statistics of Anthropometric, Glycemic and Lipid Parameters (n = 87)

Parameter	Mean ± SD
Age (years)	53.06 ± 8.23
Duration of Diabetes (years)	8.70 ± 2.89
Weight (kg)	60.78 ± 13.51
Height (cm)	161.85 ± 8.21

BMI (kg/m²)	23.11 ± 4.38
Abdominal Circumference (cm)	86.30 ± 14.89
Fasting Blood Sugar (mg/dL)	130.48 ± 22.21
Postprandial Blood Sugar (mg/dL)	230.57 ± 42.46
HbA1c (%)	10.31 ± 2.04
Triglycerides (mg/dL)	235.63 ± 53.09
Total Cholesterol (mg/dL)	166.71 ± 42.57
HDL Cholesterol (mg/dL)	42.38 ± 6.39
VLDL Cholesterol (mg/dL)	47.13 ± 10.62
LDL Cholesterol (mg/dL)	77.21 ± 40.19

Interpretation

The mean age of the participants was 53.06 ± 8.23 years and the mean duration of diabetes was 8.70 ± 2.89 years. The mean HbA1c level was 10.31 ± 2.04%, indicating poor glycemic control among the study population. Mean triglyceride, total cholesterol, VLDL cholesterol and LDL cholesterol levels were elevated, reflecting a high prevalence of dyslipidemia among patients with Type 2 Diabetes Mellitus.

Table 4: Correlation Between HbA1c and Study Parameters

Parameter	Correlation Coefficient (r)	p-value	Significance
Weight	0.15	0.17	NS
Height	-0.07	0.51	NS
BMI	0.19	0.08	NS
Abdominal Circumference	0.03	0.80	NS
Fasting Blood Sugar	0.13	0.23	NS
Postprandial Blood Sugar	0.54	<0.001	Significant
Triglycerides	0.84	<0.001	Significant
Total Cholesterol	0.85	<0.001	Significant
HDL Cholesterol	-0.13	0.24	NS
VLDL Cholesterol	0.84	<0.001	Significant
LDL Cholesterol	0.70	<0.001	Significant

Interpretation

Pearson correlation analysis revealed a statistically significant positive correlation between HbA1c and postprandial blood sugar levels ($r = 0.54$, $p < 0.001$). HbA1c also demonstrated very strong positive correlations with total cholesterol ($r = 0.85$), triglycerides ($r = 0.84$), and VLDL cholesterol ($r = 0.84$), all of which were highly significant ($p < 0.001$). A strong positive correlation was observed between HbA1c and LDL cholesterol ($r = 0.70$, $p < 0.001$). No statistically significant correlation was found between HbA1c and HDL cholesterol, BMI, weight, height, abdominal circumference, or fasting blood sugar levels.

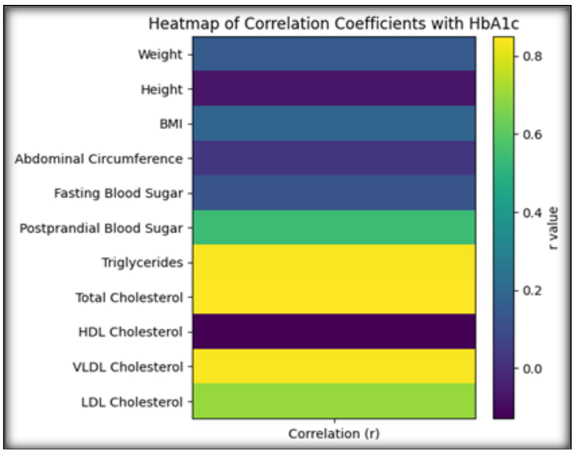

Figure 1: Heatmap Showing Correlation Between HbA1c and Anthropometric, Glycemic, and Lipid Profile Parameters in Patients with Type 2 Diabetes Mellitus

The heatmap illustrates Pearson's correlation coefficients (r) between Glycosylated Hemoglobin (HbA1c) and various anthropometric, glycemic, and lipid profile parameters among patients with Type 2 Diabetes Mellitus ($n = 87$). Positive correlation coefficients indicate a direct relationship with HbA1c, whereas negative coefficients indicate an inverse relationship. Strong positive correlations were observed between HbA1c and Total Cholesterol ($r = 0.85$), Triglycerides ($r = 0.84$), VLDL Cholesterol ($r = 0.84$), and LDL Cholesterol ($r = 0.70$) ($p < 0.001$ for all). A moderate positive correlation was observed with Postprandial Blood Sugar ($r = 0.54$; $p < 0.001$). No statistically significant correlations were observed between HbA1c and Weight, Height, Body Mass Index, Abdominal Circumference, Fasting Blood Sugar, or HDL Cholesterol ($p > 0.05$). Pearson's correlation coefficient (r) ranges from −1 to +1, with values closer to ±1 indicating stronger correlations.

Overall Results

A total of 87 patients with Type 2 Diabetes Mellitus were included in the study. The mean age was 53.06 ± 8.23 years, and males constituted 65.5% of the study population. The mean HbA1c level was 10.31 ± 2.04%, indicating poor glycemic control among participants.

Correlation analysis demonstrated that higher HbA1c levels were significantly associated with elevated total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol levels. The strongest correlation was observed between HbA1c and total cholesterol ($r = 0.85$, $p < 0.001$). These findings suggest that poor glycemic control is closely linked with worsening dyslipidemia and increased cardiovascular risk among patients with Type 2 Diabetes Mellitus.

DISCUSSION

The present hospital-based cross-sectional study was undertaken to evaluate the correlation between Glycosylated Hemoglobin (HbA1c) and serum lipid profile parameters among patients with Type 2 Diabetes Mellitus (T2DM). A total of 87 patients with T2DM were included in the study. The findings demonstrated significant positive correlations between HbA1c and atherogenic lipid parameters including total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol, suggesting that poor glycemic control is closely associated with dyslipidemia and increased cardiovascular risk. Similar associations between HbA1c and dyslipidemia have been reported by Alzahrani et al., Sharahili et al., Madhuri K et al., Bekele et al., and Khan et al.[12-14,17,18]

Age Distribution: The mean age of the study participants was 53.06 ± 8.23 years. The majority of patients (43.7%) belonged to the 50–59 years age group, followed by 28.7% in the 40–49 years age group. These findings indicate that T2DM predominantly affects middle-aged and older individuals.

The observed age distribution is comparable to that reported in several Indian studies. Madhuri K et al. reported a mean age of approximately 54 years among patients with T2DM.[14] Similar observations have been reported by Alzahrani et al. and Sharahili et al., where the majority of diabetic patients belonged to middle-aged and older age groups.[12,13] Increasing age is associated with progressive insulin resistance, β-cell dysfunction, reduced physical activity, and accumulation of cardiovascular risk factors, which contribute to the higher prevalence of diabetes in older populations.[1,3,5,15]

Gender Distribution: In the present study, males constituted 65.5% of the study population, while females accounted for 34.5%. The male predominance observed in our study is consistent with findings reported by Madhuri K et al. and Alzahrani et al.[12,14]

The higher prevalence among males may be attributed to differences in lifestyle factors, occupational stress, smoking habits, dietary practices, and healthcare-seeking behavior. Furthermore, men tend to develop metabolic syndrome and insulin resistance earlier than women, contributing to the increased burden of T2DM.[2,6]

Anthropometric Characteristics: The mean BMI of the study population was 23.11 ± 4.38 kg/m². Although obesity is a recognized risk factor for T2DM, the relatively modest BMI observed in the present study reflects the unique phenotype of South Asian populations, who tend to develop diabetes at lower BMI values compared to Western populations. Asian Indians are known to possess higher visceral adiposity and insulin resistance despite having comparatively lower BMI values.[15,16]

No statistically significant correlation was observed between HbA1c and BMI (r = 0.19, p = 0.08) or abdominal circumference (r = 0.03, p = 0.80). Similar observations have been reported by Alzahrani et al. and Bekele et al., suggesting that glycemic control may be influenced more by metabolic and hormonal factors than by anthropometric measurements alone.[12,17]

Glycemic Profile: The mean fasting blood sugar level was 130.48 ± 22.21 mg/dL, while the mean postprandial blood sugar level was 230.57 ± 42.46 mg/dL. The mean HbA1c level was 10.31 ± 2.04%, indicating poor glycemic control among the study participants.

HbA1c is considered the gold-standard marker for assessing long-term glycemic control because it reflects average blood glucose levels over the preceding 8–12 weeks.[10,11] Elevated HbA1c levels are associated with an increased risk of diabetic complications including nephropathy, retinopathy, neuropathy, and cardiovascular disease.[1,2,10]

In the present study, HbA1c demonstrated a significant positive correlation with postprandial blood sugar levels (r = 0.54, p < 0.001). This finding highlights the importance of postprandial hyperglycemia in determining overall glycemic status. Nathan et al. demonstrated that postprandial glucose contributes substantially to HbA1c levels, particularly in patients with poorly controlled diabetes.[11]

No statistically significant correlation was observed between HbA1c and fasting blood sugar levels (r = 0.13, p = 0.23). This finding suggests that a single fasting glucose measurement may not accurately reflect long-term glycemic control, emphasizing the superiority of HbA1c as a monitoring tool.[10,11]

Lipid Profile Characteristics: The mean triglyceride level in the present study was 235.63 ± 53.09 mg/dL, while mean total cholesterol, LDL cholesterol, HDL cholesterol, and VLDL cholesterol levels were 166.71 ± 42.57 mg/dL, 77.21 ± 40.19 mg/dL, 42.38 ± 6.39 mg/dL, and 47.13 ± 10.62 mg/dL respectively.

Dyslipidemia is one of the most common metabolic abnormalities associated with T2DM. Insulin resistance leads to increased lipolysis, enhanced hepatic free fatty acid flux, increased synthesis of triglyceride-rich lipoproteins, reduced lipoprotein lipase activity, and altered clearance of circulating lipoproteins.6-9 These mechanisms contribute to the characteristic diabetic dyslipidemia characterized by elevated triglycerides, elevated LDL cholesterol, elevated VLDL cholesterol, and reduced HDL cholesterol.[6-9]

HbA1c and Total Cholesterol: A very strong positive correlation was observed between HbA1c and total cholesterol (r = 0.85, p < 0.001). This indicates that worsening glycemic control is associated with increasing serum cholesterol levels.

Our findings are in agreement with those reported by Madhuri K et al., who demonstrated a significant positive correlation between HbA1c and total cholesterol among patients with T2DM.14 Similar observations have also been reported by Alzahrani et al., Sharahili et al., Bekele et al., and Khan et al.[12,13,17,18] The increase in total cholesterol may be attributed to insulin resistance-mediated disturbances in lipid metabolism and increased hepatic cholesterol synthesis.[6-9]

HbA1c and Triglycerides: The present study demonstrated a very strong positive correlation between HbA1c and triglycerides ($r = 0.84$, $p < 0.001$). This finding is consistent with previous studies that reported elevated triglyceride levels in patients with poor glycemic control.[12-14,17,18] Hyperglycemia increases free fatty acid mobilization from adipose tissue and stimulates hepatic triglyceride synthesis, resulting in hypertriglyceridemia.[6,8,9]

HbA1c and LDL Cholesterol: A strong positive correlation was observed between HbA1c and LDL cholesterol ($r = 0.70$, $p < 0.001$). Similar positive correlations between HbA1c and LDL cholesterol have been reported by Alzahrani et al., Madhuri K et al., Bekele et al., and Khan et al.[12,14,17,18] Chronic hyperglycemia promotes glycation and oxidation of LDL particles, increasing their atherogenic potential.[6,8]

HbA1c and VLDL Cholesterol: A very strong positive correlation was observed between HbA1c and VLDL cholesterol ($r = 0.84$, $p < 0.001$). Insulin resistance enhances hepatic VLDL production, resulting in elevated circulating VLDL levels.6-9 Similar findings have been reported in previous studies evaluating diabetic dyslipidemia.[12-14,17,18]

HbA1c and HDL Cholesterol: Although HbA1c showed a negative correlation with HDL cholesterol ($r = -0.13$), the association was not statistically significant ($p = 0.24$). HDL cholesterol is considered protective against cardiovascular disease because of its role in reverse cholesterol transport.[6,8] The non-significant inverse relationship observed in the present study is consistent with reports by Alzahrani et al. and Bekele et al.[12,17]

Clinical Significance of the Study: The strong positive correlations observed between HbA1c and atherogenic lipid parameters suggest that HbA1c may serve as a useful indicator of dyslipidemia in patients with T2DM. Since HbA1c testing is routinely performed in diabetic patients, it may provide additional information regarding cardiovascular risk without requiring additional investigations.

Identification of patients with elevated HbA1c levels may help clinicians recognize individuals at increased risk of dyslipidemia and initiate timely interventions including lifestyle modification, dietary counseling, optimization of glycemic control, and lipid-lowering therapy.

Summary of Findings: The present study demonstrated that poor glycemic control, as reflected by elevated HbA1c levels, is significantly associated with adverse lipid profile alterations in patients with Type 2 Diabetes Mellitus. Strong positive correlations were observed between HbA1c and total cholesterol, triglycerides, LDL cholesterol, and VLDL cholesterol, whereas HDL cholesterol showed a non-significant negative correlation. These findings support the role of HbA1c not only as a marker of glycemic control but also as a potential predictor of dyslipidemia and cardiometabolic risk in patients with Type 2 Diabetes Mellitus.

CONCLUSION

The present hospital-based cross-sectional study was conducted to evaluate the correlation between Glycosylated Hemoglobin (HbA1c) and serum lipid profile parameters among patients with Type 2 Diabetes Mellitus. The study included 87 patients with a mean age of 53.06 ± 8.23 years, with males constituting the majority of the study population.

The mean HbA1c level was $10.31 \pm 2.04\%$, indicating poor glycemic control among the participants. Correlation analysis demonstrated significant positive associations between HbA1c and atherogenic lipid parameters including Total Cholesterol ($r = 0.85$, $p < 0.001$), Triglycerides ($r = 0.84$, $p < 0.001$), VLDL Cholesterol ($r = 0.84$, $p < 0.001$), and LDL Cholesterol ($r = 0.70$, $p < 0.001$). A significant positive correlation was also observed between HbA1c and Postprandial Blood Sugar levels ($r = 0.54$, $p < 0.001$). However, no significant association was found between HbA1c and HDL Cholesterol, BMI, abdominal circumference, fasting blood sugar, weight, or height.

The findings of the present study suggest that poor glycemic control is associated with worsening dyslipidemia among patients with Type 2 Diabetes Mellitus. HbA1c can serve not only as an indicator of long-term glycemic control but also as a useful surrogate marker for identifying patients at increased risk of dyslipidemia and cardiovascular complications. Routine monitoring of HbA1c may therefore aid in early detection of cardiometabolic risk and facilitate timely therapeutic intervention.

Strengths of the Study

The present study possesses several strengths that enhance the clinical relevance of its findings. It simultaneously evaluated glycemic status and lipid abnormalities in patients with Type 2 Diabetes Mellitus, enabling a comprehensive assessment of the relationship between long-term glycemic control and dyslipidemia. HbA1c, a standardized and reliable indicator of average blood glucose levels over the preceding two to three months, was utilized as the primary measure of glycemic control, thereby ensuring robust assessment of diabetic status. In addition, a complete lipid profile including Total Cholesterol, Triglycerides, HDL-C, LDL-C, and VLDL-C was analyzed, allowing detailed evaluation of atherogenic lipid abnormalities. The study demonstrated strong statistically significant correlations between HbA1c and major lipid parameters associated with cardiovascular risk. Since HbA1c testing is routinely performed in clinical practice, the findings have direct practical applicability and may assist clinicians in identifying patients at increased risk of dyslipidemia. Furthermore, the study contributes valuable regional data regarding the association between glycemic control and lipid abnormalities among Indian patients with Type 2 Diabetes Mellitus.

Limitations of the Study: Despite its strengths, the study has certain limitations that should be considered while interpreting the results. Being a single-center study conducted at a tertiary care hospital, the findings may not be fully generalizable to the broader diabetic population. The relatively small sample size of 87 participants may have limited the statistical power of the analysis. The cross-sectional nature of the study precludes establishing a causal relationship between poor glycemic control and dyslipidemia. Several potentially important confounding factors, including dietary habits, physical activity, smoking status, alcohol consumption, and socioeconomic characteristics, were not evaluated. Information regarding antidiabetic treatment regimens, medication adherence, and duration-specific therapeutic responses was also unavailable. Advanced lipid parameters such as Apolipoprotein B, Lipoprotein(a), and small dense LDL particles were not assessed. Longitudinal cardiovascular outcomes were not studied, limiting the ability to directly evaluate future cardiovascular risk. Additionally, all study participants had HbA1c levels above 7%, which prevented comparison between patients with good and poor glycemic control. Other confounding variables such as hypertension, obesity-related metabolic disturbances, and components of metabolic syndrome were not analyzed separately. Finally, the study did not investigate the influence of duration-specific glycemic control on lipid profile abnormalities.

Clinical Implications: The findings of the present study have important clinical implications. HbA1c may serve as a simple, readily available, and cost-effective marker for predicting dyslipidemia among patients with Type 2 Diabetes Mellitus. Elevated HbA1c levels were associated with significant alterations in atherogenic lipid parameters, suggesting that patients with poor glycemic control should be routinely screened for lipid abnormalities. Early identification of dyslipidemia can facilitate timely implementation of lifestyle modifications, dietary interventions, and pharmacological treatment, thereby reducing the risk of cardiovascular complications. The results further emphasize the importance of achieving optimal glycemic control as part of an integrated strategy for managing cardiovascular risk. Incorporating HbA1c into comprehensive cardiometabolic risk assessment protocols may help clinicians identify high-risk individuals who require intensive monitoring and preventive interventions. Thus, routine HbA1c assessment may provide valuable information beyond glycemic control alone and contribute to improved overall diabetes management.

Recommendations: Based on the findings of the present study, larger multicentric studies involving diverse populations are recommended to validate and expand upon the observed associations. Prospective longitudinal investigations should be undertaken to establish causal relationships between HbA1c levels and dyslipidemia and to assess their impact on future cardiovascular outcomes. Future studies should include participants with both good and poor glycemic control to allow meaningful comparative analysis. Evaluation of additional cardiovascular risk markers such as Apolipoprotein B, Lipoprotein(a), and small dense LDL particles may provide a more comprehensive understanding of cardiometabolic risk. The influence of various antidiabetic treatment modalities on lipid metabolism should also be explored. Lifestyle-related factors including dietary patterns, physical activity, smoking, and alcohol consumption should be incorporated into future research to better account for potential confounding influences. Routine lipid screening should be encouraged among diabetic patients with elevated HbA1c levels, and integrated management approaches targeting both hyperglycemia and dyslipidemia should be emphasized to reduce the burden of cardiovascular disease in patients with Type 2 Diabetes Mellitus.

REFERENCES

1. American Diabetes Association Professional Practice Committee. Classification and diagnosis of diabetes: Standards of Care in Diabetes—2025. Diabetes Care. 2025;48(Suppl 1):S20-S42.
2. American Diabetes Association Professional Practice Committee. Cardiovascular disease and risk management: Standards of Care in Diabetes—2025. Diabetes Care. 2025;48(Suppl 1):S200-S238.
3. International Diabetes Federation. IDF Diabetes Atlas. 11th ed. Brussels, Belgium: International Diabetes Federation; 2025.
4. International Diabetes Federation. IDF Diabetes Atlas. 10th ed. Brussels, Belgium: International Diabetes Federation; 2021.
5. Genitsaridi I, Boyko EJ, Magliano DJ, et al. Global, regional and national estimates of diabetes prevalence and projections for 2050: Results from the 11th edition of the IDF Diabetes Atlas. Lancet Diabetes Endocrinol. 2025;13(1):e1-e10.
6. Goldberg IJ. Diabetic dyslipidemia: Causes and consequences. J Clin Endocrinol Metab. 2001;86(3):965-971.
7. Mooradian AD. Dyslipidemia in type 2 diabetes mellitus. Nat Rev Endocrinol. 2009;5(3):150-159.
8. Vergès B. Pathophysiology of diabetic dyslipidaemia: Where are we? Diabetologia. 2015;58(5):886-899.
9. Taskinen MR. Diabetic dyslipidaemia: From basic research to clinical practice. Diabetologia. 2003;46(6):733-749.
10. Sherwani SI, Khan HA, Ekhzaimy A, Masood A, Sakharkar MK. Significance of HbA1c test in diagnosis and prognosis of diabetic patients. Biomark Insights. 2016;11:95-104.
11. Nathan DM, Kuenen J, Borg R, Zheng H, Schoenfeld D, Heine RJ. Translating the A1C assay into estimated average glucose values. Diabetes Care. 2008;31(8):1473-1478.
12. Alzahrani SH, Baig M, Aashi MM, Alshamrani HS, Alghamdi AA, Alqarni AA, et al. Association between glycated

hemoglobin (HbA1c) and the lipid profile in patients with type 2 diabetes mellitus at a tertiary care hospital: A retrospective study. Diabetes Metab Syndr Obes. 2019;12:1639-1644.
13. Sharahili AY, Alqahtani RM, Aljohani NM, Alharbi RM, Alghamdi AA, Alqahtani MA, et al. Correlation of HbA1c level with lipid profile in type 2 diabetes mellitus patients visiting a primary healthcare center in Jeddah City, Saudi Arabia: A retrospective cross-sectional study. Cureus. 2023;15(10):e47581.
14. Madhuri K, Shet SK. Correlation of HbA1c with lipid profile in type 2 diabetes mellitus. Int J Med Pharm Res. 2023;4(1):206-211.
15. Anjana RM, Deepa M, Pradeepa R, Mahanta J, Narain K, Das HK, et al. Prevalence of diabetes and prediabetes in 15 states of India: Results from the ICMR-INDIAB population-based cross-sectional study. Lancet Diabetes Endocrinol. 2017;5(8):585-596.
16. Pradeepa R, Mohan V. Epidemiology of type 2 diabetes in India. Indian J Ophthalmol. 2021;69(11):2932-2938.
17. Bekele S, Yohannes T, Mohammed AE, Tadesse AW. Dyslipidemia and associated factors among patients with type 2 diabetes mellitus attending follow-up clinics. Pan Afr Med J. 2022;41:281.
18. Khan HA, Sobki SH, Khan SA. Association between glycaemic control and serum lipids profile in type 2 diabetic patients: HbA1c predicts dyslipidaemia. Clin Exp Med. 2007;7(1):24-29.