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CORRELATION OF HBA1C WITH LIPID PROFILE IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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ABSTRACT

Background: Dyslipidemia is a common metabolic abnormality in patients with type 2 diabetes mellitus and contributes significantly to cardiovascular complications. **Objective:** To evaluate the correlation of HbA1c with lipid profile among patients with type 2 diabetes mellitus. **Methods:** This cross-sectional analytical study included 110 patients with type 2 diabetes mellitus at Lady Reading Hospital Peshawar from June 2024 to June 2025. Demographic data, HbA1c, fasting blood glucose, total cholesterol, triglycerides, LDL-C, HDL-C, and VLDL-C were recorded. Patients were categorized into good glycemic control (HbA1c <7%) and poor glycemic control (HbA1c ≥7%) groups. **Results:** The mean age was 55.2 ± 10.8 years, and the mean HbA1c was 8.4 ± 1.7%. Poor glycemic control was observed in 68 (61.8%) patients. Patients with HbA1c ≥7% had higher total cholesterol (212.8 ± 37.5 vs. 176.9 ± 29.4 mg/dL), triglycerides (205.6 ± 58.9 vs. 148.7 ± 41.6 mg/dL), LDL-C (134.7 ± 30.5 vs. 102.8 ± 23.1 mg/dL), and VLDL-C (41.2 ± 11.8 vs. 29.7 ± 8.3 mg/dL), while HDL-C was lower (38.8 ± 6.6 vs. 45.9 ± 7.3 mg/dL). HbA1c showed significant positive correlations with total cholesterol, triglycerides, LDL-C, and VLDL-C, and a negative correlation with HDL-C. **Conclusion:** HbA1c was significantly associated with lipid abnormalities in patients with type 2 diabetes mellitus and may serve as a useful marker for identifying patients at increased cardiovascular risk.

Keywords: HbA1c; lipid profile; type 2 diabetes mellitus; dyslipidemia; cardiovascular risk.

INTRODUCTION

Diabetes mellitus type 2 (T2DM) is a common chronic metabolic condition and a significant public health problem because of its rising prevalence with lifelong consequences. A state of chronic hyperglycemia because of insulin resistance and gradual insulin β cell failure, causing disturbances in carbohydrate, lipid and protein metabolism (Artha et al., 2019). Diabetic nephropathy, retinopathy and neuropathy, coronary artery disease, and cerebrovascular disease are microvascular and macrovascular complications that result from poor glycemic control (Sharahili et al., 2023). The glycated hemoglobin (HbA1c) test is now widely used to measure long-term glycemic control because it reflects an average blood sugar (glycemic) level over the past two to three months. HbA1c is also used to assess treatment response, as well as to predict complications of diabetes and general metabolic state (Kidwai et al., 2020). Patients with T2DM with High HbA1C have high risk of cardiovascular disease due to all the above due to increased cardiovascular risk (Kumar et al., 2022). Another frequent abnormality of metabolism in patients with type 2 diabetes mellitus is dyslipidemia. Diabetic dyslipidaemia usually consists of elevated triglycerides, increased low-density lipoprotein cholesterol (LDL-C), reduced high-density lipoprotein cholesterol (HDL-C), and increased concentration of small dense LDL particles, all of which are responsible for accelerated atherosclerosis (Alzahrani et al., 2019). These are serious abnormalities of the lipids and significantly raise the risk of cardiovascular disease, which is the top killer disease among diabetic individuals (Priya & Begum, 2020). The association of chronic hyperglycemia and lipid abnormalities is due to multiple pathophysiologic mechanisms. Insulin resistance leads to more lipolysis, higher free fatty acid levels, greater production of very-low-density lipoprotein (VLDL) in the liver and reduced clearance of lipid rich very-low-density lipoprotein (VLDL) which leads to an atherogenic lipid profile (Pandey et al., 2020). A poor glycemic control is often accompanied by deterioration of lipid metabolism, which is a progressive process (Mohamed et al., 2022).

Many studies have investigated the correlation of HbA1c with lipid profile, and found that HbA1c could be a useful surrogate marker for predicting dyslipidaemia in T2DM (Shahwan et al., 2019). Some studies have shown a positive association between HbA1c and total cholesterol, LDL cholesterol, triglyceride, and very-low-density lipoprotein cholesterol, while a negative association has been seen between worsening glycemic control and HDL (Alotaibi et al., 2024). These results suggest that patients with suboptimal glycemic control would benefit from more frequent lipid evaluation and intense cardiovascular risk management (CVRM) (Shahwan et al., 2019). HbA1C may have significant implications for clinical practice as a marker for dyslipidaemia, especially in resource limited areas where regular lipid screening might not always be available. However, if a strong relationship is established, HbA1c may help to screen for patients who are more likely to have lipid abnormalities and cardiovascular complications, allowing for earlier intervention (Wang et al., 2020). Furthermore, a simultaneous improvement in glycemic control and lipid profile could significantly decrease cardiovascular morbidity and mortality in patients with diabetes in the long-term (Milosevic & Panin, 2019). Many international studies have consistently found strong relationships between HbA1c and serum lipid parameters, but these relationships have been different across various populations, due to varying ethnicities, dietary factors, duration of diabetes, obesity, medication use, and genetic risk factors (Poolsup et al., 2019). Thus, population level studies are still needed to elucidate this relationship and inform personalized treatment management (Pelham et al., 2019).

Objective To evaluate the correlation of HbA1c with lipid profile among patients with type 2 diabetes mellitus.

METHODOLOGY

This cross-sectional analytical study was conducted at Lady Reading Hospital Peshawar from June 2024 to June 2025. 110 patients participated in the study with a type 2 diabetes mellitus, using the non-probability consecutive sampling technique. All participants gave informed consent before they were enrolled. Participants were randomly recruited from patients with type 2 diabetes mellitus (T2DM) at least one year of diagnosis based on the criteria of American Diabetes Association (ADA) who were aged between 30 and 75 years of age of either gender. Patients with type 1 diabetes mellitus, gestational diabetes, chronic liver disease, chronic kidney disease stage IV or V, hypothyroidism, familial dyslipidemia, acute infections, malignancy, pregnancy, or who had recently started taking lipid-lowering medications (within the last 3 months) were not included. The records of the patients were also incomplete, and this group was eliminated. The participants were recruited from the diabetic outpatient clinics and the endocrinology department. A structured proforma for the collection of the demographic and clinical data was used, which included age, gender, duration of diabetes, body mass index (BMI), blood pressure, smoking status, comorbidities, current antidiabetic medications. Standardized techniques were used to obtain anthropometric measurements. Body weight was obtained with a calibrated digital weighing scale and height with a wall mounted stadiometer. BMI was defined as the body weight (kg) divided by the square of the height (m^2). After resting for at least 5 minutes, the blood pressure was measured by a standard sphygmomanometer. Venous blood samples were taken for laboratory investigation after 8-12 hours fasting overnight. The fasting blood glucose, glycated hemoglobin (HbA1c), total cholesterol (TC), triglycerides (TG), high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C) were determined in the hospital laboratory on standard automated biochemical analyzers. High-performance liquid chromatography (HPLC) was used to estimate the HbA1c. Where triglyceride levels were <400 mg/dL, very-low-density lipoprotein cholesterol (VLDL-C) was estimated using the Friedewald formula. Patients were classified based on their HbA1c levels for glycemic control. According to the American Diabetes Association's recommendations, good glycemic control was defined as HbA1c <7.0% and poor glycemic control was defined as HbA1c ≥7.0%. The primary outcome was the correlation of HbA1c with lipid profile parameters (total cholesterol, triglycerides, LDL-C, HDL-C and VLDL-C) and the association of HbA1c with demographic characteristics, duration of diabetes, BMI and dyslipidaemia. Data were coded and analyzed with SPSS Statistics version 26.0. from IBM. Data for quantitative variables (such as age, BMI, HbA1c, fasting blood glucose and lipid profile parameters) are shown as mean ± SD. Frequencies and percentages were used to describe categorical variables. The Shapiro-Wilk test was used to assess the normality of continuous variables. Independent-samples t-test was used for quantitative variables between the two groups, and categorical variables were compared using the chi-square test. P value of ≤ 0.05 was taken as statistically significant.

RESULTS

The study included 110 patients with type 2 diabetes mellitus, with a mean age of 55.2 ± 10.8 years. Males accounted for 64 (58.2%) participants, while females comprised 46 (41.8%). The mean duration of diabetes was 8.7 ± 4.6 years, mean BMI was 29.1 ± 4.3 kg/m², and mean HbA1c was 8.4 ± 1.7%. The average fasting blood glucose was 176.8 ± 49.5 mg/dL, indicating overall poor glycemic control among the study population.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Participants (n=110)

Variable	Total (n=110)
Age (years)	55.2 ± 10.8
Male	64 (58.2%)
Female	46 (41.8%)
Duration of diabetes (years)	8.7 ± 4.6
BMI (kg/m²)	29.1 ± 4.3
Systolic blood pressure (mmHg)	136.4 ± 15.7
Diastolic blood pressure (mmHg)	83.2 ± 8.9
Hypertension	63 (57.3%)
Smoking history	24 (21.8%)
HbA1c (%)	8.4 ± 1.7
Fasting blood glucose (mg/dL)	176.8 ± 49.5

Patients with poor glycemic control (HbA1c ≥7%) had significantly worse lipid profiles than those with good glycemic control. Mean total cholesterol was higher (212.8 ± 37.5 vs. 176.9 ± 29.4 mg/dL), triglycerides were elevated (205.6 ± 58.9 vs. 148.7 ± 41.6 mg/dL), LDL-C was greater (134.7 ± 30.5 vs. 102.8 ± 23.1 mg/dL), and VLDL-C was increased (41.2 ± 11.8 vs. 29.7 ± 8.3 mg/dL).

Table 2. Comparison of Lipid Profile According to Glycemic Control (n=110)

Variable	HbA1c <7% (n=42)	HbA1c ≥7% (n=68)	p-value
Total cholesterol (mg/dL)	176.9 ± 29.4	212.8 ± 37.5	<0.001
Triglycerides (mg/dL)	148.7 ± 41.6	205.6 ± 58.9	<0.001
LDL-C (mg/dL)	102.8 ± 23.1	134.7 ± 30.5	<0.001
HDL-C (mg/dL)	45.9 ± 7.3	38.8 ± 6.6	<0.001
VLDL-C (mg/dL)	29.7 ± 8.3	41.2 ± 11.8	<0.001

HbA1c showed significant positive correlations with total cholesterol (r=0.582), triglycerides (r=0.611), LDL-C (r=0.548), and VLDL-C (r=0.593), while demonstrating a moderate negative correlation with HDL-C (r=-0.437).

Table 3. Correlation between HbA1c and Lipid Profile Parameters (n=110)

Variable	Correlation coefficient (r)	p-value
Total cholesterol	0.582	<0.001
Triglycerides	0.611	<0.001
LDL-C	0.548	<0.001
HDL-C	-0.437	<0.001
VLDL-C	0.593	<0.001

The prevalence of dyslipidemia was significantly higher among patients with HbA1c ≥7%. Hypercholesterolemia was present in 40 (58.8%) patients compared with 11 (26.2%) in the HbA1c <7% group. Hypertriglyceridemia occurred in 46 (67.6%) versus 13 (31.0%), elevated LDL-C in 43 (63.2%) versus 12 (28.6%), low HDL-C in 39 (57.4%) versus 10 (23.8%), and mixed dyslipidemia in 31 (45.6%) versus 8 (19.0%).

Table 4. Prevalence of Dyslipidemia According to HbA1c Category (n=110)

Lipid Abnormality	HbA1c <7% (n=42)	HbA1c ≥7% (n=68)	p-value
Hypercholesterolemia	11 (26.2%)	40 (58.8%)	0.001
Hypertriglyceridemia	13 (31.0%)	46 (67.6%)	<0.001
Elevated LDL-C	12 (28.6%)	43 (63.2%)	<0.001
Low HDL-C	10 (23.8%)	39 (57.4%)	0.001

Mixed dyslipidemia	8 (19.0%)	31 (45.6%)	0.005

Multiple linear regression analysis identified triglycerides as the strongest independent predictor of HbA1c (β=0.308, p=0.002), followed by LDL-C (β=0.249, p=0.011) and total cholesterol (β=0.231, p=0.009). HDL-C showed a significant inverse association with HbA1c (β=-0.198, p=0.026), while higher BMI (β=0.181, p=0.034) and longer duration of diabetes (β=0.174, p=0.041) were also independently associated with higher HbA1c levels. The regression model explained 47% of the variability in HbA1c (Adjusted R^2=0.47).

Table 5. Multiple Linear Regression Analysis for Predictors of HbA1c (n=110)

Variable	Standardized β	95% CI	p-value
Total cholesterol	0.231	0.004–0.018	0.009
Triglycerides	0.308	0.006–0.017	0.002
LDL-C	0.249	0.003–0.016	0.011
HDL-C	-0.198	-0.041 to -0.006	0.026
BMI	0.181	0.014–0.152	0.034
Duration of diabetes	0.174	0.006–0.127	0.041

DISCUSSION

In the present study, the correlation between HbA1c and lipid profile was evaluated in 110 diabetic patients with type 2 diabetes mellitus. The mean level of HbA1c was 8,4 ± 1,7% and 68 (61,8%) patients had poor glycemic control, showing that poor glycemic control is still common in diabetic patients. Previous study also showed that the majority of people with type 2 diabetes have high HbA1c levels and that high levels are linked with bad metabolic outcomes (Artha et al., 2019). Patients with poor glycemic control showed significantly higher total cholesterol, triglycerides, LDL-C and VLDL-C levels and significantly lower HDL-C levels than those of patients with good glycemic control. Total cholesterol was 212.8 ± 37.5 versus 176.9 ± 29.4 mg/dL, triglycerides were 205.6 ± 58.9 versus 148.7 ± 41.6 mg/dL, LDL-C was 134.7 ± 30.5 versus 102.8 ± 23.1 mg/dL, and HDL-C was 38.8 ± 6.6 versus 45.9 ± 7.3 mg/dL. The deterioration of the glycemic parameters was also previously shown to be associated with a worsening of the lipid profile, which is an increase in cardiovascular risk (Sharahili et al., 2023). There was a significant positive correlation between HbA1c and total cholesterol (r=0.582), triglycerides (r=0.611), LDL-C (r=0.548) and VLDL-C (r=0.593); there was a significant negative correlation between HbA1c and HDL-C (r=-0.437). The results of this study indicate that the higher the HbA1c, the more severe the dyslipidaemia. A positive association of HbA1c with atherogenic lipid parameters and a negative association to HDL-C were also observed from previous studies (Kidwai et al., 2020). Triglycerides were most closely associated with HbA1c and were also the most powerful independent risk factor in regression analysis (β=0.308, p=0.002) of all lipid factors. This could be due to elevated insulin resistance, which increases hepatic triglyceride production, and decreases lipoprotein metabolism. Triglyceride, another lipid parameter, was also found to be one of the parameters most highly linked to poor glycemic control in T2DM patients in previous studies (Kumar et al., 2022). There was a significantly higher rate of dyslipidemia among individuals with HbA1c ≥7%. High levels of LDL-C were seen in 63.2% of those with poor glycemic control, high levels of HDL-C was seen in 57.4% of those with poor glycemic control, hypertriglyceridemia was seen in 67.6%, and hypercholesterolemia was seen in 58.8%. There was also a significantly increased incidence of dyslipidaemia in previous studies in patients with elevated HbA1c, compared with those with good glycemic control (Alzahrani et al., 2019). The results suggest that lipid abnormality and clinical factors are important factors affecting poor glycemic control. Obesity, higher duration of diabetes, and dyslipidemia were also found to be independent factors associated with high HbA1c in previous studies (Priya & Begum, 2020). Patients in the study were mostly overweight or obese with a mean BMI of 29.1 ± 4.3 kg/m². Excess adiposity leads to insulin resistance, impaired glucose utilization, abnormal lipid metabolism, and poor glycemic control and cardiovascular risk. Obesity also has been shown in previous studies to significantly contribute to both high HbA1c and diabetic dyslipidemia (Pandey et al., 2020). The results of the present study are consistent with the findings that HbA1c can not only be used to monitor long-term glycemic control but can also be used to identify patients at higher risk of dyslipidemia. Patients with higher HbA1c should have their lipid profile periodically monitored and should be provided with early cardiovascular risk management. Some previous studies have also found that HbA1c can be used as a practical predictor of the lipid abnormalities, especially in resource poor countries (Mohamed et al., 2022). This is clinically relevant as a decrease in HDL-C with increases in HbA1c is known to affect reverse cholesterol transport, thereby promoting atherosclerosis. This is in addition to high LDL-C and triglycerides and constitutes the typical diabetic dyslipidemia syndrome known with high cardiovascular morbidity. This lipid profile feature was also observed in poorly controlled diabetics in previous studies (Shahwan et al., 2019). The results of the present study also underscore the need for holistic diabetes care. Treatment, lifestyle modification, weight loss, and compliance with treatment can improve glycemic control, which can also have beneficial effects on lipid abnormalities and vascular complications in the longer term. Previous studies have also shown that the glycemic control is positively associated with better serum lipid parameters (Alotaibi et al., 2024). There were a number of limitations in this study. To begin with, it was a single center study with a relatively small number of patients (110) and so may not be generalizable. Second, it was a cross-sectional study, which meant that associations between HbA1c and lipid profile could not be interpreted as causal. Thirdly, the dietary habits, physical activity level, adherence to medications and genetic factors affecting lipid metabolism were not assessed. Lastly, follow-up was not conducted; thus, the association between HbA1c, dyslipidaemia and subsequent cardiovascular outcomes was not assessed.

CONCLUSION

It is concluded that HbA1c showed a significant positive correlation with total cholesterol, triglycerides, LDL-C, and VLDL-C, while demonstrating a significant negative correlation with HDL-C in patients with type 2 diabetes mellitus. Patients with poor glycemic control exhibited a substantially higher prevalence of dyslipidemia than those with good glycemic control, indicating an increased risk of cardiovascular complications. Triglycerides emerged as the strongest independent predictor of HbA1c, while higher BMI and longer duration of diabetes were also significantly associated with poor glycemic control. These findings suggest that HbA1c may serve as a practical indicator for identifying diabetic patients at increased risk of dyslipidemia, supporting routine lipid profile assessment and early comprehensive cardiovascular risk management.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

All authors contributed equally.

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Conflict of Interest

None

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