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Original Research Article

Study On The Association Between Glycemic Control and Lipid Profile with The Risk of Cardiovascular Events in Type 2 Diabetics

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Abstract:

Introduction: Type 2 diabetes mellitus (T2DM) increases cardiovascular risk due to chronic hyperglycemia and dyslipidemia. Poor glycemic control and abnormal lipid profiles, particularly elevated LDL-C and low HDL-C, contribute to adverse cardiovascular events. This study examines their association with cardiovascular outcomes in T2DM to guide risk assessment and preventive care.

Methods: A five-month prospective observational study was conducted at Government Medical College, Machilipatnam, including T2DM patients aged 35–75 years. Demographic, clinical, and laboratory data were collected. Patients were followed for cardiovascular events, confirmed through clinical, biochemical, and imaging evaluations. Exclusion criteria included prior CVD, T1DM, CKD, infections, or malignancy.

Results: In this study of 120 T2DM patients, 25% experienced cardiovascular events over five months. Higher HbA1c, LDL-C ≥ 130 mg/dL, and hypertension significantly predicted events. HbA1c ≥ 9% had the strongest association (OR 3.25, p=0.031), highlighting poor glycemic control as a key cardiovascular risk factor.

Conclusion: Poor glycemic control, elevated LDL-C, and hypertension significantly increased cardiovascular event risk in T2DM patients. HbA1c ≥ 9% was the strongest predictor. The study underscores the need for comprehensive management of metabolic parameters to prevent cardiovascular complications and improve outcomes in individuals with T2DM.

Key words: Type 2 Diabetes Mellitus, Cardiovascular events, Glycemic control, Lipid profile, Risk.

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Introduction

Type 2 diabetes mellitus (T2DM) is a global health concern, significantly contributing to the burden of cardiovascular disease (CVD), the leading cause of mortality among diabetics. Chronic hyperglycemia and dyslipidemia are key metabolic disturbances in T2DM that accelerate atherosclerosis and endothelial dysfunction, ultimately leading to adverse cardiovascular events (CVEs) such as myocardial infarction and stroke. Glycemic control, typically assessed using glycated hemoglobin (HbA1c), plays a pivotal role in minimizing microvascular and macrovascular complications. Emerging evidence suggests that poor glycemic control is independently associated with increased cardiovascular risk, particularly when combined with lipid abnormalities including elevated LDL-C, low HDL-C, and high triglycerides [1].

Dyslipidemia in T2DM often presents as atherogenic lipid triad high triglycerides, low HDL-C, and small dense LDL particles further exacerbating CVD risk [2]. While intensive glycemic control may reduce cardiovascular outcomes in early diabetes, the extent of its impact remains debated, especially in the context of coexisting dyslipidemia [3]. Recent studies emphasize the importance of a multifactorial approach addressing both glucose and lipid abnormalities to mitigate cardiovascular complications in T2DM patients [4]. This study aims to explore the association between glycemic control and lipid profile parameters with the incidence of CVEs in individuals with type 2 diabetes, to aid in risk stratification and optimize preventive strategies.

Methodology

A prospective observational study was conducted at the department of Biochemistry, government Medical College, Machilipatnam, from 15 April 2025 to 20 May 2026. Necessary approvals were obtained from the institution. Informed written consent obtained from the study members.

The study included adult patients aged 35 to 75 years with a confirmed diagnosis of T2DM, attending the outpatient and inpatient departments during the

study period. Patients with known CVD at baseline, type 1 diabetes, chronic kidney disease (stage 4 or above), active infections, malignancy, or those on lipid-lowering therapy for less than three months were excluded.

Demographic and clinical data were systematically collected using a predesigned structured proforma. Key demographic details included age, sex, and residential background. Clinical parameters such as duration of T2DM, presence of comorbidities (e.g., hypertension), smoking status, and family history of CVD were documented. Anthropometric measurements including height, weight, and body mass index (BMI) were recorded using standardized procedures. Vital signs, particularly systolic and diastolic blood pressures, were measured in a resting state using a calibrated sphygmomanometer. Fasting venous blood samples were collected in the morning after an overnight fast of 8–10 hours. Laboratory investigations included estimation of HbA1c, fasting plasma glucose (FPG), and fasting lipid profile comprising total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides were analysed using automated analyser.

Each participant was prospectively monitored over a five-month period to track the incidence of new CVEs. Outcome measures included acute coronary syndrome (ACS), angina, non-fatal myocardial infarction (MI), ischemic stroke, and hospitalizations related to heart failure. Participants were advised to report any symptoms suggestive of cardiac or neurological complications during follow-up. Clinical evaluations were performed monthly and during any acute presentation. Confirmation of CVEs was based on a combination of clinical examination, electrocardiography (ECG), serum cardiac biomarkers (e.g., troponin-I), echocardiographic assessment, and neuroimaging techniques such as CT or MRI for stroke diagnosis. Hospital admission records were also reviewed when necessary. All adverse CVEs were documented in a standardized outcome log, ensuring consistency and completeness in data recording for statistical analysis.

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using SPSS version 22. Descriptive statistics were used for baseline variables. Pearson correlation and logistic regression analyses were conducted to determine the association between HbA1c, lipid profile, and the occurrence of CVEs. P value < 0.05 was considered statistically significant.

Results

The study included 120 T2DM patients, mean age was 56.4 ± 9.8 years. There were 68 male (56.7%). Mean duration of diabetes was 8.1 ± 4.5 years, mean BMI was 27.6 ± 3.4 kg/m². Hypertension was present in 72 (60%), 38 (31.7%) had smoking history, and 44 (36.7%) reported CVD family history. Mean HbA1c was 8.2 ± 1.3%, average FPG was 148.5 ± 36.2 mg/dL. Mean total cholesterol was 198.6 ± 38.7 mg/dL, while LDL-C averaged 121.3 ± 30.1 mg/dL. HDL-C levels were low, with a mean of 38.9 ± 7.2 mg/dL. Triglyceride levels were elevated, with a mean value of 178.4 ± 48.5 mg/dL. During the five-month follow-up, CVEs were observed in 30 (25%) members; angina was the most common event (15; 12.5%), followed by acute coronary syndrome 12; 10%) and myocardial infarction (8; 6.7%). Heart failure related hospitalizations occurred in 9 (7.5%), while ischemic stroke was reported in 6 (5%). Of the 32 individuals with HbA1c < 7%, only 4 (12.5%) experienced CVEs. In contrast, 14 out of 58 (24.1%) with HbA1c between 7–8.9% and 12 out of 30 (40%) with HbA1c ≥ 9% had events (Ψ^2 = **6.39;** P = **0.041)** (Table 1). Multivariate logistic regression revealed that HbA1c ≥ 9%, LDL-C ≥ 130 mg/dL, and hypertension were significant predictors of CVEs. HbA1c ≥ 9% had the highest adjusted odds ratio (3.25, P=0.031), followed by hypertension (OR 2.88, P=0.038), indicating strong associations with adverse cardiovascular outcomes (Table 2).

Table 1: Association between HbA1c and CVE

HbA1c in %	Participants	CVD events
< 7	32 (26.6)	4 (3.3)
7 – 8.9	58 (48.3)	14 (11.6)
≥ 9	30 (25)	12 (10)
Total	120 (100)	30 (25)

Table 2: Multivariate logistic regression for predictors of CVE

Predictor	Adjusted OR	95% CI	P value
HbA1c ≥ 9%	3.25	1.12–9.45	0.031
LDL-C ≥ 130 mg/dL	2.74	1.05–7.18	0.04
HDL-C < 40 mg/dL	1.92	0.88–4.18	0.098
Triglycerides ≥ 150 mg/dL	2.21	0.94–5.18	0.071

Hypertension	2.88	1.06–7.79	0.038

Discussion

The baseline characteristics of the study population highlight the significant burden of cardiovascular risk factors among patients with type 2 diabetes mellitus (T2DM). The mean age of 56.4 years and mean diabetes duration of 8.1 years are consistent with other Indian cohorts, reflecting a midlife onset and long-standing disease which increase atherosclerotic risk [5]. A high prevalence of hypertension (60%) and smoking (31.7%) further exacerbates the cardiovascular risk, aligning with prior studies demonstrating these as independent contributors to CVD in diabetics [6]. The observed mean BMI of 27.6 kg/m² suggests that most participants were overweight or obese, consistent with the role of adipose tissue in insulin resistance and metabolic syndrome [7].

The metabolic profile of participants revealed poor glycemic control, with a mean HbA1c of 8.2%, exceeding the recommended targets. This finding is significant as higher HbA1c levels are strongly associated with increased risk of cardiovascular morbidity and mortality [8]. Additionally, the lipid profile showed an atherogenic pattern, including elevated total cholesterol (198.6 mg/dL), LDL-C (121.3 mg/dL), low HDL-C (38.9 mg/dL), and elevated triglycerides (178.4 mg/dL), which are characteristic of diabetic dyslipidemia. This triad of hypertriglyceridemia, low HDL-C, and high LDL-C has been implicated in the progression of atherosclerosis and CVEs in T2DM [9]. These findings underscore the need for integrated management of glucose and lipid levels to mitigate cardiovascular risk in diabetic populations.

During the five-month follow-up, CVEs were reported in 30 (25%) patients, indicating a significant burden of macrovascular complications among individuals with T2DM. Angina (12.5%) emerged as the most frequent manifestation, followed by acute coronary syndrome (10%) and myocardial infarction (6.7%), consistent with previous findings that coronary artery disease remains the leading cause of morbidity in diabetics [10, 11]. Heart failure related hospitalizations (7.5%) and ischemic stroke (5%) also contributed to the event burden, underscoring the multisystem impact of poorly controlled diabetes [12]. These rates are comparable to those observed in major cardiovascular outcome trials in diabetics, which link hyperglycemia, dyslipidemia, and hypertension with increased CVE risk [13]. The clustering of these events within a relatively short follow-up period emphasizes the need for aggressive and sustained control of cardiometabolic risk factors in T2DM patients to prevent both fatal and non-fatal vascular complications.

This study highlights a clear association between poor glycemic control and increased CVE risk in individuals with T2DM. Among participants with HbA1c < 7%, only 12.5% experienced CVEs, compared to 24.1% with HbA1c between 7–8.9% and 40% with HbA1c ≥ 9%. The trend is statistically significant ($\chi^2 = 6.39$, $p = 0.041$), underscoring the impact of chronic hyperglycemia on macrovascular outcomes. These findings are consistent with prior research that shows a progressive increase in cardiovascular risk with rising HbA1c levels [14]. Prolonged exposure to hyperglycemia induces endothelial dysfunction, oxidative stress, and systemic inflammation, thereby accelerating atherosclerosis [15].

In multivariate analysis, HbA1c ≥ 9% remained the strongest independent predictor of CVEs (adjusted OR 3.25, P = 0.031). This aligns with results from the UKPDS and advance trials, where elevated HbA1c levels were associated with increased cardiovascular morbidity and mortality [8]. Additionally, LDL-C ≥ 130 mg/dL and hypertension were also significantly associated with CVEs (OR 2.74 and 2.88, respectively), reflecting the importance of lipid and blood pressure management in diabetics. Dyslipidemia, characterized by high LDL-C, promotes plaque formation and thrombosis, particularly in individuals with T2DM, where lipoprotein metabolism is often impaired [16].

The findings emphasize the need for integrated cardiovascular risk management in T2DM. Optimal control of HbA1c, LDL-C, and blood pressure should be the cornerstone of therapeutic strategies to prevent major CVEs. These results support the recommendations from major guidelines advocating individualized glycemic targets, use of statins, and antihypertensive therapy for high-risk diabetics. Given the progressive nature of T2DM and the compounding effect of multiple risk factors, early and sustained intervention is critical to reduce the burden of CVEs.

Conclusion: This study demonstrates a significant association between poor glycemic control and increased risk of CVEs in patients with T2DM. Higher HbA1c levels, particularly ≥ 9%, along with elevated LDL-C and hypertension, emerged as independent predictors of adverse cardiovascular outcomes. The findings emphasize the importance of integrated management of glycemia, lipids, and blood pressure to reduce cardiovascular risk in diabetics. Early identification and aggressive control of these modifiable factors through lifestyle modifications and pharmacotherapy can help prevent long-term complications and improve quality of life in this high-risk population.

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