International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Research Article *DOI: 10.61336/im/26-2-75*

MACROVASCULAR COMPLICATIONS AND ASSOCIATED RISK FACTORS IN PATIENTS WITH DIABETES MELLITUS: A HOSPITAL-BASED CROSS-SECTIONAL STUDY

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Received: **January 09, 2026**
Revised: **January 29, 2026**
Accepted: **February 19, 2026**
Published: **February 26, 2026**

Abstract

Background: Macrovascular complications remain the leading cause of morbidity and mortality among patients with type 2 diabetes mellitus (T2DM) in India. Rapid epidemiological transition, urbanization, and lifestyle changes have further amplified this burden. This study aimed to assess the prevalence of macrovascular complications and identify associated risk factors among patients with T2DM in a tertiary care hospital setting. ***Methods:*** A hospital-based cross-sectional study was conducted among 200 adults with T2DM over a 12-month period in Gujarat, India. Demographic details, clinical characteristics, laboratory parameters, and treatment profiles were recorded. Macrovascular complications—including coronary heart disease (CHD), cerebrovascular disease (CVD), and peripheral vascular disease (PVD)—were identified based on clinical history, examination, and relevant investigations. ***Results:*** Macrovascular complications were present in 41.5% of patients. CHD was the most prevalent complication (33.5%), followed by CVD (14.5%) and PVD (4.0%). Patients with macrovascular complications were significantly older and had a longer duration of diabetes. Hypertension and smoking/tobacco use showed strong associations with macrovascular disease, whereas glycaemic control and lipid parameters did not demonstrate significant associations. ***Conclusion:*** The study highlights a substantial burden of macrovascular complications among patients with T2DM. Early identification and aggressive management of modifiable risk factors, particularly hypertension and smoking, are essential to reduce cardiovascular morbidity and mortality in this population.

Keywords: Coronary heart disease; Diabetes mellitus; Macrovascular complications; Peripheral vascular disease; Risk factors

INTRODUCTION

Diabetes mellitus (DM) is a major global non-communicable disease with rapidly increasing prevalence across all populations. The International Diabetes Federation estimates that 537 million adults were living with diabetes in 2021, a figure projected to rise to 783 million by 2045.[1] India bears a disproportionate share of this burden, with 77 million individuals affected in 2019, expected to exceed 134 million by 2045.[2] Type 2 diabetes mellitus (T2DM) accounts for nearly 90% of diabetes cases worldwide and is characterized by insulin resistance and progressive β-cell dysfunction. Chronic hyperglycaemia leads to both microvascular complications—such as retinopathy, nephropathy, and neuropathy—and macrovascular complications, including coronary heart disease, cerebrovascular disease, and peripheral vascular disease, which result from accelerated atherosclerosis of large vessels.[1,2]

Macrovascular complications are the principal cause of morbidity and mortality in diabetes, accounting for nearly 50–80% of deaths. Individuals with diabetes have a 2–4 fold higher risk of cardiovascular disease than the general population, and diabetes is recognized as a coronary artery disease risk equivalent by international guidelines.[3] The Framingham Heart Study and subsequent large-scale studies have demonstrated that diabetes confers a myocardial infarction risk comparable to that of non-diabetic individuals with prior cardiovascular events.[4] In India, rapid urbanization, sedentary lifestyles, and dietary changes have contributed to the growing burden of diabetes and its complications.[5] Indian studies report wide variation in macrovascular complication prevalence, with coronary heart disease being the most common (14.8–40%), followed by cerebrovascular disease (3.5–10%) and peripheral vascular disease (3.9–11.8%).[6,7] The Chennai Urban Rural Epidemiology Study (CURES) demonstrated a higher prevalence of macrovascular

complications in urban compared to rural populations, reflecting differential exposure to cardiovascular risk factors.[8]

Multiple modifiable and non-modifiable factors contribute to macrovascular complications in diabetes. Advanced age, longer duration of diabetes, poor glycaemic control, hypertension, dyslipidaemia, obesity, smoking, and family history of diabetes are well-established risk predictors.[9] However, the relative impact of these factors varies across populations and regions, underscoring the need for population-specific studies to guide targeted prevention strategies.[10]

Despite the high burden of diabetes in India, data on the prevalence and risk factors of macrovascular complications, particularly from western India remain limited.[11] Understanding region-specific epidemiology is essential for developing effective screening, risk stratification, and preventive strategies tailored to the Indian context. This study was therefore undertaken to determine the prevalence of macrovascular complications among patients with diabetes mellitus and to identify the associated risk factors in a hospital-based setting.

MATERIALS AND METHODS

Study Design and Setting: This cross-sectional observational study was conducted over a period of 12 months at epartment of General Medicine, C. U. Shah Medical College, Surendranagar, Gujarat, India. The study protocol was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participants prior to enrollment.

Study Population: A total of 200 patients with type 2 diabetes mellitus attending the outpatient department or admitted to medical wards during the study period were included using a consecutive sampling technique.

• Inclusion criteria were adults aged ≥18 years with a diagnosis of type 2 diabetes mellitus as per American Diabetes Association criteria [12], of either sex, who provided informed consent.
• Exclusion criteria included patients with type 1 diabetes mellitus, gestational diabetes, critically ill patients unable to provide consent, and those with incomplete medical records.

Sample Size: Based on previous Indian studies reporting a macrovascular complication prevalence of approximately 30%, with a 95% confidence interval and 7% precision, the minimum sample size was calculated as 165. To account for non-response and incomplete data, 200 patients were recruited [13].

Data Collection: Data were collected using a pre-designed structured questionnaire, including demographic details, duration of diabetes, family history of diabetes, smoking/tobacco use, alcohol consumption, comorbidities (hypertension, dyslipidemia), and treatment details (oral hypoglycaemic agents, insulin, or combination therapy).

Clinical Examination: Anthropometric measurements including height, weight, and body mass index (BMI) were recorded. Blood pressure was measured in the sitting position after 10 minutes of rest using a standard mercury sphygmomanometer, and the average of two readings was documented.

Laboratory Investigations: Fasting and postprandial blood samples were collected for estimation of fasting blood glucose, postprandial blood glucose, glycated hemoglobin (HbA1c), and lipid profile (total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides). All investigations were performed using standardized automated techniques in the hospital laboratory.

Definition of Macrovascular Complications: Macrovascular complications were defined based on clinical history, examination findings, and relevant investigations:

- Coronary Heart Disease (CHD): Documented history of myocardial infarction, angina pectoris, positive stress test, or coronary revascularization procedures confirmed by medical records or electrocardiographic changes
- Cerebrovascular Disease (CVD): History of stroke or transient ischemic attack confirmed by clinical examination and neuroimaging (CT/MRI brain)
- Peripheral Vascular Disease (PVD): History of intermittent claudication, absent peripheral pulses, or confirmed by Doppler studies

Definition of Risk Factors:

- Hypertension: Blood pressure ≥140/90 mmHg or on antihypertensive medications
- Dyslipidemia: Total cholesterol >200 mg/dL, LDL >130 mg/dL, HDL <40 mg/dL (men)/<50 mg/dL (women), or triglycerides >150 mg/dL
- Obesity: BMI ≥25 kg/m² (Asian criteria)
- Poor glycemic control: HbA1c ≥7%
- Smoking/tobacco use: Current or past tobacco use in any form

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using SPSS version 22.0. Descriptive statistics were presented as mean ± standard deviation for continuous variables and frequencies with percentages for categorical variables. Student's t-test was used to compare means between groups, and chi-square test was used for categorical variables. A p-value <0.05 was considered statistically significant.

RESULTS

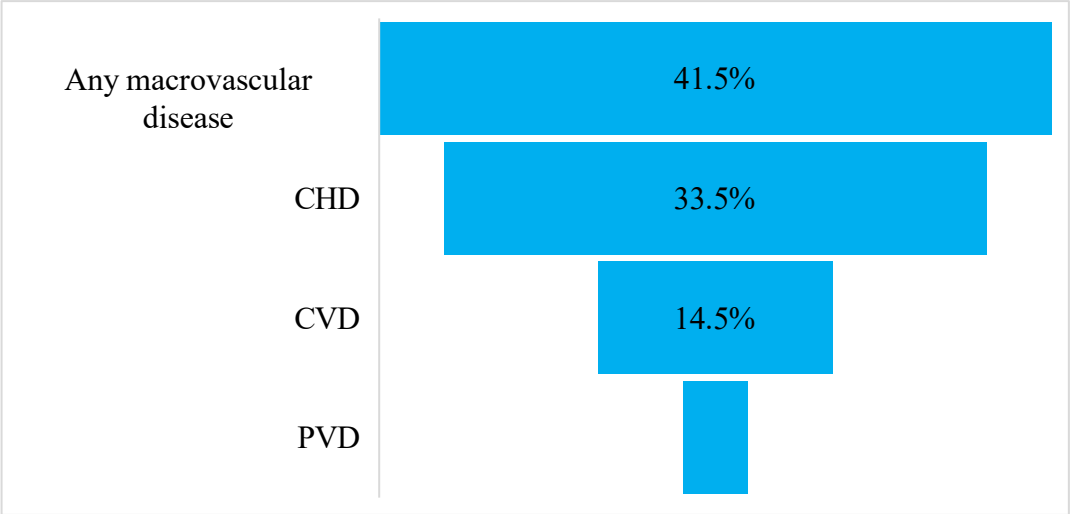
The study included 200 patients with type 2 diabetes mellitus, comprising 110 males (55%) and 90 females (45%). The mean age was 58.6 ± 12.9 years, with a mean diabetes duration of 8.2 ± 8.4 years. The mean BMI was 24.1 ± 4.2 kg/m². Poor glycaemic control (HbA1c ≥7%) was observed in 169 patients (84.5%) (Table 1). Hypertension was present in 38.5% of patients, obesity in 43.5%, smoking/tobacco use in 35%, dyslipidaemia in 18%, and family history of diabetes in 31%. Most patients were treated with oral hypoglycaemic agents alone (62%), followed by insulin therapy (17%), combination therapy (11.5%), and diet alone (9.5%) (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Study Population (n = 200)

Variable	Value
Age (years), mean ± SD	58.6 ± 12.9
Gender	
Male sex, n (%)	110 (55.0)
Female sex, n (%)	90 (45.0)
Duration of DM (years), mean ± SD	8.2 ± 8.4
BMI (kg/m²), mean ± SD	24.1 ± 4.2
Poor glycaemic control (HbA1c ≥7%), n (%)	169 (84.5)
Risk Factor	
Hypertension, n (%)	77 (38.5)
Dyslipidaemia, n (%)	36 (18.0)
Obesity, n (%)	87 (43.5)
Smoking/tobacco use, n (%)	70 (35.0)
Family history of DM, n (%)	62 (31.0)
Treatment	
Diet alone, n (%)	19 (9.5)
Oral hypoglycaemic agents, n (%)	124 (62.0)
Insulin, n (%)	34 (17.0)
OHA + Insulin, n (%)	23 (11.5)

Macrovascular complications were identified in 83 patients (41.5%). Coronary heart disease was the most common complication (33.5%), followed by cerebrovascular disease (14.5%) and peripheral vascular disease (4%) (Figure 1).

Figure 1: Prevalence of Macrovascular Complications among Diabetic Patients



The mean age, duration of diabetes, and BMI were comparable between males and females, with no statistically significant differences. Glycaemic parameters, including fasting blood glucose, post-prandial blood glucose, and HbA1c levels, were similarly distributed across both genders. Lipid profile parameters—total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides—did not show significant gender-based differences. Macrovascular complications were more frequent in males than females, including coronary heart disease (40.0% vs 25.6%), cerebrovascular disease (17.3% vs 11.1%), and peripheral vascular disease (3.6% vs 4.4%), though these differences were not statistically significant. Hypertension prevalence was similar between genders. Smoking/tobacco use was significantly higher among males (47.3%) compared to females (20.0%) (p=0.005). Family history of diabetes did not differ significantly between males and females (27.3% vs 35.5%; p=0.64). [Table 2].

Table 2: Clinical Characteristics of Patients with Diabetes Mellitus (DM) by Gender

Variable	All (n = 200)	Males (n = 110)	Females (n = 90)	p value (M vs F)
Age (years)	58.6 ± 12.9	58.9 ± 12.7	58.2 ± 13.4	0.30
Duration of DM (years)	8.2 ± 8.4	7.4 ± 7.9	9.3 ± 9.0	0.20
BMI (kg/m²)	24.1 ± 4.2	24.4 ± 4.3	23.9 ± 4.2	0.61
Glycaemic profile				
FBG (mg/dL)	180.9 ± 50.8	184.9 ± 57.1	175.1 ± 42.1	0.25
PP_2BS mg/dL)	241.9 ± 76.5	248.3 ± 84.7	243.4 ± 62.2	0.50
HbA1c (%)	9.2 ± 0.02	9.41 ± 0.03	9.0 ± 0.02	0.153
Lipid Profile				
Total cholesterol (mg/dL)	156.9 ± 51.7	153.8 ± 51.8	160.7 ± 51.8	0.82
HDL cholesterol (mg/dL)	42.5 ± 9.7	41.5 ± 9.0	43.6 ± 10.5	0.7
LDL cholesterol (mg/dL)	106.0 ± 36.1	104.1 ± 36.6	109.5 ± 35.3	0.67
Triglycerides (mg/dL)	139.2 ± 76.9	143.4 ± 93.6	133.9 ± 49.6	0.12
Macrovascular disease, n (%)				
PVD, n (%)	8 (4.0)	4 (3.6)	4 (4.4)	<0.001
CHD, n (%)	67 (33.5)	44 (40.0)	23 (25.6)	0.17
CVD, n (%)	29 (14.5)	19 (17.3)	10 (11.1)	0.07
Hypertension, n (%)				
Systolic hypertension, n (%)	77 (38.5)	43 (39.1)	34 (37.8)	0.31
Diastolic hypertension, n (%)	35 (17.5)	17 (15.4)	18 (20.0)	0.74
Smoking/substance use, n (%)	70 (35.0)	52 (47.3)	18 (20.0)	0.005
Family history of DM, n (%)	62 (31.0)	30 (27.3)	32 (35.5)	0.64

Patients with peripheral vascular disease were significantly older (69.4 ± 6.2 years) compared to those with coronary heart disease (60.6 ± 12.9 years), cerebrovascular disease (58.6 ± 13.1 years), and those without macrovascular complications (52.6 ± 13.0 years) ($p<0.001$). Similarly, the duration of diabetes was longest among patients with PVD (13.5 ± 2.9 years), followed by CHD (9.2 ± 8.4 years), CVD (8.2 ± 8.5 years), and those without macrovascular disease (5.5 ± 5.7 years) ($p<0.001$) [Table 3].

BMI was highest among patients with PVD (27.8 ± 1.6 kg/m²), though the difference across groups was not statistically significant (p=0.10). Glycaemic control, as assessed by HbA1c, was comparable across all groups (p=0.45). Lipid parameters, including total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides, did not differ significantly between patients with and without macrovascular complications [Table 3].

Systolic blood pressure was significantly higher in patients with CVD (151.7 ± 27.1 mmHg) and CHD (148.1 ± 28.7 mmHg) compared to those without macrovascular disease (134.8 ± 25.5 mmHg) (p<0.001). Diastolic blood pressure followed a similar pattern, being highest in patients with CVD (90.4 ± 13.2 mmHg) and lowest in patients without complications (82.6 ± 11.8 mmHg) (p=0.002) [Table 3].

Smoking/tobacco use was significantly more prevalent among patients with macrovascular complications, particularly CVD (68.9%), PVD (62.5%), and CHD (47.6%), compared to patients without macrovascular disease (34.2%) (p<0.001). Treatment patterns and family history of diabetes did not show significant associations with macrovascular complications [Table 3].

Table 3: Comparison of Clinical Characteristics According to Type of Macrovascular Complication

Variable	PVD (n = 8)	CHD (n = 63)	CVD (n = 29)	No Macrovascular Disease (n = 117)	p value
Age (years)	69.4 ± 6.2	60.6 ± 12.9	58.6 ± 13.1	52.6 ± 13.0	<0.001
Duration of DM (years)	13.5 ± 2.9	9.2 ± 8.4	8.2 ± 8.5	5.5 ± 5.7	<0.001
BMI (kg/m²)	27.8 ± 1.6	24.2 ± 4.2	24.2 ± 4.2	24.1 ± 4.2	0.1
HbA1c (%)	9.37 ± 0.03	9.2 ± 0.02	9.1 ± 0.02	9.1 ± 0.02	0.45
Lipid Profile					
Total cholesterol (mg/dL)	156.7 ± 49.1	156.9 ± 51.8	155.7 ± 51.9	156.6 ± 52.5	0.74
HDL cholesterol (mg/dL)	42.3 ± 9.8	42.6 ± 9.8	42.3 ± 9.8	42.4 ± 9.8	0.95
LDL cholesterol (mg/dL)	106.1 ± 35.8	106.5 ± 36.0	106.0 ± 36.3	106.5 ± 36.5	0.64
Triglycerides (mg/dL)	143.0 ± 83.8	139.2 ± 76.9	139.1 ± 77.6	139.7 ± 77.7	0.22
Blood Pressure					
SBP (mmHg)	132.4 ± 22.2	148.1 ± 28.7	151.7 ± 27.1	134.8 ± 25.5	<0.001
DBP (mmHg)	79.6 ± 8.4	88.0 ± 14.5	90.4 ± 13.2	82.6 ± 11.8	0.002
Treatment					
Insulin therapy, n (%)	1 (12.5)	5 (7.9)	4 (13.8)	30 (25.6)	0.51
Oral hypoglycaemic agents, n (%)	3 (37.5)	40 (63.5)	23 (79.3)	78 (66.6)	0.39
OHA + Insulin therapy, n (%)	3 (37.5)	14 (22.2)	1 (3.4)	14 (12.0)	0.057
Diet alone, n (%)	1 (12.5)	4 (6.3)	1 (3.4)	15 (12.8)	0.069
Smoking/tobacco use, n (%)	5 (62.5)	30 (47.6)	20 (68.9)	40 (34.2)	<0.001
Family history of DM, n (%)	3 (37.5)	18 (28.6)	7 (24.1)	44 (37.6)	0.59

DISCUSSION

Burden of Macrovascular Complications

- Prevalence of Macrovascular Complications: This hospital-based cross-sectional study highlights the substantial burden of macrovascular complications among patients with type 2 diabetes mellitus. Overall, 41.5% of patients had macrovascular complications, with coronary heart disease being the most common (33.5%), followed by cerebrovascular disease (14.5%) and peripheral vascular disease (4.0%). These findings emphasize the high cardiovascular risk associated with diabetes and the need for comprehensive cardiovascular risk assessment and management in diabetic patients.
- Coronary heart disease: The prevalence of CHD in this study (33.5%) is comparable to regional data, with

Yadav et al. reporting 22% in North India,[13] and Shaikh et al. reporting 40.1% in a South Asian cohort.[10] The CURES study reported a lower prevalence of 21.4% among urban Indian diabetics.[5] The higher prevalence observed in our hospital-based study likely reflects differences in study population and disease severity.

- Cerebrovascular disease: The prevalence of CVD in this study (14.5%) is comparable to regional data. Al-Khawlani et al. reported a lower prevalence of 5.8% among diabetic patients in Yemen,[14] while Indian studies have reported rates ranging from 6.4% to 10.1%.[15] The higher prevalence observed in our study may be related to the older age and longer duration of diabetes in the study population.
- Peripheral vascular disease: In this study, PVD was relatively uncommon (4.0%), consistent with reports from Asian populations showing lower prevalence compared to Western cohorts. Mohan V et al. similarly reported a lower occurrence of PVD among South Asian patients with diabetes.[16] This finding may also reflect underdiagnosis due to limited routine use of vascular screening tools such as ankle–brachial index or Doppler studies.

Risk factors for macrovascular complications

- Age: Our study identified several significant risk factors for macrovascular complications. Advanced age emerged as a significant risk factor for macrovascular complications, with patients with peripheral vascular disease being older than those without complications (69.4 vs 52.6 years; $p<0.001$). This finding supports the established role of aging in atherosclerosis and is consistent with evidence from the UK Biobank study identifying age as a strong predictor of vascular complications in diabetes.[17]
- Duration of diabetes: In the present study, longer duration of diabetes was significantly associated with macrovascular complications, particularly PVD (13.5 years) and CHD (9.2 years), compared to patients without complications (5.5 years). This duration-dependent risk has been consistently demonstrated in landmark trials such as UKPDS and DCCT/EDIC.[18] Prolonged hyperglycaemia contributes to vascular injury through mechanisms including oxidative stress, advanced glycation end-product formation, and endothelial dysfunction.
- Hypertension: In the present study, hypertension showed a strong association with macrovascular complications, with significantly higher systolic (148.1–151.7 mmHg) and diastolic (88.0–90.4 mmHg) blood pressures among patients with CHD and CVD compared to those without complications ($p<0.001$ and $p=0.002$, respectively). This finding supports the synergistic role of diabetes and hypertension in cardiovascular risk, as demonstrated in recent Indian study.[19] The high prevalence of hypertension (38.5%) in this cohort underscores the need for aggressive blood pressure control to prevent macrovascular complications.
- Smoking and Tobacco Use: In the present study, smoking/tobacco use was significantly more common among patients with macrovascular complications (47.6–68.9%) compared to those without complications (29.2%) ($p<0.001$). This finding is concerning given the synergistic effect of smoking and diabetes on cardiovascular risk. A meta-analysis including Indian populations reported a 2–3 fold increase in CHD risk among diabetic smokers.[20] The high prevalence of smoking among males in this study (47.3%) underscores the need for integrated tobacco cessation strategies in diabetes care.
- Glycaemic Control: In the present study, despite poor glycaemic control in the majority of patients (84.5% with HbA1c ≥7%), HbA1c did not show a significant association with macrovascular complications. This observation aligns with evidence suggesting a stronger relationship between glycaemic control and microvascular rather than macrovascular outcomes.[21] The cross-sectional design may also limit the ability to capture the long-term impact of glycaemic control on macrovascular disease.
- Dyslipidaemia: In this study, the prevalence of dyslipidaemia was relatively low (18%), possibly reflecting underdiagnosis, treatment effects, or ethnic differences in lipid patterns. Asian Indians are known to exhibit atherogenic dyslipidaemia characterized by high triglycerides and low HDL cholesterol even at lower total cholesterol levels.[22] The lack of significant association between lipid parameters and macrovascular complications may be due to subgroup sample size limitations or evolving lipid management practices.

Clinical Implications: The high prevalence of macrovascular complications (52%) highlights the need for routine cardiovascular risk assessment in all patients with diabetes. Identification of advanced age, longer duration of diabetes, hypertension, and smoking as key risk factors provides actionable targets for intervention. Additionally, the high proportion of patients with poor glycaemic control indicates the need for intensified treatment strategies, patient education, and regular monitoring.

Limitations: This study has certain limitations. Its cross-sectional design limits causal inference between risk factors and macrovascular complications. Being hospital-based, selection bias toward patients with more severe disease may have led to overestimation of complication prevalence. The small number of PVD cases reduced statistical power for subgroup analysis. Reliance on clinical diagnosis and routine investigations may have resulted in under-detection of asymptomatic disease, as advanced vascular diagnostic modalities were not uniformly applied.

CONCLUSION

This study demonstrates a high burden of macrovascular complications among patients with type 2 diabetes

mellitus, with coronary heart disease being the most prevalent complication. Advanced age, longer duration of diabetes, hypertension, and smoking/tobacco use were identified as significant risk factors. The substantial prevalence of modifiable risk factors and poor glycemic control in our study population highlights critical gaps in current diabetes care and prevention strategies. These findings emphasize the urgent need for comprehensive cardiovascular risk assessment, aggressive management of modifiable risk factors, and implementation of structured screening programs for early detection of macrovascular complications in diabetic patients.

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