Al Ameen J Med Sci 2026;19(2):99-103 ● US National Library of Medicine enlisted journal ● ISSN 0974-1143

ORIGINAL ARTICLE CODEN: AAJMBG

Predictors of cardiovascular autonomic dysfunction in patients with type 2 diabetes mellitus: A cross-sectional study

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Received: 18th December 2025; ***Accepted:*** 21st January 2026; ***Published:*** 01st April 2026

Abstract: *Background:* Cardiovascular autonomic dysfunction (CAD) is a frequent yet under-recognized complication of Type 2 Diabetes Mellitus (T2DM) and is associated with increased cardiovascular morbidity and mortality. Early identification using standard autonomic function tests can facilitate timely intervention. *Objectives:* To assess cardiovascular autonomic function in patients with T2DM; to determine the association between duration of diabetes and cardiovascular autonomic dysfunction; and to identify clinical predictors of autonomic dysfunction in patients with T2DM. *Methods:* A cross-sectional study was conducted among patients with T2DM attending the outpatient department. Sympathetic and parasympathetic autonomic function was assessed using standard cardiovascular reflex tests. Association between duration of diabetes and autonomic dysfunction was analyzed, and predictors were identified using logistic regression analysis. *Results:* A substantial proportion of patients with T2DM exhibited abnormal cardiovascular autonomic function. Autonomic dysfunction increased significantly with longer duration of diabetes. Age, duration of diabetes, resting pulse rate, and blood pressure parameters emerged as significant predictors of cardiovascular autonomic dysfunction. *Conclusion:* Cardiovascular autonomic dysfunction is common in patients with T2DM and is strongly associated with disease duration and adverse clinical predictors. Routine screening using simple autonomic function tests should be incorporated into diabetes care for early detection and prevention of cardiovascular complications.

Keywords: Type 2 Diabetes Mellitus, Cardiovascular Autonomic Dysfunction, Autonomic Neuropathy, Predictors, Cross-Sectional Study.

Introduction

Type 2 Diabetes Mellitus (T2DM) is a major global public health problem with a rapidly increasing prevalence, particularly in developing countries [1]. Chronic hyperglycemia in diabetes leads to a wide spectrum of micro vascular and macro vascular complications, among which diabetic autonomic neuropathy represents one of the most serious and underdiagnosed conditions [2-3]. Cardiovascular autonomic dysfunction (CAD), a manifestation of diabetic autonomic neuropathy, results from damage to the autonomic nerve fibers supplying the heart and blood vessels [4]. It is associated with resting tachycardia, orthostatic hypotension, exercise intolerance, silent myocardial ischemia, and an increased risk of sudden cardiac death [5-7].

Despite its clinical importance, CAD often remains asymptomatic in the early stages and is frequently overlooked in routine clinical practice [8]. Assessment of cardiovascular autonomic function using non-invasive reflex tests provides a reliable and practical method for detecting both sympathetic and parasympathetic dysfunction [9-10]. Previous studies have reported that parasympathetic dysfunction occurs earlier and more frequently than sympathetic impairment in patients with T2DM [11-12].

Duration of diabetes has been consistently identified as a major risk factor for the development of autonomic dysfunction [13]. In addition to disease duration, clinical factors such as age, resting heart rate, and blood

pressure parameters have been shown to influence autonomic function in patients with diabetes [14-15]. However, limited data are available regarding predictors of cardiovascular autonomic dysfunction in many Indian settings. Therefore, the present study was undertaken to assess cardiovascular autonomic function in patients with T2DM, examine its association with duration of diabetes, and identify clinical predictors of autonomic dysfunction.

Problem Statement: Predictors of Cardiovascular Autonomic Dysfunction in Patients with Type 2 Diabetes Mellitus: A Cross-Sectional Study

Primary Objective: To assess cardiovascular autonomic function in patients with type 2 diabetes mellitus using standard sympathetic and parasympathetic tests.

Secondary Objectives:

1. To determine the association between duration of diabetes and cardiovascular autonomic dysfunction.
2. To identify clinical predictors of autonomic dysfunction among patients with type 2 diabetes mellitus.

Material and Methods

Study Design and Setting: A cross-sectional study was conducted in the Department of Physiology, Al-Ameen Medical College Hospital and Government District Hospital, Bijapur

Study Population: Patients diagnosed with Type 2 Diabetes Mellitus were recruited during the study period.

Inclusion Criteria:

- Patients aged ≥18 years with confirmed T2DM
- Willingness to participate and provide informed consent

Exclusion Criteria:

- Type 1 diabetes mellitus
- Known cardiovascular disease, arrhythmias, or heart failure
- Neurological disorders or other systemic illnesses affecting autonomic function
- Use of drugs known to influence autonomic function

Data Collection: Baseline clinical data including age, gender, duration of diabetes, resting pulse rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and body temperature were recorded.

Assessment of Cardiovascular Autonomic Function: Autonomic function was evaluated using standard non-invasive tests [9-10]:

Sympathetic function tests:

- Blood pressure response to standing
- Blood pressure response to sustained handgrip
- Blood pressure response to cold pressor test

Parasympathetic function tests:

- Heart rate response to standing (30:15 ratio)
- Heart rate response to deep breathing
- Valsalva ratio

Results were interpreted using established normal values. Presence of abnormality in one or more tests was considered evidence of autonomic dysfunction.

Statistical Analysis: Data were expressed as mean ± standard error of mean (SEM) and frequencies (%). Association between duration of diabetes and autonomic dysfunction was analysed using appropriate statistical tests. Logistic regression analysis was performed to identify predictors of autonomic dysfunction, expressed as odds ratios (OR) with 95% confidence intervals (CI). A p-value <0.05 was considered statistically significant.

Results

Table 1 presents the baseline demographic and clinical profile of patients with Type 2 Diabetes Mellitus included in the study. The mean age and duration of diabetes indicate that most participants were middle-aged with longstanding diabetes. Resting pulse rate and blood pressure values reflect the underlying cardiovascular status of the study population. These baseline parameters are essential for interpreting autonomic function results, as age, duration of diabetes, and blood pressure

are known contributors to cardiovascular autonomic dysfunction.

Table-1: Baseline Clinical Characteristics of Patients with Type 2 Diabetes Mellitus	
Variable	**Mean ± SEM/n(%)**
Number of subjects	31
Age (years)	52.6 ± 2.34
Gender (Male/Female)	18 / 13
Duration of diabetes (years)	8.4 ± 1.12
Resting pulse rate (bpm)	79.4 ± 1.10
Systolic BP (mmHg)	136.2 ± 3.03
Diastolic BP (mmHg)	83.2 ± 1.93
Body temperature (°F)	96.4 ± 0.68

Table 2 shows the sympathetic autonomic responses assessed through blood pressure changes during standing, sustained handgrip, and cold pressor tests. A significant alteration in systolic and diastolic blood pressure responses following these stimuli indicates impaired sympathetic cardiovascular regulation in patients with Type 2 Diabetes Mellitus. These findings support the presence of sympathetic autonomic dysfunction, which is commonly observed in diabetic patients due to long-term metabolic and vascular changes.

Table-2: Sympathetic Autonomic Function Tests in Type 2 Diabetes Mellitus			
Test	**At Rest / Supine (Mean ± SEM)**	**After Stimulus (Mean ± SEM)**	**p-value**
SBP response to standing (mmHg)	136.4 ± 3.0	128.3 ± 3.22	<0.05
DBP response to standing (mmHg)	83.2 ± 1.93	86.1 ± 1.83	<0.05
DBP response to sustained handgrip (mmHg)	83.2 ± 1.9	115.2 ± 1.9	<0.001
SBP response to cold pressor test (mmHg)	136.4 ± 3.0	142.9 ± 3.3	<0.05

Table 3 summarizes parasympathetic autonomic function using the 30:15 ratio, heart rate response to deep breathing, and Valsalva ratio. Reduced values in these parameters indicate parasympathetic dysfunction, which is considered an early and predominant feature of cardiovascular autonomic neuropathy in diabetes. The observed abnormalities highlight reduced vagal control of heart rate in the study population.

Table-3: Parasympathetic Autonomic Function Tests in Type 2 Diabetes Mellitus		
Test	**Mean ± SEM**	**Normal / Abnormal**
30:15 ratio	1.12 ± 0.0016	Abnormal
HR response to deep breathing (bpm)	13.20 ± 0.97	Abnormal
Valsalva ratio	1.41 ± 0.006	Borderline / Reduced

Table 4 demonstrates the relationship between duration of diabetes and cardiovascular autonomic dysfunction. A higher proportion of autonomic dysfunction is observed in patients with longer duration of diabetes, with a statistically significant association. This finding emphasizes the progressive nature of autonomic nerve damage with increasing disease duration in Type 2 Diabetes Mellitus.

Table-4: Association between Duration of Diabetes and Autonomic Dysfunction				
Duration of Diabetes	**n**	**Normal Autonomic Function**	**Autonomic Dysfunction**	**p-value**
< 5 years	9	6	3	
5–10 years	12	4	8	<0.05
> 10 years	10	2	8	

Table 5 presents the predictors of cardiovascular autonomic dysfunction identified through regression or association analysis. Variables such as age, duration of diabetes, resting pulse rate, systolic blood pressure, and diastolic blood pressure show significant associations with autonomic dysfunction. These predictors reflect the combined influence of aging, disease chronicity, and cardiovascular stress on autonomic regulation in diabetic patients.

Table-5: Predictors of Cardiovascular Autonomic Dysfunction in Type 2 Diabetes Mellitus

Variable	Odds Ratio (OR)	95% CI	p-value
Age	1.08	1.01–1.15	<0.05
Duration of diabetes	1.32	1.12–1.56	<0.01
Resting pulse rate	1.10	1.02–1.19	<0.05
Systolic BP	1.05	1.01–1.10	<0.05
Diastolic BP	1.07	1.01–1.14	<0.05

Discussion

The present study demonstrates a high prevalence of cardiovascular autonomic dysfunction among patients with Type 2 Diabetes Mellitus, supporting earlier reports that autonomic neuropathy is a common complication of long-standing diabetes [3,6,13]. Parasympathetic dysfunction was prominent in the study population, as evidenced by reduced 30:15 ratio, heart rate response to deep breathing, and Valsalva ratio. This finding is consistent with previous studies indicating that parasympathetic fibers are affected earlier due to their longer length and greater metabolic vulnerability [11-12,16].

A significant association was observed between duration of diabetes and autonomic dysfunction, with higher prevalence among patients with longer disease duration. Similar findings have been reported by Tesfaye et al. and Ziegler et al., highlighting the cumulative effect of chronic hyperglycemia on autonomic nerve damage [13,17]. Logistic regression analysis identified age, duration of diabetes, resting pulse rate, SBP, and DBP as significant predictors of cardiovascular autonomic dysfunction. Elevated resting heart rate has been recognized as an early marker of autonomic imbalance and increased cardiovascular risk in diabetic patients [14,18]. Blood pressure abnormalities further reflect impaired autonomic regulation and vascular dysfunction [19].

These findings emphasize the need for routine screening of cardiovascular autonomic function in patients with T2DM, particularly those with longer disease duration and adverse clinical profiles.

Conclusion

Cardiovascular autonomic dysfunction is a common and clinically significant complication in patients with Type 2 Diabetes Mellitus. It is strongly associated with longer duration of diabetes and clinical predictors such as age, resting pulse rate, and blood pressure parameters. Early detection through simple, non-invasive autonomic function tests should be incorporated into routine diabetes care to reduce cardiovascular morbidity and mortality.

Financial Support and sponsorship: Nil

Conflicts of interest: There are no conflicts of interest.

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Cite this article as: Chavan NR, Rathod LH and Totad RD. Predictors of cardiovascular autonomic dysfunction in patients with type 2 diabetes mellitus: A cross-sectional study. *Al Ameen J Med Sci* 2026; 19(2):99-103.

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