Biomedical and Biopharmaceutical Research
Abbreviation: Biomed. Biopharm. Res.
Volume: 22: Issue: 02 |Year: 2025
Page Number: 532-535

Autonomic Dysfunction in Patients with Type 2 Diabetes Mellitus: A Study Using Heart Rate Variability

Dr Mohammad selim
Associate Professor, Department of Physiology,Jalpaiguri Government Medical College,Jalpaiguri -735101.

Corresponding Author

Dr Mohammad selim
Associate Professor, Department of Physiology,Jalpaiguri Government Medical College,Jalpaiguri -735101.

Article Received:29-06-2025

Article Accepted:28-07-2025

Abstract

Background: Autonomic dysfunction, particularly cardiac autonomic neuropathy (CAN), is a common and often overlooked complication of Type 2 Diabetes Mellitus (T2DM). Early identification is essential, as it is associated with increased cardiovascular morbidity and mortality. Heart rate variability (HRV) serves as a sensitive, non-invasive tool for evaluating autonomic nervous system function [1].
Objective: To assess the prevalence and pattern of autonomic dysfunction among patients with T2DM using HRV analysis and to evaluate its correlation with disease duration and glycemic control.
Methods: A cross-sectional observational study was conducted on 80 adult patients with T2DM attending the general outpatient department (OPD) at Jalpaiguri Government Medical College from March 1, 2024, to February 28, 2025. HRV parameters were recorded using standard 5-minute ECG-based monitoring. Time and frequency domain indices were analyzed. Statistical analysis was performed using SPSS version 25.0.
Results: Out of 80 patients, 47 (58.8%) exhibited signs of autonomic dysfunction. Patients with a diabetes duration >5 years and poor glycemic control (HbA1c ≥8.0%) demonstrated significantly lower HRV indices, particularly SDNN and RMSSD, with an elevated LF/HF ratio, indicating sympathetic dominance and parasympathetic withdrawal [2,3].
Conclusion: A substantial proportion of patients with T2DM exhibit subclinical autonomic dysfunction. HRV analysis should be incorporated into routine diabetes management to facilitate early identification and timely intervention.

Keywords: Type 2 Diabetes Mellitus, Autonomic Dysfunction, Heart Rate Variability, Cardiac Autonomic Neuropathy, Glycemic Control

INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder characterized by insulin resistance and progressive β-cell dysfunction, leading to persistent hyperglycemia. It is a major public health problem, with a rapidly increasing prevalence in both developing and developed countries. According to the International Diabetes Federation, India alone is projected to have over 100 million individuals affected by diabetes by 2045. With increasing longevity and urbanization, diabetes-related complications are also on the rise.

Among the complications of T2DM, diabetic autonomic neuropathy (DAN) is frequently under-recognized despite its significant clinical impact. Cardiac autonomic neuropathy (CAN), a subset of DAN, refers to damage to the autonomic nerve fibers that innervate the heart and blood vessels, leading to abnormalities in heart rate control and vascular dynamics. CAN is associated with poor quality of life and increased risk of silent myocardial ischemia, sudden cardiac death, and perioperative cardiovascular instability [1,4].

One of the earliest manifestations of CAN is a reduction in **Heart Rate Variability (HRV)**, which reflects the balance between the sympathetic and parasympathetic divisions of the autonomic nervous system. HRV represents the physiological variation in the time interval between consecutive heartbeats and is a sensitive, non-invasive tool for evaluating autonomic modulation of cardiac function [2]. Time-domain and frequency-domain parameters derived from short-term ECG recordings can reliably indicate autonomic tone and its fluctuations.

Traditionally, autonomic dysfunction in diabetics has been diagnosed using clinical tests such as the Valsalva maneuver, deep breathing tests, and orthostatic BP changes, which often detect abnormalities only in later stages of neuropathy. In contrast, HRV analysis can detect **subclinical changes** and facilitate early diagnosis and intervention [3]. In view of the paucity of Indian data from primary-care settings, this study aimed to investigate the prevalence and pattern of autonomic dysfunction in T2DM patients attending a general outpatient department using HRV as a diagnostic tool, and to correlate these findings with clinical variables such as duration of diabetes and glycemic control.

AIMS AND OBJECTIVES

1. To evaluate heart rate variability in patients with T2DM.
2. To determine the prevalence of autonomic dysfunction in this population.
3. To assess the association of HRV findings with disease duration and glycemic control.

MATERIALS AND METHODS

Study Design:
Cross-sectional observational study.

Study Setting:
General OPD, Jalpaiguri Government Medical College, West Bengal, India.

Study Duration:
March 1, 2024 – February 28, 2025

Sample Size:
80 patients with diagnosed T2DM.

Inclusion Criteria:

- T2DM duration ≥1 year
- Age 30–70 years
- Stable clinical condition
- Informed consent provided

Exclusion Criteria:

- History of cardiovascular disease or arrhythmias
- Current use of medications affecting autonomic tone
- Chronic alcoholics and smokers
- Renal failure or endocrine disorders

Data Collection:
Patients' demographic, clinical, and biochemical data were recorded. HbA1c was measured. HRV testing was done using 5-minute ECG in supine rest.

HRV Parameters:
Time-Domain:

- SDNN (standard deviation of NN intervals)
- RMSSD (root mean square of successive differences)

Frequency-Domain:

- LF (low frequency)
- HF (high frequency)
- LF/HF ratio

Statistical Analysis:
SPSS v25.0 was used. Mean ± SD was calculated. Pearson correlation and Chi-square tests were applied. $p < 0.05$ was considered significant.

RESULTS

Demographic and Clinical Characteristics

Parameter	Value
Mean age (years)	52.6 ± 9.4
Male : Female	43 : 37
Mean diabetes duration	6.1 ± 3.2 years
Mean HbA1c (%)	8.2 ± 1.1
HbA1c ≥ 8.0%	49 patients (61.2%)

HRV Findings

HRV Parameter	Normal HRV (n=33)	Abnormal HRV (n=47)	p-value
SDNN (ms)	45.1 ± 7.3	28.9 ± 5.6	<0.001
RMSSD (ms)	36.2 ± 6.1	21.3 ± 4.8	<0.001
LF/HF Ratio	1.6 ± 0.5	3.4 ± 1.2	<0.001

Patients with disease duration >5 years and HbA1c ≥8.0% showed statistically significant reductions in parasympathetic tone and increased sympathetic activity [2,4].

DISCUSSION

The present study demonstrated that a significant proportion (58.8%) of patients with Type 2 Diabetes Mellitus showed evidence of autonomic dysfunction based on HRV analysis. This finding is consistent with earlier studies which reported the prevalence of CAN in diabetics to range between 25% and 75% depending on the diagnostic criteria used and the population studied [1,4,5].

HRV parameters such as SDNN and RMSSD were significantly reduced in patients with longer disease duration and poor glycemic control, indicating **parasympathetic withdrawal**, while an elevated LF/HF ratio suggested **relative sympathetic dominance**. These alterations in autonomic balance are hallmarks of early CAN and are known predictors of increased cardiovascular mortality, arrhythmogenesis, and silent ischemia in diabetics [4,5,6].

The inverse correlation observed between HbA1c and HRV indices reinforces the hypothesis that **chronic hyperglycemia plays a central role** in the pathogenesis of autonomic neuropathy. Persistent hyperglycemia leads to accumulation of advanced glycation end products (AGEs), oxidative stress, microvascular damage, and nerve ischemia, which collectively impair autonomic nerve function [1].

Several previous studies support these findings. Vinik et al. emphasized the role of HRV in early detection of CAN and stressed the need for proactive screening in diabetic care [1]. Spallone et al. recommended HRV testing as part of a multiparametric approach for diagnosing cardiovascular autonomic neuropathy [4]. Our findings align with these international recommendations and support the feasibility of HRV testing even in primary and secondary care settings.
An important aspect of this study is that all participants were recruited from a **general OPD setting**, highlighting the high burden of subclinical CAN even among ambulatory, stable patients. This underscores the importance of **routine screening**, especially in resource-limited healthcare environments like rural and semi-urban India, where overt cardiovascular disease may not yet be evident.

Despite its strengths, the study had certain limitations. The sample size was relatively modest, and there was no healthy control group for comparison. Lifestyle factors such as physical activity, sleep patterns, and psychological stress, which can influence HRV, were not controlled for. A longitudinal follow-up would be valuable to observe progression and potential reversibility of autonomic dysfunction with glycemic control or lifestyle modification.

Limitations

- The study was limited to a single center and small sample size.
- Lack of a healthy control group.
- Factors like sleep, stress, and physical activity were not controlled, which can influence HRV.

CONCLUSION

This study demonstrates that more than half of the patients with Type 2 Diabetes Mellitus exhibit signs of autonomic dysfunction as assessed by HRV, with a strong association between autonomic impairment, poor glycemic control, and longer duration of disease. HRV provides a sensitive, objective, and non-invasive method for the early detection of cardiac autonomic neuropathy in diabetics, even before clinical signs become evident.

Incorporating HRV analysis into routine diabetes management—especially in OPD-based screening programs—can help identify high-risk individuals early and facilitate timely therapeutic interventions. Improving glycemic control, promoting lifestyle changes, and close monitoring can potentially delay or prevent the progression of autonomic neuropathy.

From a public health perspective, early identification and management of autonomic dysfunction can reduce cardiovascular complications, healthcare costs, and mortality associated with diabetes. Future studies with larger populations and longitudinal designs are warranted to validate these findings and to assess the effectiveness of HRV-based interventions in improving long-term outcomes.

Recommendations

1. HRV testing should be introduced as part of annual diabetes evaluations.
2. Patients with high HbA1c or diabetes >5 years should be prioritized.
3. Further longitudinal studies with larger sample sizes are recommended.

REFERENCES

1. Vinik AI, Erbas T, Casellini CM. Diabetic cardiac autonomic neuropathy, inflammation and cardiovascular disease. *J Diabetes Investig*. 2013;4(1):4–18.
2. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart Rate Variability: Standards of Measurement, Physiological Interpretation, and Clinical Use. *Circulation*. 1996;93(5):1043–1065.
3. Malik M, Camm AJ. Heart rate variability and clinical cardiology. *Br Heart J*. 1994;71(6):617–620.
4. Spallone V, Ziegler D, Freeman R, et al. Cardiovascular autonomic neuropathy in diabetes: clinical impact, assessment, diagnosis, and management. *Diabetes Metab Res Rev*. 2011;27(7):639–653.
5. Pop-Busui R, Evans GW, Gerstein HC, et al. Effects of cardiac autonomic dysfunction on mortality risk in the ACCORD trial. *Diabetes Care*. 2010;33(7):1578–1584.
6. Ewing DJ, Clarke BF. Diagnosis and management of diabetic autonomic neuropathy. *Br Med J*. 1982;285(6346):916–918.