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Type 2 Diabetes Mellitus and its Impact on Cardiac Autonomic Function and ECG Patterns: A Comparative Study

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Abstract

Background and Objectives: Globally, diabetes mellitus has become a significant public health concern, particularly in India. Diabetic neuropathy is prevalent in approximately half of individuals with long-standing diabetes mellitus. Several factors, including the duration of diabetes, glycemic control, age, and gender, contribute to cardiac autonomic dysfunction in diabetes mellitus. The aim of this study was to investigate different electrocardiogram (ECG) abnormalities in type 2 diabetes mellitus patients compared to a control group.

Methodology: This research adopted a hospital-based cross-sectional approach, involving 65 diabetic patients and 65 control subjects who were matched for age and gender. Resting ECG readings were obtained from both study and control groups. Statistical analysis was performed using SPSS version 19.0, employing the unpaired t-test to assess differences in means. A p-value less than 0.05 was deemed statistically significant.

Results: The study findings indicated significant variations in certain ECG parameters, including resting heart rate, RR interval, PR interval, QRS axis, and QTc interval, between the study and control groups. Additionally, diabetic patients exhibited a higher incidence of abnormal heart rate responses during deep breathing and postural hypotension.

Conclusion: The assessment of cardiovascular reflexes and ECG in type 2 diabetic patients offers a practical approach for identifying the presence of cardiac dysautonomia.

Keywords: Diabetes Mellitus, Autonomic Nervous System, Electrocardiography.

Introduction

Globally, diabetes mellitus has emerged as a significant public health concern, with a particular focus on India. Diabetes is a chronic metabolic disorder characterized by prolonged high blood sugar levels. It can be broadly classified into two types: type I and type II, with type II accounting for 90% of cases. As of 2014, there were 387 million people worldwide living with diabetes, and it is projected that an additional 205 million will be affected by 2035. Alarmingly, nearly 46% of individuals with diabetes remain undiagnosed, and 77% of them reside in low-

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and middle-income countries. In the Southeast Asian region, an estimated 75 million people have diabetes, of which 66 million are in India, boasting a prevalence rate of 8.3% [1].

Diabetic neuropathy, a complication of long-standing diabetes mellitus, affects almost half of these patients [2]. The underlying causes and clinical manifestations of diabetic neuropathies are multifaceted. Hyperglycemia plays a central role in their development. Diabetic neuropathy can present as polyneuropathy, mononeuropathy, or autonomic neuropathy, affecting various bodily systems, including the cardiovascular, gastrointestinal, and genitourinary systems. Tragically, one-third to half of patients with overt symptoms of autonomic neuropathy die within a decade, often due to cardiac arrest [3].

In the context of diabetes mellitus, the factors contributing to cardiac autonomic dysfunction include the duration of diabetes, the level of glycemic control, age, and gender [4-6]. Importantly, cardiac autonomic dysfunction often remains asymptomatic in the early stages of diabetes, underscoring the critical need for early detection to mitigate complications. Common features of cardiac autonomic neuropathy encompass exercise intolerance, postural hypotension, elevated resting heart rate, fixed heart rate response, and painless myocardial infarction. The presence of autonomic neuropathy post-diagnosis has been linked to a high mortality rate, reaching up to 50% within three years, suggesting its significance as a poor prognostic indicator.

Electrocardiogram (ECG) records the heart's electrical activity and holds potential as a diagnostic tool for identifying heart rhythm abnormalities in patients with diabetes mellitus. Early detection of autonomic dysfunction in individuals with diabetes can significantly reduce morbidity and mortality. Therefore, it is essential to investigate various ECG abnormalities associated with autonomic dysfunction in diabetes mellitus patients. This study aims to explore different ECG irregularities in patients with type 2 diabetes mellitus in comparison to a control group.

Material and Methods

The research was conducted at a tertiary-care hospital in India, as a hospital-based cross-sectional study. It involved 130 adult participants, equally divided into a study group (with diabetes) and a control group (without diabetes). Participants were selected from the outpatient department based on specific inclusion and exclusion criteria. Inclusion criteria required diabetes duration of at least 2 years. Exclusion criteria included elderly patients, those with known heart diseases, hypertension, kidney problems, thyroid disorders, certain medications, infections, lung diseases, movement disorders, and electrolyte imbalances.

The study evaluated autonomic dysfunction using various tests, including tachycardia in resting ECG and heart rate response to deep breathing for parasympathetic function, and blood pressure response to standing and QTc prolongation for sympathetic function. Resting ECGs were taken twice, and RR and QTc intervals were measured using standard procedures.

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Statistical analysis was performed using SPSS version 19.0, with a significance level set at p<0.05. Informed consent was obtained from all participants in the local language.

Autonomic dysfunction was assessed by the following manoeuvres: parasympathetic function by tachycardia in resting ECG and heart rate response to deep breathing (HRBD); and sympathetic function by blood pressure response to standing and QTc prolongation. The resting ECG was conducted twice, with a 15-minute gap, for all participants in both the study and control groups. A 12-lead Cardiograph was employed, following standard procedures. During the test, subjects were instructed to lie still and breathe evenly at a rate of six breaths per minute (5 seconds for both inhalation and exhalation). A continuous ECG recording was taken for 1 minute.

For analysis, the maximum and minimum RR intervals during each breathing cycle were recorded and converted into beats per minute. The average difference between the maximum and minimum heart rates across the six measured cycles was calculated, and a variation of more than 10 beats was considered abnormal. RR and QTc intervals were measured using lead V2 on the resting ECG tracing. The QT interval was measured from the start of the QRS complex to the downward slope of the T wave, where it crosses the isoelectric line. In the presence of a U wave, the QT interval was measured to the lowest point of the T wave and the U wave. A QTc interval exceeding 460 milliseconds was deemed abnormally prolonged.

Results

The study findings revealed notable differences in certain ECG parameters between the study and control groups. Specifically, the mean resting heart rate was significantly higher in the study group compared to the control group. A similar pattern of higher values was also observed for the PR interval. In contrast, the QTc interval remained elevated in the study group, while the QRS axis showed relatively lower values among the study group participants. There were no statistically significant changes observed in QRS duration between the study and control groups (refer to Table 1).

Table 1: ECG changes in study and control groups

ECG Parameter	Study Group (Mean ± SD)	Control Group (Mean ± SD)	p-value
Resting Heart Rate (bpm)	90.8 ± 14.25	78.7 ± 11.93	<0.05
PR Interval (ms)	168.2 ± 10.92	144.6 ± 17.38	<0.05
RR Interval (ms)	705.6 ± 119.74	828.3 ± 117.6	<0.05
QRS Axis (°)	31.8 ± 28.67	70.2 ± 26.44	<0.05
QRS Duration (ms)	72.3 ± 11.93	68.9 ± 9.14	0.1
QTc Interval (ms)	412.74 ± 43.15	359.92 ± 24.8	<0.05

While a clinically significant number of patients in the study group exhibited ECG changes suggestive of ischemia or infarction, it is important to note that these differences did not reach statistical significance. Specifically, ECG evidence of ischemia was detected in 33.84% of study group participants, compared to 15.38% in the control group. Similarly, ECG evidence of infarction was observed in 13.84% of study group participants, as opposed to 7.69% in the

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control group. However, it is worth highlighting that these differences did not achieve statistical significance. Abnormal HRBD was also noted in the study group (refer to Table 2).

Among the patients who presented with ECG changes suggestive of ischemia or infarction, six individuals (20%) were asymptomatic, underlining the importance of vigilant monitoring and early detection in diabetes mellitus cases.

Table 2: ECG changes and Cardiac Autonomic abnormalities in study participants

Abnormalities	Study Group (n)	Control Group (n)	p-value	Odds Ratio (95% CI)
ECG changes of Ischemia/Infarction				
Present	29	14	0.048	2.33 (0.95–5.74)
Absent	36	51		
Evidence of Infarction				
Yes	22	10	0.1	2.47 (0.85–7.15)
No	43	55		
Evidence of Ischemia				
Yes	9	5	0.65	1.57 (0.35–6.97)
No	56	60		
Conduction Blocks (Intraventricular)				
Present	8	3	0.41	3.14 (0.34–28.92)
Absent	57	62		
HRBD				
Abnormal	21	8	0.04	2.86 (0.94–8.73)
Normal	44	57		
Postural Hypotension				
Present	7	1	0.32	NA
Absent	58	64		

Discussion

In a study by Ziegler et al. [7], cardiac autonomic diabetic neuropathy was reported in 22.1% of patients with type II diabetes mellitus. In our study, we observed ECG changes in 36% of the participants in the study group who had type II diabetes mellitus. Kahn et al. [8] discovered that patients with cardiac dysautonomia exhibited higher resting heart rates and lower maximal heart rates during exercise compared to diabetic patients without autonomic neuropathy. Our study yielded similar results.

Furthermore, our study found a significant prolongation of the PR interval, reflecting AV conduction, in diabetic patients. This finding aligns with a study conducted by Mustonen et al. [9] during a 4-year follow-up of middle-aged diabetic and nondiabetic subjects. We also noted

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a higher prevalence of prolonged QTc intervals in the diabetic group compared to the nondiabetic group, which concurs with results from a study by Mathur and Gupta. [10].

The association between diabetes mellitus and cardiovascular complications, particularly ischemic heart disease, has been well established in previous studies [11, 12]. In our study, we observed silent ischemic heart disease in 33.84% of diabetic patients, whereas a study by Negrusz-Kawecka et al. [12] reported a lower incidence of 22%. This observation is crucial, as sudden unexpected deaths have been linked to patients with cardiac autonomic neuropathy, often attributed to asymptomatic ischemic heart disease [13].

HRBD, indicating parasympathetic damage, was abnormal in diabetic patients in our study, consistent with the findings of a study by Domuschiev [14]. In summary, our study revealed a higher prevalence of cardiac autonomic dysfunction in patients with diabetes compared to non-diabetic individuals.

Strengths of our study include the meticulous selection of patients and controls following standardized procedures, minimizing inter-observer and instrumental bias since one investigator and one instrument were used throughout. However, a limitation of our study is the lack of a temporal association between the duration of diabetes mellitus and cardiac autonomic neuropathy. Further large-scale studies may be needed to establish the potential pathogenesis behind cardiac autonomic dysfunction and the feasibility of using various cardiovascular reflexes as a screening tool.

Conclusion

Patients with diabetes mellitus exhibit ECG alterations that indicate the presence of subclinical or clinical autonomic cardiac neuropathy more frequently than individuals without diabetes. The assessment of different cardiovascular reflexes and ECG parameters in type 2 diabetic patients can be a valuable approach for identifying cardiac dysautonomia.

Conflict of interest: none

References

1. IDF Diabetes Atlas 2013. [Internet]. Available from: http://www.idf.org/sites/default/files/EN_6E_Atlas_Full_0.pdf
2. Longo D, Fauci A, Kasper D, Hauser S, Jameson J, Loscalzo J. Harrison's Principles of Internal Medicine, 18th edn. New York: McGraw-Hill Professional; 2012.
3. Walker BR, Colledge NR, Ralston SH, Penman I. Davidson's Principles and Practice of Medicine. Philadelphia, PA: Elsevier Health Sciences; 2013.
4. Stella P, Ellis D, Maser RE, Orchard TJ. Cardiovascular autonomic neuropathy (expiration and inspiration ratio) in type 1 diabetes: incidence and predictors. J Diabetes Complications. 2000; 14:1–6.
5. Witte D, Tesfaye S, Chaturvedi N, Eaton SE, Kempler P, Fuller JH; EURODIAB Prospective Complications Study Group. Risk factors for cardiac autonomic neuropathy in type 1 diabetes mellitus. Diabetologia. 2005;48:164–171.Vijay Prasad C, Darshan Savery M, Vishnu Prasad R. Cardiac autonomic dysfunction and ECG abnormalities in patients with type 2 diabetes mellitus—a comparative cross-sectional study. Natl J Physiol Pharm Pharmacol. 2016; 6:178-181.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 10, 2023

6. Rav Acha M, Glikson M. Type 2 diabetes mellitus association with atrioventricular block. Eur Heart J. 2023 Mar 1; 44(9):762-764.
7. Ziegler D, Gries F, Mühlen H, Rathmann W, Spüler M, Lessmann F. Prevalence and clinical correlates of cardiovascular autonomic and peripheral diabetic neuropathy in patients attending diabetes centers. The Diacan Multicenter Study Group. Diab Metab. 1992;19:143–151.
8. Kahn JK, Sisson JC, Vinik AI. QT interval prolongation and sudden cardiac death in diabetic autonomic neuropathy. J Clin Endocrinol Metab. 1987;64:751–754.
9. Mustonen J, Uusitupa M, Mäntysaari M, Länsimies E, Pyörälä K, Laakso M. Changes in autonomic nervous function during the 4-year follow-up in middle-aged diabetic and nondiabetic subjects initially free of coronary heart disease. J Intern Med. 1997;241:231–239.
10. Mathur C, Gupta D. QTc prolongation in diabetes mellitus—an indicator of cardiac autonomic neuropathy. J Indian Acad Clin Med. 2006;17:34.00.
11. Kannel WB, McGee DL. Diabetes and cardiovascular disease: the Framingham study. JAMA. 1979;241:2035–2038.
12. Negrusz-Kawecka M, Moszczyńska-Stulin J, Zytkiewicz-Jaruga D, Salomon P. Frequency of silent ischemic heart disease in patients with diabetes mellitus. Pol Merkur Lekarski. 1997;3:53–56.
13. Vinik AI, Ziegler D. Diabetic cardiovascular autonomic neuropathy. Circulation. 2007;115:387–397.
14. Domuschiev I. Cardiac autonomic neuropathy and its correlation with retinopathy in type 2 diabetics. Biotechnol Biotechnol Equip. 2005;19:180–183.