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ORIGINAL RESEARCH

Assessing the Influence of Glycemic Control on Cardiac Autonomic Neuropathy in Type 1 and Type 2 Diabetic Patients: A Tertiary Care Perspective

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ABSTRACT

Background: Cardiac autonomic neuropathy (CAN) is a serious yet underdiagnosed complication in diabetes mellitus, associated with increased cardiovascular morbidity and mortality. Early detection using simple bedside tests can help identify asymptomatic individuals and allow timely intervention. **Objectives:** To assess the prevalence of asymptomatic cardiac autonomic dysfunction in type 1 and type 2 diabetic patients using bedside autonomic function tests, and to evaluate the impact of glycemic control and clinical variables on CAN. **Material and Methods:** This cross-sectional observational study included 150 participants: 50 type 1 diabetics, 50 type 2 diabetics, and 50 healthy controls. Bedside tests including heart rate variability with deep breathing, Valsalva maneuver, postural blood pressure change, and sustained handgrip were used to assess autonomic function. Clinical and biochemical parameters were recorded, and statistical analysis was performed using ANOVA and chi-square tests. **Results:** Definite CAN was found in 50% of type 1 and 66% of type 2 diabetic patients. Poor glycemic control (high HbA1c), microalbuminuria, prolonged QTc intervals, and retinopathy were significantly associated with CAN. Age, gender, BMI, duration of diabetes, and occupation showed no significant association. Income level and family history of cardiac deaths emerged as important predictors, particularly in type 2 diabetics. **Conclusion:** Cardiac autonomic neuropathy is highly prevalent among diabetics, particularly in type 2 patients.Simple bedside tests are valuable tools for early detection. Routine screening and aggressive glycemic control may help reduce cardiovascular risks in diabetic populations.

Keywords: Cardiac autonomic neuropathy, Diabetes mellitus, Bedside autonomic tests

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder that has reached epidemic proportions worldwide, characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both [1]. Among its numerous complications, cardiac autonomic neuropathy (CAN) remains one of the most underdiagnosed yet clinically significant conditions, particularly in type 1 (T1DM) and type 2 diabetes mellitus (T2DM) [2]. CAN is defined as the impairment of autonomic control of the cardiovascular system, leading to resting tachycardia, exercise intolerance, orthostatic hypotension, and even silent myocardial ischemia, contributing substantially to increased cardiovascular morbidity and mortality in diabetic patients [3,4].

The early stages of CAN are often asymptomatic, making timely detection crucial. Recent studies have emphasized the importance of routine screening for CAN in diabetic populations, especially through bedside autonomic function tests, which offer a simple, non-invasive, and cost-effective tool to detect subclinical autonomic dysfunction [5]. These tests, including heart rate variability (HRV) with deep breathing, Valsalva maneuver, and postural blood pressure changes, can identify early abnormalities in autonomic regulation before the development of overt organ damage [6,7].

Glycemic control plays a pivotal role in the pathogenesis and progression of CAN. Longitudinal studies have shown that intensive glycemic control

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can significantly reduce the incidence and progression of CAN in both
T1DM and T2DM patients [8]. However, despite good glycemic control, some individuals still develop CAN, suggesting that other metabolic and genetic factors may also contribute to its development [9].
In India, where the burden of diabetes is growing rapidly, there is limited data on the prevalence of asymptomatic CAN in both types of diabetes, especially using bedside tests in tertiary care settings [10]. Therefore, this study aims to assess the utility of bedside autonomic function tests in detecting asymptomatic autonomic dysfunction in T1DM and T2DM patients, with a focus on evaluating the impact of glycemic control on the prevalence and severity of CAN.

MATERIAL AND METHODS

This cross-sectional observational study was conducted at a tertiary care hospital in an Indian institute. A total of **150 participants** were included, divided as follows:

- **Type I diabetes mellitus (T1DM):** 50 patients
- **Type II diabetes mellitus (T2DM):** 50 patients
- **Healthy controls:** 50 individuals without diabetes, matched for age and sex

Inclusion criteria:

- Age between 18–65 years
- Diagnosed T1DM or T2DM for at least 5 years (for diabetic participants)
- Absence of overt target organ damage (such as nephropathy, retinopathy, or clinical neuropathy)

Exclusion criteria:

- History of cardiovascular diseases, hypertension, or other chronic illnesses
- Use of medications affecting autonomic function (e.g., beta-blockers)
- Alcohol or substance abuse
- Pregnancy

The study received approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants before enrollment.Written informed consent was obtained from all participants. Clinical history including age, sex, duration of diabetes, and treatment details were recorded. Physical examination was carried out, and laboratory investigations such as fasting blood glucose, postprandial glucose, HbA1c, and lipid profile were documented.

Bedside autonomic function tests performed:

1. **Heart rate response to deep breathing (HRDB)** – parasympathetic function
2. **Valsalva ratio (VR)** – parasympathetic function
3. **30:15 ratio on standing** – parasympathetic function
4. **Blood pressure response to standing** – sympathetic function
5. **Blood pressure response to sustained handgrip** – sympathetic function
6. All tests were conducted in the morning in a quiet, temperature-controlled room, following the standardized Ewing and Clarke protocols.

STATISTICAL ANALYSIS

Data were analyzed using SPSS software (version XX). Continuous variables were expressed as mean ± SD, categorical variables as percentages. ANOVA and chi-square tests were used to compare groups. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1 shows the demographic variables and clinical features among Type I diabetics, Type II diabetics, and healthy controls. The mean age was lowest in the Type I group (27.1 ± 6.5 years), followed by controls (42.3 ± 15.8 years), and highest in the Type II group (57.0 ± 7.1 years). Males predominated in all groups, particularly among controls (88%). Family history of diabetes was more common in Type II patients (44%) compared to Type I (16%) and controls (14%). Cardiac deaths were more frequently reported in Type II patients (32%). Smoking and alcohol habits were more common in controls. Clinical signs of autonomic dysfunction like skin changes, hair loss, sweating abnormalities, and nail changes were predominantly seen in Type II diabetics, with little to none in controls.
Table 2 illustrates the prevalence of cardiac autonomic neuropathy (CAN) among Type I and Type II diabetics. In Type I diabetics, 44% had no CAN, 6% had early CAN, and 50% had definite CAN. In Type II diabetics, 24% had no CAN, 10% had early CAN, and 66% had definite CAN. Overall, definite CAN was more common in Type II diabetics, indicating a higher burden of autonomic involvement compared to Type I diabetics.
Table 3 presents the correlation of various clinical and demographic variables with the presence or absence of CAN in both Type I and Type II diabetics. Age, gender, and occupation showed no significant association with CAN in either group. However, lower income levels were significantly associated with higher CAN prevalence in both groups. HbA1c, urine microalbumin levels, QTc interval, and presence of retinopathy were significantly higher in patients with CAN, particularly in the Type II group. Family history of cardiac deaths was significantly related to CAN in Type II diabetics. Smoking, alcohol, BMI, and duration of diabetes did not show a strong correlation with CAN presence.

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Table 1: Demographic variables and clinical features of autonomic dysfunction in the study

Variable	Type-1 (n=50)	Type-2 (n=50)	Control (n=50)
Age (years)	27.1 ± 6.5	57.0 ± 7.1	42.3 ± 15.8
Gender			
Male (%)	34 (68%)	26 (52%)	44 (88%)
Female (%)	16 (32%)	24 (48%)	6 (12%)
Family history			
Diabetes (%)	8 (16%)	22 (44%)	7 (14%)
Cardiac death (%)	9 (18%)	16 (32%)	8 (16%)
Habits			
Smoking (%)	16 (32%)	22 (44%)	14 (28%)
Alcohol (%)	9 (18%)	21 (42%)	16 (32%)
Clinical autonomic dysfunction			
Skin changes (%)	8 (16%)	24 (48%)	0 (0%)
Nail changes (%)	5 (10%)	4 (8%)	0 (0%)
Hair loss (focal) (%)	11 (22%)	23 (46%)	0 (0%)
Foot ulcer (%)	0 (0%)	1 (2%)	0 (0%)
Pedal edema (%)	0 (0%)	2 (4%)	0 (0%)
Sweating abnormalities (%)	6 (12%)	18 (36%)	0 (0%)

Table 2: Prevalence of cardiac autonomic neuropathy among type 1 and type 2 diabetics in the study population

CAN Status	Type I DM (n=50)	Type II DM (n=50)	Total DM (n=100)
No CAN	22 (44%)	12 (24%)	34 (34%)
Early CAN	3 (6%)	5 (10%)	8 (8%)
Definite CAN	25 (50%)	33 (66%)	58 (58%)

Table 3: Correlation of variables with or without cardiac autonomic neuropathy (CAN) in Type I DM and Type II DM

Variables	Total patients (n=50)	CAN in Type I DM Absent (n=22) / Present (n=28)	P-value	Total patients (n=50)	CAN in Type II DM Absent (n=12) / Present (n=38)	P-value
Age (years)	27.1 ± 6.5	26.8 ± 6.0 / 27.4 ± 6.7	0.160	57.0 ± 7.1	56.5 ± 6.9 / 57.3 ± 6.8	0.920
Gender						
(Male) (%)	34 (68%)	15 (68.2%) / 19 (67.9%)	0.910	26 (52%)	5 (41.7%) / 21 (55.3%)	0.310
Female (%)	16 (32%)	7 (31.8%) / 9 (32.1%)		24 (48%)	7 (58.3%) / 17 (44.7%)	
Income						
up to 2000 (%)	8 (16%)	1 (4.5%) / 7 (25%)	<0.001**	22 (44%)	1 (8.3%) / 21 (55.3%)	0.002**
Income 2001–5000 (%)	28 (56%)	8 (36.4%) / 20 (71.4%)		20 (40%)	6 (50%) / 14 (36.8%)	
Income 5001–10000 (%)	10 (20%)	10 (45.5%) / 0 (0%)		6 (12%)	4 (33.3%) / 2 (5.3%)	
Income >10000 (%)	4 (8%)	3 (13.6%) / 1 (3.6%)		2 (4%)	1 (8.3%) / 1 (2.6%)	
Occupation						
(Unskilled) (%)	6 (12%)	2 (9.1%) / 4 (14.3%)	0.930	6 (12%)	0 (0%) / 6 (15.8%)	0.740
Semi-skilled (%)	14 (28%)	5 (22.7%) / 9 (32.1%)		6 (12%)	2 (16.7%) / 4 (10.5%)	
Skilled (%)	12 (24%)	5 (22.7%) / 7 (25%)		5 (10%)	1 (8.3%) / 4 (10.5%)	
Professional (%)	3 (6%)	1 (4.5%) / 2 (7.1%)		2 (4%)	0 (0%) / 2 (5.3%)	

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Housewife (%)	7 (14%)	3 (13.6%) / 4 (14.3%)		24 (48%)	6 (50%) / 18 (47.4%)	
Not working (%)	8 (16%)	4 (18.2%) / 4 (14.3%)		7 (14%)	3 (25%) / 4 (10.5%)	
Family H/O DM						
absent (%)	43 (86%)	19 (86.4%) / 24 (85.7%)	1.000	28 (56%)	7 (58.3%) / 21 (55.3%)	0.730
Family H/O cardiac deaths						
present (%)	7 (14%)	3 (13.6%) / 4 (14.3%)		22 (44%)	5 (41.7%) / 17 (44.7%)	
absent (%)	42 (84%)	20 (90.9%) / 22 (78.6%)	0.420	33 (66%)	12 (100%) / 21 (55.3%)	0.008**
Smoking						
(Non-smoker) (%)	35 (70%)	13 (59.1%) / 22 (78.6%)	0.320	30 (60%)	7 (58.3%) / 23 (60.5%)	0.740
Current smoker (%)	12 (24%)	8 (36.4%) / 4 (14.3%)		12 (24%)	2 (16.7%) / 10 (26.3%)	
Past smoker (%)	3 (6%)	1 (4.5%) / 2 (7.1%)		8 (16%)	3 (25%) / 5 (13.2%)	
Alcohol						
(Never) (%)	42 (84%)	17 (77.3%) / 25 (89.3%)	1.000	30 (60%)	8 (66.7%) / 22 (57.9%)	0.150
Social drinker (%)	6 (12%)	3 (13.6%) / 3 (10.7%)		16 (32%)	3 (25%) / 13 (34.2%)	
Past drinker (%)	2 (4%)	2 (9.1%) / 0 (0%)		4 (8%)	1 (8.3%) / 3 (7.9%)	
BMI (kg/m²)	19.5 ± 2.9	19.1 ± 2.8 / 19.8 ± 3.0	0.170	26.7 ± 3.0	25.6 ± 3.1 / 27.0 ± 2.9	0.160
Duration of DM (years)	10.0 ± 3.8	9.4 ± 3.2 / 10.5 ± 4.3	0.260	9.8 ± 3.4	8.7 ± 3.1 / 10.0 ± 3.4	0.250
HbA1c (%)	8.4 ± 1.2	7.3 ± 0.6 / 9.2 ± 0.8	<0.001**	8.7 ± 1.7	7.2 ± 0.5 / 9.3 ± 1.7	<0.001**
Urine microalbumin (mg)	46.0 ± 63.1	17.5 ± 3.0 / 66.7 ± 77.5	0.020*	70.0 ± 85.0	18.2 ± 2.7 / 82.0 ± 91.0	0.030*
QTc interval (msec)	420 ± 43	397 ± 27 / 436 ± 45	0.040*	430 ± 43	407 ± 36 / 437 ± 43	0.040*
Retinopathy (%)	8 (16%)	0 / 8 (28.6%)	<0.001**	28 (56%)	0 / 28 (73.7%)	<0.001**

DISCUSSION

This study assessed the prevalence of cardiac autonomic neuropathy (CAN) in type 1 and type 2 diabetic patients using simple bedside tests and evaluated its association with glycemic control and clinical variables. The findings demonstrate a significantly higher prevalence of definite CAN in type 2 diabetics (66%) compared to type 1 diabetics (50%), highlighting the greater vulnerability of type 2 patients to autonomic complications. These results align with previous studies, which have consistently shown that type 2 diabetes carries a higher burden of CAN due to the combination of insulin resistance, metabolic syndrome, and often delayed diagnosis [11].

Our study revealed that poor glycemic control, reflected by elevated HbA1c levels, was significantly associated with the presence of CAN in both type 1 and type 2 diabetics. This observation is supported by recent evidence showing that tight glycemic control reduces the risk of CAN progression, particularly in early stages [12]. Moreover, microalbuminuria and prolonged QTc intervals were found to be significantly associated with CAN, underlining the link between autonomic dysfunction and subclinical microvascular damage [13]. These findings suggest that CAN can serve as an early marker of diabetic end-organ damage and may offer opportunities for intervention before irreversible complications develop.

Interestingly, factors such as age, gender, occupation, BMI, and duration of diabetes did not show a significant association with CAN in our study. However, income levels and family history of cardiac deaths were found to be important predictors, particularly in the type 2 diabetic group. Recent

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Indian studies have highlighted the role of socioeconomic status in diabetes outcomes, suggesting that lower income levels are associated with poorer glycemic control, reduced access to healthcare, and delayed detection of complications like CAN [14].

The use of bedside tests in this study allowed for a practical, non-invasive, and cost-effective approach to assess autonomic function. These simple tools have been validated in prior research and continue to be recommended for routine screening, particularly in resource-limited settings [15]. Early detection of asymptomatic CAN provides an important window for intensifying glycemic control and lifestyle interventions to prevent cardiovascular morbidity.

CONCLUSION

Cardiac autonomic neuropathy is a common and often underrecognized complication in both type 1 and type 2 diabetes, with a significantly higher prevalence among type 2 diabetics. Poor glycemic control, microvascular damage markers, and lower socioeconomic status were important predictors of CAN in this study. Bedside autonomic function tests proved to be valuable tools in detecting subclinical autonomic dysfunction. Routine screening for CAN, along with aggressive management of hyperglycemia, may help reduce cardiovascular risks and improve long-term outcomes in diabetic patients.

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