

Early Detection of Cardiovascular Changes in Type 2 Diabetes Mellitus Patients using Electrocardiogram as a Diagnostic Tool: A Cross-Sectional Study in a Tertiary Care Hospital in North East India

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Abstract

Background: Diabetes mellitus (DM) is a group of metabolic disorders that occur due to defects in insulin secretion, insulin action, or both. In comparison to the general population, type 2 DM (T2DM) patient have two-fold higher risks for developing cardiovascular diseases (CVD). Abnormalities detected during resting electrocardiogram (ECG) is associated with increased risk of diabetes induced CVD mortality and morbidity.

Aims and Objectives: The study aims to observe the ECG parameters in patients with T2DM for early detection of cardiovascular changes, asymptomatic for CVD, and the effect of duration of disease and glycemic control on the ECG parameters of these patients.

Materials and Methods: A cross-sectional study was carried out in a Tertiary Care Hospital Affiliated to a Agartala Government Medical College situated in the North-East India. One hundred known diabetic patients were enrolled for the study. Details history of the patient was taken as per the case study format. Blood samples were analyzed for glucose (fasting and postprandial), glycosylated hemoglobin. Resting 12 leads ECG was recorded at the outpatient department for all patients.

Results: Statistical analysis was carried out using SPSS software and results were statistically analyzed and correlated. PR intervals were significantly higher ($P = 0.01$) in type 2 diabetics. There was a significant ($P = 0.03$) positive correlation between the hemoglobin A1C (HbA1C) level and corrected QT interval (QTc) interval. Disease duration had significant positive correlation with RR interval ($P = 0.03$).

Conclusion: Resting ECG abnormalities in patients with T2DM indicate the onset of cardiovascular changes. Our study showed an early onset of ECG changes indicative of cardiovascular morbidity in T2DM patients that deteriorate with increasing HbA1C level and duration of disease. Regular monitoring of T2DM patients with ECG can help in the early detection of cardiovascular disease.

Key words: Cardiovascular complications, Diabetes mellitus, Electrocardiogram changes, Glycemic control, Corrected QT interval

INTRODUCTION

Diabetes mellitus (DM) is a group of metabolic disorders characterized by hyperglycemia, hyperlipidemia resulting

from variable interactions of hereditary and environmental factors due to defects in insulin secretion, insulin action, or both. Type 2 DM (T2DM) is the most common type of diabetes, contributing more than 90% of DM worldwide which affects the other metabolic pathways and consequently causes end-organ damage in multiple organ-systems of the human body.^[1] It is associated with many long-term complications in the form of microangiopathy such as neuropathy, retinopathy, and nephropathy as well as macrovascular complications such as coronary artery disease (CAD), stroke, and peripheral

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vascular disease. According to the estimates of the American Diabetes Association (ADA), 65–80% of diabetic patients die from cardiovascular disease, 75% of which is attributed to CAD.^[2] Silent ischemia or angina, where ischemic chest pain is blunted or absent, remains one of the unique complications of diabetes.^[3] In addition, studies have shown that the fatality rate of CAD is significantly higher in diabetic patients. Cardiac autonomic neuropathy is another common complication of T2DM which can cause postural hypotension, exercise intolerance, and silent myocardial infarction.^[4] Early detection of cardiovascular changes in T2DM patients can reduce the burden of morbidity and mortality in these patients. Electrocardiogram (ECG) is a non-invasive technique for assessing the activity of the heart which can be used as a tool for screening for cardiovascular complications in T2DM patients. Usefulness of ECG as a prognostic tool in cases of hypertension, cardiac failure has been shown in multiple studies.^[5] Various studies have shown the ECG abnormalities like prolonged corrected QT interval (QTc) interval in patients with T2DM. Although ECG abnormalities are found in diabetic patients in different studies, very few studies are done in Northeastern part of India. The aim of our study is to assess the ECG parameters in T2DM patients who are symptomatic for cardiac disease and to find out the correlation between ECG changes and duration of disease and hemoglobin A1C (HbA1C) level.

MATERIALS AND METHODS

Objectives

The objectives of this study were as follows:

1. To study the ECG parameters in patients with T2DM for the early detection of cardiovascular changes, asymptomatic for cardiovascular diseases (CVD).
2. To study the effect of duration of disease and glycemic control on the ECG parameters.

A hospital-based cross-sectional study was done in adults with T2DM attending diabetes and nutritional clinic outpatient department (OPD) of Agartala Government Medical College (AGMC) and Govind Ballabh Pant Hospital (GBPH), Agartala who had no complaints of CVD. Ethical clearance was obtained from the Ethical committee of AGMC and GBPH. The study included 100 T2DM patients attending diabetic clinic in AGMC and GBPH. The study subjects were evaluated by general history, clinical examination, and blood HbA1C level. The study was conducted between the periods from August 2020 to April 2022.

Inclusion Criteria for the Cases

The following criteria were included in the study:

1. Patients aged between 30 and 60 years

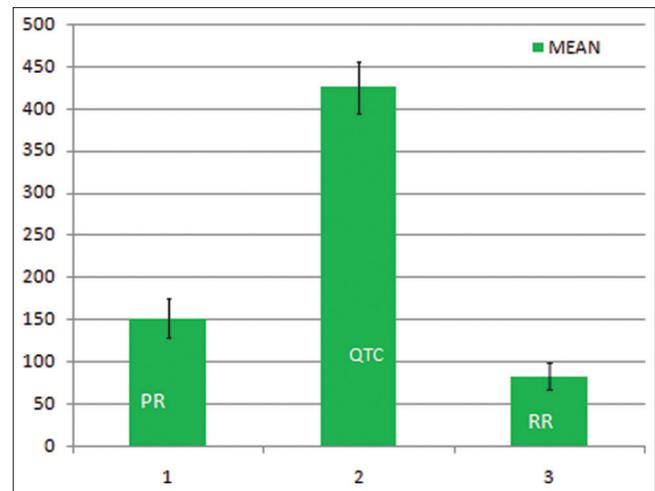


Figure 1: Bar diagram representation of the mean values of the electrocardiogram. **PR Intervals were found to be significantly higher ($P < 0.01$) among type 2 diabetes mellitus patients

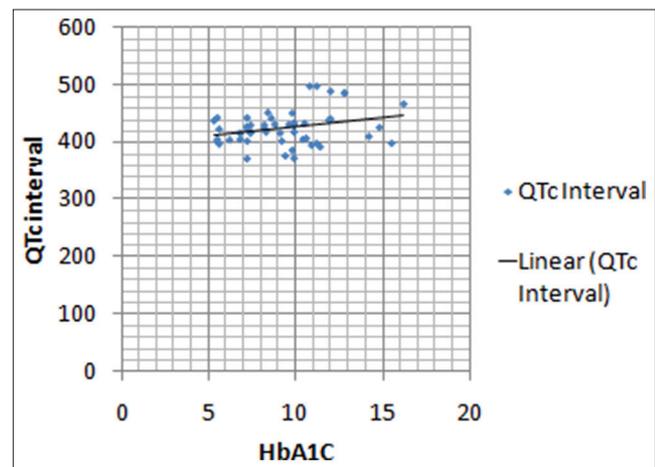


Figure 2: Correlation graph of hemoglobin A1C with corrected QT interval ($P < 0.03$)

2. Diagnosed cases of T2DM as given by the ADA. Patients who fulfill the following criteria for the diagnosis of DM:
 - a. Symptoms of diabetes plus random blood glucose concentration ≥ 11.1 mmol/L (200 mg/dL) or
 - b. Fasting blood sugar ≥ 7.0 mmol/L (126 mg/dL) or
 - c. HbA1C $\geq 6.5\%$ or
 - d. Postprandial blood sugar ≥ 11.1 mmol/L (200 mg/dL) during an oral glucose tolerance test.
3. Patients having no cardiovascular complaints
4. Co-operative and willing to participate in the study.

Exclusion Criteria for the Cases

The following criteria were excluded from the study:

1. Already existing microvascular complications of diabetes such as retinopathy, neuropathy, and nephropathy
2. Known cases of cardiovascular disorders such as hypertension, CAD, and congestive cardiac failure.

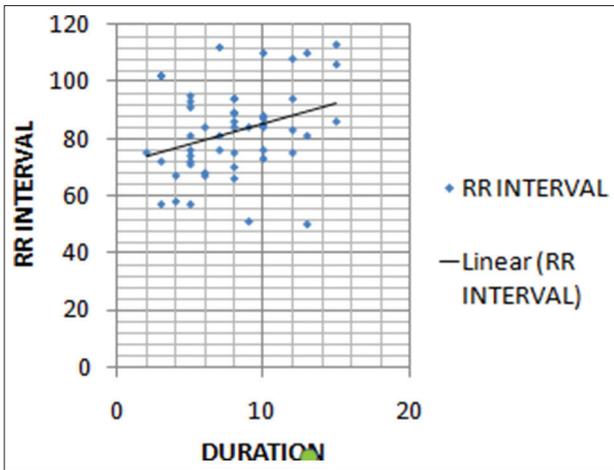


Figure 3: Correlation graph of duration of disease with RR interval ($P < 0.03$)

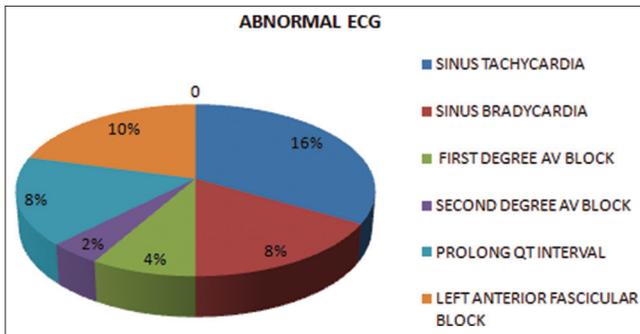


Figure 4: Pie chart representation of percentage of abnormal electrocardiogram in type 2 diabetes mellitus patients

Table 1: ECG parameters in type 2 diabetes mellitus patients

ECG parameter	Sample size (n=100)		
	RR interval (mean±SD)	QTc interval (mean±SD)	RR interval (mean±SD)
Values	151.24±23.38	424.92±30.41	82.44±15.69

ECG: Electrocardiogram

3. Presence of any other concomitant diseases disrupting cardiovascular homeostasis such as thyroid disorders, pheochromocytoma, chronic renal failure due to any cause, respiratory disorders, and dyselectrolytemia.
4. History of smoking, alcoholism or intake of any drugs such as vasodilators, diuretics, anti-arrhythmic, beta-blockers, alpha-agonist, or alpha-blockers.
5. Those who are not willing to participate in the study.

Study Tools

- Electrocardiograph – Model No. CARDIART 6108T
- Sphygmomanometer
- Stethoscope
- HbA1C kit
- Case Study Format.

Recording of ECG

Patients were made to relax comfortably in the ECG recording room. Resting ECG parameters of the patients were recorded (selected as elaborated in the sub-heading sampling procedure) only after obtaining their informed consent as per the inclusion criteria. All the variables such as name, age, and sex were noted as per the case study format. The following routine ECG parameters were assessed using Standardization (Calibration): 10 mm = 1 mV

- PR interval – 0.12–0.2 s/120–200 ms
- QTc interval – 0.39 ± 0.04 s/390 ± 40 ms
- RR interval – 60–100/min.

Data were analyzed using SPSS 15.0. *P* value was calculated to assess the significance of difference of ECG parameters. $P < 0.05$ was considered significant.

RESULTS

A total of 100 T2DM patients had participated in this study. Mean HbA1C level was $9.51 \pm 2.65\%$. ECG parameters are summarized in Table 1 and Figure 1. PR interval was significantly higher ($P = 0.01$) in type 2 diabetics. There was a positive correlation between the HbA1C level and PR, QTc, and RR interval. However, the positive correlation between HbA1C level and QTc interval was statistically significant ($P = 0.03$) as shown in Figure 2. Disease duration also had positive correlation with RR and QTc interval. However, the correlation between duration of disease with RR interval was statistically significant ($P = 0.03$) as mentioned in Figure 3. Pie chart representation of percentage of abnormal ECG in T2DM patients has been shown in Figure 4.

DISCUSSION

The present study included 100 known diabetic subjects who are asymptomatic for cardiovascular disease. Their blood glucose parameters were estimated and resting ECG was recorded in these patients to observe whether any changes were present. PR intervals were significantly higher ($P = 0.02$) in type 2 diabetics. There was a positive correlation between the HbA1C level and PR, QTc, and RR interval. Positive correlation between HbA1C with QTc interval was significantly higher ($P = 0.02$). Disease duration had positive correlation with RR and QTc interval. Positive correlation between duration of disease with RR interval was statistically significant ($P = 0.03$). The presence of ECG abnormality indicated onset of cardiovascular complications which deteriorated with increasing HbA1C as well as with duration of disease.

Gupta *et al.* conducted a study in a tertiary care hospital of Bareilly, North India. One hundred diabetics presenting

to medicine OPD/In-patient department were evaluated for ECG abnormalities.^[6] The research revealed that 26% asymptomatic diabetics had ECG abnormalities and most of them had a 5–10 year of duration of the disease. They also showed that 70% patients with ECG changes had poor glycemic control. In a study comprising 200 patients in two referral centers in Nigeria, the prevalence of ECG abnormalities detected in diabetics was as follows: prolonged QTc (25.5%), T-wave changes (22%), left ventricular hypertrophy (LVH) (18.5%), sinus tachycardia (15.5%), ischemic heart disease (9%), conduction defects (7%), and ectopic beats (4%). The mean duration of disease in this study was 20 years.^[7] Dzudie *et al.* carried out a study among 420 diabetics receiving chronic care at two hospitals in the Sub-Saharan region; ECG abnormalities were investigated and identified.^[8] The main electrocardiographic aberrations were: T-wave abnormalities (20.9%), LVH (16.4%), arrhythmia (16.2%), ischemic heart disease (13.6%), conduction defects (11.9%), QTc prolongation (10.2%), and ectopic beats (4.8%). The authors also found that blood pressure variables were consistently associated with all electrocardiographic abnormalities.

Fatima Bello Sani concluded in their study that the prevalence of IHD by ECG criteria in persons with type 2 diabetes was 20%.^[9] None of the patients with suggestive ECG findings of IHD presented with typical angina pain. Ewing *et al.* 1991, Rossing *et al.* 2001, and Maser *et al.* observed in their studies that typical impairment of ECG parameters in diabetic people was in QT region of the ECG.^[10-12] Khoharo and Halepoto, in their study, concluded that in patients with DM, QT_c prolongation and autonomic dysfunction are closely correlated and QT_c prolongation is considered to be a specific sign of autonomic cardiac dysfunction and high mortality risk.^[13] Ana De Santiago in her PHD concluded that ECG findings can be predictors of more serious events which could be aggressively prevented.^[14] Prolongation of QT_c was studied by Chugh *et al.* Nelson *et al.* individually and concluded that prolonged QT_c is indeed a sign of CAN and a predictor of cardiovascular mortality in type 2 diabetes.^[15,16] Chugh *et al.*, in a longitudinal study on 221 patients, showed that ECG abnormalities were found in 24.9% at the beginning of the study.^[15] It increased to 44.3% at the end of the study with average duration of follow-up of 5.9 years.

Finding of all these studies supports the finding of our study. Increased blood glucose level in diabetics leads to the activation of protein kinase C, which can cause atherosclerotic changes in the blood vessels, retarding the blood flow to the myocardium. Altered blood flow can lead to ischemic damage to the myocardial cells. Microvascular and macrovascular complications are well known in DM. Hyperglycemia is also proposed to cause end-organ damage

by increasing the generation of reactive oxygen species. In T2DM, hyperglycemia also leads to the formation of the advanced glycation end product, which can cause degeneration of autonomic neurons leading to cardiac autonomic neuropathy. The combined effect of all these factors is neuronal damage in the brain.

The findings of our study, that is, the presence of ECG changes even when the patients are asymptomatic for cardiovascular disease, emphasize on regular ECG monitoring of diabetic patients. Prompt management of diabetes and controlling HbA1c level can prevent further cardiac complications. All type 2 diabetic patients should be screened for cardiovascular changes at the time of diagnosis and regularly thereafter using simple 12 lead ECG recording to reduce the burden of cardiovascular morbidity and mortality.

CONCLUSION

Resting ECG abnormalities are common among T2DM patients even in absence of any symptoms. Regular ECG monitoring can help in screening for cardiovascular complications among those T2DM patients who are asymptomatic for CVD and can prevent the cardiovascular mortality and morbidity. Regular assessment of ECG parameters and maintaining strict glycemic control can delay the cardiovascular complications in asymptomatic diabetic patients.

Limitations of the Present Study

The sample size in the present study is relatively small. Furthermore, unknown and subclinical complications, which are unaccounted for, may contribute to ECG changes.

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