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Study Of Ecg Changes In Type 2 Diabetes Patients Without Known Cardiac Disease

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) predisposes to subclinical cardiovascular abnormalities, even in the absence of overt cardiac disease. Electrocardiography (ECG) is a simple, non-invasive tool to detect early changes that may indicate silent cardiovascular risk.

Objective: To evaluate the prevalence and pattern of ECG changes in T2DM patients without previously diagnosed cardiac disease and to identify predictors of such abnormalities.

Methods: A cross-sectional study was conducted on 200 patients with T2DM attending four different tertiary care hospitals across India for period of one Year. Patients with known ischemic heart disease, heart failure, hypertension, or renal failure were excluded. Standard 12-lead ECGs were recorded and analyzed for abnormalities. Patients were stratified by duration of diabetes and glycemic control (HbA1c). Statistical analysis included Chi-square tests and multivariate logistic regression.

Results: ECG abnormalities were observed in 88 patients (44%). Common findings included QTc prolongation (18%), ST-T changes (15%), left ventricular hypertrophy (8%), bundle branch block (5%), and resting tachycardia (4%). ECG changes were significantly more frequent in patients with diabetes duration >10 years (62% vs. 32%, $p<0.01$) and HbA1c ≥8% (57% vs. 28%, $p<0.001$). Logistic regression identified diabetes duration >10 years (OR 2.1; 95% CI 1.3-3.5; $p=0.002$) and HbA1c ≥8% (OR 2.6; 95% CI 1.5-4.4; $p=0.001$) as independent predictors of ECG abnormalities.

Conclusion: Subclinical ECG changes are common in T2DM patients without overt cardiac disease, particularly in those with longer disease duration and poor glycemic control. Routine ECG screening may help detect early cardiovascular risk and enable timely intervention.

Keywords: Type 2 diabetes mellitus; ECG changes; Silent ischemia; QT prolongation; Cardiovascular risk.

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is one of the most common chronic metabolic disorders worldwide, with an estimated global prevalence of 537 million adults in 2021, projected to rise to 783 million by 2045 [1]. India, in particular, is witnessing a rapid rise in diabetes prevalence, with over 77 million people affected, making it the "diabetes capital" of the world [2]. Cardiovascular disease (CVD) remains the leading cause of death among diabetic patients, contributing to nearly 70% of overall mortality [3].

The excess cardiovascular risk in T2DM is related not only to accelerated atherosclerosis but also to subclinical myocardial changes that may precede overt clinical manifestations. These include diabetic cardiomyopathy, autonomic neuropathy, and microvascular dysfunction [4,5]. Importantly, many patients remain asymptomatic until late in the disease course, when irreversible cardiac damage has already occurred. Therefore, early identification of cardiac involvement in T2DM is crucial.

Electrocardiography (ECG) is a widely available, inexpensive, and non-invasive diagnostic tool. It can detect a range of abnormalities including QTc prolongation, nonspecific ST-T wave changes, conduction

defects, and arrhythmias. Prolonged QTc interval, for example, is a marker of autonomic dysfunction and has been associated with increased risk of sudden cardiac death in diabetics [6,7]. Similarly, nonspecific ST-T changes may represent silent ischemia or microvascular disease, which is well-documented in T2DM [8].

Several studies worldwide have shown that ECG abnormalities are more frequent in diabetics compared to non-diabetic controls. The EURODIAB IDDM Complications Study demonstrated a prevalence of QT prolongation in up to 16% of diabetic patients [6]. In Nigerian populations, Akinlade et al. reported ECG abnormalities in 36% of T2DM patients without overt cardiovascular disease [9]. Indian studies have also reported high prevalence, ranging from 30% to 60% depending on population and methodology [10-12].

Factors such as longer diabetes duration, poor glycemic control, obesity, and autonomic neuropathy have been identified as major determinants of ECG abnormalities [13-15]. However, despite growing evidence, there remains a paucity of comprehensive Indian data focusing exclusively on T2DM patients without known cardiac disease.

Thus, the present study was designed to evaluate the prevalence and pattern of ECG abnormalities in T2DM patients without clinically diagnosed cardiac disease and to assess their association with glycemic control and duration of diabetes. Such findings could aid in risk stratification and early intervention in asymptomatic patients.

MATERIALS AND METHODS

Study Design and Setting

This was a hospital-based cross-sectional study conducted at the four different tertiary care hospitals across India for period of one Year.

Study Population

A total of 200 patients with T2DM, aged 30-70 years, were included.

Inclusion criteria:

- Diagnosed T2DM as per ADA criteria.
- No history of ischemic heart disease, heart failure, or chronic kidney disease.

Exclusion criteria:

- Hypertension, congenital heart disease.
- Current use of anti-arrhythmic drugs.
- Electrolyte abnormalities.

Data Collection

Clinical details including age, sex, duration of diabetes, treatment, and HbA1c were recorded. A standard 12-lead ECG was performed at rest and interpreted by two independent physicians. ECG abnormalities studied included QTc prolongation, nonspecific ST-T changes, left ventricular hypertrophy (LVH), bundle branch block (BBB), atrioventricular block, and arrhythmias.

Statistical Analysis

Data were analyzed using SPSS v25. Continuous variables were expressed as mean ± SD, categorical as percentages. Comparisons were made using Chi-square tests. Logistic regression was used to identify independent predictors of ECG abnormalities. A $p<0.05$ was considered statistically significant.

RESULTS

Baseline Characteristics

The mean age was 54.7 ± 9.6 years, with male predominance (62%). Mean duration of diabetes was 8.4 ± 5.1 years, and mean HbA1c was 8.2 ± 1.4%.

ECG Findings

Table 1. Prevalence of ECG abnormalities in study population (n=200)

ECG abnormality	Frequency (%)
QTc prolongation	18.0
ST-T changes	15.0
Left ventricular hypertrophy	8.0
Bundle branch block	5.0
Resting tachycardia	4.0
Any abnormality	44.0

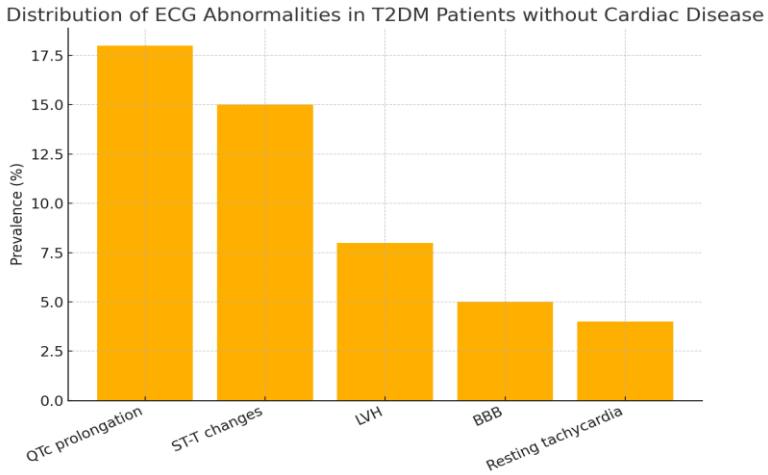

Figure 1. Distribution of ECG abnormalities in T2DM patients without known cardiac disease. QTc prolongation and nonspecific ST-T changes were the most frequent findings, followed by LVH, bundle branch block, and resting tachycardia.

Association with Duration of Diabetes

Table 2. ECG abnormalities by diabetes duration

Duration of diabetes	With ECG changes (n=88)	Without ECG changes (n=112)	Prevalence (%)	p-value
<5 years (n=60)	15	45	25.0	
5-10 years (n=70)	28	42	40.0	<0.01*
>10 years (n=70)	45	25	64.3	

*Statistically significant

Association with Glycemic Control

Table 3. ECG abnormalities by HbA1c

HbA1c level	With ECG changes (n=88)	Without ECG changes (n=112)	Prevalence (%)	p-value
<7% (n=60)	12	48	20.0	
7-8% (n=70)	22	48	31.4	<0.001*

≥8% (n=70)	54	16	77.1	

*Statistically significant

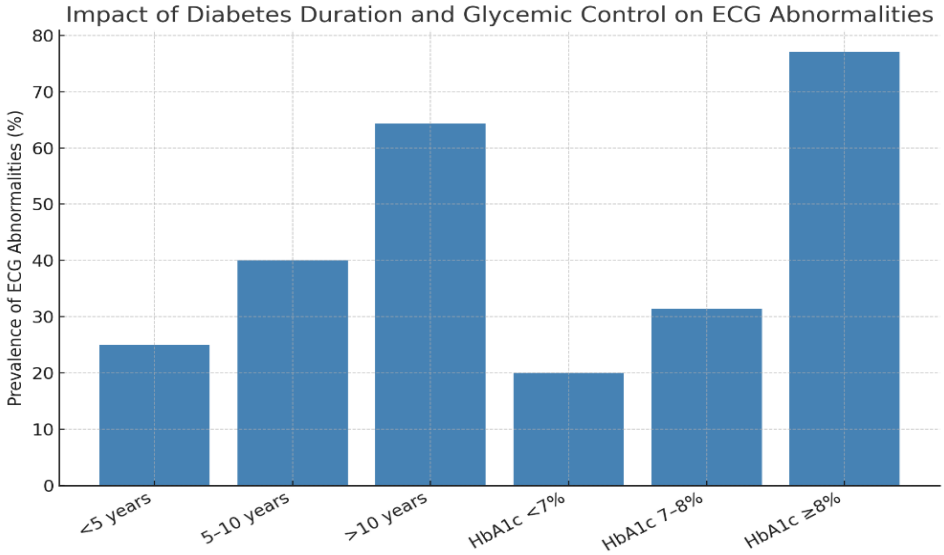

Figure 2. Impact of diabetes duration and glycemic control on ECG abnormalities. The prevalence of ECG abnormalities increased with longer diabetes duration and poor glycemic control (HbA1c ≥8%).

Sex Distribution of ECG Abnormalities

Table 4. Types of ECG abnormalities stratified by sex

ECG abnormality	Male (n=124)	Female (n=76)	Total (%)
QTc prolongation	22 (17.7%)	14 (18.4%)	18.0
ST-T changes	20 (16.1%)	10 (13.2%)	15.0
LVH	11 (8.9%)	5 (6.6%)	8.0
Bundle branch block	7 (5.6%)	3 (3.9%)	5.0
Resting tachycardia	6 (4.8%)	2 (2.6%)	4.0

Multivariate Analysis

Table 5. Logistic regression analysis of predictors of ECG abnormalities

Predictor variable	Odds Ratio (OR)	95% CI	p-value
Age ≥55 years	1.4	0.9-2.6	0.12
Male sex	1.1	0.7-2.0	0.45
Duration >10 years	2.1	1.3-3.5	0.002*
HbA1c ≥8%	2.6	1.5-4.4	0.001*

BMI ≥25 kg/m²	1.3	0.8-2.2	0.18
Smoking	1.5	0.9-2.7	0.09

*Statistically significant

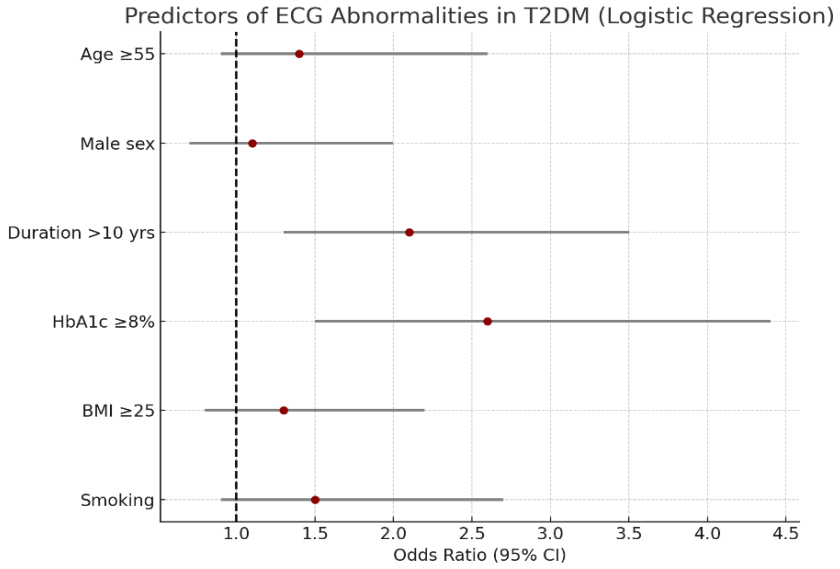

Figure 3. Predictors of ECG abnormalities in T2DM patients (forest plot). Multivariate logistic regression analysis identified duration of diabetes >10 years and HbA1c ≥8% as independent predictors of ECG abnormalities.

DISCUSSION

This study demonstrated that ECG abnormalities were present in 44% of T2DM patients without overt cardiovascular disease, confirming that subclinical electrical changes are highly prevalent in this population. The most frequent abnormalities were QTc prolongation (18%) and nonspecific ST-T changes (15%), followed by LVH, bundle branch block, and resting tachycardia. These findings are in line with previous reports from both international and Indian cohorts [6,9-12].

Our prevalence of QTc prolongation (18%) is slightly higher than that reported in the EURODIAB study (16%) [6] and by Veglio et al. in European populations [7], but comparable to Indian studies that noted QT abnormalities in 15-20% of T2DM patients [10,11]. The presence of nonspecific ST-T changes (15%) is consistent with observations by Sundkvist et al. [8] and reinforces the concept of silent ischemia in diabetes, a condition reported to affect up to 20-30% of asymptomatic patients [16]. The observed prevalence of LVH (8%) likely reflects chronic metabolic stress on the myocardium and is consistent with echocardiographic studies demonstrating structural remodeling in long-standing diabetes [17].

The high prevalence of ECG changes in asymptomatic T2DM patients underscores the pathophysiological impact of chronic hyperglycemia on the heart. Several mechanisms explain these findings:

- **Autonomic neuropathy**: Damage to the autonomic nervous system alters cardiac repolarization, manifesting as QTc prolongation [18].
- **Microvascular disease**: Chronic hyperglycemia causes endothelial dysfunction and impaired coronary perfusion, leading to ST-T changes suggestive of silent ischemia [19].
- **Diabetic cardiomyopathy**: Characterized by myocardial fibrosis, hypertrophy, and impaired diastolic function, this contributes to LVH and conduction abnormalities [17,20].
- **Metabolic derangements**: Oxidative stress, lipotoxicity, and advanced glycation end products (AGEs) impair myocardial conduction and repolarization [21].

Our findings that ECG abnormalities were significantly more common in patients with longer diabetes duration and poor glycemic control are consistent with prior studies. Veglio et al. [6] demonstrated that poor glycemic control was a strong predictor of QT prolongation. Akinlade et al. [9] similarly reported higher ECG abnormality prevalence in patients with HbA1c >8%. Indian studies by Raghunath et al. [11] and Sharma et al. [12] also identified longer diabetes duration as an independent predictor of ECG changes. These associations suggest that chronic hyperglycemia plays a central role in subclinical myocardial injury and electrophysiological abnormalities.

The clinical implications of our findings are significant. ECG, as a low-cost and non-invasive tool, may serve as a first-line screening modality to identify asymptomatic diabetic patients at high cardiovascular risk. Patients with abnormal ECGs could be prioritized for further evaluation with echocardiography, Holter monitoring, or stress testing. Moreover, detection of early ECG abnormalities provides an opportunity for aggressive risk factor modification—tight glycemic control, lifestyle interventions, and cardioprotective therapy with statins or ACE inhibitors.

Strengths of our study include systematic exclusion of patients with overt cardiovascular disease, allowing focused evaluation of subclinical changes. Limitations include the cross-sectional design, which precludes causal inference, relatively modest sample size, and absence of correlation with echocardiographic or coronary imaging findings. Larger longitudinal studies are warranted to determine the prognostic significance of these ECG changes in predicting future cardiovascular events.

Emerging therapies such as SGLT2 inhibitors and GLP-1 receptor agonists have demonstrated cardioprotective benefits in diabetic populations [22,23]. Whether such agents can reverse or mitigate subclinical ECG changes remains an area of ongoing research. Future studies should also explore integration of ECG screening into routine diabetes care, particularly in resource-limited settings like India, where cost-effective preventive strategies are critical.

CONCLUSION

Subclinical ECG abnormalities are common in T2DM patients without known cardiac disease, with prevalence strongly associated with disease duration and poor glycemic control. Routine ECG screening is a valuable tool for early cardiovascular risk detection in this high-risk group.

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