Original Article

Prevalence and Pattern of Electrocardiographic Abnormalities in Type 2 Diabetes Mellitus: A Cross-sectional Analysis

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Abstract

Background: Type 2 diabetes mellitus (T2DM) is associated with a high risk of cardiovascular morbidity and mortality, often presenting with asymptomatic cardiac involvement. Electrocardiography (ECG), a simple and noninvasive diagnostic tool, can aid in the early detection of subclinical cardiac abnormalities in diabetic individuals. **Material and Methods:** This hospital-based cross-sectional observational study was conducted over 24 months at a tertiary care center in North India. A total of 245 T2DM patients aged ≥30 years were enrolled. Detailed clinical evaluation, laboratory investigations, and resting 12-lead ECG were performed. ECG findings were categorized and analyzed for prevalence and pattern of abnormalities. Patients with known cardiovascular diseases or confounding conditions were excluded. Statistical analysis was conducted using SPSS version 26, with significance at $p < 0.05$. **Results:** Of the 245 participants, 29.4% exhibited ECG abnormalities. The most common abnormalities included QTc interval prolongation (25.7%), T wave changes (25.7%), arrhythmias (13.5%), and conduction defects such as RBBB (6.1%) and LBBB (5.3%). Axis deviations and ST-segment changes were also noted. ECG abnormalities were more prevalent in males (57.6%) and most commonly observed in the 50–59 age group (34.3%). A significant proportion (59.2%) of patients were newly diagnosed with T2DM at enrollment. **Conclusion:** A considerable proportion of T2DM patients demonstrate silent ECG abnormalities, highlighting the importance of routine ECG screening in diabetes care. Early detection of subclinical cardiovascular involvement, especially in high-risk groups like middle-aged males, can guide timely intervention and improve clinical outcomes.

Keywords: Type 2 Diabetes Mellitus, ECG abnormalities, QTc prolongation, T wave changes, cardiovascular risk, subclinical ischemia, India, cross-sectional study.

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Introduction

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic disorder marked by insulin resistance and relative insulin deficiency, contributing to sustained hyperglycemia and multiple organ complications. Its global prevalence is rising at an alarming rate, with India projected to have over 100 million affected individuals by 2035, making it one of the top contributors to the global diabetes burden.[1,2] Among the various complications associated with T2DM, cardiovascular disease (CVD) remains the most common and fatal, accounting for over 50% of diabetes-related deaths.[3] Diabetic individuals exhibit a 2–4 times higher risk of developing coronary artery disease, heart failure, and arrhythmias compared to the non-diabetic population.[4,5]

Electrocardiography (ECG), a non-invasive, cost-effective, and widely accessible tool, plays a critical role in detecting early cardiac abnormalities in diabetic patients, many of whom remain asymptomatic due to autonomic neuropathy.[6] Common ECG changes in T2DM include ST-T wave abnormalities, QTc interval prolongation, conduction defects such as bundle branch blocks, axis deviations, and signs of left ventricular hypertrophy—each correlating with poor glycemic control, increased disease duration, and other risk factors like hypertension and dyslipidemia.[7–9]

Despite the high burden of silent cardiac involvement, ECG is often underutilized in routine diabetes care. Numerous studies have emphasized its utility in risk stratification and early identification of subclinical cardiovascular disease.[10,11] However, Indian data, particularly from tertiary care settings, remain limited. This study assessed the prevalence and pattern of ECG abnormalities in T2DM patients. It evaluated their association with glycemic indices and other clinical parameters, emphasizing the need to integrate routine ECG screening in diabetes management protocols.

Materials and Methods

Study Design: This was a hospital-based cross-sectional

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observational study conducted over 24 months. The aim was to evaluate the prevalence and pattern of electrocardiographic (ECG) abnormalities in patients diagnosed with Type 2 Diabetes Mellitus (T2DM).

Place of Study: The study was conducted in the Department of Medicine, Era's Lucknow Medical College and Hospital (ELMC&H), Lucknow, a tertiary care center in North India.

Methodology: A total of 245 adult patients aged 30 years and above, with a confirmed diagnosis of Type 2 Diabetes Mellitus (T2DM) as per the American Diabetes Association (ADA) criteria, were included in the study. Patients were selected using a consecutive sampling technique from both the Outpatient Department (OPD) and Inpatient Department (IPD) of the Department of Medicine at Era's Lucknow Medical College and Hospital (ELMC&H), Lucknow. Informed written consent was obtained from all participants before enrollment.

To avoid confounding variables, patients were excluded if they had a known history of hypertension, pre-existing cardiac conditions such as coronary artery disease or arrhythmias, current or past tobacco use, use of beta-blockers or antiarrhythmic drugs, dyselectrolytemia, congenital heart disease, chronic respiratory illness, or any systemic disorder that could alter ECG findings.

All patients underwent thorough clinical evaluation, including demographic profiling, duration of diabetes, treatment history, physical examination, and anthropometric measurements such as body mass index (BMI). Each participant underwent laboratory investigations, including fasting blood sugar (FBS), postprandial blood sugar (PPBS), glycated hemoglobin (HbA1c), lipid profile (total cholesterol, triglycerides, HDL, LDL, VLDL), renal function tests (serum urea and creatinine), serum uric acid, and urine microalbuminuria. All patients were recorded using a calibrated 12-lead resting electrocardiogram (ECG). To eliminate interpretative bias, all ECGs were interpreted independently by experienced physicians and cardiologists blinded to the patients' clinical and biochemical data.

Electrocardiographic abnormalities were grouped into specific categories: conduction defects (right bundle branch block [RBBB], left bundle branch block [LBBB]), rhythm abnormalities (sinus tachycardia, sinus bradycardia, atrial fibrillation), QTc interval prolongation, ST-segment changes (elevation or depression), T wave changes (including flat T waves), and axis deviations (right-axis and left-axis deviation). Each patient was assessed for the presence of one or more abnormalities. The number and combination of ECG abnormalities per individual were also recorded. Based on clinical indication, patients showing significant ECG changes were referred for further cardiovascular assessment, including treadmill testing (TMT), 2D-echocardiography, or Holter monitoring. The collected data were analyzed to determine the prevalence and distribution of ECG abnormalities among the T2DM population, and their correlation with clinical and biochemical variables.

Statistical Analysis: All collected data were compiled using Microsoft Excel and analyzed using SPSS software (version 26). Descriptive statistics were used to summarize the data, including mean, standard deviation, and percentages. The Chi-square or Fisher's exact test was applied for categorical data to assess the association between electrocardiographic (ECG) abnormalities and various clinical variables. At the same time, the student's t-test or ANOVA was used to measure continuous variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations: The study was conducted in accordance with ethical principles and institutional guidelines. Approval was obtained from the Institutional Ethics Committee of Era's Lucknow Medical College and Hospital. Written informed consent was secured from all participants. Patient confidentiality and data privacy were strictly maintained throughout the study.

Results

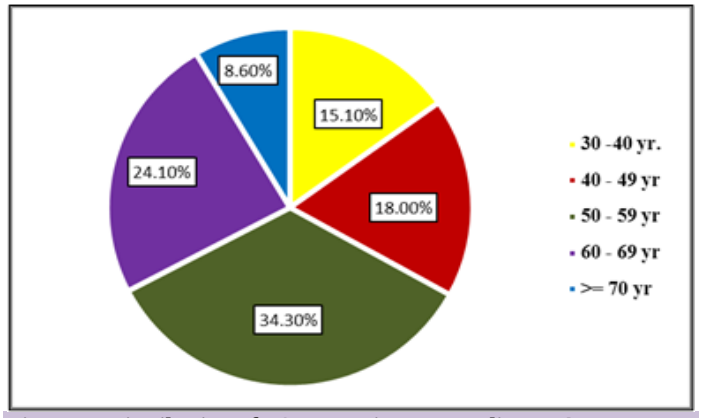

Figure 1: Distribution of T2DM Patients according to Age

The highest prevalence of Type 2 Diabetes Mellitus occurs in individuals aged 50–59 years, accounting for 34.3% of cases. This emphasizes a strong age-related risk, especially among middle-aged and older adults.

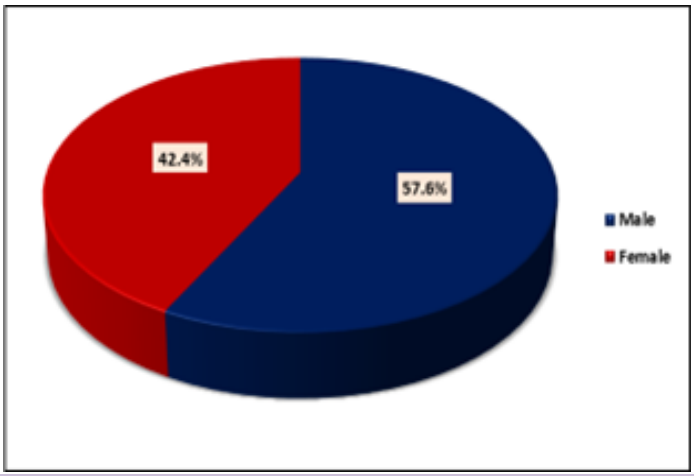

Figure 2: Distribution of Subjects according to Sex

Type 2 Diabetes Mellitus is more prevalent among males (57.6%) than females (42.4%), suggesting possible influences from lifestyle, genetics, or health behaviors. Nonetheless, both sexes require focused preventive and management strategies.

Table 1: Distribution of Subjects according to ECG Finding

ECG Finding	No.	%
Normal	173	70.6%
Abnormal	72	29.4%

ECG findings revealed that the majority of patients had normal ECG readings (70.6%, n=173), while 29.4% (n=72) exhibited abnormal ECG findings. This indicates that nearly one-third of the patients had some form of ECG abnormality.

Table 2: Distribution of Subjects according to number of Abnormalities found in ECG Reports

ECG Finding	No.	%
No abnormality	173	70.6%
One abnormality	16	6.5%
Two Abnormalities	25	10.2%
Three abnormalities	9	3.7%
More than three abnormalities	22	9.0%

ECG findings showed that 70.6% (n=173) of patients had no abnormalities, while 6.5% (n=16) had one abnormality. Additionally, 10.2% (n=25) presented with two abnormalities, 3.7% (n=9) had three abnormalities, and 9.0% (n=22) exhibited more than three abnormalities. This distribution highlights that nearly 30% of patients had at least one ECG abnormality.

Table 3: Distribution of Subjects according to ECG Findings

ECG Finding	No.	%	95% CIL	95% CIU
Axis deviation	22	9.0%	5.4%	12.6%
Right-axis deviation	5	2.0%	0.3%	3.8%
Left-axis deviation	17	6.9%	3.8%	10.1%
Arrhythmias	33	13.5%	9.2%	17.7%
Sinus tachycardia	19	7.8%	4.4%	11.1%
Sinus bradycardia	7	2.9%	0.8%	4.9%
AF	4	1.6%	0.0%	3.2%
1st DEGREE AV BLOCK	14	5.7%	2.8%	8.6%
RBBB	15	6.1%	3.1%	9.1%
LBBB	13	5.3%	2.5%	8.1%
QTc Interval Prolongation	63	25.7%	20.2%	31.2%
ST- Segment Change	16	6.5%	3.4%	9.6%
ST- Segment Elevation	1	.4%	-0.4%	1.2%
ST- Segment Depression	15	6.1%	3.1%	9.1%
T Wave Change	63	25.7%	20.2%	31.2%
Flat T- Wave	49	20.0%	15.0%	25.0%

The distribution of ECG findings among the study population highlights various cardiac abnormalities. Axis deviation was observed in 9.0% of cases, with right-axis deviation in 2.0% and left-axis deviation in 6.9%. Arrhythmias were noted in 13.5%, while sinus tachycardia and sinus bradycardia were present in 7.8% and 2.9%, respectively. Atrial fibrillation (AF) was seen in 1.6% of patients, and 1st-degree AV block was found in 5.7%. Among conduction abnormalities, right bundle branch block (RBBB) and left bundle branch block (LBBB) were detected in 6.1% and 5.3% of cases, respectively.

QTc interval prolongation was a significant finding in 25.7% of patients. ST-segment changes were seen in 6.5%, with ST-segment elevation in 0.4% and ST-segment depression in 6.1%. T-wave changes were also prevalent, affecting 25.7%, with flat T-waves present in 20.0% of patients. These findings suggest a notable burden of cardiac involvement, emphasizing the need for careful monitoring and cardiovascular risk assessment in this population.

Discussion

This study aimed to investigate the prevalence and patterns of electrocardiographic (ECG) abnormalities in patients with Type 2 diabetes mellitus (T2DM) and their association with demographic characteristics. The results highlight a significant burden of subclinical cardiac abnormalities in diabetic individuals, with key insights drawn from age and sex distribution, as well as the frequency and nature of ECG findings.

In our study, the highest prevalence of T2DM was observed in the 50–59-year age group (34.3%), followed by the 60–69 year (24.1%) and 40–49 year (18.0%) age groups. These findings concord with Ramachandran et al,[12] who reported a peak prevalence of T2DM in individuals aged 45–65 in urban South India. Similarly, Misra and Khurana,[13] identified advancing age as a critical risk factor for T2DM, attributing this trend to progressive insulin resistance and β-cell dysfunction. Al-Lawati et al,[14] also reported a rising prevalence of diabetes after the age of 40 years in Oman. These findings underscore that middle-aged and older adults represent the core demographic affected by T2DM.

A male predominance was noted in our cohort, with 57.6% of

patients being male and 42.4% female. This pattern mirrors observations by Mohan et al,[15] and Shrivastava et al,[16] who found a higher prevalence of T2DM among males in urban Indian populations. However, Gupta et al,[17] reported a more balanced gender distribution, suggesting that regional, cultural, and healthcare access differences may influence these trends. In contrast, data from the American Diabetes Association,[18] in Western populations have shown equal or slightly higher prevalence among women, possibly due to better awareness and routine screening practices.

ECG abnormalities were present in 29.4% of patients in our study, which aligns closely with findings from Maheshwari et al,[19] who reported a 28.5% prevalence in a similar diabetic cohort. Haffner et al,[20] and the UK Prospective Diabetes Study (UKPDS),[21] both emphasized the high incidence of silent ischemia and subclinical cardiac alterations in patients with diabetes, often detectable only via ECG. Deepa et al,[22] in the Chennai Urban Population Study, reported silent myocardial ischemia in nearly 30% of asymptomatic diabetic individuals, reinforcing the value of ECG in early cardiovascular risk stratification.

Importantly, ECG abnormalities in our study often occurred in combination. While 6.5% of patients had one abnormality, 10.2% had two, 3.7% had three, and 9.0% had more than three abnormalities. This clustering suggests multi-system cardiac involvement. Raut et al,[23] reported similar findings, particularly among patients with a longer duration of diabetes. Ewing and Clarke,[24] also noted a broad spectrum of autonomic and conduction disturbances, often occurring simultaneously. Joshi et al,[25] attributed this multiplicity to cumulative metabolic and vascular damage due to chronic hyperglycemia.

The most common ECG abnormalities observed were QTc interval prolongation and T wave changes, respectively, in 25.7% of patients. Flat T waves were found in 20.0%. These findings are consistent with Faglia et al,[26] who reported QTc prolongation in approximately 26% of diabetic patients and linked it with diabetic autonomic neuropathy. Ewing and Clarke,[24] also identified T-wave abnormalities as frequent in people with diabetes, associated with subclinical ischemia and electrolyte imbalances.

Arrhythmias were observed in 13.5% of patients, with sinus tachycardia (7.8%), sinus bradycardia (2.9%), and atrial fibrillation (1.6%) being the most common. Conduction abnormalities, such as right bundle branch block (RBBB) and left bundle branch block (LBBB), were found in 6.1% and 5.3% of patients, respectively. These findings mirror those of Saedi et al,[27] who reported similar rates of conduction defects among T2DM patients, and Knuuti et al,[28] who emphasized the high incidence of silent ischemia and conduction delays in people with diabetes, often preceding clinical cardiovascular events.

Notably, 59.2% of patients in our study had no prior diagnosis of diabetes. This agrees with Ramachandran et al,[12] who reported that over half of diabetes cases in urban Indian populations remain undiagnosed. The high proportion of newly detected diabetes in our cohort further supports the need for routine opportunistic screening, particularly in high-risk age groups. ECG abnormalities in these undiagnosed individuals underline the silent progression of both diabetes and its cardiovascular complications.

Conclusion

This study demonstrates a notable prevalence of electrocardiographic (ECG) abnormalities among patients with Type 2 Diabetes Mellitus (T2DM). QTc interval prolongation, T wave changes, arrhythmias, and conduction defects are the most frequently observed abnormalities. These findings highlight the silent yet significant cardiovascular involvement in diabetic individuals, including a substantial proportion of newly diagnosed cases. The results emphasize the critical need to incorporate routine ECG screening into standard diabetes care protocols to enable early detection of subclinical cardiac changes. Early identification and timely management of such abnormalities are especially vital in high-risk groups, such as middle-aged males, who represent the largest burden of disease. Integrating ECG evaluation into routine diabetes management could significantly enhance cardiovascular risk stratification, improve clinical outcomes, and reduce diabetes-related morbidity and mortality.

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Conflicts of interest

There are no conflicts of interest.

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