e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(2); 76-81

Original Research Article

ECG Predictors of Mortality in Acute STEMI

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Received: 03-12-2025 / Revised: 02-01-2026 / Accepted: 04-02-2026
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Conflict of interest: Nil

Abstract:

Background: Early electrocardiographic findings provide rapid risk stratification in ST-elevation myocardial infarction (STEMI), yet data from rural Indian tertiary-care settings remain limited. ECG markers such as ischemia grade, rhythm disturbances, and conduction abnormalities may predict short-term outcomes. This study evaluated the prognostic value of admission ECG variables in STEMI patients in a rural Indian cohort.

Methods: This single-center observational study included 212 consecutive patients with STEMI presenting to a tertiary hospital in rural India over one year. Baseline clinical data, admission ECG characteristics, angiographic findings, and in-hospital outcomes were collected. Standard ECG definitions were applied, and ischemia severity was graded where applicable. Associations between ECG variables and in-hospital mortality were analyzed using p values.

Results: Anterior and inferior STEMI were the most common presentations, with most patients in sinus rhythm and normal heart rate at admission. QRS abnormalities, pathological Q waves, and grade 3 ischemia were observed in a subset of patients. In-hospital mortality was significantly higher in those with anterior wall involvement, tachycardia, atrial fibrillation/flutter, conduction disturbances, pathological Q waves, and grade 3 ischemia. These ECG features showed strong associations with adverse outcomes.

Conclusion: Admission ECG parameters, particularly ischemia grade and conduction abnormalities, are valuable early predictors of in-hospital mortality in STEMI patients in rural tertiary-care settings.

Keywords: ST-elevation myocardial infarction; electrocardiography; ischemia grade; in-hospital mortality.
DOI: 10.25258/ijcpr.18.2.12

Introduction

The management of ST-elevation myocardial infarction (STEMI) has evolved substantially with the adoption of primary percutaneous coronary intervention (PCI) over thrombolytic therapy. Despite this advance, mortality remains considerable, with reported 30-day mortality of 7.4–11.4% and 1-year mortality of 13.7–14% [1,2]. In addition to death, STEMI is frequently complicated by serious yet potentially preventable outcomes, including malignant arrhythmias, conduction abnormalities, heart failure, and mechanical complications [3–8].

Beyond the assessment of acute ST-T changes, detailed electrocardiographic (ECG) evaluation plays a key role in identifying patients at higher risk of adverse outcomes. Several ECG findings—such as tachycardia, atrial fibrillation, other arrhythmias, and conduction disturbances—have been shown to independently predict mortality in STEMI [9,10]. Bundle branch blocks are associated with increased risks of cardiogenic shock and heart failure [8,11.12], while pathological Q waves and T-wave inversion correlate with poorer prognosis [2]. Within the Sclarovsky–Birnbaum ischemia grading system, grade 3 ischemia, characterized by ST elevation with terminal QRS distortion, is linked to higher mortality compared with grade 2 ischemia [1,13].

The standard 12-lead ECG therefore remains a cornerstone for both diagnosis and early risk stratification in acute STEMI. It is non-invasive, inexpensive, widely accessible, and capable of revealing clinically meaningful prognostic markers. This study aimed to evaluate—and potentially validate—the prognostic significance of various ECG parameters recorded at first medical contact in an unselected cohort of patients with acute myocardial infarction presenting with either ST elevation or left bundle branch block (LBBB), all treated with emergent coronary angiography in the contemporary primary PCI era.

Materials and Methods

Study design and population: This was a single-center, observational study conducted over a one-year period at a tertiary care hospital serving a predominantly rural population in India. Consecutive patients presenting with acute myocardial infarction were screened, and 212 patients with ST-elevation myocardial infarction (STEMI) who underwent emergent coronary angiography were included in the analysis. The diagnosis of acute myocardial infarction was based on clinical presentation, electrocardiographic findings, and cardiac biomarker elevation, in accordance with contemporary guidelines.

Data Collection: Demographic details, cardiovascular risk factors, clinical presentation, treatment characteristics, and in-hospital outcomes were collected from hospital medical records and catheterization laboratory reports. ECGs analyzed in the study were the first diagnostic ECGs obtained at initial medical contact, either in the emergency department or during pre-hospital referral from peripheral centers. Survival and outcome data were obtained from inpatient records and follow-up documentation available in hospital files.

ECG Recording and Analysis: Standard 12-lead ECGs, and 15-lead ECGs where posterior wall involvement was suspected, were recorded at presentation. STEMI was defined using guideline-recommended ST-segment elevation criteria, including sex-specific cut-offs for leads V2–V3 and lower thresholds for posterior leads V7–V9 [14]. ECGs were analyzed manually by a trained investigator, with difficult cases reviewed jointly to ensure consistency.

ST-segment elevation patterns were classified into anterior, inferior, lateral, inferobasal (posterior), and combined territories. For statistical analysis, anatomically related territories were grouped. In patients with LBBB or pacemaker rhythm, the diagnosis of myocardial infarction was established based on symptoms, cardiac biomarkers, and coronary angiographic findings, and ST-segment location was not categorized.

ECG variables and coronary angiography: Heart rhythm, heart rate, conduction abnormalities, and bundle branch blocks were recorded using standard definitions. Tachycardia was defined as >100 bpm and bradycardia as <40 bpm. Pathological Q waves and T-wave inversion were identified using conventional criteria, excluding leads aVR, III, and V1. Infarct evolution was classified as pre-infarction syndrome or evolving myocardial infarction based on ST-segment, Q-wave, and T-wave changes. Ischemia severity was graded as grade 2 or grade 3 based on terminal QRS distortion; grading was not performed in patients with QRS duration ≥120 ms.

Coronary angiography was used to identify the culprit vessel, categorized as left anterior descending, left circumflex, right coronary artery, or left main, and correlated with ECG findings.

Statistical Analysis: Continuous variables were summarized as mean ± SD or median (IQR), and categorical variables as frequencies and percentages. Group comparisons were performed using appropriate parametric or non-parametric tests, and associations between ECG variables and in-hospital mortality were evaluated using regression analysis. Statistical significance was assessed using p values, with $p \leq 0.05$ considered significant.

Results

The study population consisted predominantly of male patients with a high prevalence of traditional cardiovascular risk factors, including hypertension, diabetes mellitus, dyslipidemia, and smoking. Most patients underwent primary percutaneous coronary intervention, reflecting contemporary reperfusion practices in a tertiary care setting (Table 1).

Table 1: Baseline characteristics of the study population (n = 212)

Variable	Value
Mean age, years (SD)	66.8 (11.9)
Male sex, n (%)	149 (70.3)
Hypertension, n (%)	116 (54.7)
Diabetes mellitus, n (%)	48 (22.6)
Dyslipidemia, n (%)	97 (45.8)
Current or former smoker, n (%)	105 (49.5)
Prior myocardial infarction, n (%)	34 (16.0)
Mean serum creatinine, µmol/L (SD)	88.1 (42.7)
Primary PCI performed, n (%)	198 (93.4)

Anterior and inferior wall ST-elevation myocardial infarction constituted the majority of presentations in the study population. Most patients had heart rates within the normal range and presented in sinus rhythm, while a smaller but clinically important proportion showed tachycardia, atrial fibrillation/flutter, or high-grade atrioventricular block at initial evaluation (Table 2).

Table 2: Distribution of ECG characteristics at presentation (n = 212)

ECG parameter	n (%)
ST-elevation location	
Anterior (antero-apical / anteroseptal)	98 (46.2)
Inferior / inferolateral	86 (40.6)
Lateral	15 (7.1)
Inferobasal (posterior)	13 (6.1)
Heart rate	
40–100 bpm	179 (84.4)
<40 bpm	4 (1.9)
>100 bpm	29 (13.7)
Rhythm	
Sinus rhythm	181 (85.4)
Atrial fibrillation/flutter	21 (9.9)
High-grade AV block	10 (4.7)

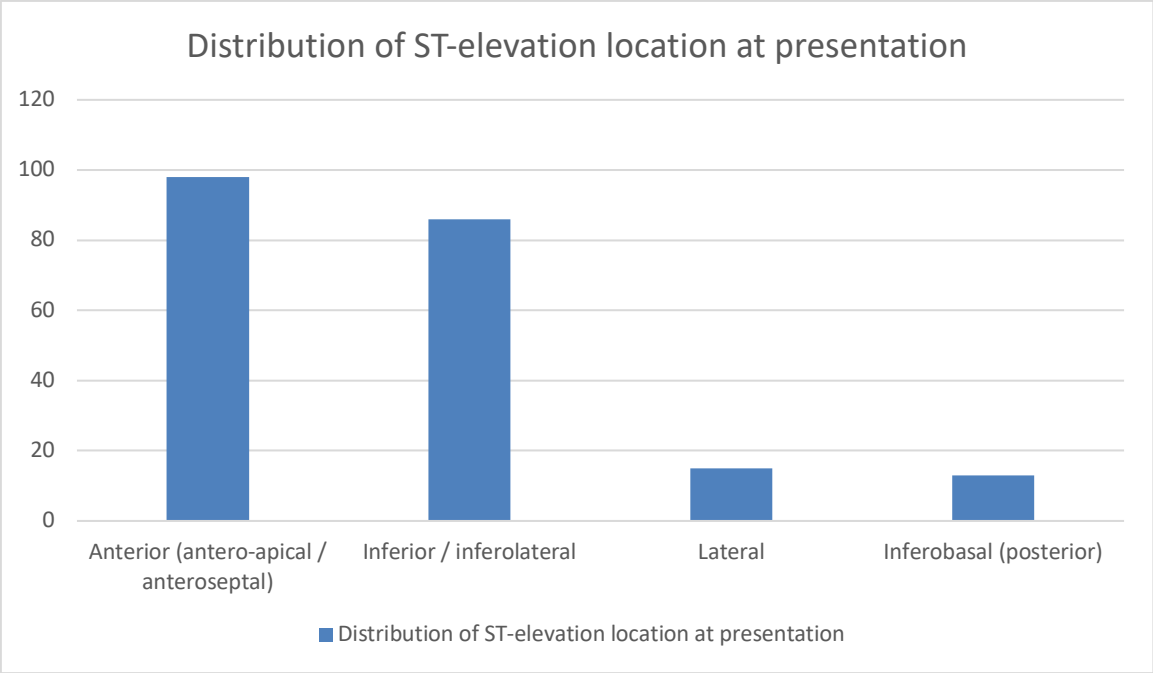

Figure 1: Distribution of patients based on location of ST-elevation at presentation.

Most patients demonstrated normal QRS duration on admission ECG, although bundle branch blocks and nonspecific intraventricular conduction delays were observed in a subset. Pathological Q waves were present in approximately one-fifth of patients, and grade 3 ischemia, indicating more severe myocardial injury, was identified in a smaller but high-risk group (Table 3).

Table 3: QRS abnormalities and ischemia grade on ECG (n = 212)

ECG finding	n (%)
Normal QRS duration (<120 ms)	185 (87.3)
Left bundle branch block	4 (1.9)
Right bundle branch block	12 (5.7)
Nonspecific IVCD	11 (5.1)
Pathological Q waves	46 (21.7)
Grade 2 ischemia	134 (63.2)
Grade 3 ischemia	29 (13.7)

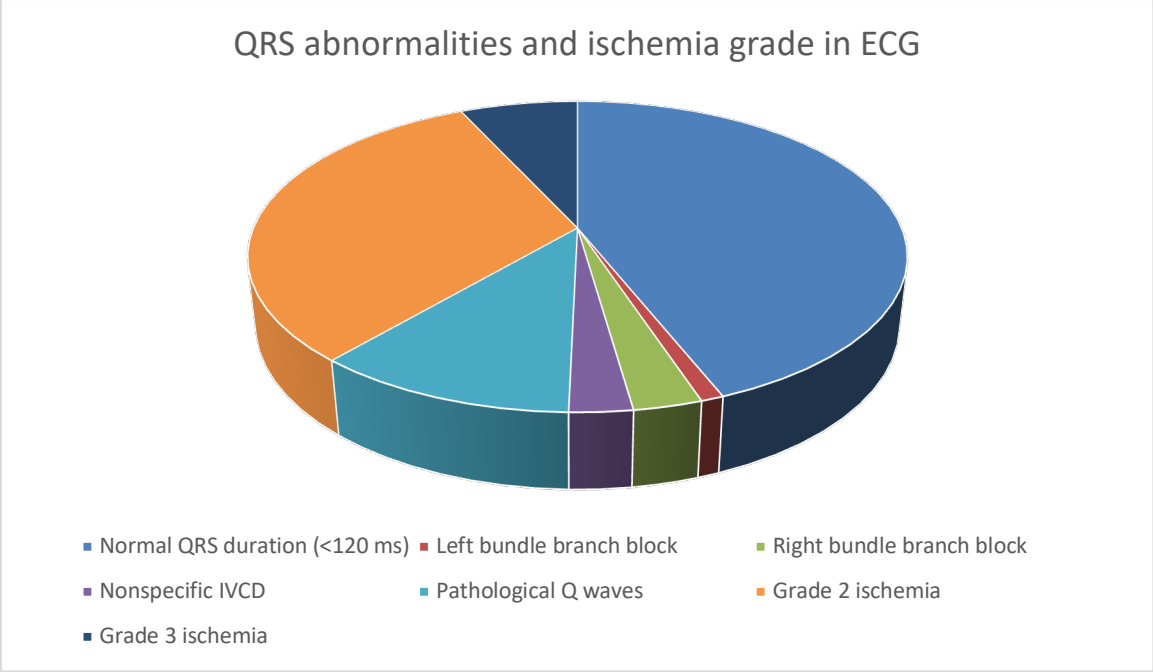

Figure 2: QRS abnormalities and ischemia grade on ECG.

In-hospital mortality was significantly higher among patients with anterior wall involvement, tachycardia at presentation, atrial fibrillation/flutter, conduction abnormalities, pathological Q waves, and grade 3 ischemia. These ECG features were strongly associated with adverse outcomes, highlighting their value as early predictors of mortality in acute STEMI (Table 4).

Table 4: Association of key ECG predictors with in-hospital mortality

ECG variable	Mortality (%)	p-value
Anterior STEMI vs others	18.4 vs 8.1	0.01
Heart rate >100 bpm	31.0	<0.001
Atrial fibrillation/flutter	28.6	0.004
LBBB or IVCD	33.3	<0.001
Pathological Q waves	26.1	0.002
Grade 3 ischemia	34.5	<0.001

Discussion

The main finding of this study is that several ECG features recorded at first medical contact were strongly associated with adverse outcomes in patients with acute STEMI treated predominantly with primary PCI. In this cohort of 212 patients, conduction abnormalities (LBBB and nonspecific intraventricular conduction delay), atrial fibrillation or flutter, and elevated heart rate (>100 bpm) were associated with significantly higher in-hospital mortality. In contrast, inferior or inferolateral ST-elevation was associated with a more favorable prognosis, while grade of ischemia did not predict increased mortality. These findings underscore the continued prognostic relevance of ECG interpretation beyond ST-segment analysis alone.

Conduction disturbances emerged as important markers of risk. Historically, LBBB has been associated with high mortality in acute myocardial infarction, particularly in the thrombolytic era, with reported mortality rates approaching 40% [15]. Subsequent studies have consistently shown worse outcomes in patients with LBBB, including higher rates of cardiogenic shock and both short- and long-term mortality [8,16]. Although RBBB has recently been recognized as an indication for emergent reperfusion, its prognostic significance remains debated [14]. In our study, broader QRS abnormalities—particularly LBBB and nonspecific intraventricular conduction delay—were associated with higher mortality, aligning with earlier observations that prolonged QRS duration itself may be a marker of extensive myocardial injury and worse prognosis [11,17].

Atrial fibrillation or flutter was one of the strongest predictors of mortality in the present study, consistent with prior literature. AF in the setting of STEMI has been linked to increased risks of heart failure, thromboembolic events, and death [18–20]. The association between AF, elevated heart rate, and mortality likely reflects both hemodynamic compromise and more extensive ischemic burden

[21]. Our findings reinforce the concept that arrhythmic manifestations on the presenting ECG are not merely epiphenomena but important indicators of disease severity requiring heightened clinical vigilance.

Interestingly, neither ischemia grade nor infarct evolution pattern was associated with increased all-cause mortality in this cohort. While previous studies have shown grade 3 ischemia to be associated with larger infarct size and higher mortality [22.23], more recent data suggest that with contemporary primary PCI and optimized antithrombotic therapy, this excess risk may be attenuated [19,23]. The relatively better outcomes observed in inferior or inferolateral infarctions are consistent with prior studies demonstrating smaller infarct size and preserved ventricular function compared with anterior infarctions [24]. Overall, this study highlights the value of selected ECG patterns—particularly conduction abnormalities, arrhythmias, and heart rate—as practical, low-cost tools for early risk stratification in STEMI patients, even in resource-limited tertiary care settings.

Conclusion

This study demonstrates that specific ECG features present at first medical contact—particularly left bundle branch block, nonspecific intraventricular conduction delay, atrial fibrillation or flutter, and elevated heart rate—are strong predictors of mortality in patients with acute ST-segment elevation myocardial infarction treated with primary PCI. In contrast, inferior or inferolateral infarct location was associated with a more favorable outcome, while ischemia grade did not predict increased mortality in the contemporary treatment era. These findings highlight the continued importance of comprehensive ECG assessment as a simple, rapid, and widely available tool for early risk stratification and clinical decision-making in STEMI patients, especially in resource-limited tertiary care settings.

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