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Original Research Article

Prognostic Significance of Electrocardiographic Findings in Patients with Acute ST-Elevation Myocardial Infarction

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Abstract:

Background: Early electrocardiographic (ECG) findings are crucial for rapid risk stratification in ST-elevation myocardial infarction (STEMI), yet evidence from rural tertiary-care centers in India remains scarce. Parameters such as ischemia grade, rhythm disturbances, and conduction abnormalities may serve as predictors of short-term outcomes. This study aimed to assess the prognostic significance of admission ECG variables in STEMI patients within a rural Indian cohort.

Methods: A single-center observational study was conducted over one year, enrolling 182 consecutive STEMI patients presenting to a tertiary hospital in rural India. Baseline clinical characteristics, admission ECG findings, angiographic data, and in-hospital outcomes were collected. Standard ECG definitions were applied, and ischemia severity was graded when appropriate. Associations between ECG features and in-hospital mortality were analyzed using p values.

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

Conclusion: Admission ECG features—particularly conduction abnormalities, arrhythmias, and ischemia grade—remain valuable predictors of in-hospital mortality in STEMI patients. These findings highlight the importance of comprehensive ECG assessment as a rapid, accessible, and cost-effective tool for early risk stratification in rural tertiary-care settings.

Keywords: ST-elevation myocardial infarction; electrocardiography; conduction abnormalities; ischemia grade; in-hospital mortality.

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Introduction

Management of ST-elevation myocardial infarction (STEMI) has undergone major transformation with the widespread adoption of primary percutaneous coronary intervention (PCI), which has largely replaced thrombolytic therapy. Nevertheless, mortality remains significant, with 30-day rates reported between 7.4–11.4% and 1-year rates of 13.7–14% [1,2]. Beyond death, STEMI is often complicated by serious but potentially avoidable outcomes, including malignant arrhythmias, conduction disturbances, heart failure, and mechanical complications [3–8].

Electrocardiographic (ECG) assessment extends well beyond the recognition of acute ST-T changes and plays a crucial role in identifying patients at elevated risk of adverse events. Several ECG features—such as tachycardia, atrial fibrillation, other arrhythmias, and conduction abnormalities—have been independently linked to mortality in STEMI [9,10]. Bundle branch block has been associated with higher risks of cardiogenic shock and heart failure [8,11,12], while the presence of pathological Q waves and T-wave inversion has been correlated with worse outcomes [2]. Within the Sclarovsky–Birnbaum ischemia classification, grade 3 ischemia—defined by ST elevation with terminal QRS distortion—carries a greater mortality risk compared with grade 2 ischemia [1,13].

Thus, the standard 12-lead ECG continues to serve as a cornerstone in both diagnosis and early risk stratification of acute STEMI. It is non-invasive, cost-effective, widely available, and capable of revealing prognostic markers of clinical importance. The present study was designed to assess—and potentially validate—the prognostic relevance of ECG parameters recorded at first medical contact in an unselected population of patients with acute myocardial infarction presenting with either ST elevation or left bundle branch block (LBBB), all of whom underwent emergent coronary angiography in the modern PCI era.

Materials and Methods

Study Design and Population: This investigation was a single-center, observational study carried out over the course of one year at a tertiary care hospital catering primarily to a rural population in India. Consecutive patients presenting with acute myocardial infarction were screened, and 182 individuals with ST-elevation myocardial infarction (STEMI) who underwent urgent coronary angiography were included. The diagnosis of acute myocardial infarction was established based on clinical presentation, electrocardiographic findings, and elevated cardiac biomarkers, in line with current guideline recommendations.

Data Collection: Information on demographics, cardiovascular risk factors, presenting symptoms, treatment details, and in-hospital outcomes was extracted from hospital records and catheterization laboratory documentation. The ECGs analyzed were the first diagnostic tracings obtained at initial medical contact, either in the emergency department or during pre-hospital referral from peripheral centers. Survival and outcome data were retrieved from inpatient records and follow-up notes available in hospital files.

ECG Recording and Analysis: Standard 12-lead ECGs were recorded at presentation, with 15-lead ECGs performed when posterior wall involvement was suspected. STEMI was defined according to guideline-based ST-segment elevation criteria, incorporating sex-specific thresholds for leads V2–V3 and lower cut-offs for posterior leads V7–V9 [14]. ECGs were manually interpreted by a trained investigator, with complex cases reviewed collaboratively to ensure consistency.

ST-segment elevation was categorized into anterior, inferior, lateral, inferobasal (posterior), and combined territories, with anatomically related regions grouped for statistical purposes. In patients with left bundle branch block (LBBB) or pacemaker rhythm, myocardial infarction was diagnosed using symptoms, biomarkers, and angiographic findings, without classification of ST-segment territory.

ECG Variables and Coronary Angiography: Heart rhythm, rate, conduction abnormalities, and bundle branch blocks were documented using standard definitions. Tachycardia was defined as >100 bpm, while bradycardia was defined 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 according to terminal QRS distortion, with grading omitted in patients with QRS duration ≥120 ms.

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

Statistical Analysis: Continuous variables were expressed as mean ± standard deviation or median (interquartile range), while categorical variables were summarized as frequencies and percentages. Group comparisons were conducted using appropriate parametric or non-parametric tests. Associations between ECG parameters and in-hospital mortality were examined through regression analysis. Statistical significance was defined as $p \leq 0.05$.

Results

The baseline characteristics of the study population showed a mean age of 66.8 years, with men comprising the majority (70.3%). Hypertension was the most common comorbidity, present in over half of the patients (54.7%), followed by dyslipidemia (45.8%) and diabetes mellitus (22.6%). Nearly half of the cohort were current or former smokers (49.5%), while 16% had a prior history of myocardial infarction. The mean serum creatinine was 88.1 µmol/L, reflecting preserved renal function in most patients. Importantly, primary PCI was performed in 93.4% of cases, underscoring the high rate of guideline-directed reperfusion therapy in this population (Table 1).

Table 1: Baseline characteristics of the study population (n = 182)

Variable	Value
Mean age, years (SD)	66.8 (11.9)
Male sex, n (%)	128 (70.3)
Hypertension, n (%)	100 (54.7)
Diabetes mellitus, n (%)	41 (22.6)
Dyslipidemia, n (%)	84 (45.8)
Current or former smoker, n (%)	90 (49.5)
Prior myocardial infarction, n (%)	29 (16.0)
Mean serum creatinine, µmol/L (SD)	88.1 (42.7)
Primary PCI performed, n (%)	170 (93.4)

At presentation, the majority of patients demonstrated anterior ST-elevation (46.2%), followed closely by inferior or inferolateral involvement (40.6%), while lateral and posterior territories were less frequently affected (7.1% and 6.1%, respectively). Most patients had a heart rate within the normal range of 40–100 bpm (84.4%), with tachycardia (>100 bpm) observed in 13.7% and bradycardia (<40 bpm) in only 1.9%. Sinus rhythm predominated in the cohort (85.4%), whereas atrial fibrillation/flutter was present in 9.9% and high-grade atrioventricular block in 4.7%. These findings highlight the predominance of anterior and inferior STEMI patterns and the relative infrequency of severe rhythm disturbances at initial presentation (Table 2).

Table 2: Distribution of ECG characteristics at presentation (n = 182)

ECG parameter	n (%)
ST-elevation location	
Anterior (antero-apical / anteroseptal)	84 (46.2)
Inferior / inferolateral	74 (40.6)
Lateral	13 (7.1)
Inferobasal (posterior)	11 (6.1)
Heart rate	
40–100 bpm	154 (84.4)
<40 bpm	3 (1.9)
>100 bpm	25 (13.7)
Rhythm	
Sinus rhythm	156 (85.4)
Atrial fibrillation/flutter	18 (9.9)
High-grade AV block	9 (4.7)

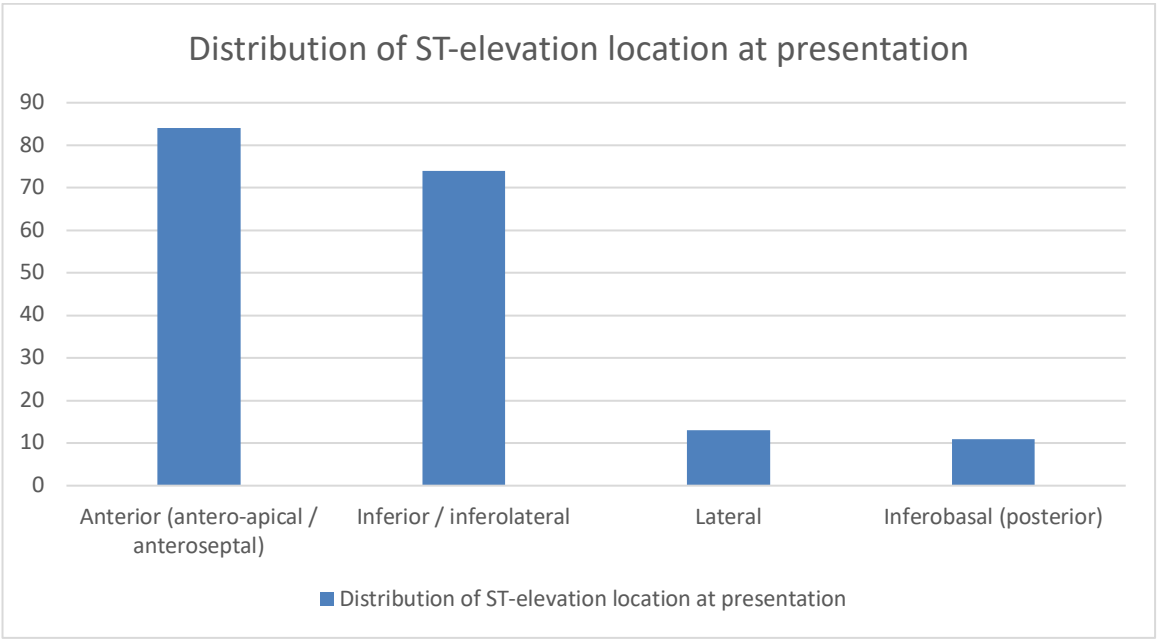

Figure 1: Distribution of patients based on location of ST-elevation at presentation.

Among the study population, the majority of patients had a normal QRS duration (<120 ms), observed in 87.3%. Conduction abnormalities were relatively uncommon, with left bundle branch block present in 1.9%, right bundle branch block in 5.7%, and nonspecific intraventricular conduction delay in 5.1%. Pathological Q waves were identified in 21.7% of patients, reflecting prior or extensive myocardial injury. Regarding ischemia severity, grade 2 ischemia was more frequent (63.2%), while grade 3 ischemia, characterized by terminal QRS distortion, was noted in 13.7% of cases (Table 3).

Table 3: QRS abnormalities and ischemia grade on ECG (n = 182)

ECG finding	n (%)
Normal QRS duration (<120 ms)	159 (87.3)
Left bundle branch block	3 (1.9)
Right bundle branch block	10 (5.7)
Nonspecific IVCD	9 (5.1)
Pathological Q waves	40 (21.7)
Grade 2 ischemia	115 (63.2)
Grade 3 ischemia	25

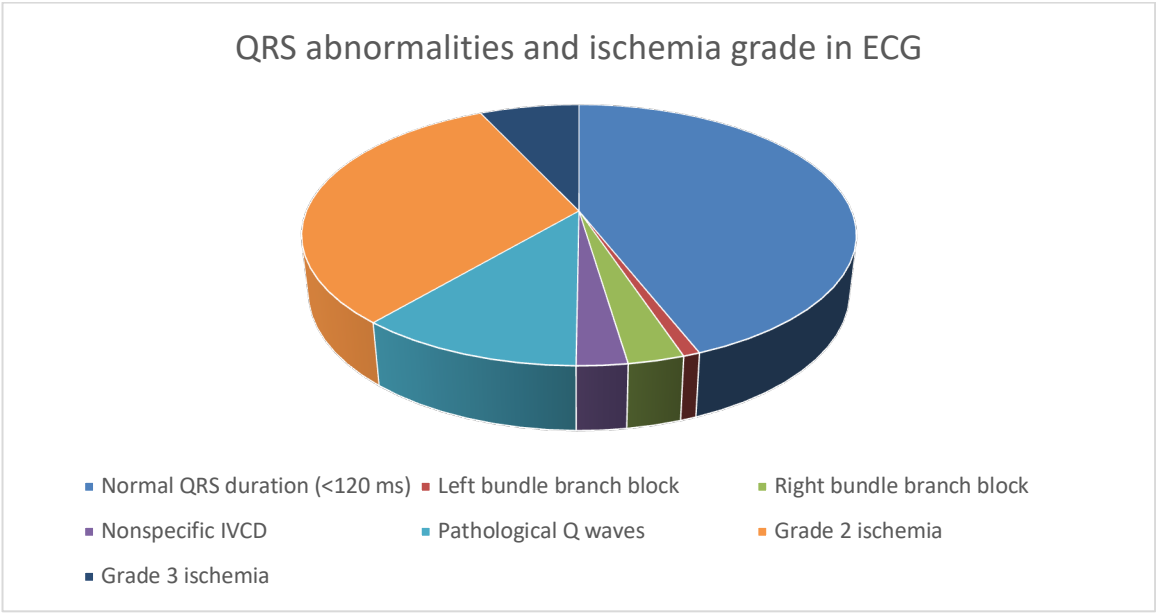

Figure 2: QRS abnormalities and ischemia grade on ECG.

In-hospital mortality was significantly influenced by several ECG predictors. Patients with anterior STEMI had higher mortality compared with those with infarction in other territories (18.4% vs 8.1%, p = 0.01). Tachycardia at presentation was associated with the worst outcomes, with 31.0% mortality, while atrial fibrillation/flutter also carried a substantial risk (28.6%, p = 0.004). Conduction abnormalities such as LBBB or nonspecific IVCD were linked to a 33.3% mortality rate, and pathological Q waves were associated with 26.1% mortality (p = 0.002). Grade 3 ischemia emerged as the most ominous marker, with mortality reaching 34.5% (p < 0.001) (Table 4).

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

ECG variable	Mortality (%)	Approx. deaths (n)	p-value
Anterior STEMI vs others	18.4 vs 8.1	15 vs 8	0.01
Heart rate >100 bpm	31.0	8	
Atrial fibrillation/flutter	28.6	5	0.004
LBBB or IVCD	33.3	4	
Pathological Q waves	26.1	10	0.002
Grade 3 ischemia	34.5	9	

Discussion

The central observation from this study is that several ECG features recorded at first medical contact were strongly linked to adverse outcomes in patients with acute STEMI managed primarily with primary PCI. In this cohort of 182 patients,

conduction disturbances (LBBB and nonspecific intraventricular conduction delay), atrial fibrillation/flutter, and tachycardia (>100 bpm) were all associated with significantly higher in-hospital mortality, whereas inferior or inferolateral ST-elevation was related to better prognosis, and ischemia grade did not predict excess mortality. These findings reaffirm the prognostic importance of ECG interpretation beyond ST-segment changes alone.

Conduction abnormalities proved to be key markers of risk. Historically, LBBB has been tied to high mortality in acute myocardial infarction, particularly in the thrombolytic era, with rates approaching 40% [15]. Subsequent studies have consistently demonstrated 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 urgent reperfusion, its prognostic role remains debated [14]. In our analysis, broader QRS abnormalities—especially LBBB and nonspecific intraventricular conduction delay—were associated with increased mortality, supporting earlier evidence that prolonged QRS duration may reflect extensive myocardial damage and poor prognosis [11,17].

Atrial fibrillation/flutter emerged as one of the strongest predictors of death, consistent with prior reports. AF in the setting of STEMI has been linked to higher risks of heart failure, thromboembolism, and mortality [18–20]. The association between AF, elevated heart rate, and adverse outcomes likely reflects both hemodynamic compromise and greater ischemic burden [21]. These results emphasize that arrhythmic findings on the presenting ECG are not incidental but rather important indicators of disease severity requiring close clinical attention.

Interestingly, neither ischemia grade nor infarct evolution pattern was associated with increased mortality in this cohort. While earlier studies reported grade 3 ischemia to be linked with larger infarcts and higher mortality [22,23], more recent evidence suggests that with modern PCI strategies and optimized antithrombotic therapy, this excess risk may be mitigated [19,23]. The relatively favorable outcomes seen in inferior or inferolateral infarctions align with prior observations of smaller infarct size and preserved ventricular function compared with anterior infarctions [24]. Overall, this study underscores the value of selected ECG features—particularly conduction abnormalities, arrhythmias, and heart rate—as practical, inexpensive tools for early risk stratification in STEMI patients, even within resource-limited tertiary care settings.

Conclusion

This study shows that certain ECG findings found at the time of first medical contact—specifically left bundle branch block, nonspecific intraventricular conduction delay, atrial fibrillation/flutter, and tachycardia—serve as strong predictors of mortality in patients with acute STEMI undergoing primary PCI. Conversely, inferior or inferolateral infarct patterns were linked to more favorable outcomes, while ischemia grade did not demonstrate prognostic significance in the modern treatment era. These results emphasize the enduring importance of a thorough ECG evaluation as a rapid, accessible, and cost-effective tool for early risk stratification and guiding clinical decisions in STEMI, particularly within resource-constrained tertiary care environments.

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