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Original Article

Predicting mortality using prognostic scores and electrocardiographic parameters in ST-elevation myocardial infarction patients undergoing thrombolysis

Mamatha Reddy*[1], Vaasanthi Chintala[2], Bairam Balaji[3]

Abstract

Background: The short- and long-term outcomes of thrombolysis has been predicted by various scores and models based on the electrocardiogram. This study aimed to compare various mortality predictors in ST-elevation myocardial infarction (STEMI) patients undergoing thrombolysis.

Methods: A prospective, case-control, single-center study was performed at MGM Hospital, Warangal, India, between November 2019 and November 2021. A total of 100 STEMI patients were enrolled, out of which 50 were controls (patients who survived after seven days of thrombolysis) and 50 were cases (patients who died after seven days of thrombolysis). Aldrich score, TIMI risk index (TRI), Sclarovsky-Birnbaum Ischemia Grading (SB-IG) algorithm, presence of Q waves, total ST-segment deviation, and the number of leads with ST-segment elevation (STE) in anterior wall MI (AWMI) were calculated.

Results: The mean age of the case group was 55.3 ± 11.6 years, and that of the control group was 55.5 ± 10.1 years. Males comprised 46.0% and 66.0% of the case and control groups. The c-statistic of TRI was found to be the highest (c = 0.68; P = 0.001), followed by the SB-IG algorithm (c = 0.58; P = 0.021), the sum of R waves in AWMI (c = 0.5; P = 0.019), the number of leads with STE in AWMI (c = 0.47; P = 0.778), total ST-segment deviation (c = 0.47; P = 0.552), Aldrich score for AWMI (c = 0.43; P = 0.590), presence of Q waves (c = 0.40; P = 0.676), and Aldrich score for inferior wall MI (c = 0.32; P = 0.071).

Conclusion: TRI and SB-IG algorithms had moderate accuracy in predicting seven-day mortality in STEMI patients undergoing thrombolysis. Other scores and parameters viz. Aldrich score, presence of Q waves, total ST-segment deviation, and the number of leads with STE in AWMI had very poor accuracy in predicting in-hospital outcomes. More extensive studies with longer durations are required to validate our findings.

Keywords: STEMI, ECG, Prognosis, Mortality, Thrombolysis, Myocardial Infarction, India

Background

Cardiovascular diseases (CVD) account for the highest number of deaths globally, taking the lives of ~17.9 million people annually [1]. Coronary artery disease (CAD) is the most common CVD presentation, representing approximately half of all CVD [2]. One of the acute manifestations of CAD, ST-elevation myocardial infarction (STEMI), results in transmural ischemia leading to myocardial necrosis [3]. Timely myocardial reperfusion is the goal of treatment for STEMI, which attempts to preserve the Myocardium, lower the size of the eventual infarct, and reduce subsequent mortality rates. One way to achieve this goal is by administering thrombolytics. Coronary patency is achieved in 50-75% of patients undergoing thrombolytic therapy [4]. Although the outcomes seem inferior to primary percutaneous coronary intervention, thrombolysis is still the preferred treatment strategy when the time from medical contact to the device is more than 90 minutes. Approximately 6.9% of STEMI patients treated with thrombolytics present with a new-onset atrioventricular block [3]. Therefore, thrombolysis does not always ensure event-free survival. The immediate prognosis in STEMI patients is inversely related to the extent of myocardial damage. For a long time, the electrocardiogram (ECG) has been considered an essential part of diagnosis and initial evaluation for patients with chest pain. Serial ECG alterations are identified by leads facing the ischemic zone shortly after the blockage of a coronary artery. Additionally, the ECG is useful in determining

*Correspondence: mamathac04@gmail.com
[1]Department of Cardiology, Mahatma Gandhi Memorial Hospital, Warangal, Telangana- 506002, India
A full list of author information is available at the end of the article

the size of the myocardial ischemic area at risk (AAR), distinguishing between transmural and subendocardial ischemia, and confirming the presence of prior infarctions using abnormal Q waves in leads unrelated to the current infarction [5]. Methods that could swiftly evaluate the amount of damaged Myocardium and thus identify individuals most likely to benefit from reperfusion therapy would be helpful in clinical practice. Some various models and scores predict the myocardial AAR and subsequent mortality in STEMI patients undergoing thrombolysis. Studies have attempted to use the admission ECG to calculate the ischemic AAR [6-8]. ECG methods to assess AAR include the Aldrich score [9]. Sclarovsky-Birnbaum Ischemia Grading (SB-IG) algorithm [10], presence of Q waves [11], total ST-segment deviation [12], and the number of leads with ST-segment elevation (STE) in anterior wall myocardial infarction (AWMI). Another important model that predicts mortality is the TIMI risk index (TRI) [13], which is not based on ECG changes. These methods use complex algorithms or formulae using simple parameters such as age, systolic blood pressure, etc., to predict a patient's mortality risk by expressing a numerical value calculated at the time of admission. The purpose of the current study was to compare the predictive abilities of these seven risk scores and parameters in determining seven-day mortality in STEMI patients undergoing thrombolysis.

Methods

Study design and population

Between November 2019 and November 2021, a prospective, single-center, case-control study was performed at MGM Hospital, Warangal, India. A total of 100 STEMI patients were enrolled in the study. Cases were defined as STEMI patients who died within seven days of thrombolysis, and controls were defined as STEMI patients who survived even after seven days of thrombolysis.

Inclusion and exclusion criteria

Patients with STEMI who presented within the window period of 12 hours [14] for thrombolysis were included. Those presenting with STEMI after the window period or those with a contraindication to thrombolysis were excluded from the study.

Measurements

At the time of admission, Aldrich score, TRI, SB-IG, presence of Q waves, total ST-segment deviation, and the number of leads with STE in AWMI were calculated (Tables 1-3).

Table 1: TIMI Risk Index and its correlation with the risk of death. (Reproduced from Morrow et al. [15])

TRI	Risk group	Risk of death		
		24 h	In-hospital	30 days
≤12.5	1	0.2	0.6	0.8
>12.5-17.5	2	0.4	1.5	1.9
>17.5-22.5	3	1.0	3.1	3.3
>22.5-30	4	2.4	6.5	7.3
>30	5	6.9	15.8	17.4

TRI: Thrombolysis in Myocardial Infarction Risk Index

Table 2: SB-IG algorithm and their observations on the ECG (Taken from Birnbaum et al. [16])

SB-IG algorithm	Observation
No ischemia	Baseline
Grade I ischemia	Tall symmetrical T wave without ST elevation
Grade II ischemia	ST elevation ≥0.1 mV without distortion of the terminal portion of the QRS wave
Grade III ischemia	ST elevation with distortion of the terminal portion of the QRS (emergence of the J point ≥50% of the R wave in leads with qR configuration), or disappearance of the S wave in leads with an Rs configuration

Table 3: Correlation of ST deviation with AMI size (Reproduced from Aldrich et al. [6])

AMI Location	ST Parameters	R
Anterior	Number of leads with ST↑	0.72
	ΣST↑ all leads	0.52
	ΣST↑ V_1 through V_3	0.38
	ΣST↑ V_1 through V6	0.48
	ΣST↑ V_1 through V_3, I, aVL	0.46
Inferior	Number of leads with STΔ	0.50
	ΣST↑ all leads	0.61
	ΣST↑ all leads + ΣST↓ V_1 through V_3	0.60
	ΣST↑ II, III, aVF	0.61
	↑ II, III, aVF + ΣST↓ V_1 through V_3	0.59

Q waves were considered pathological if they were>40 ms (1 mm) wide, >2 mm deep, > 25% of the depth of the QRS complex, or seen in leads V1 through V3 [17]. SB-IG was estimated using the classification as follows: 1) Grade I- tall, peaked, symmetrical T waves, 2) Grade II- slope elevation of ST segment, 3) Grade III- Distortion of the terminal QRS complex in the form of J point elevation of >50% of the preceding R wave or loss of normal S wave. TRI, Aldrich score, and ST segment deviation were calculated using the following formulae:

TRI = heart rate in beats per min x [(age/10)2]/systolic blood pressure

Aldrich score = acute myocardial infarct size (anterior) = 3[1.5(number leads ST↑) – 0.4]; (inferior) = 3[0.6(∑ST↑ II, III, aVF) + 2.0]

ST segment deviation = 3[0.22 (ΣST↓ + ΣST↑) − 0.02],

where ↓ indicates depression and ↑ elevation, derived from measurements on the initial ECG, predicts the size of the AMI in the percentage of the left ventricle as estimated on the final ECG. The quantitative initial ST-segment deviation correlates linearly to the final AMI size in patients with maximum ST-segment depression in leads V1 through V3 [18].

Statistical analysis

All variables were analyzed and expressed as numbers (n). Continuous variables displaying normal distribution were expressed as mean ± SD. The chi-square test and independent t-test were used to compare the demographic characteristics of the two groups. A P-value less than 0.05 was considered statistically significant. ROC curves were generated, and the AUCs were calculated to compare the accuracies of scores and ECG parameters. Statistical analyses were performed using Statistical Package for Social Sciences version 20.0 (IBM, Chicago, IL, USA).

Results

Descriptive and general characteristics of related factors

In this study, 100 STEMI patients were enrolled at our institute. Out of 100 patients, 50 were cases (patients who died seven days after thrombolysis), and 50 were controls (patients who survived seven days after thrombolysis). The mean age of the case group was 55.3 ± 11.6 years, and that of the control group was 55.5 ± 10.1 years (Table 1). The case group comprised 27 females (54%) and 23 males (46%), and the control group had 17 females (34%) and 33 males (66%) (Table 4).

Table 4: Baseline characteristics of patients (n=100)

Category	Group		P-value
	Case (N = 50)	Control (N = 50)	
Age (years), n (%)			
≤ 40	2 (4.0)	5 (10.0)	0.356
41-50	17 (34.0)	9 (18.0)	
51-60	17 (34.0)	22 (44.0)	
61-70	12 (24.0)	12 (24.0)	
> 70	2 (4.0)	2 (4.0)	
Mean (SD)	55.3 (10.1)	55.5 (11.6)	
Females, n (%)	27 (54.0)	17 (34.0)	0.044
STE in R, n (%)			
Yes	8 (16.0)	00	
No	12 (24.0)	00	

P-value calculated using chi-square test; STE: ST Elevation

As shown in Table 5, Q-wave was observed in 33 patients (66%) in the case group and 31 patients (62%) in the control group (P = 0.676). The mean length of R-waves in AWMI was 16.3 ± 10.5 mm in the case group and 27.1 ± 21.3 mm in the control group (P = 0.019) (Table 2). In a comparison of scores, the mean TRI was 35.4 ± 22.7 in the case group and 22.3 ± 13.7 in the control group (P = 0.001) (Table 2). The mean SB-IG system was 2.9 ± 0.3 in the case group and 2.7 ± 0.5 in the control group (P = 0.021) (Table 5). The area under the receiver operating characteristics (ROC) curve for various mortality prediction scores are given in Table 2 and Figure 1. Highest AUC was observed for TRI (c = 0.68), followed by the SB-IG algorithm (c = 0.58), the sum of R waves in AWMI (c = 0.50), the number of leads with STE in AWMI (c = 0.47), total ST-segment deviation (c = 0.47), Aldrich score for AWMI (c = 0.43), presence of Q waves (c = 0.40) Aldrich score for inferior wall MI (c = 0.32).

Discussion

In this study, we tried to study the intentions of HCPs, including the global burden of the acute coronary syndrome (ACS) is increasing rapidly. STEMI is the most serious presentation of ACS [3]. The success of reperfusion therapy, either using thrombolytics or PCI, depends upon various factors such as age, gender, ischemia time, ischemic preconditioning, and collateral and residual antegrade flow [10,19,21].

In this study, patients who underwent thrombolysis for STEMI were included. We identified the power of various scores and ECG-based parameters such as Aldrich score, TRI, SB-IG algorithm, presence of Q-waves, the sum of R waves, total ST-segment deviation, and the number of leads with STE in AWMI in predicting the in-hospital outcomes in STEMI patients undergoing thrombolysis. We found that TRI was better at predicting seven-day mortality than the other parameters based on the area under the ROC curve (c = 0.68).

The mean age of cases was 55.3 ± 10.1 years, and controls were 55.5 ± 11.6 years. This was similar to the GRACE registry [22] had a mean age of 64 ± 13 years for STEMI patients. Another study by Aziz et al. [23] had a mean age of 56.6 ± 11.7 years for STEMI patients. In the current study, we did not observe a significant increase in mortality rate with an increase in age. However, according to the GUSTO-I trial [24], which included patients with acute myocardial infarction (AMI), the increase in mortality with the increase in age was significant (P < 0.001). This may be due to the inclusion of patients ≥ 85 years in the GUSTO-I trial, which were not present in our study. TRI had the best ability to discriminate between cases and controls (P = 0.0001) regarding in-hospital outcomes. Additionally, it was the only predictor that was able to approach the acceptable c-statistic threshold of 0.7 [25], suggesting that it was moderately accurate in predicting seven-day mortality. A simple bed-side tool, TRI has been studied extensively as a predictor of 30-day mortality. Morrow et al. [24], in their study to validate TIMI risk score in STEMI patients, found that the score showed strong 30-day prognostic capacity overall (c = 0.74 vs. 0.78 in derivation set) and among patients receiving acute reperfusion therapy (c = 0.79). In the same study, mortality prediction in patients not receiving reperfusion therapy was not as robust (c = 0.65) [26]. In a study by Ruff et al. [27], TRI was a good predictor of all-cause death. They found a strong relationship between increasing TRI and 30-day mortality (1.2%-20.7%, P < 0.0001) [27].

A lower c-statistic value for TRI in the current study compared to the studies mentioned above may be due to the differences in study duration. In this study, we predict seven-day outcomes, whereas most studies conducted earlier have studied 30-day outcomes. Nevertheless, TRI had the highest discriminative performance of all models assessed according to c-statistics. In 1993, Birnbaum, Sclarovsky, and colleagues published their findings about the utility of the initial ECG pattern in predicting in-hospital mortality in patients with an evolving anterior wall AMI [21]. The algorithm helps in predicting the extent of ischemia, which can be differentiated into three grades based on the relation between the acute appearances of the T wave, the ST segment, and the QRS complex. The SB-IG algorithm was evaluated by Hasdai et al. [28] in patients with inferior wall AMI. It was found that patients with minimal STE were at the highest risk for in-hospital mortality. All other parameters tested in this study, i.e., Aldrich score for AWMI, Aldrich score for IWMI, presence of Q-waves, the sum of R waves in AWMI, number of leads with STE in AWMI, and total ST-segment deviation performed poorly in ROC analysis with c-statistics 0.43, 0.32, 0.40, 0.50, 0.47 and 0.47, respectively. The Aldrich score estimates myocardial AAR based on STE, and studies have indicated that this score is unstable with time [29]. Aldrich et al. [6] found that the number of leads with STE in AWMI was an important variable (r = 0.72) in predicting AMI size. Koivula et al. [30], in their study on finding the prognostic role of Q-waves in STEMI patients, found that patients with Q-waves had larger infarct areas, which could explain the high one-year mortality seen in these patients. In their study on the prognostic Significance of ST-segment deviation in STEMI patients, De Luca et al. [31] found that ST-segment deviation had good prognostic utility based on the area under the ROC curve (c = 0.73) in terms of one-year morality.

In another study by Daly et al. [32], ST-segment deviation had poor prognostic utility (c = 0.61) in STEMI patients. The applications of this study need to be weighed against the limitations. Firstly, this was a single-center study with a limited number of patients. This restricts its applicability to the population in general. Secondly, we did not consider the effect of age, gender, ischemic preconditioning, and collateral and residual antegrade flow on the success of thrombolytic therapy. Last, we were unable to perform 30-day and long-term follow-up, which should be aimed at further studies.

Table 5: Comparison of scores and ECG parameters between the study groups

Score, mean (SD)	Group		c-statistic	P-value
	Case (N = 50)	Control (N = 50)		
TRI	35.4 (22.7)	22.3 (13.7)	0.677	0.001
Aldrich score (AWMI)	24.0 (7.2)	25.1 (7.34)	0.431	0.590
Aldrich score (IWMI)	18.1 (17.0)	21.8 (6.3)	0.321	0.071
SB-IG algorithm	2.9 (0.3)	2.7 (0.5)	0.582	0.021
Presence of Q waves, n (%)	33 (66.0)	31 (62.0)	0.401	0.676
Sum of R waves in AWMI	16.3 (10.5)	27.1 (21.3)	0.498	0.019
Number of leads with STE in AWMI	5.7 (1.5)	5.9 (1.6)	0.471	0.778
Total ST-segment deviation	20.3 (9.3)	21.5 (10.4)	0.465	0.552

TRI: Thrombolysis in Myocardial Infarction Risk Index; AWMI: Anterior Wall Myocardial Infarction; IWMI: Inferior Wall Myocardial Infarction; SB-IG: Sclarovsky-Birnbaum Ischemia Grading; STE: ST Elevation

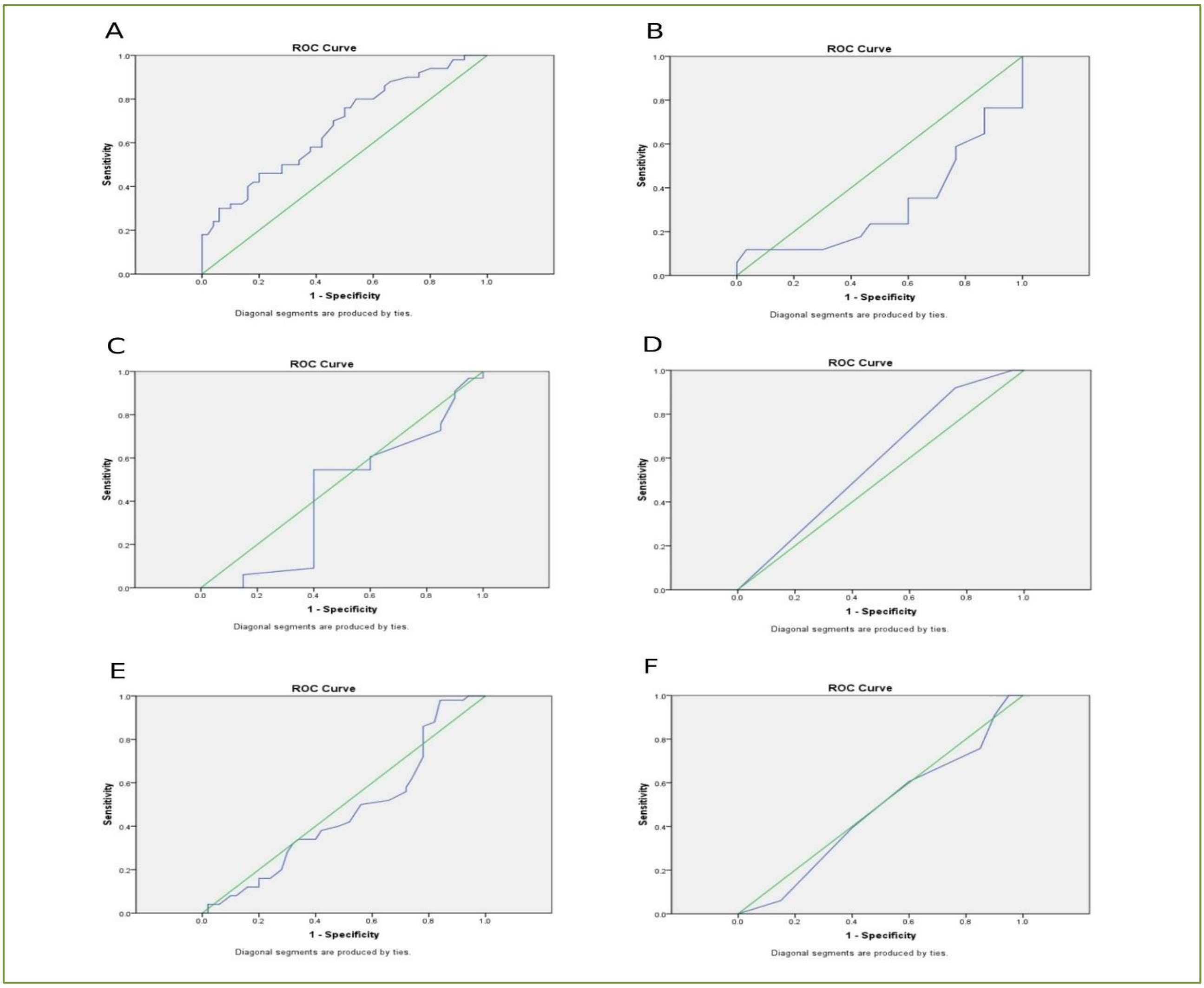

Figure 1: Receiver operating characteristics curve for A) TIMI risk index; B) Aldrich score for inferior wall myocardial infarction; C) Aldrich score for anterior wall myocardial infarction (AWMI); D) Sclarovsky-Birnbaum score; E) Total ST deviation; and F) Number of leads with ST elevation in AWMI.

Conclusion

Amongst various predictors of outcomes in patients receiving thrombolysis for STEMI, TRI and SB-IG algorithms had moderate accuracy in predicting seven-day mortality. Other scores and ECG parameters, viz. Aldrich score, presence of Q-waves, the sum of R waves in AWMI, total ST-segment deviation, and the number of leads with STE in AWMI had very poor accuracy in predicting in-hospital outcomes. However, more extensive studies with longer durations are required to validate our findings.

Abbreviation

STEMI: ST-Elevation Myocardial Infarction; ECG: Electrocardiogram; TRI: TIMI Risk Index; SB-IG: Sclarovsky-Birnbaum Ischemia Grading algorithm; STE: ST-Segment Elevation; MI: Myocardial Infarction AWMI: Anterior Wall MI; IWMI: Inferior Wall MI; CVD: Cardiovascular Diseases; CAD: Coronary Artery Disease; AAR: Area at Risk.

Declaration

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Availability of data and materials

Data will be available by emailing mamathac04@gmail.com.

Authors' contributions

All authors have contributed equally in designing, writing, the analysis and interpretation of the study and drafting and reviewing the article. All authors read and approved the final version of the manuscript.

Ethics approval and consent to participate

We conducted the research following the Declaration of Helsinki. The protocol of the study was approved by the Institutional Ethics Committee of MGM Hospital, Warangal, India (19100003008D; approved on 24/10/2019). Written informed consent was obtained from all participants or their legal representatives.

Consent for publication

Not applicable

Competing interest

The authors declare that they have no competing interests.

Author Details

[1]Department of Cardiology, Mahatma Gandhi Memorial Hospital, Warangal, Telangana- 506002, India.

[2]Department of General Medicine, Mahatma Gandhi Memorial Hospital, Warangal, Telangana- 506002, India.

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