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Importance of Positive T-wave in Lead aVR and Major Adverse Cardiac Events in Patients with ST Elevation Myocardial Infarction: A Cohort Study

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ABSTRACT

Introduction: It is well known that ST-Segment Elevation Myocardial Infarction (STEMI) is a significant contributor to both illness and death on a global scale. An Electrocardiogram (ECG) is an easily accessible bedside tool for diagnosing acute myocardial infarction. The T wave is usually negative in lead aVR (augmented unipolar right arm lead). However, a positive T wave in lead aVR has been shown to be associated with adverse in-hospital outcomes in patients with Acute Coronary Syndrome (ACS).

Aim: To examine whether a positive T wave in lead aVR can be used as an indicator to predict Major Adverse Cardiac Events (MACE) during the hospital stay in patients with STEMI.

Materials and Methods: A cohort study was performed at Shri BM Patil Medical College, Hospital and Research Centre, Vijayapura, involving patients admitted with STEMI. A total of 98 newly diagnosed ST-segment elevation patients were classified into two groups: Group A (positive T wave) in lead aVR with an amplitude of ≥ 0 mV, and Group B (negative T wave) in lead aVR with an amplitude of ≤0 mV. The hospital stays of STEMI patients were evaluated for adverse cardiac events. Chi-square test was used to assess relationships between categorical variables.

Results: A total of 98 patients were evaluated, among which two were excluded. Hence, among 96 patients considered, 25 were females and 71 were male, with average ages of 57 years in Group A and 55 years in Group B. Among the 96 patients, 34 had positive T waves (35.4%) and 62 had negative T waves (64.5%) in lead aVR. The study revealed significantly higher rates of in-hospital MACE (heart failure, pulmonary oedema, and arrhythmias) in patients with positive T waves (Group A) in lead aVR, with p-values <0.05, which were statistically significant.

Conclusion: The present study showed that a positive T wave in lead aVR is a valuable and cost-effective tool for predicting in-hospital MACE in patients with STEMI. Utilising this simple and readily available ECG measurement could support clinicians in detecting high-risk patients who require closer monitoring and more aggressive interventions, potentially leading to improved patient outcomes and resource allocation.

Keywords: Cardiovascular diseases, Electrocardiography, Myocardial ischaemia

INTRODUCTION

The high mortality rate associated with ACS highlighted the critical need for early detection. Only 22% of individuals presenting with chest discomfort at emergency cardiology clinics are diagnosed with coronary artery disease [1]. ACS imposes a significant economic burden globally and is a significant cause of disability and mortality. The disease is influenced by various risk factors, and its prevalence is rising in India [2]. Geographically, racially, culturally, educationally, institutionally, and economically, India is a greatly diverse country. The second largest population on Earth resides in India. These factors further increase the difficulty in managing ACS. World Health Organisation (WHO) reports show that the incidence of ACS is increasing in India, pointing to a dramatic shift in the country's epidemiology [3]. There are about three million reported STEMI cases annually in India, making ACS the main cause of mortality there [4].

ACS encompasses conditions such as Unstable Angina (UA), STEMI, and non STEMI (NSTEMI), all of which manifest as acute chest pain due to myocardial ischaemia. While the pathophysiology may differ, these conditions share an underlying imbalance between oxygen supply and demand [5]. ACS is affected by different risk factors, including non modifiable factors like family history, ethnicity, sex, age, genetic predisposition, as well as, modifiable factors like diabetes, hypertension, obesity, smoking/tobacco use, and diet [6]. It is crucial to effectively predict and manage significant adverse cardiac events, such as heart failure, cardiogenic shock, pulmonary oedema, arrhythmias, and re-infarction, in high-risk patients [7].

Electrocardiography, introduced in 1902 by the Dutch physician William Einthoven, 15. He provided information about the electrophysiology of the heart [8]. Electrocardiography is now considered an important and common aspect of the initial assessment of patients with cardiac symptoms. It is a non invasive, low-cost, and easily accessible technique for assessing ACS [9]. Lead aVR, one of the twelve leads on the ECG, has long been overlooked, but new research has shown that it can help with both the diagnosis and prognosis of various myocardial illnesses [10,11].

The T wave in lead aVR is usually negative and typically moves in the same direction as the QRS complex [12]. However, recent studies have demonstrated a significant relationship between a positive T wave in lead aVR and major adverse cardiac outcomes, such as heart failure, pulmonary oedema, persistent ventricular tachycardia or ventricular fibrillation, cardiogenic shock, and cardiac mortality resulting from STEMI [13-15]. With this scenario, the present study aimed To examine whether a positive T wave in lead aVR can be used as an indicator to predict MACE during the hospital stay in patients with STEMI.

MATERIALS AND METHODS

The present cohort study was conducted on patients who were admitted with STEMI at Shri BM Patil Medical College and Research Centre, Vijayapura, Karnataka, from November 2019 to June 2021.

The sample size was calculated using the following formula:

$$n=\frac{z^2p.(1-p)}{d^2}$$

Here:

Z indicates the z statistic at a 5 percent level of significance,

d denotes the error margin,

p signifies the anticipated prevalence rate (50%),

n = 100.

The Institutional Ethics Committee (IEC) provided prior approval for this study (IEC/No-131/2019).

Inclusion criteria: Patients with prolonged chest discomfort and other angina equivalents typical of myocardial ischaemia, admitted to the Intensive Coronary Care Unit (ICCU) with a diagnosis of STEMI, were included.

Exclusion criteria: Patients with NSTEMI, left bundle branch block, and those with previous history of myocardial infarction were excluded from the study.

A total of 98 patients were evaluated based on inclusion and exclusion criteria. They were divided into two distinct groups based on the presence of a positive T wave (Group A) and a negative T wave (Group B) in lead aVR. The study collected patients' clinical history, including age, gender, previous medical conditions, cardiovascular risk factors, and symptoms, while conducting thorough physical examinations to assess vital signs, cardiac sounds, and other relevant findings. Laboratory investigations included assessing cardiac biomarkers {troponin levels, Creatinine Kinase (CK), CK-MB}, as well as lipid profile, renal function, and other parameters relevant to myocardial infarction.

A 2D echocardiogram was performed to evaluate left ventricular dysfunction and contractility. An ECG at the time of admission was conducted to diagnose STEMI and identify a positive T wave in lead aVR. A chest X-ray was taken to observe features of pulmonary oedema. Patients were Followed-up during their in-hospital stay to monitor MACE, such as heart failure, pulmonary oedema, arrhythmias, cardiogenic shock, and death.

STATISTICAL ANALYSIS

A descriptive summary was provided for all the characteristics. Continuous variables were described using summary statistics in the form of mean±SD. Percentages and numbers were used for categorical data. To compare haemodynamic and laboratory data independent 't' test was used. The Chi-square test was applied to examine the relationship between two categorical variables. A p-value of 0.05 or less was considered statistically significant. Microsoft Excel version 7 (Microsoft Corporation, NY, USA) and Statistical Package for the Social Sciences (SPSS) software version 21.0 were used for all statistical calculations.

RESULTS

In the present study, 98 patients had STEMI, of whom two were excluded based on the exclusion criteria. One patient had a prior history of Ischemic Heart Disease (IHD), and the other patient had a Left Bundle Branch Block (LBBB). Hence, 96 patients were included in the present analysis and were divided into Group A and Group B based on lead aVR findings. Out of the 96 patients, 34 patients (35.4%) had Group A, and 62 patients (64.5%) had Group B in lead aVR on the ECGs.

[Table/Fig-1] provides an overview of the demographic and clinical features. Patients in Group A were older than those in Group B.

The findings of the electrocardiograph are presented in [Table/Fig-2]. STEMI in the inferior leads (II, III, aVF) was more frequent in patients with positive T waves in lead aVR.

Demographics	Group-A (n=34)		Group-B (n=62)		p-value
Age >50 years	57 (33-79)		55 (25-88)		0.65
Age	No.	%	No.	%	
21-30	0	0	2	3.3	
31-40	2	5.8	3	4.9	
41-50	2	5.8	15	24.1	
51-60	20	58.8	25	40.3	
61-70	5	14.8	11	17.7	
71-80	5	14.8	5	8	
81-90	0	0	1	1.6	
Male/Female	27/7	79%/20.5%	44/18	70.9%/29 %	0.37
Family history of coronary artery disease	5	14.70%	13	20.90%	0.45
Diabetes	18	52.90%	24	38%	0.18
Hypertension	14	41.70%	21	33.80%	0.48
Smoking	20	58.80%	22	35.40%	0.03
Alcohol	7	20.50%	15	24.10%	0.69
Haemodynamic and laboratory data	**Mean**	**SD**	**Mean**	**SD**	**p-value**
Pulse rate (beats per minute)	86.7	27.3	87.4	19.1	0.9
Systolic blood pressure (mmHg)	110.5	30.3	108.2	25.9	0.75
Haemoglobin (gm%)	13.9	2.1	13.4	2.5	0.48
White blood cells (109/L)	13953	3493.6	11946	5175.5	0.15
Troponin I	11.71	16.46	21.25	58.41	0.21
CK-MB	82.73	103.27	69.79	72.81	0.56
Creatinine	1.12	0.38	0.89	0.3	0.009
Left ventricular ejection fraction (<40%)	23 (67.6%)		37 (59.6%)		0.44
Symptoms					
Chest pain	29	85.20%	55	88.70%	0.6
Dyspnoea	25	73.50%	38	61.20%	0.23
Abdominal pain	4	11.70%	8	12.90%	0.87
Palpitation	9	26.40%	8	12.90%	0.1
Syncope	14	41.10%	11	17.70%	0.06

[Table/Fig-1]: Socio-demographic data (Chi-square test), Haemodynamic and laboratory data (Independent 't' test) and symptoms (Chi-square test) recorded in the study subjects.

ECG Findings	Group-A (n=34)		Group-B (n=62)	
V3, V4 (Anterior wall STEMI)	11	32.30%	19	30.60%
V3, V4, I, AVL, V5, V6 (Antero-lateral wall STEMI)	0	0	7	11.20%
V1, V2, V3, V4 (Antero-septal wall STEMI)	9	26.40%	12	19.30%
II, III, AVF (Inferior wall STEMI)	14	41.10%	24	38.70%

[Table/Fig-2]: Electrocardiographic findings.

The results of the distribution of MACE are shown in [Table/Fig-3]. The results indicate that, compared to patients with negative T waves in lead aVR, patients with positive T waves were more likely to experience MACE, such as heart failure, pulmonary oedema, and arrhythmias (p≤0.05).

DISCUSSION

The study findings revealed that Group A in lead aVR was a predictor of major adverse events in patients with STEMI. Group A in lead aVR was associated with occlusive disease of the long Left Anterior Descending (LAD) artery and decreased left ventricular ejection fraction in patients with previous anterior wall myocardial infarction.

Events	Group-A (n=34)		Group-B(n=62)		p-value
Heart failure	20	58.80%	21	33.80%	0.02
Pulmonary oedema	23	67.60%	24	38.00%	0.01
Cardiogenic shock	18	52.90%	29	46.70%	0.56
Arrhythmia	7	20%	3	4.90%	0.02
Deaths	5	14.70%	6	9.60%	0.46

[Table/Fig-3]: Distribution of Major Adverse Cardiac Events (MACE) (Chi-square test) p<0.05 (statistically significant).

According to Shinozaki K et al. [16], blocking the long LAD artery, which supplies the inferior, apical, and lower lateral portions of the left ventricle, can lead to extensive myocardial ischaemia and significant left ventricular dysfunction.

In a study by Torigoe K et al., [17], it was found that individuals with a positive T wave in lead aVR were more likely to have multivessel disease, especially in patients with a history of myocardial infarction. Ayhan E [18] also reported that patients with anterior wall STEMI and positive T waves in lead aVR had a higher incidence of proximal LAD occlusion and multivessel disease. This suggested that the presence of positive T waves may indicate extensive Coronary Artery Disease (CAD), resulting in widespread myocardial ischaemia and negative clinical outcomes.

Although, the exact cause of Group A in lead aVR is still unknown, it has been suggested that concurrent myocardial ischaemia in the inferior, apical, and lower lateral walls leads to delayed repolarisation and the inversion of the T-wave vector towards the injured areas. This results in a positive T wave in lead aVR [16,18].

In the present study, 96 patients were included and analysed to predict in-hospital MACE such as heart failure, pulmonary oedema, cardiogenic shock, arrhythmias (ventricular tachycardia, supraventricular tachycardia, atrial fibrillation), and death. The most common age group observed was 51-60 years, which aligns with the findings of Ayhan E [18] who studied 169 patients and reported a similar age group with a mean age of 58%.

Kobayashi A et al., [10] conducted a study on 190 patients hospitalised with ACS and found that the predominant age group was 60-70 years. Additionally, Ajay VS and Prabhakaran D's study indicated a shift in the mean age group since the early 70s. They found that ACS occured a decade earlier in the Indian population compared to Western countries [19]. This difference may be attributed to factors such as lack of education about the disease, risk factors, evidence-based treatment, and non compliance with medications.

In this study, a male predominance was observed, with 71 male patients (73.9%) and 25 female patients (26.1%), which is consistent with the analysis conducted by Shinozaki K et al., [16], where 96 male patients and 26 female patients were included. However, Aygul N [20] reported a significantly higher proportion of male patients (742) compared to female patients (208) in their study.

The study identified smoking (p-value=0.03) as a significant modifiable risk factor for STEMI among the research subjects. Smoking and positive T waves in lead aVR showed a strong association. The most common symptoms observed among study subjects with STEMI were chest pain, dyspnoea, and syncope. Various studies have shown significant variations in the association of different risk factors with ACS. Ayhan E reported that among 169 patients with ACS, diabetes mellitus was present in 16.9% (n=53), smoking in 60.3% (n=53), and hypertension in 50.9% (n=53) [18].

The study had a higher incidence of risk factors such as alcohol consumption, diabetes mellitus, hypertension, and smoking for ACS compared to the present study. The study results are consistent with the analysis conducted by Krishnan MN on 5167 patients with ACS, where diabetes mellitus was present in 15% (n=775) of patients, hypertension in 28% (n=1446) of patients, and smoking in 28% (n=1446) of patients [21]. Similarly, an analysis by Rao V et al., on 100 patients with ACS found that diabetes was present in 67% of patients, hypertension in 52% of patients, smoking in 61% of patients, and alcohol consumption in 21% of patients [22]. An analysis reported by Unal B et al., concluded that a modest reduction in major risk factors like smoking, hypertension, and diabetes mellitus can significantly increase the life expectancy of patients with ACS [23]. Therefore, implementing policies to control tobacco use, promote a healthy diet, and educating patients about diabetes control is essential for improving the life expectancy of patients with ACS.

In this study, the most common symptom was chest pain (85.2% vs. 88.7%), followed by dyspnoea (73.5% vs. 61.2%), syncope (41.1% vs. 17.7%), palpitations (26.4% vs. 12.9%), and abdominal pain (11.7% vs. 12.9%) in both Group A and Group B. Similarly, an analysis by Goel PK on 609 patients admitted with AC found that the most frequent symptom was chest pain (n=510, 84%), followed by dyspnoea (n=53, 8.7%), and epigastric pain (n=16, 2.6%) [24]. A study by Canto JG reported that chest pain was present in 67% of patients, which is lower than what was observed in our study [25].

In this study, hemodynamic and laboratory data revealed a significant correlation between serum creatinine and STEMI. An analysis by Reddy CT et al., reported that ECG identification of the culprit artery not only helps localise the occlusion but also predicts the severity of myocardial infarction and guides emergency management [26]. Positive T waves in lead aVR were present in 34 patients with ST-segment elevation, accounting for 35.4% of the total patients in the current study.

In the present study, patients in Group A experienced more MACE, which is consistent with the findings of Ayhan E indicating that a positive T wave in lead aVR is associated with a higher likelihood of experiencing MACE during hospitalisation [18]. Okuda K's analysis also showed that a decrease in the negativity of the T wave amplitude in lead aVR was associated with an increased risk of death in patients diagnosed with heart failure [27]. The latest work by Kazemi B et al., confirmed a significant association between Group A in lead aVR and an elevated risk of adverse clinical outcomes, including in-hospital mortality, length of stay, cardiovascular mortality and rehospitalisation, within a six-month period in patients diagnosed with STEMI [11].

Limitation(s)

While the study investigating the correlation between a Group A in lead aVR and MACE in patients with STEMI offers valuable insights, it is essential to acknowledge its limitations. One notable limitation is that it was conducted at a single centre, potentially limiting its generalisability to diverse patient populations and varying healthcare practices seen in different settings. Additionally, due to its cohort design, the analysis might not have accounted for the long-term outcomes of the patients. Also, the caculated sample size of the study was not met. A longer follow-up duration with a larger sample size would be beneficial to gain a complete comprehension of the relation between Group A in lead aVR and MACE. Furthermore, the study solely assessed the initial ECG presented by patients upon admission, overlooking the potential influence of revascularisation procedures on the incidence of a positive T wave. Despite these limitations, the study's findings provide a foundation for further research and validation studies to establish the clinical significance of using a positive T wave in lead aVR as a predictive tool for MACE in STEMI patients.

CONCLUSION(S)

The importance of a positive T wave in lead aVR in cardiology is greater than currently recognised. There is an elevated risk of in-hospital major adverse cardiac outcomes, such as heart failure, pulmonary oedema, cardiogenic shock, and mortality, in patients with a positive T wave in lead aVR on the ECG among study subjects diagnosed with STEMI. Therefore, the positive T wave in lead aVR can be used to predict in-hospital MACE in STEMI-diagnosed patients.

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