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Original Article

Internal Medicine Section

Association between Frontal QRS-T Angle and Major Adverse Cardiovascular Events among Patients with Acute Myocardial Infarction: A Cross-sectional Study

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ABSTRACT

Introduction: Acute myocardial infarction has reached epidemic proportions in the Indian population. The premature onset of acute myocardial infarction has shifted the focus of research. An abnormal frontal QRS-T angle can be used as a marker of acute myocardial infarction and can also predict Major Adverse Cardiac Events (MACE) such as heart failure, complex ventricular arrhythmias (sustained ventricular tachycardia or ventricular fibrillation), early post-infarction angina, mechanical complications, and cardiac death resulting from acute myocardial infarction. Predicting the likelihood of serious adverse cardiovascular events and mortality in patients who have experienced an acute myocardial infarction aids in developing immediate and short-term treatment plans.

Aim: To assess the association between the Frontal QRS-T angle and MACE among patients with Acute Myocardial Infarction (MI).

Materials and Methods: A cross-sectional study was conducted on adult patients admitted with a diagnosis of acute MI at the Department of Medicine, BLDE (Deemed to be University) Shri B.M. Patil Medical College Hospital and Research Centre, Vijayapura, Karnataka, India from January 2021 to June 2022. A total of 95 patients were enrolled in the study and classified into two groups: Group A (n=68) with a frontal QRS-T angle of <100 degrees, and Group B (n=27) with a frontal QRS-T angle of >100 degrees. The patients were monitored for the emergence of serious MACE such as heart failure, pulmonary oedema, cardiogenic shock, arrhythmias, and death while they were in the hospital. Statistical analysis was performed using the Chi-square test, Independent t-test, and Mann-Whitney U test as applicable. A p-value of <0.05 was considered statistically significant.

Results: The most common age group in Group A was 60-70 years, while in Group B it was 50-60 years. A total of 95 patients with acute MI were enrolled and divided into two groups. Out of 95 patients, 68 patients with a frontal QRS-T angle <100 degrees were in Group A, and 27 patients with a frontal QRS-T angle >100 degrees were in Group B. There was a significant difference between the two groups with respect to MACE, including heart failure (Group A=8.8%, Group B=77.8%, p=0.00), pulmonary oedema (Group A=10.3%, Group B=77.8%, p=0.00), and cardiogenic shock (Group A=7.4%, Group B=40.7%, p=0.00).

Conclusion: A frontal QRS-T angle of >100 degrees was a reliable factor for assessing in-hospital major adverse cardiac outcomes such as heart failure, pulmonary oedema, and cardiogenic shock. Hence, a frontal QRS-T angle of >100 degrees on a 12-lead ECG is a cost-effective, reliable, and non-invasive parameter of MACE in patients with acute MI.

Keywords: Acute coronary syndrome, Cardiogenic shock, Electrocardiogram, Heart failure, Major adverse cardiac events

INTRODUCTION

Ischaemic heart disease is one of the leading causes of death worldwide. It was responsible for 19 million fatalities globally in 2020 [1]. In developing nations, acute Myocardial Infarction (MI) is a significant risk factor for morbidity and mortality. The diagnosis and prognosis of acute MI are directly connected to Electrocardiogram (ECG) alterations. As the leading cause of death in India, acute MI has already surpassed communicable diseases. Approximately three million cases of ST-Segment Elevation Myocardial Infarction (STEMI) alone burden the healthcare system each year [2].

Complications such as heart failure, cardiogenic shock, pulmonary oedema, arrhythmias, and re-infarction are considered Major Adverse Cardiovascular Events (MACE) [3]. Predicting the likelihood of serious MACE and mortality in patients who have experienced acute MI aids in developing both immediate and short-term treatment plans.

An ECG machine is a valuable tool in the diagnosis of acute MI and has shown to be highly effective in categorising patients based on the degree of risk for a range of cardiac morbidity and overall mortality [4]. Population-based studies have shown that certain electrocardiographic variables can be used for clinical risk stratification for MACE [5].

Literature has shown that regional myocardial lesions are associated with changes in QRS complex configuration, which can cause a change in the frontal QRST angle on a 12-lead ECG [6]. Recent research suggests that the frontal QRST angle is a relevant electrocardiographic measure of the dispersion between depolarisation and repolarisation. Additionally, it has been demonstrated that a higher spatial QRS-T angle is linked to higher mortality in the general population [6]. Measuring the spatial QRS-T angle requires specialised software as it is not routinely measured on 12-lead electrocardiographic machines. On the other hand, the frontal QRS-T angle can be easily calculated from a routine 12-lead ECG without the need for specialised software. Studies have revealed a substantial link between the frontal and spatial QRS-T angles [7].

Therefore, an abnormal frontal QRS-T angle can be used as a marker of acute MI and can also predict MACE such as heart failure, complex ventricular arrhythmias (sustained ventricular tachycardia or ventricular fibrillation), early post-infarction angina, mechanical complications, and cardiac death resulting from acute MI [8].

However, research on the predictive value of the frontal QRS-T angle in the occurrence of MACE following acute MI is limited. The aim of

the study was to assess the association between the frontal QRS-T angle and MACE among patients with acute MI. The objective of the study was to evaluate modifiable and non modifiable risk factors for acute MI.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Intensive Cardiac Care Unit (ICCU) of BLDE (Deemed to be University), Shri B.M. Patil Medical College Hospital and Research Centre, Vijayapura, Karnataka, India, between January 2021 and June 2022. Approval for present study was obtained from the Institutional Ethics Committee with the number (IEC/NO-09/2021 dated on 22/01/2021) and the study was also registered in the Clinical Trials Registry-India with the number (CTRI/2021/04/032888).

The frontal QRS-T was calculated as the absolute value of difference between the QRS axis and T axis yielding value of difference between 0 degree and 180 degrees. The QRS axis was calculated using the isoelectric method and T axis was determined in which leads the highest T-waves were seen.

Inclusion criteria: The inclusion criteria were patients admitted with acute myocardial infarction (STEMI and NSTEMI).

Exclusion criteria: Patients with unstable angina, patients having bundle branch block on ECG (LBBB or RBBB), patients on a temporary or permanent pacemaker and patients with old ischaemic heart disease disease were excluded from the study.

Sample size calculation: With an anticipated proportion of mortality among patients with acute MI and a higher frontal QRS-T angle at 28%, the study would require a sample size of 95 patients with a 95% level of confidence and 10% absolute precision [8]. The formula used was:

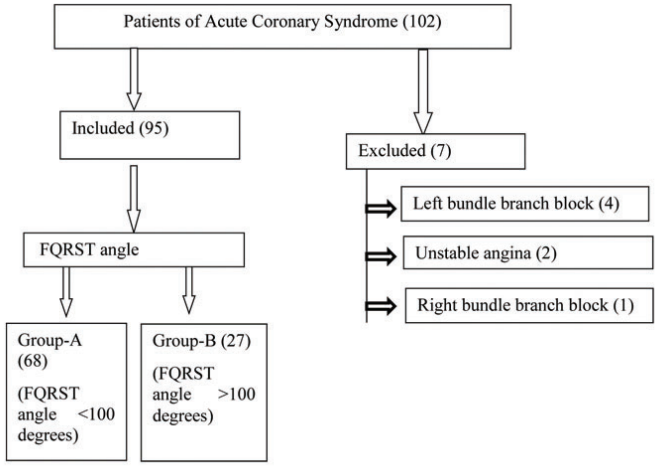
Formula used: $\frac{n=z^2\ p*q}{d^2}$

{Where Z = Z statistic at α level of significance, d^2 = Absolute error, P = Proportion rate (Prevalence = 28%), q = (100-p)}.

Study Procedure

A total of 102 patients with acute MI admitted to the ICCU were screened, and 95 patients who satisfied the inclusion criteria were enrolled using convenience sampling [Table/Fig-1]. Written informed consent was obtained before enrolling the patients in the study. The study also assessed the risk factors associated with acute MI, including both non modifiable factors (age, sex) and modifiable factors (diabetes, hypertension, smoking, alcohol, tobacco chewing) [9].

The patients were divided into two groups based on their frontal QRS-T angle. Patients with a frontal QRS-T angle <100 degrees were assigned to Group A, and patients with a frontal QRS-T angle >100 degrees were assigned to Group B [8]. The patients included in the study underwent a standardised assessment, including history and examination, ECG at admission, cardiac enzymes {Troponin I/ Troponin T, Creatine Phosphokinase- MB (CPK-MB)}, and other necessary laboratory investigations such as complete blood count, renal function test, serum electrolytes, and 2D echo study [10].



[Table/Fig-1]: Algorithm showing the study protocol.

A 12-Lead surface electrocardiography was performed using BPL Cardiart 6108T or VESTA 301i, with a paper speed of 25 mm/sec and voltage of 10 mm/sec. The ECG machine was used for the diagnosis of acute MI and was assessed for the frontal QRS-T angle. Heart rate, PR interval, QRS duration, QT interval, corrected QT interval, QRS axis, T wave, and T axis were analysed from each patient's initial ECG recording.

Patients were followed up during their in-hospital course for the occurrence of MACE, namely: death, heart failure, complex ventricular arrhythmias (sustained ventricular tachycardia or ventricular fibrillation), early post-infarction angina, or mechanical complications. Heart failure was diagnosed clinically according to the American Heart Association guidelines of 2022 [11]. Complex ventricular arrhythmias were monitored using ECG strips or 12-lead ECG recordings. Early post-infarction angina was defined as recurrent typical chest discomfort during hospital admission following relief of the index MI. Mechanical complications, as recorded by echocardiography, included acute mitral regurgitation, rupture of the interventricular septum, left ventricle pseudoaneurysm formation, and rupture of the left ventricle free wall. The relationship between the in-hospital outcome of MACE and the frontal QRS-T angle was studied.

STATISTICAL ANALYSIS

The primary outcome measure was to study the association between the frontal QRS-T angle and MACE between the two groups. The association between the frontal QRS-T angle and non modifiable and modifiable risk factors was also studied. The data obtained were entered into a Microsoft Excel sheet, and statistical analysis was performed using Statistical Packages for Social Sciences (SPSS) version 20.0. Categorical variables were compared using the Chi-square test. The Chi-square test was used to compare categorical variables between the two groups. A p-value of less than 0.05 was considered statistically significant. All statistical tests performed were two-tailed.

RESULTS

Out of the 95 patients, 32 patients (33.7%) were female and 63 patients (66.3%) were male. The most common age group in Group A was 60-70 years, while in Group B it was 50-60 years. Depending on the nature of work, the patients were further classified into four categories: business, service, housewife, and farmer.

The modifiable and non modifiable risk factors were studied [Table/Fig-2]. Out of the 95 patients in the study, 49 patients (72.1%) in Group A and 21 patients (77.8%) in Group B were over the age of 50, which was one of the risk factors. Male sex was observed in 46 patients (67.6%) compared to 17 patients (63%) in Group B.

Risk factors			Group A (n=68)		Group B (n=27)			p-value
			n	%	n	%	Chi-square	
Non modifiable	Age (in years)	> 50	49	72.1	21	77.8	0.326	0.568
	Gender	Male	46	67.6	17	63	0.190	0.663
		Female	22	32.4	10	37.0		
Modifiable	Diabetes		4	5.9	2	7.4	0.076	0.783
	Hypertension		13	19.1	8	29.6	1.240	0.265
	Smoking		24	35.3	9	33.3	0.033	0.856
	Alcohol		12	17.6	0	0	5.454	0.020*
	Tobacco chewing		27	39.7	12	44.4	0.179	0.672

[Table/Fig-2]: Distribution of risk factors in Group A and Group B.
*p<0.05, Significant

Smoking was observed in 33 patients, of which 24 patients (35.3%) were in Group A and 9 patients (33.3%) were in Group B. Hypertension was observed in 21 patients, with 13 patients (19.1%) in Group A and 8 patients (29.6%) in Group B. Diabetes was observed in six patients, with 4 patients (5.9%) in Group A and 2 patients (7.4%) in Group B. Tobacco chewing was observed in 39 patients, with 27 patients (39.7%) in Group A and 12 patients (44.4%) in Group B. Alcohol consumption was observed in 12 patients in Group A and zero patients in Group B. There was a significant difference in alcohol consumption with a p-value of 0.020.

The Left Ventricular Ejection Fraction (LVEF) was studied using 2D Echo Doppler [Table/Fig-3]. In Group A, among 68 cases, LVEF <40% was observed in 21 patients (30.9%), while LVEF >40% was observed in 47 patients (69.1%). In Group B, out of 27 cases, LVEF <40% was observed in 22 patients (81.5%), while LVEF >40% was observed in 5 patients (18.5%).

	Group A (n=68)		Group B (n=27)			
LVEF	n	%	n	%	Chi-square	p-value
<40%	21	30.9	22	81.5	19.971	p-value= 0.00*, S
>40%	47	69.1	5	18.5		
Total	68	100.0	27	100.0	-	

[Table/Fig-3]: Distribution of left ventricular ejection fraction (%) in Group A and Group B .
*p<0.05, Significant

The relationship between MACE and the frontal QRS-T angle was studied [Table/Fig-4]. Heart failure was found in 6 (8.8%) patients in Group A and 21 (77.8%) patients in Group B (p=0.00). Pulmonary oedema was found in 7 (10.3%) patients in Group A compared to 21 (77.8%) patients in Group B (p=0.00). Cardiogenic shock was found in 5 (7.4%) patients in Group A compared to 11 (40.7%) patients in Group B (p=0.00).

	Group A (n=68)		Group B (n=27)		Chi-square	p-value
Events	n	%	n	%		
Heart failure	6	8.8	21	77.8	45.170	p=0.00, S
Pulmonary oedema	7	10.3	21	77.8	42.341	p=0.00, S
Cardiogenic shock	5	7.4	11	40.7	15.382	p=0.00, S

[Table/Fig-4]: MACE in Group A and Group B.
*p<0.05, Significant

Thus, a frontal QRS-T angle >100 degrees was found to be associated with the occurrence of major adverse events in patients with acute MI.

DISCUSSION

The study aimed to investigate the frontal QRS-T angle as an important parameter in assessing the in-hospital outcome of MACE in patients with acute MI. The modifiable and non modifiable risk factors of acute MI were also assessed. A total of 95 patients with acute MI were enrolled in present study. Among these, 68 patients with a frontal QRS-T angle <100 degrees were in Group A, while 27 patients with a frontal QRS-T angle >100 degrees were in Group B. There was a significant difference (p<0.05) in the occurrence of MACE, including heart failure (p=0.00) (Group A=8.8%, Group B=77.8%), pulmonary oedema (p=0.00) (Group A=10.3%, Group B=77.8%), and cardiogenic shock (p=0.00) (Group A=7.4%, Group B=40.7%).

The most common age group in present study was 50-70 years. Similar findings were reported by Sawant AC et al., where the mean age of the enrolled patients ranged from 50 to 70 years [8]. Another study by Lown MT et al., included 1843 patients with a mean age of 70.1±13.1 years [12]. Our results are consistent with these previous studies, indicating that increasing age is an important non modifiable risk factor for the development of MI [12]. Additionally, advanced age can affect the diagnosis, leading to decreased sensitivity and specificity of troponins among patients [13].

In present study, there was a male predominance, with 63 patients (66.3%) being males and 32 patients (33.7%) being females. This finding is similar to the study conducted by Sawant AC et al. in 2019, which included 267 patients and reported that 187 (70%) were male [8]. The disparity in gender distribution may be attributed to increased exposure to risk factors such as smoking, drinking, hypertension, and diabetes mellitus among males.

In another study by Zadeh B et al., conducted from February 2015 to March 2017, out of 169 patients, 125 (73.96%) were male and 44 (26.03%) were females [14]. This further supports the male predominance in the development of MI. Modifiable risk factors such as smoking and alcohol consumption, which are more common in males compared to females, may contribute to this disparity.

The LVEF is a measure used to assess the systolic function of the heart and is an important predictor of cardiac mortality. It has been observed that patients with a frontal QRS-T angle >100 degrees have a higher incidence of reduced ejection fraction and depressed left ventricular systolic function [14].

In a study conducted by Brezinov OP et al., LVEF was evaluated as an independent factor for predicting the prognosis of Acute Coronary Syndrome (ACS). The study concluded that there is a strong correlation between LVEF and the prognosis of ACS [15]. Similarly, a study by Li YH et al. found a negative correlation between the planar QRS-T angle and LVEF in patients with old MI, with a larger planar QRS-T angle indicating a lower LVEF. Their analysis showed that for every 13.8° increase in the planar QRS-T angle, LVEF decreased by 5% when LVEF was less than 50% [16].

The relationship between the frontal QRS-T angle and major adverse cardiac events was also investigated in present study. The results showed that a frontal QRS-T angle >100 degrees was associated with the occurrence of major adverse events in patients with acute MI. These findings are consistent with a study conducted by Sawant AC et al., which identified the frontal QRS-T angle as a strong predictor of mortality in patients with acute MI [8].

In a study by Gotsman I et al., involving 2929 heart failure patients, it was concluded that the frontal QRS-T angle has a strong predictive value for outcomes and is an ominous sign [17].

The MACE remain significant adverse outcomes of MI, as concluded in a study by Poudel I et al., in 2019 [3]. The present study also found a positive relationship between an increase in the frontal QRS-T angle and MACE. This could be because the widening of the frontal QRS-T angle is proportional to the amount of potentially recoverable myocardium at risk. Hence, the frontal QRS-T angle can be used to predict treatment outcomes in patients presenting with MI, allowing for heightened vigilance and the development of better immediate and short-term treatment plans.

Limitation(s)

The study was conducted at a single centre, limited to one institute only. Future multicentre studies with larger sample sizes will be beneficial in providing more accurate predictions of MACE using the frontal QRS-T angle in patients with acute MI.

CONCLUSION(S)

The current study of patients with acute MI revealed an elevated risk of major adverse cardiac outcomes, such as heart failure, pulmonary oedema, and cardiogenic shock, among those with a frontal QRS-T angle >100 degrees on electrocardiograph. Additionally, an increase in the frontal QRS-T angle was associated with a decrease in left ventricular ejection fraction (LVEF). Therefore, the frontal QRS-T angle can provide insight into anticipating in-hospital MACE in patients with acute MI.

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