

Original Article

Association Between T p-e / QT Ratio In 12 Lead ECG and Major Adverse Cardiac Events during Hospital Stay among Acute ST Elevation Myocardial Infarction Patients

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Background : T peak to T end interval divided by QT interval (T p-e / QT ratio) in 12 lead ECG (Electrocardiogram) is better indicator of total repolarization dispersion as compared to other ECG parameters. Elevated value of T p-e / QT ratio detected in acute ST elevation Myocardial Infarction (MI) patients on admission is associated with poor in hospital prognosis due to various Major Adverse Cardiac Events (MACE) like Tachyarrhythmia, Cardiogenic Shock, Congestive Cardiac Failure and Death.

Material and Methods : This is a hospital based prospective study done in 73 patients of acute ST elevation MI admitted in our Tertiary Care Hospital. Patients having age of more than 18 years, giving informed written consent and having acute ST elevation MI were enrolled from duration of March, 2021 to October, 2022. Patients who were not willing for study as well as ECGs unsuitable for analysis, taking antiarrhythmic drugs, having electrolyte abnormalities, previous history of MI and having other Structural Heart Diseases like Valvular Heart Disease, myocarditis, pericarditis, Cardiomyopathies were excluded. On admission, T p-e / QT ratio was calculated in all enrolled patients confirmed with acute ST elevation MI. This was correlated with relevant demographic and clinical variables as well as MACE, mortality and recovery of patients during hospital stay.

Results : Total 41 patients (56.16%) had normal ratio of T p-e / QT (<0.25). 24 patients (32.87%) had Mild elevation of ratio between 0.25 to 0.35. In 8 patients (10.96%) presented with very high ratio of >0.35. Association of all MACE showed positive correlation with high values of T p-e / QT ratio (> 0.25). It was very strongly associated with values >0.35 and statistically significant too.

Conclusion : In acute ST elevation patients, deranged T p-e / QT ratio predicts poor in hospital prognosis even in ECG carried out on admission. This interpretation helps to explain poor prognosis, to provide close monitoring for MACE and early referral to higher center for further intervention.

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Key words : T p-e / QT ratio, ECG, Acute ST elevation MI, MACE.

Myocardial Infarction (MI) is defined as myocardial necrosis due to coronary ischemia. MI is a common cardiovascular disease and a leading cause of death Worldwide¹. The annual number of deaths from CVD in India has increased from 2.26 million (1990) to 4.77 million (2020)².

Coronary Heart Disease prevalence rates in India have been estimated over the past several decades and have ranged from 1.6% to 7.4% in rural populations and from 1% to 13.2% in urban populations³.

Many advanced approaches have been developed for the management of patients with MI, such as thrombolytic therapy and interventional therapy⁴⁻⁶. However, MI remains a major problem worldwide.

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Editor's Comment :

- During evaluation of all patients with myocardial infarction, calculate this ECG parameter T p-e/QT Ratio, so that complications can be predicted on admission itself and timely refer patients for higher centers.

Patients with complicated acute MI, many times present with ventricular arrhythmias and other subsequent adverse events during early periods and have significant risk of mortality^{7,8}.

Recently, the interval from the peak to the end of T wave [T peak-Tend interval (Tp-e)] was used in predicting arrhythmias, associated Major Adverse Cardiac Events (MACE) and Sudden Cardiac Death (SCD) in some cardiac conditions⁹⁻¹¹.

Within ECG, heart rate is a factor, that can also affect Tp-e interval. So Tp-e/QT ratio, which is not affected by the variations in heart rate, was proposed as a more precise index than QT and QTc dispersion or Tp-e interval, for demonstrating the Dispersion of Repolarization (DOR). Tp-e/QT ratio can be used as

an index of arrhythmogenesis even in the presence of short, normal, or long QT intervals and additionally they indicated Tp-e/QT ratio as a better marker of ventricular repolarization¹².

The Tp-e/QT ratio shows consistency within the narrow range of 0.15 to 0.25. A higher Tp-e/QT ratio has been associated with arrhythmic and other adverse events associated with many clinical conditions¹². There are many Major Adverse Cardiac Events (MACE) seen in patients of acute ST elevation patients which include Congestive Cardiac Failure (CCF), Ventricular Tachycardia (VT), Ventricular Fibrillation (VF), Shock, etc.

Yet only limited knowledge is available about this index (Tp-e/QT ratio) in patients presenting with STEMI. So, this current study was aimed to determine the Tp-e/QT ratio in patients with STEMI at the time of admission and its association with Major Adverse Cardiac Events (MACE) during the hospital stay.

MATERIAL AND METHODS

It was a prospective cohort hospital-based study during March, 2021 to October, 2022. Total 73 Indoor patients admitted to Medicine Department of our Tertiary Care Hospital having age more than 18 years who had fulfilled criteria for Acute ST elevation Myocardial Infarction and given informed written consent for study participation were enrolled. Institutional Ethical Committee approval was taken prior to study. Methods of Electrocardiography (ECG), advantages and disadvantages by the study were explained to patients and relatives.

Objectives :

- To determine Tp-e/QT ratio in ECG of acute ST elevation MI patients.
- To determine association between Tp-e/QT ratio with Major Adverse Cardiac Events (MACE) during hospital stay.

At the time of admission, 12 lead Electrocardiography (ECG) was taken after explaining all procedure to the patients. Within ECG, T wave peak to T wave end distance (Tp-e interval) as well as QT interval were measured. Ratio of Tp-e interval and QT interval was calculated. Ratio <0.25 was considered normal. Ratio in range of 0.25 to 0.35 was considered mildly abnormal and >0.35 severely abnormal.

Evaluation of Tp-e was done only in leads showing ST-segment elevation at the J point. The QT interval was calculated from the beginning of the QRS complex to end of T wave (Te). Tpeak (Tp) is defined at the point having maximal deflection of the T wave,

while T end (Te) is defined as the point on descending limb of the T wave at which the maximal downslope's tangent crosses the isoelectric baseline. The distance between Tpeak to T end is called Tp-e interval. All measured Tp-e intervals were expressed at the end as average of measurements made from 2 or 3 consecutive complexes.

Patient's having age less than 18 years, ECGs unsuitable (like atrial fibrillation) for analysis, taking anti-arrhythmic drugs, having structural heart diseases like Cardiomyopathies, Myocarditis, Pericarditis, past history of Myocardial Infarction, electrolyte imbalance and not willing for study participation were excluded.

Detailed history, thorough general and systemic examination were done for each patient as per proforma of study. Investigations including ECG, Echocardiography, cardiac enzymes (like CPK MB and Troponin) and other basic reports were done.

Patients were evaluated serially throughout their hospital course to identify Major Adverse Cardiac Events (MACE) which include Congestive Cardiac Failure (CCF), Ventricular Tachycardia (VT), Ventricular Fibrillation (VF), Shock, need for ventilator support, Sudden Cardiac Death, etc.

The data was entered in MS excel spread sheet and analyzed with the help of Open epi and SPSS software. Qualitative data was represented by percentage whereas quantitative data was represented by mean and SD. Chi Square and Fisher Exact test were applied to know the association between two qualitative variables at 95% level of confidence.

RESULTS

In present study, out of total 73 patients, for age group of 56-65 years, we included maximum number of patients ie, 29 (39.72%). It was followed by 16 patients (21.91%) in age group >65 years, 14 patients (19.17%) in age group 46-55 years, 10 patients (13.69%) in age group 35-45 years and 4 patients (5.47%) in age group of <35 years. Mean age in the study group was 57.28 with Standard Deviation of 13.08 years.

Out of all patients, 48 patients (65.75%) were Male and 25 Patients (34.24%) were females.

39 patients (53.42%) were Hypertensive and 34 patients (46.57%) were non-hypertensive. 37 patients (50.68%) were diabetic and 36 patients (49.31%) were non-diabetic.

Distribution of patients according to demographic and clinical variables are shown in Table 1.

On ECG interpretation, Tp-e / QT ratio was within

Table 1 — Distribution of STEMI patients according to Age, Gender, Hypertension and Diabetes. (Demographic and clinical variables)

Age (years)	No of cases (n=73)	Cases (%)
<35	4	5.47%
35-45	10	13.69%
46-55	14	19.17%
56-65	29	39.72%
>65	16	21.91%
Gender	No of cases (n=73)	Cases (%)
Male	48	65.75%
Female	25	34.24%
Hypertension	No of cases (n=73)	Cases (%)
Present	39	53.42%
Absent	34	46.57%
Diabetes	No of cases (n=73)	Cases (%)
Present	37	50.68%
Absent	36	49.31%

the normal ratio of <0.25 in 41 patients (56.16%), followed by 24 patients (32.87%) presenting with ratio between 0.25-0.35.

There were 8 patients (10.95%) presenting with very high Tp-e/QT ratio, ie, more than 0.35. Table 2.

In the present study, out of all the patients suffering from Major Adverse Cardiac Events, the maximum number of patients developed Congestive Cardiac Failure ie, 19 patients (26.02%). It was followed by cardiogenic shock in 15 patients (20.54%) and Tachyar Rhythmias (VT/VF) in 12 patients (16.43%). There were 5 patients (6.84%) who required ventilator support. Mortality was seen in 5 patients (6.84%).

Patients presenting with Anterior wall MI were maximum ie, 26 patients (35.61%). It was followed by patients presenting with Inferior wall MI- 18 patients (24.65%), Antero-Septal MI - 13 patients (17.80%) and Antero-Lateral MI – 8 patients (10.95%). There were 4 patients (5.47%) presenting with Posterior wall MI, 3 patients (4.10%) presenting with Infero-Posterior wall MI and 1 patient (1.36%) presenting with Lateral wall MI.

According to our study, average T p-e / QT ratio was maximum in Infero-Posterior Wall MI patients which was 0.31 followed by Anterior Wall MI patients and Antero-Lateral MI patients which was 0.27. Average T p-e / QT ratio of patients presenting with Inferior Wall MI was 0.25; of patients presenting with Antero-Septal MI was 0.21; of patients presenting with Posterior Wall MI was 0.21 and of patients presenting with Lateral Wall MI was 0.20

Major Adverse Cardiac Events were seen maximum in patients of AnteriorWall

Table 2 — Distribution of STEMI patients according to Tp-e/QT ratio

Tp-e/ QT ratio (in ECG at the time of admission)	No of cases (n=73)	Cases (%)
Less than 0.25	41	56.16%
0.25 to 0.35	24	32.87%
More than 0.35	8	10.95%
Total	73	100%

MI followed by patients of Antero-Lateral wall MI, Inferior wall MI, Infero-Posterior Wall MI and Posterior wall MI.

No Major Adverse Cardiac Events were seen in patients of Antero-Septal wall MI and Lateral wall MI (Table 3).

On correlation of MACE with ECG, CCF was seen in all the 8 patients (100%) having Tp-e/QT ratio >0.35, in 10 patients (41.66%) with ratio in the range of 0.25-0.35 followed by 1 patient (2.43%) with ratio <0.25. P value is <0.0001 which is statistically significant.

Tachyar-rhythmias, VT/VF were seen in 6 patients (75%) having T p-e/QT ratio > 0.35, in 6 patients (25%) having Tp-e /QT ratio in range of 0.25-0.35 and none having <0.25 ratio. P value is <0.0001 which is statistically significant.

Shock was seen in 5 patients (62.5%) having Tp-e / QT ratio >0.35, in 9 patients (37.5%) having ratio 0.25-0.35 followed by 1 patient (2.43%) having ratio <0.25. P value is <0.0001 which is statistically significant.

Ventilator support was needed in 2 patients (25%) having ratio >0.35, in 3 patients (12.5%) having ratio 0.25-0.35 and none having ratio <0.25. P value is 0.01 which is statistically significant.

Death occurred in 3 patients (37.5%) having ratio >0.35, in 2 patients (8.33%) having ratio 0.25-0.35 and none with ratio <0.25. P value is 0.0013 which is statistically significant (Table 4).

DISCUSSION

The interval from the peak of the T wave (which coincides with end of repolarization of epicardial cells)

Table 3 — Details of Wall Involved and Major Adverse Cardiac Events (MACE) in STEMI patients

MI according to Wall Involvement	CCF (Congestive Cardiac Failure)	VT/VF (Ventricular Tachycardia/ Ventricular Fibrillation)	Shock	VS (Ventilatory Support)	Death
AWMI	8(42.10%)	5(41.66%)	3(20%)	2(40%)	1(20%)
ALMI	4(21.05%)	4(33.3%)	5(33.3%)	2(40%)	2(40%)
IWMI	5(26.31%)	3(25%)	5(33.3%)	1(20%)	1(20%)
PWMI	1(5.26%)	0	0	0	0
IPWMI	1(5.26%)	0	2(13.3%)	0	1(20%)
Total	19 (100%)	12 (100%)	15(100%)	5 (100%)	5(100%)

Table 4 — Correlation of Tp-e / QT ratio and Major Adverse Cardiac Events (MACE) in STEMI patients

MACE (Major Adverse Cardiac Events)	Tp-e/QT ratio			p value
	<0.25	0.25-0.35	>0.35	
CCF (Congestive Cardiac Failure) :				
Present	1(2.43%)	10(41.66%)	8(100%)	<0.0001
Absent	40(97.56%)	14(58.33%)	0	
VT/VF (Ventricular Tachycardia/Fibrillation) :				
Present	0	6(25%)	6(75%)	<0.0001
Absent	41(100%)	18(75%)	2(25%)	
Shock :				
Present	1(2.43%)	9(37.5%)	5(62.5%)	<0.0001
Absent	40(97.56%)	15(62.5%)	3(37.5%)	
VS (Ventilatory Support) :				
Present	0	3(12.5%)	2(25%)	<0.01
Absent	41(100%)	21 (87.5%)	6(75%)	
Death :				
Present	0	2(8.33%)	3(37.5%)	<0.0013
Absent	41(100%)	22(91.66%)	5(62.5%)	

to the end of the T wave (which coincides with the end of repolarization of endocardial cells) serves as an index of total dispersion of repolarization (transmural, apicobasal and global). This descending limb of T wave correlates with relative refractory period. If it is prolonged, that means myocardium is more vulnerable. So, changes in this parameter (Tp-e interval) may forecast the risk of ventricular arrhythmia and other complications¹³.

Among other ECG parameters, QT interval denotes ventricular depolarization and repolarization. QT Interval is taken as the distance between the beginning of the Q wave and the end of T wave. But it varies according to heart rate.

In comparison with T p-e interval and QT interval, Tp-e / QT ratio is shown to be a more sensitive index of ventricular repolarization, as it provides an estimate of the dispersion of repolarization relative to the total duration of repolarization. Moreover, Tp-e/QT ratio (standardizing T p-e interval with corresponding QT interval) was found to remain constant despite dynamic changes in heart rate. This novel index has been suggested to be surrogate marker of arrhythmogenesis, other major complications and sudden Cardiac Death¹⁴.

A higher Tp-e/QT ratio has been linked to arrhythmia and subsequent adverse events in a variety of clinical conditions including myocardial infarction.

Patients with acute ST elevation MI, can present with many life threatening immediate, early and late complications. Out of all these cardiac arrhythmias, particularly tachyarrhythmias, Cardiogenic Shock, CCF, hypoxia needing ventilator support and sudden Cardiac Death are major adverse cardiac events

known as MACE¹⁵.

Our study was done in patients presenting with acute ST elevation MI to assess Tp-e/QT ratio in ECG and to evaluate its relationship with Age, Sex, Hypertension, Diabetes Mellitus, Wall Involved and MACE (including CCF, VT/VF, Shock, Ventilator Support and Death).

Out of all our enrolled patients, maximum number of patients, total 29 (39.72%) were in age group of 56-65 years and minimum number, total 4 (5.47%) were in age group of <35 years.

Mean age in the study group was 57.28 with Standard Deviation of 13.08 years.

In similar study done by Kiran GR, *et al*¹⁶, out of 321 subjects the majority of patients, 196 (61.1%) belonged to the age group of 50-69 years; followed by 50 (15.6%) in age group 40-59 years; followed by 44 (13.7%) in age group more than 70 years and followed by 31 (9.6%) in age group less than 30 years. According to Nag T, *et al*¹⁷, majority (73.3%) patients had age >60 years and 11.8 % patients had age between 20 to 39 years. According to study by Walia R, *et al*¹⁸, the mean age± SD (year) was 42.7±16.6 year.

We had total 48 Males (65.75%) and 25 Females (34.24%) for study participation. In study by Kiran GR, *et al*¹⁶, out of total 321 patients, 73.2% Males and 26.8% Females were enrolled. According to Walia R, *et al*¹⁸, the study population included 2227 subjects, of which there were 1068 Men and 1159 Women, ie, 48% Males and 52% Females. According to Deora S, *et al*¹⁹, the study population included 611 subjects, there were 589 Men and 22 Women, ie, 96.4% males and 3.6% females. According to Katakam PC, *et al*²⁰ the study population included 126 subjects there were 109 men and 17 women, ie, 86.5% Males and 13.5% Females.

We enrolled 39 patients (53.42%) of hypertension, while similar study by Kiran GR, *et al*¹⁶ had 39.2 %, Walia R, *et al*¹⁸ had 43.6%, Deora S, *et al*¹⁹ had 10 % and Katakam PC, *et al*²⁰ had 52 % hypertensive patients.

We enrolled 37 patients (50.68%) of diabetes while similar study by Kiran GR, *et al*¹⁶ had 34.5 %, Walia R, *et al*¹⁸ had 16.4 %, Deora S, *et al*¹⁹ had 8.9 % and Katakam PC, *et al*²⁰ had 19% Diabetes patients.

During our study we found maximum number of patients with anterior wall involvement followed by inferior wall and antero-septal MI. Similar proportion was seen in study by Kiran GR, *et al*¹⁶, Pandya T, *et al*²¹, Zachariah G, *et al*²².

During our study, Tp-e / QT ratio was within the

normal ratio of <0.25 in 41 patients (56.16%), followed by 24 patients (32.87%) present with ratio between 0.25-0.35. There were 8 patients (10.95%) presenting with very high Tp-e / QT ratio, ie, more than 0.35.

Study by Saylyk F, *et al*³, and Shu J, *et al*⁴ had found that as compared to healthy individuals, T p-e / QT ratio was abnormally high in patients with complicated Ischaemic Heart Disease.

Out of 73 subjects in our study, MACE were found overall in 25 (34.24%) patients. It included 19 patients (26.02%) of CCF, 15 patients (20.54%) of Cardiogenic Shock, 12 patients (16.43%) of tacharrhythmias, 5 patients (6.84%) needing Ventilator Support and death in 5 patients (6.84%). According to Kiran GR, *et al*¹⁶, out of 321 patients included in study, during hospitalization about 66 (20.5%) patients experienced MACE. Out of which 58 patients (18.1%) had heart failure, 33 patients (10.3%) had Ventricular Tachyarrhythmias and 27 patients (8.4%) had Cardiogenic Shock. The in-hospital all cause mortality was seen in 16 patients (5%). According to Zhao X, *et al*⁵, out of 338 subjects, 99 subjects (29.3%) had MACE. Mortality was seen in 29 subjects (8.6%). According to Reza AT, *et al*⁶, out of 178 subjects, 19 subjects (10.7%) had MACE. According to Shu J, *et al*⁴, out of 120 subjects, 34 subjects showed malignant ventricular arrhythmia.

We also found in this study that Anterior wall MI patients had maximum number of MACE followed by Antero-lateral wall MI, Inferior wall MI, Infero-posterior wall MI and Posterior wall MI. No MACE were seen in patients with Anteroseptal and Lateral wall MI. Average T p-e / QT ratio was also found higher in Anterior wall MI, Infero-posterior wall MI and Antero-lateral wall MI. Study by Kiran GR, *et al*¹⁶, Özbek SC, *et al*⁷, Reza AT, *et al*⁶ had also similar findings.

There was statistically significant association found between high T p-e / QT ratio and MACE in present study. MACE were highest in patients with ratio >0.35, followed by mid range ratio of 0.25-0.35 and lowest for normal range of ratio <0.25. According to Kiran GR, *et al*¹⁶, Tp-e / QT ratio is significantly higher in patients experiencing MACE and who died in hospital.

According to Zhao X, *et al*⁵, out of 388 subjects, 115 subjects had high Tp-e / QT ratio. Out of 115 subjects with high Tp-e / QT ratio, MACE was seen in 48.1% subjects of which death was seen in 21.9% subjects. According to Reza AT, *et al*⁶, out of 178 subjects, 82 subjects had high Tp-e / QT ratio. Out of 82 subjects with high Tp-e / QT ratio, there was occurrence of malignant ventricular arrhythmia in 16

subjects (19.5%). According to Shu J, *et al*⁴, Tp-e / QT ratio in patients with acute Myocardial Infarction is obviously longer than that in healthy individuals and has a notable association with malignant ventricular arrhythmia. According to Shenthar J, *et al*⁸ Tpeak-end/QT ratio is prolonged in patients with STEMI compared with healthy individuals and higher Tpeak-end/QT ratio predicts malignant ventricular arrhythmias. According to Mugnai G, *et al*⁹, Tpeak-to-Tend /QT remains a predictor of early ventricular arrhythmias and arrhythmic death.

CONCLUSION

Patients having abnormally high T p-e / QT ratio in ECG was strongly associated with major adverse cardiac events during hospital stay, which was statistically significant. ECG being primary modality in diagnosing MI, can serve as easy, bedside, affordable and feasible tool to predict poor prognosis, need of close monitoring and early referral for MI patients. There should be routine practice to calculate T p-e / QT ratio in ECG done on arrival for MI patients.

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