Research Article

Correlation of TIMI Frame Count with Corresponding QTC & QTC Dispersion in Patients with Primary PCI

Vakili, Hosein MD[1]; Farokhnejad, Somaye MD*; Naghshbandi, Erfan MD[2]; Amali, Omid MD[3]; Namazi, Mohamad Hasan MD[4]; Eslami, Vahid MD[5]; Akbarzade, Mohamad Ali MD[6]; Gachkar, Latif MD[7]; Safi, Morteza MD[8];

1.Vakili, Hosein; MD; Interventional cardiologist; cardiovascular research center. shahid beheshti university of medical sciences, Tehran, Iran.
2.Naghshbandi, Erfan; MD; Interventional cardiology fellow; cardiovascular research center. Shahid beheshti university of medical science.
3Amali, Omid; MD; Interventional cardiology fellow; cardiovascular research center. Shahid beheshti university of medical science.
4.Namazi, Mohamad Hasan; MD; Interventional cardiologist; cardiovascular research center. Shahid beheshti university of medical science.
5.Eslami, Vahid; cardiovascular research center. MD; Interventional cardiologist ; Shahid beheshti university of medical science.
6.Akbarzade, Mohamad Ali; MD; Electrophysiologist; cardiovascular research center. Shahid beheshti university of medical science.
7.Gachkar, Latif; MD; Methodologist; cardiovascular research center. Shahid beheshti university of medical science.
8.Safi, Morteza; MD; Interventional cardiologist; cardiovascular research center. Shahid beheshti university of medical science.

*__Corresponding Author: Farokhnejad Somaye;__ MD; Interventional cardiology fellow; cardiovascular research center. Shahid Beheshti university of medical science, Saadat Abad, Tehran, Iran

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Abstract

Background: *STEMI describes an emergent and life-threatening condition that can prolong repolarization and so QT in surface ECG. Early coronary reperfusion can cause remission in electrical instability by decreasing QT and QTd. Furthermore, T-peak–T-end interval (TP-TE), has been established to be prolonged in patients with STEMI and can predict all-cause mortality.*

Methods: *We obtained an ECG at the time of admission for every patient with acute STEMI and another one 24 hours after PPCI therapy. ECGs were analyzed manually for QTC, QTd, QT/QRS, presence of fragmented QRS, and TP-TE interval.*

Results: *We evaluated 203 patients with ST-elevation myocardial infarction. QTc (408±42ms pre-PCI vs 396 ms ±36 post-PCI, P<0.01), QTd (51±28 ms pre-PCI vs 42±23 ms post-PCI, P<.001), QT/QRS (4.3±1 pre-PCI vs 4.1± 0.9 post-PCI, P<0.01) and TP-TE interval (90±23 ms pre-PCI vs 77±23 post-PCI, P<.001) were prolonged by myocardial infarction and significantly recovered after PPCI. There was a significant correlation between TIMI Frame Count, QTC & QTd reduction (p< 0.01 , r= -0.2 & p< 0.01 , r= -0.2 respectively).*

Conclusion: *Reperfusion success is correlated with repolarization recovery rates and the lower TIMI frame count as an evaluation of revascularization, the higher repolarization recoveries.*

Keywords: *Myocardial Infarction, TIMI frame count, QTC.*

Introduction

Acute ST-elevation myocardial infarction (STEMI) explains an emergent and life-threatening condition that occurs due to the abrupt closure of an epicardial coronary artery. In this situation, the downstream myocardium is at risk for cell death and as a consequence electrical instability which can be measured in specific ways in surface ECG.

Primary percutaneous coronary intervention (PPCI) is the accepted treatment for patients with ST-segment elevation myocardial infarction **(**1,2**)**. Reperfusion therapy improves prognosis, however, studies mentioned recently that even with insufficient epicardial vessel recanalization, myocardial tissue perfusion would be inadequate as a result of a disturbance in myocardial microcirculation. **(**3-5**)**.

TIMI frame count (TFC) is a validated technique for epicardial blood flow evaluation **(**6**)**. It is a quantitative assessment of the number of cine-frames that contrast reaches to determined distal landmarks **(**7**)**. It is an inverted index of coronary flow velocity that correlates with Doppler-derived average peak velocity **(**8**)**.

Cardiac arrhythmia is one of the serious complications of STEMI. With some measurements on ECG, the risk of arrhythmia can be predicted. In STEMI repolarization prolongs and so QT in ECG **(**9**)**. Roukema et all proved a direct correlation between myocardial ischemia and QT interval prolongation **(**10**)**. The relationship between the extent of myocardial ischemia and QT dispersion (QTd) has also been reported **(**11**)**. Ventricular repolarization disturbance can be represented by QT dispersion and early coronary reperfusion can cause a reduction in electrical instability by decreasing QTd **(**12**)**.

T-peak–T-end interval (TP-TE), which describes the interval between the peak and end of the T-wave, which represents the repolarization dispersion **(**13**)**, have established to be prolonged in patients with STEMI and can predict all-cause mortality **(**14,15**)** and worse short- and long-term outcomes in patients with STEMI **(**16,15,17**)**. Some data suggests that the TP-TE interval stands for transmural dispersion, while the other speculate that it reflects the global dispersion of repolarization. **(**18, 19**)**

Since STEMI is associated with arrhythmias and cardiac arrest the purpose of the present study was to investigate the effect of revascularization on arrhythmical indices and to show whether there was a correlation between TFC and arrhythmic indices.

Methods

Study Participants

In brief, the study population included 203 patients who have been admitted with acute STEMI to the Emergency Department, Modarres Hospital, Shahid Beheshti University of Medical Science, and followed PPCI. All participants provided written informed consent before enrolling in the study.

ECG analysis

We obtained an ECG at the time of admission to the emergency department and after 24 hours of PPCI. ECGs were compared for QTC, QTd, QT/QRS, presence of fragmented QRS, and TP-TE interval. We calculated QTC with the Bazett formula (: **QT**C = **QT** / √ RR). QTd was defined as the difference between the longest and the shortest QT intervals within a 12-lead ECG. Fragmented QRS was explained as the presence of notching in the R or S wave in the absence of wide QRS. The QTC, QTd, and TP-TE were measured manually.

PPCI

Angiography was done immediately after the diagnosis of acute STEMI. All angiography & angioplasty procedures were done with Siemens Axiom Artis. During the procedure activated coagulation time (ACT) adjusted between 250-300 seconds with regards to whether or not eptifibatide is used. Patients in whom coronary angioplasty with balloon or stent was done included in the study. Successful angioplasty was considered as the residual stenosis less than 20%. TFC was calculated as the number of cine frames required for the culprit's vessel to be filled with contrast to standardized distal landmarks in the final angioplasty film when the procedure was completed. A normal frame count was defined as 20 ± 3.0 frames for the Right coronary artery (RCA); 22 ± 4 frames for the Left circumflex artery (LCX) and 36 ± 2 and 21 ± 1 frames uncorrected and corrected respectively for the Left anterior descending artery (LAD) **(**6**)**.

Follow up

We followed up with all of our patients for Arrhythmia, Re MI, Stroke, Mortality, and any other complications during their admission.

Statistical Analysis

Data analysis was done with SPSS 26.0 statistical software package with the significance level set at $p<0.05$ (two-tailed). We used Pearson Correlation for the assessment of correlation between QTC Changes and TIMI Frame Count. And also Paired sample t-test and Wilcoxon sign rank test was used for comparing arrhythmic indices before and after the interventional procedure.

Results

Subject Characteristics

The table summarizes the demographic, metabolic, and health behavior characteristics of patients who had the entrance criteria. The study population included 203 patients with STEMI (mean age 59±13 years; males 76%) who underwent PPCI.

Table 1: Characteristics of the 203 patients with myocardial infarction diagnosis admitted at the emergency department

age	59±13(34-93)
BMI(Kg/m2)	27±3(19-46)
BSA(m2)	1.9±0.2(1-2.7)
DM (%)	27
HTN (%)	35
HLP (%)	36
SMOKING (%)	41
FH (%)	24
CKD (%)	1.5
OBESITY (%)	9
MALE (%)	76

Values are given as means ± SD with range or percentages

BMI: Body mass index, BSA: body surface area, DM: diabetes mellitus, HTN: hypertension, HLP: hyperlipidemia, FH: family history, CKD: chronic kidney disease.

Follow up

On follow-up, during the hospital admission, the rate of in-hospital mortality was 8 out of 203 (3.9%) and the rest discharged. Arrhythmia was the most frequent complication (n=16, 7.9%). Re MI happened in 2 patients (1%). And fortunately, there was no stroke during hospital admission.

ECG results

The patients with STEMI were administrated ECG recorded 10 minutes after coming to the emergency department and 24 hours after PPCI. We missed the second ECG for 4 patients who passed away 24 hours after the PPCI procedure. 4 patients out of 203 were admitted with non-sinus rhythm (2%) and the rest had sinus rhythm. After revascularization ST resolute more than 50% in 158 patients (78%).

ECGs were evaluated for the presence of fragmented QRS; and QTc, QTd, TP-TE, QT/QRS were calculated manually. QTc (408±42 ms pre-PCI vs 396 ±36 ms post-PCI, P<0.01), QTd (51±28 ms pre-PCI vs 42±23 ms post-PCI, P<0.001), QT/QRS (4.3±1 pre-PCI vs 4.1± 0.9 post-PCI, P<0.01) and TP-TE interval (90±23ms pre-PCI vs 77±23ms post-PCI, P<0.001) were prolonged by myocardial infarction and

significantly recovered after PPCI (Paired T-test). Fragmented QRS was noticed in 154 patients at admission (76.9%) & reduced to 145 patients after revascularization (71.4%), which was reduced no significantly (p=0.35, Wilcoxon sign rank test).

As mentioned mortality rate was 3.9% during their hospital admission. QTc had no significant reduction in these patients in comparison to discharged patients (18.7±23.5 ms vs 11.4±28.5, P=0.48), and also QTd in the same way (3.7±17 ms vs 9.4±24 ms, P=0.51).

Arrhythmia occurred in 7.9% of our participants. In this group of patients, Qtc increased 6±38 ms compared to 13.2±26.9 in patients who did not experience this complication and it was significant. P=0.011) but QTd had no significant change in these two groups. (4.7±34 ms vs 9.5±23.3 ms P=0.46)

Other complications were too rare for subgroup analysis.

PPCI results

Anterior STEMI was the most frequent type (n=46, 23%). The mean symptom to hospital time was 198 ±117 (0- 480) minutes. Patients were transmitted to the catheterism laboratory with a door to balloon time of 26±7 (9-45) minutes. PPCI Procedure time was 46±16 (15-109) minutes. The mean fluoroscopy time was 16±6 (6-36) minutes. Patients received 2059 ±1058 (649 -9874) mGy x-ray, and 293± 118 (100-800) cc contrast was used for each procedure.

TIMI flow grade was 2.86±0.391 (1-3) at an average of symptom to Balloon time of 225± 119 (10-510) minutes.

Correlation between ECG characteristics & TIMI frame count

Overally there was a significant correlation between TIMI Frame Count with QTC & QTd reduction ($p< 0.01$, $r= -0.2$, $p< 0.01$, $r= -0.2$ respectively). (**Figure-1**)

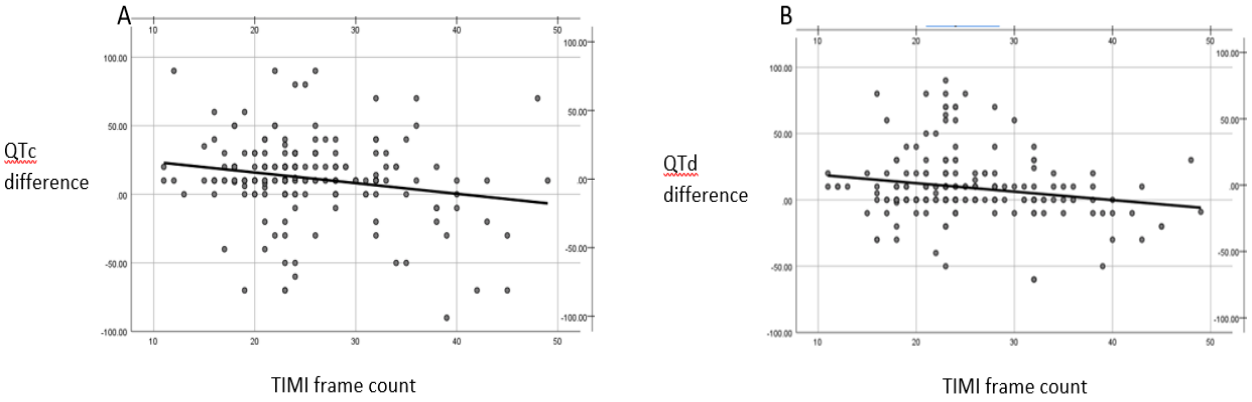

Figure 1. Correlation of TIMI frame count with QTc (a) and QTd (B). As shown in A in higher TIMI frame count, which indicates poor angioplastic results, QTc has improved smaller than lower TIMI frame counts. Figure B shows the same results for QTd

In sub group analysis the correlation between TIMI Frame Count & QTC difference was significant in diabetic ($p< 0.01$, $r= -0.3$), male ($p< 0.05$, $r= -0.2$), hypertensive ($p< 0.01$, $r= -0.3$), smoker ($p< 0.01$, $r= -0.3$), non-obese ($p< 0.005$, $r= -0.2$), Ant sept MI ($p= 0.04$, $r= -0.5$) patients.

The correlation between TIMI Frame Count and corresponding QTd difference in male ($p< 0.01$, $r= -0.2$), hyperlipidemic ($p< 0.05$ & $r= -0.2$), smoker ($p< 0.05$ & $r= -0.2$), none obese ($p< 0.01$, $r= -0.2$) and ant sept MI ($p< 0.01$, $r= -0.8$) patients was also significant.

We could demonstrate a Correlation between TIMI frame count and LV ejection fraction as well ($r=-0.2$, $p=0.001$, **Figure-2**)

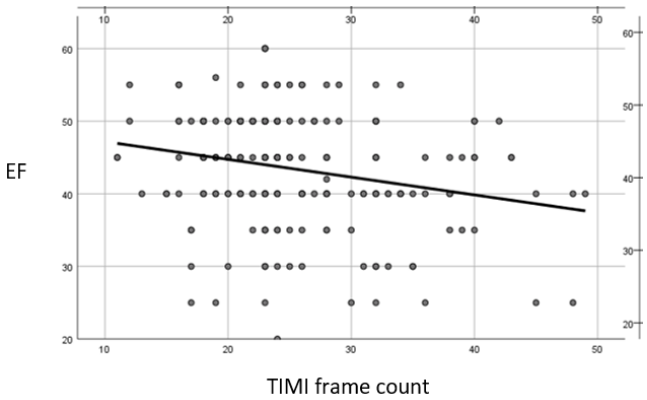

Figure 2. in lower TIMI frame counts as a result of successful angioplasty LVEF is higher.

Discussion

This study investigated the relationship between TIMI frame count and arrhythmic indices changes in patients with STEMI undergoing PPCI.

Acute STEMI induces electrochemical and metabolic changes in cardiac cells, which affects electrochemical gradient, tissue oxygen level, ion channel conditions, and pH consequently. These alterations have a complex effect on the duration of action potential and thus repolarization indices display modestly compatible changes **(**15- 17, 20- 22**)**. During cardiac ischemia delayed and heterogeneous repolarization recovery is shown with QT prolongation in the surface ECG **(**9,23-25**)** which is a result of an increase in extracellular potassium level, acidosis, and anoxia and can cause a reduction in membrane excitability and prolongation in the recovery of excitability following an action potential **(**26**)**. Moreover, QT prolongation could be due to the presence of non-ischemic reasons, including autonomic alterations, even when tissue perfusion is successfully restored. **(**13**)**

It was demonstrated in previous studies that QT & QTd is increased in the early phase of STEMI and is reduced after successful thrombolysis of the culprit artery. **(**9, 12,23, 27**)**. Treatment of acute STEMI with PPCI contributes to reperfusion of occluded coronary artery which leads to preserving myocardial function, improving survival **(**28**)**, reducing electrophysiological instability and so reducing the QT dispersion **(**25**)**.

In the setting of STEMI to define reperfusion success in clinical practice, several methods are available, including TIMI grade, corrected TIMI frame count, Myocardial Blush Grade (MBG), and ST resolution **(**29-36**)**. We used corrected TIMI frame count which is an accurate method.

We hypothesized that after STEMI, repolarization indices such as QTC and TP-TE will prolong. Also due to chemical and electrical disturbances, there will be a higher QTd during the ischemic period. After revascularization, these changes will be reversible somehow and as a consequence QTC & TP-TE returns to normal values and QTd will decrease. Also, we wanted to demonstrate that the severity of these changes is related to reperfusion success which is represented with TIMI frame count.

We had the following main findings; QTC & TP-TE mean was higher during STEMI and they decreased 24h after revascularization. We also found that QTd decreased statistically significantly after revascularization.

Similar to our findings, Aydinlar et all and Cadgas et al. (in a small group of patients n=26), showed in their studies that successful PCI may improve ventricular repolarization abnormalities **(**37, 13**)**.

In another study, Duyuler et al. demonstrated that TP-TE as a repolarization index of myocardial cells was closely associated with myocardial blush grade **(**38**)**. Ali et al. In a similar study proved such reduction in QTd after successful reperfusion with rhyolitic thrombectomy **(**39**)**. Also, Hasan et al. and Alici et al. showed manual thrombectomy added to PPCI can lead to more reduction in QTd, in patients with STEMI. **(**11, 40**)**.

In accordance with this data, we realized that the rate of these repolarization recoveries correlates with the reperfusion features. It means the lower the TIMI frame count as an evaluation of revascularization, the higher repolarization recoveries. Therefore, elevated TFC was mechanism-related with QTC & QTd interval in STEMI.

In subgroup analysis, there was a statistically significant correlation between reperfusion success and repolarization indices in a patient with cardiovascular risk factors such as DM, HTN, smoking, and male sex. It can ascertain that such patients are more susceptible to ischemic consequences. On the other side, this relationship was not significant in obese patients. The study revealed that there was a significant correlation in anteroseptal MI which can be due to more severe ischemia in antseptal STEMI in comparison with other types of infarctions.

Study limitations

We used the manual method to measure and calculate repolarization indices which is an accepted method in clinical practice. Some studies have shown weak inter-and intraobserver reproducibility of manual measurements in ECG parameters **(**14, 41**)**. Also, manual measurements may accompany by individual bias. Besides, there was some confusion in how to measure such indices, especially for elevated ST-segment to assess T-wave markers. And some medications might interfere with QT values calculations and were not standardized during patient enrollment.

Assessment of Reperfusion success was done by visual evaluation of coronary angiogram. A more specific and sensitive method, such as coronary flow reserve, or cardiac magnetic resonance, was not used.

Conclusion

In patients with STEMI who undergo PPCI, reperfusion success is correlated with repolarization recovery rates, and the lower TIMI frame count as an evaluation of revascularization, the higher repolarization recoveries.

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Conflict of interest: The Authors declares that there is no conflict of interest.

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