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The Role of T Peak — T End Interval Reduction on Electrocardiogram as a Marker of Successful Reperfusion in Patients with ST Elevation Myocardial Infarction undergoing Fibrinolytic Therapy

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Abstract

Background: Immediate reperfusion is the key of ST Elevation Myocardial Infarction (STEMI) Management. Despite the superiority of primary percutaneous coronary intervention (PCI), fibrinolytic therapy is still the preferred choice in many settings because of their availability and easy resources. Assessment of successful fibrinolytic determines the next strategy, ST-segment resolution (STR) correlates well with TIMI flow, reflects myocardial perfusion, and has a better prognostic value. T Peak – T End (Tpe) interval is proposed to be a valuable tool for reperfusion marker as it measures the transmural dispersion of repolarization (TDR) which can be an additional myocardial perfusion assessment. This study aims to see whether the Tpe interval reduction can be a marker of the successful reperfusion in patients with STEMI treated with fibrinolytic.

Methods: This cross-sectional study involved STEMI patients underwent fibrinolytic therapy. Tpe interval was measured at admission and 90 minutes after fibrinolytic, then the changes in the form of difference (ms) and resolution (%) were assessed and compared between successful and failed reperfusion groups according to STR.

Results: Among total of 86 patients, there were 53 patients (61.2%) with successful reperfusion. Tpe interval reduction was greater in the successful reperfusion group. The value of Tpe difference in predicting STR ≥ 50% had a sensitivity of 66% and specificity of 75.8% with an area under curve (AUC) of 0.726 and a cut-off point of 20 ms. While the AUC of Tpe resolution 0.726 with a cut-off point of 16.2%, had a sensitivity of 66% and a specificity of 72.7%.

Conclusion: The Tpe interval reduction can be a valuable additional marker of successful reperfusion in patients with STEMI treated with fibrinolytic.

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Keywords: T peak – T end Interval, ECG, Successful Reperfusion, STEMI, Fibrinolytic.

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Introduction

The principal treatment of ST-elevation myocardial infarction (STEMI) is the immediate restoration of coronary blood flow with reperfusion therapy to prevent myocardial necrosis and improves survival.[1] Within 12 hours of onset, reperfusion can be achieved either by the primary percutaneous coronary intervention (PCI) or fibrinolytic therapy.[2] Despite the superiority of recommendation and efficacy of primary PCI, fibrinolytic is still suitable in many settings because of its advantages in terms of availability and resources.[1] In indonesia from 1024 STEMI patients in the Jakarta Acute Coronary Syndrome registry, 7.6% used fibrinolytics and as expected its utilisation significantly higher in non-PCI centres.[3]

ST-segment resolution (STR) is the established marker of successful fibrinolytic that correlates well with TIMI flow (epicardial perfusion). Moreover, it reflects myocardial perfusion and has a better prognostic value.[1,2] The repolarization parameter on the ECG that was originally used to stratify the risk of ventricular arrhythmias in MI, currently also developed as an additional assessment of myocardial perfusion. QT dispersion is one of it but the results obtained are inconsistent.[4-6]

T Peak – T End (Tpe) interval is an ECG parameter that describes the transmural dispersion of repolarization (TDR). Ischemia causes TDR amplification and leads to Tpe prolongation.[7,8] Previous studies stated a significant relationship between the Tpe interval and successful reperfusion, both using primary PCI and fibrinolytic.[9-11] Besides its prognostic value, the role of Tpe interval as an additional indicator of reperfusion particularly in fibrinolytic is still a potential area of research. The aim of the study is to investigate the role of Tpe reduction as a marker of successful reperfusion in STEMI patients treated with fibrinolytic.

Methods

This is an observational analytical study with a cross-sectional design, involving 86 patients obtained from medical records at Haji Adam Malik Hospital Medan from October 2017 to July 2021. This study included patients with STEMI ≤ 12 hours onset underwent fibrinolytic therapy with a minimum age of 18 years. Patients with atrial fibrillation, bundle branch block, pacemaker rhythm, electrolyte imbalances, valvular or congenital heart diseases, flat or difficult to assess T waves will be excluded. This study was approved by Research Ethics Committee, Faculty of Medicine, University of Sumatera Utara, Medan.

A 12-lead ECG examination using *Bionet Cardiotouch* 3000 with a speed of 25 mm/s and an amplitude of 10 mV. For precision, the ECG will be scanned and measured using the ImageJ application. The Tpe interval is the distance between the absolute maximum deflection of the T wave from the isoelectric line (T peak) and the end of the T wave (T end), i.e. the point of intersection between the isolelectric line and the line drawn following the tangential slope of the T peak (**Figure 1**). It is calculated in lead V2 or alternatively in V5, V4, and V6, respectively. Measurements were taken at admission (pre) and 90 minutes after (post) fibrinolytic was started, then the changes in the form of difference (ms) and resolution (%) were assessed and compared between successful and failed reperfusion groups according to STR. The successful reperfusion group was characterized by STR ≥ 50% and STR < 50% was labelled as a failed reperfusion group.

Statistical analysis were performed by SPSS for Windows Version 25. Categorical variables are summarized as frequencies and percentages. Continuous variables are presented as mean + standard deviation or median (min-max). Normality of the continuous variables was evaluated by Kolmogorov-Smirnov test. Bivariate analysis were using unpaired-T or Mann Whitney test. A one-tailed p value < 0.05 was considered significant. ECG will be validated by two cardiologists to know the interobserver variability using Bland Altman test. Receiver operating characteristic (ROC) curve analyses were performed to determine the best cut-off value of Tpe difference and resolution for predicting STR ≥ 50%.

Results

Baseline Characteristics

Over 86 patients, there were 53 patients (61.2%) in successful reperfusion group and 33 patients (38.4%) in failed reperfusion group. The mean age was similar

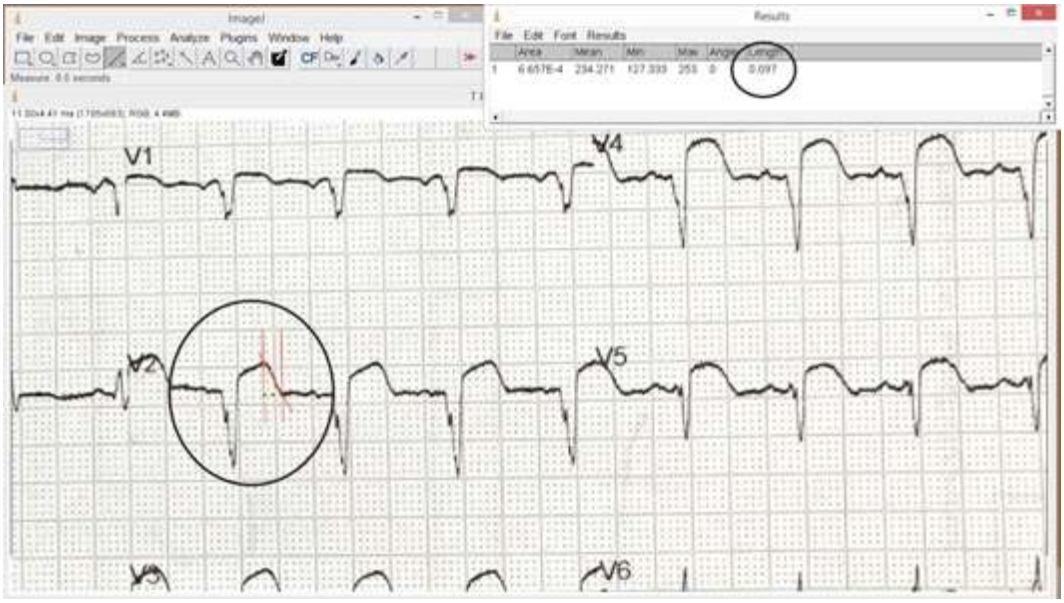

Figure 1. Tpe Interval Measurement using ImageJ application.

Table 1. Baseline Characteristics.

Parameter	STR		P value
	≥ 50% (N=53)	< 50% (N= 33)	
Age, years	57.3 + 7.7	55.4 + 8.2	0.282c
Male, N(%)	45 (84.8)	28 (84.8)	> 0.999b
Hypertension, N(%)	16 (30.1)	7 (21.2)	0.507a
Diabetes Mellitus, N(%)	20 (37.7)	7 (21.2)	0.172a
Dyslipidemia, N(%)	21 (39.6)	15 (45.4)	0.758a
Smoker, N(%)	40 (75.4)	26 (78.7)	0.927a
Family History, N(%)	10 (18.8)	8 (24.2)	0.747a
Systolic BP, mmHg	120 (90–200)	120 (80–190)	0.185d
Diastolic BP, mmHg	80 (60–120)	80 (50–110)	0.652d
Fibrinolytic Agent, N(%)			
Streptokinase	30 (56.6)	17 (51.5)	0.663a
Alteplase	23 (43.4)	16 (48.4)	
Infarct Location, N(%)			
Anterior	25 (47.2)	17 (51.5)	0.865a
Non-Anterior	28 (52.8)	16 (48.4)	
Onset, hours	4 + 1.9	6.6 + 2.2	< 0.001c
Killip Class, N(%)			
I-II	48 (90.5)	26 (78.7)	0.199b
III-IV	5 (9.5)	7 (21.2)	
Sodium, mEq/L	134 (129–147)	135 (125–145)	0.595d
Potassium, mEq/L	4.3 + 0.4	4.42 + 0.43	0.181c
Chloride, mEq/L	102.5 + 4.5	101.4 + 5.8	0.345c
Troponin I, ng/ml	1.3 (0–32)	2.4 (0–32)	0.133d
CK-MB, U/L	57 (13–673)	55 (18–541)	0.641d
LVEF, %	55 (35–65)	52 (30–60)	0.024d

[a]Chi Square, [b]Fisher, cunpaired-T, [d]Mann Whitney, BP=Blood Pressure, STR=ST-Segment Resolution, LVEF=Left Ventricular Ejection Fraction

Table 2. ECG Findings and Successful Reperfusion.

Parameter	STR		P value
	≥ 50% (N=53)	< 50% (N= 33)	
Pre-Fibrinolytic HR, s	64.8 (47.2–98.8)	70.3 (38.5–121.7)	0.349*
Post- Fibrinolytic HR, s	64.8 (47.2–99.1)	70.8 (38.5–124.2)	0.136*
Pre-Fibrinolytic Tpe, ms	120 (95–233)	117 (80–197)	0.143*
Post- Fibrinolytic Tpe, ms	88 (50–115)	100 (56–179)	0.016*
Tpe Differences, ms	26 (2–139)	11 (-15–32)	<0.001*
Tpe Resolutions, %	25 (1.2–59.6)	9.1 (-18.5–34.8)	<0.001*

*Mann Whitney, STR=ST-Segment Resolution, HR=Heart Rate, Tpe = T Peak – T End

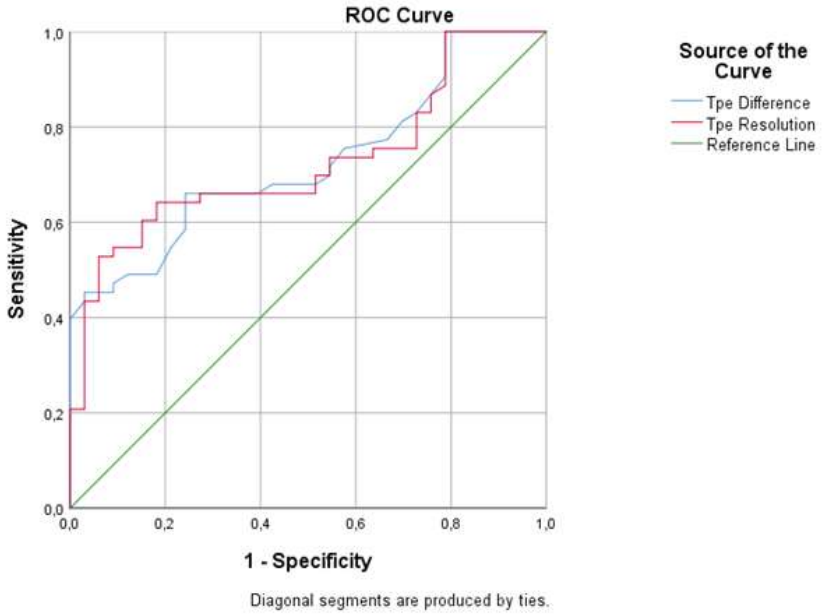

Figure 2. Comparasion of ROC Curve between Tpe difference and resolution in predicting Successful Reperfusion (STR ≥ 50%).

in both groups, the percentage of non-anterior infarcts was more common in the successful reperfusion group (52.8%) while anterior in the failed reperfusion group (48.4%). The clinical presentation at admission was dominated by Killip class I-II with the similar blood pressure in both groups. The fibrinolytic agent used consisted of streptokinase and alteplase which did not differ between the two groups. In general, there were no statistically significant differences in baseline characteristics in the two groups (table 1), except for onset and LVEF. The mean onset of the failed reperfusion group was longer at 6.6 + 2.2 hours, while the successful reperfusion group was 4 + 1.9 hours (p < 0.001). The median value of the LVEF in the successful reperfusion group (55%) was higher than in the failed reperfusion group (52%) (p 0.024).

T Peak – T End Interval and Successful Reperfusion

There was no statistical difference between pre and post-fibrinolytic in terms of heart rate parameters. The pre-fibrinolytic Tpe interval value was higher in the successful reperfusion group (120 ms) than in the reperfusion failure group (117 ms) ms but this difference was not statistically different. The value of the post-fibrinolytic Tpe interval was found to be significantly different between two groups, the value was lower in successful reperfusion group at 88 ms while in the failed

reperfusion group it was 100 ms with a p value of 0.016. There was a larger and more significant reduction in the Tpe interval in the successful reperfusion group with a higher median of difference and resolution of Tpe of 26 ms and 25%, respectively (table 2).

From the Receiver Operating Characteristic (ROC) curve, it was found that both difference and resolution of Tpe values could be significantly predict successful reperfusion (STR ≥ 50%). The Tpe difference has an area under curve (AUC) of 0.726 (0.621-0.830) with an optimal cutoff value of 20 ms (66% sensitivity and 75.8% specificity). For Tpe resolution it has an AUC of 0.726 (0.619-0.832) with an optimal cut-off value of 16.2% (66% sensitivity and 72.7%). Both pre and post-fibrinolytic Tpe parameters have good interobserver reliability with limit of agreement of -2.84 – 2.49 and -2.98 – 1.87, respectively.

Discussion

Assessment of the successful reperfusion will determine the next strategy, ESC stated three criteria of successful fibrinolytic. Chest pain is subjective, lack of standardized measurement, and influenced by treatment. Reperfusion arrhythmias were associated with increased infarct size and decreased ventricular functioning. While STR is a main parameter that has been extensively studied in assessment of reperfusion. STR reflects the state of myocardial perfusion and has a good correlation with TIMI flow. Good epicardial perfusion without STR is associated with a poor prognosis. This is because during acute MI (AMI), microvascular dysfunction can occur, so that the assessment of perfusion at the myocardial level has a better clinical value.[1,2, 5,12,13]

Recent studies tried several alternative modalities of reperfusion assessment, including the ventricular repolarization parameter.[14] There are many parameters but we try to see if the Tpe interval reduction can be a marker of the successful reperfusion in patients with STEMI treated with fibrinolytic. Under normal conditions there is a dispersion of myocardial repolarization duration transmurally (TDR), which is reflected by the Tpe interval on the ECG. Ischemia in AMI will change metabolic processes and ion channels at the cellular level and prolong the action potential, resulting in an inhomogeneity of the action potential between normal and ischemic tissue. This will cause TDR amplification which manifests as a prolongation of the Tpe interval and reperfusion will restore this state.[7,8,15]

The main finding of this study is that the Tpe interval reduction can be a marker of successful reperfusion in STEMI patients underwent fibrinolytic. This is showed by the lower Tpe interval value and a larger change in terms of difference and resolution of the Tpe value in the successful reperfusion group. Djiwanarko et al and Coner et al also found lower Tpe values in the successful fibrinolytic group.[9,11] Recent studies assessed the relationship between Tpe intervals and evaluation of myocardial ischemia in coronary artery disease either treated by fibrinolytic or PCI. [5,19,16-18]

The majority of the baseline characteristics of this study were not found to be different except for the onset and LVEF. This study demonstrated an earlier mean onset and higher LVEF in the successful reperfusion group. Khalifa et al found that onset < 4 hours was one of the predictor of successful fibrinolytic. Gaining access to reperfusion therapy as soon as possible is the key to of STEMI management with the greatest absolute benefit if performed within 2 hours. Mortality benefit of successful fibrinolytic is achieved by preservation of left ventricular function as the findings of the GUSTO trial that showed higher LVEF in the TIMI group. [3.1,2,19]

For clinical applications, we observed the Tpe interval reduction by evaluating the changes of the parameters in the form of difference and resolution. The present study found that both parameters had a greater value in the group with successful reperfusion. Based on our knowledge, the use of Tpe resolution parameter in predicting successful reperfusion has not been found in previous studies. Djiwanarko et al found that the Tpe interval difference was greater in the successful reperfusion group which was assessed 30 minutes post-fibrinolytic with negative values in the failed reperfusion group, meaning that there was a prolongation of the Tpe interval.[9] In this study we found positive values but smaller compared to successful reperfusion group. Coner et al also found similar results but emphasized that the Tpe interval value at admission is an indicator in predicting successful reperfusion.[11] In contrast to the purpose of this study, we wanted to see the role of the Tpe interval reduction in assessing successful reperfusion so that the parameters in the form of difference and resolution are more appropriate to explain this matter.

Study Limitation

This study is a single center with a small sample size, does not include coronary angiography due to the high variation in the time interval between fibrinolytic and PCI in our local center. The fibrinolytic agents used were not uniform although the difference between the two fibrinolytic reperfusion groups was not significant. Onset, established as one of major predictor of successful fibrinolytic, should be taken into consideration when generalizing this study.

Conclusion

The Tpe interval reduction can be a valuable additional marker of successful reperfusion in patients with STEMI treated with fibrinolytic with a cut-off value of Tpe difference of 20 ms and Tpe resolution of 16.2%.

Acknowledgements

Cardiac Centre of Adam Malik Hospital Medan, North Sumatra - Indonesia.

Abbreviations

AUC	:	Area Under The Curve
LVEF	:	Left Ventricular Ejection Fraction
PCI	:	Percutaneous Coronary Intervention
STR	:	ST-segment resolution
STEMI	:	ST Segment Elevation Myocardial Infarction
TIMI	:	Thrombolysis In Myocardial Infarction

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