ORIGINAL ARTICLE

Repolarization parameters in patients with acute ST segment elevation myocardial infarction treated with primary percutaneous coronary intervention with respect to predischarge ST-T pattern: A preliminary study

Krzysztof Szydło[1], Krystian Wita[1], Maria Trusz-Gluza[1], Karolina Zawada[2],
Anna Piecuch[2], Anna Kulach[2], Ewa Kucz[2], Anna Tyrka[2], Iga Kornacka[2],
Patrycja Trams-Stawowska[2], Grzegorz Pieda[2]

[1]1st Department of Cardiology, Medical University of Silesia, Katowice, Poland
[2]Student Scientific Society, Medical University of Silesia, Katowice, Poland

Abstract

Background: *Negative T wave and lack of ST segment elevation in predischarge ECG in ST-segment elevation myocardial infraction (STEMI) patients are given as markers of good prognosis. Repolarization duration, especially its late part (TpeakTend — TpTe), likewise ST-T patterns, is related to local post-myocardial infarction myocardial attributes. We analyzed the differences in QT parameters in STEMI patients with negative or not-negative T wave pattern in predischarge ECG.*

Methods: *The data from 83 STEMI patients (LVEF > 45%, first MI, one-vessel disease) who underwent successful percutaneous coronary intervention of infarct-related coronary artery (TIMI 3 flow) were collected. According to ST-T patterns in predischarge ECG, the cohort was divided into two groups: 38 patients with persistent ST elevation and/or non-negative T wave pattern (STT+), and 45 patients with negative T wave, without ST elevation (STT–). QT, QTpeak, and TpTe intervals were obtained from 5 consecutive beats of sinus rhythm 60–70 bpm between 6 a.m. and 8 a.m. from Holter recording, corrected to the heart rate (HR) with Bazett's formula.*

Results: *The study groups did not differ in gender, age, or treatment. No true antiarrhythmics were given. Both QTc and TpTec were longer in STT+ patients: 459 ± 26 ms vs. 440 ± 25 ms, p = 0.01 and 108 ± 10 ms vs. 96 ± 11 ms, p = 0.000015, respectively. Prolongation of late repolarization was found both in anterior and inferior infarction.*

Conclusions: *STEMI patients who underwent successful percutaneous coronary intervention of infarct-related coronary arteries and demonstrated persistent ST elevation, without negative T wave at hospital discharge, had a longer repolarization duration, especially the late phase of it. Further studies are necessary to assess the prognostic value of this finding.* (Cardiol J 2009; 16: 52–56)

Key words: acute myocardial infarction, percutaneous coronary intervention, repolarization, transmural dispersion, ST segment, T wave

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Introduction

The primary goal in the management of acute ST segment elevation myocardial infarction (STEMI) is early restoration of normal epicardial coronary flow. The most effective reperfusion technique is primary percutaneous coronary intervention (PCI). A strong link has been found between early restoration of ST segment elevation and reperfusion of the culprit coronary artery, measured with TIMI flow grade [1–4]. It has been suggested that ST segment restoration is related to epicardial artery patency, whereas negative T waves reflect subendocardial injury related to myocardial infarction (MI) and PCI. Complete ST segment restoration was also associated with better left ventricle function and lower mortality. Similar observations were presented for early inversion of T wave [5].

QT interval, predominantly reflecting the repolarization time, was found to be prolonged in patients with acute ischemia caused by coronary occlusion during angioplasty [6], with a remarkable decrease during the first hours following the procedure [7]. The relationship between QT prolongation and early dilatation of the left ventricle after acute MI was also shown [8]. New interest is focused on the terminal part of QT interval (TpeakTend — TpTe) reflecting transmural heterogeneity of repolarization. There are conflicting data on the duration of TpTe soon after acute MI. However, it seems that, like ST-T patterns, TpTe interval is related to local post MI myocardial attributes.

The purpose of the study was to analyze differences in the duration of total repolarization (QT) and its late part (TpTe) in STEMI patients who underwent primary PCI, with different patterns of ST-T segment: ST elevation and/or non-negative T wave, and without ST elevation with negative T wave, in predischarge ECG.

Methods

We studied 83 consecutive patients (60 males; mean age 59.6 ± 10 years) who underwent the first STEMI treated successfully with primary PCI and stenting of the culprit coronary artery (TIMI flow grade 3) within 12 hours from the onset of symptoms. Patients with multi-vessel coronary disease, left ventricular ejection fraction (LVEF) < 45%, QRS duration $\geq$ 120 ms and atrial fibrillation, or other sustained arrhythmias were not included.

Echocardiography and catheterization

Two-dimensional echocardiography was performed twice in each patient, upon admission to hospital and on the fifth day of acute MI, with a commercial system Vivid 7 (GE). Left ventricular ejection fraction was obtained from the second examination. Coronary angiography and primary PCI of infarct-related artery were performed by percutaneous femoral approach. Antegrade perfusion of the culprit artery was graded according to the TIMI classification system.

### ECG, 24-hour Holter ECG recording and repolarization parameters

Standard 12-lead ECG recordings were analyzed twice: the admission ECG for diagnosis of STEMI and its location, and the second, performed on the fifth day, for ST-T pattern assessment. The patients were divided into two groups according to the ST-T pattern in the 12-lead ECG: group STT+ with persistent ST segment elevation > 1 mm in two infarct-related leads and/or non-negative T wave (positive or biphasic), and group STT– with isoelectric ST segment with negative T wave.

Holter recording was performed before discharge (on the 4–6th day) using three channel Lifecard Del-Mar Reynolds recorders with a sampling rate of 128 Hz and analyzed with a Pathfinder 700 system. Repolarization parameters were assessed manually from ECG strips with sinus rhythm 60–70 bpm, preceded by a period of at least 5 min of stable sinus rhythm at the same frequency, taken between 6 a.m. and 8 a.m. by Holter recording (1 mV/10 mm, 25 mm/s). Channel CM5, which is closest to the V5 or V4 leads of standard surface 12-lead ECG recording [9], was used. In case of biphasic T waves, T peak was indicated as a maximum (if positive) or nadir (if negative) of the first component of the T wave [10] (Fig. 1). Data from 5 consecutive measurements were averaged. The following parameters were measured: QT — time from the QRS onset to the end of the T wave, QTpeak (QTp) — time from the QRS onset to the peak of the T wave, and TpeakTend (TpTe) — time from the peak to the end of T wave. All intervals were corrected according to Bazett's formula using the preceding RR interval — QTc, QTpeakc (QTpc), TpeakTendc (TpTec).

The study was approved by the local bioethical committee and all patients gave their informed consent.

Statistical analysis

All variables are given as mean $\pm$ one standard deviation. Data were compared with Student's t-test and ANOVA, MANOVA or Mann-Whitney U test, ANOVA Friedman, and χ^2 test where appropriated. MANOVA was used for analysis of the influence of
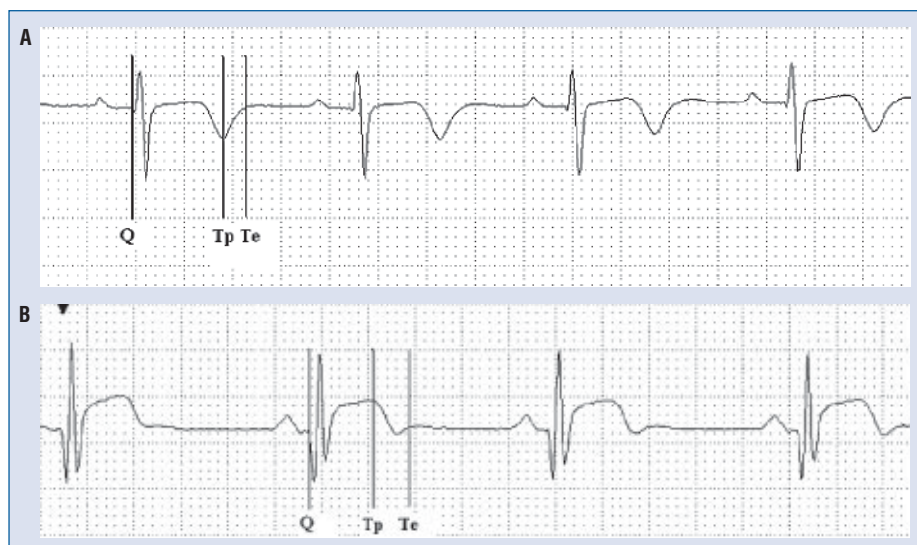
Figure 1. Examples of measurement points of the QRS onset (Q), T wave peak (Tp), and the offset of T wave (Te) in two patients from: STT– group (**A**) and STT+ group (**B**).

more than one independent factor on numeric study variable. Statistical analyses were performed with Statistica 7.1 PL software.

Results

The study cohort consisted of 45 STT– patients and 38 STT+ patients. Patients with PCI of either the left circumflex or right coronary artery were analyzed together as non-anterior STEMI (all with inferior MI).

The clinical characteristics of the study groups are summarized in Table 1. There were no significant differences between groups in age, gender, or the presence of diabetes or arterial hypertension, as well in LVEF and type of culprit coronary artery. No true antiarrhythmics were given. No patients had echocardiographic signs of left ventricular hypertrophy.

The results of QT interval analyses in both study groups are summarized in Tables 2 and 3. The QTc and TpTec intervals in the STT+ group were significantly longer than those obtained in the STT– group (Table 2). TpTec interval was significantly longer in the STT+ patients regardless on the site of STEMI, trends toward longer values of QTc were also observed — QTc interval was significantly longer in patients with anterior MI in the STT+ group, but not in STT– patients (Table 3). Nevertheless, the effect of the site of STEMI or type of culprit coronary artery, as well arterial hypertension and diabe-

Table 1. Study population characteristics.

Parameter	STT–	STT+	P
Gender (male/female)	31/14	29/9	0.45
Age (years)	61 ± 10	58 ± 9	0.11
LVEF (%)	55 ± 5	53 ± 5	0.34
Diabetes mellitus	19 (42%)	24 (63%)	0.07
Arterial hypertension	22 (49%)	25 (66%)	0.12
LAD/RCA/Cx disease	17/24/4	21/13/4	0.08
Anterior/inferior site	17/28	22/16	0.07
Beta-blocker	96%	100%	NS
ACEI	91%	100%	NS
Statins	96%	92%	NS

ACEI — angiotensin converting enzyme inhibitor, Cx — left circumflex coronary artery, LAD — left anterior descending coronary artery, LVEF — left ventricle ejection fraction, RCA — right coronary artery

Table 2. Repolarization parameters in study groups.

	QTc [ms]	QTpc [ms]	TpTec [ms]
STT–	440 ± 25	344 ± 21	96 ± 11
STT+	459 ± 26	351 ± 20	108 ± 11
p	0.009	0.15	0.000015

tes, on the differences observed between the study groups in repolarization parameters was found to be not significant (MANOVA analyses).

Table 3. Repolarization parameters in patients with respect to infarction site.

Parameter		Anterior	Non-anterior
QTc	STT–	449 ± 25	434 ± 24
	STT+	467 ± 23	$447 \pm 27^*$
		0.067	0.27
QTpc	STT–	351 ± 20	339 ± 21
	STT+	357 ± 17	341 ± 21
		0.31	0.77
TpTec	STT–	98 ± 9	95 ± 12
	STT+	110 ± 11	106 ± 10
p		0.002	0.007

$^*p = 0.02$ for anterior *vs.* non-anterior

Discussion

In this study we demonstrated that patients with first STEMI who underwent primary PCI, with single-vessel disease, preserved or slightly disturbed left ventricular contractility, with persistent ST segment elevation and/or non-negative T waves at hospital discharge had longer QTc and TpTec intervals. Additionally, we also found that prolongation of repolarization was not related to the site of acute MI, the presence of diabetes, or arterial hypertension.

Most previous studies have focused on the relationship between predischarge ST segment and T wave changes in STEMI patients and myocardial viability, contractility disturbances, or short- and long-term outcome. However, to date, only a few papers have presented data of analyses of repolarization duration in patients with acute MI treated with primary PCI [7, 8]. To the best of our knowledge, there has been no study on the relation between ST-T patterns and repolarization duration.

Selection of the optimal lead for assessment of QT intervals in MI patients is still unclear. Anzelevitch [10] indicated that TpTe should be obtained from precordial leads. According to our observations the highest amplitude of QRS complex and T wave was found in the CM5 (V5) lead, which we selected in our study, as in the Inoue report [11]. Hirota [12] reported that prolongation of repolarization in patients with acute anterior MI reached peak value within 1–5 days after coronary intervention. Other investigators [1] showed that ST segment and T wave attained a stable pattern 7–10 days after acute phase. Therefore, in our opinion, the predischarge ECG may be accurate for the assessment of associations between ST-T pattern and repolarization duration.

Complete resolution of ST elevation combined with negative T wave was found in 54% of our patients. Similar results were reported by Dong et al. [13] who obtained complete ST segment resolution in 47% of stenting STEMI patients. Persistent ST elevation, despite an open epicardial artery with TIMI grade flow 3 after PCI, is an indicator of impaired tissue reperfusion, which determines worse short- and long-term prognosis. On the contrary, rapid ST segment resolution after successful PCI correlates with better microvascular function [14]. Similarly, T wave inversion is regarded as an independent negative risk factor for outcomes in STEMI patients and worsening of left ventricle function [4]. Therefore, the 12-lead ECG has been used in many studies as a surrogate marker of tissue-level perfusion [1, 15].

In our patients, persistent ST segment elevation and/or non-negative T waves at hospital discharge were associated with longer TpTe interval, which probably reflects regional variations in ventricular repolarization. These results are in concordance with observations on the presence of a relationship between microvascular dysfunction and inhomogeneity of transmural dispersion of repolarization (TpTe), which has been suggested in few recent studies [14, 16, 17]. Furthermore, the late phase of repolarization (TpTe), reflecting electrical instability of myocardium, plays a crucial role in arrhythmogenesis. For example, several lines of evidence indicate that an increase in the TpTe interval is associated with a higher risk of torsade de pointes or sudden cardiac death in patients with long QT syndrome. Our study needs follow-up to provide further analysis of prospective values of the presented findings.

Limitations of the study

The results of this study should be considered in the light of its limitations. In the present study we measured QT intervals manually. Beat-to-beat automatic analysis, according to our experience, is more accurate and may provide additional information on the dynamics of the repolarization process. However, the repolarization parameters were obtained manually because not all the recordings were suitable for automatic analysis, which failed mainly when biphasic T waves were present. Despite this, manual assessment of repolarization is commonly used.

Secondly, it seems that for more detailed analysis our patients should be classified into four groups: no ST elevation and negative T wave, ST elevation and negative T wave, no ST elevation and positive T wave, and ST elevation and positive T wave.

However, only 83 patients were recruited in our study, which is insufficient for accurate statistical tests.

Conclusions

Patients with STEMI who underwent successful PCI of infarct-related coronary artery and demonstrate persistent ST elevation, without negative T wave at hospital discharge, have a longer duration of repolarization, especially late phase. Prospective studies are necessary to explain the prognostic value of this finding.

Acknowledgements

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