Differences in the Selvester QRS score after primary PCI strategy and conservative treatment for STEMI patients with negative T waves

Egle Kalinauskiene MD, PhD1 | Dalia Gerviene MD, PhD1
Ljuba Bacharova MD, DSc, MBA2,3 | Zora Krivosikova RNDr, PhD4 | Albinas Naudziunas MD, PhD, DSc1

1Department of Internal Medicine, Lithuanian University of Health Sciences, Kaunas, Lithuania
2International Laser Center, Bratislava, Slovakia
3Institute of Pathophysiology, Medical School, Comenius University, Bratislava, Slovakia
4Slovak Medical University, Bratislava, Slovakia

Correspondence
Egle Kalinauskiene, Department of Internal Medicine, Medical Academy of Lithuanian University of Health Sciences, Jovainiu 2, LT-47144 Kaunas, Lithuania.
Email: eglekalin@yahoo.com

Abstract

Background: According to current guidelines, the main indications for PCI in patients with STEMI are ST-segment deviations and defined time from the onset of symptoms. Negative T wave at admission can be a sign of prolonged ischemia or spontaneous reperfusion. In both situations, the urgent intervention is questionable. We evaluated the infarct size and in-hospital mortality in STEMI patients with negative T wave in cases of primary PCI strategy compared with conservative treatment.

Methods: A retrospective analysis of 116 STEMI patients with negative T wave at the presenting ECG was performed. Sixty-eight patients (59%) underwent primary PCI strategy (PCI group), and 48 (41%) were treated conservatively (non-PCI group). The infarct size estimated by using the Selvester score, and in-hospital mortality were evaluated.

Results: The difference between Selvester score values at admission and at discharge in the non-PCI group was statistically significant (1.48; 95% CI 0.694–2.27), while no significant difference was observed in the PCI group (−0.07; 95% CI −0.546–0.686). The in-hospital mortality was higher in the non-PCI group; however, the numbers were relatively small: PCI 2 (2.9%) and non-PCI 5 (10.4%).

Conclusion: In this study, we showed a reduction in the infarct size estimated by Selvester score in STEMI patients with negative T wave who were treated conservatively, while there was no significant change in the infarct size after primary PCI strategy. The higher mortality in patients treated conservatively could be attributed to higher age and comorbidities in the non-PCI group. It seems that conservative treatment strategy might be an option in STEMI patients with negative T wave.

Keywords

conservative treatment, in-hospital mortality, primary PCI strategy, Selvester QRS score, ST-segment elevation myocardial infarction
The preferred reperfusion strategy for patients with acute ST-segment elevation myocardial infarction (STEMI) is primary percutaneous coronary intervention (PCI) [Ibanez et al., 2018]. It was documented that early PCI results in reduction in mortality, morbidity, and hospital length of stay [Keeley, Boura, & Grines, 2003]. The important factor for these beneficial outcomes is the time interval from the onset of symptoms [Ioannidis & Katritsis, 2007]. However, duration of symptoms reported by patients is a subjective and inaccurate measure for estimating the ischemic time [Kirchberger, Heier, Wende, Scheidt, & Meisinger, 2012; Ladwig et al., 2017]. Obviously, a more objective measure allowing a better estimate of ischemia duration is needed.

In the time course evolution of ECG changes in STEMI patients, the ST-segment elevation is the dominant finding in the initial phase. Later, pathologic Q-wave and terminal T-wave inversion appear, followed by inverted T wave [Klainman et al., 1987]. It was shown that in patients presenting with STEMI and undergoing urgent PCI, the terminal T-wave inversion is an independent risk factor for in-hospital major adverse cardiac event, inadequate ST resolution, and prolonged hospital stay [Shimada, Po, Kanei, & Schweitzer, 2013; Koivula et al., 2019]. Considering the electrical axis and the polarity of the lead aVR, analogically it was shown that positive T wave in lead aVR among patients with an anterior wall STEMI treated with primary PCI is an independent predictor of in-hospital mortality [Ayhan et al., 2013]. The DANAMI-2 substudy showed that consideration of Q-wave and T-wave morphology can be useful for indicating patients for PCI or fibrinolytic therapy as an alternative option [Escola et al., 2007].

Studies and clinical trials with acute STEMI patients are carried out usually in PCI-capable hospitals, analyzing study populations with strict inclusion and exclusion criteria. However, there are hospitals not capable of performing PCI. Patients admitted to these hospitals usually have duration of symptoms too long for PCI or fibrinolytic treatment and have contraindications for these procedures, or the transport to the PCI-capable hospital is problematic [Kristensen et al., 2014]. The most frequently discussed aspects of management are the selection and implementation of a reperfusion strategy [Antman, 2008], together with an open question on the effect of the conservative (pharmacological) treatment.

In this study, we evaluated the effect of urgent intervention and conservative therapy on the infarct size estimated by the Selvester score and in-hospital mortality in nonselected patients admitted with ST-segment elevation and negative T wave to the PCI-capable and non-PCI-capable hospitals.

2 MATERIAL AND METHODS

We retrospectively analyzed data of STEMI patients with negative T wave at admission, admitted to all hospitals in the Kaunas city: the hospital of Lithuanian University of Health Sciences (PCI-capable hospital) between July 2014 and December 2014, to the Kaunas Clinical Hospital and Kaunas Republic Clinical Hospital (non-PCI-capable hospitals) between January 2013 and December 2014.

Patients were eligible for inclusion if they had ST-segment elevation at the J point ≥1 mm and negative T wave ≥1 mm in two or more contiguous leads on presenting ECG and elevated cardiac troponin (I, T, or high-sensitivity) values, with at least one value above the 99th percentile upper reference limit. Patients with ventricular pacemaker, intraventricular conduction defects, and low quality of ECG were excluded.

The total study population consisted of 116 patients divided into two groups:

- PCI group: n = 68, aged 38–89 years (average 69.5 years) who underwent coronarography, and the majority of them underwent consequent revascularization (angioplasty: 51 (75%), stenting in all cases of angioplasty, except of one patient).
- Non-PCI group: n = 48, aged 62–94 years (average 80.3 years), treated conservatively (pharmacotherapy without reperfusion therapy).

The standard 12-lead ECGs at admission to the hospital and before the discharge from the hospital were evaluated by two blinded readers. The ST-segment elevation and negative T-wave amplitude in leads with ST-segment elevation ≥1 mm were measured in three consecutive beats, and the average was used for analysis. The size of MI at the admission to the hospital and before the discharge from the hospital was estimated using the Selvester QRS scoring system [Loring, Chelliah, Selvester, Wagner, & Strauss, 2011]. In 7 patients who died during hospitalization, the latest available ECG was considered for analysis.

The clinical data and the in-hospital mortality data were obtained from the hospital records, and the in-hospital mortality was defined as all-cause mortality.

2.1 Statistical analysis

The continuous variables are presented as average and standard deviation if normally distributed and as median and interquartile range if not normally distributed. The differences between groups were tested using unpaired Student t test for normally distributed continuous variables and the Man-Whitney U test for continuous variables not normally distributed. Categorical variables are presented as number and percent, and the chi-square test was used to test the differences between categories. Considering small numbers in some subgroup, the exact tests were used. Statistical analysis was performed using the Statistical Package for Social Science 23 for Windows. Differences were considered as statistically significant if p < .05.

The study was conducted in accordance with the Declaration of Helsinki. The study protocol was approved by Kaunas Regional Biomedical Ethics Committee and Authorization for the processing of personal data for research purposes of the State Data Protection Inspectorate.
3 | RESULTS

The basic characteristics of the study population are presented in Table 1. The patients in the non-PCI group were significantly older, with significantly higher proportion of women. The proportion of the antero-lateral location of MI was significantly higher in the non-PCI group, and the heart rate was significantly higher. Regarding comorbidities, the non-PCI group had higher occurrence of renal failure and paroxysmal atrial fibrillation.

As seen in Table 2, there were statistically significant differences in therapy between the groups. A lower proportion of the patients in the non-PCI group received aspirin, other antiplatelet drugs, dual antiplatelet therapy, and statins, and on the other hand, this group received more frequently diuretics and nitrates.

No significant differences between the values of ST-segment elevations and the negative T-wave amplitude, as well as of the values of the Selvester score, were observed between the groups at the admission (Table 3). There were differences in the number of leads with negative T wave between the groups. Selvester score significantly decreased at discharge in the non-PCI group (1.48; 95% CI 0.694–2.27), while no significant difference was observed in the PCI group (−0.07; 95% CI −0.546–0.686) (Figures 1 and 2). In cases of antero-lateral location, Selvester score significantly decreased at discharge in the non-PCI group (1.45; 95% CI 0.470–2.449), while no significant difference was observed in the PCI group (0.00; 95% CI −0.541–0.541). In cases of infero-posterior location, the tendency to the decrease in the non-PCI group was noted (1.50; 95% CI −0.091–3.091), while no difference was observed in the PCI group (−0.192; 95% CI −1.346–0.962). There was no difference regarding the time
to presentation: in the group within 12 hr in the non-PCI cases prevailed patients with the decrease in QRS score (68.8% of patients), while in the PCI cases—with no decrease (73.3% of patients); also in the group >12 hr in the non-PCI cases prevailed patients with the decrease in QRS score (59.3% of patients), while in the PCI cases—with no decrease (60.0% of patients). In cases within 12 hr, Selvester score significantly decreased at discharge in the non-PCI group (2.75; 95% CI 1.140–4.360), while no significant difference was observed in the PCI group (0.20; 95% CI 0.950–1.350). In cases of >12 hr, the tendency to the decrease in the non-PCI group was observed (0.704; 95% CI 0.342–1.749), while no difference was observed in the PCI group (−0.16; 95% CI 0.80–0.30).

The in-hospital mortality was higher in the non-PCI group; however, the numbers were relatively small for further statistical analysis: PCI 2 (2.9%) and non-PCI 5 (10.4%), respectively (Table 3).

**4 | DISCUSSION**

Main results of the study: In STEMI patients with ST-segment elevation and the negative T wave in the presenting ECG, we found:

1. No differences in the values of ST-segment deviation and of the negative T-wave amplitude, in the estimated MI size, as well as in the pain duration at the admission to the hospital between the PCI and non-PCI groups;
2. At the discharge from the hospital, we observed statistically significant decrease in MI size estimated by the Selvester score in the non-PCI group, while no statistically significant difference was found in the group PCI;
3. The in-hospital mortality was higher in the non-PCI group; however, the numbers were relatively small for statistical analysis.

For estimating the MI size, we used a standard ECG-based scoring system—the Selvester QRS score that considers quantitative changes in the QRS complex to estimate the infarct size [Loring et al., 2011; Geerse et al., 2009; Rosengarten et al., 2013; Rovers et al., 2009; Wieslander et al., 2016]. The Selvester score has been shown to correlate significantly with autopsy-measured myocardial infarct
size. Walamies, Siitonen, & Koskinen 1995 showed that the QRS score is related to the degree of permanent myocardial injury, even after thrombolysis. The QRS score at admission was an independent predictor of microvascular obstruction after PCI [Watanabe et al., 2016]. More recent study showed that in patients undergoing the primary PCI, the QRS score at presentation electrocardiogram correlated with infarct size and mortality [Shiomi et al., 2017]. Also, the infarct size as estimated by QRS scoring at hospital discharge was an independent and predictive metric in patients with STEMI undergoing primary PCI [Tjandrawidjaja et al., 2010]. On the one hand, some studies failed to show significant correlation with infarct size in patients who underwent thrombolytic therapy [Marki & Lipman, 1991; Christian et al., 1991]. There was a different quantitative relationship between QRS score and MI size assessed by delayed contrast-enhanced magnetic resonance imaging (DE-MRI) in the acute state of early reperfused MI compared with nonreperfused MI, partly explained by differences in MI size [Knippenberg et al., 2010]. DE-MRI is considered to be the most accurate method by which to assess myocardial necrosis in the chronic state. However, assessment of the infarct size in the acute MI remains a challenge for DE-MRI [Montecucco, Carbone, & Schindler, 2016]. QRS scoring in anterior infarcts correlated with cardiac MRI MI size both early after MI and at follow-up; however, no correlation was seen among nonanterior infarcts [Holmes et al., 2016]. We received the most significant results in anterior MI, while only the tendency was observed in inferior MI. In cases of antero-lateral location, the difference between Selvester score values at admission and at discharge in the non-PCI group was statistically significant, while no significant difference was observed in the PCI group; in cases of infero-posterior location, the tendency to the decrease in the non-PCI group was observed, while no difference was observed in the PCI group. The presence of Q waves is less informative than the global QRS score: It was not indicative of transmural MI in reperfused patients [Engblom et al., 2005]. They show, however, that the global QRS score was significantly related to both MI size and transmurality by cardiac MRI in these patients. Thus, the conclusion of that study was that QRS scoring could potentially be used for diagnosing and characterizing MI in patients with suspected recent MI. Therefore, in our study we used the global QRS score and a new modification of Selvester QRS scoring system [Loring et al., 2011] that was introduced to optimize its performance in a broader population by accounting for the different ventricular depolarization sequences in patients with bundle branch/fascicular blocks or ventricular hypertrophy, and corrected according to age and gender.

At admission to the hospital, there were no differences in the MI size between PCI and non-PCI groups. There were some differences in the repolarization between the groups; however although statistically significant, the difference was small (Table 3). Surprisingly, we observed slight, but statistically significant decrease in the MI size at the discharge in the non-PCI group, while there was no statistically significant difference in the MI size the group PCI. If the mechanical or pharmacological re-establishment of the blood flow (reperfusion) starts early, it can save part of hypoperfused myocardial area. However, reperfusion itself may cause injury by triggering recruitment and activating inflammatory processes [Montecucco, 2016]. Neutrophil infiltrate resolves 3-7 days after MI, and timely resolution of neutrophil inflammation is a critical step for optimal healing of the infarcted heart. It can be speculated that PCI in cases of negative T waves at admission prolongs this period, and it is too late for myocardial salvage. It is possible that the decrease in the conservative group is due to spontaneous recanalization and natural healing of the infarcted heart.

There are controversial statements in relation to the appearance of negative T wave in STEMI patients. On the one hand, a negative T wave is considered as a sign of the later stage of MI, that is, of a longer duration of ischemia as a major determinant of the extent of myocardial damage [Klainman et al., 1987; Shimada et al., 2013]. On the other hand, it was documented that the appearance of the negative T wave before reperfusion therapy could be due to spontaneous recanalization of infarct-related artery, in particular if the STEMI location is anterior [Hira, Moore, Huang, Wilson, & Birnbaum, 2014; Alsaaob et al., 2014]. Thus, the presence of negative T wave could be a sign not only for the late stage of MI, but also of successful spontaneous reperfusion, especially if clinical symptoms suggest the duration of MI not longer than 2 days [Kalinauskiene, Vaicekavicius, & Kulakiane, 2005; Kalinauskiene et al., 2007]. In both situations, the urgent interventional treatment is questionable: In the case of a successful spontaneous reperfusion, there is no reason for intervention; in the case of the late stage of STEMI, the intervention may be already ineffective. In this study, we did not see a benefit of PCI in terms of reducing the MI size.

On the other hand, the in-hospital mortality was significantly higher in the non-PCI group. Patients admitted to the non-PCI hospitals were older, with higher proportion of women, having more comorbidities and received less antiplatelet agents and statins than patients in the PCI-capable hospital. The mortality numbers were small for statistical analysis, and therefore, we can only speculate what were the main factors contributing to the difference in in-hospital mortality. In this study, there were no differences in the values of ST-segment deviation and of the negative T wave between the PCI and non-PCI groups at the admission to the hospital, as well as in the pain duration. Also, the MI size estimated by the Selvester score at the admission to the hospital did not differ between the PCI and non-PCI groups. It can be assumed that apart of the severity of MI, the other factors contributed to the higher morbidity in the non-PCI group. This assumption is in agreement with findings of others demonstrating the effect of age, gender, renal failure, and therapy on the short-term mortality and long-term mortality [Goto et al., 2012; Shihara et al., 2002; Wright et al., 2006].

The in-hospital mortality in this study was 2.9% for the PCI group and 10.4% for the non-PCI group. Several recent studies have highlighted a fall in acute and long-term mortality following STEMI in parallel with greater use of reperfusion therapy, primary percutaneous coronary intervention (PCI), modern antithrombotic therapy, and secondary prevention [Townsend et al., 2016; Puymirat et al.,
Current guidelines clearly define the indications for PCI in STEMI patients, stressing the time (duration of symptoms) as the decisive factor. However, in reality there are a number of patients exceeding this time window: The duration of pain reported by patients is a subjective measure, and a number of patients are coming late because the symptoms are not recognized or underestimated. Thus, the distribution of patients between PCI-capable and no-PCI-capable hospitals depends not only on the guidelines, but on other factors as well, including patients’ preference and availability of the PCI-capable hospitals.

In this study, it is obvious that there were implicitly other factors affected the decision: Patients admitted to the non-PCI hospitals were older, with higher proportion of women, and having more comorbidities. There was also difference in the pharmacological therapy between groups; a smaller proportion of the patients in the non-PCI hospitals received an optimal treatment, and although according the guidelines, optimal drugs should receive all patients, the symptoms are not recognized or underestimated. Thus, the distribution of patients between PCI-capable and no-PCI-capable hospitals depends not only on the guidelines, but on other factors as well, including patients’ preference and availability of the PCI-capable hospitals.

This study was focused on a specific subset of STEMI patients with ST elevation and negative T wave at the presenting ECG and on the effect of the primary PCI strategy on the MI size as compared to the conservative treatment. Primary PCI strategy did not reduce the MI size in these patients. Although the non-PCI group represented the more disadvantaged group regarding gender, age, comorbidities, and therapy, we observed better outcomes in the non-PCI group regarding the MI size. On the other hand, these disadvantages lead to higher proportion of in-hospital mortality. The indication of STEMI patients with the negative T wave for primary PCI strategy remains an open question.

ACKNOWLEDGMENT

This study was partly supported by the grant APVV 16-0158.

REFERENCES


How to cite this article: Kalinauskiene E, Gerviene D, Bacharova L, Krivosikova Z, Naudziunas A. Differences in the Selvester QRS score after primary PCI strategy and conservative treatment for STEMI patients with negative T waves. *Ann Noninvasive Electrocardiol*. 2019;24:e12684. https://doi.org/10.1111/anec.12684