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The modified Selvester QRS score: Can we predict successful ST segment resolution in patients with myocardial infarction receiving fibrinolytic therapy?

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Abstract

Background: *We sought to explore whether the simplified Selvester QRS scoring system could predict ST segment resolution in patients with first acute ST segment elevation myocardial infarction who receive pharmacological reperfusion therapy.*

Methods: *We enrolled 60 consecutive patients admitted to the critical care unit with the diagnosis of first acute ST segment elevation myocardial infarction presenting within 24 hours from symptom onset, and eligible for reperfusion therapy. All patients received streptokinase in the usual dose regimen. Patients underwent resting high-quality 12-lead electrocardiogram recordings to calculate the modified QRS score and estimate the sum of ST segment elevation before (STE1) and 90 minutes after (STE2) streptokinase. The difference between STE1 and STE2 was then measured and accepted as the sum of ST segment resolution, expressed as ΣSTR. Patients were classified into two groups: those with ΣSTR ≥ 50% of STE1 (the resolution group) and those with ΣSTR < 50% (the non-resolution group).*

Results: *The mean QRS score was significantly lower in the resolution group compared to the non-resolution group (2.88 ± 1.34* vs *5.93 ± 1.56, respectively, p < 0.001). There was a highly significant negative correlation between QRS score and ΣSTR with a correlation coefficient r = –0.76. Using a cut-off value of ≥ 4, the QRS score had a sensitivity of 93%, specificity of 72%, positive and negative predictive values of 74% and 92% respectively, for predicting ΣSTR < 50%.*

Conclusions: *The Selvester QRS score can reliably predict adequate ST segment resolution in patients with first acute ST segment elevation myocardial infarction receiving fibrinolytic therapy, with a high sensitivity and an acceptable specificity.* (Cardiol J 2010; 17, 4: 367–373)

Key words: QRS score, ST segment resolution, acute myocardial infarction

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Introduction

The immediate therapeutic goal of reperfusion therapy is to restore full antegrade flow in the infarct-related epicardial coronary artery, as well as to achieve adequate myocardial perfusion at tissue level. Failure to improve tissue perfusion despite successful restoration of epicardial coronary flow (the so called 'no-reflow phenomenon') has been associated with poor clinical outcome [1], and independently predicted six-months mortality [2]. It is well established that early and complete resolution of ST-segment elevation is a powerful predictor of infarct-related artery patency and preserved myocardial perfusion at tissue level [3, 4].

Successful ST segment resolution as an electrocardiographic sign of restored myocardial perfusion may vary according to how far the infarction process has progressed. The presence of Q waves at the time of presentation of first acute ST segment elevation myocardial infarction (STEMI) reflects a more advanced stage of the infarction process [5].

The Selvester QRS scoring system was initially developed to estimate electrocardiographically the size of myocardial infarction. It includes 54 criteria that form the basis of a 32-point scoring system, with each point equivalent to approximately 3% of the left ventricle [6]. In fact, multiple versions of the Selvester QRS score have been published which help quantify myocardial scar in the presence of normal and abnormal ventricular conduction [7]. While multiple versions of the Selvester QRS scoring system have been reported, we chose to study the ability of the simplified QRS score [8], measured from the admission (pre-thrombolytic) electrocardiogram (ECG), to predict adequate resolution of ST segment elevation in patients with first acute STEMI who receive pharmacological reperfusion therapy.

Methods

Patient selection

We enrolled 60 consecutive patients admitted to our critical care unit between January 2007 and January 2008, with the diagnosis of first acute STEMI presenting within 24 hours from symptom onset, eligible for reperfusion therapy (presenting within 12 hours after symptom onset, or presenting thereafter with persistent symptoms). The diagnosis of STEMI was based on 12-lead ECG showing ST segment elevation ≥ 1 mm in at least two contiguous leads plus one of the following: 1) prolonged chest discomfort typical of myocardial ischemia, 2) elevated cardiac biomarkers: creatine kinase MB and/or troponin more than twice the upper limit of normal lab reference. We excluded patients with bundle branch block, paced rhythm, left fascicle block, ECG signs of ventricular hypertrophy and those with cardiogenic shock. Before inclusion, informed written consent was obtained from each patient and the study protocol was reviewed and approved by our local institutional human research committee as it conforms to the ethical guidelines of the 1975 Declaration of Helsinki, as revised in 2002.

Definition of risk factors

The presence of hypertension was defined as systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg, previously recorded by repeated non-invasive office measurements, which lead to life-style modification or antihypertensive drug therapy. The presence of diabetes mellitus was defined as fasting plasma glucose ≥ 126 mg/dL, and/or two hour post glucose load ≥ 200 mg/dL, or specific anti-diabetic drug therapy. Dyslipidemia was defined as LDL cholesterol > 100 mg/dL, and/or serum triglycerides > 150 mg/dL, and/or HDL cholesterol < 40 mg/dL and < 50 mg/dL in women.

Methods

All included patients received fibrinolytic therapy in the form of streptokinase by intravenous infusion, at a dose of 1 500 000 U over 30–60 minutes. Standard anti-ischemic medications were allowed and remained unchanged during the study period. All patients underwent resting high-quality 12-lead ECG recordings, from which the following was estimated:

1. QRS score calculated according to the simplified form of the Selvester scoring system based on 37 criteria capable of generating 29 points [8].
2. ST segment elevation, measured 20 ms after the J point. The height (in mm) of ST segment elevations was measured in leads I, aVL and V1 through V6 for anterior infarctions, and in leads II, III, aVF, V5 and V6 for inferior infarctions. The sum of all measured ST segment elevations was expressed as STE1.

Resting ECG was repeated for all patients 90 minutes following the initiation of fibrinolytic therapy, from which the sum of ST segment elevations was measured again, as described before, and expressed as STE2. The difference between STE1 and STE2 was then measured and accepted as the sum of ST segment resolution, expressed as ΣSTR. Patients were, subsequently, classified into two

Table 1. Baseline characteristics of the whole study cohort and the two study groups.

	Whole cohort (n = 60)	Resolution group (n = 32)	Non-resolution group (n = 28)	P
Age (years)	54.7 ± 9.9	52.3 ± 8.5	57.4 ± 10.8	< 0.05
Males	53 (88.3)	30 (93.8)	23 (82.1)	> 0.05
Smoking	31 (51.7)	20 (62.5)	11 (39.3)	> 0.05
Diabetes	25 (41.7)	8 (25)	17 (60.7)	< 0.05
Hypertension	32 (53.3)	11 (34.4)	21 (75)	< 0.05
Dyslipidemia	38 (63.3)	25 (78.1)	13 (46.4)	< 0.05
Family history of IHD	18 (30)	9 (28.1)	9 (32.1)	> 0.05
Heart rate	84 ± 9	82 ± 7	86 ± 11	> 0.05
SBP [mm Hg]	118 ± 11	116 ± 8	120 ± 13	> 0.05
DBP [mm Hg]	77 ± 7	76 ± 6	78 ± 8	> 0.05
Anterior MI	36 (60)	14 (43.8)	22 (78.6)	< 0.05
Dyspnea	15 (25)	2 (6.25)	13 (46.4)	< 0.001
Orthopnea	10 (16.7)	2 (6.25)	8 (28.6)	< 0.05
Basal cripitations	15 (25)	2 (6.25)	13 (46.4)	< 0.001
3rd heart sound gallop	3 (5)	0 (0)	3 (10.7)	> 0.05

Continuous variables are presented as mean ± standard deviation, while categorical variables are presented as numbers (percentage); SBP — systolic blood pressure; DBP — diastolic blood pressure; IHD — ischemic heart disease; MI — myocardial infarction

groups: those with ΣSTR ≥ 50% of STE1 (the resolution group) and those with ΣSTR < 50% of STE1 (the non-resolution group).

Statistical analysis

All continuous variables were presented as mean ± standard deviation, if they were normally distributed. Differences in the normally distributed variables were assessed using the *t*-test and the paired *t*-test for dependent variables. Categorical variables were described with absolute and relative (percentage) frequencies. Comparisons between the two individual groups were performed using the unpaired *t*-test (parametric) and Mann Whitney test (non parametric) for continuous variables, and Pearson's χ^2 test for categorical variables. Pearson's correlation coefficient test was performed to study the correlation between the QRS score and the ΣSTR. Finally, we generated receiver operating characteristic (ROC) curves to identify the optimal cut-off value of QRS score that best predicts ΣSTR < 50% of STE1. All tests were two-sided and a probability value of $p < 0.05$ was considered statistically significant. Analyses were performed with SPSS version 12.0 statistical package (SPSS Inc., Chicago, IL, USA).

Results

A total of 60 consecutive patients with first acute STEMI who received fibrinolytic therapy were enrolled in the study. The baseline characteristics of the overall cohort, as well as the two individual study groups, are shown in Table 1. The mean age was 54.7 ± 9.9 years, 53 (88.3%) being males. The mean time from symptom onset to reperfusion was 3 ± 1.04 hours for the whole series. As compared to the resolution group, patients in the non-resolution group were older (57.4 ± 10.8 *vs* 52.3 ± 8.5 years respectively, $p < 0.05$), more likely to be diabetic [17 (60.7%) *vs* 8 (25%) respectively, $p < 0.05$], hypertensive [21 (75%) *vs* 11 (34.4%) respectively, $p < 0.05$], but less likely to be dyslipidemic [13 (46.4%) *vs* 25 (78.1%) respectively, $p < 0.05$], with a greater prevalence of dyspnea [13 (46.4%) *vs* 2 (6.25%) respectively, $p < 0.001$], orthopnea [8 (28.6%) *vs* 2 (6.25%) respectively, $p < 0.05$], and basal cripitations [13 (46.4%) *vs* 2 (6.25%) respectively, $p < 0.001$]. Similarly, patients in the non-resolution group had a significantly longer time from symptom onset to reperfusion (3.29 ± 1.15 *vs* 2.75 ± ± 0.88 h respectively, $p < 0.05$). Anterior rather than inferior infarction was more prevalent in the non--resolution group than the resolution group ($p < 0.05$).

Table 2 shows the electrocardiographic data of the overall cohort as well as the two study groups. There was no significant difference between the two groups concerning STE1 ($p > 0.05$). However, STE2 was significantly lower in the resolution group compared to the non-resolution group (3.47 ± 2.66 *vs* 8.71 ± 3.97 mm, respectively, $p < 0.001$). Ultimately, the mean QRS score was significantly lower in the resolution group compared to the non-

Table 2. Electrocardiographic data of the overall cohort and the two study groups.

	Whole cohort (n = 60)	Resolution group (n = 32)	Non-resolution group (n = 28)	P
QRS score	4.3 ± 2.1	2.9 ± 1.3	5.9 ± 1.6	< 0.001
STE1	11.2 ± 6.4	10.6 ± 7.5	11.9 ± 4.9	> 0.05
STE2	5.9 ± 4.2	3.5 ± 2.7	8.7 ± 3.9	< 0.001

All variables are presented as mean ± standard deviation; STE1 — the sum of ST segment elevations at baseline; STE2 — the sum of ST segment elevations at 90 minutes

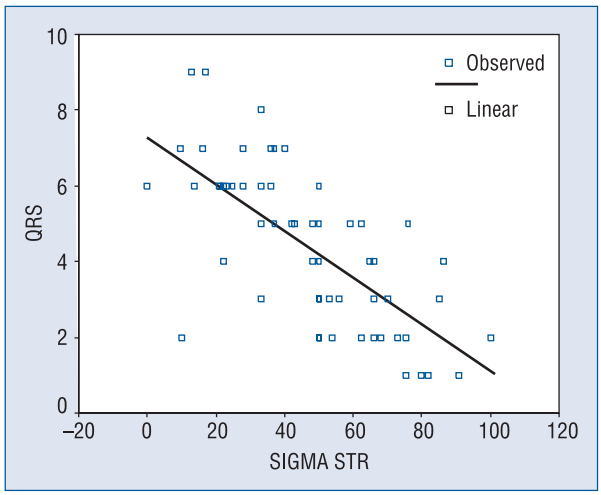

Figure 1. Linear regression curve showing a highly significant negative correlation between QRS score and ΣST segment resolution.

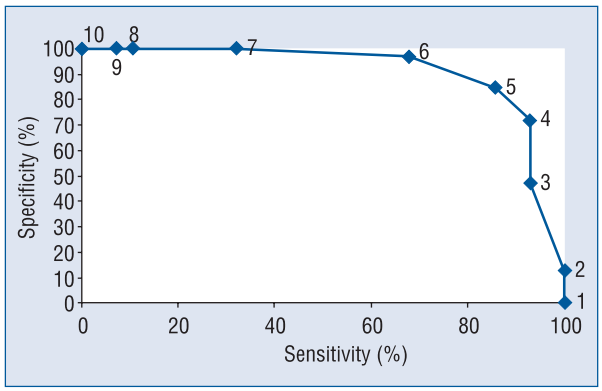

Figure 2. Receiver operating characteristic (ROC) curve showing the optimal cut-off point of QRS score that best predicts ΣST segment resolution < 50%.

-resolution group (2.88 ± 1.34 *vs* 5.93 ± 1.56 respectively, p < 0.001).

There was a highly significant negative correlation between QRS score and ΣSTR with a correlation coefficient r = –0.76 (Fig. 1). Receiver operating characteristic (ROC) curves identified a cut-off value of ≥ 4 as the optimal cut-off value of QRS score that best predicted ΣSTR < 50% of STE1. Using this cut-off value, the QRS score had a sensitivity of 93%, specificity of 72%, positive and negative predictive values of 74% and 92% respectively, for predicting ΣSTR < 50% of STE1 (Fig. 2).

Discussion

The prognostic value of ST segment resolution has been extensively studied in thrombolysis trials, showing that patients with acute STEMI who have incomplete ST segment resolution are more prone to have persistent infarct-related artery occlusion [9], larger infarct size [10], and a higher risk of death and congestive heart failure [11]. On the other hand, it was established that complete ST segment resolution is a powerful predictor of infarct-related artery patency and preserved myocardial tissue perfusion [3, 4]. In this regard, the presence of abnormal Q waves on admission in patients with acute STEMI can predict slower and less complete ST segment resolution, thus reflecting reduced myocardial perfusion even with patent infarct-related artery [12].

Previously, one study with Doppler guidewire demonstrated that coronary flow velocity pattern specific to substantial no-reflow was found at the moment of reperfusion in some patients. These patients had a larger number of Q waves before reperfusion, as compared to their counterparts with velocity pattern characteristic of microvascular perfusion [13]. Moreover, a former study showed that abnormal Q waves on admission were associated with higher peak creatine kinase values, and higher prevalence of heart failure and mortality in patients with anterior myocardial infarction [14].

Ideally, an early prognostic indicator in patients with acute myocardial infarction should be simple, rapid, non-invasive and easy to perform in all patients. An assessment by ECG would fulfill all of these criteria [11]. It has been demonstrated that the presence of Q waves at presentation in patients

with first acute STEMI reflects a more advanced stage of the infarction [5]. Although the Selvester QRS scoring system has gone originally developed to estimate 'electrocardiographically' the infarct size in a well-established infarction, we sought to employ it (in a simplified form) to quantify the QRS complexes during an early stage of an ongoing infarction process. In this way, we hypothesized, we could have a measure of 'how advanced the infarction process was. We adopted the '< 50%' ST segment resolution as a cut-off level to predict failed reperfusion, since it was formerly recognized as a marker of failed thrombolysis [15], unfavorable prognosis, and was even regarded as a recruitment criterion for rescue angioplasty [16].

Prior work used Q wave cut-offs from the Selvester scoring system combined with analysis of the T wave amplitude to formulate the 'Anderson-Wilkins Acuteness Score' aiming to explore the acuteness of ischemia in cases of STEMI and hence predict the potential benefit from reperfusion therapy [17–21]. It may be that the 'Anderson-Wilkins Acuteness Score' can be improved by incorporating more criteria from the Selvester score. Therefore, it would be valuable to see if the more complete QRS score provides value over what is now just Q wave measurements in the Anderson-Wilkins score (along with T wave amplitude measurements).

The current study demonstrated that a 'simplified form' of the Selvester QRS score can reliably identify patients with acute STEMI who would achieve successful ST segment resolution after receiving fibrinolytic therapy. In these patients, a cut-off value of ≥ 4 of the simplified QRS score could best isolate those who would have inadequate ST segment resolution after this therapy. Patients presenting beyond the time window of benefit from fibrinolytic therapy (more than 12 h after symptom onset), sometimes have persistent symptoms. In these patients, giving fibrinolytic therapy might still have a probable, though doubtful, role. Thus, it seems appealing to identify those who are more likely to benefit from fibrinolysis in this patient category. Evaluation of the width and amplitude of QRS complexes in admission ECG recordings (and hence calculation of the QRS score) would simply and readily offer the chance for this stratification. In this way, one would avoid giving fibrinolytic therapy (with its notorious risk of bleeding) to patients who are less likely to get its benefit, and restrict it only to those who are more likely to improve.

Moreover, 'silent' acute myocardial infarction can be incidentally discovered in ECG recordings of patients presenting with symptoms other than chest pain, especially diabetics and patients who develop infarction under general anesthesia. In these patients, it is often hard to delineate precisely the time of onset of infarction, and consequently it is not clear whether the patient still lies within the time window of thrombolysis. Under this situation, estimation of the QRS score would reliably offer the opportunity to recognize patients who are more likely to benefit from fibrinolytic regimens. Furthermore, even among patients presenting within the time window of thrombolysis, some have an unusually elevated risk of bleeding (for example, elderly patients). In these patients, finding a high QRS score (at or above the cut-off value of 4) would be a compelling factor against giving a fibrinolytic regimen.

Formerly, one study concluded that a high QRS score is an independent predictor of incomplete ST segment recovery and 30-day major cardiac events in patients with STEMI treated with primary percutaneous coronary intervention [5]. Evidence suggests that the extent of myocardial salvage when reperfusion is achieved with percutaneous intervention is less time-dependent than that for thrombolysis. The mechanisms underlying this disparity are as yet unclear. However, they may include restoration of full antegrade flow in the infarct-related artery with percutaneous intervention, and decreasing efficacy of fibrinolytic agents as coronary thrombi mature with the passage of time [22]. Therefore, evaluating 'how far the infarction process has gone' would seem more essential in the setting of reperfusion by fibrinolytic regimens than when it is intended by means of primary intervention.

Anterior (rather than inferior) infarction was more prevalent in the group with incomplete ST segment resolution (the non-resolution group). Concordantly, De Lemos et al. [16] demonstrated that patients with anterior infarction develop significantly less ST segment resolution than those with inferior infarction despite only modest differences in epicardial blood flow. This suggests that ST resolution correlates less with epicardial blood flow in patients with anterior versus inferior infarction. The frequent (normal) presence of J point elevation in the precordial leads might serve to reduce the extent of ST segment resolution that would, otherwise, be observed. Furthermore, anterior infarction is often associated with a larger infarct size and greater tissue injury than inferior infarction [16].

Unsurprisingly, symptoms of left ventricular dysfunction were commoner in patients with incomplete ST segment resolution (the non-resolution group). Similarly, Iwakura et al. [23] noted that pa-

tients with no-reflow evidenced by myocardial contrast echocardiography, had a significantly higher Killip class on hospital admission than those with no evidence of no-reflow. Insufficient myocardial perfusion at tissue level would lead to loss of more contractile units, something that would translate into poorer contractile function and pump failure.

Limitations of the study

Our findings are based on a single center study with a relatively small cohort size; a fact that makes it difficult to generalize our results to cover all patients with acute STEMI. Multicenter studies using the same protocol and examining a larger number of patients are needed before firm conclusions can be adequately made. Furthermore, the performance of an absolute QRS score partition value might be modified by the proximity of the single artery occlusion: an advanced small infarction due to more distal occlusion with a small QRS score might not be expected to 'reperfuse' as much as a proximal obstruction that is associated with an early and reversible injury, and that might have eventually a similar total score. Moreover, adequate follow-up is needed to reveal whether the QRS score can predict the occurrence of major adverse cardiac events in the short and long term. Finally, considering the modest reperfusion rates of streptokinase, it is not known exactly how many patients eventually achieved successful reperfusion. Adequate tissue reperfusion would be more precisely evaluated by other techniques such as myocardial contrast echocardiography. Comparing both the later-phase and pre-discharge QRS score findings in these patients would add further value in demonstrating the 'ultimate' infarct size in the group with adequate, as well as inadequate, ST segment resolution. This question remains open for future research.

Conclusions

A 'simplified form' of the Selvester QRS score can reliably predict the occurrence of adequate ST segment resolution in patients with first acute STEMI receiving fibrinolytic therapy. Using the cut-off value of ≥ 4, the QRS score can predict inadequate ST segment resolution with a high sensitivity and an acceptable specificity.

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