

Changes of electrocardiographic and echocardiographic data after early and late mechanical recanalization of infarct-related artery with and without stent implantation

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Summary. *Objective.* To show differences in the changes of electrocardiographic and echocardiographic data after early and late mechanical recanalization of infarct related artery with and without stent implantation and to assess the value of QRS score in the follow-up period.

Material and methods. A total of 248 consecutive patients were divided into these groups: early angioplasty (≤ 24 hours) without stents ($n=114$) or with stents ($n=6$) and later (> 24 hours) angioplasty without stents ($n=114$) or with stents ($n=14$). The changes in QRS score and echocardiographic left ventricular ejection fraction during the hospital and 3-month follow-up periods were compared between the groups.

Results. QRS score did not increase in a hospital in early or late angioplasty with stents groups, while in the groups without stents especially of early angioplasty increased (2.6 ± 2.5 vs. 3.6 ± 2.4 , $P=0.001$). Left ventricular ejection fraction increased after 3 months only in early angioplasty groups especially with stents (30.0 ± 3.5 vs. 38.4 ± 5.2 , $P=0.008$), but there were no significant differences between the QRS score at discharge and after 3 months (5.4 ± 4.3 vs. 5.0 ± 1.9).

Conclusions. Myocardial injury did not increase in a hospital in the cases of early or late angioplasty with stents, while in the cases without stents increased. Left ventricular ejection fraction increased after 3 months only in the cases of early angioplasty especially with the stent implantation, but the QRS score showed no differences, so the QRS score may be not predictive of improvement in ejection fraction at follow-up.

Introduction

Myocardial reperfusion therapy results in better function of the left ventricle (LV) and improved survival after acute myocardial infarction (AMI) in cases of early and successful recanalization of the infarct-related artery (IRA) and complete myocardial reperfusion (1, 2), but late recanalization (3 or more days after AMI) or incomplete myocardial reperfusion is associated with an increased risk of death and LV dysfunction (3, 4). Whilst improvement in perfusion is the usual finding after successful angioplasty, there is considerable disparity between the angiographic appearance of restored TIMI flow in IRA and the electrocardiographic (ECG) symptoms of myocardial tissue reperfusion insufficiency manifested by persistent ST segment elevation after recanalization (5–7). Ito *et al.* (8, 9) demonstrated that restoration of normal epicardial blood flow is not sufficient to ensure ade-

quate myocardial reperfusion; the latter requires perfusion at the level of the coronary microcirculation and myocytes. Myocardial perfusion in the distribution of the dilated artery was shown to improve progressively until 3 months, but thereafter no improvement was seen (10). Uren *et al.* (11) showed delayed recovery of coronary resistive vessel function after coronary angioplasty, which may continue for up to 3 months.

Whereas changes in ST segment dislocation amplitude have been extensively studied, the significance of QRS complex and T wave changes during reperfusion and the first days is less clear, especially when changes in the QRS complex and T wave may be complementary and additive to ST segment monitoring (12). Previous studies have shown that QRS complex is informative in the assessment of MI size and myocardial viability after reperfusion therapy (13–15). Although some authors showed that the pre-discharge

QRS score was predictive of infarct size only in patients with completely resolved ST segment and with negative T wave (16, 17), the informative value of QRS score in the acute stage of MI is undoubtedly clear. However, its value in the follow-up period is less clear since it was shown that the QRS normalization during a 1-year follow-up was unaffected by an aggressive treatment strategy with revascularization via balloon angioplasty or bypass surgery (18).

Thus, our aim was not only to show differences in the changes of electrocardiographic and echocardiographic data after early and late mechanical recanalization of IRA with and without stent implantation, but also to assess a value of QRS score in the follow-up period.

Material and methods

This study was performed prospectively on 248 consecutive patients who arrived at the Department of Cardiology, Kaunas University of Medicine, with first ST-elevation AMI diagnosed in the presence of typical chest pain greater than 30-min duration and ST segment elevation ≥ 1 mm (at the J point) in two or more contiguous leads on the 12-lead ECG and underwent early PCI (≤ 24 hours) without stent ($n=114$) or with stent implantation ($n=6$) and later PCI (>24 hours) without stent ($n=114$) or with stent implantation ($n=14$). Exclusion criteria were the following: concomitant valvular or myopathic heart disease, intraventricular conduction defects.

Serial 12-lead ECGs, recorded at admission, on the first day after PCI, at discharge, and after 3 months, were analyzed, and ECG stages of AMI were assessed by the following criteria (19):

I stage – the ST segment elevation ≥ 0.1 mV, a positive T wave, no abnormal Q wave.

II stage – the ST segment elevation ≥ 0.1 mV, abnormal Q wave. In accordance with Selvester QRS scoring system (20), Q wave was considered abnormal, if it was present in leads V1, V2, V3, or it was ≥ 20 ms in lead V4, or it was ≥ 30 ms in any other lead except III and aVR.

III stage – the ST segment is still elevated but a negative T wave has started to form.

IV stage – the ST segment is in isoelectric line with the negative T wave.

Selvester QRS score simplified and modified by Wagner *et al.* (21) was measured manually by single observer for each electrocardiogram.

Echocardiographic LV ejection fraction in accordance with the guidelines set by the American Society

of Echocardiography (22) was measured at admission, at discharge, and after 3 months.

Statistical analysis

Values were expressed as the mean \pm standard deviation. Statistical significance was accepted when the probability value was $P < 0.05$. Differences in continuous variables between the two groups were assessed using unpaired Student's *t* test. Differences in the same groups between the baseline data and at 3 months were assessed using paired *t* test.

Results

Baseline characteristics

There were no significant differences in AMI location among four patient groups: anterior-lateral/inferior-posterior/mixt MI – 40/68/6 and 2/3/1 in the cases of early PCI (without and with stents, respectively) and 51/54/9 and 6/6/2 in the cases of later PCI (without and with stents, respectively), gender: female only 7% and 10.5% in the cases of early and later PCI without stents, respectively, and 0 and 7% in the groups of early and later PCI with stents, respectively, as well as in the age of patients and QRS score at admission (Table). However, the baseline echocardiographic LV ejection fraction was lower in the cases of early PCI (without or with stents) than in the cases of later PCI. Naturally, patients had later ECG stage of AMI in cases of later PCI (without or with stents).

Changes in electrocardiographic and echocardiographic data

While there were no significant differences in QRS score among four patient groups at admission, but it was greater in the cases of early than late PCI (without or with stents) after PCI and at discharge from a hospital (Table). QRS score at discharge was greater than at admission only in the cases of PCI without stent implantation (early or late).

There were no significant differences between the QRS score at discharge and after 3 months in all groups. However, echocardiographic LV ejection fraction increased after 3 months in the cases of early PCI, especially in the cases of early PCI with stent implantation.

Discussion

Because final infarct size is a major determinant of LV function, a relation between QRS score and LV ejection fraction could be expected. However, previous studies showed that the relationship between

Table. Patient groups of early and late PCI without and with stent implantation

| | Characteristic | Early PCI | | | Late PCI | | |
|---|---|-------------------------------|------------------------|------|----------------------------|------------------------|-------|
| | | without stents (n=114) | with stents (n=6) | P | without stents (n=114) | with stents (n=14) | P |
| 1 | Age (years) | 58.2±10.6 | 54.5±9.5 | | 58.9±10.7 | 57.6±15.1 | |
| 2 | ECG stage at admission | 1.7±0.8 | 1.8±0.7 | | 2.6±1.2 | 2.7±1.4 | |
| 3 | QRS score at admission | 2.6±2.5 | 3.3±2.1 | | 2.5±2.4 | 2.0±1.8 | |
| 4 | Echocardiographic left ventricular ejection fraction at admission | 40.0±7.4 | 33.8±7.2 | 0.02 | 43.4±8.4 | 44.1±7.2 | |
| 5 | ECG stage after PCI | 2.9±0.9 | 3.0±1.1 | | 3.3±0.9 | 3.6±0.8 | |
| 6 | QRS score after PCI | 3.6±2.5 | 4.2±2.3 | | 2.9±2.1 | 2.4±1.7 | |
| 7 | ECG stage at discharge | 3.7±0.7 | 3.8±1 | | 3.9±0.5 | 4.1±0.7 | |
| 8 | QRS score at discharge | 3.6±2.4 | 4.8 ±4.1 | | 3.0±2.2 | 1.4±1.6 | 0.004 |
| 9 | After 3 months/at discharge | (n=40) | (n=5) | | (n=44) | (n=5) | |
| | QRS score | 3.9±0.6/ 3.5±2.3 | 5.0±1.9/ 5.4±4.3 | | 2.2±1.8/ 2.3±2.0 | 1.8±1.8/ 1.6±1.7 | |
| | Echocardiographic left ventricular ejection fraction | 41.9±7.3/ 39.4±6.0* | 38.4±5.2/ 30.0±3.5° | | 43.5±6.8/ 39.9±8.9 | 45.0±3.1/ 40.4±10.0 | |
| | P | | | | | | |
| | 2 – 5 | 0.00001 | 0.02 | | 0.00001 | 0.02 | |
| | 3 – 6 | 0.0009 | | | | | |
| | 3 – 8 | 0.001 | | | 0.05 | | |
| | | without stents early/late PCI | | | with stents early/late PCI | | |
| | 2 | 0.00001 | | | | | |
| | 4 | 0.0007 | | | 0.004 | | |
| | 6 | 0.007 | | | 0.03 | | |
| | 8 | 0.02 | | | 0.007 | | |

Values are expressed as mean±SD.

*P=0.04, °P=0.008.

QRS score after thrombolytic therapy on day 7 and ejection fraction at 1 month was not linear (the authors concluded that it is likely to reflect effects of ventricular loading conditions and compensatory changes in contractile function of noninfarcted regions on the ejection fraction) (14) and that the QRS normalization during 1-year follow-up seems unaffected by an aggressive treatment strategy with revascularization via balloon angioplasty or bypass surgery, since the considerable normalization of the QRS complex also occurs after AMI treated with thrombolytic therapy (18). In both these studies, the ECGs were scored with the complete Selvester 32-point scoring system. Our previous study using 29-point Selvester QRS score simplified and modified by Wagner and our method of recanalizational effectiveness assessment by the rate

of changes in ECG stages showed that thrombolysis gives positive impact on subsequent myocardial functional recovery only in cases of sufficient myocardial reperfusion, although the QRS score decreased during 3-year follow-up in the group of insufficient myocardial reperfusion after thrombolysis as well as in the group of sufficient myocardial reperfusion after thrombolysis (23). Adler *et al.* (17) also showed that the predischarge 32-point QRS score was predictive of infarct size only in those in whom ST elevation after intravenous thrombolysis or percutaneous transluminal revascularization resolved completely. The present study shows that QRS score alone is not predictive of improvement in LV ejection fraction at follow-up, because echocardiographic ejection fraction increased after 3 months in the cases of early PCI, especially in

the cases of early PCI with stent implantation, while there were no significant differences between the QRS scores at discharge and after 3 months.

The informative value of QRS score in the acute stage of MI is undoubtedly clear (13–15), so our study also showed that myocardial injury estimated by QRS score did not increase from admission to a hospital until discharge in the cases of PCI (early or late) with stent implantation, while in the cases of PCI without the stent implantation, especially in the cases of early PCI without stent implantation, it increased.

Limitations

The main limitation of this study is the differences in LV ejection fraction at admission: the baseline ejection fraction at admission was already lower in the groups of early PCI than late PCI (without or with stents) and in the group of early PCI without stents was greater than in the group of early PCI with stents. Nevertheless, changes of QRS score in a hospital showed better results in the cases of PCI with stents than without stents and changes of LV ejection fraction at follow-up showed better results in the cases of early PCI, especially with the stent implantation, than in

the cases of more late PCI, though LV ejection fraction at admission was the least in the group of early PCI with the stent implantation.

Another limitation of this study is a small number of patients examined at follow-up, so after 3 months assessing the ECG and echocardiographic data, at discharge we analyzed only the data of those patients who arrived after 3 months (Table).

Conclusions

Myocardial injury estimated by QRS score did not increase from admission to a hospital until discharge in the cases of coronary angioplasty with stent implantation (early or late), while in the cases of coronary angioplasty without stent implantation, especially in the cases of early angioplasty without stent implantation, it increased. Echocardiographic left ventricular ejection fraction increased after 3 months in the cases of early coronary angioplasty, especially in the cases of early angioplasty with stent implantation, but there were no significant differences between the QRS score at discharge and after 3 months, so the QRS score may be not predictive of improvement in left ventricular ejection fraction at follow-up.

Elektrokardiografiniai ir echokardiografiniai pokyčiai po miokardo infarktą sukėlusios arterijų angioplastikos

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Raktažodžiai: elektrokardiograma, miokardo infarktas, vainikinių arterijų angioplastika.

Santrauka. Darbo tikslas. Nustatyti skirtumus tarp elektrokardiografinių ir echokardiografinių pokyčių ištikus miokardo infarktui po ankstyvosios ir atidėtos perkutaninės angioplastikos neimplantavus stento ir implantavus stentą bei įvertinti QRS indekso reikšmę vėlyvuju laikotarpiu.

Tyrimo medžiaga ir metodai. Iš eilės tirti 248 ligoniai ir suskirstyti į grupes: ankstyvosios (≤ 24 val.) angioplastikos grupę neimplantavus stento ($n=114$) arba implantavus stentą ($n=6$) ir vėlyvesnės (>24 val.) angioplastikos grupę neimplantavus stento ($n=114$) arba implantavus stentą ($n=14$). Palyginta šių grupių ligonių QRS indekso ir echokardiografinės kairiojo skilvelio išstūmimo frakcijos dinamika ligoninėje ir praėjus 3 mėn. po angioplastikos.

Rezultatai. QRS indeksas nepadidėjo stacionariu laikotarpiu ir atidėtos angioplastikos implantavus stentą grupėse, bet grupėse ligonių, kuriems neimplantuoti stentai, ypač ankstyvosios angioplastikos grupėse, padidėjo: $2,6 \pm 2,5$ vs. $3,6 \pm 2,4$, $p=0,001$. Kairiojo skilvelio išstūmimo frakcija padidėjo po 3 mėn. tik ankstyvosios angioplastikos grupėse, ypač implantavus stentą: $30,0 \pm 3,5$ vs. $38,4 \pm 5,2$, $p=0,008$, bet QRS indeksas išrašant iš ligoninės ir praėjus 3 mėn. reikšmingai nesiskyrė: $5,4 \pm 4,3$ vs. $5,0 \pm 1,9$.

Išvados. Miokardo pažeidimas stacionariu laikotarpiu reikšmingai nedidėjo ankstyvosios ir atidėtos perkutaninės angioplastikos grupėse implantavus stentą, tuo tarpu neimplantavus stento, padidėjo. Kairiojo skilvelio išstūmimo frakcija padidėjo po 3 mėn. tik ankstyvosios angioplastikos grupėje, ypač implantavus stentą, bet QRS indekso skirtumų nenustatyta. Taigi QRS indeksas gali nerodyti išstūmimo frakcijos pagerėjimo vėlyvuju laikotarpiu.

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