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DETECTION OF VIABLE MYOCARDIUM DURING DOBUTAMINE ECHOCARDIOGRAPHY USING DOPPLER MYOCARDIAL IMAGING IN PATIENTS WITH RECENT MYOCARDIAL INFARCTION

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Summary. *The aim of this study was a quantitative assessment of regional systolic and diastolic myocardial velocity in basal condition and during dobutaimine echocardiography in viable and in non-viable myocardial segments using pulsed wave Doppler myocardial imaging (PW-DMI).*
In the group of 34 patients, 13±3 days after acute myocardial infarction low dose dobutamine echocardiography (LDDE) was performed. Viability was defined as an improvement of wall motion during LDDE in dyssynergic left ventricular segment. Before and after LDDE wall motion score (WMS) was calculated. Apical views were used to assess myocardial velocity at baseline and after LDDE. In each of 11 left ventricular segments, peak early (E) and late (A) diastolic velocities and systolic (S) velocity were measured and ratio E/A was calculated.
At baseline echocardiography 122 (32.6%) left ventricle segments were dyssynergic. During LDDE 51 (41.8%) viable myocardial segments in 16 (47%) patients were detected, while 71 segments were non-viable. In patients with viable myocardial segments WMS decreased significantly (P<0.001) after LDDE.
Baseline values of E and S myocardial velocities and E/A ratio were significantly higher (P<0.005 and P<0.01 and P<0.001) in viable compared to non-viable myocardial segments. Viability by PW-DMI sampling at LDDE corresponded with an significant improvement of E (P<0.01), S (P<0.005) velocities and E/A ratio (P<0.05) compared to the baseline values.
In conclusion, PW-DMI allows quantitative assessment of regional systolic and diastolic myocardial velocities and detection of viable myocardium in basal condition and during LDDE.

Key words: *Viable myocardium, Doppler myocardial imaging, dobutamine echocardiography, recent myocardial infarction*

Introduction

In patients with recent myocardial infarction, the most important questions are the transmural extent of necrosis, the state of the residual infarct-related artery and the presence and extent of viable myocardium (1). The question is how to identify patients with dysfunctional myocardium that is still viable and has the potential for functional recovery. The methods that have been used to assess myocardial viability include positron emission tomography and F18-fluorodeoxyglucose (2). Dobutamine stress echocardiography has also been used by some groups to study myocardial viability, particularly in low dose protocols used to evaluate myocardial contractile reserve (3,4). It is an expensive, noninvasive, readily available and accurate method of identifying contractile reserve in myocardial regions with resting wall motion abnormalities. However dobutamine echocardiography has some potential limitations. During standard dobutamine echocardiography only regional systolic function can be assessed. Another limitation is that it is only a semiquantitative method. The new technique of pulsed-wave Doppler myocardial imaging (PW-DMI) can compensate conventional stress echocardiography limitation by offering quantitative measurements of regional myocardial velocitiy and analyzing both regional systolic and diastolic function (5,6).

The purpose of the study was a quantitative assessment of regional systolic and diastolic myocardial velocity in basal conditions and during dobutamine echocardiography (DE) in viable and in non-viable myocardial segments in patients with recent myocardial infarction using PW-DMI.

Methods

Study population: Thirty-four patients (28 males and 6 females, mean age 54.7±8.6 years) 13±3 days after acute myocardial infarction were examined. Patients with postinfarction angina, congestive heart failure, cardiomyopathy, valvular heart disease, arrhythmias, intraventricular conduction disturbances, pericar-

ditis, pulmonary hypertension and poor basal echocardiographic window were excluded from the study. Beta blocker administration was interrupted before the study. The study protocol was approved by the hospital Ethics Committee and all patients gave informed consent.

Dobutamine stress echocardiography: After obtaining a baseline electrocardiogram and echocardiogram (Acuson-Sequoia C256, Mountain View, CA, USA, harmonic mode) in all patients dobutamine was infused at a starting dose of 5 mcg/kg/min for 5 min, followed by 10 mcg/kg/min for 5 min - low dose DE (LDDE). Before, during and up to 10 min after drug administration continuous ECG and two-dimensional echocardiogram were monitored, and 12-lead ECG and blood pressure at each step of the test were recorded. Two-dimensional echocardiogram in the apical 4-5 and 2-chamber views, was monitored throughout the test. Digital acquisition of images and side-by-side display on cine-loops were used. Endpoints of the test included completion of the protocol, improvement in wall motion in dyssynergic segments, detection of worsening wall motion, ST-segment deviation >2 mm, systolic blood pressure >220 mmHg or diastolic blood pressure >120 mmHg, significant symptoms or arrhythmias.

Doppler myocardial imaging: At baseline and after dobutamine infusion in all patients PW-DMI studies were performed using apical transthoracic echocardiographic Doppler spectrum. PW-DMI recording was obtained by positioning a sample volume in each of the 11 myocardial wall segments. Wall motion velocity was then detected throughout each cardiac cycle and displayed in the graphic format of a Doppler spectrum. Peak systolic (S), early (E) and late (A) diastolic myocardial velocity were measured and E/A ratio was calculated. For each segment a frozen image of the PW-DMI signals from three consecutive cardiac cycles was obtained at the end of datum acquisition sequence for of-line analysis. The final value represented the mean of three consecutive cardiac cycles.

Echocardiographic analysis: Echocardiographic images were evaluated using side-by-side display on cine-loops. The left ventricle was divided into 11 segments according to a model derived from that proposed by Edwards et al (7) and modified to consider the apex as a single segment (8). Left ventricular wall motion was assessed quantitatively and graded as normal, hypokinetic, akinetic or dyskinetic. A score from 1 (normal) to 4 (dyskinetic) was assigned to each segment under basal condition and after LDDE and wall motion score (WMS) was calculated before and after LDDE by summation of the individual segment scores. Criterion for myocardial viability was an improvement in contractility of one or more than one grade during LDDE in dyssynergic left ventricle segment.

Results

During LDDE ventricular arrhythmias occurred in 3 (8.8%) patients and supraventicular in one patient. No patients had sustained arrhythmia, significant increased in blood pressure, worsening of wall motion or significant symptoms and none required interruption of the test.

At baseline echocardiography 122 (32.6%) left ventricular segments were dyssynergic; severe hypokinesia in 61 (50%); akinesia in 49 (40.2%) and dyskinesis in 12 (9.8%). Per patient the mean number of dyssynergic segments was 3.6±1.9. During LDDE 51 (41.8%) viable myocardial segments in 16 (47%) patients were detected, while 71 segments were non viable. In patients with viable myocardial segments value of WMS was significantly less (P<0.001) after LDDE compared to the baseline values (Figure 1). Myocardial velocities were measured in 105 (86%) out of 122 dyssynergic segments: in 47 (92.2%) viable and in 58 (81.7%) non-viable myocardial segments.

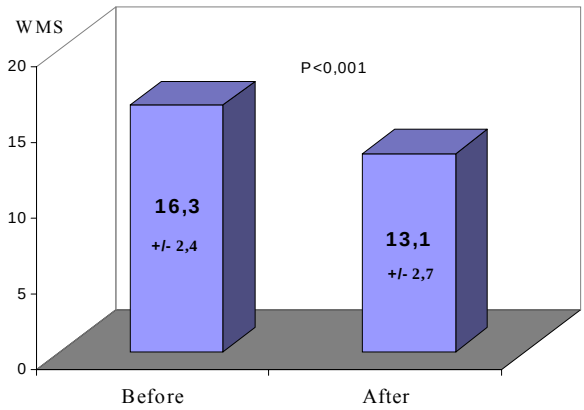

Fig. 1. Value of wall motion score (WMS) before and after low-dose of dobutamine in patients with viable myocardium

Baseline values of peak E diastolic velocity (P<0.005), S velocity (P<0.01) and E/A ratio (P<0.001) in viable myocardial segments were significantly higher, compared to the values of the same parameters in non-viable myocardial segments (Table 1). After LDDE in viable myocardial segments peak E diastolic velocity, S velocity and E/A ratio increased significantly (P<0.01, P<0.005 and P<0.05) and A diastolic velocity was higher compared to the values before LDDE (table 2). In non-viable myocardial segments no improvement of myocardial velocity after LDDE was detected.

Table 1. Baseline values of peak early (E) and late (A) diastolic velocity, systolic (S) velocity and E/A ratio in viable and non-viable myocardial segments

Parameters	Viable	Non-viable	P
E (cm/s)	6.70 ± 1.70	5.60 ± 2.10	0.005
A (cm/s)	7.80 ± 1.50	7.40 ± 1.90	NS
E/A ratio	0.86 ± 0.12	0.75 ± 0.19	0.001
S (cm/s)	6.50 ± 1.90	5.40 ± 2.20	0.01

Table 2. Values of peak early (E) and late (A) diastolic velocity, systolic (S) velocity and E/A ratio in viable myocardial segments before and after low-dose dobutamine echocardiography (LDDE)

Parameters	Before LDDE	After LDDE	P
E (cm/s)	6.70 ± 1.70	7.80 ± 2.10	0.01
A (cm/s)	7.80 ± 1.50	8.50 ± 1.90	NS
E/A ratio	0.86 ± 0.12	0.92 ± 0.18	0.05
S (cm/s)	6.50 ± 1.90	7.90 ± 2.30	0.005

Discussion

Left ventricular systolic function is a major determinant of long-term prognosis in patients with coronary artery disease (9). It is also clear that a subset of patients with impaired left ventricular function can improve substantially after revascularization (10). This translates into prolonged survival and a decrease in heart failure symptoms. That's why the differentiation between viable and non-viable tissue is of great clinical importance. A large variety of techniques have been introduced to assess viable myocardium and the most cost-effective imaging techniques to detect reversible contractile function currently are stress echocardiography and nuclear perfusion/metabolism imaging.

Today dobutamine echocardiography has become a useful diagnostic tool for the detection of myocardial viability. Several protocols of dobutamine administration have been proposed (3). In the present study we used low-dose dobutamine (5 and 10 mcg/kg/min; 5 min step) infusion protocol. As shown in a previous study, in the "classic" low-dose stepwise protocol (3 min step), sufficient dobutamine plasma concentrations might not be achieved to evaluate improved wall thickening in all patients (11). In all patients a significant plasma dobutamine concentration to evaluate improved wall thickening was achieved after a 6 min infusion period. We therefore assessed improved wall thickening after a 10 min dobutamine infusion.

Viable myocardial regions have a positive inotropic reserve, which can be stimulated by dobutamine and detected by echocardiography. We demonstrated significant reduction of WMS in patients in whom viable myocardium at LDDE was detected.

Echocardiography has the advantage of widespread availability, but subjective evaluation remains a limitation (12). The new PW-DMI technique compensates standard stress echocardiography limitations, with the advantages of regional ventricular wall dynamics quantification and analyzing both regional systolic and diastolic function.

So far, few reports indicate the potential of Doppler myocardial imaging and more particularly PW-DMI sampling, to detect myocardial viability (13,14). Our results confirm that PW-DMI is a useful technique in the quantification of regional myocardial velocity and can indicate the presence of viable myocardium in basal conditions as well as during LDDE. We showed significantly higher baseline values of peak E diastolic velocity, S velocity and E/A ratio in viable compared to non-viable myocardial segments. In our study peak ejection velocity of non-viable myocardium reproduced velocity values of dysfunctional myocardium found by Katz et al (15) and Yamada et al (16).

In the present study we showed that viability by PW-DMI sampling at LDDE corresponded with an significant improvement in segmental peak E diastolic velocity, S velocity and ratio E/A compared to baseline values. Our results are similar to those reported by Rambaldi et al (17) who described the use of PW-DMI in a series of 40 patients during LDDE and showed that ejection velocities were significantly higher in viable compared to non-viable myocardial segments.

Conclusions

In patients with recent myocardial infarction, PW-DMI allows quantification of regional systolic and diastolic myocardial velocity and detection of viable myocardial segments.

Values of peak E diastolic and systolic myocardial velocities and E/A ratio are significantly higher in viable compared to non-viable myocardial segments.

Improvement of systolic and diastolic myocardial velocities and E/A ratio during LDDE is associated with the presence of viable myocardium.

The association of an improvement of wall motion and regional myocardial velocity will increase the sensitivity and the diagnostic capacity of the echocardiography in detecting viable myocardium.

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DETEKCIJA VIABILNOG MIOKARDA TOKOM DOBUTAMIN EHOKARDIOGRAFSKOG TESTA PRIMENOM MIOKARDNOG DOPPLERA U BOLESNIKA SA SKORAŠNJIM INFARKTOM MIOKARDA

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Kratak sadržaj: *Cilj studije bio je kvantitativna procena regionalnih sistolnih i dijastolnih brzina miokarda u bazalnim uslovima i tokom dobutamin ehokardiografskog testa u viabilnim (živo miokardno tkivo) i neviabilnim segmentima miokarda leve komore primenom pulsnog miokardnog Dopplera (PW-DMI).*
Grupi od 34 bolesnika, 13±3 dana posle akutnog infarkta miokarda uradjen je ehokardiografski test primenom malih doza dobutamina (LDDE). Viabilnost miokarda definisana je kao popravljanje regionalne zidne pokretljivosti tokom LDDE u segmentima leve komore koji su u bazalnim uslovima ispoljili disinergiju. Pre i posle LDDE izračunavan je skor zidne pokretljivosti (WMS). Miokardne brzine odredjivane su pre i posle LDDE iz apikalnih preseka leve komore. U svakom od 11 segmenata leve komore, merena je maksimalna sistolna (S) brzina, rana (E) i kasna (A) dijastolna brzina miokarda i izračunavan odnos E/A. Ehokardiografskim pregledom u bazalnim uslovima registrovana je disinergija u 122 (32,6%) segmenta leve komore. Tokom LDDE 51 (41,8%) segment kod 16 (47%) bolesnika ispoljio je viabilnost, dok je 71 segment bio neviabilan. Posle LDDE, u bolesnika sa viabilnim segmentima miokarda leve komore registrovano je značajno smanjenje WMS ($P<0,001$). Bazalne vrednosti miokardnih brzina E i S i odnosa E/A bile su značajno veće ($P<0,005$; $P<0,01$ i $0,001$) u viabilnim u poredjenju sa neviabilnim segmentima miokarda. Odredjeno parametrima PW-DMI, tokom LDDE, prisustvo viabilnog miokarda karakteriše značajno povećanje E ($P<0,01$), S ($P<0,005$) miokardnih brzina i odnosa E/A ($P<0,05$) u poredjenju sa bazalnim vrednostima.
Naša studija je pokazala da primena PW-DMI pruža mogućnost kvantitativne procene regionalnih sistolnih i dijastolnih miokardnih brzina, a time i otkrivanje viabilnog miokarda kako u bazalnim uslovima, tako i tokom LDDE.

Ključne reči: *Viabilni miokard, miokardni Doppler, dobutamin ehokardiografija, skorašnji infarkt miokarda*