ASSESSMENT OF MYOCARDIAL VIABILITY WITH DOBUTAMINE STRESS ECHOCARDIOGRAPHY IN PATIENTS WITH LOW EJECTION FRACTIONS AND DIABETES MELLITUS TYPE II

Vladimir Miloradović1, Nikola Jagić1, Dejan Petrović1, Marija Popovic1
1 Clinic for Internal medicine, Clinical Center Kragujevac, Serbia
2 Center for Cardiology, Clinical, Centre Kragujevac, Serbia
3 Center for Urology and Nephrology, Clinical Center Kragujevac, Serbia

EIHOKARDIOGRAFJSKA PROCENA VITALNOG MIOKARDA DOBUTAMIN STRES EIHOKARDIOGRAFIJOM KOD PACIJENATA SA NISKOM EJEKCIONOM FRAKCIJOM I DIJABETES MELLITUSOM

Vladimir Miloradović1, Nikola Jagić1, Dejan Petrović1 i Marija Popović1
1 Interna klinika Klinički centar Kragujevac, Srbija
2 Centar za radiologiju Klinički centar Kragujevac, Srbija
3 Centar za urologiju i nefrologiju Klinički centar Kragujevac, Srbija

Received / Primljen: 21. 7. 2010. Accepted / Prihvaćen: 11. 5. 2010.

Introduction
The prediction of improvements in left ventricular ejection fraction (EF) after revascularisation in patients with ischemic cardiomyopathy relies only on the extent of viable myocardium. The amounts of viable tissue and scar tissue are important but their relationship is different in diabetic and non-diabetic patients.

Design and Methods:
This study included 50 patients with a low EF (EF<40% by the Simpsons method) divided into two groups. The first group consisted of 30 patients with registered coronary artery disease and normal glyceregulation, and the second group consisted of 20 patients with diabetes mellitus and registered coronary artery disease. All patients underwent dobutamine stress echocardiography before surgical revascularisation and 8 weeks after surgery (2-5 months). Dobutamine infusion was terminated at 15 μg/kg/min.

Results:
The mean number of hypokinetic segments was 4.32±2.9 before testing, 1.9±2.07 at a 15 μg/kg/min dose of dobutamine, 2.5±2.12 after revascularisation in the group with diabetes mellitus type II and 4.77±2.11, 1.87±2.18, and 2.97±2.28, respectively, in the group without diabetes mellitus type II. The mean number of akinetic segments was 5.95±2.63, 5.45±2.65 and 5.35±2.62 in the group with diabetes mellitus type II and 4.57±1.68, 3.5±2.26, 3.2±2.16 in the group without diabetes mellitus type II. The wall motion score index (WMSI) was 1.99±0.32 before test and 1.86±0.31 after revascularisation in the first group and 1.85±0.27 and 1.58±0.24, respectively, in the second group. The sensitivity for the detection of viable myocardium was 100% CI (93%-100%) in both groups, and the specificity was 96% CI (93%-98%) in the group with diabetes mellitus type II and 91% (89%-95%) in the group without diabetes mellitus type II.

Conclusions:
Our study shows that recovery of function occurs in a sizeable number of revascularised dysfunctional segments. This method was very helpful for the assessment of truly "viable" segments in patients with a poor prognosis.

Key words:
dobutamin, echocardiography, diabetes mellitus
Myocardial viability is related to a deterioration in contractile function that is potentially reversible if adequate restoration of coronary circulation occurs. Recent findings have indicated that the degree of dysfunction is the main parameter influencing long-term survival in these patients (1, 2). Left ventricular (LV) dysfunction is not necessarily irreversible and can be improved after myocardial revascularisation. Patients with expressive dysfunction of the LV can gain the greatest benefit from bypass surgery because they represent the most sensitive group for the progressive loss of the contractile myocardium; however, they also have the highest mortality rate when it comes to surgical procedures. When surgical revascularisation of the myocardium is discussed, it is necessary to take into account its adequacy, graft occlusion, restenosis, and the existence of associated myocardial disease, such as LV hypertrophy. Clinicians primarily treat patients, not myocardial segments, and recent studies have taken into account global LV function, physical capacity, quality of living and mortality as the most important parameters (3). Other factors that are taken into account while defining diagnostic tests are feasibility, accessibility and the experience of the test performer. Regional myocardial dysfunction after myocardial infarction is not always manifested by irreversible damage to the entire affected tissue. Shortly after an acute ischemic event, stunned myocardium spontaneously disappears.

In 1990, stress echocardiography was used for the first time to detect vital myocardial tissue by application of small doses of dobutamine, a drug that recovers the entropic reserves, by Pierard (4). Today, this method is the gold standard due to its relatively high sensitivity, specificity and diagnostic accuracy, with a low cost of performance compared to other diagnostic techniques. The application of pharmacological echocardiography dobutamine stress testing in the most difficult group of patients with low ejection fractions, as well as the disclosure of vital tissue in diabetic patients indicated for surgical and percutaneous myocardial revascularisation is of the highest importance, primarily due to its direct impact on the outcome and prognosis of future procedures. As the literature does not provide sufficient data on either the evaluation of the vital myocardium in coronary patients with long-term diabetes mellitus type 2 or the results after myocardial revascularisation, it is important to investigate this problem, which was the aim of this study (5).

**MATERIALS AND METHODS**

The study included 50 patients with ischemic heart disease and a low ejection fraction. The research was conducted at the Clinical Center in Kragujevac and the Institute for Cardiovascular Diseases “Dedinje” in Belgrade. Patients were subjected to a dobutamine echocardiography stress test (DSE), with the addition of atropine (DASE). All patients were also subjected to coronarography and a revascularisation procedure. After revascularisation lasting for 8 weeks (a period of 2 to 5 months), an assessment of myocardial recovery was conducted.

**Analysis of study population.**

Inclusion criteria for patients were as follows: optimal ultrasound images, an end-diastolic diameter (EDD) ≥ 6.0 cm (M-mode), an ejection fraction (EF) < 40% (Simpson method) and changes in the coronary blood vessels indicative of significant coronary stenosis (> 50% diameter stenosis) verified by coronaryography. Patients were divided into two groups. The first group consisted of patients with diabetes mellitus, and the second consisted of patients without diabetes mellitus. The group with diabetes mellitus type 2 had a defined glycemic profile and a defined profile of glycosylated haemoglobin (HbA1c), as reliable parameters of adequate disease control. Patients were excluded due to the existence of any of the following: congestive heart failure, unstable angina pectoris, significant ventricular arrhythmias, severe valve disease and any contraindications for dobutamine infusion or the administration of atropine (6).

**Dobutamine infusion protocol.**

The most widely used protocol for DASE, which is used at our institution and is used in this paper, includes the following: after the basic echocardiography study, dobutamine is given intravenously at an the initial dose of 5μg/kg/min over 3 minutes, which then increases to 10μg/kg/min in the subsequent 3 minutes, and then again to 20μg/kg/min and 30μg/kg/min, up to a maximum of 40 μg/ kg/min, in three-minute intervals. If sub-maximum frequency is not achieved (calculated by the formula 220 - age x 0.85 for men or 200- age x 0.85 for women), atropine is given in a dose of 0.25 mg, up to a maximum dose of 2 mg. The echocardiogram is continuously monitored. Four views (parasternal long-axis, parasternal short-axis at the papillary muscle level, apical four-chamber, and two-chamber) are recorded at rest, at each stage of dobutamine infusion, and 3 minutes after the termination of infusion. Each of the stages of the test is digitalised directly (on-line) from four sections with the digital system of NovaMicrosonics.

**Interpretation of echocardiography findings.**

Segmental myocardial contractility was assessed according to the recommendations of the American Society for echocardiography. The left chamber is divided into 16 segments on the basis of these guidelines. The left ventricular wall motion score index (WMSI) is calculated for each stage of the test by summing the points of each segment. The contractility of each segment is determined semi-quantitatively with a score from 1 to 4, with normal contractility segments assessed as 1 (> 5mm motion of endocardium), hypokinesis assessed as 2 (< 5mm motion of endocardium), akinesia as 3 (absence of endocardium motion or < 2mm) and diskinesis as 4 (paradoxical motion to the outside during systole). The characterisation of tissue was made on the basis of segmental wall motion before the test and at low and high dobutamine dosages.
Stress echocardiography.

Before the test and after each stage of the test, echocardiographic records were made on a three-channel electrocardiogram. The ECG was then assessed as normal, ischemic or non-diagnostic. Ischemic changes were defined as the appearance of ST segment depression > 0.1 mV or > 0.2 mV in the leads with ST abnormalities at rest. The electrocardiogram was assessed as non-diagnostic if there was a block of the left branch after digitalis therapy or due to the presence of ST depression > 2 mm at rest.

Coronary angiography.

Visual assessment of stenosis diameter, shown as a percentage, was conducted by two experienced angiographers. Significant coronary stenosis is defined as a reduction of more than 50% in the absolute diameter of the lumen of the main epicardial arteries or their main branches. Patients with verified significant stenosis of at least one major coronary artery were considered to have ischemic dilated cardiomyopathy.

Statistics.

For the purposes of statistical data processing, various methods of descriptive and differential statistics were used. Tables and graphic displays of descriptive statistical methods were produced, as were measures of central tendency and measures of variability in absolute and relative numbers. For the differential statistical analyses, the following methods were used: t-test, χ²-test, Mann-Whitney U-test, two-factor analysis of variance with repeated measures; in this way, WMSI were tested, as was the differential statistical analyses, the following methods were used: t-test, χ²-test, Mann-Whitney U-test, two-factor analysis of variance with repeated measures observed between the two groups, the χ²-test was used. In a similar situation with a non-normal distribution, the t-test was used. In a similar situation with a non-normal distribution, the t-test was used. For comparison of the average number of segments of certain observed categories of wall motion among the two groups, in each of the studied periods of monitoring, a two-factor analysis of variance was performed. On the basis of test results and outcomes after revascularisation, the specificity and sensitivity test was determined.

RESULTS

Clinical and basic echocardiography and electrocardiography information.

The information obtained from the investigated groups is shown in Table 1. Statistically significant differences observed in the groups are not shown when it comes to anthropometrical values and echocardiography data except for body weight and body mass indexes (BMI), which were statistically significantly higher in the group with diabetes mellitus type 2.

<table>
<thead>
<tr>
<th>Baseline data</th>
<th>Ischemic heart disease</th>
<th>Diabetes mellitus and ischemic heart disease</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (±SD) (year)</td>
<td>62.7±3.57</td>
<td>60.25±5.52</td>
<td>NS</td>
</tr>
<tr>
<td>body weight (±SD) (kg)</td>
<td>82.27±11.23</td>
<td>89.6±9.99</td>
<td>p=0.022</td>
</tr>
<tr>
<td>body height (±SD) (cm)</td>
<td>174.67±8.86</td>
<td>173.35±6.17</td>
<td>NS</td>
</tr>
<tr>
<td>body mass index (BMI)</td>
<td>26.55±2.88</td>
<td>29.88±2.85</td>
<td>p=0.000</td>
</tr>
<tr>
<td>gender (n (%))</td>
<td>male</td>
<td>24 (80%)</td>
<td>15 (75%)</td>
</tr>
<tr>
<td></td>
<td>female</td>
<td>6 (20%)</td>
<td>5 (25%)</td>
</tr>
<tr>
<td>NYHA (n (%))</td>
<td>class II</td>
<td>25 (83.3%)</td>
<td>17 (85%)</td>
</tr>
<tr>
<td></td>
<td>class III</td>
<td>5 (16.7%)</td>
<td>3 (15%)</td>
</tr>
<tr>
<td>Ejection fraction</td>
<td>29.6±4.71</td>
<td>29.55±4.3</td>
<td>NS</td>
</tr>
<tr>
<td>End diastolic diameter (mm)</td>
<td>66.73±3.82</td>
<td>65.15±3.48</td>
<td>NS</td>
</tr>
<tr>
<td>angina (n (%))</td>
<td>yes</td>
<td>19 (63.3%)</td>
<td>9 (45%)</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>11 (36.7%)</td>
<td>11 (55%)</td>
</tr>
<tr>
<td>family history (n (%))</td>
<td>yes</td>
<td>16 (53.3%)</td>
<td>8 (40%)</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>14 (46.7%)</td>
<td>12 (60%)</td>
</tr>
<tr>
<td>dyslipidemia (n (%))</td>
<td>yes</td>
<td>17 (56.7%)</td>
<td>16 (80%)</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>13 (43.3%)</td>
<td>4 (20%)</td>
</tr>
<tr>
<td>smoking (n (%))</td>
<td>yes</td>
<td>17 (56.7%)</td>
<td>11 (55%)</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>13 (43.3%)</td>
<td>9 (45%)</td>
</tr>
<tr>
<td>hypertension (n (%))</td>
<td>yes</td>
<td>19 (63.3%)</td>
<td>15 (75%)</td>
</tr>
<tr>
<td></td>
<td>no</td>
<td>11 (36.7%)</td>
<td>5 (25%)</td>
</tr>
</tbody>
</table>

Table 1. Clinical and echocardiographic findings

Stress test results and side effects.

Between the subjects with ischemic dilative cardiomyopathy with or without glycoregulation disorders, statistically significant differences in the average values of dobutamine dose, atropine, attained sub-maximum frequency, systolic and diastolic blood pressure were not recorded. Statistically significant difference was also not recorded in manifestations such as chest pain, nausea, arrhythmia and changes in the ST segment.

Echocardiographic tracking of LV wall motion results.

Two factorial analyses of variance with repeated measures were used to test the result of of LV-segment classifications at rest, with small doses of dobutamine, with maximal doses of dobutamine and after the test. Individual analyses was made for groups with ischemic dilative cardiomyopathy with or without glycoregulation disorders. In both of the examined groups, LV function was significantly reduced. The expansion of regional dyssynergy was signifi-
cant in both examined groups. At a low dose, dobutamine improves the contractility examined in both groups, with an increasing number of segments marked as normokinetic to account for segments with persistence in kinetic. High doses of dobutamine caused an increase in the number of segments with persistent in kinetic in both examined groups. The test was performed in both groups after myocardial revascularisation using the same protocol (Table 2). Analysis of certain categories of motion segment classification observed both before the test in relation to the number recorded while using low doses of dobutamine and after revascularisation, as well as in groups of patients with ischemic dilated cardiomyopathy with or without diabetes mellitus, revealed that the number of segments with normal motion was significantly lower before the test. The number of hypokinetic segments was statistically different both before the test in relation to the number recorded while using low doses of dobutamine and after revascularisation, whereas differences were not found when using high-dose dobutamine in either group. No significant statistical difference was found between the number of akinetic and dyskinetic segments in either of the analysed measurement intervals in both groups (Figure 1). In the group of subjects with coronary disease and diabetes mellitus type 2, the change in type of the number of segments during dobutamine stress testing and after revascularisation was statistically significant (Figure 2). The number of normal segments with small dobutamine doses was the highest; declines were recorded with increasing doses, whereas values increased again after revascularisation in the group with or without diabetes mellitus type II. In all measurement intervals, the number was the highest. The number of hypokinetic segments after revascularisation was lower than with high doses of dobutamine, as well as before the test in the both groups. Akinetic and dyskinetic segments showed the same dynamics, as did hypokinetic segments. The value of WMSI of the observed group was tracked before, during and after the test and after revascularisation. For comparison of the values, two-factor analyses of variance with repeated measures were used. Differences in WMSI values are due to different times of measurement or test phases as well as the period after the revascularisation and are also due to individual differences between the subjects, as well as the differences between the groups. Measurement time in this model is given as an inner group factor, whereas differences between coronary disease with or without the presence of diabetes mellitus are given as a factor of differences between the groups. The response to the test carried out on defined values of WMSI in the observed measurement periods was not significantly different between the tested groups. The level of differences in the observed index values did not change significantly over time, and the difference in WMSI values that existed before the test, during the test and after myocardial revascularisation were approximately the same, as shown in Table 3.

Table 2. Grading of LV segments per patients at stress test and after revascularisation

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>low dose dobutamine</th>
<th>pick dose dobutamine</th>
<th>after revascularisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemic heart disease</td>
<td>Normal segments(n)</td>
<td>6.67±2.09</td>
<td>10.63±2.27</td>
<td>8.5±±2.54</td>
</tr>
<tr>
<td></td>
<td>Hypokinetic segments (n)</td>
<td>4.77±2.11</td>
<td>1.87±2.18</td>
<td>3.3±±2.72</td>
</tr>
<tr>
<td></td>
<td>Akinetic and dyskinetic segments (n)</td>
<td>4.57±1.68</td>
<td>3.5±2.26</td>
<td>4.17±1.91</td>
</tr>
<tr>
<td>Diabetes mellitus and ischemic heart disease</td>
<td>Normal segments(n)</td>
<td>5.75±2.2</td>
<td>8.65±2.39</td>
<td>6.6±±3.3</td>
</tr>
<tr>
<td></td>
<td>Hypokinetic segments (n)</td>
<td>4.3±2.9</td>
<td>1.9±2.07</td>
<td>3.1±±2.69</td>
</tr>
<tr>
<td></td>
<td>Akinetic and dyskinetic segments (n)</td>
<td>5.95±2.63</td>
<td>5.45±2.65</td>
<td>6.25±2.31</td>
</tr>
</tbody>
</table>

Table 3. WMSI per patient at the stress test and after revascularisation

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>LD dobutamine</th>
<th>PD dobutamine</th>
<th>after revascularisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemic heart disease</td>
<td>1.85±0.27</td>
<td>1.56±0.26</td>
<td>1.74±0.22</td>
<td>1.58±0.24</td>
</tr>
<tr>
<td>Ischemic heart disease and diabetes mellitus</td>
<td>1.99±0.32</td>
<td>1.83±0.32</td>
<td>2±0.35</td>
<td>1.86±0.31</td>
</tr>
</tbody>
</table>

Figure 1. Classification of the segments during the test and after revascularisation in patients without diabetes mellitus type II

Figure 2. Classification of the segments during the test and after revascularisation in patients with diabetes mellitus type II
Heart attack is the cause of death in about 25% of people in the U.S. and Europe. The mortality rate in patients with deterioration of LV function is growing by 15-60% per year (7). Previous studies (8) have shown a reduction of these rates after revascularisation, with a concomitant improvement in symptoms. After revascularisation, potential benefits must be weighed against the high operating mortality rate in patients with LV dysfunction, which ranges from 5 to 37%. A useful effect of revascularisation is to improve the blood supply of dysfunctional but viable myocardium, with a gradual improvement of regional and total LV function. This is confirmed by a number of studies (9) in which improvements occurred after revascularisation in patients with LV dysfunction but viable myocardial tissue. Previous studies have dealt very little with the role of DSE in the assessment of viable myocardium in the group of patients with low ejection fractions. When it comes to patients with associated long-term diabetes mellitus, this question has been completely unexplored.

In our studied population, a high level of homogenisation has been reached, which creates ideal conditions for the evaluation of diagnostic methods in which only separate variables affect the outcome of the test. The smaller frequency of angina pectoris can be primarily attributed to the existence of autonomic neuropathies. The link between silent coronary events through autonomic neuropathies and lesions of afferent transmission of sensory impulses has been known for long time, as O’Sullivan (1991. Yr.), Jeremendy (1993.) and Jalal et al. (1999.) have shown (10). On the other hand, according to findings obtained by selective coronaryography, assumptions about the extent of heart disease as a precondition for the development of pain in the analysis of the examined group of patients with diabetes mellitus are invalid. Specifically, Koistinen et al. (1992) (11) have shown by inducing ischemia through efforts in angiography in proven coronary patients that symptomatic patients do suffer from more difficult forms of arteriosclerosis.

Using electrocardiogram analysis, the classification of patients based on previously examined groups according to the presence and location of the Q wave is viewed as a relatively reliable parameter (12) of past coronary events. Conventional techniques used for the determination of viable myocardium include the absence of the Q wave on the EKG, the absence of LV regional dysfunction and fixed scintigraphic perfusion defects. Q view on the EKG is not specific for myocardial infarction; it can be caused by any form of ischemia, under which circumstances it may be reversible. Today, the presence of myocardial thickening as a response to dobutamine infusion observed in akinetic segments, despite the existence of Q view as a sign of IM on EKG, is understood based on pathological studies (91). These studies report that regional contractile dysfunction in relation to the presence of Q view is not always an indicator of transmural scar formation. Bruken (1986., god.) and Berlinerblau et al. (1994) (13) reported a high prevalence (68%, 72%) of metabolically viable myocardium in regions with Q view. Localisation of Q view in the examined population has shown commonalities among the investigated groups. More frequent appearances on the lower wall among patients in the diabetic group may affect the accuracy of diagnostic tests based on the difficult visualisation of individual segments (14). Rather, homogeneous distributions of coronary heart disease according to the main coronary blood vessels in the investigated groups, with a larger percentage of changes in the RCX and RCA compared to the studies of Pierarda (1990), La Cann (1994) and Piscionea (2001), is a great relief in assessing the predictive value of WMSI and its dynamics during the DSE test, whereas on the other hand it can affect the accuracy of diagnostic methods because of the difficulty in visualising individual segments (15, 16).

From our analysis of blood pressure and cardiac frequency, which are considered the best indicators of cardiac work (17-19), as well as the average value of dobutamine and atropine (20, 21), external events and changes in the final oscillations of EKG, we have confirmed previously established conclusions regarding DASE. The value of dobutamine was not significantly different in the investigated groups, and it ranges through the wide scale of values reported in previous studies (22). Average values for systolic pressure increases fell within the expected range, whereas in hypertonic patients, an increase in systolic pressure was more evident, an effect that has previously been recorded and impacts the sensitivity and specificity of the test (23). Rare changes in the ST segment, registered in several major studies, are a confirmation of the very low sensitivity of ST segment changes with DSE(121). In our work, among the patients with proven multi-vessel coronary disease, reported changes are the expected results. In the group of diabetes patients, the lower representation can be explained by a reduced sensitivity of EKG in these patients and a number of abnormalities while resting that makes the reading more difficult (24).

In the interpretation of regional kinetics while resting, it is likely that mental stress can provoke silent ischemia (25). One-third of all patients who have acute IM with ST elevation never manifested a diagnostic Q view, and 10-15% of IM patients with clinically significant Q view in the period of 2 years leads to his loss. One-third of the total number of IM events remain clinically silent, with approximately 10% belonging to the silent NSTEMI and 5% to silent STEMI that form silent that are lost during time. In the population of patients with diabetes, this percentage is slightly higher than in the general population and may range up to 45% of suffered IM events (26). Mild hypocontractility is often a source of misinterpretation, and in fact is a normal form of a wall motion. Unlike stunned myocardium, which dominates in the early post-infarction period, with chronic myocardial ischemia, hibernated myocardium is dominant as a consequence of the decrease in coronary flow and post-ischemic dysfunction accompanied by
ultrastructural damage of myocytes with a corresponding loss of myofilaments and contractile materials (27, 28). It is clear that this form of dyssynergy at rest dominates in our patient population. Looking at the average number of segments according to the degree of their kinetics, it can be concluded that scar changes are more expanded in the group of patients with diabetes due to a greater average value of the segments with severe kinetic dysfunction. The answer to this situation may be found in the frequency and time of thrombolytic therapy and the degree of coronary heart disease development, i.e., accelerating atherosclerosis and the status of microcirculation (29). This process is accelerated by a smaller number of segments with preserved kinetics in this group. According to the average values of segment kinetics, statistically significant differences have been registered in both groups in the number of normal kinetic segments in relation to the other. The value of WMSI in the group with regular glycoregulation, as well as in the group of patients with diabetes, corresponds to the values published in previous studies (151-153) by authors who treated patients with low EF.

Analysing regional responses between the examined groups’ unique tendencies towards improvements in contractility at low doses of dobutamine has been detected, as the expected response taking into consideration that its maximum positive isotropic effect is achieved in this manner. More studies have shown that it is a dose of 7.5 μg/ kg/min. By analysing the responses of individual segments that showed improvements at the low dose and were classified in the potentially viable segments, a double tendency was recorded. One group consists of segments with consistent kinetic improvements, whereas the second group consists of segments with bi-phase responses to high doses of dobutamine. New segments with deteriorations in their kinetics have also been registered. Other segments did not show a change in the dynamics of movement during dobutamine infusion. These results correspond to the study of Vigne et al. (30), whereas they minimally deviate from the results of Afridy et al. (31), who were using a continuous increase of 5μg/kg/min in their study. The use of WMSI in the difficult scoring on a four-level scale has influence when there is a diffuse hypocontractility of the chamber.

Three months after complete myocardial revascularisation, a control echocardiogram determined the segments with preserved contractile reserve. Statistically significant differences were noticed in the number of normal kinetics segments in both groups compared to the ones with disturbed kinetics. A tendency towards the movement of segments in the control echocardiography was similar for both groups, and WMSI movement follows this tendency. Identical results were published by Hennessy et al. (32). Unlike the initial papers by Topola et al. (1984.god.), Lazar et al. (1989.god.) and La Cann et al. (1994.god.), in which estimations of viable myocardium were made immediately after myocardial revascularisation, when publishing results with specificity equal to the ones based on later estimations, today it is certain that the right assessment of viable myocardium should be performed 3 months after the completion of revascularisation procedures (33). The reasons for delayed answers lie in the different criteria for patient selection, the variety of information regarding graft circulation capabilities, different postoperative time periods of evaluation and different methods for wall motion analysis. Moreover, myocardial preservation techniques during surgical revascularisation and the duration of aortic clamping can have an impact on postoperative segmental contractility. Revascularisation techniques need to be taken into account, as do their percentage representation in the tested population. Several factors modify postoperative contractility independently of the procedure. Reductions in postoperative vascular resistance may positively affect kinetics in the early period. It is well known that segments that show improvement with low doses of dobutamine have statistically smaller amounts of fibrotic tissue (34). Additionally, segments in which kinetics are improved after revascularisation have a significantly lower percentage of fibrosis. The highest diagnostic accuracy of DSE is reached by analyses of combinations of continuous improvement and bi-phase response during the test. Afridy et al. first announced the importance of combining improvements in kinetics with bi-phase response. Kaul (35) suggested that this be the goal of every ischemia provocation test in dysfunctional myocardium because it may be the best predictor of functional repair after revascularisation. Today it is known that it is the response of the myocardium to low doses of dobutamine that is decisive, in contrast to the hypothesis of Armstrong that suggested improvements at any dosage. Constant kinetic improvement during the test, which usually occurs in hypokinetic segments, bears very little predictive value, and the mechanism itself remains unknown (36, 37). Improvements may occur in the field of nontransmural myocardial infarction with the engagement of external tissue in the absence of critical stenosis. Revascularisation of this part of the myocardium does not show any improvement. Functional changes in the border zone of ischemia can also affect the test results. Recent research indicates that the area of dysfunction is spread over more than 30% or 1 cm outside the ischemic zone. In this way, dobutamine enhances the contractility of non-ischemic tissue that is characterised as necrotic. To overcome this problem, the principle to ignore improvements in the area up to 1cm around the affected tissue is used.

DASE showed that the sensitivity in diagnosing viable myocardium in the group of ischemic dilated cardiomyopathy patients was 95% in our study. The results of several studies, ranging from 68-100% (38). In the group of ischemic dilated cardiomyopathy and diabetes mellitus type 2 patients, the sensitivity of the test was 93%. The sensitivity given by the work of France et al. was 86%. Test sensitivity analysis is necessary to consider all aspects of the implementation of the echocardiography stress test, i.e., the method of titrating dobutamine during the test, especially at low doses of 2.5, 5 or 10μg/kg/min-duration. Other factors include the adequacy of the ultrasound de-
The difference between these pathophysiological entities, acute myocardial stunning or repeated stunning (46), including acute myocardial ischemia, myocardial hibernation. Deterioration may be the result of various causes, if adequate resaturation of the coronary circulation takes place. The viability of the myocardium represents a deterioration in contractile function that is potentially reversible or working capacity after revascularisation. The final results can be measured by ventricular volume and EF in the long run, after the IM.

In our work, the DASE showed a 91% specificity in the group of patients with ischemic dilated cardiomyopathy, whereas in the group with diabetes mellitus type 2 this value was 96%. This is a relatively high specificity in relation to the results of other studies (43-45). Echocardiography testing with a high dose of dobutamine, the addition of atropine and the provocation of ischemia, i.e., bi-phase response, do reduce the sensitivity of the test; however, as it is well known, these methods also increase the specificity of the test. It is also known that the contractility of border areas around the ischemic zone impacts the decrease in sensitivity; even 40% akinetic and 5% dyskinetic segments that showed kinetic improvements during the test are a consequence of nontransmural IM and have a completely normal histological material. Low EF and multi-vessel coronary heart disease, in the absence of the significant influence of diabetes mellitus in test feasibility, produces actual sensitivity and specificity. The improvement in regional function of the chamber is not the main signal for interpretability of wall motion, i.e., the related objective, while improving the global functions of LV and patients status. These final results can be measured by ventricular volume and EF or working capacity after revascularisation.

The viability of the myocardium represents a deterioration in contractile function that is potentially reversible if adequate resaturation of the coronary circulation takes place. Deterioration may be the result of various causes, including acute myocardial ischemia, myocardial hibernation, acute myocardial stunning or repeated stunning (46). The difference between these pathophysiological entities is probably not relevant to the clinical aspects of the disease, as not only does this situation often coincide, but the treatment would represent complete revascularisation. An accurate diagnosis of viable but not contractile myocardium in patients with ischemic heart disease and preceding IM allows the application of treatment on the basis of heart failure symptoms and angina pectoris while also taking into account the effects of revascularisation. Recent views suggest that, whereas the level of LV dysfunction is the main parameter for prognosis, LV dysfunction is not necessarily irreversible and can be improved after the procedure of myocardial revascularisation. Patients with significant LV dysfunction can benefit from bypass surgery or percutaneous coronary interventions the most because they are at the highest risk in the event of further loss of contractile tissue mass; however, they also have the highest level of mortality with respect to surgical procedures. When we discuss surgical revascularisation of the myocardium, its adequacy should be taken into account (graft occlusion and restenosis), as should the existence of associated myocardial diseases, LV hypertrophy, and myopathic processes. Recent studies have taken into account the global function of LV, physical capacity, quality of life and death rate as their most important parameters. Other factors that are taken into account in the definition of diagnostic tests are feasibility, accessibility and experience of the test performer (47-53).

LIMITATIONS OF THE RESEARCH

Our study had several limitations. Firstly, the number of patients tested was small. Secondly, coronaryography results were not compared with starting echocardiography studies in terms of the comparison of myocardial dysfunction with the existence of residual flow and occluded coronary arteries. Thirdly, the effect of silent ischemia on the segmental contractility, especially in the diabetic group. Moreover, there are a number of restrictions when it comes to the interpretation of echocardiography studies. Visualisation and segmental analysis of large chambers, as is the case with our patients, is always difficult. The cine loop allows researchers to monitor and compare segments of the wall next to one another, but the selection of identical segments is the responsibility of the echocardiographer. The timing of the cardiac cycle is very important and any error in the recording start makes the loop useless. Attention should be given to the interpretation of data from the basal segment of the inferior wall, due to the overlap with echoes from the valve or even atrium chamber wall. Additionally, the images taken in parasternal cross-section should be carefully interpreted due to the presence of artefacts. It is necessary to visualise the apex effectively, as it is the most the most common place for abnormalities (54-56). By using high-dose dobutamine and provoking ischemia, we have reduced the sensitivity of the test. We did not use a dose of 7.5 μg/kg/min as our starting dose. Factors such as postoperative disturbed sympathetic tone, heart frequency,
aortic pressure and overfilling of the LV can influence heart movements. Very frequent appearance of abnormal movement of the septum after surgical intervention is also a problem. Finally, the echocardiography study was conducted over a wide time range after revascularisation (2-5 months). It is widely accepted that the golden standard is 3 months (57-59).

REFERENCES

1. Emond M, Mock MB, Davis KB et al. Long-term survival of medically treated patients in the Coronary Artery Surgery Study (CASS) registry. Circulation 90: 2645, 1994
11. Iskandrian AS, Hakki aH, Kane SA et al. Rest and redistribution thallium -201 myocardial scintigraphy to predict improvement in left ventricular function after coronary artery bypass grafting. Am J Cardiol 51: 1312, 1983


32. Swinburn JMA and senior R. Myocardial viability assessed by dobutamine stress echocardiography predicts reduced mortality early after myocardial infarction: determining the risk of events after myocardial infarction(DREAM)study Haert. 2006;92: 44-48


