

Myocardial contractility improvement after coronary artery by-pass grafting in a 1-year observation: The role of myocardial viability assessment

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Abstract

Background: Left ventricular (LV) contractility impairment in coronary artery disease patients may be the effect of heart muscle hibernation due to chronic ischemia. Revascularization is the only method to restore contractile function in these patients. The time and degree of LV function improvement have not been precisely determined, and the published data are discordant. The aim of our study was to evaluate the time of myocardial contractility recovery after surgical revascularization in patients with systolic LV dysfunction in relation to the results of echocardiography stress tests.

Methods: The study included 50 patients with multivessel coronary artery disease and decreased left ventricular ejection fraction (LVEF < 40%) qualified for coronary artery by-pass grafting. The intervention was preceded by rest echocardiography, low dose dobutamine stress test (5–10 µg/kg/min) and by low dose dipyridamole stress test (0.24 mg/kg during 4 min) performed on the next day. Consecutive rest echocardiograms were performed immediately after the intervention and after 3, 6 and 12 months. LVEF and the index of left ventricular contractility (WMSI, wall motion score index) were evaluated at each examination.

Results: During 1-year follow-up after coronary artery by-pass grafting (CABG), significant improvement in LV systolic function was observed (LVEF increased, WMSI reduced), with major changes occurring over the first 6 months. The correlation of echocardiography parameters (EF, WMSI) at stress tests and during 1-year follow-up showed that the strongest relationship exists between the change in WMSI both in dobutamine and dipyridamole stress tests and the improvement in WMSI observed after 6 months.

Conclusions: LV function improvement after CABG in patients with systolic LV dysfunction was most pronounced 3 to 6 months after the intervention. Both types of stress tests are characterized by similar diagnostic value for assessing LV myocardial viability. WMSI calculated during stress was identified to have the strongest prognostic value. (Cardiol J 2007; 14: 246–251)

Key words: myocardial viability, revascularization, time of systolic function recovery

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Introduction

Surgical myocardial revascularization (CABG, coronary artery by-pass grafting) brings most benefit to those patients, in whom left ventricular dysfunction related to coronary artery disease is the effect of chronic heart muscle hibernation [1]. According to Braunwald and Rutherford, heart muscle hibernation is defined by the decrease of contractility caused by prolonged reduction of coronary blood flow. During prolonged ischemia, the coronary blood flow is usually sufficient for the survival of myocytes, while being insufficient to fully provide for metabolic requirements related to the contraction [2]. Contractility impairment can only be reversed by the means of revascularization [3]. It is important to note that the return to the normal or quasi-normal state is possible [4]. The time needed for left ventricular function improvement depends on the degree of degenerative changes and connective tissue proliferation [5]. The time and degree of improvement have not been precisely determined. Few papers discussing the above issues have been published, providing inconsistent assessment of dysfunction reversal after CABG [6].

The progress of heart muscle viability assessment techniques permits a better selection of patients with coronary artery disease and associated left ventricular dysfunction for cardiosurgical treatment. Moreover, in patients with areas of viable myocardium a much smaller degree of unfavorable left ventricular remodeling is observed after revascularization [7].

Diagnostic tests assessing heart muscle viability have therefore become an important element in qualifying patients for by-pass grafting, especially in the case of low left ventricular ejection fraction (LVEF), since the presence of contractility disorders in rest echocardiography does not necessarily point to the permanence of the lesion. Viability assessment combined with clinical presentation and the evaluation of coronary vessel status is presently the basis for choosing the optimum treatment. Dobutamine and dipyridamole stress echocardiography are used to assess myocardial viability, being both inexpensive and relatively easily accessible methods. Studies comparing the values of both tests for the evaluation of LV systolic function recovery after CABG are scarce.

The aim of this study was to assess the time of heart muscle contractility recovery after revascularization in patients with left ventricular systolic dysfunction in relation to the results of both tests.

Methods

Patient characteristics

The study included 50 patients (42 men and 8 women; mean age of 60 years) who were operated in the Clinical Department of Cardiac Surgery of the Medical University of Białystok over the period of May 2002 – February 2004. All the patients fulfilled the following criteria:

- chronic, stable coronary disease;
- diminished left ventricular systolic function found in echocardiography: LVEF < 40% (confirmed by ventriculography);
- qualification for CABG;
- lack of hemodynamically significant accompanying valvular disease;
- presence of adequate technical conditions permitting the performance of stress tests.

The study protocol has been accepted by the local Bioethics Committee of the Medical University. The stage of heart failure was evaluated using the New York Heart Association (NYHA) classification according to commonly accepted criteria. The clinical advancement of coronary artery disease was evaluated using the Canadian Cardiovascular Society (CCS) classification. Basic demographic data and clinical characteristics of the investigated group are presented in Table 1.

All the patients underwent coronary angiography with ventriculography for clinical indications and were subsequently qualified for surgical revascularization due to the presence of multivessel disease (according to current Polish Cardiac Society

Table 1. Patient characteristics.

Mean age (years)	60 ± 9 (min. 39; max. 75)
Body weight [kg]	82 ± 13
Height [cm]	171 ± 7
Body mass index	28 ± 4 (min. 21; max. 36)
Duration of CAD [years]	Mean 6.5 (min. 3 months; max. 20 years)
History of myocardial infarct	All studied patients
Arterial hypertension	20 patients/40%
Diabetes	11/22%
Dyslipidemia	36/72%
Smoking	24/48%
Family history of CAD	29/58%
NYHA class	Mean III ± I
CCS class	Mean 3 ± 1
Left ventricular ejection fraction	34% ± 4%
Number of changed coronary vessels	All patients: 3 vessels

CAD — coronary artery disease

guidelines). A complete coronary revascularization was performed in all the patients. Patients were also administered the usual pharmacological treatment, according to current guidelines.

Study design

Rest echocardiography. Two-dimensional transthoracic examination determining the classic parameters according to the American Society of Echocardiography guidelines, was performed 3–5 days before the coronary artery by-pass grafting. Left ventricular contractility was assessed by analyzing the systolic increase in wall thickness, employing a division into 16 segments [3]. Wall motion score index (WMSI) was determined, assigning to each of the segments of the left ventricle a number of points corresponding to the visual assessment of contractility, i.e.: 1) normokinesis (normal contractility), 2) hypokinesis (diminished systolic wall thickness increase), 3) akinesis (absence of systolic wall thickness increase), 4) dyskinesis (centrifugal wall movement). The WMSI was calculated by summing up the points assigned to individual segments and by dividing the sum by the number of segments. LVEF was calculated in a two-dimensional presentation, employing the biplane Simpson's method and calculating the mean value from three consecutive heart cycles. The two parameters were assessed both during rest echocardiography and in stress tests.

Follow-up examinations were performed during hospitalization, in the first week following by-pass grafting and at 3, 6 and 12 months after the intervention.

Echocardiography stress tests. Dobutamine test. The patients were administered no drugs with a positive inotropic effect during the 3 days preceding the examination. The test with low dose dobutamine (5–10 $\mu\text{g}/\text{kg}/\text{min}$) was performed 3–4 days before the operation. After recording the standard projections in a rest examination (parasternal long and short axis projections, apical 2- and 4-chamber projections), intravenous dobutamine infusion was administered. Recording on a magneto-optic disk started 6 min after the infusion was initiated. Heart rate and arterial blood pressure were monitored during the test and for 10 minutes after it was finished. Criteria for interrupting the test were: a decrease in arterial blood pressure of at least 10%, chest pain, increasing dyspnea, significant supraventricular and ventricular arrhythmia.

Dipyridamole test. The patients consumed no caffeine-containing products and discontinued any theophylline-derived drugs during the 24 hours

preceding the examination. The test with a small dose of dipyridamole was performed 3–4 days before the operation, on the day following the dobutamine test. Similar to the case of dobutamine, after recording the four standard parameters in a rest examination, 0.28 mg/kg of dipyridamole was administered during 4 min in an intravenous infusion. Recording on a magneto-optic disk and a video tape started 4 min after the infusion was initiated. All the above mentioned standard projections were documented. Heart rate and arterial blood pressure were monitored during the test and for 10 min afterwards. Criteria for interrupting the test were: appearance of a chest pain, ventricular ectopic beats, arterial blood pressure decrease and ST change.

Left ventricular contractility was assessed by analyzing the systolic increase in wall thickness and LVEF changes. Both parameters were assessed at rest after completing the dobutamine and dipyridamole tests. Rest echocardiography images recorded before CABG, evaluating baseline left ventricular contractility disorders, were compared to images recorded 5–6 days after the operation and after 3, 6 and 12 months. All tests were performed by an experienced echocardiographer.

Heart muscle viability was defined as an increase in wall contractility of at least 1 point in the 4 points scale. Viability assessment was performed during the examination by comparing the stress test and the baseline test recordings.

All patients obtained the usual treatment for coronary artery disease, according to current standards.

Statistical analysis

Data distribution was checked with the Kolmogorow-Smirnow test. For qualitative variables, data are presented as quantitative and percentage distribution, and for continuous variables as mean value \pm standard deviation and the minimum and maximum values within the investigated group. Mean value from three consecutive measurements was used for echocardiography analysis. T-test for dependent and independent paired samples or the Wilcoxon test was used for analysis. The correlation index reflecting the degree of relationship between data sets was calculated using the Pearson or Spearman method, depending on the type of variables. Results were considered statistically significant when the variability level was < 0.05 . Calculations were performed using a MEDCALC 8.1.0.0 statistical program (Frank Schoonjans 2005).

Table 2. Left ventricular ejection fraction (LVEF) and left ventricular contractility index values (WMSI) at baseline and after dobutamine and dipyridamole stress tests ($p < 0.0001$ in relation to baseline values).

	Baseline parameters	After dobutamine administration	After dipyridamole administration
LVEF	33.7% ± 4.1%	41.0% ± 5.6% ($p < 0.0001$)	40.3% ± 5.1% ($p < 0.0001$)
WMSI	1.96 ± 0.19	1.59 ± 0.23 ($p < 0.0001$)	1.63 ± 0.24 ($p < 0.0001$)

Results

Echocardiography assessment

Before the operation. Table 2 presents ejection fraction and left ventricular contractility index values at baseline and after dobutamine and dipyridamole stress tests. A similar improvement in LVEF and WMSI was noted after both tests: baseline EF value was of 33.7% ± 4.1%, after dobutamine administration it increased to 41.0% ± 5.6% ($p < 0.0001$), and after dipyridamole stress test it increased to 40.3% ± 5.1% ($p < 0.0001$); WMSI value before revascularization was of 1.96 ± 0.19, after dobutamine it diminished to 1.59 ± 0.23 ($p < 0.0001$), and after dipyridamole to 1.63 ± 0.24 ($p < 0.0001$).

After the operation. Directly following CABG, mean EF value increased slightly and was of 35.2% ± 4.1% (from baseline 33.7% ± 4.1%). At 3 months from the operation a further increase to 37.8% ± 5.1% ($p = 0.0002$) was observed. It was rising over the following months to attain 38.9% ± 5.3% ($p < 0.0001$) at 6 months. At 1 year from the intervention, EF value was of 39.6% ± 5.6% ($p < 0.0001$ in relation to baseline values). The differences after 6 months and 1 year from the operation were not statistically significant. They were significantly different from baseline values. Figure 1 presents the gradual improve of left ventricular systolic function over 1-year observation period.

Baseline LV wall contractility index value was of 1.96 ± 0.19. Following CABG it decreased to 1.83 ± 0.18. Further improvement was noted after 3 months of observation, with a decrease to 1.74 ± 0.20 ($p < 0.0001$). At 6 months from the intervention WMSI reached the value of 1.66 ± 0.22 ($p < 0.0001$), and at 1 year 1.60 ± 0.24 ($p < 0.0001$). WMSI differences compared to baseline examination were statistically significant. Thus the surgical intervention resulted in a gradual improvement of LV wall contractility index (Fig. 2).

Both in the dopamine and dipyridamole tests, the relation between the change in the parameter value during stress test and its change during the

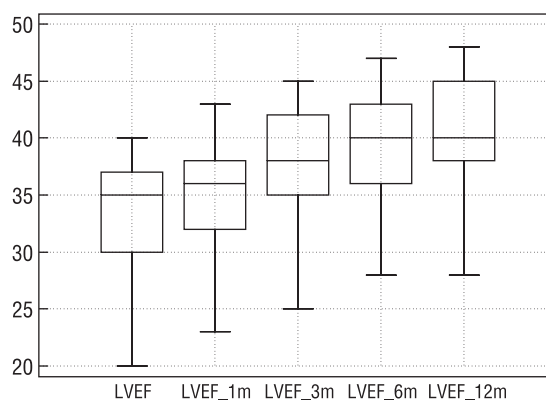


Figure 1. Left ventricular ejection fraction (LVEF) during 1-year follow-up — baseline LVEF (LVEF), after coronary artery bypass grafting (LVEF_1m), after 3 (LVEF_3m), 6 (LVEF_6m) and 12 (LVEF_12m) months of observation.

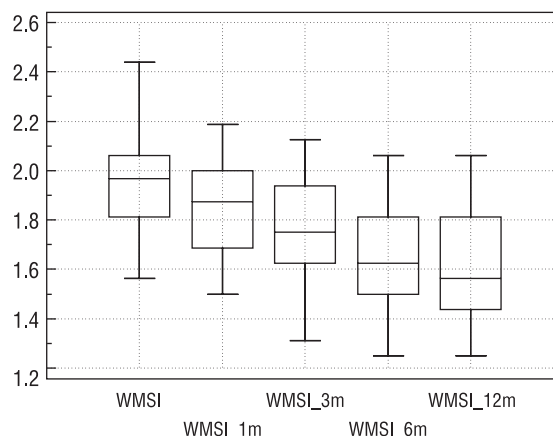


Figure 2. Wall motion score index (WMSI) during follow-up — baseline WMSI (WMSI), after coronary artery bypass grafting (WMSI_1m), after 3 (WMSI_3m), 6 (WMSI_6m) and 12 (WMSI_12m) months of observation.

period before and after 6 months from the operation was stronger for WMSI than for LVEF (Fig. 3, 4).

These results indicate that the largest improvement of left ventricular function occurred

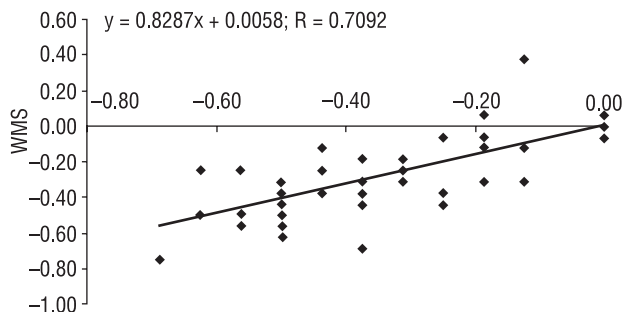


Figure 3. Change in wall motion score (WMS) at 6 months vs. WMS after dobutamine administration.

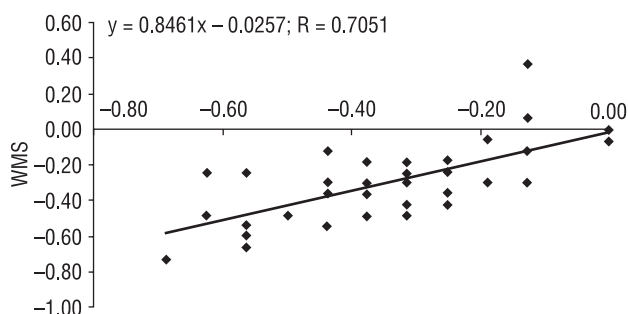


Figure 4. Change in wall motion score (WMS) at 6 months vs. WMS after dipyridamole administration.

during the first 6 months following CABG. We also demonstrated the comparable prognostic value of both stress tests for predicting contractility improvement after the intervention. Left ventricular wall contractility index calculated after the administration of both drugs proved to have the highest prognostic value.

Discussion

The time and degree of LV function recovery following surgical revascularization have not been closely investigated. Available literature provides discordant data concerning the time of regression of left ventricular contractility impairment due to heart muscle hibernation [6]. Some authors reported immediate contractility improvement after coronary artery by-pass grafting [6]. On the other hand, Szulczyk et al. [8] did not observe significant changes in left ventricular systolic function after 3 months from revascularization. However, Bax et al. [9] demonstrated significant improvement in LVEF as well

as in NYHA and CCS class at 3 months from the intervention. This concerned only the patients with viable heart muscle found in at least 4 segments.

In our group of patients, maximum improvement in LV contractility parameters was observed after 6 months from CABG. A similar time of systolic function recovery after revascularization was noted by Soto and Beller [2] and by Pagano et al. [10]. On the other hand, Rizzello et al. [11] observed the improvement in NYHA and CCS class in patients with viability confirmed in at least 4 segments at an even later time: 9–12 months from the intervention. In view of these data, Bax [9] emphasizes with reason that the choice of the optimum contractility assessment period after CABG remains unclear. Literature data suggest that cardiomyocyte function recovery may be expected between 6 and 12 months after the intervention [12, 13], or sometimes after a much longer period of up to 4 years [14].

Differences observed in the literature may be related to the large spectrum of metabolic disorders occurring in the state of heart muscle hibernation. Cardioprotective mechanisms of the hibernated myocardium may prove insufficient in the case of a long-lasting ischemia. This may cause irreversible morphologic changes, resulting in myocyte degeneration and, in consequence, in a delayed or incomplete contractility improvement [15]. It should be assumed that the regression of LV contractility disorders due to heart muscle hibernation depends on the duration and degree of ischemia [5, 15]. If myocyte degeneration process is advanced, more time is needed for the reconstruction of the contractile apparatus. It can be presumed that progressing heart damage with cell necrosis, myocardial fibrosis and irreversible contractility disorders would occur with no revascularization [8].

In the investigated group of patients the duration of coronary artery disease was moderately long, with a mean value of 6.5 years. Available literature does not provide sufficient data concerning the relationship between the degree of left ventricular function recovery and the duration of coronary artery disease. However, it is emphasized that an early surgical intervention is the only treatment that may stop the progressing heart damage [8].

A small study group and the single study center were limiting factors of our work. Moreover, our study had the character of an observation with randomized choice of patients. The discussed uncertainties may be cleared out by a multicenter randomized study.

Conclusions

1. Maximum left ventricular function improvement in patients with left ventricular systolic dysfunction who underwent surgical revascularization was noted between 3 and 6 months after the intervention.
2. Stress tests both with dobutamine and dipyridamole are characterized by a similar diagnostic value for identifying left ventricular muscle viability.
3. Left ventricular wall contractility index calculated during stress test proved to have the highest prognostic value of contractility recovery following coronary artery bypass grafting.

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