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Early Results after Coronary Artery Bypass Grafting in Patients with Severe Ischemic Left Ventricular Dysfunction

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INTRODUCTION The number of patients with severe ischemic left ventricular dysfunction (ILVD), who undergo coronary artery bypass, increasing each year. ILVD is an established risk factor for mortality in patients after myocardial revascularization during the early and late postoperative periods.

AIM OF STUDY To evaluate the early results of surgical myocardial revascularization in patients with coronary artery disease (CAD) and severe ILVD.

MATERIAL AND METHODS The study included 149 patients with coronary artery disease with severe left ventricular dysfunction (LV ejection fraction (EF) \leq 39%), operated from January 2002 to December 2018. Different variables were assessed (pre- and postoperative) including LV ejection fraction and end systolic volume index (ESVI).

RESULTS The average age of the patients was 59.36 ± 8.97 years (from 30 to 78 years), 93% of the patients were men. In 28 patients (19%), ILVD developed against the background of myocardial infarction (MI) and in 121 (81%) due to ischemic cardiomyopathy (ICMP) with a history of myocardial infarction. The mean EF before surgery was 36.64 ± 3.17 (from 21 to 39%). In the postoperative period, there was an increase in EF, which averaged 44.92 ± 4.92 (from 36 to 59%) ($p < 0.001$). The mean LV ESVI before surgery was 60.23 ± 11.52 ml/m². In the immediate postoperative period ESVI decreased to 46.26 ± 12.40 ml/m² ($p < 0.001$). The average number of bypass coronary arteries in one patient was 3.9 ± 0.87 . There was also a decrease in the degree of mitral regurgitation in most patients after coronary artery bypass grafting (CABG) ($p < 0.001$). Hospital mortality was 2% (3 patients).

CONCLUSION In patients with severe ischemic left ventricular dysfunction coronary artery bypass grafting can be performed with low mortality. Surgical myocardial revascularization can be considered a safe and effective operation for patients with coronary artery disease with a satisfactory condition of the distal coronary arteries, low ejection fraction, and with a predominance of viable myocardium.

Keywords: left ventricular dysfunction, coronary artery bypass grafting

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IABC – intra-aortic balloon counterpulsation

IHD – Ischemic heart disease

AC – artificial circulation

ICMP – ischemic cardiomyopathy

IESV – index of end systolic volume

ILVD – ischemic left ventricular dysfunction

CABG – coronary artery bypass grafting

LV – left ventricle

MI – mitral insufficiency

AMI – acute myocardial infarction

ICU – intensive care unit

EF – ejection fraction

Echo-CG – echocardiography

INTRODUCTION

Some studies comparing the results of surgical and drug treatment of patients with ischemic heart disease (IHD) and severe ischemic myocardial dysfunction have shown that coronary artery bypass grafting does not lead to an improvement in the immediate and long-term results, and does not improve their quality of life. High hospital mortality was the reason to consider severe ischemic left ventricular dysfunction (ILVD) as a contraindication to direct myocardial revascularization, which limited its use in such patients. At the same time, isolated drug therapy in patients with ILVD did not lead to significant changes in the natural course of the disease. [1]. Unsatisfactory results of myocardial revascularization in patients with severe left ventricular (LV) dysfunction, as a rule, are associated with diffuse lesions of the distal coronary artery by the atherosclerotic process and the subsequent suboptimal term of shunt functioning, as well as the predominance of nonviable myocardium over viable [2]. At the same time, a number of authors note that surgical myocardial revascularization in patients with an ejection fraction (EF) below 35% has an acceptable hospital mortality (from 3 to 15%) and leads to an improvement in the functional state of patients. Several studies evaluating the effectiveness of surgical myocardial revascularization have shown that these patients benefit most from coronary artery bypass grafting (CABG), especially if symptoms of angina pectoris predominate, rather than heart failure [3]. Coronary artery bypass grafting in patients with severe ischemic dysfunction of the LV myocardium preserves the remaining viable myocardium, prevents expansion of the LV cavity, and improves the systolic function of the ischemic hibernated myocardium areas. Nevertheless, the level of postoperative mortality in these patients in the early postoperative period ranges from 1.6 to 40% [4].

Purpose of the study — to evaluate the early results of surgical myocardial revascularization in patients with coronary artery disease with pronounced ILVD, as well as to determine the factors that influence these results.

MATERIAL AND METHODS

The present study included 149 patients with coronary artery disease and severe systolic ILVD with LVEF \leq 39%, who underwent isolated CABG (without additional surgical interventions) at the N.V. Sklifosovsky Research Institute for the period from 2002 to 2018. The main criteria for selecting patients for the study were the presence of coronary artery disease with pronounced ICMP (EF \leq 39%) according to echocardiography (Echo-CG), and a satisfactory condition of the distal coronary arteries on coronary angiograms.

Data were obtained from medical records, physical and instrumental examination of patients. Assessment of age, gender, as well as the influence of risk factors on treatment outcome. The following were considered risk factors: diabetes mellitus, arterial hypertension, smoking, obesity, hypercholesterolemia, renal failure, chronic obstructive pulmonary disease, oncological diseases, multifocal atherosclerosis, cerebrovascular disease of the brain, acute period of myocardial infarction, critical stenosis of left coronary artery, severe forms of IHD and cardiac arrhythmia.

All patients underwent two-dimensional echo-CG and coronary angiography before surgery. All patients underwent a standard anesthetic protocol during surgery, which included sevoflurane, fentanyl, and propofol. Operations were performed through a median sternotomy. The left internal thoracic artery, large saphenous veins, and radial arteries were used as autografts. Coronary artery bypass grafting in the majority of patients was performed under artificial circulation (AC) in the mode of moderate hypothermia or normothermia. The protection of the myocardium in some patients was carried out using a pharmaco-cold solution "Consol" and using "ice gruel" from a physiological solution of sodium chloride for local hypothermia of the myocardium. In the past few years, warm blood solutions have been used to protect the myocardium. In all patients, cardioplegic solution was injected into the coronary arteries every 20 minutes through the aortic root (sometimes through autografts). CABG was performed using traditional methods with the achievement of "adequate" revascularization in all patients. A very important point is revascularization of the anterior descending artery, since due to its stenosis or occlusion the main processes associated with the remodeling of the LV cavity occur.

After the end of the operation, patients were transferred to the intensive care unit (ICU), where artificial lung ventilation, stabilization of hemodynamics, body temperature, correction of fluid and electrolyte balance were continued. Patients were extubated as soon as they met the following criteria: recovery of consciousness with pain control, acceptable respiratory strength, normalization of arterial blood gases, hemodynamic stability with minimal cardiotoxic support, and no bleeding.

The following variables were analyzed: cardiac output, malignant arrhythmia, perioperative myocardial infarction, respiratory failure, transient ischemic attack or cerebral stroke, the need for intra-aortic balloon counterpulsation (IABC), LVEF, ILVD before the surgery and in the postoperative period, length of stay in the ICU, and hospital mortality.

All results were collected prospectively in standardized forms and entered into a computerized database. Statistica 10 software was used for statistical analysis. All data were expressed as mean \pm standard deviation and compared using the chi-square test and an independent t-test. A p-value <0.05 was considered statistically significant.

RESULTS OF THE STUDY

In the period from January 2002 to December 2018, 149 patients with coronary artery disease and $EF \leq 39\%$ were operated on. The average age of patients was 59.36 ± 8.97 years (range, 30 to 78 years), 93% of patients were men. The number of patients who underwent CABG with AC was 146 (98%), and CABG without AC was performed in 3 (2%) (Table 1). Before the operation, a study of myocardial viability was performed using scintigraphy and stress echocardiography. The average number of preoperative risk factors in each patient was 6.34 ± 1.51 , of which hypertension was the most common – in 96% patients. The mean EF before the operation was $36.64 \pm 3.17\%$ (from 21 to 39%), which improved in the postoperative period and averaged $44.92 \pm 4.92\%$ (from 36 to 59%), and it was respectively expressed in a decrease in ICSO (before surgery 60.23 ± 11.52 ml / m², after surgery – 46.26 ± 12.40 ml / m² ($p < 0.001$)). In most patients, according to Echo-KG, a decrease in the degree of mitral regurgitation after coronary revascularization was noted ($p < 0,001$). Thus, in 21 out of 149 patients, before the operation, mitral insufficiency (MI) was grade I, and in 27 patients – grade II. After the operation MI grade I was observed only in 10 patients, and in 38 patients MI was absent. Control myocardial scintigraphy showed an improvement in the perfusion of ischemic viable areas after their revascularization with an increase in LVEF, a decrease in intraventricular pathological asynchrony. ($p < 0,001$).

Table 1

Characteristics of patients in the preoperative period*

Age	59.36 ± 8.97 years
Gender:	
male	138 (93%)
female	11 (7%)
Number of coronary artery stenoses:	
Stenosis of two arteries	19 (13%)
Three artery stenosis	130 (87%)
Damage to the left trunk of the coronary artery	39 (26%)
IABP	11 (7%)
NYHA class	
II	1 (1%)
III	20 (13%)
IV	127 (85%)
Arterial hypertension	143 (96%)
Obstructive pulmonary disease	80 (54%)
Smoking	79 (53%)
Diabetes	40 (27%)
Arrhythmia	34 (23%)
Myocardial infarction	28 (19%)
Multifocal atherosclerosis	24 (16%)
Renal failure	20 (13%)
Obesity	18 (12%)
Violation of cerebral circulation (in history)	8 (5%)
Hyperlipidemia	6 (4%)
Oncology	2 (1%)

Notes: * the data are expressed as mean \pm standard deviation or quantitative (%), IABP – intra-aortic balloon pump; NYHA – New York Heart Association

On average, in CABG, 3.93 ± 0.87 distal anastomosis was performed per patient. Most patients had three-vessel stenotic lesions (87%), and two-vessel stenotic lesions – 13%. Before the surgery IABP was performed in only 11 patients (7%), and in the postoperative period – in 3 patients to maintain low cardiac output. The average stay of patients in the ICU was 1.75 ± 1.13 days (from 1 to 8). The average time spent in the hospital was 13.10 ± 4.47 days (from 6 to 44).

In addition, the 30-day mortality rate was 2% (3 patients), and the need for long-term cardiotoxic support (morbidity) was observed only in 2.7% of cases (4 patients). A higher number of preoperative risk factors correlated with the level of postoperative mortality and morbidity ($p < 0.001$) (Table. 2).

Table 2
Postoperative morbidity and mortality rates in univariate analysis

	Incidence (p-value)	Mortality (p-value)
Age	0.257	0.147
A combination of 2, 3 or more risk factors	<0.001	<0.001
Preoperative ejection fraction	0.947	0.02
Number of affected arteries	0.448	0.512
Number of grafts used	0.676	0.428
Stay in an intensive care unit	<0.001	<0.001
Hospital stay	<0.001	0.356

CONCLUSION

One of the most difficult areas in cardiac surgery is the treatment of patients with ischemic left ventricular dysfunction. Patients with multiple coronary artery disease and severe left ventricular dysfunction are at high risk for coronary artery bypass grafting. Various rates of mortality and morbidity (from 2.7 to 33% and from 30 to 67%, respectively) have been reported even in recent studies [5-7]. Heart transplantation is an alternative treatment option in these patients, but the number of such operations is limited by a lack of donors.

According to a literature review, after surgical myocardial revascularization in patients with ischemic left ventricular dysfunction, compared with drug therapy, there is a better survival rate, an improvement in functional status, and a decrease in the incidence of sudden cardiac deaths caused by arrhythmias [1, 8–10]. However, surgical revascularization of coronary arteries in severe ischemic left ventricular dysfunction can result in high postoperative mortality due to perioperative low cardiac output syndrome. Recent advances in preoperative assessment of myocardial viability, in surgical technique, improvement of myocardial protection and anesthetic care have made it possible to obtain acceptable results of surgical treatment of patients with ischemic left ventricular dysfunction. Accordingly, more patients with severely impaired left ventricular function undergo coronary artery bypass grafting.

Operations of isolated coronary revascularization in patients with ischemic heart disease with severe systolic dysfunction of the left ventricle are performed in most cases under conditions of extracorporeal circulation. Some authors favor coronary revascularization on beating heart in patients with low left ventricular ejection fraction. As a rule, only in 15-20% of cases coronary artery bypass grafting is performed on a beating heart. Such a small percentage of coronary surgery in “off pump” conditions is due to the severity and prevalence of atherosclerotic lesions of the coronary arteries, as well as the complexity of exposure of the heart, especially its posterior surface with a significant increase in the volume of the ventricles. Our experience shows that in these patients it is quite safe and effective to perform multivessel bypass grafting under extracorporeal circulation. Incomplete myocardial revascularization due to the difficulty of positioning an enlarged heart during an operation without cardiopulmonary bypass cannot be ideal for these patients.

In our study, data were collected from 149 patients with left ventricular ejection fraction $\leq 39\%$. Baseline demographic information and preoperative variables are presented in Table. 1.

The in-hospital mortality rate of 2% explains that even these patients with a marked decrease in left ventricular systolic function can be treated relatively safely with good coronary artery bypass grafting. In comparison with the results of other modern studies, our data are quite acceptable.

In the postoperative period, patients showed an improvement in left ventricular ejection fraction and a decrease in left ventricular volume after surgical myocardial revascularization ($p < 0.001$).

The unifying opinion underlying our results is that surgical myocardial revascularization preserves a viable functioning heart muscle from subsequent infarction and “awakens” the hibernated myocardium, which in turn leads to an objective improvement in the left ventricular ejection fraction, a decrease in left ventricular volume, improving congestive heart failure and functional class [11–13].

A decrease in the degree of mitral regurgitation after coronary revascularization was noted. Of 48 patients with degree I – II mitral insufficiency, 38 patients after surgery had no mitral insufficiency completely, and in 10 it was I degree ($p < 0.001$). This improvement in mitral regurgitation is attributed to the restoration of myocardial function by providing blood flow to previously dysfunctional areas of ischemic or hibernated myocardium, which is the main cause of ischemic mitral regurgitation. We believe that a range of preoperative, perioperative and postoperative factors could contribute to satisfactory short-term results. These include: assessment of myocardial viability, a high percentage (in all patients) of using the internal thoracic artery, and adequate use of inotropic drugs in the intraoperative and early postoperative periods. In addition, complete myocardial revascularization and successful myocardial protection are important factors and predictors of favorable short-term and long-term outcomes after coronary artery bypass grafting in patients with poor left ventricular function. The analysis of the conducted study showed that surgical revascularization in patients with severe ischemic left ventricular dysfunction provides a low and acceptable hospital mortality, potential benefits for left ventricular ejection fraction and ischemic mitral regurgitation. The limitations of this study were the short period of postoperative follow-up (30

days after the operation) and the use of only echocardiographic parameters of the left ventricular ejection fraction to assess its systolic function. The univariate analysis shows the relationship between the influence of risk factors on perioperative mortality [14].

This study will be continued to cover more patients and evaluate the changes and benefits for survival in the later postoperative period.

FINDINGS

1. Coronary artery bypass grafting in patients with severe ischemic left ventricular dysfunction can be performed with low mortality.
2. Surgical myocardial revascularization can be considered a safe and effective operation for patients with coronary artery disease with a satisfactory condition of the distal coronary arteries, a low ejection fraction, and a predominance of viable myocardium.

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