Multi-component reconstructive heart surgery as an alternative to transplantation in a patient with combined cardiac pathology and critically low left ventricular contractility

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Introduction. *Cardiovascular diseases rank leading in the world. The decompensation of chronic heart failure is the direct cause of death in most patients. The choice of a definitive treatment tactics is the key factor in these patients.*

Clinical case. *A patient who had experienced myocardial Q-infarction with an ST segment elevation of anterior septal location complicated by the left ventricle anterior wall aneurysm and a decreased myocardial contractility was hospitalized with subcompensated chronic heart failure. Previously, and*

initially with that hospitalization, the patient was considered a candidate for heart transplantation. After the examination, a decision was made on the possibility of a multi-component reconstructive heart surgery, which was performed with a good clinical effect.

Conclusion. *The presented clinical case has confirmed the possibility of correcting the combined pathology in a patient with low myocardial contractility obtaining good immediate and long-term (1.5 years after surgery) results.*

Keywords: heart failure, cardiomyopathy, prosthetic heart valves, cardiopulmonary bypass, scintigraphy, heart transplantation

AA, ascending aorta

AIVB, anterior interventricular branch

AV, aortic valve

AVB, atrio-ventricular block

CHF, chronic heart failure

Echo-CG, echocardiography

EDV, end-diastolic volume

EF, ejection fraction

ESV, end-systolic volume

FC, functional class

HR, heart rate

HT, heart transplantation

IHD, ischemic heart disease

LA, left atrium

LCA, left coronary artery

LV, left ventricle

LVG, left ventriculography

MV, mitral valve

NYHA, New York Heart Association

PASP, pulmonary artery systolic pressure

PCI, percutaneous coronary intervention

RA, right atrium

RV, right ventricle

SatO$_2$, arterial oxygen saturation

TSG, tomoscintigraphy

TV, tricuspid valve

Introduction

The treatment of chronic heart failure (CHF) is an urgent problem arising due to a continuously increasing number of cases with this pathology in the world [1]. The "traditional" treatment tactics is aimed at eliminating the causes of CHF and includes conservative, endovascular, and surgical methods and, if they turn ineffective or unfeasible, the question should be considered of either replacing the failed organ completely by means of transplantation, or creating more favorable conditions for organ function by the implantation of resynchronization devices or mechanical circulatory support systems [2, 3].

Patients with severe CHF resulting from coronary pathology, previous myocardial infarction with the formation of the left ventricle (LV) aneurysm, and valvular defects are often considered candidates for heart transplantation (HT), given a high operational risk inherent in this cohort of patients in case of the "traditional" surgical treatment.

At the same time, HT is characterized by a number of specific features, among which the development of complications associated with immunosuppressive therapy (acute and chronic rejection, infection) comes first [4]. Therefore, in patients with a correctable morphological cause of CHF, even in the end-stage, the possibility of a "traditional" intervention should primarily be considered.

When deciding on the choice of a treatment technique for a patient with terminal CHF, it is extremely important to assess the degree of myocardial damage reversibility by using various methods (ultrasound, radiopaque, radioisotope) [5–7]. Of no less importance for the choice of treatment tactics is to take into consideration the premorbid status of the patient and the severity of damage to the target organs.

When choosing a reconstructive intervention, the main focus should be placed on reducing surgical risks. One of the options to reduce the extent of surgery is a combined approach including endovascular methods [8]. Impaired functions of visceral organs should be corrected as much as possible. The cardiotonic therapy courses with levosimendan are to be undertaken as a method of additional myocardial stimulation in the perioperative period [9].

This report demonstrates the clinical case of a successful multicomponent surgical treatment in a patient with severe CHF who was initially considered a candidate for HT.

Clinical observation

Patient M., 47 years old, having complaints of shortness of breath at minimal physical exertion and a decreased exercise tolerance was hospitalized to the Department of Urgent Cardiac Surgery, Circulatory

Support, and Cardiac Transplantation at N.V. Sklifosovsky Research Institute for Emergency Medicine on 25.08.2017.

From the medical history, it was known that in September 2014, without a previous history of ischemic heart disease (IHD), the patient suffered a myocardial Q-infarction with ST segment elevation at anterior septal location. After 3 hours from the onset of anginal pains at the local hospital where percutaneous coronary intervention (PCI) was not available on technical reasons, the patient received an Actilyse thrombolytic therapy accoridng to a standard scheme. After 2 days, for early recurrent angina pectoris and an increasing heart failure of up to Killip Class III–IV with the development of pulmonary edema, the patient was transferred to a Moscow hospital where the coronary angiography was performed and a proximal occlusion of the anterior interventricular branch (AIVB) of the left coronary artery (LCA) was diagnosed that was treated by means of transluminal balloon angioplasty with stenting the LCA AIVB using a single stent coated with a Cypher SELECT drug (Fig. 1).
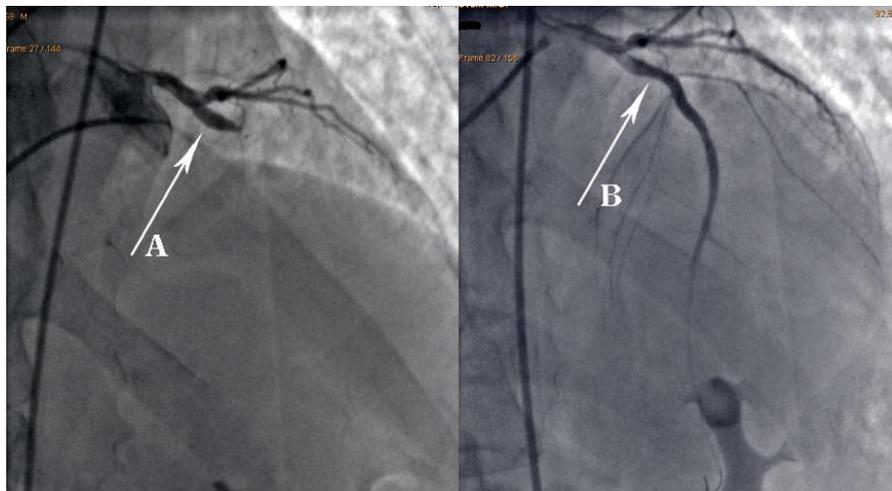

Fig. 1. Coronary angiograms of Patient M. Arrow A indicates the occlusion of the anterior interventricular branch of the left coronary

artery, arrow B indicates the anterior interventricular branch of the left coronary artery after percutaneous coronary intervention

The course of myocardial infarction was complicated by an acute LV aneurysm formation, the decrease in the LV ejection fraction (EF) to 35%, and ischemic mitral regurgitation. Then, the patient was newly diagnosed with an ascending aortic (AA) aneurysm of over 7 cm in diameter (Fig. 2).

Fig. 2. Computed tomography scan (A) and aortogram (B) of Patient M. Arrows indicate an ascending aortic aneurysm

Immediately after having suffered a myocardial infarction, the patient had a clinical presentation of CHF. The load tolerance decreased over time for which the patient was examined at Academician V.I.Shumakov National Medical Research Center of Transplantology and Artificial Organs in December 2014, where ischemic cardiomyopathy was diagnosed. However, given the AA aneurysm, the risk of HT was calculated as being extremely high. The patient was recommended a drug therapy for heart failure.

A significant heart failure deterioration was avoided over the following 3 years, by using progressively increasing doses of drugs. By 2017 the conservative treatment ceased to be effective, and the patient was

hospitalized with subcompensated heart failure to N.V.Sklifosovsky Research Institute for Emergency Medicine to consider the feasibility of HT.

Objectively, the condition at admission was regarded as moderately severe due to the signs of subcompensated heart failure. The skin was pale, there was diffuse cyanosis, no peripheral edema was noted. There was coarse breathing in lungs, without wheezing; the respiratory rate was 18 per minute, SatO$_2$ was 96% when breathing with atmospheric air. Heart sounds were muffled, the rhythm was regular with a heart rate (HR) of 70 beats per minute, blood pressure was 100/70 mm Hg, blowing systolic murmur was auscultated over the entire surface of the heart. The liver extended 4 cm below the costal margin. Ascites was determined at percussion. Despite a diuretic therapy, diuresis was slightly reduced.

On examination:

The 6-minute walk test: 100 meters that corresponds to heart failure functional class (FC) IV according to the New York Heart Association (NYHA) functional classification.

Electrocardiography: sinus rhythm, heart rate 64 per minute, the electrical axis of the heart is left axis deviated, first-degree AV block, signs of cardiosclerosis along the anterior wall.

Echocardiography (Echo-CG): ascending aorta 7.7 cm. Left atrium (LA) 163 mL. LV: end-diastolic size 7.7 cm, end-systolic size 5.8 cm, end-diastolic volume (EDV) 320 mL, end-systolic volume (ESV) 171 mL, EF 23%, posterior wall thickness 1.0 cm, interventricular septum 1.0 cm, akinesis of the apical region, diffuse hypokinesis. Right atrium (RA) 132 mL. Right ventricle (RV) 4.0 cm (anteroposterior size). Aortic valve (AV): thin flaps, no signs of stenosis, 3rd-degree regurgitation into LV. Mitral

valve (MV): thin flaps, no signs of stenosis, 3rd-degree regurgitation into RA. Tricuspid valve (TV): thin flaps, no signs of stenosis, 2nd–3rd degree regurgitation into RA. Pulmonary artery systolic pressure (PASP) 98 mm Hg.

Coronarography: coronary blood supply of the RCA type. No hemodynamically significant lesions have been detected in the coronary artery basin, a stent in the proximal third of the LCA AIVB is competent, however, the passage of the contrast medium along the LCA AIVB is slowed down (Fig. 3).
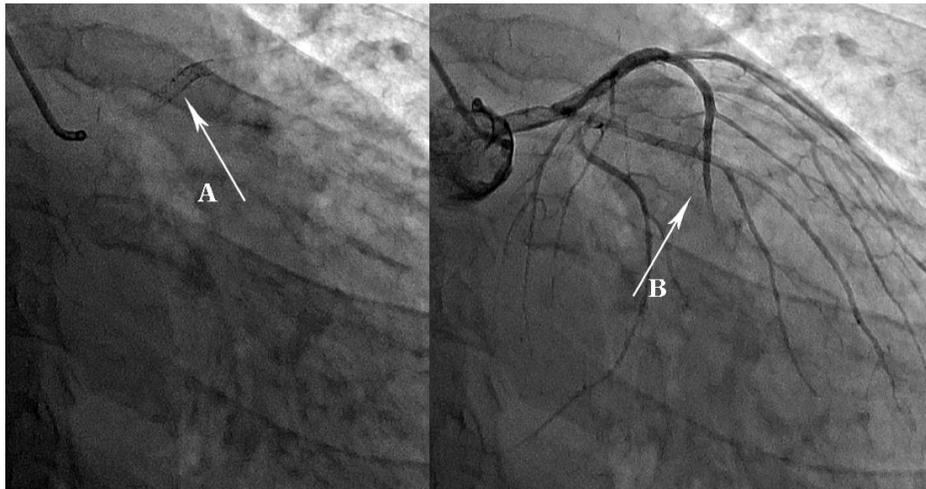

Fig. 3. Coronary angiograms at 3 years after percutaneous coronary intervention. Arrow A indicates the stent in the anterior interventricular branch of the left coronary artery. Arrow B indicates the incomplete filling of the anterior interventricular branch of the left coronary artery, while the distal bed of its other branches is already filled with contrast medium, which indicates a slowdown of the passage along the anterior interventricular branch of the left coronary artery

AA angiography: ascending aorta is expanded to 8.0 cm, 3rd-degree regurgitation on AV (Fig. 4).
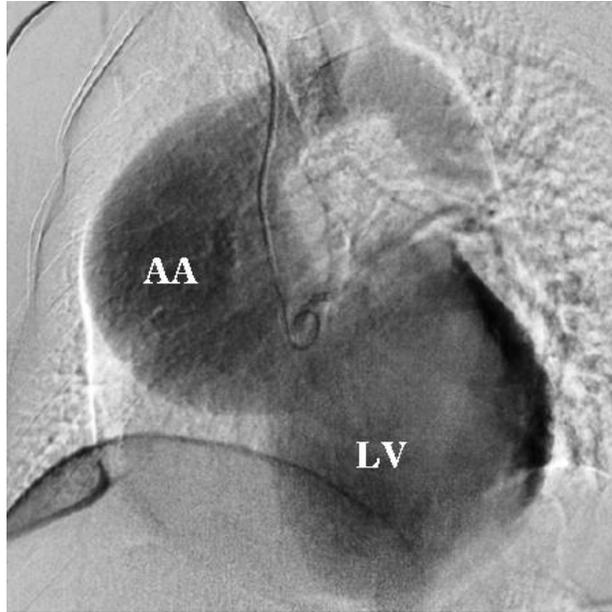

Fig. 4. Angiography of the ascending aorta. The diagnostic catheter is installed in the right coronary sinus. AA, ascending aorta; LV, left ventricle. Contrast enhancement of the left ventricle is similar to the contrast enhancement of the ascending aorta, which indicates a severe aortic regurgitation

Left ventriculography (LVG): LV volumetric parameters are significantly increased, akinesis of the anterior, anterior-septal, and apical areas, EF 20%, 3rd-degree regurgitation into the LA cavity.

Myocardial perfusion tomoscintigraphy (TSG) at rest: myocardium of the markedly enlarged LV is visualized (EDV 500 ml, ESV 404 ml) with the focus of lack perfusion, 10 x 4.1 cm in size, along the anterior wall and apex, (extensive anterior apical aneurysm); the lateral, diaphragmatic and basal thirds of the anterior wall are preserved and functioning, LVEF 25%.

Dilatation of the RV, RVEF 20%. Interventricular asynchrony is 0 m/sec (Fig. 5).
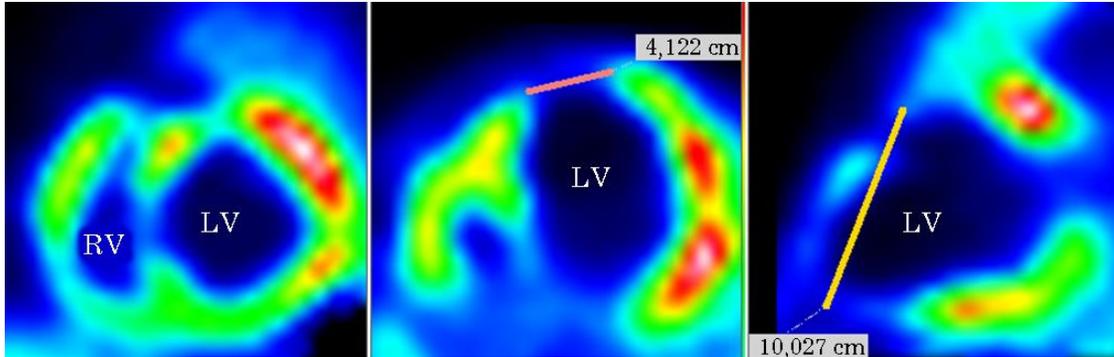

Fig. 5. Myocardial perfusion tomoscintigram. LV, left ventricle; RV, right ventricle. The sizes of the left ventricle aneurysm in different planes are quantified. Areas of myocardial perfusion are marked in red for good perfusion, in green for satisfactory perfusion, and the lack of perfusion is marked in blue

Based on the results of the examinations, it was concluded that the patient had a significant volume overload in the left heart due to the total AV and MV insufficiency, the presence of a large LV aneurysm, while the left ventricle myocardium remained viable outside the aneurysm zone. The possibility of coping with the left heart volume overload in combination with surgical remodeling of the LV and the prospects for restoring global myocardial contractility served as arguments in favor of reconstructive surgery.

In order to improve myocardial contractility before surgery, the patient was administered a 24-hour infusion of levosimendan.

On September 7, 2017 (2 weeks after hospitalization), the patient underwent surgical treatment that included: the AV and AA prosthetics with

a valve-containing On-X - 25 conduit with the reimplantation of the coronary artery orifice using the Kouchoukos technique, the MV prosthetics with On-X - 25/33 prosthesis, De Vega TV annuloplasty, and the LV Dor endoventriculoplasty under conditions of cardiopulmonary bypass.

Specific measures at surgery: retrograde cardioplegia with Custodiol solution (3000 mL after clamping the aorta + 1000 mL after 120 minutes of clamping the aorta), the implantation of the MV prosthesis with a complete preservation of subvalvular structures, a moderate hypercorrection of TV.

Cardiac function (sinus rhythm) resumed at the end of surgery spontaneously, hemodynamic stability was achieved by dopamine infusion at a dose of 5 µg/kg/min, dobutamine 5 µg/kg/min, adrenaline 20 ng/kg/min. The cardiac index was 2.4 L/min/m^2 on surgery completion (vs. 1.94 L/min/m^2 at surgery beginning).

The duration of cardiopulmonary bypass was 247 minutes, that of aortic clamping was 190 minutes.

Hemodynamics in the postoperative period remained stable, by the end of day 2 the infusion of dopamine and adrenaline became possible to be discontinued. Dobutamine infusion in decreasing doses continued for up to 8 days.

The duration of mechanical lung ventilation after surgery was 20 hours. The patient was transferred from the intensive care unit to the hospital ward on the 3rd day.

Due to persisting signs of myocardial insufficiency (LVEF 27–28%, an impossibility of reducing inotropic support), a repeated infusion of levosimendan was performed on day 5 after surgery.

On day 15 after surgery, the patient was discharged from the hospital.

Control examinations were made immediately before the patient's discharge, and later on at 1.5 years after surgical treatment. The changes in the results over time are presented in the Table and Fig. 6

Table. Changes in the results of instrumental investigations over time in Patient M.

Investigation technique and results	Before surgery (baseline)	After surgery	
		After 15 days	After 1.5 years
Echocardiography :			
LV EDV, ml	320	175	210
LV ESV, ml	171	125	120
LVEF,%	23	33	39
AV regurgitation, degree	3	0	0
MV regurgitation, degree	3	0	0
TV regurgitation, degree	2-3	0	0
PASP, mmHg	98	n/a	35
LVG : LVEF,%	20	n/a	35
Myocardial perfusion at rest at TSG:			
LV EDV, ml	500	n/a	336
LV ESV, ml	404	n/a	236
LVEF,%	25	n/a	39
RVEF,%	20	n/a	40
The 6-minute walk, m	100	n/a	> 500
NYHA FC of CHF, class	IV	n/a	0 – I

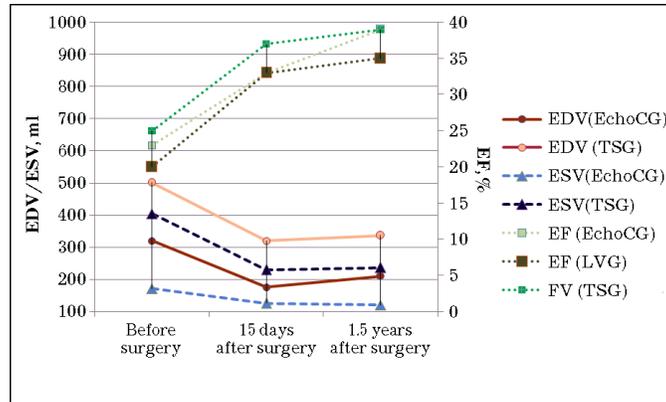Note: n/a, non-applicable, i.e. the study was not performed

Fig. 6. Dynamics of volumetric characteristics of the left ventricular cavity, and the left ventricle ejection fraction

At postoperative examination of the patient before his discharge from hospital, marked decreases in LV volumetric parameters (EDV 175 mL, ESV 125 mL) were noted without their significant increases over time (after 1.5 years: EDV 210 mL, ESV 120 mL). An increase in LVEF was also seen confirmed by various instrumental methods (from 23% to 39% by EchoCG, from 20% to 35% by LVG, from 25 to 39% by myocardial perfusion scintigraphy). Moreover, according to the results of myocardial scintigraphy, a significant increase in the actively perfused volume of the myocardium (Fig. 7) and an increase in LVEF from 20 to 40% were noted.
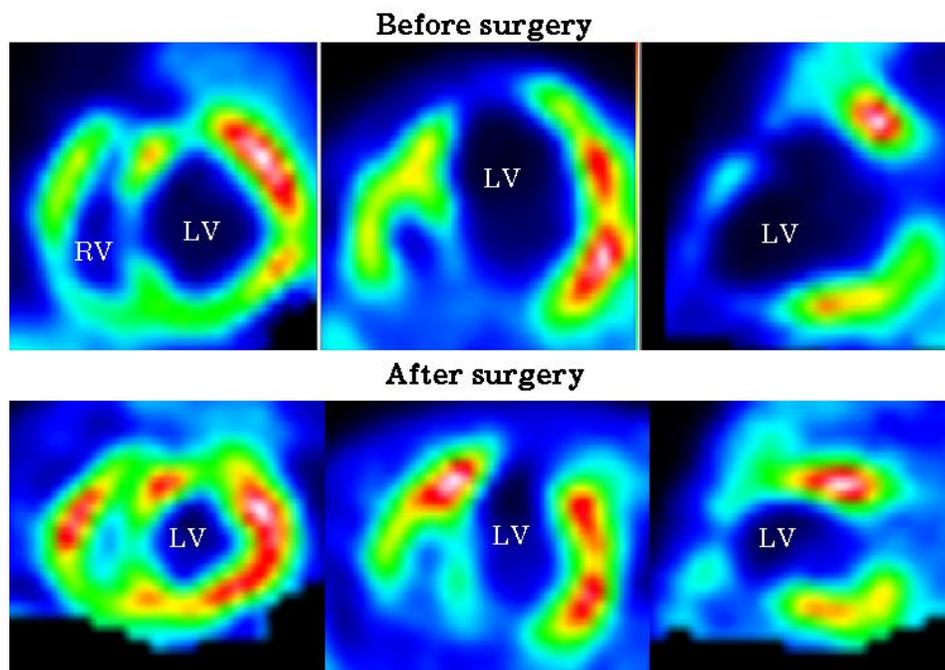
Fig. 7. The comparison of perfusion tomoscintigram of Patient M. before and after surgery. LV, left ventricle, RV, right ventricle. Areas of myocardial perfusion are marked in red for good perfusion, in green for satisfactory one, and the lack of perfusion is marked in blue

No malfunctions of the cardiac prosthetic valves or AA vascular prosthesis were detected, a significant decrease in pulmonary hypertension was seen (from 98 to 35 mm Hg). No negative dynamics in coronary blood flow was noted (as per coronary angiography performed at 1.5 years after surgery).

Subjectively, the patient feels significantly better, does not express the clinical signs of heart failure, tolerates physical activity, which is confirmed by the results of the 6-minute walk test (after 1.5 years: a distance of more than 500 m, which corresponds to the heart failure of 0–1 NYHA FC. The patient's follow-up continues.

Discussion

The decrease in global myocardial contractility is a key independent factor affecting the outcome of "traditional" surgical treatment. Despite advances in therapeutic and surgical methods, the treatment of patients with moderate or severe LV dysfunction who have undergone heart surgery remains a challenge. Patients with low LVEF are known to have a higher risk of postoperative complications and mortality after heart surgery [10, 11]. Thus, the identification of high risk patients of an unsatisfactory outcome of surgery plays a key role in the decision-making process regarding the choice of patient treatment tactics. Low LVEF per se is a major predictor of a poor outcome and is included in all currently available assessment systems [10, 11].

In view of the above, patients with low LVEF are often considered candidates for HT, the implantation of circulation assist devices (VAD), or cardiac resynchronization therapy, even if there is a possibility of the surgical correction of the existing pathology (heart disease, coronary heart disease, LV aneurysm) [12].

Currently, the HT in the treatment of end-stage heart failure remains high and is recognized as the "gold standard", however, this method cannot be reproduced with proper frequency, due to a shortage of donor organs and an inadequate availability of transplant care in Russia. In addition, HT is characterized by a number of specific features, among which the development of complications associated with immunosuppressive therapy (acute and chronic rejection, infection) comes first. The implantation of circulatory support systems as an alternative prolonged method of treating heart failure ("destination therapy") is limited by a high cost of the devices and, as a consequence, there are only occasional cases of their implantation

in clinics involved in the treatment of the end-stage heart failure. The risk of thromboembolic complications requiring a continuous anticoagulant therapy, infectious complications at the site of the power cable coming out of the skin, imperfect power sources, the need for close monitoring of the device functioning, all these are additional negative aspects of this promising method and they does not allow achieving the life expectancy that has already become normal after HT.

The listed limitations of "definitive" methods of the end-stage CHF treatment dictate the need to search for options of performing a "traditional" surgical or combined, stage-by-stage treatment of patients with borderline forms of pronounced CHF that has a potentially correctable morphological cause.

The study of the literature showed that HT is associated with a significantly better quality of life and body functional capabilities in patients with low myocardial contractility than "open" cardiac surgery they undergo [13]. However, in patients with LVEF not exceeding 20%, "open" surgery, such as the coronary artery bypass grafting, can be performed with an acceptable hospital mortality rate of 4.6–7.1%, which is similar to that for HT [14].

Conclusion

Our clinical case report has confirmed the feasibility of the combined pathology correction with obtaining acceptable immediate and long-term (1.5 years after surgery) results in a patient with a low myocardial contractility. The positive effects of surgery include a significant increase in the total left ventricle ejection fraction from 23% to 39% (one should bear in mind that before the surgery, the effective left ventricle ejection fraction and

cardiac index in the presence of total aortic and mitral valve regurgitation were at least 2 times lower), a significant improvement in the patient's quality of life due to diminishing chronic heart failure manifestations, avoidance of the need for immunosuppressive therapy and, accordingly, of its related complications. The patient selection criteria for the "traditional" surgery, as an alternative to heart transplantation, in patients with low LV contractility should include the sufficient myocardial reserves as estimated by scintigraphy, at least, and the technical feasibility of adequately correcting the existing pathology.

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