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Surgical Treatment of Aortic Stenosis in Patients with Low Ejection Fraction.

Alsu I. Abdrahmanova[1], I. V. Abdulyanov[2], and Oleg R. Esin[3].

[1]Kazan Federal University, PhD, assistant professor of Department of Fundamental Basis of Clinical Medicine of the Institute of Biology and Fundamental Medicine of the Kazan Federal University, 420012, Russia, Kazan, Karla Marksa Str., 74.

[2]PhD, assistant professor of Department of cardiology, roentgen-endovascular and cardio-vascular surgery of SBEI CPE "Kazan State Medical Academy" of the Ministry of Health of Russia

[3]Assistant of Department of Fundamental Basis of Clinical Medicine of the Institute of Biology and Fundamental Medicine of the Kazan Federal University[1]

ABSTRACT

A retrospective study of the results of surgical treatment of severe aortic valve stenosis with a low left ventricular ejection fraction was conducted. The study included 38 patients with left ventricular systolic dysfunction (LVSD ≤ 40%) and the maximum transvalvular gradient of 40 mm Hg against the aortic stenosis of various etiology. Patients underwent examination of changes in functional cardiac parameters after the aortic valve replacement under cardiopulmonary bypass. All patients underwent echocardiography that included an integrated 2D and Doppler examination of the heart prior to surgery and 3 months after surgery. A high risk of surgery was expected, according to Euroscore II, nearly 4 to 5%, the average score was 5.8 ± 2.4. The main high-risk factors were low cardiac output, pulmonary hypertension and a heart failure class. Hospital mortality was 0%. The result was the improvement in left ventricular ejection fraction by 10% (p=0.003), and the beginning of the reverse cardiac remodeling. Patients with low LVSD and severe aortic stenosis have a potential clinical effect after surgery with the possible absence of mortality.

Surgical treatment of patients with severe aortic stenosis with low left ventricular ejection fraction has shown good results in contrast to the proposed stratification of the surgery risk.

Keywords: a severe aortic stenosis, low left ventricular ejection fraction, aortic valve replacement.

Corresponding author

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INTRODUCTION

A multicenter research conducted in Europe and the Russian Federation showed that the aortic stenosis is the most common form of valvular pathology. Aortic stenosis accounts for 43% of the total number of valvular heart disease, while the share of patients with aortic stenosis having surgical intervention on heart valves was 46.6% [1]. Aortic stenosis is characterized by a long asymptomatic course; the symptoms expression leads to an unfavorable prognosis with patient's survival of 15 to 50% within 5 years according to different studies [2].

Aortic valve (AV) replacement is the only treatment for aortic stenosis. Modern mortality in case of isolated replacement is 1 to 3% in patients under 70 years old and 4.8% in patients over 70 years old [3, 4].

Left ventricular dysfunction, hypertrophy of the left ventricle (LV) and heart failure, as a rule, are observed in the course of the disease and are independent risk factors of overall mortality and sudden cardiac death. Therefore, low left ventricular ejection fraction (LVEF) increases the perioperative risk and adverse outcome of surgical treatment [5]. Patients with low left ventricular ejection fraction have a postoperative mortality of up to 21%.Other studies show a high survival rate of patients with initially low left ventricular ejection fraction, as the group of patients included only those survived for their analysis [6, 7]. The possible reverse remodeling of the left ventricular myocardium after surgery, the possibility of regression of left ventricular hypertrophy and dilatation are half known [8]. Therefore, it is necessary to study surgical treatment results of a severe aortic stenosis with low left ventricular ejection fraction.

METHODS

The study retrospectively, based on case records examination, involved the patients with the performed aortic valve replacement with cardiopulmonary bypass (CPB) in the period from 2012 to 2015 in the State Autonomous Healthcare Institution "Interregional Clinical Diagnostic Center", with total 258 operations conducted. In this group, the patients with left ventricular systolic dysfunction (LVEF ≤ 40%) and the maximum transvalvular gradient of 40 mm Hg against the backdrop of aortic stenosis of different etiology were identified. Total patients involved in the study were 38 (14.7%) persons, whose clinical characteristics is presented in Table 1. The most common cause of AV stenosis was its calcination in 48% of cases, rheumatic heart disease in 38% of cases, and AV stenosis due to congenital bicuspid valve was in 14% of patients.

All patients underwent echocardiography that included an integrated 2D and Doppler examination of the heart prior to and 3 months after surgery. Hemodynamic assessment of aortic stenosis was calculated according to standard methods by 2D study, in M-mode and Doppler mode. Also, all patients underwent selective coronary angiography. A hemodynamically significant stenosis of the coronary artery was defined as the narrowing of the vessel luminal diameter of one or more coronary arteries ≥70%, or narrowing of the left main coronary artery trunk ≥ 50%.

All patients were under postoperative supervision. All operated patients were under outpatient observation in the State Autonomous Healthcare Institution "Interregional Clinical Diagnostic Center", the follow-up turnout of patients three months after the surgery was 100%.

Table 1: Clinical and hemodynamic data from patients' case records

Characteristics	Value, ± SD (value range)	Characteristics	Value, ± SD (value range)
Age	62.3±6.6 (48 – 74)	*EchoCG*	
Sex: m/f	26/12	LVEF, %	36.3±4.1 (24 – 40)
Suffered MI	4 (10.5%)	EDD, cm	5.7±0.8 (4.1 – 6.8)
Pre-operative symptoms:		ESD, cm	4.3±0.7 (3.0 – 5.8)
Arrhythmia	8 (21%)	Cardiac output, l/min	3.9±1.6 (1.7-6.2)
Dyspnea	38 (100%)	Cardiac index, l/min/m^2	2.14±0.6 (0.9-3.6)
Angina	27 (71%)	IVS thickness, cm	1.35±0.2 (0.8-2.0)
Fainting	5 (13%)	Maximum trasvalvular	85±28.7 (42 – 144)

		gradient, mm Hg	
ECG:		AV opening area, planimetric calculation, cm^2	0.6±0.2 (0.4 – 1)
Sinus rhythm	33 (87%)	Systolic pressure in the pulmonary artery, mm Hg	54.4±16.1 (28 – 83)
Atrial fibrillation	5 (13%)	Severe mitral disease: stenosis/insufficiency	5(13%)/9(23.7%)
Left bundle branch block	9 (23.7%)	Severe tricuspid insufficiency	7 (18.4%)
Left ventricular hypertrophy	14 (36.8%)	Hemodynamically significant coronary bed lesion: abs.n. (%) / average number of arteries	11 (29%)/1.5

Statistical processing was performed by using the descriptive statistics by calculating the mean and standard deviation. The ratio between the preoperative and postoperative values of LVEF was assessed by using a parametric paired t-test. The calculation was made in the program Statistica 6.0, StatSoft Inc.

RESULTS

Before the operation, the surgical mortality and possibility of adverse cardiac events was estimated by using the Euroscore 2 scale [9, 10]. When counting, there was an expected high surgical risk of 4 to 5% on average, the average score was 5.8 ± 2.4. The main high-risk factors were low cardiac output, pulmonary hypertension and a heart failure class. The results of surgical treatment are shown in Table 2. The valve replacement was conducted with the use of the mechanical prostheses "MedEng-2", and biological prostheses "Medtronic Hancock II" and "Carpentier-Edwards Perimount". No operative mortality and cardiac events were observed, the 30-day survival rate was 100%. 14 (36.8%) patients required a prolonged cardiac support with dopamine, in an amount of μg per kg/min., subject to the developed left ventricular failure.

Table 2: Patient surgical characteristics

Characteristics	Value, ± SD
Prosthesis types: biological/mechanical	7(18.4%)/31(81.6%)
Average prosthesis size	22.4±1.9 (19 – 27)
MV intervention	14 (36.8%)
MV replacement	8 (21%)
TK plastic reconstruction	7 (18.4%)
Coronary bypass surgery	11 (29%)
Euroscore 2, points	5.8±2.4 (2 – 14)
Aortic clamping time, min.	76.5±31.8 (38 – 141)
CI time, min.	103.4±42.4 (48 – 204)
Cardiotonic support: abs. n.(%)/time, h.	14(36.8%)/38±4.2

Before surgery, the average HF class was 3±0.5, and in the postoperative period before discharge from the hospital 35 (92%) patients showed symptomatic improvement and improved HF FC respectively. See Table 3.

Table 3: Heart failure dynamics acc. to NYHA

Pre-operative NYHA-based FC		Post-operative NYHA-based FC	
II	5 (13%)	I	19 (50%)
III	28 (74%)	II	15 (39.5%)
IV	5 (13%)	III	4 (10.5%)

After surgery, according to echocardiography, LVEF in the general group increased from 36.3±4.1 to 39.7±6.3% (p=0.003), postoperative LVEF ranged from 28 to 49%, see Fig. 1. Mean transvalvular gradient on the artificial valve was 27.3±10.7 mm Hg, which resulted in an increase in cardiac output (CO) and cardiac

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index (CI) (r≤0.05), but 4 (10, 5%) patients had a low CI (less than 2 l/min/m^2). Also, there was a decrease in the thickness of the interventricular septum (IVS) by 15% on average (r≤0.01).

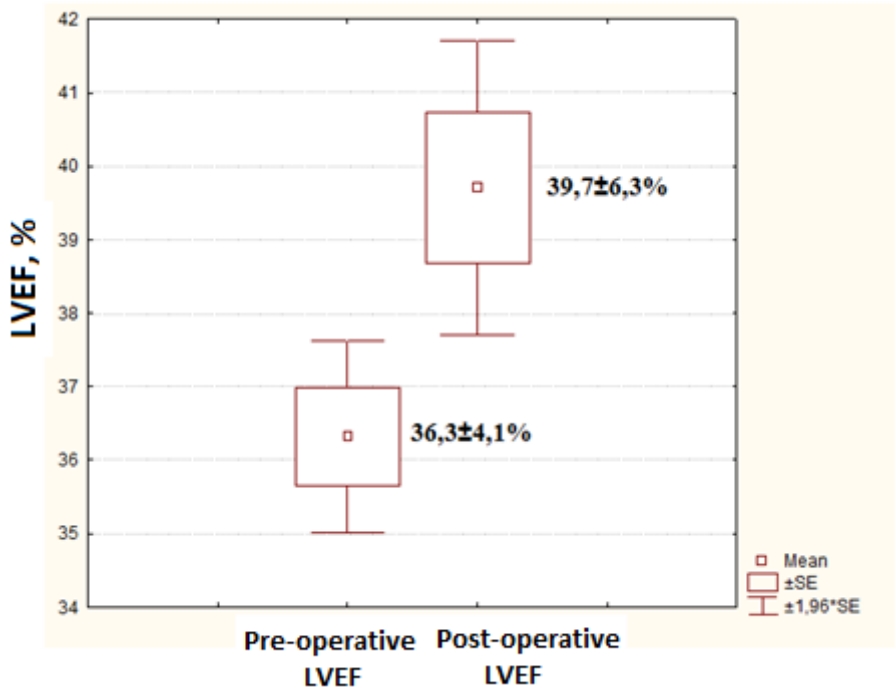

Figure 1. Dynamics of LVEF at AV replacement in patients with initially low EF.

The elimination of the aortic stenosis led to a decrease in pressure in the pulmonary circulation, and consequently to a decrease in pulmonary artery pressure (r≤0.01), see Table. 4.

Table 4: The dynamics of functional parameters according to echocardiography prior to and 3 months post operation

Characteristics	Value, ± SD (value range)	Value, ± SD (value range)	p value
LVEF, %	36.3±4.1 (24 – 40)	39.7±6.3 (28 – 49)	0.003
EDD, cm	5.7±0.8 (4.1 – 6.8)	5.2±0.6 (4.2 – 6.8)	0.04
ESD, cm	4.3±0.7 (3.0 – 5.8)	4.2±0.8 (3.1 – 5.6)	0.35
Cardiac output, l/min	3.9±1.6 (1.7-6.2)	4.6±0.9 (2.5-7.5)	0.002
Cardiac index, l/min/m^2	2.14±0.6 (0.9-3.6)	2.5±0.6 (1.2-3.9)	0.001
IVS thickness, cm	1.35±0.2 (0.8-2.0)	1.18±0.1 (0.9-1.4)	0.000
Average trasvalvular gradient, mm Hg	85±28.7 (42 – 144)	27.3±10.7 (11 – 60.8)	0.000
Systolic pressure in the pulmonary artery, mm Hg	54.4±16.1 (28 – 83)	35.7±7 (25 – 57)	0.000

SUMMARY

A severe aortic stenosis is accompanied by the development of concentric LV hypertrophy on the background of the increased intraluminal pressure, which is a compensatory adaptation. During prolonged load on the wall of the left ventricle there occurs increase in afterload and the left ventricular dilatation. These changes affect the LV systolic function, causing a sharp decline in LVEF [8, 11]. Left ventricular function is a predictor of poor treatment outcome, and patients become controversial for choosing a method of surgical treatment [12]. In our observation, the replacement of an aortic valve with a low left ventricular ejection fraction significantly improved the contractile function of the left ventricle at least by 10% (in the general group). The lack of recovery of the contractile function of the left ventricle was observed in patients with

initially low transaortic gradient (40-47 mm Hg), which was observed in 4 (10.5%) patients of the general group. This is due to the depletion of compensatory mechanisms of the LV wall, which has led to a sharp decrease in both cardiac output and respectively transvalvular gradient [13]. Improvement of the left ventricular ejection fraction occurred in 26 (68%) patients in the nearest time. In 32% of cases (12 patients), left ventricular ejection fraction either remained unchanged or decreased, the lack of dynamics after 3 months in this group of patients may be due to the development of a temporary left ventricular failure in the postoperative period. A prolonged severe aortic stenosis leads to “mitralization” of the disease due to increased end-diastolic pressure in the left ventricular cavity, with the development of severe functional impairment of a mitral valve, which was observed in 23.7% of patients. CO and CI in the postoperative period in the group of patients reached standard values on average. Despite the fact that the low CI in the preoperative period is a negative predictor of postoperative course [14], its improvement perhaps, was the absence factor of 30-day mortality. Reduced pressure in the left ventricle and the load on the left ventricular wall quickly affected the thickness of the myocardium, with further reduction of LV hypertrophy (IVS size decreased). Linear dimensions of the left ventricle, according to echocardiography, also decreased, and the EDD decreased more significantly from 5.7±0.8 cm to 5.2±0.6 cm (p=0.04). Changes in IVS thickness, reduction of the EDD and ESD indicate the reduced afterload and the beginning of reverse cardiac remodeling. The results of surgical treatment did not dependt on the presence of comorbidities, gender and age of patients - 6 (15.7%) patients were over 70 years old.

CONCLUSION

Patients with severe aortic stenosis and left ventricular systolic dysfunction is a small group of patients - 14.7% of all aortic valve replacement surgeries caused by stenosis. Patients with low LVEF and severe aortic stenosis have a potential clinical effect after surgery with the possible absence of mortality. Surgical treatment of such patients has shown good results in contrast to the proposed stratification of the surgery risk.

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