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VALVE-SPARING OPERATIONS ON THE AORTIC VALVE AND THE ASCENDING AORTA: RADICAL CORRECTION OF CONGENITAL AND ACQUIRED HEART DISEASES. IMMEDIATE OUTCOMES

G.A. Akopov, T.N. Govorova, A.S. Ivanov

Shumakov National Medical Research Center of Transplantology and Artificial Organs, Moscow, Russian Federation

This paper presents the immediate outcomes of valve-sparing operations on the aortic valve and ascending aorta in radical correction of congenital and acquired heart disease. **Materials and methods.** The study enrolled 50 patients with aortic insufficiency who were operated upon at Shumakov National Medical Research Center of Transplantology and Artificial Organs from 2011 to 2019. The mean age was 48 ± 16 years, 64% of them were men (n = 32). The study included patients with tricuspid (n = 36, 72%) and bicuspid (n = 14, 28%) aortic valves. Aortic valve reimplantation was performed in 32 (64%) patients, aortic root remodeling - in 1 (2%). 17 (34%) patients had no aortic root reconstruction or remodeling. Aortic valve reimplantation was done in 4 (8%) cases in combination with coronary artery bypass grafting, and in 4 (8%) with mitral and tricuspid valve repair. **Results.** Thirty-day mortality was 0%. In 1 case (2%), a permanent pacemaker was installed due to complete atrioventricular block. There were no neurological and coronary events, and cases of endocarditis. In all patients (100%), aortic valve insufficiency after surgical correction did not exceed grade 1 according to echocardiographic follow-up examination. On aortic valve mean and peak gradients were 8 ± 6 and 15 ± 7 mm Hg, respectively. **Findings.** Type I and II valve-sparing reconstructive surgery (for bicuspid and tricuspid aortic valves) is an excellent alternative to prosthetic repair with great postoperative outcomes, low valve-associated complications and low mortality.

Keywords: valve-sparing surgery, aortic valve reconstruction, aortic insufficiency, aortic regurgitation.

According to European studies, dystrophic diseases constitute the main group of patients with aortic insufficiency – about two-thirds of all observations (Iung B., 2003). Among them there is a significant group of patients with elastic uncalcified tricuspid or bicuspid valves, with aortic insufficiency type 1 (aortic root enlargement with normal leaflet mobility) or type 2 (leaflet prolapse) (Lancellotti P., 2010; le Polain de Waroux J.B., 2007; Lansac E., 2008).

Congenital supraaortic stenosis is the rarest obstructive lesion of the left ventricle. Using the Doty technology, an inverted Y-shaped incision is performed in the ascending aorta down to the noncoronary sinus and the right coronary sinus to the left of the right coronary artery ostium. In some cases, an incision in the right coronary sinus is made to the right of the right coronary artery ostium if the coronary artery is too close to the commissure between the left and right aortic valve leaflets. Extended aortoplasty aims at a more symmetrical enlargement of the aortic root by suturing an inverted Y-shaped patch into the non-coronary sinus and right coronary sinus. Despite small number of observations, many authors consider this technique to be preferable.

In 2017, Tirone David presented his long-term results of aortic valve reimplantation over the past 20 years. In-hospital mortality rate was 1%, survival rate was 72%, and the freedom from reintervention was 96% (David T.E., 2017). In the same year, reconstructive valve-sparing surgeries were included in the European Guidelines for the Management of Valvular Heart Disease as an alternative to aortic valve replacement (class IC) (Baumgartner V., 2017; Karciauskas D., 2019). To date, the choice of access for aortic root reconstruction does not affect long-term outcomes, and a minimally invasive approach has excellent early and mid-term outcomes compared to the conventional midline approach (Charchyan E.R., 2020).

There are many questions surrounding bicuspid valve reconstruction. In 2019, American colleagues analysed 770 publications and 92 major papers, selecting 26 studies. The results showed low hospital mortality, high 5-year survival, and low risk of reintervention. The authors also noted that strengthening of the annulus fibrosus improves long-term outcomes, while calcification and fibrosis of the leaflets, on the contrary, increase the risk of re-intervention (Arnaoutakis G.J., 2019; Boodhwani

Corresponding author: Tuyaara Govorova. Address: 1, Shchukinskaya str., Moscow, 123182, Russian Federation.
Phone: (985) 852-30-17. E-mail: tuyagov@inbox.ru

M., 2009). Insufficient height of leaflet coaptation less than 9 mm at intraoperative assessment may also be a predictor of recurrent aortic insufficiency >2+, less 9 mm at intraoperative assessment (Karciauskas D., 2019).

Objective: to evaluate the immediate outcomes of valve-sparing reconstructions in aortic valve insufficiency.

MATERIALS AND METHODS

The study enrolled 50 patients with aortic insufficiency, who were operated at our center from 2011 to 2019. The mean age was 48 ± 16 years, 64% men (n = 32). The study included patients with tricuspid (n = 36, 72%) and bicuspid (n = 14, 28%) aortic valves. Five patients (10%) were diagnosed with Marfan syndrome. Before surgery, all patients underwent standard examinations (electrocardiography, echocardiography, chest X-rays and contrast-enhanced spiral CT, as well as examinations to exclude concomitant conditions). Preoperative characteristics of the patients are presented in Table 1.

Table 1

Preoperative patient characteristics (n = 50)

Characteristics	Value
Male	32 (64%)
Age, y	48 ± 16
Arterial hypertension	38 (76%)
Hemodynamically significant coronary artery stenosis	12 (24%)
Stanford type A aortic dissection	8 (16%)
Ascending aortic aneurysm	35 (70%)
Aortic arch aneurysm	2 (4%)
Mitral valve disease	12 (24%)
Tricuspidal valve disease	7 (14%)
Marfan syndrome	5 (10%)
New York Heart Association (NYHA) Functional Classification	
Class 1	0
Class 2	10 (20%)
Class 3	32 (64%)
Class IV	17 (34%)
Aortic valve insufficiency	
<2 degrees	17 (34%)
2 degrees	12 (24%)
≥3 degrees	21 (42%)
Bicuspid aortic valve	14 (28%)
Tricuspid aortic valve	36 (72%)
Ejection fraction, %	60 ± 7
Left ventricular mass index (LVMI)	226.1 ± 44.5

Malformation was corrected through a median sternotomy in 47 patients (94%); the rest of the patients had the malformation corrected through an upper median mininotomy. Cannulation was performed in the aorta and right atrium; the left ventricle was drained through the right superior pulmonary vein. For combined pathology, two cannulas were used in the inferior and superior vena cava. Myocardial protection was performed by selective administration of cold cardioplegic solution. In isolated lesions, blood hyperkalemic cardioplegia was performed according to the Calafiori technique; custodiol was used for cases of combined pathology. The volume and frequency of administration varied depending on patient characteristics and extent of surgery performed.

CASE STUDY

On January 9, 2019, a 31-year-old female patient G. was admitted to the cardiac surgery department with the following diagnosis: "Marfan syndrome. Debakey type 1 dissecting aortic aneurysm, subacute stage. Aortic valve regurgitation grade 3. Mitral valve regurgitation grade 2, tricuspid valve regurgitation grade 2. Pulmonary hypertension group 2; Atrial fibrillation, paroxysmal form. Circulatory insufficiency IIb, functional class IV.

The patient's medical history shows that the patient has been suffering from arterial hypertension for a long time, the maximum reaching 180/100 mmHg. In 2019, an echocardiographic examination conducted at her residence revealed an aortic aneurysm with dilatation of the ascending aorta to 6.7 cm.

At the time of examination, her condition was of moderate severity. Marfanoid appearance, scoliosis. Acrocyanosis, pasty legs and feet. BP = 130/60 mmHg, heart rate = 74 beats per minute. Muffled heart sounds, arrhythmic. A systolic murmur was heard in the second intercostal space on the right and a diastolic murmur on the apex. ECG showed atrial fibrillation, normoform, left axis deviation (LAD).

EchoCG showed aortic valve fibrous ring 2.5 cm, at the level of Valsalva sinus 6.0 cm, ascending aorta 7.5 cm, arch 2.9 cm. The left atrium is 5.5 cm (anteroposterior size), 5.3 × 6.6 cm (from apical access). The right ventricle is 3.6 cm. The left ventricle: EDD 6.8 cm, EDV 238 mL, ESD 4.8 cm, ESV 106 mL, stroke volume (SV) 132 mL. Ejection fraction (EF) 56% (according to Teichholz). Interventricular septum (IVS) 1.2 cm, left ventricular (LV) posterior wall 1.25 cm. Left ventricular mass (LVM) 495.1 g. Left ventricular mass index (LVMI) 257.3 g/m^2. Aortic valve regurgitation grade 3, mitral valve regurgitation grade 2, tricuspid valve regurgitation grade 2. Pulmonary artery pressure 50 mmHg.

Chest spiral CT findings: aortic annulus 3.5 cm, ascending diameter 8.3 cm, 5.2 cm at the Valsalva sinus level, aortic arch diameter 2.9 cm. LV EDD 7.7 cm (Fig. 1).

Ultrasound examination of the brachiocephalic arteries and the lower limb arteries revealed no hemodynamically significant stenoses. Coronary angiography: right type, without hemodynamically significant stenoses.

On January 10, 2019, ascending aorta replacement by David procedure and aortic arch replacement with a multi-branch prosthesis under cardiopulmonary

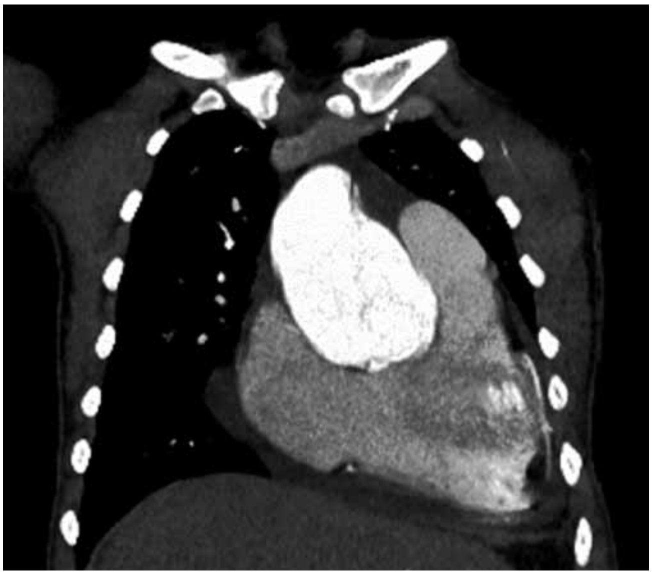

Fig. 1. Contrast-enhanced chest CT scan, lumen of the ascending aorta

bypass (CPB), circulatory arrest and selective antegrade cerebral perfusion (SACP) were performed.

Intraoperatively, the heart was enlarged owing to left ventricular hypertrophy, there was systolic-diastolic tremor over the aorta, the pulmonary artery was not tense. The ascending aorta is dilated to 8 cm. Aneurysmal dilation of the aorta ends at the union of the ascending aorta with the aortic arch. Further, the aorta is about 2 cm in diameter.

The aortic arch and vena cava were cannulated, with the latter being bypassed (Fig. 2). CPB was initiated with hypothermia at 24.8 °C, myocardial protection with chilled cardioplegic solution "Custodiol" (3 litres) into the coronary artery orifices. Heart drainage through the right superior pulmonary vein.

After clamping the aorta, longitudinal aortotomy was performed. On examination, the aortic wall was degeneratively changed, thinned (Fig. 3). The dissection began in the Valsalva sinuses of the non-coronary and right coronary artery with a detachment of the right coronary artery orifice and went beyond the aortic forceps. The aortic wall was dissected circularly with multiple intimal ruptures in the ascending section. The aortic valve was tricuspid, the cusps with marginal thickening, sagging into the left ventricular cavity in the place with detached commissures. The aortic annulus was about 3 cm (Fig. 4).

The ascending aorta was excised with the isolation of the aortic commissures and coronary artery orifices

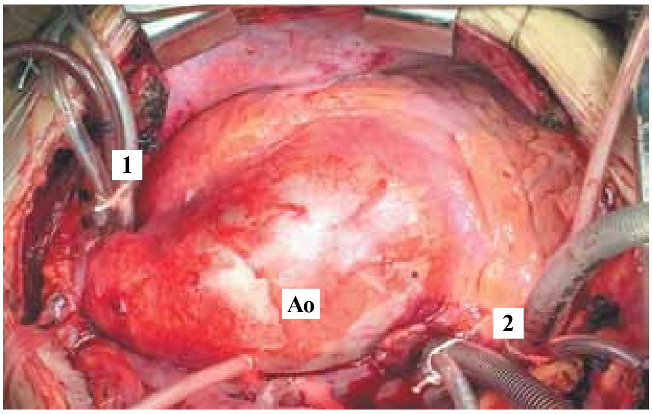

Fig. 2. Cannulation of the aortic arch (1) and vena cava (2).

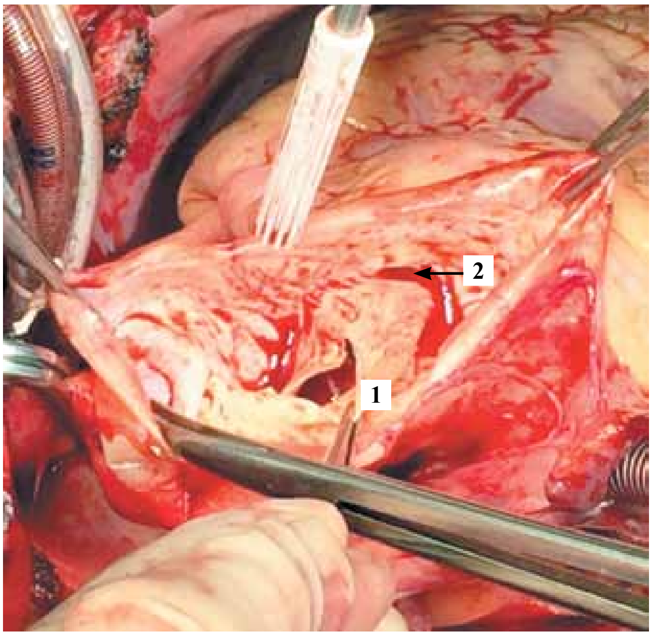

Fig. 3. Longitudinal aortotomy. Aortic valve (1), right coronary arterial orifice (2)

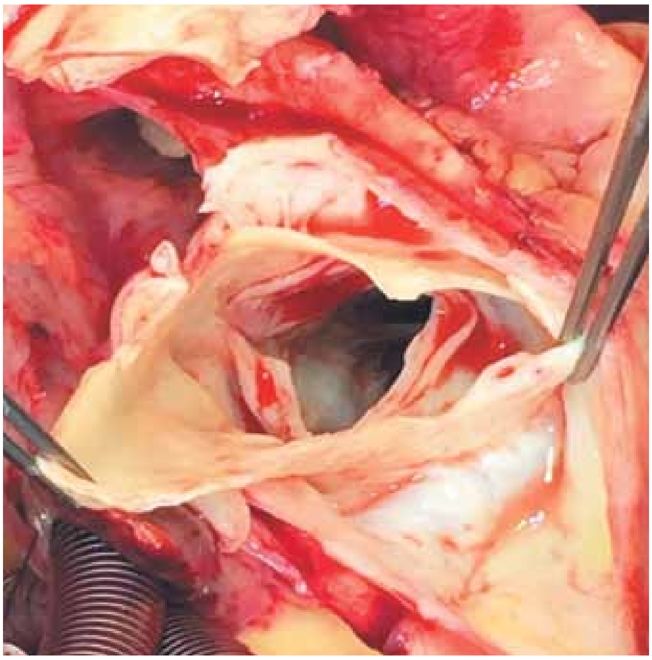

Fig. 4. Aortic root

on the sites. The aortic annulus was stitched with 12 U-shaped sutures on the spacers from the ventricular side. The aortic root was reimplanted into the Gelweave™ Valsalva vascular prosthesis. Multiple nodal sutures were used to perform plication of the right coronary and non-coronary leaflets (Fig. 5).

Against the background of hypothermia at 25 °C, cardiopulmonary bypass was stopped and bilateral SACP through the brachiocephalic trunk and the left common carotid artery was started. The clamp was removed from the aorta. The aortic wall at the arch level was also 2/3 dissected with intimal ruptures in several places and separation of the brachiocephalic trunk and left common carotid artery orifices. The aortic arch was excised. The diameter of the descending thoracic aorta was 18 mm, which prevented lowering of the "elephant trunk" into the descending aorta. A continuous twisted suture formed a distal anastomosis of a multi-branch prosthesis with the descending aorta with a "sandwich" angioplasty of the aortic wall. Cannulation of the additional prosthesis branch. Distal perfusion was started.

An anastomosis of the distal branch of the prosthesis with the left subclavian artery was formed with prolene 5-0 continuous twisted suture. Blood flow through the subclavian artery was initiated.

Interprosthetic anastomosis (ascending aorta and multi-branch prosthesis) was formed with prolene 5-0 continuous twisted suture. Clamp was removed from the aorta; coronary blood flow was restored.

Anastomosis of the middle branch of the prosthesis with the left carotid artery (LCA) was formed with prolene 5-0 continuous twisted suture. Blood flow was started on the LCA. Anastomosis of the proximal branch of the prosthesis with the brachiocephalic trunk was formed with prolene 5-0 continuous twisted suture. Blood flow was started along the brachiocephalic trunk (Fig. 6).

After warming, cardiac activity was restored with the help of two defibrillator shocks, almost immediately with sinus rhythm. At the end of the surgery, there was satisfactory hemodynamics against the background of moderate doses of catecholamines (Dopamine 3 μg/kg/min and Dobutamine 2 μg/kg/min).

CPB was ended, the vena cava and aorta were decannulated. Perfusion branch was ligated with suturing. An electrode was sutured to the right ventricular myocardium. Hemostasis. The pericardial and anterior mediastinal cavities were drained, the pericardium was sutured, and the sternum was tightened with 7 wire sutures. Postoperative wound was sutured tightly in layers. Iodine. Aseptic sticker.

CPB time 271 min, myocardial ischemia 216 min, circulatory arrest 40 min, SACP 110 min. Intraoperative blood loss 1000 mL. Total duration of mechanical ventilation was 11 hours 29 minutes. Length of stay in the intensive care unit was 1 day. During the first 24 hours, 300 mL of serous-hemorrhagic discharge were received via backup drains.

The postoperative period was uneventful. According to EchoCG, the aortic annulus was 2.4 cm, the ascending aorta was 3.4 cm, the arch was 3.0 cm. The left atrium was 4.4 × 5.2 cm (from the apical access). Left ventricle: EDD 5.9 cm, EDV 174 mL, ESD 4.2 cm, ESV 78 mL, SV 96 mL. EF 57% (according to Teichholz). IVS 1.2 cm, LV posterior wall 1.2 cm. LVM 375.7 g. LVMI 195.2 g/m^2. Aortic valve regurgitation grade 1, mitral valve regurgitation grade 2, tricuspid valve regurgitation grade 1. Pulmonary artery pressure 26 mmHg. A chest spiral CT scan with 3D reconstruction was performed in the postoperative period (Fig. 7).

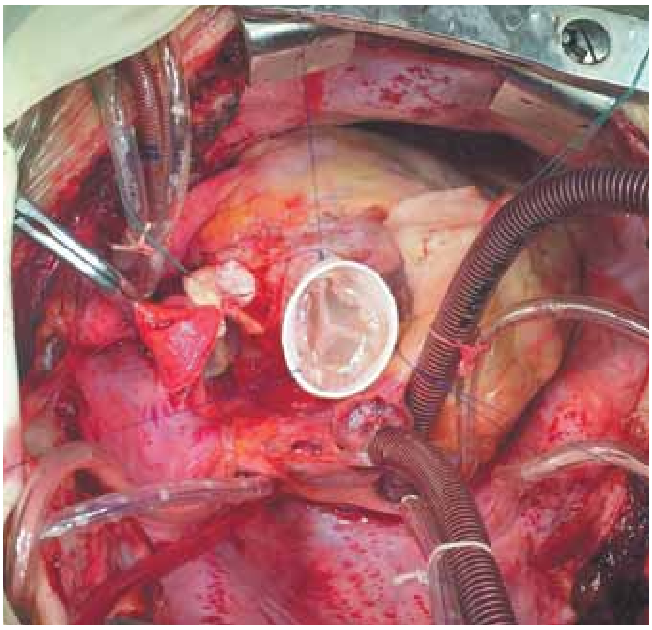

Fig. 5. Valve sparing aortic root replacement, David procedure

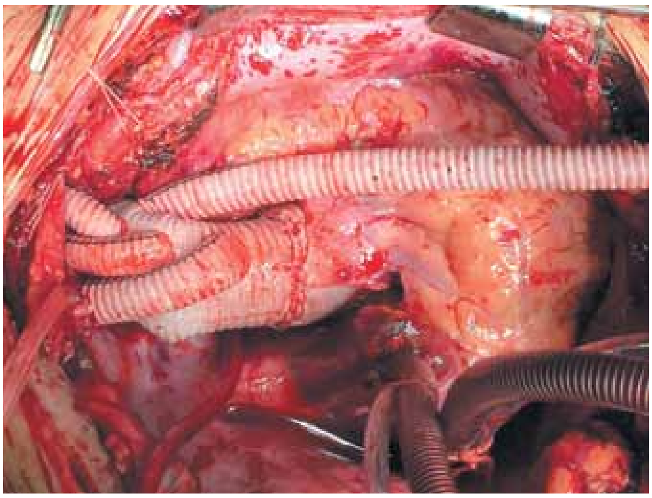

Fig. 6. Aortic arch replacement using a trifurcated branched graft

Histological examination showed dysplastic changes in the aorta.

Fig. 7. 3D volume rendered CT reconstruction

Table 2

Surgical correction and postoperative indicators

Characteristics	Value
David I	**23 (46%)**
with mitral and tricuspid valve repair	1 (2%)
with mitral and tricuspid valve repair and CABG surgery	1 (2%)
with elephant trunk prosthesis	1 (2%)
Florida Sleeve	**9 (18%)**
Standard	7 (14%)
with mitral and tricuspid valve repair	1 (2%)
with CABG surgery	1 (2%)
Yacoub	**1 (2%)**
Aortic valve repair without root procedure	**17 (34%)**
Supracoronary intervention with sinotubular narrowing	**6 (12%)**
with CABG surgery	3 (6%)
Aortic valve leaflet repair	**10 (20%)**
with mitral and tricuspid valve repair	3 (6%)
with CABG surgery	1 (2%)
with subaortic diaphragm resection	1 (2%)
Doty	**1 (2%)**
CPB time, min	128 ± 31
Aortic cross-clamp time, min	103 ± 31
Body temperature during artificial circulation, °C	32 ± 2
Need for catecholamines	32 (64%)
Adrenalin	3 (6%)
Norepinephrine	2 (4%)
Early extubation in the operating room	33 (66%)
Intensive care unit stay, days	2 ± 1
Postoperative wound duration, days	10 ± 4
Permanent pacemaker implantation	1 (2%)
30-day in-hospital mortality	0

The patient was discharged on day 17 after surgery in a satisfactory condition under the supervision of a cardiologist and surgeon at her residence.

IMMEDIATE OUTCOMES

Surgical correction and postoperative indicators are presented in Table 2.

The David I procedure was performed in 23 patients (46%), Florida Sleeve in 9 (18%), and isolated aortic valve leaflet plasty without aortic root replacement in 11 (22%). Central leaflet plication was performed in 18 patients (36%).

CPB had to be reconnected in 2 cases (4%) due to eruption of the suture of the right coronary artery orifice.

The 30-day mortality was zero. In 1 case (2%), a permanent pacemaker was installed due to complete atrioventricular block. There were no neurological and coronary events, as well as cases of endocarditis.

Echocardiographic examination revealed that in all patients (100%), aortic insufficiency after surgical correction did not exceed grade 1. On the aortic valve, the mean and peak gradients were 8 ± 6 and 15 ± 7 mm Hg, respectively.

CONCLUSION

Valve-sparing reconstructive surgery, preserving the native leaflets, is a very good alternative to aortic valve replacement, featuring excellent postoperative outcomes. Indications include intact types 1 and 2 leaflets, both the bicuspid and the tricuspid aortic valves.

The authors declare no conflict of interest.

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