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Outcomes of Surgical Treatment of Patients with Aortic Valve Diseases and Post-Stenotic Expansion of the Ascending Aorta

Aliev Sherzod Makhmudovich, Kayumov Arabbek Ravshanovich

State Institution "Republican Specialized Scientific and Practical Medical Center for Surgery, Named after Academician V.Vakhidov", Tashkent, Uzbekistan

Abstract **Objective.** The study aimed to compare the results of supracoronary prosthesis and ascending portion of the aorta (APA) endoprosthesis with aortic valve (AV) replacement. **Material and methods.** The object of the study was 90 patients operated on at the State Institution "Republican Specialized Scientific and Practical Medical Center for Surgery, named after academician V.Vakhidov" (Tashkent) for AV diseases for the period from 2017 to 2019, who had a concomitant expansion of the APA with a diameter of 40 up to 55 mm. The patients of the first group (n=40) underwent standard AV replacement (AVR) and supracoronary ascending aortic replacement (SCAAR+AVR group); the second group (n=50) patients underwent AVR in combination with exoprosthetic ascending aortic repair (EAAR+AVR). **Results.** EAAR+AVR compared with SCAAR+AVR allowed to obtain good early postoperative results; in particular, the duration of CPB was reduced from 152.68±48.87 min to 96.62±32.49 min ($p<0.001$), the aortic occlusion time was decreased from 114.33±29.26 min to 72.28±24.34 min ($p<0.001$), the frequency of cases of the need for prolonged mechanical ventilation was reduced from 50% to 20% ($p<0.001$), the connection of cardiotonic support was reduced from 48% to 38%. The frequency of increasing the diameters of the sinus of Valsalva was decreased from 11% to 0%, the reoperation rate from 8% to 2% and the mortality rate from 15% to 4%. **Conclusion.** Exoprosthetic ascending aortic repair will improve the results of surgical treatment in patients with aortic valve disease by reducing complications, the length of stay of patients in the intensive care unit, and reduce the cost of surgical treatment (by narrowing the indications for the use of expensive consumables).

Keywords Aortic valve disease, Aortic valve replacement, Supracoronary ascending aortic replacement exoprosthetic ascending aortic repair, Outcomes

1. Introduction

Despite the use of screening programs, continuous improvement, and the widespread introduction of imaging diagnostic methods and surgical aids, aortic valve (AV) malformations and aortic aneurysms remain among the most common causes of sudden cardiac death [1,2,3]. According to the world literature, the prevalence of thoracic aortic aneurysm is 5-10 cases per 100,000 population per year. The five-year survival rate is 64%. Based on anatomical location, the disease is classified into aortic root or aneurysm of ascending part of the aorta (APA), which is the most common (≈60%), followed by descending aortic aneurysm (≈35%) and aortic arch (<10%) [1,4,5].

Treatment of thoracic aortic aneurysm is one of the most challenging and topical issues of modern cardiology and cardiovascular surgery. According to world literature, surgery for aortic valve (AV) and APA aneurysm accounts for 8-12% of all acquired heart defects. The active development of reconstructive surgery for AV pathology and aortic aneurysms has led to significant success in treating this pathology [2,4,6].

However, among the unresolved issues, the choice of the method of surgical intervention seems to be the most important [2,5,6]. For reasonable health care, the development of a unified approach to the surgical correction of aortic stenosis and post-stenotic expansion of the APA, as well as the improvement of technical aspects, providing for a reduction in the volume and traumatization of surgical intervention, while maintaining the radicalness of the operation, are essential.

The study aimed to compare the results of supracoronary prosthesis and APA endoprosthesis with AV replacement.

2. Material and Methods

The object of the study was 90 patients operated on at the State Institution "Republican Specialized Scientific and Practical Medical Center for Surgery, named after

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academician V.Vakhidov" (Tashkent) for AV defects for the period from 2017 to 2019, who had a concomitant expansion of the APA with a diameter of 40 up to 55 mm.

The initial examination included an assessment of clinical status with NYHA heart failure class, standard laboratory tests, echocardiography, coronary angiography, and aortic CT. Clinical and laboratory evaluation of patients was performed through hospitalization and 12 months from the start of the study.

Echocardiography was performed using echocardiographic equipment (VIVID 7D, GE Vingmed Ultrasound, "Philips iE33" Philips Healthcare, USA). Global heart function was assessed by measuring LV end-diastolic volume, LV end-systolic volume, and Simpson's LV ejection fraction. Hemodynamic changes in the AV (pressure gradient, severity of regurgitation) and linear parameters of the aorta were assessed: the diameter of the fibrous ring and the size of the aorta at the level of the sinuses of Valsalva and APA. The aorta was measured from the parasternal position along the long axis. In the postoperative period, transthoracic echocardiography was mandatorily at the time of discharge and 12 months after release.

Aortic dilatation was established by contrast-enhanced CT angiography and APA transthoracic echocardiography.

Ninety patients with AV malformations and post-stenotic expansion of the APA were examined. The patients of the first group (n=40) underwent standard AV replacement and supracoronary ascending aortic replacement (SCAAR+AVR group); the second group (n=50) patients underwent AV replacement in combination with exoprosthetic ascending aortic repair (EAAR+AVR).

- in the SCAAR+AVR comparison group, in 82.5% of cases (33 out of 40), a mechanical AV prosthesis was used; in the remaining 17.5% (7 out of 40), points biological valve was used.
- in the leading group EAAR+AVR also in most (76.0%; 38 out of 50) cases, a mechanical valve prosthesis was used (p=0.604).

Preoperative EchoCG parameters were comparable between the groups.

According to the etiology of AV defect, the patients were distributed as follows:

- degenerative defect was detected in 27.5% (11 out of 40) of cases in the SCAAR+AVR group and 36% (18 out of 50) in the EAAR+AVR group (p=0.746).
- Bicuspid AK was diagnosed in the SCAAR+AVR group in 52.5% (21 out of 40) cases, in the EAAR+AVR group - in 52% (26 out of 50).
- in other cases, rheumatic AV malformation was diagnosed: 20% (21 out of 40) in the SCAAR+AVR group and 12% (6 out of 50) in the EAAR+AVR group (p=0.746).

As the primary mechanism for the development of pathology, AV stenosis was identified in the majority of 60% (24 of 40) cases in the SCAAR+AVR group and 64% (32 of 50) in the EAAR+AVR group (p=0.827). AA deficiency was noted in the remaining 40% (16 of 40) of cases in the SCAAR+AVR group and 36% (18 of 50) in the EAAR+AVR group.

Thus, the groups were comparable in terms of aetiology (p=0.517), the types of valve prostheses used (p=0.604) and the incidence of stenosis (p=0.807) or AV insufficiency (p=0.508).

When comparing preoperative EchoCG parameters from Fig. Table 1 shows that the end-diastolic volume of the left ventricle (LV EDV) in the SCAAR+AVR group averaged 152.72±49.4 (values varied from 119 to 176 ml) and in the EAAR+AVR group it was 153.12±42.98 ml (from 120 up to 176 ml) without a significant intergroup difference (p=0.962).

The mean left ventricular ejection fraction (LVEF) was 55.85±7.06% (ranging from 53.75% to 61.25%) in the SCAAR+AVR group and 53.72±4.58% (from 50.25% to 56%) in the EAAR+AVR group (p=0.030).

In the same way, the mean values of the end-diastolic size of the left ventricle (LV EDD) had no intergroup statistical difference. Thus, the mean LV EDR in the SCAAR+AVR group was 53.61±10.4 mm (indicators varied from 47.5 mm to 62 mm), and in the EAAR+AVR group, it was 54.2±10.66 mm (from 47 to 62.75 mm) (p>0.999).

On the side of the AC on the preoperative EchoCG, the following average values of linear parameters were obtained: the diameter of the fibrous ring of the AC was 24.32±3.49 mm (from 22 to 25.5) and 23.92±2.51 mm (from 22 to 25) in the SCAAR+AVR and EAAR+ group AVR, respectively (p=0.892).

The mean diameters of the sinuses of Valsalva were 37.92±6.02 mm in the SCAAR+AVR group (range 34 to 39.5 mm) and 38.16±3.28 mm (range 36 to 40 mm) in the EAAR+AVR group, with no statistical difference between groups (p=0.177). The mean ascending aortic diameter in the EAAR+AVR group was 45.94±3.28 mm (range 44 to 48 mm), while in the SCAAR+AVR group, it was 46.92±1.69 mm (range 45 to 48), also without a significant difference (p=0.058).

3. Results

The following additional surgical procedures were performed intraoperatively, as shown in Fig. 1. Thus, mitral valve repair (MVP) was performed in 18% (7 out of 40) cases in the SCAAR+AVR comparison group and 26% (13 out of 50) in the EAAR+AVR group (p=0.446). Coronary artery bypass grafts were performed with equal frequency in both the SCAAR+AVR group (10%; 4 of 40) and the EAAR+AVR group (10%; 5 of 50).

The duration of cardiopulmonary bypass (CPB) averaged 152.68±48.87 min in the SCAAR+AVR group (indicators varied from 124 to 172 min), which was significantly longer than in the EAAR+AVR group, where this indicator averaged 96.62±32.49 min (from 68 to 120 min), with a statistical difference (p<0.001) between the groups (Fig. 1).

Accordingly, the duration of aortic occlusion (OA)

averaged 114.33±29.26 min in the SCAAR+AVR group (from 94 to 131 min), which was also statistically significantly longer (p<0.001) than in the EAAR+AVR group, where the duration of OA was on average 72.28±24.34 min (from 52 to 91 min).

When comparing resuscitation parameters in the early postoperative period, the following data were obtained, marked in Fig. 2. Thus, the duration of artificial lung ventilation (ALV) averaged 20.58±8.05 hours (from 15 to 23 hours) in the SCAAR+AVR group and 15.7±9.65 hours (from 11 to 18 hours) in the EAAR+AVR group, which was less with a statistically significant difference (p<0.001). At the same time, the incidence of cases requiring prolonged mechanical ventilation was also lower in the EAAR+AVR group than in the SCAAR+AVR group (20% vs 55%; p<0.001).

No statistical significance was obtained (p=0.415) when comparing patients' average length of stay in the intensive care unit (ICU). Thus, for the SCAAR+AVR group, this indicator was 2.17±1.45 days (52.8 hours), and for the EAAR+AVR group, it was 2.14±2.18 days (51.36 hours).

Cardiac support with inotropic and vasopressor drugs was required in 38% (19 of 50) of cases in the EAAR+AVR group and 48% (19 of 40) of patients in the SCAAR+AVR group, with no significant difference (p=0.397).

The total volume of postoperative blood loss was 252.5±68.83 ml (values varied from 200 to 300 ml) in the SCAAR+AVR group and 305.4±81.12 ml (from 250 to 350 ml) in the EAAR+AVR group, which was statistically significantly higher (p=0.001).

On the first day after surgery, the volume of blood loss through drains was higher in the SCAAR+AVR group, amounting to 199.75±89.91 ml (from 150 to 200 ml), than in the EAAR+AVR group – 180±88.06 ml (from 150 to 200 ml), without significant difference (p=0.152).

In the early postoperative period, the APA diameter in the SCAAR+AVR group averaged 32.9±1.01 mm (from 32 to 34), significantly decreasing from the initial values of 46.92±1.69 mm. Also, in the EAAR+AVR group, a significant decrease in this parameter could be observed from 45.94±3.28 mm to 31.56±1.36 mm (range 30 to 32 mm). No intergroup statistical difference was noted. At the same time, the AV pressure gradient (Table 1) differed statistically significantly in favour of the EAAR+AVR group – 17.94±2.51 mm Hg. Art. versus 19.82±3.86 mm Hg. Art. (p=0.020).

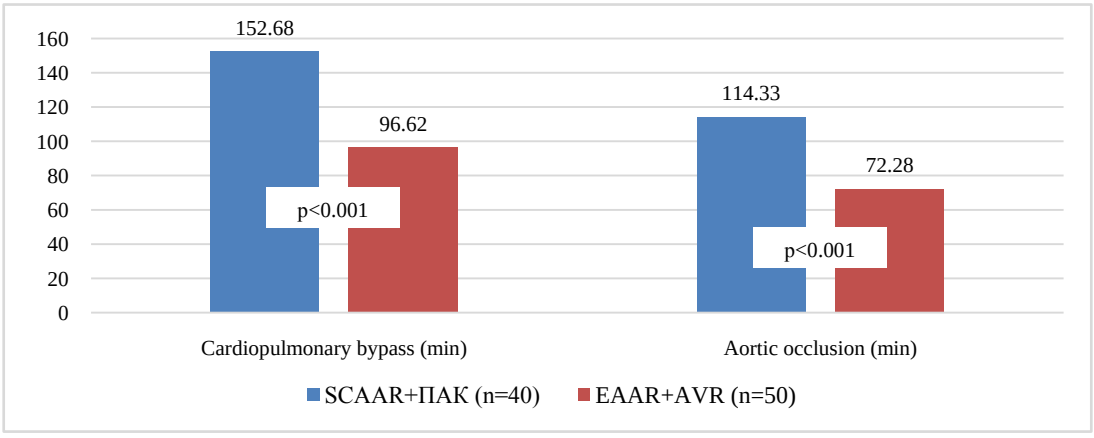

Figure 1. Comparison of cardiopulmonary bypass and aortic occlusion duration between SCAAR+AVR and EAAR+AVR groups

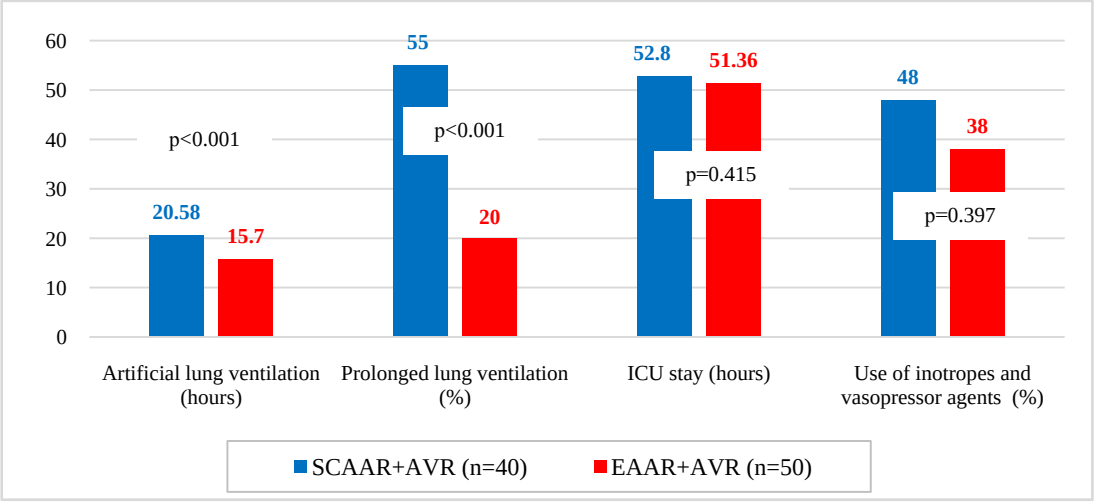

Figure 2. Comparison of some ICU parameters between the SCAAR+AVR and EAAR+AVR groups

Table 1. Dynamics of changes in linear EchoCG parameters

	SCAAR+AVR (n=40)	EAAR+AVR n=50	CI 95%	p
Before surgery				
Annulus diameter, mm	24.32±3.49	23.92±2.51	0 [-1; 1]	0.892
Diameter APA, mm	46.92±1.69	45.94±3.28	-1 [-2; 0]	0.058
Diameter of the sinus of Valsalva, mm	37.92±6.02	38.16±3.28	1 [-1; 4]	0.177
After surgery				
The gradient on AV, mm Hg Art.	19.82±3.86	17.94±2.51	-2 [-3; 0]	0.020*
Diameter APA, mm	32.9±1.01	31.56±1.36	NA NA	NA
Diameter of the sinuses of Valsalva, mm	36.95±5.89	37.1±2.28	2 [0; 3]	0.058
12 months after surgery				
Diameter APA, mm	34.49±1.07	31.56±1.36	-1 [-2; 0]	0.001
Diameter of the sinus of Valsalva, mm	38.08±5.82	32.58±3.93	-4 [-7; -2]	<0.001

The diameters of the sinus of Valsalva were as follows: 36.95±5.89 mm (from 33 to 39.5 mm) in the group of patients after SCAAR+AVR and 37.1±2.28 mm (from 36 to 39) in the EAAR+AVR group without a statistical difference (p=0.058).

Statistically significant differences were noted based on a study of patients 12 months after surgical treatment. Thus, significantly smaller (p=0.001) APA diameters (31.56±1.36 mm; from 30 to 32 mm) were obtained in the EAAR+AVR group than in the SCAAR+AVR group (34.49±1.07 mm; from 32 to 36 mm).

A similar trend was noted for the diameters of the sinuses of Valsalva. So, after 12 months in the group of patients with SCAAR+AVR, the mean diameter of the sinus of Valsalva was 38.08±5.82 mm (from 34 to 43 mm), which was significantly larger (p<0.001) than the average value obtained in patients of the EAAR+AVR group. - 32.58±3.93 mm (from 31 to 35 mm).

In a comparative analysis of the frequency of cases with an increase in the diameter of the APA and the sinuses of Valsalva in the postoperative period, in both groups, there were no cases of an increase in the diameter of the APA either in the early or in the late postoperative period (p>0.999).

At the same time, in the SCAAR+AVR group, in the long-term period, in 11% (4 of 37 examined patients) of cases, an increase in the diameter of the sinus of Valsalva was noted, while in the EAAR+AVR group, this figure was 0.0% (p = 0.030; remotely there were all 50 patients included in the study group examined).

The indicators of reoperations and lethal outcomes obtained during the study are presented in fig. 2. Thus, there were 15% of cases with a fatal outcome in the SCAAR+AVR group (6 out of 40 patients), which was more (p=0.132) than in the EAAR+AVR group - 4% (2 cases out of 50).

Also, the frequency of reoperations in the SCAAR+AVR group was higher than in the EAAR+AVR group - 8% (3 out of 40) versus 2% (1 out of 5) (p=0.319).

4. Conclusions

Aortic valve replacement, combined with the exoprosthetic ascending aortic repair, is accompanied by relatively better postoperative parameters and a decreased frequency of reoperations and mortality.

As expected, a change in the approach to the treatment of this group of patients will improve the results of treatment by reducing complications, the length of stay of patients in the intensive care unit, and reduce the cost of surgical treatment (by narrowing the indications for the use of expensive consumables).

SCAAR – supracoronary ascending aortic replacement,
AVR – aortic valve replacement,
EAAR - exoprosthetic ascending aortic repair
APA – ascending portion of the aorta

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