Mid-Term Results of Aortic Valve Sparing Root Surgery Operations

Berra Zümrüt Tan Recep[1](İD), Deniz Göksedef[2](İD)

[1]Clinic of Pediatric Cardiac Surgery, University of Health Sciences Başakşehir Çam and Sakura City Hospital, İstanbul, Türkiye
[2]Department of Cardiovascular Surgery, İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, İstanbul, Türkiye

ABSTRACT

Introduction: In this study, we retrospectively analyzed the mid-term outcomes of patients who underwent aortic valve-sparing root replacement (VSARR).

Patients and Methods: Ninety-six patients operated on due to annuloaortic ectasia in our clinic between 2012 and 2016 were examined. Twenty-four patients who underwent VSARR were included in the study. They were evaluated using echocardiography and computed tomography in terms of mortality and reoperation according to their preoperative demographic characteristics, aortic regurgitation (AR), and annular dilatation levels.

Results: The early mortality rate was 12.5% (n= 3) and was associated with emergency operation and total arch replacement. The mean follow-up was 33.00 ± 9.53 months. The early mortality rate was 12.5% (n= 3) and was associated with emergency surgery and total arch replacement (p= 0.035, p< 0.05). The mean follow-up was 33.00 ± 9.53 months. None of the patients required reoperation. While postoperative AR was seen in one patient with Takayasu's arteritis (n= 1, 4.16%), it was not observed in the patients with Marfan syndrome or bicuspid aortic valve disease. Postoperative AR and preoperative AR were related (p= 0.012, p< 0.05), but preoperative annulus diameter was not (p= 0.296, p> 0.05). There was no difference in valve durability between the use of Dacron and Valsalva grafts (p= 0.724, p> 0.05).

Conclusion: For patients with aortic root aneurysms, elective VSARR is a good surgical option. However, the presence of comorbidities is related to high mortality because it necessitates urgent and complicated surgery for patients with aortic dissection.

Key Words: Valve-sparing aortic root replacement; acute aortic dissection; marfan syndrome; bicuspid aortic valve

Aort Kapak Koruyucu Kök Cerrahi Operasyonlarının Orta Dönem Sonuçları

ÖZET

Giriş: Çalışmamızda aort kapak koruyucu kök replasmanı yapılan hastaların orta dönem sonuçları retrospektif olarak incelendi.

Hastalar ve Yöntem: Kliniğimizde 2012 ve 2016 yılları arasında anuloaortik ektazi nedeniyle ameliyat edilen 96 hasta incelendi. Çalışmaya VSARR yapılan 24 hasta dahil edildi. Hastalar preoperatif demografik özellikleri, aort yetersizliği ve anuler dilatasyon dereceleri ve kullanılan greft materyaline göre mortalite ve reoperasyon açısından ekokardiyografi ve bilgisayarlı tomografi ile değerlendirildi.

Bulgular: Erken mortalite oranı %12.5 (n= 3) idi ve acil cerrahi ve total arkus replasmanı ile ilişkiliydi (p= 0.035, p< 0.05). Ortalama takip süresi 33.00 ± 9.53 ay idi. Hastaların hiçbirine reoperasyon gerekmedi. Postoperatif ciddi aort yetersizliği (AR), Takayasu arteriti olan bir hastada görülürken (n= 1,%4.16), Marfan sendromu ve biküspit aorta olanlarda rastlanmadı. Postoperatif AR ile preoperatif AR derecesi ilişkiliyken (p= 0.012, p< 0.05), preoperatif annulus çapı değildi (p= 0.296, p> 0.05). Dacron ya da Valsalva greft kullanımı ile kapak durabilitesi açısından fark görülmedi (p= 0.724, p> 0.05).

Sonuç: Aort kök anevrizması olanlarda elektif yapılan VSARR, cerrahide iyi bir seçenektir. Aort disseksiyonu olanlarda acil ve komplike cerrahi gerektirmesi ile komorbiditelerin varlığı yüksek mortalite ile ilişkili olduğu düşünülmüştür.

Anahtar Kelimeler: Kapak koruyucu aort kök replasmanı; akut aort disseksiyonu; marfan sendromu; biküspit aort kapak

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Correspondence

Berra Zümrüt Tan Recep

E-mail: bzumrut.tan@gmail.com
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INTRODUCTION

Aortic root replacement with a composite graft is the traditional surgical technique for aortic root aneurysms[1]. However, valve-sparing surgery has become popular in recent years[2,3]. Preservation of native aortic valve tissue provides an advantage in reducing thromboembolic and hemorrhagic complications associated with mechanical valves and reoperations due to bioprosthesis degeneration, especially in young patients[4,5].

There are two types of valve-sparing aortic root replacement (VSARR): the reimplantation technique, first described by David in 1992, and remodeling, introduced by Yacoub in 1983[2,6]. Today, VSARR is not limited to these two techniques[7,8]. In 2003, Dr. Craig Miller described modifications according to aortic suture lines[7]. There is currently no consensus as to which technique is superior. The results are controversial due to short-term follow-up and small sample size[9,10]. The reimplantation procedure applied in our clinic is thought to be advantageous in decreasing the risk of postoperative aortic regurgitation (AR) and aortic root dilation in patients with aortic dissection and Marfan syndrome. The purpose of the present study was to share the mid-term results of patients who underwent VSARR.

PATIENTS and METHODS

Ninety-six patients operated on due to annuloaortic ectasia in our clinic between 2012 and 2016 were retrospectively examined. Twenty-four patients who underwent aortic valve-sparing root surgery were included in the study; those who underwent aortic root replacement with a composite graft were excluded. In the present study, the effects of preoperative diagnosis, aortic insufficiency degree, surgical technique, simultaneous procedures, and the graft material used on mortality and reoperation were examined using 1, 6, and 12-month echocardiography and computed tomography (CT) scans of the patients. According to the echocardiography scans, AR was grouped as mild, moderate, or severe. In severe AR, the central jet width (as assessed by color flow Doppler) is greater than 65% of the LV outflow tract, the regurgitant volume is greater than or equal to 60 mL per beat, and the regurgitant fraction is greater than or equal to 50%. Computed tomography scanning was applied in all patients in the pre-and postoperative periods to assess aortic diameters, blood flow, and thrombosis in the true and false lumen in cases of aortic dissection. Early mortality was defined as hospital mortality.

Surgical technique

There are two basic types of VSARR, reimplantation, and remodeling procedures. In the present study, reimplantation was performed in 23 patients. In line with the reimplantation procedure, the aortic root was dissected to the level below the aortic annulus. The aneurysmal tissues were roughly excised during surgery while sparing the aortic valve, and then the aortic valve was reimplanted into a Dacron or Valsalva graft. The graft was stitched to the ventricular aortic junction beneath the leaflets proximally. The location of the commissures was detected according to the leaflet height in the graft, the valve was replanted with a continuous suture, and coaptation lines were created. Aortic root restoration was completed by anastomosing the coronary ostium. A Florida sleeve operation was also performed on one of the patients. This surgical technique does not require a full excision of the aortic wall or coronary artery reconstruction. The location corresponding to the left coronary artery is marked on the graft and a keyhole-like slit is opened. The left and non-coronary cusp is surrounded by the graft. The right coronary artery is excised with surrounding tissue and implanted on the graft. In this method, the ventricular aortic junction, the sinus of Valsalva, and the sinotubular junction are supported with a graft, while the coronary orifice is excluded.

The graft size was determined after excision of the aneurysm and the diameter of the sinotubular junction was evaluated with Hegar dilators. The graft diameter was then determined by adding 4-6 mm to the previous measurement according to the body mass index (BMI) of the patient. In the Florida sleeve technique, preferably a Valsalva graft is used, which is 6-8 mm larger than the aortic annulus diameter based on the BMI of the patient.

Statistical Analysis

NCSS software (NCSS, Kaysville, Utah, USA) was used for the statistical analysis. While evaluating the study data, descriptive statistical methods (mean, standard deviation, median, frequency, and ratio) were used along with the Shapiro-Wilk test and box plots to determine the compliance of the variables with the normal distribution. The Mann-Whitney U test was used for intergroup comparisons of non-normally distributed quantitative variables. McNemar's test, Fisher's exact test, and the Fisher-Freeman-Halton test were used for the comparison of qualitative data. Significance was set at the $p< 0.05$ level.

RESULTS

The demographic, echocardiographic, and operative findings of the patients were examined. The mean age was 55.46 ± 13.01 and 83.3% of the patients were male. While 62.5% of the patients (n= 25) had hypertension, 33.3% (n= 8) had coronary artery disease. Emergency surgery was performed

in 16.7% (n= 4) of the patients due to Type A aortic dissection. Indications other than for emergency surgery were accepted as a diameter greater than 50 mm in symptomatic patients, the symptomatic nature of the patient, and comorbid connective tissue disease. Of the patients that underwent elective surgery, 8.1% (n= 2) had a Marfan syndrome diagnosis, another 8.1% (n= 2) had bicuspid aortic valves, and 4.16% (n= 1) had Takayasu's arteritis.

Reimplantation was applied in 95.8% (n= 23) of the patients and the Florida sleeve technique in 4.2% (n= 1). Distal anastomosis was performed with open anastomosis under total circulatory arrest in 91.7% (n= 22). Simultaneous hemiarch replacement was performed in 75% (n= 18), total arch replacement in 16.7% (n= 4), coronary artery bypass graft in 33.3% (n= 8), and mitral ring in 8.3% (n= 2) (Table 1). The cross-clamp time of the patients was 121.41 ± 22.97 minutes

Table 1. Patients characteristics and operative details

		n	%
Gender	Female	20	83.3
	Male	4	16.7
Follow-up time expect for early mortality (month)		12-48 (34)	33.00 ± 9.53
Aortic pathophysiology	Anuloaortic ectasia	15	62.5
	Emergency operation (Type A aortic dissection)	4	16.7
	Marfan syndrome	2	8.3
		2	8.3
	Takayasu arteritis	1	4.16
Surgical procedure	Reimplantation procedure	23	95.8
	Florida Sleeve procedure	1	4.2
Operative extend	Ascending aorta	2	8.3
	Hemiarcus	18	75.0
	Total arcus	4	16.7
Total circulatory arrest		22	91.7
Concomitant CABG		8	33.3
Concomitant mitral repair		2	8.3
Preoperative AR grade	Mild	6	25.0
	Moderate	11	45.8
	Severe	7	29.2
Postoperative AR grade (n= 21)	Mild	16	76.2
	Moderate	4	19.0
	Severe	1	4.8
Postoperative type B dissection (n= 21)		1	4.8
Graft number (mm)	26	3	12.5
	28	7	29.2
	30	9	37.5
	32	4	16.7
	34	1	4.2
Graft type	Dacron Graft	15	62.5
	Valsalva Graft	9	37.5

AR: Aortic regurgitation, CABG: Coronary artery bypass graft, BAV: Bicuspid aortic valve.

Table 2. Evaluation of the factors affecting postoperative aortic regurgitation

		Postoperative AR			
		Mild	**Moderate**	**Severe**	**bp**
Preoperative AR	Mild	**6 (28.6)**	5 (23.8)	5 (23.8)	
	Moderate	0	**3 (14.3)**	1 (4.8)	**1 (4.8)**
	Severe	0	0	**1 (4.8)**	
Annulus diameter	Min-max	35-59 (44)	27-48 (38)	**30-30 (30)**	**0.296[a]**
	Mean ± SD	43.25 ± 5.57	37.75 ± 9.50	30.00	
Graft type n (%)	Valsalva Graft	5 (71.4)	2 (28.6)	0 (0.0)	**0.724[b]**
	Dacron Graft	11 (78.6)	2 (14.3)	1 (7.1)	
BAV	(-)	14 (87.5)	4(100)	**1 (100)**	**1.000**
	(+)	2 (12.5)	0	**0**	
Marfan syndrome	(-)	14 (87.5)	4 (100)	**1 (100)**	**1.000**
	(+)	2 (12.5)	0	**0**	

AR: Aortic regurgitation, BAV: Bicuspid aortic valve.
Mc Nemar test. *p< 0.05
[a]Mann-Whitney U.
[b]Fisher's Freeman Test.

Table 3. Comparisons by mortality

		Mortality n (%)		p*
		(-)	**(+)**	
Emergency operation	(+)	1 (25.0)	3 (75.0)	0.035*
	(-)	17 (85.0)	3 (15.0)	
Total arcus replacement	(+)	1 (25.0)	3 (75.0)	0.035*
	(-)	17 (85.0)	3 (15.0)	

[b]Fisher's Exact Test.
*p< 0.05

(min-max: 89-165) and the cardiopulmonary bypass (CPB) time was 158.50 ± 16.52 minutes (min-max: 125-180).

The relationship between preoperative demographic and echocardiographic examinations and postoperative AR was evaluated. According to the diagnoses, Marfan syndrome and bicuspid aortic valve were not risk factors for postoperative AR (p> 0.05). However, in a patient who was diagnosed with a bicuspid aortic valve and simultaneous cusp intervention, an average postoperative gradient of 22 mmHg was detected. This patient had preoperative mixed-type valve pathology. Severe postoperative valve dysfunction was observed in the patient with Takayasu's arteritis (p< 0.05). It was observed that the risk of postoperative AR increased as the preoperative AR degree increased (p< 0.05). There was no difference in AR according to the annulus diameter and the graft material used (Table 2).

Early mortality was identified in 12.5% (n= 3) of the patients. The mortality rates of those who underwent emergency surgery were higher by a statistically significant margin (p= 0.035; p< 0.05). The causes of death were low flow rate and multi-organ failure due to sepsis. In addition, simultaneous total arch replacement and the elephant trunk procedure were risk factors for mortality (p= 0.035; p< 0.05). There was no early mortality in patients who underwent elective surgery (Table 3).

DISCUSSION

In the present study, postoperative severe AR was seen in only one patient, and that patient was diagnosed with Takayasu's arteritis. Although there is no study on this subject in the literature, it is thought to be related to aortopathy. None of the patients with Marfan syndrome and bicuspid aortic valve had

severe AR and therefore underwent reoperation. It is thought that the application of reimplantation in all patients influenced this situation. Simultaneous leaflet repair was performed in a patient with a bicuspid valve. A mean postoperative aortic gradient of 22 mmHg was detected. Preoperative aortic valve gradient detection is thought to be a relative contraindication for reimplantation. Preoperative aortic annulus diameters were not found to be influential in terms of AR. Postoperative AR rates were quite low compared to those in other studies; the reasons behind this include the small number of patients who underwent leaflet repair and the insufficient follow-up period of the patients (Table 1, 2).

The primary disadvantage of aortic valve-sparing root surgery is replacement and reoperation due to recurrent AR. In the study by Hanke et al., Marfan syndrome, preoperative annulus diameter, and leaflet intervention were reported to be risk factors for AR. Although the mean AR rate was not statistically significant in patients with Marfan syndrome, it was higher after the remodeling technique. It is thought that the key factor determining AR in both techniques was the learning curve[11].

Today, the increasing number of VSARR operations has led to more research being conducted on the topic. In the reimplantation technique, it is necessary to use 4-5 mm grafts to create a neoaortic sinus[12]. Valsalva grafts were created by De Paulis et al. as a solution to this[13]. Although better hemodynamic outcomes were expected, no studies demonstrated their superiority over straight tube grafts in terms of survival or aortic valve-related reoperations[14-16]. The need for aortic leaflet repair was also found to be higher in those using a Valsalva graft, which is a risk factor for late VSARR reoperation[17].

Settepani et al. performed reimplantation with Valsalva grafts in 45 patients with Marfan syndrome during the course of their study. The goal was to determine the height of the commissures and the place where they will be implanted. The results obtained were similar to those in patients who underwent a reimplantation operation with a Dacron graft, and they were considered good. However, there are no studies showing the long-term outcomes of patients[18].

In another study, by Paccini et al., 151 patients underwent reimplantation with a Valsalva graft. Non-reoperational survival rates were low compared to the reimplantation procedure with a Dacron graft. However, leaflet repair was suggested as a risk factor for reoperation in the study. The risk of late reoperation was high in patients with residual AR[19].

David reported his results for the 20 years prior to 2021. He explained that the development of AR after reimplantation was slow and progressive, but only severe in 10% of patients. He also explained that the degenerative process in the aortic root was slowed and reduced by placing a noncompliant Dacron graft. No additional benefit was demonstrated with the use of Valsalva grafts[20].

In the present study, a Valsalva graft was used in 37.5% (n= 9) of the patients. There was no difference in postoperative AR between the Dacron and Valsalva grafts. It is thought that the low AR rates may have influenced this. Residual severe AR was not detected in patients receiving either graft. The short follow-up period of the patients and the scarcity of studies using Valsalva grafts were other reasons why the results could not be evaluated clearly. The bleeding revision rate was found to be 20% (n= 3) in patients who had Dacron grafts and 22% (n= 2) in those who had Valsalva grafts, and the difference was not significant (Table 2).

When previous studies were reviewed, it was observed that early mortality ranged from 0.9% to 12%[21]. The risk factors reported were advanced age, emergency surgery, comorbid mitral/coronary artery disease, and long CPB duration[22]. Causes of early mortality were low cardiac output and multiorgan failure. Patients were compared according to preoperative diagnosis, elective or emergency surgery, and surgical method. It was observed that both techniques were safe to be applied in elective cases but the mortality in aortic dissection was high, as it was in other studies[21].

Aortic root surgery is controversial in patients with Type A aortic dissection. According to the first reports, the early mortality rate after VSARR ranged from 28% to 58%[23,24]. It is performed together with hemiarch or total arch replacement in most centers and low reoperation rates are reported[25,26]. Although VSARR is not considered the first choice in acute dissection, it has been suggested as a viable alternative in reports in recent years. In one study, no difference was found between David and non-David patients in terms of early mortality and major postoperative complications, i.e., AR. It was also emphasized that the risk of late redissections and aneurysms was higher in the non-David group[27]. In another study, the David procedure was superior to the Bentall procedure in terms of hospital mortality and postoperative complications[28].

David et al. reported that aortic dissection was an independent risk factor for mortality[29]. Conducting a David operation on emergency patients was controversial in the past. However, no difference was found between the survival rates of VSARR and operations such as the Bentall procedure[30]. Today, the idea that the David procedure is effective and safe

in this patient group is becoming more prevalent. There are studies that associate this with surgeons gaining greater experience with VSARR. The general opinion is that VSARR should be applied in Type A dissection in the group of young patients who have not developed dissection-related complications[31].

In Beckmann et al.'s study with 732 patients, the mortality rate in the first 30 days after VSARR was 3.8% in elective patients and 16.9% in those who underwent emergency surgery for type A dissection. Some think it can be performed in young and stable dissection patients, but the priority in this patient group is survival[32].

Reimplantation is considered the first choice in patients with aortic dissection in our clinic. In the present study, the early mortality rate was 12% (n= 3). These patients were operated on under emergency conditions and underwent simultaneous total arch replacement. Similar to other studies, the cause of mortality was low flow and sepsis. When they were taken into surgery, 8.3% (n= 2) of the patients had experienced a stroke and 4.16% (n= 1) had tamponade. Mortality after elective surgery was 0%. Type A aortic dissection and simultaneous total arch replacement were risk factors for mortality. It was thought that the patient's preoperative age, poor general condition, and the fact that surgery required a more complicated and longer CPB period in patients who had total arch replacement were related to this situation. Another cause of mortality in patients diagnosed with type A aortic dissection after VSARR was type B dissection complications. However, in the checks performed on a patient that we followed up on, the false lumen was thrombosed and there were no complications. In a study conducted by Yacoub et al., late mortality was high in patients who were operated on for aortic dissection. Mortality in these patients appeared to be due to comorbid simultaneous arch surgery, CHF, and complications in the remaining aorta[3]. According to the literature, late mortality in patients ranges from 4% to 7.5%. In the meta-analysis published by Zhou et al. in 2020, the risk of late mortality and reoperation was three times higher after remodeling. Early mortality tends to occur after reimplantation, although there is a difference in postoperative risk of severe AR and stroke[33].

In the present study, the late mortality rate was 14%. All deaths were due to non-cardiac causes. In general, although late mortality seems to be higher compared to other studies, not a single death due to cardiac causes was detected. No reoperation was observed. There were no thromboembolic complications or endocarditis. According to these results, the rates are lower than those in other studies. The small number of patients with aortic dissection among the patients followed up may have been influential in this situation. Late mortality was nonexistent in patients with Marfan syndrome and bicuspid aortic valve, and no complications were seen in the remaining aorta in the tomography scans of the patients.

CONCLUSION

Despite the small sample size in the present study, the diversity of the patients made comparisons possible. While no relationship was found between preoperative annulus diameter, Marfan syndrome, and bicuspid aortic valve in terms of aortic valve durability, the preoperative AR degree was considered important. No mortality was observed in the elective patients, although mortality was correlated with emergency surgery and simultaneous total arch replacement. Some attest that it should be performed in selected young patients who will be operated on for type A dissection and who do not have comorbidities.

Limitations

The primary limitation of this research lies in the small sample size of patients, which further diminishes when considering only those with mortality or specific demographic characteristics.

Ethics Committee Approval: The study was approved by İstanbul University-Cerrahpaşa Faculty of Medicine Clinical Research Ethics Committee (Decision no: 02-45967, Date: 05.02.2016).

Informed Consent: This is retrospective study, we could not obtain written informed consent from the participants.

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