THE INJECTOR

DOI: 10.5281/zenodo.8322524
The Injector 2023;2(3):128-136

Original Article

Comparison of postoperative results of patients undergoing Bentall surgery using Biovalsalva and composite grafts

Ayşe Çiçek[1], Yeşim Güner[2], Mihriban Yalçın[1], Korhan Erkanlı[3]

[1]*Ordu State Hospital, Department of Cardiovascular Surgery, Ordu, Turkey*
[2]*Kütahya Health Sciences University Faculty of Medicine, Department of Cardiovascular Surgery, Kütahya, Turkey*
[3]*İstanbul Medipol University, Faculty of Medicine, Department of Cardiovascular Surgery, İstanbul, Turkey*

Abstract

Objective: Biovalsalva grafts have been used as new grafts in recent years due to the need to reduce complications and mortality of Bentall surgery. This study compared the postoperative results of patients who underwent Bentall operations using Biovalsalva grafts and those who used valved conduit grafts.

Methods: Between January 2015 and March 2017, the study included 40 patients who were diagnosed with ascending aortic aneurysms (AAAs) and underwent the Bentall procedure in our clinic. Twenty patients using Dacron grafts were included in Group I and 20 patients using Biovalsalva grafts were included in Group II. The patients were compared in terms of cardiopulmonary bypass (CPB), cross-clamp times, preoperative and postoperative first month echocardiography (ECHO) results, length of stay in the hospital and intensive care unit, amount of drainage and inotropic use.

Results: The age of the patients using Biovalsalva grafts was significantly higher than those using composite grafts ($p<0.001$). The comparison of the patients in terms of CPB time showed no significant difference ($p=0.174$). The cross-clamp time was significantly lower in patients treated with Biovalsalva grafts than in those treated with composite grafts ($p=0.023$). The mortality results between the two groups showed no significant difference.

Conclusion: Although the Biovalsalva graft did not make any additional difference in terms of postoperative ECHO findings, morbidity, or mortality, it significantly shortened the cross-clamp time. Better results can be achieved with the increase in the use of Biovalsalva grafts.

Keywords: Bentall operation, biovalsalva graft, composite graft, mortality.

Address for correspondence: Mihriban Yalçın, Ordu State Hospital, Şahincili, 52200, Ordu, Turkey.
Phone: +90 452 234 32 32 **E-mail:** mihribandemir33@hotmail.com **ORCID:** 0000-0003-4767-0880
Received: 5 May 2023 **Revised:** 19 July 2023 **Accepted:** 24 July 2023 **Published:** 6 September 2023
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INTRODUCTION

Aortic root replacement, as first described by Bentall, is a procedure that involves the replacement of the ascending aorta containing the aortic valve and aortic root with a tube graft and the reimplantation of the coronary arteries in this graft. With the improvement of tube grafts and aortic root conduits as well as the development of anastomosis and hemostasis techniques, only the interposition of the valved conduit has become the preferred procedure today (1). Despite the development of many modifications and new surgical techniques after the original technique of Bentall and De Bono, and the introduction of more advanced collagen and gelatin-enhanced grafts, biological tissue adhesives, new drugs and equipment, complications in aortic root replacements are still a serious problem (2). Biovalsalva grafts have recently been used as one of the solutions in response to these needs. The present study compared the postoperative results of patients who underwent Bentall operations using Biovalsalva grafts and those who used valved conduit grafts.

MATERIALS AND METHODS

Between January 2015 and March 2017, the study included 40 patients who were diagnosed with ascending aortic aneurysms (AAAs) in our clinic and who underwent the Bentall procedure. After median sternotomy, cardiopulmonary bypass (CPB) was achieved by ascending aorta or femoral or axillary artery cannulation. Echocardiography (ECHO) findings, the age of the patient, the structure of the valve preoperatively and the surgeon's experience played an important role in the decision to intervene in the valve and ascending aorta. Dacron and Biovalsalva grafts were used in Bentall surgery. Twenty patients using Dacron grafts were assigned to Group I and 20 patients using Biovalsalva grafts were assigned to Group II. Patients who had undergone previous surgery, urgent surgery, or surgery for aortic dissection were excluded from the study. The study compared patients' CPB, cross-clamp times, and preoperative and postoperative first month ECHO results. In addition, it examined their terms of length of stay in the hospital and intensive care unit, amount of drainage and inotropic use.

Statistical analysis

Statistical analysis of the study findings was performed using SPSS 24 for Mac. Descriptive statistical methods (mean, standard deviation, frequency) were used to evaluate the study data. Student's t test was used for comparisons between two groups of variables that met parametric assumptions and the Mann–Whitney U test was used for comparisons between two groups of variables that did not meet parametric assumptions. One-way MANOVA was used to evaluate the variables of height, weight, Body Mass Index (BMI) and Body Surface Area (BSA) between the two groups. The chi-square test was used to compare qualitative data and Yates correction was used in case the expected frequencies were not met. The results of all analyses were evaluated at the significance levels of $p<0.05$ and $p<0.01$.

RESULTS

In our study, 35% (n=7) of the patients who used composite grafts were female and 65% (n=13) were male. Of the cases in which Biovalsalva grafts were used, 20% (n=4) were female and 80% (n=16) were male. There was no statistically significant difference between the two groups in terms of sex. The ages of the patients who used composite grafts ranged from 21 to 71 years, with a mean of 50.9±15.86 years. The ages of the patients who received Biovalsalva grafts ranged from 60 to 78 years, with an average of 69.00±5.33 years. The age of the patients using Biovalsalva grafts was significantly higher than that of the patients using composite grafts ($p<0.01$). Examination ofthe height, weight, BMI and BSA data of the patients who underwent composite grafts and Biovalsalva grafts showed no statistically significant difference based on the results of multivariate analysis (Table 1).

Table 1. Comparison of demographic data of the patients who underwent composite and Biovalsalva grafts

		Composite (Group I)	Biovalsalva (Group II)		
		N(%)	N(%)	χ^2	p
HT	No	10(50.0)	9(45.0)	0.100	0.752
	Yes	10(50.0)	11(55.0)		
DM	No	19(95.0)	15(75.0)	1.765	0.184
	Yes	1(5.0)	5(15.0)		
CAD	No	14(70.0)	13(65.0)	0.114	0.736
	Yes	6(30.0)	7(35.0)		
PAD	No	20(100.0)	18(90.0)	0.475	0.491
	Yes	0(0.0)	2(10.0)		
Atrial fibrilation	No	19(95.0)	17(85.0)	0.278	0.598
	Yes	1(5.0)	3(15.0)		
COPD	No	18(90.0)	16(80.0)	0.196	0.658
	Yes	2(10.0)	4(20.0)		
Renal disease	No	18(90.0)	19(95.0)	0.000	1.000
	Yes	2(10.0)	1(5.0)		
Dyslipidemia	No	12(60.0)	18(90.0)	4.800	0.028*
	Yes	8(42.1)	2(10.0)		
Smoking	No	8(42.1)	13(65.0)	2.055	0.152
	Yes	11(57.9)	7(35.0)		

Abbreviations: CAD: Coronary artery disease, COPD: Chronic Obstructive Pulmonary Disease, DM: Diabetes Mellitus, HT: Hypertension, PAD: Peripheral Arterial Disease.

When both groups were compared in terms of aortic valve diseases, preoperative aortic valve endocarditis was detected in one (5%) of the patients who underwent composite graft (p=1.000). Aortic valve insufficiency was detected in 95% (n=19) of patients in Group I and 70% (n=14) of patients in Group II (p=0.096). In terms of aortic valve endocarditis and aortic valve regurgitation, there was no significant difference between composite graft and Biovalsalva graft patients. Again, 20% of the patients in Group I (n=4) had aortic valve stenosis, while 50% (n=10) in Group II had aortic valve stenosis (p=0.047). A bicuspid aortic valve was present in 50% (n=10) of the patients who underwent composite grafts, whereas 20% (n=4) of the patients who underwent Biovalsalva grafts had a bicuspid aortic valve (p=0.047).

Both groups were compared in terms of the ascending aortic aneurysm diameter measured in computed tomography examinations of preoperative patients. The aneurysm diameters of the patients who underwent composite grafts ranged from 43 to 70 mm, with an average of 55.0±7.99 mm. The aneurysm diameters of the patients who underwent Biovalsalva grafts ranged from 46 to 70 mm, with a mean of 54.94±6.52 mm (p=0.962). The mean ejection fraction of the patients in Group I was 56.75±7.65 and that of the patients in Group II was 56.85±8.10, which are close to each other (p=0.968). When aortic valve forward flow was examined, the mean value was 2.18±0.91 in Group I and 2.94±1.34 in Group II patients (p=0.129).

The comparison of the patients who underwent aortic root replacement using composite grafts and Biovalsalva grafts showed no significant difference in terms of CPB time (p=0.174). However, the cross-clamp duration was significantly lower in patients treated with Biovalsalva grafts compared to those treated with composite grafts (p=0.023) (Table 2).

Table 2. Comparison of operative features of the patients who underwent composite and Biovalsalva grafts

	Mean±SD	Mean±SD	U	p
CPB time (min.)	140.05±40.67	121.0±27.14	149.50	0.174
Cross clamp time (min.)	97.75±35.28	71.50±20.48	116.00	0.023*

Abbreviations: CPB: Cardiopulmonary Bypass.
*Mann–Whitney U test $p<0.05$

Table 3 presents the operative characteristics of the patients. The duration of stay in the intensive care unit for the patients in Group I was a maximum of six days, with an average of 1.85±1.49 days and a maximum of nine days for Group II, with an average of 2.35±2.18 days. The maximum length of stay in both groups was 25 days, with an average of 8.30±4.72 days in Group I and 7.75±3.41 days in Group II. Based on these data, there was no statistically significant difference between the groups in terms of the duration of intensive care unit and hospital stay.

Table 3. Comparison of operative features of patients who underwent aortic root replacement with composite and Biovalsalva grafts

		Composite Group I	**Biovalsalva Group II**
		N(%)	**N(%)**
	Ascending aorta	16(80)	12(60.0)
Arterial cannulation	Femoral artery	4(20)	7(35.0)
	Axillary artery	0(0.0)	1(5.0)
	Ascending aorta	20(100)	17(85.0)
Aortic replacement	Ascending aorta and hemiarch	0(0.0)	3(15.0)
Additional operation	No	11(55)	11(55.0)
	Yes	9(45)	9(45.0)
	No	11(55.9)	11(55.0)
	CABG	5(25)	6(30.0)
	MVR	2(10)	1(5.0)
	Other	2(10)	1(5.0)
	CABG+other	0(0.0)	1(5.0)
	21	2(10)	0(0.0)
Prosthesis size	23	8(40)	7(35.0)
(Aortic valve)	25	5(25)	11(55.0)
	27	5(25)	2(10.0)
IABP	No	20(100)	18(90.0)
	Yes	0(0.0)	2(10.0)

Abbreviations: CABG: Coronary Artery Bypass Grafting, IABP: Intraaortic balloon pump, MVR: Mitral Valve Replacement.

In the statistical analysis performed by evaluating the total drainage of the patients in the study group, there was no significant difference between the two groups. Similarly, there was no statistically significant difference between the two groups in terms of the time the patients were intubated in the intensive care unit (p=0.491). Table 4 presents the postoperative complications of patients who underwent composite and Biovalsalva grafts. The need for inotropes in patients who used only Biovalsalva grafts was significantly higher than that in patients treated with composite grafts (p=0.034).

Table 4. Comparison of the groups in terms of postoperative complications

		Composite (Group I)	Biovalsalva (Group II)		
		N(%)	N(%)	χ^2	p
Revision	No	15(75.0)	16(80)	0.143	0.705
	Yes	5(25.0)	4(20)		
Sepsis	No	19(95.0)	20(100)	0.000	1.000
	Yes	1(5.0)	0(0.0)		
Stroke	No	20(100)	20(100)	-	-
	Yes	0(0.0)	0(0.0)		
Ventilation (>48 hours)	No	18(90.0)	16(80.0)	1.800	0.180
	Yes	2(10.0)	4(20.0)		
Pneumonia	No	11(55.0)	11(55.0)	0.000	1.000
	Yes	9(45.0)	9(45.0)		
Dialysis due to renal insufficiency	No	19(95.0)	19(95.0)	0.000	1.000
	Yes	1(5.0)	1(5.0)		
Pacemaker	No	18(90.0)	17(84.2)	0.333	0.564
	Yes	2(10.0)	3(5.3)		
Atrial fibrilation	No	14(70.0)	14(70.0)	0.000	1.000
	Yes	6(30.0)	6(30.0)		
Use of inotropes	No	10(50.0)	4(20.0)	4.500	0.034*
	Yes	10(50.0)	16(80.0)		

*Mann–Whitney U test p<0.05

Table 5 shows the postoperative ECHO results of the patients. Considering the postoperative ECHO findings of the patients who used the Biovalsalva graft, the left ventricular end diastolic and end systolic diameters were significantly higher than those of the patients who used the composite graft.

Table 5. Comparison of postoperative ECHO results of the patients treated with composite and Biovalsalva grafts

	Composite	Biovalsalva		
	Mean±SD	**Mean±SD**	**U**	**p**
EF (%)	54.78±10.39	52.07±9.49	95.5	0.273
Gradient maximum	14.73±9.46	11.33±9.13	93.5	0.401
Gradient mean	7.57±4.78	5.50±5.35	91.0	0.345
Ascending aortic diameter (cm)	3.26±0.49	3.55±0.36	81.0	0.108
Left ventricular end diastolic diameter (cm)	4.95±0.75	5.44±0.60	65.5	0.026*
Left ventricular end systolic diameter (cm)	3.18±0.80	3.79±0.82	55.0	0.008**

Abbreviations: EF: Ejection Fraction.

**Mann–Whitney U test p<0.05*

***Statistical significance with Yates correction*

When we evaluated the mortality results of the study patients, there was no intraoperative death in either group. When examined in terms of postoperative mortality, one patient in Group I and two patients in Group II died. One patient who underwent a composite graft died of multiorgan failure, one patient in Group II died of multiorgan failure and one patient died without being discharged from the hospital due to cardiogenic shock. There was no significant difference in terms of mortality results between the two groups (Table 6).

Table 6. Comparison of mortality results of the patients treated with composite and Biovalsalva grafts

		Composite (Group I)	Biovalsalva (Group II)		
		N(%)	**N(%)**	**χ^2**	**p**
Intraoperative death	No	20(100)	20(100)	-	-
	Yes	0(0.0)	0(0.0)		
Death in 30 days	No	19(95.0)	18(90.0)	0.333	0.564
	Postoperative	1(5.0)	2(10.0)		
Cause of death in 30 days (n=3)	Multiple organ failure	1(100)	1(50.0)	0.000	1.000
	Cardiogenic shock	0(0.0)	1(50.0)	1.000	0.317

DISCUSSION

Bleeding and separation around the coronary ostium anastomosis are major problems with the button Bentall modification. In addition, the high-pressure hematoma formed between the composite graft and its surroundings causes not only separation of the coronary anastomosis but also compression of the composite graft (3). In the button Bentall procedure, high early and late reoperation rates are seen due to bleeding and false aneurysm formation from the coronary ostium directly anastomosed with the aortic graft. Bleeding may be a much more serious issue than what is reported in publications. It can lead to heart failure, arrhythmia, infection, hemorrhagic shock and cardiac tamponade (4). In addition, excessive blood transfusions to patients with bleeding can cause decreased organ function, allergic reactions, microembolization, citrate toxicity and other metabolic disorders. While some bacterial, viral and parasitic infections can be transmitted by blood transfusions, blood transfusion suppresses the immune system and increases the risk of postoperative bacterial infection. Cases of transfusion-related acute lung injury or noncardiac pulmonary edema have been reported (5). Such complications have pushed surgeons to seek new techniques. In the skirted double-layer proximal anastomosis technique developed by Uzun et al., the use of extra material and cost-effectiveness eliminates the bleeding that may occur from this anastomosis, while coronary ostium anastomoses are easily and effectively controlled with antegrade blood cardioplegia. With the combination of these two features, bleeding from proximal and coronary ostial anastomoses, which are the most dangerous bleeding sites in aortic root replacements, is significantly reduced, and direct and indirect complications related to bleeding can be prevented (6). In our study, there was no significant difference between the patients who used composite grafts and Biovalsalva grafts in terms of postoperative drainage ($p=0.655$) and reoperation due to bleeding ($p=0.705$).

Prolonged cardiopulmonary bypass times are also a risk factor affecting morbidity and mortality in other open heart surgeries, such as proximal aortic surgery (7). The study by Kaya et al. examinedthe results of 102 patients who underwent Bentall surgery using Biovalsalva grafts. It revealed that the mean duration of CPB time was 194 minutes and the mean aortic cross-clamp time was 133 minutes (8). In our study, the mean CPB time of the patients who underwent Biovalsalva grafts was 121 min and the mean cross-clamp time was 71 min. The average CPB time of the patients to whom we applied composite grafts was 140 min, and the average cross-clamp time was 140 min. Although there was no significant difference between the two groups in terms of CPB times, the cross-clamp times of the patients who underwent Biovalsalva grafts were significantly shorter.

In the study by Kaya et al., 13% of the patients required mechanical ventilation support for more than 48 h and tracheostomy was applied to three patients. The average length of stay in the intensive care unit was three days (8).

In our study, mechanical ventilation support lasting longer than 48 h was required in 20% of the patients who underwent Biovalsalva grafts and 10% of patients who underwent composite grafts, but none of our patients who participated in the study required tracheostomy. In addition, the average duration of stay in the intensive care unit was 2.35 days, the mean duration of hospital stay was 7.75 days. There was no significant difference compared to the patients who underwent composite grafts. Both the increase in patient age and the reduction in the limit for the use of biological valves may increase the need to use biological valves in aortic root pathology. Biologic valve conduits are advantageous in that they do not require lifelong use of oral anticoagulants, have a low risk of thromboembolism and all numbers are available (9). In the study by Kaya et al., there were no thromboembolic events, but postoperative ischemic cerebral events were observed in five patients. Our study however, found no thromboembolic events or strokes. Some serious postoperative complications have been reported with the Biovalsalva graft. Tan et al. reported in 2009 that they found incidentally acute dissection when a patient with a Biovalsalva graft was opened due to pericardial tamponade on the third postoperative day (10). In 2013, Yikuno et al. reported that a patient who underwent a Bentall operation using a Biovalsalva graft was operated on again for a 7.5 cm diameter aortic root aneurysm and chronic dissection one year after the operation (11). In both reported complications, the surgeons found that the layers of the graft were separated from each other when they reoperated on the patients. In fact, Chocron et al. reported two cases of acute dissection after intraoperative cross-clamp removal. In these two cases, they observed that blood entered between the three leaves of the Biovalsalva graft, causing dissection (12). We did not encounter such complications during our follow-up period.

Although complications such as stroke, pulmonary embolism and tracheostomy were not observed, sepsis was observed in one patient who used a composite graft. In the postoperative period, lung infection was observed in nine patients in both groups. Additionally, dialysis was performed in one patient in both groups due to renal failure. A temporary pacemaker was required in one patient with a composite graft, a permanent pacemaker in one patient, a temporary pacemaker in two patients with a Biovalsalva graft and a permanent pacemaker in one patient (p=0.564). New-onset atrial fibrillation was seen in six patients with composite grafts and six patients with Biovalsalva grafts. There was no significant difference between the two groups in terms of complications. Galicia-Tornell et al. examined the hospital mortality of 1862 patients who underwent the Bentall procedure, reporting that there was a 13% mortality rate due to septic shock and ventricular fibrillation (13). In our study, one patient who underwent a composite graft died due to multiorgan failure, one patient who underwent a Biovalsalva graft died due to multiorgan failure and one patient died due to cardiogenic shock within 30 days (p=0.564).

In our study, considering the preoperative and postoperative ECHO findings, preoperative bicuspid valve was significantly higher in patients who underwent composite grafts, whereas aortic valve stenosis was significantly higher in patients who underwent Biovalsalva grafts. Therefore, the preoperative aortic valve maximum and mean gradient were significantly higher in patients with Biovalsalva grafts. The postoperative use of inotropes was significantly higher in patients who underwent Biovalsalva grafts. Postoperative left ventricular end diastolic and end systolic diameters were significantly higher in the Biovalsalva graft in the composite graft. In a retrospective study, Chirichilli et al. reported favorable freedom from cardiac death, thromboembolism, hemorrhage, structural valve deterioration, infective endocarditis and reoperation rates at 16 years (14). Lechiancole et al. reported actuarial survival rates of 86±4%, 75±6%, 59±7% and 51±9% at 5, 10, 15 and 20 years, respectively (15).

In our study, in the one-month period, the Biovalsalva graft did not make any additional difference in terms of postoperative ECHO findings, morbidity or mortality. However, it significantly shortened the cross-clamp time. In 2021, Igarashi et al. reported 63 patients (the Valsalva conduit was used in 19 patients) who had undergone root replacement by the modified Bentall procedure. They reported that the Valsalva graft may play a role in improving valve durability and decreasing valve-related complications. However, surgeons expect further improvement in long-term outcomes by means of the Valsalva graft (16). According to De Paulis et al., without any major modification of the original technique, the Valsalva graft might provide optimal sinus reconstruction and simply improve anatomical root reconstruction to optimize the physiologic movement of the cusps during the cardiac cycle (17).

Biovalsalva grafts have been used as new grafts in recent years due to the need to reduce complications and mortality of Bentall surgery. Their advantages include their being readily available during the operation and not requiring anticoagulants. Valsalva aims to reduce the tension on the coronary graft and to provide better anastomosis and hemostasis, since it is more similar to the anatomical structure. In addition, the greater physiology of the anastomosis of the coronary ostia prevents it from becoming king; thus, less coronary ischemia appears. Only using a proper technique with a Valsalva graft may lead to good anatomic root reconstruction with physiologic blood flow and normal aortic valve function (18). The literature supports the importance of considering both the skirt and collar features when selecting a Valsalva graft for aortic root surgery (19).

Limitations:

The limitations of our study include the small number of patients, short follow-up period of one month and retrospective nature of the study.

CONCLUSION

As we reported in our study, although the Biovalsalva graft does not bring any additional difference in terms of postoperative ECHO findings, morbidity and mortality, we think that the reduction in cross-clamp time is an advantage. However, we attribute the requirement for higher postoperative use of inotropes to the older patient population. Better results can be achieved with the increase in the use of Biovalsalva grafts.

Conflicts of interest: The authors declare no conflicts of interest.
Financial support and sponsorship: None.
Peer review: Externally peer-reviewed.
Authorship contributions: Idea/Concept: KE; Design: AÇ; Control/Supervision: MY; Data Collection and/or Processing: AÇ; Analysis and/or Interpretation: MY; Literature Review: AÇ,YG; Writing the Article: MY; Critical Review: KE.

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