

Does Additional Aortic Procedure Carry a Higher Risk in Patients Undergoing Aortic Valve Replacement?

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Background: With growing attention to the aortopathy associated with aortic valve diseases, the number of candidates for accompanying ascending aorta and/or root replacement is increasing among the patients who require aortic valve replacement (AVR). However, such procedures have been considered more risky than AVR alone. This study aimed to compare the surgical outcome of isolated AVR and AVR combined with aortic procedures. **Materials and Methods:** A total of 86 patients who underwent elective AVR between 2004 and June 2010 were divided into two groups: complex AVR (n=50, AVR with ascending aorta replacement in 24 and the Bentall procedure in 26) and simple AVR (n=36). Preoperative characteristics, surgical data, intra- and postoperative allogenic blood transfusion requirement, the postoperative clinical course, and major complications were retrospectively reviewed and compared. **Results:** The preoperative mean logistic European System for Cardiac Operative Risk Evaluation (%) did not differ between the groups: 11.0±7.8% in the complex AVR group and 12.3±8.0% in the simple AVR group. Although complex AVR required longer cardiopulmonary bypass (152.4±52.6 minutes vs. 109.7±22.7 minutes, p=0.001), the quantity of allogenic blood products did not differ (13.4±14.7 units vs. 13.9±11.2 units). There was no mortality, mechanical circulatory support, stroke, or renal failure requiring hemodialysis/filtration. No difference was found in the incidence of bleeding (40% vs. 33.3%) which was defined as red blood cell transfusion ≥5 units, reoperation, or intentional delayed closure. The incidence of mediastinitis (2.0% vs. 0%), ventilator ≥24 hours (4.0% vs. 2.8%), atrial fibrillation (18.0% vs. 25.0%), mean intensive care unit stay (34.5 hours vs. 38.8 hours), and median hospital stay (8 days vs. 7 days) did not differ, either. **Conclusion:** AVR combined with additional aortic or root replacement showed an excellent outcome and recovery course equivalent to that after isolated AVR.

Key words: 1. Aortic valve, surgery
2. Aorta, surgery

INTRODUCTION

A dilated ascending aorta is a well-known risk factor for poor long-term prognosis after aortic valve replacement

(AVR). It is generally accepted that AVR alone cannot reverse the pre-existing dilatation of the ascending aorta or the aortic root [1]. With the growing attention to the aortopathy associated with aortic valve diseases, the indications for addi-

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Table 1. Indications for complex AVR

Diagnosis	Total no.	AVR+AAR	Bentall with MV	Bentall with SG	TCA required
Ascending aorta or root dilatation	38	15	11 ^{a)}	12	12
Porcelain aorta	10	9	1	0	7
Takayasu's arteritis with AR	1	-	1	-	1
Chronic type A dissection	1	-	-	1	1
Sum	50	24	13	13	21

AVR, aortic valve replacement; AAR, ascending aorta replacement; MV, mechanical valve; SG, stentless graft; TCA, total circulatory arrest.

^{a)}Four patients with Marfan syndrome were included.

tional replacement of the ascending aorta or the root have been expanded [2-4]. However, aortic or root replacement has been considered to be more complicated than isolated aortic valve replacement, carrying higher complication rate and transfusion requirement. In this study, we aimed to clarify whether this traditional belief remains valid.

MATERIALS AND METHODS

From January 2004 through June 2010, a total of 86 patients underwent elective AVR in Seoul National University Bundang Hospital. Retrospective reviews of their medical records were performed to investigate preoperative characteristics, surgical data, perioperative blood transfusion, postoperative course, and the incidence of major complications. The outcomes were compared after dividing the patients into two groups: complex AVR (n=50; AVR with ascending aorta replacement in 24, and Bentall procedure in 26) and simple AVR (n=36). Late follow-up data were collected in June 2011.

The indications for additional ascending aorta or root replacement were as follows (Table 1). An ascending aorta larger than 5.0 cm at its maximal diameter was replaced with a prosthetic graft. In the patients who had bicuspid aortic valve (BAV) or small body surface area ($<1.4 \text{ m}^2$), the threshold for ascending aorta replacement was lowered to 4.5 cm. In patients with dilated aortic root (sinus of Valsalva diameter $\geq 4.5 \text{ cm}$), total root replacement with a mechanical valved conduit or a stentless bioprosthesis was performed instead of separate AVR and replacement of the supraannular aorta. Indications other than dilatation included severely athe-

rosclerotic aorta, Takayasu's aortitis, and chronic dissection.

1) Statistical methods

Data was entered in a Microsoft Excel 2007 spreadsheet (Microsoft Co., Redmond, WA, USA) and transferred to a SAS ver. 9.2 (SAS Institute Inc., Cary, NC, USA) for data description and analysis. The characteristics are presented as percentage or mean \pm standard deviation. Continuous variables were presented as means and standard deviations and compared between groups by Student's t-test. Categorical variables are presented as frequencies and percentages and χ^2 or Fisher's exact test were used for comparison between groups.

RESULTS

The preoperative profiles did not differ between the two groups (Table 2). The logistic European System for Cardiac Operative Risk Evaluation was 11.0 ± 7.8 in the complex AVR group and 12.3 ± 8.0 in the simple AVR group. There were no statistical differences in the two groups' age, body mass index (BMI), sex, incidence of hypertension, diabetes, renal failure, stroke, or smoking. The incidence of left ventricular dysfunction and atrial fibrillation did not differ, either.

The surgical data and early clinical outcome are shown in Table 3. The mean cardiopulmonary bypass time was 109.7 ± 2.67 minutes in simple AVR, and 152.4 ± 52.56 minutes in complex AVR ($p=0.012$). The mean cross-clamp time was also longer in the complex AVR group, but there was no statistical significance. The postoperative course and incidence of major complications also showed no difference between the two groups. In addition, there was no difference in the pa-

Table 2. Patients' preoperative characteristics

Characteristic	Simple AVR (n=36)	Complex AVR (n=50)	p-value ^{a)}
Age (yr)	63.39±13.55	61.48±13.30	0.517 ^{b)}
BMI (kg/m ²)	24.19±3.56	23.26±3.43	0.224 ^{b)}
EuroSCORE (%)	12.34±7.94	10.97±7.80	0.824 ^{b)}
Sex (male)	13 (36)	18 (36)	0.992
Hypertension	14 (39)	17 (34)	0.641
Diabetes	5 (14)	8 (16)	0.787
COPD	4 (11)	6 (12)	1.000
CRF	1 (3)	2 (4)	1.000
LV dysfunction	2 (6)	7 (14)	0.293
Atrial fibrillation	1 (3)	2 (4)	1.000
Stroke	2 (6)	0 (0)	0.172
Smoking	8 (22)	9 (18)	0.992

Values are presented as mean±standard deviation or number (%). AVR, aortic valve replacement; BMI, body mass index; EuroSCORE, European System for Cardiac Operative Risk Evaluation; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; LV, left ventricular.

^{a)} χ^2 tests were used for all comparisons unless otherwise noted.

^{b)} t-test.

parameters related with bleeding such as the requirement for transfusion and the summated incidence of large quantity transfusion (red blood cell transfusion ≥ 5 units), reoperation, or intentional delayed closure (40% in simple AVR versus 33.3% in complex AVR).

Three patients who were in the complex AVR group were lost to follow-up. In the remaining patients, the mean follow-up duration was 50.5±23.66 months (range, 11 to 88 months) in the simple AVR group and 31.4±2.90 months (range, 2 to 84 months) in the complex group. The overall survival rates during those follow-up periods were 93.3% (28 out of 30) in the simple AVR group and 93.6% (45 out of 47) in the complex AVR group.

Four patients, two in each group, died during the follow-up periods. Two deaths, one in each group, were cardiac-related. One patient died of myocardial failure after redo AVR that was performed at 44 months after the initial surgery for severe prosthetic stenosis caused by pannus overgrowth. The other patient died of acute myocardial infarction at 57 months after the Bentall procedure which was performed for aortic

Table 3. Clinical outcomes

	Simple AVR (n=36)	Complex AVR (n=50)	p-value
CPB time (min)	109.72±22.67	152.4±52.56	0.012
Cross-clamp time (min)	87.00±21.08	116.48±34.17	0.082
Mechanical ventilation >24 hr	2 (5.5)	4 (8)	0.12
Mean ICU stay (hr)	38.8	34.5	
ICU stay >3 day	2 (5.5)	0 (0)	0.17
Hospital stay >7 day	14 (38.8)	21 (42)	0.38
Median hospital stay (day)	7	8	
In-hospital death	0	0	-
Postoperative IABP or ECMO	0	0	-
Stroke	0	0	-
Postoperative hemodialysis	0	0	-
Atrial fibrillation	9 (26)	9 (18)	0.64
Mediastinitis	0 (0)	1 (2)	0.23
Re-exploration due to bleeding	1 (3)	3 (6)	0.07
Transfused RBC (>5 u)	9 (25)	16 (32)	0.67
Intraoperative RBC+FFP (u)	4.11±3.74	3.94±3.99	0.73
Postoperative RBC+FFP (u)	3.08±4.00	3.64±5.50	0.32
Total transfused RBC (u)	3.83±3.18	4.54±3.59	0.15
Total transfused PLT (u)	6.66±6.66	5.80±8.42	0.11

Values are presented as mean±standard deviation or number (%).

AVR, aortic valve replacement; CPB, cardiopulmonary bypass; ICU, intensive care unit; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation; RBC, red blood cell; u, units; FFP, fresh frozen plasma; PLT, platelet concentration.

regurgitation caused by Takayasu's aortitis. In this patient, total occlusion of the right coronary artery and stenosis of left coronary ostial anastomosis had been found during the follow-up. The remaining two deaths were caused by cancer.

DISCUSSION

As the long-term results of AVR have been published, the addition of root or ascending aortic replacement is being performed more frequently than before. Progressive proximal aortic dilatation or aortic dissection after AVR is a poor prognostic factor [5]. The incidence and clinical impact are valued differently by different surgeons. In 2003, Andrus et al. [6] published the natural history of ascending aortic dilatation after AVR, for 185 patients. Only 15% of them had an increase in the aortic diameter of more than 0.3 cm annually, but no patients developed aortic dilatation more than 5.5 cm after a mean 33.6 months of follow-up. They concluded that no replacement of ascending aorta would be done routinely at the time of AVR.

On the other hand, some studies reported that the reoperation rate on ascending aorta or aortic root in patients with previous AVR was up to 28%, which was due to aortic dissection or aneurysm [7-9]. The incidence of acute type A dissection after AVR is reported to be from 0.2% to 2.3% [10-13]. The incidences of such untoward long term outcomes are known to be increased by several patient factors. Hypertension is a risk factor of postoperative aortic dilation [14,15]. Patients with BAV are known to be at higher risk: 1% for aortic dissection and almost 10% for progressive aortic enlargement [12,16,17]. Thanks to recent studies that identified structural and histological abnormalities in the ascending aorta of the BAV patients, aortic dilatation in BAV is no longer regarded as simple 'poststenotic' dilatation.

Preoperative aortic size is also an important risk factor. Natsuaki et al. [14] report that patients with an ascending aorta larger than 40 mm had a higher risk of aortic dissection or dilation of the aorta after AVR than those who had not. In the study by Tsutsumi et al. [18] who investigated 285 patients who underwent isolated AVR, ten patients (3.5%) developed type A aortic dissection during 7.6 ± 8.1 years follow-up period. Male sex, thinning or fragility of the aortic

wall, hypertension, and ascending aortic dilatation of more than 45 mm at the time of AVR combined with aortic regurgitation were considered to be prognostic factors for post-AVR aortic dissection. Indeed, there was a linear correlation between the ascending aorta diameter at AVR and the probability of developing type A aortic dissection, 0.4% for an ascending aorta diameter of less than 3 mm, 9.3% for 40 to 49 mm, and 55.6% for more than 50 mm.

Current guidelines by the American College of Cardiology and American Heart Association recommend replacing the ascending aorta at the time of aortic valve surgery if the ascending aorta is more than 4.5 cm in diameter for patients with BAV and 5 cm for others [19]. Many surgeons insist on a smaller (4.0 cm) criterion for patients with Marfan syndrome [20]. In addition, there are surgeons who believe that body size should be taken into consideration [21]. However, due to the lack of long-term large scale analysis, it remains controversial whether it is beneficial to lower the size threshold of aorta or root replacement for smaller patients.

Aortic valve stenosis or insufficiency is associated with various types of aortitis such as infective endocarditis, Takayasu's disease, and Behcet's disease. A severely atherosclerotic or 'porcelain' aorta, making cannulation and clamping impossible, is also one of the conditions under which ascending aorta replacement is necessary [22]. Sometimes, aggressive decalcification in patients with aortic valve stenosis can injure the aortic wall, making root replacement the safer option.

Despite of the substantial incidence of situations necessitating additional aortic or root replacement combined with AVR, many surgeons still regard such 'complex' AVR as a more complicated and risky procedure. Alternative procedures to replacement, such as wrapping or reduction plasty, are preferred by those surgeons. Our study, which showed that the risk was not increased by adding ascending aorta or root replacement to AVR, is in accord with contemporary data reported by respected institutions [23,24]. The Mount Sinai group reported that the Bentall operation was not inferior to simple AVR in a review of long-term result after the Bentall operation in 206 patients with BAV [25]. The overall hospital mortality was 2.9% and stroke rate was 1.9%. Five-year survival was 95% and 10-year survival was 89%. Their report of

597 patients who underwent the Bentall operation published in 2010 showed remarkable reduction in hospital mortality as the cases of aortic root replacement increased. Mortality was 10.9% till 1988, 4.2% after 2005, and 3.9% by 2010 [26]. Compared with data from the Society of Thoracic Surgeons National Cardiac Database [27], in which the mortality rate after simple AVR is 3.6% to 4.6%, it can be said that root replacement is no more an overly risky procedure at least in the hands of experienced surgeons.

CONCLUSION

Despite the technical complexity and additional cardiopulmonary bypass time, the addition of aortic or root replacement to aortic valve replacement did not result in higher operative risk, prolongation of postoperative recovery, or increased blood transfusion. For patients who have reasonable indications based on current evidences, the prospect of performing additional aortic or root replacement should not be dismissed for fear of increased complexity or untoward outcomes.

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