Original Article

Long-term Follow-up after Aortic Valve Replacement with a Small Aortic Prosthesis

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Although aortic valve replacement (AVR) is an effective treatment for patients with aortic valvular disease, the implantation of a small aortic prosthesis may result in residual left ventricular outflow stenosis and transvalvular gradient. In this study, the outcome in the long-term period of patients treated with a small aortic prosthesis was analyzed retrospectively. Twenty-four patients with AVR were divided into two groups, group A and group B. Group A consisted of 16 patients with 21 mm-sized prosthetic valves, and group B consisted of 8 patients with 19 or 16 mm-sized prosthetic valves. There were no significant differences in preoperative cardiac function or operative procedure in the two groups. The mean follow-up period (months) was 55.0 in group A and 51.3 in group B.

Results: One patient died of cerebral infarction in group A. There were no significant differences in cardiothoracic ratio (CTR), left ventricular ejection fraction (LVEF), and left ventricular mass index (LVMI) between the two groups. Postoperative physical activity according to the New York Heart Association (NYHA) classification showed no significant differences in the two groups. Despite using a small prostheses for AVR, the postoperative course was good in the long-term period, although careful follow-up is necessary. (Ann Thorac Cardiovasc Surg 2005; 11: 245–8)

Key words: small aortic valve, cardiac function, long-term

Introduction

Aortic valve replacement (AVR) is an effective treatment for patients with aortic valvular disease. Surgeons usually try to avoid the use of a small aortic prosthesis because of the potential for residual left ventricular outflow stenosis and transvalvular pressure gradient. Small prosthetic valves were implanted in some cases with small aortic annulus such as elderly aortic stenosis (AS) patients. A small aortic annulus is generally associated with poor outcome after AVR. Previous studies demonstrated that mortality was higher in patients receiving a small (≦21 mm) aortic prosthesis.[1,2] The purpose of this study was to analyze retrospectively the outcome in the long-term period of patients with a small aortic prosthetic valve.

Patients and Method

Between June 1992 and June 2001, 24 patients underwent aortic valve replacement using small (≦21 mm) prosthetic valves. Patients with a stentless valve, St. Jude Medical® Mechanical Heart Valve HP Series (St. Jude Medical Inc., St. Paul, MN), ATS Open Pivot® Heart Valve AP series (ATS Medical, Inc., Minneapolis, MN) and CarboMedics Top Hat™ Supra-Annular Aortic Valve series (CarboMedics Inc., Austin, TX) were excluded from this study. Concomitant surgery with mitral valve replacement or thoracic aortic treatment was also excluded.

Patients were divided into two groups; group A and

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Table 1. Preoperative profile of the patients

		Group A (n=16)	Group B (n=8)	*p* value
Age (y/o)		65±3	71±3	<0.05
Gender (Male/Female)		13/3	1/7	<0.05
Disease	AS	2	6	
	ASR	3	1	
	AR	11	1	
CTR (%)		56±2	57±3	ns
LVEF (%)		62±3	58±5	ns
BSA (m^2)		1.51±0.03	1.31±0.06	<0.05
LVMI (g/m^2)		212±26	183±35	ns
NYHA heart function classification				
	I	1	0	
	II	9	3	
	III	5	3	
	IV	1	2	

NYHA; New York Heart Association, CTR; cardiothoracic ratio, LVEF; left ventricular ejection fraction, BSA; body surface area, LVMI; left ventricular mass index, ns; not significant

group B. Group A consisted of 16 patients with a 21 mm-sized prosthetic valve, and group B consisted of 8 patients with a 19 or 16 mm-sized prosthetic valve. The mean age was 65 (ranged 48-79) y/o in group A and 71 (ranged 52-78) y/o in group B. There were 13 males and 3 females in group A, and one male and 7 females in group B. The preoperative diagnoses of the group A patients included aortic regurgitation (AR) in 11 patients, AS in 2 and aortic stenosis with regurgitation (ASR) in 3. Preoperative diagnoses in group B patients included AS in 6, AR in 1 and ASR in 1. Preoperative pressure gradient was measured in AS and ASR patients, and was 95±6 mmHg in group A and was 98±10 mmHg in group B by cardiac catheterization or echocardiography. The body surface area was 1.51±0.03 m^2 in group A, and 1.31±0.06 m^2 in group B with a significant difference ($p<0.05$).

Preoperative cardiac function (Table 1)
The cardiothoracic ratio (CTR) was 56±2% in group A and 57±3% in group B. Left ventricular ejection fraction (LVEF) was 62±3% in group A and 58±5% in group B, and left ventricular mass index (LVMI) was 212±26 g/m^2 in group A and 183±35 g/m^2 in group B, measured using echocardiography. According to the New York Heart Association (NYHA) heart function classification, in group A one patient belonged to Class I, nine belonged to Class II, five belonged to Class III and one belonged to Class IV, and in group B three belonged to Class II, three belonged to Class III and two belonged to Class IV. There were no significant differences of cardiac status between the two groups.

Operative procedure
Cardiopulmonary bypass and aortic cross clamp times were 157±9 minutes and 99±7 minutes in group A, and 159±14 minutes and 92±8 minutes in group B, respectively, with no significant difference. In group A, six disk valves, seven bileaflet valves and three stented bioprosthetic valves were implanted. In group B, two disk valves, one bileaflet valve and three stented bioprosthetic valves of 19 mm in size, and two bileaflet valves of 16 mm in size were implanted.

Long-term follow-up
The mean follow-up period was 55.0±9.2 months in group A and 51.3±10.9 months in group B. Chest X-ray, electrocardiography and echocardiography were performed and cardiac events were recorded.

Values are expressed as the mean ± standard error of the mean (SEM). For statistical analysis, the t-test was used. A p value of less than 0.05 was considered to be significant.

Results

Cardiac events
An eighty-two year old group A patient with a bioprosthetic valve suddenly died of cerebral infarction 30 months after AVR. New ventricular arrhythmia occurred in one group A patient. A permanent pacemaker generator was implanted into two group A patients due to bradycardia caused by sick sinus syndrome and atrial fibrillation. No cardiovascular events occurred in group B patients.

Table 2. Postoperative cardiac function

	Group A (n=16)	Group B (n=8)	
Follow-up period (Mo)	55.0±9.2	51.3±10.9	ns
CTR (%)	54±1	55±2	ns
LVEF (%)	63±3	68±3	ns
LVMI (g/m^2)	178±21	130±22	ns
NYHA heart function classification			
I	9	3	
II	6	5	
III	0	0	
IV	0	0	

NYHA; New York Heart Association, CTR; cardiothoracic ratio, LVEF; left ventricular ejection fraction, BSA; body surface area, LVMI; left ventricular mass index, ns; not significant

Postoperative cardiac function (Table 2)
CTR was 54±1% in group A and 55±2% in group B with no significant difference. LVEF was 63±3% in group A and 68±3% in group B. LVMI was 178±21 g/m^2 in group A and 130±22 g/m^2 in group B. There were no significant differences in both parameters of two groups (Fig. 1). CTR, LVEF and LVMI tended to improve postoperatively compared to the preoperative status, but there were no significant differences. According to the NYHA classification, nine patients in group A belonged to Class I and six belonged to Class II. In group B, three patients belonged to Class I and five belonged to Class II (Fig. 2).

Discussion

There are some problems in patients with a small aortic annulus who underwent AVR, as a result of the so called "prosthesis-patient mismatch." Prosthesis-patient mismatch has been recognized by the American Society of Thoracic Surgeons and has been identified as a non-structural dysfunction.[3,4] Residual left ventricular outflow stenosis and transvalvular pressure gradient affect the prognosis of patients with AVR in spite of normal valve function. These patients experienced poor physical capacity associated with a higher rate of late mortality including cardiac failure, and sudden death due to ventricular arrhythmia. Transvalvular gradients are determined by two factors: the effective orifice area (EOA) of the valve and the transvalvular flow, both of which are usually measured by echocardiography. The transvalvular flow is related to cardiac output largely determined by BSA. Some studies have analyzed the prosthesis from the point of size,[1,2] and others from echocardiographic findings. One of the most useful indices is the EOA of the valve. EOA is a proper character in vitro and is smaller than the geographic orifice area.[5-7] Indexed EOA (EOA/

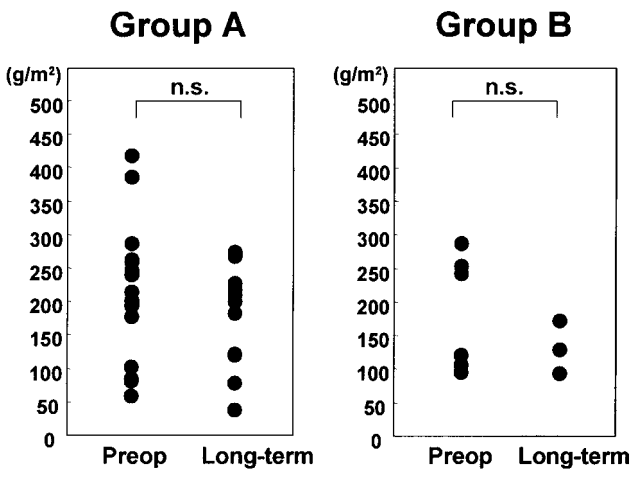

Fig. 1. Left ventricular mass index.

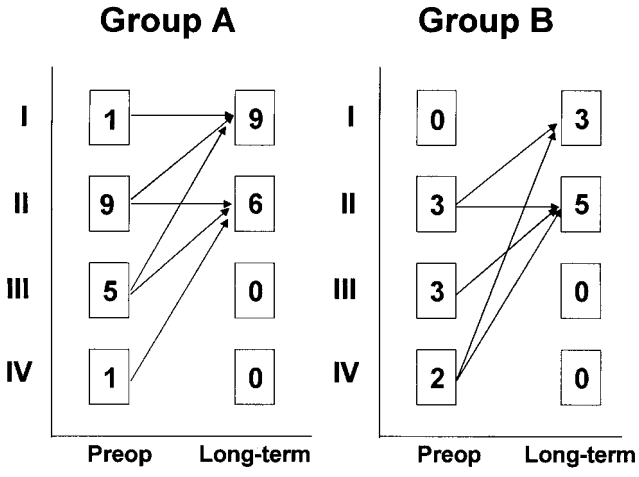

Fig. 2. NYHA heart function classification.

BSA) of less than 0.85 is the accepted criteria for prosthesis-patients mismatch which has resulted in poor improvement of left ventricular hypertrophy after AVR.[8] An indexed EOA of 0.85 or higher is an optimal value for better hemodynamics and an EOA of 0.06 or less should be considered for re-operation.[7,9]

Some methods were previously used to place a larger valve. A valve with the relatively large orifice area measuring the same size compared to the standard type, such as a stentless valve, St. Jude Medical HP series, ATS AP series and CarboMedics TOP HAT series is implanted at the supra-annular position. Other alternatives are enlargement of the aortic root, although the operative risk may be increased as weighed against the anticipated benefits. These alternative surgical techniques require a longer learning period, and are frequently associated with longer aortic cross-clamp times and increased blood loss during the operation. It is important that benefits using these techniques to avoid small aortic valves overcome these surgical risks, considering such factors as preoperative cardiac status, age and postoperative physical activity of patients. Our strategy for annular enlargement is as follows: In mechanical valve patients, we select the high performance type prosthesis instead of annular enlargement. But in bioprosthetic valve patients, we select annular enlargement rather than a small prosthetic valve except for cases with a severely calcified aortic wall and/or poor cardiac function. We think that indication for annular enlargement in high-aged AS patients with small aortic annulus is limited, although this method is useful, because they sometimes show severe calcification of the aortic wall and annulus.

In this study, patients with stentless bioprosthesis, enlargement of the aortic root and high performance type mechanical valves were excluded because patients with small aortic valves require more careful follow-up for the long-term period. A small valve was selected to shorten the aortic cross-clamp time in four of eight group B patients who belonged to NYHA Class III or IV. There were no differences in cardiac function in group A compared to group B for long term follow up. Group B patients were higher aged and their physical actions were limited, with small bodies. Thus a small prosthesis was considered to be an acceptable valve. In long-term follow-up, only one patient died of cerebral infarction and others have been moderately healthy despite the small aortic prosthesis. Careful observation is necessary.

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