Original Article

Journal of Cardiovascular Medicine and Surgery
Volume 7 Number 2-3, April to September 2021
DOI: http://dx.doi.org/10.21088/jcms.2454.7123.72-321.6

A Combined Anterior and Posterior Enlargement for Narrow Aortic Root in Pediatric Population

T Ramakrishna Dev[1], Sai Surabhi P[2], R V Kumar[3]

How to cite this article:
T Ramakrishna Dev, Sai Surabhi P, R V Kumar/ A Combined Anterior and Posterior Enlargement for Narrow Aortic Root in Paediatric Population/J Cardiovasc Med Surg.2021;7(2-3): 43-48.

Author's Affiliation: [1,2]Associate Professor, [3]Professor, Department of Cardio Thoracic Surgery, Nizam's Institute of Medical Sciences, Punjagutta, Hyderabad 5000082, Telangana, India.

Corresponding Author: Sai Surabhi P, Associate Professor, Department of Cardio Thoracic Surgery, Nizam's Institute of Medical Sciences, Punjagutta, Hyderabad 5000082, Telangana, India.

E-mail: drsaisurabhi@gmail.com

Abstract

Objective: Aortic stenos is with narrow aortic root is a rare presentation. Posterior aortic root enlargement and anterior aortic root enlargement individually have their own limitations. We present our experience combining both procedures in cases where single procedure of root enlargement is not sufficient. By both anterior and posterior root enlargement, we successfully could insert an adult size mechanical prosthesis with minimal morbidity and no mortality in paediatric patients.

Materials and Methods: we report our experience with three cases with small aortic root, allowing the implantation of only 15mm size aortic valve, initially. Posterior enlargement allowed implantation of 17mm valve, but, using a combined approach, a maximum size of 21mm aortic valve could be implanted.

Results: All the three cases had an uneventful postoperative period with relief of symptoms and significant reduction in postoperative gradients with minimal morbidity and no mortality.

Conclusion: Combined aortic root enlargement allows insertion of an adult size prosthesis and has been found to minimize the chance of Patient Prosthetic Mismatch and the morbidity associated with a redo surgery in paediatric cases and is demonstrated to be safe and feasible with improvement in quality of life in patients with small aortic root with minimal morbidity and no mortality.

Keywords: Congenital aortic stenos is; Narrow aortic root; Root enlargement; Aortic valve replacement.

Introduction

The impact of prosthesis patient mismatch (PPM]) after aortic valve replacement (AVR) remains controversial. Previous reports have stated that the use of small mechanical aortic prostheses raises concern about residual left ventricular outflow obstruction, increased pressure gradients, affected left ventricular function without mass regression and associated morbidity and mortality.[1,2] Recent reports support the fact that PPM has a negative impact on survival for young patients.[3,4]

In order to avoid PPM, surgical techniques have evolved for enlargement of the small aortic root. Nicks and associates (1970)[5] and Nunez and associates (1983)[6] proposed a posterior approach for enlargement, either through the non-coronary sinus, across the aortic ring as far as the origin of the mitral valve or by resecting the posterior commissure (between left and non-coronary cusps) with the base of the gap formed by the fibrous origin of the anterior mitral leaflet.

Another posterior enlargement technique was introduced by Manougian[7] with the aortotomy extending into the non coronary sinus, lateral opening of the left atrium and into the anterior leaflet of the mitral valve. Besides the posterior enlargement techniques the Konno[8] and Rastan[9] anterior enlargement (through the right coronary sinus extending into the right ventricular outflow tract) has been reported in many cases. Recently, a two directional aortic annular enlargement (combination of posterior and anterior enlargement)[10] and a double patch technique for posterior enlargement[11] have been reported.

The objective of our study was to retrospectively assess the immediate and intermediate results on paediatric patients who have undergone combined anterior and posterior aortic root enlargement to avoid PPM.

Case Report

3 patients at 12y, 13y, 15y of age were diagnosed with bicuspid aortic valve with severe aortic stenosis.

Presenting complaint was dyspnoea NYHA class III in 2 of the cases and syncope in 1 case.

Pre op 2D Echo showed bicuspid aortic valve with severe aortic stenosis and increased gradients in all cases.

Surgical Technique Standard median sterno tomy and Pericardium was harvested for root enlargement. Aortic cannulation and bicaval venous cannulation was performed following systemic heparinization after reaching target ACT. Cardiopulmonary bypass was initiated and the patient was cooled down to 28 C. A vent catheter was inserted into the left atrium from the right superior pulmonary vein. Cardiac arrest and myocardial protection were provided with root cold blood hyperkalemiccardioplegia after aortic clamp with surface myocardial cooling.

Aortotomy was performed and the incision was extended through the non coronary cusp to the roof of the left atrium and annulus of the anterior mitral leaflet-Manougian type posterior enlargement. The right ventricle outflow tract was opened parallel to the left anterior descending artery and an incision was extended to the interventricular septum. The septum and the anterior aortic root was enlarged with a Dacron patch or bovine pericardium or patients own pericardium (Konno-Rastan procedure). The Manougian posterior enlargement was reinforeced with the patients own pericardium. Teflon reinforced pledgetted 2-0 polyester sutures were taken in an interrupted fashion and an adequate sized aortic prosthesis was implanted. The aortotomy and Right ventricular out flow tract were reconstructed using the double patch technique. Weaning was achieved in accordance with minimal inotropes and surgery concluded conventionally. The patients were ventilated for 6-8 hrs. ICU stay for 48-54hrs and total hospital stay for 7-9days

Post operative period was uneventful in all three cases. Post op 2D Echo showed significant reduction in aortic valve gradients.

All patients, after their hospital discharge, were followed up by the senior surgeons and attending cardiologist at one-month, three-months, six-months and annually thereafter with serial Echo (TTE or TEE when deemed necessary).

Statistical analysis: The analyses were performed using SPSS. Variables were presented as mean ± S.D. Differences were considered statistically significant if the P-value was <0.05 with a 95% confidence interval. The echocardiographic parameters were measured in sinus rhythm and were recorded over 5 cardiac cycles.

Age	Sex	Body weight (Kg)	BSA (kg/m2)	Aortic annulus size	EVOA (cm2)	Pre op AVG (PPG/MPG)	Size of aortic valve	CPB time (min)	Cross clamp time(min)	Post op AVG (PPG/MPG)
12Y	Fem	30	1.03	16mm	0.7	88/68 mm Hg	19mm	195	150	22/14 mm Hg
13Y	Fem	34	1.15	16mm	0.5	86/54 mm Hg	21mm	174	120	24/16 mm hg
15Y	Male	43	1.34	17mm	0.5	90/50 mm Hg	21mm	170	100	28/15 mm Hg

Results

There was no operative or hospital mortality. The length of CPB and aortic crossclamping (AoCx) was increased as compared to routine AVR (two-fold increase) (80–90 min vs. 190 min).

The population that underwent combined anterior and posterior enlargement had a similar requirement ofventilatory support as compared to routine AVR (6-8hrs). The amount of postoperative bleeding was the same. Total length of stay (LOS) was 7–9 days, the same as in routine AVR.

Follow up period was 1 years. The functional recovery was evident in all patients during this period converting from NYHA class III–IV to class I–II.

Survival

Survival was 100 % with a mean follow up of 1 year.

Functional

Effective valve orifice area increased from 0.7±0.2 cm2 to 1.4±0.5 cm 2 (P<0.01). The LVEF remained unchanged. Peak systolic gradient decreased from 90±10 mmHg to 25±5 mmHg (P<0.001) and the mean gradient decreased from 58±10 mmHg to 15±5 mmHg (P<0.001). The average of postoperative peak and mean gradient of the paediatric patients with small aortic root and the combined approach were increased as compared to the ones from routine AVR because of the implantation of small size prosthesis (<21 mm). However, LV hypertrophy and mass were significantly regressed.

	Pre-operative	**Post-operative**	
LVIVS	16.5±1.3 mm	14.3±1.7 mm	P<0.01
LVPWT	16.7±1.4 mm	14.5±8 mm	P<0.01
LV Mass (g)	184±20 g	130±15 g	P<0.01
Peak gradient	90±10 mmHg	25±5mmHg	P<0.001
Mean gradient	58±10 mmHg	15±5 mmHg	P<0.001
EVOA	0.7±0.2 cm2	1.4±0.5 cm2	P<0.01
EF	55±5	58±7	NS
LVEDP	16±3	17±4	NS
NYHA	III–IV	I–II	

LVIVS: left ventricular intraventricular septum, LVPWT: left ventricular posterior wall thickness, LV mass: left ventricular mass, EVOA: effective valve orifice area, EF: ejection fraction, LVEDP: left ventricular end diastolic pressure, NYHA: New York Heart Association.

Echocardiographic changes

No perivalvular leak or mitral regurgitation were developed. Left ventricular hypertrophy regressed. Left ventricular intraventricular septal thickness (LVIVS) was significantly decreased (16.5±1.3 mm to 14.3±1.7 mm, P<0.01). Left ventricular posterior wall thickness (LVPWT) was significantly decreased (16.7±1.4 vs. 14.5±1.8 mm, P<0.01)

LV mass regression

LV mass regressed significantly from 184±20 g to 130±15 g (P<0.01). This regression occurred six months after the procedure and continued for the next 1–2 years. After that period LV mass remained stable.

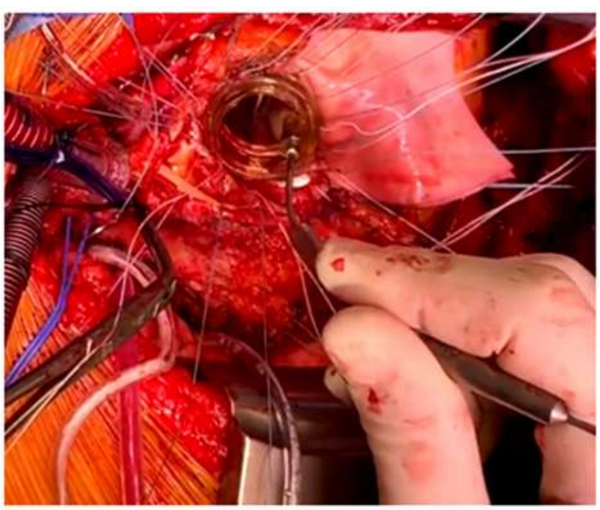

Fig. 1: Aortic Root Sizing

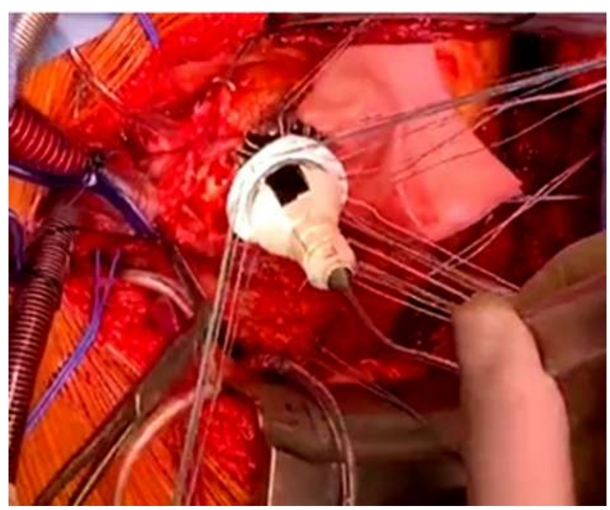

Fig. 2: Aortic Valve Implantation

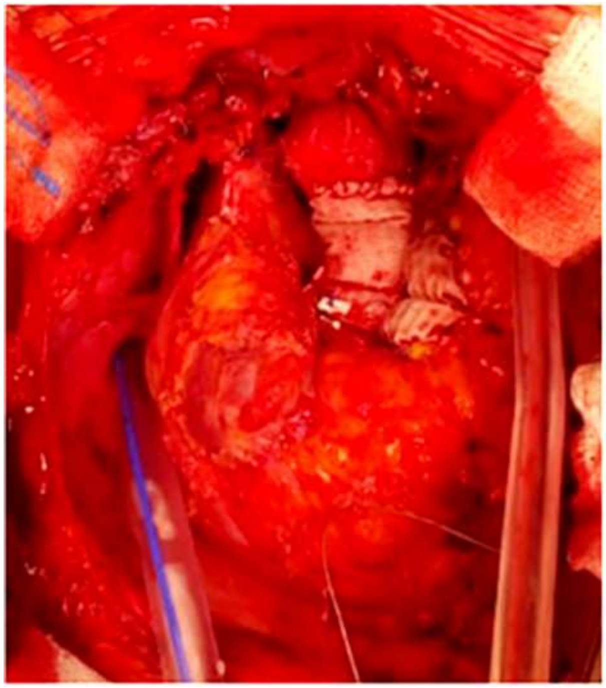

Fig. 3: Dacron.

Fig. 4: Open rvot and aorta.

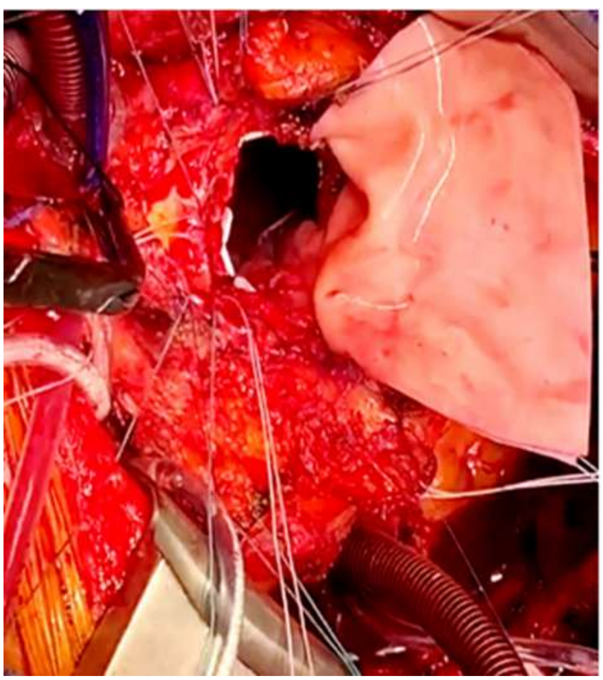

Fig. 5: Patch Reconstruction.

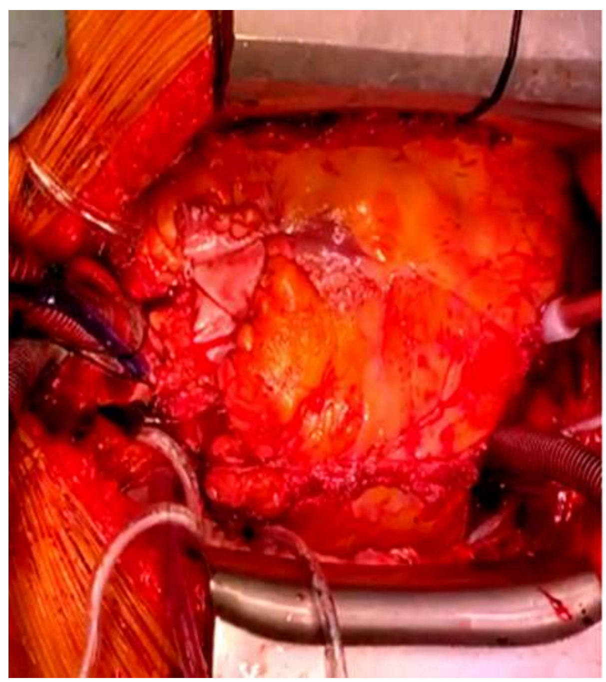

Fig. 6: Pericardial Patch Complete.

Discussion

Rahimtoola[12] in 1978 stated that 'mismatch' can be considered to be present when the effective prosthetic valve area, after insertion into the patient, is less than that of a normal human valve. PPM has been recognized by the American Society of Thoracic Surgeons and it has been identified as a non-structural dysfunction.

When the predicted valve area index for the valve to be implanted is <0.8 cm2/m2, then enlargement should be performed. Sommers and David[13] enlarged the small aortic annulus and implanted bioprostheses in 98/530 patients (18%) with AS. Although the procedure increased the operative mortality for AVR, patients who underwent the enlargement had long term survival and freedom from cardiac and valve related death comparable to those patients who received larger aortic prostheses.

Castro et al.[14] followed the same principle in 114/657 patients (17%) most of them female, with a low mortality rate (0.9%) and additional 20 min AoCx. However, there was no long term follow-up period in their study. Enlargement of the small aortic annulus in patients <65 years of age seems to be the method of choice to avoid prosthesis patient mismatch (PPM). Nevertheless, it is not necessary in patients 65 years of age with a relatively small body size who receive a bioprosthetic valve, in the experience of Sakamoto et al.[15]

The combined anterior and posterior root enlargement procedure in pediatric cases with small aortic annulus is a simple, safe and effective adjunct permitting the insertion of a valve one or two sizes larger than that which could be accommodated by the native annulus.[16]

To avoid PPM, we followed the combined root enlargement technique in a series of 3 paediatric patients. In all these patients, it could have been impossible to implant an adult size prosthesis, without enlarging the small aortic annulus.

Rao et al.[19] have shown that hemodynamic comparisons between prosthetic valves are inaccurate if based solely on industry-labelled valve sizes. Stentless and stented valves have similar hemodynamic profiles in the small aortic root when matched on true measured internal diameters. In addition, actual sizes, dimensions and tissue annular diameters of various small mechanical aortic prostheses varied considerably from their marked diameters. These differences should be considered to ensure the optimal prosthesis selection for each patient.

Various bioprostheses (stentless), although they require surgical techniques that are more demanding and necessitate longer AoCx, lead to improved hemodynamics and LV remodelling in patients with small aortic root. Significant factors influencing the occurrence of transient PPM are the gender, age, BSA and the patient's annulus index. However, PPM seems to dissolve after a one-year period.[20,21]

Patient prosthesis mismatch and its impact on late survival remains unclear. Izzat et al.[22] studied six types of small aortic prostheses using dobutamine stress echocardiography and found that the main predictor of transprosthetic gradient is the inherent characteristics of each particular prosthesis with relatively insignificant contributions from variations in BSA. They concluded that PPM is not a problem of clinical significance when certain modern valve prostheses are used.

Pibarot et al.[23] in their study found that the projected indexed effective orifice area (EOA), calculated at time of operation, accurately predicts resting and postoperative gradients and consequently the potential occurrence of PPM. Most authors agree that in patients with severe LV hypertrophy it may be important to elude PPM to avoid a significant increase in mortality and improve LV mass regression. PPM may be tolerable in patients with lesser degree of hyperthrophy.[3,4,24] Hanayama et al.[25] have shown that severe PPM is rare after AVR. PPM, abnormal gradient and size of valve implanted do not influence LV mass index or intermediate term survival.

Combined anterior and posterior aortic root enlargement procedure in paediatric cases is recommended to enlarge the small aortic annulus and implant adult size mechanical prostheses and prevent patient prosthetic mismatch, despite the fact it takes longer CPB and AoCx times. The study was done in three cases with small aortic root, allowing the implantation of only 15mm size aortic valve, initially. Posterior enlargement allowed implantation of 17mm valve, but, using a combined approach, a maximum size of 21mm aortic valve can be implanted. Ourimmediate results were satisfactory, even in a small number of patients who presented with extremely difficult small annuli to handle. Immediate results favoured the continuation of this procedure since both functional and anatomical improvement of the left ventricle was present at the end of this study. Intermediate results have clearly demonstrated a significant LV mass regression associated with an improved clinical status in all patients.

Conclusion

In patients with advanced aortic valve disease, goals of AVR are to reduce pressure and volume overload on LV, symptomatic relief and improve long term survival. Small sized prosthetic valves cause PPM and need for redo complex surgery. Combined aortic root enlargement procedure in paediatric cases reduces chances of PPM and allows implantation of adult sized valve, minimising chances of redo surgery at later date. Combined aortic root enlargement is demonstrated to be safe and feasible with improvement in quality of life in pediatric patients with small aortic root with minimal morbidity and no mortality.

References

1. Pibarot P, Dumesnil JG, Lemieux M, Cartier P, Metras J, Durand LG. Impact of prosthesis-patient mismatch on hemodynamic and symptomatic status, morbidity and mortality after aortic valve replacement with bioprosthetic heart valve. J Heart Valve Dis 1998;7:211–218.
2. Del Rizzo DF, Abdoh A, Cartier P, Doty D, Westaby S. Factors affecting left ventricular mass regression after aortic valve replacement with stentless valve. SeminThoracCardiovascSurg 1999;11:114–120.
3. Tasca G, Brunelli F, Cirillo M, DallaTomba M, Mhagna Z, Troise G, Quaini E. Impact of valve prosthesis-patient mismatch on left ventricular mass regression following aortic valve replacement. Ann ThoracSurg 2005;79:505–510.
4. Moon MR, Pasque MK, Munfakh NA, Melby SJ, Lawton JS, Moazami N, Codd JE, Crabtree TD, Barner HB, Damiano RJ. Prosthesis-patient mismatch after aortic valve replacement: impact of age and body size on late survival. Ann ThoracSurg 2006;81:481–489.
5. Nicks R, Cartmill T, Bernstein L. Hypoplasia of the aortic root. The problem of aortic valve replacement. Thorax 1970;25:339–346.
6. Nunez L, Aguado MG, Pinto AG, Larzea JL. Enlargement of the aortic annulus by resecting the commissure between the left and noncoronary cusps. Texas Heart Institute J 1983;10:301–303.
7. Manougian S, Seybold-Epting W. Patch enlargement of the aortic valve ring by extending the aortic incision into the anterior mitral leaflet. J ThoracCardiovascSurg 1979;78:402–412.
8. Konno S, Imai Y, Iida Y, Nakajima M, Tatsuno K. A new method for prosthetic valve replacement in congenital aortic stenosis associated with hypoplasia of the aortic valve ring. J ThoracCardiovascSurg 1975;70:909–917.
9. Rastan H, Koncz J. Aortoventriculoplasty. A new technique for the treatment of left ventricular outflow tract obstruction. J ThoracCardiovascSurg 1976;71:245–249.
10. Otaki M, Oku H, Nakamoto S, Kitayama H, Ueda M, Matsumoto T. Twodirectional aortic annular enlargement for aortic valve replacement in the small aortic annulus. Ann ThoracSurg 1997;63:261–263.
11. Molina JE. Enlargement of the aortic annulus using a double-patch technique: a safe and effective method. Ann ThoracSurg 2002;73:667– 670.
12. Rahimtoola SH. The problem of valve-prosthesis-patient mismatch. Circulation 1978;58:20–24.
13. Sommers KE, David TE. Aortic valve replacement of the aortic annulus. Ann ThoracSurg 1997;63:1608–1612.
14. Castro LJ, Arcidi JM, Fisher AL, Gaudiani VA. Routine enlargement of the small aortic root. A preventive strategy to minimize mismatch. Ann ThoracSurg 2002;74:31–36.
15. Sakamoto Y, Hasimoto K, Okuyama H, Takakura H, Ishii S, Taguchi S, Kagawa H. Prevalence and avoidance of patient-prosthesis mismatch in aortic valve replacement in small adults. Ann ThoracSurg 2006;81: 1305–1309.
16. Nakamo S, Matsuda H, Shimazaki Y, Taniguchi K, Kaneko M, Ueda T, Mori T, Kawashima Y. An appraisal of patch enlargement of the small aortic annulus in 33 patients undergoing aortic valve replacement. Eur J CardiothoracSurg 1992;6:347–349.
17. He Guo-Wei, Grunkeweier GL, Gately, HL, Furnary AP, Starr A. Up to thirty-year survival after aortic valve replacement in the small aortic root. Ann ThoracSurg 1995;59:1056–1062.
18. Sawant D, Singh AK, Feng WC, Bert AA, Rotenberg F. St. Jude Medical cardiac valves in small aortic roots: follow up to sixteen years. J ThoracCardiovascSurg 1997;113:499–509.
19. Rao V, Christakis GT, Sever J, Fremes SE, Bhatnagar G, Cohen G, Borger MA, Abouzahr L, Goldman BS. A novel comparison of stentless versus stented valves in the small aortic root. J ThoracCardiovascSurg 1999;117:431–438.
20. Hvass U, Palatianos GM, Frassani R, Puricelli C, O'Brien M. Multicentric study of stentless valve replacement in the small aortic root. J ThoracCardiovascSurg 1999;117:267–272.
21. Gelsomino S, Morocutti G, Frassani R, Da Col P, Carella R, Livi U. Usefulness of the Cryolife O'Brien stentlesssuprannular aortic valve to prevent prosthesis-patient mismatch in the small aortic root. J Am CollCardiol 2002;39:1845–1851.
22. Izzat MB, Kadir J, Reeves B, Wilde P, Bryan AJ, Angelini GD. Patientprosthesis mismatch is negligible with modern small-size aortic valve prosthesis. Ann ThoracSurg 1999;68:1657–1660.
23. Pibarot T, Dumesnil JG, Cartier PC, Me´tras J, Lemieux MD. Patient– prosthesis mismatch can be predicted at the time of operation. Ann ThoracSurg 2001;71:S265–S268.
24. Fuster RG, Argudo JA, Albarova OG, Sos FH, Lopez SC, Codon˜er MB, Min˜ano B, Albarran IR. Patient-prosthesis mismatch in aortic valve replacement: really tolerable? Eur J CardiothoracSurg 2005;27:441– 449.
25. Hanayama N, Christakis GT, Mallidi HR, Joyner CD, Fremes SE, Morgan CD, Mitoff PR, Goldman BS. Patient prosthesis mismatch is rare after aortic valve replacement: valve size may be irrelevant. Ann ThoracSurg 2002;73:1822–1829.