Follow-up paper - Aortic and aneurysmal

The Nicks–Nunez posterior enlargement in the small aortic annulus: immediate–intermediate results

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Received 12 May 2006; received in revised form 25 July 2006; accepted 26 July 2006

Abstract

Objective: To avoid prosthesis–patient mismatch, posterior enlargement of the small aortic annulus using the Nicks–Nunez surgical approach was performed in fifteen patients and the immediate–intermediate results are reported retrospectively. Methods: During the period November 1995 to June 2005, 220 patients underwent aortic valve replacement (AVR) for primary aortic stenosis (AS). Fifteen patients (15/220 = 6%), all women, 40–76 years old (mean age 65.8 years) with AS, underwent AVR applying the Nicks–Nunez posterior enlargement of the small aortic annulus with an effective aortic valve area 0.7 ± 0.2 cm². In addition, mitral valve replacement (MVR) was performed in two patients and coronary artery bypass grafting (CABG) in three (2 grafts/pt). Endarterectomy of the ascending aorta was performed in one patient. With the exception of one patient, mechanical valves were used. In all cases, transesophageal echo (TEE), normothermic cardiopulmonary bypass (CPB), left ventricular venting, antegrade crystalloid cardioplegic arrest and local myocardial cooling, was used. The defect after the enlargement was closed with autologous pericardium in four and synthetic graft in eleven patients. The follow-up period was 5–120 months (mean 61.5 months). Results: There was no operative or hospital mortality. The length of CPB and aortic crossclamping was increased as well as the duration of mechanical ventilation. In one, out of two patients, in whom the decision for enlargement was delayed, intraaortic balloon pump was used. However, there was no other morbidity and the final length of stay was 7–10 days (same as for routine AVR). One patient died five years later from lung cancer. Serial follow-up transthoracic echoes have shown statistically significant improvements in left ventricular–intraventricular septum thickness (LVIVS) (16.5 ± 1.3 mm vs. 14.3 ± 1.7 mm, P < 0.01), left ventricular posterior wall thickness (LVPPWT) (16.7 ± 1.4 mm vs. 14.5 ± 1.8 mm, P < 0.01), left ventricular (LV) mass/g (415 ± 33 vs. 388 ± 41, P < 0.01), peak gradient (98 ± 10 mmHg vs. 48.7 ± 7 mmHg, P < 0.001) and in mean gradient (58 ± 10 mmHg vs. 22.8 ± 8 mmHg, P < 0.001). The functional aortic valve orifice postoperatively was 1.4 ± 0.5 cm². The ejection fraction (EF) and the left ventricular end-diastolic pressure (LVEDP) were unchanged. Conclusions: Immediate and intermediate results reveal the safety of the procedure and the significant functional and anatomical improvement of the left ventricle. Although the number of patients is small, female patients, small or large, seem to be the usual candidates for this procedure.

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Keywords: Nicks–Nunez procedure; Small aortic root

1. 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 and a lesser one for older patients. Although PPM was not important in small patients, PPM negatively impacted survival for average and large-size patients with mechanical valves [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 our patients that have undergone aortic annular enlargement to avoid PPM.

### 2. Materials and methods

During the period November 1995 to June 2005, 220 patients underwent aortic valve replacement (AVR) for primary aortic stenosis (AS) by the same surgeon (KSR). Fifteen of those 220 patients (6%), all women (age 40–76 years, mean 65.8) with a primary diagnosis of AS, underwent AVR after a posterior enlargement of their small aortic annulus using the Nicks–Nunez procedure. Mean effective aortic valve area was 0.7 ± 0.2 cm². Twelve women had a body surface area (BSA) < 1.7 m² and were defined as small patients, and three women had a BSA between 1.7–2.1 m² and were defined as average. Their body weight (BW) ranged from 45–110 kg (mean 66.7 kg). Nine of them were in NYHA class III and 6 in NYHA IV. One patient had AI in addition to AS, another one had a history of closed mitral valve commissurotomy (CMVC), two patients had mitral regurgitation (MR), one had mitral stenosis (MS) and another one had a history of coarctation repair at a younger age (Table 1). Associated surgical procedures performed included: CABG (n=3, 2 grafts/pat),

### Table 1

<table>
<thead>
<tr>
<th>Age</th>
<th>NYHA</th>
<th>BW (kg)</th>
<th>BSA (m²)</th>
<th>Dx</th>
<th>Cor</th>
<th>EF (%)</th>
<th>Peak gradient (mmHg)</th>
<th>Mean gradient (mmHg)</th>
<th>EVOA (cm²)</th>
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<tr>
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### Table 2

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<th>AoCx (min)</th>
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<td>160</td>
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<tr>
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<td>102</td>
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<tr>
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<td>Vascutek</td>
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<td>Vascutek</td>
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<td>178</td>
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<td>AVR – St.Jude #21 mm Regent</td>
<td>Pericardium</td>
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<td>Pericardium</td>
<td>220</td>
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CABG × 1 = 1, CABG × 2 = 2.
mitral valve replacement \((n=2)\) and endarterectomy of the ascending aorta \((n=1)\) (Table 2). Pre- and intraoperative transthoracic and transesophageal echocardiograms were used in all cases. All cases were treated with normothermic CPB, left ventricular venting, antegrade crystalloid cardioplegic arrest (St.Thomas) and local myocardial cooling. All posterior enlargements, except two, were planned in advance. Our criteria for planning a root enlargement were: (a) Small aortic root <18 mm, (b) severe left ventricular hypertrophy especially in left ventricular outflow (16 mm) and (c) extensively calcified small aortic root. We did not encounter any case that a planned enlargement was proven unnecessary. The majority of patients received a mechanical prosthesis (St. Jude Medical, \(n=14\)). Ten patients received a Regent prosthesis (sizes 19–21 mm effective orifice area – EVOA 1.7 cm\(^2\), 2.05 cm\(^2\), respectively). Four patients received a HP prosthesis (sizes 19–21 mm EVOA 1.3 cm\(^2\), 1.6 cm\(^2\), respectively)\(^1\). One patient received a bioprosthesis \((n=1)\).

The created defect was closed with fresh autologous pericardium in four patients and synthetic graft (Dacron) in 11 patients. Whenever the aortic wall was soft, fresh autologous pericardium was used, otherwise synthetic Dacron graft was used (Figs. 1 and 2). The enlargement was conducted with a teardrop-shaped patch, which was sutured with 4-0 prolene, while the width of the patch was 2\( \times \)3 times the length of the cut into the fibrous curtain below the aortic annulus.

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

Statistical analysis: The analyses were performed using software (SPSS 12.0 for Windows, SPSS). Variables were presented as mean \(\pm\) 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.

Statistical analysis was conducted using \(t\)-test and the ANOVA method.

### 3. 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). In two cases, CPB and AoCx were longer, due to delay of decision for enlargement after an unsuccessful initial placement of a smaller size valve (19 mm).

Despite application of fast track extubation protocols, the population that required posterior enlargement had a longer ventilatory support as compared to routine AVR (two-fold increase, 48 h vs. 24 h). The amount of postoperative bleeding was about the same (850 ml vs. 630 ml). Total length of stay (LOS) was 7–10 days, the same as in routine AVR.

Follow-up period was 5–120 months (mean 61.5 months). The functional recovery was evident in all patients during this period converting from NYHA class III–IV to class I–II.

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\(^1\) St. Jude Medical Inc., One Lillehei Plaza, St. Paul, Minnesota, USA.
One patient died from lung cancer five years after the initial procedure.

3.1. Survival

Actuarial survival at the end of our study was (1/15) 93.3% with a mean follow-up of 61.5 months. The patient died of non cardiac causes.

3.2. Functional

Effective valve orifice area increased from 0.7 ± 0.2 cm² to 1.4 ± 0.5 cm² (P < 0.01). The LVEF remained unchanged. Peak systolic gradient decreased from 98 ± 10 mmHg to 48 ± 7 mmHg (P < 0.001) (Table 3) and the mean gradient decreased from 58 ± 10 mmHg to 22 ± 8 mmHg (P < 0.001). The average of postoperative peak and mean gradient of the patients with small aortic root and the Nicks–Nunez 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 but not in the average of routine AVR.

3.3. 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) (Fig. 3).

3.4. LV mass regression

LV mass regressed significantly from 415 ± 33 g to 388 ± 41 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 (Table 3, Fig. 3).

4. 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 Nicks–Nunez operation in the 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 Nicks–Nunez technique of enlargement in a series of 15 patients, all women, small or large, with a BSA of 1.48 to 1.87 m² and body weight of 45 to 110 kg. In all these patients, it could have been impossible to implant a prosthesis of 17 mm, with the exception of two, without enlarging the small aortic annulus and implanting one or two sizes larger prosthesis.

An argument against enlargement in the elderly patients is the implantation of small size valves with satisfactory long-term survival. He et al. [17] believe that concomitant CABG and age are independent variables to determine the long-term survival. In their group of patients without CABG, age was the only independent variable for long-term survival whereas in the group of patients with CABG, BSA <1.7 m² was the only independent variable. They concluded that patients with small aortic root and small BSA may have satisfactory long-term results after isolated AVR and that old age and concomitant CABG were risk factors for long-term survival. Other investigators [18] implanted small size prostheses (< 21 mm) in patients older than 70 years and during a follow-up period up to 16 years (mean 6 ± 4 years) reported acceptable hemodynamic performance, while the risk of sudden death, irrespective of BSA and valve size, was not statistically different.

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 tobutamid 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 hypertrophy [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.

We do not hesitate to enlarge the small aortic annulus and implant diameter-enhanced mechanical prostheses such as the St. Jude Medical prosthesis despite the fact it takes longer, as total CPB and AoCx times are increased. However, our immediate results were satisfactory, even in a small number of patients who presented with extremely difficult small annuli to handle. Our immediate results favor the continuation of this procedure since both functional and anatomical improvement of the left ventricle was present at the end of this study. Our intermediate results have clearly demonstrated a significant LV mass regression associated with an improved clinical status in all patients.

References