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What is This?
Impact of aortic prosthesis-patient mismatch on left ventricular mass regression

Mohamed A Alassal¹,², Bedir M Ibrahim³ and Nabil Elsadeck⁴

Abstract

Background: Prostheses used for aortic valve replacement may be small in relation to body size, causing prosthesis-patient mismatch and delaying left ventricular mass regression. This study examined the effect of prosthesis-patient mismatch on regression of left ventricular mass after aortic valve replacement.

Methods: We prospectively studied 96 patients undergoing aortic valve replacement between 2007 and 2012. Mean and peak gradients and indexed effective orifice area were measured by transthoracic echocardiography at 3 and 6 months postoperatively. Patient-prosthesis mismatch was defined as indexed effective orifice area $\leq 0.85 \text{cm}^2/\text{m}^2$.

Results: Moderate prosthesis-patient mismatch was present in 25% of patients. There were no significant differences in demographic and operative data between patients with and without prosthesis-patient mismatch. Left ventricular dimensions, posterior wall thickness, transvalvular gradients, and left ventricular mass decreased significantly after aortic valve replacement in both groups. The interventricular septal diameter and left ventricular mass index regression, and left ventricular ejection fraction were better in patients without prosthesis-patient mismatch. There was a significant positive correlation between the postoperative indexed effective orifice area of each valve prosthesis and the rate of left ventricular mass regression.

Conclusions: Prosthesis-patient mismatch leads to higher transprosthetic gradients and impaired left ventricular mass regression. A small-sized valve prosthesis does not necessarily result in prosthesis-patient mismatch, and may be perfectly adequate in a patient with small body size.

Keywords

Aortic valve stenosis, body size, heart valve prosthesis implantation, hypertrophy, left ventricular, prosthesis fitting

Introduction

Aortic stenosis is the most common valvular heart disease. Left ventricular (LV) hypertrophy is typically observed in the course of the disease. The main purpose of aortic valve replacement (AVR) is to relieve valve stenosis and reduce LV pressure or volume load, which will allow LV mass regression. However, a postoperative pressure gradient often persists, especially in patients who receive a prosthesis measuring 21 mm or less, which would be expected to compromise the extent of LV mass regression.¹⁻⁴ It has been emphasized that implantation of a small prosthesis does not necessarily result in prosthesis-patient mismatch (PPM), and can be perfectly adequate in a patient with a small body size, while larger patients are predisposed to PPM probably because they have higher cardiac output requirements.⁵,⁶ The indexed effective orifice area (EOA) provides a reliable estimation of the relationship between prosthesis size and body size. In general, the EOA of an implanted aortic prosthesis must be matched to the size of the patient to provide sufficient gradient relief, promote LV mass regression, and improve survival.⁷,⁸ The aim of this work was to study the effect of PPM on postoperative LV mass.
regression after AVR and to compare patients with and without PPM.

**Patients and methods**

This prospective study consisted of 67 consecutive patients with isolated pure aortic stenosis, who underwent AVR between February 2007 and March 2011 at 2 cardiac centers in Saudi Arabia. The study protocol was approved by the local ethical committee, and fully informed written patient consent was obtained. We excluded patients with aortic regurgitation, myocardial infarction, previous cardiac surgery, and those undergoing concomitant surgical procedures such as mitral valve surgery or coronary artery bypass.

On admission, the patients were underwent a clinical evaluation, routine laboratory tests, plain chest radiography (posteroanterior and lateral views), a standard preoperative 12-lead electrocardiogram, and Doppler echocardiography. The dimensions of the LV were assessed. The end-diastolic interventricular septum thickness and posterior wall thickness were recorded. LV mass index was calculated on the basis of body surface area. LV systolic performance was evaluated by means of the ejection fraction.

All procedures were performed in a standardized fashion using a full sternotomy and cardiopulmonary bypass, typically with high ascending aortic cannulation, a right superior pulmonary vein vent, and 2-stage venous cannulation of the right atrium. Myocardial protection was afforded by potassium-enriched crystalloid intermittent cardioplegia (antegrade or retrograde routes, or combined), and moderate hypothermia. After arrest of the heart and opening of the aorta through an oblique aortotomy, the diseased valve was excised with careful removal of any calcium over the valve or LV outflow tract. A valve seizer is used to choose the appropriate size of prosthesis for each patient. All patients received a mechanical bileaflet St. Jude Medical valve prosthesis (St. Jude Medical, Inc., St. Paul, MN, USA). The aortotomy was closed in 1 or 2 layers. The patient was weaned from cardiopulmonary bypass, and the sternum was closed after insertion of retrosternal and retrocardiac chest tubes.

The patients were scheduled for follow-up in the outpatient clinic at 2 weeks, 1 month, 3 months, and 6 months after discharge from the hospital. Each patient underwent clinical evaluation, routine laboratory tests, plain chest radiography, a 12-lead electrocardiogram, and Doppler echocardiography. The postoperative indexed EOA was calculated. The reduction of mean and peak transvalvular gradients after AVR was calculated by subtracting the postoperative value from the preoperative value and dividing by the preoperative value. The 96 patients were classified into 2 groups: group A was 72 (75%) patients with no PPM (indexed EOA >0.85 cm²·m⁻²); and group B was 24 (25%) patients with PPM (indexed EOA ≤0.85 cm²·m⁻²). LV mass regression after AVR was studied in both groups. The distribution of prosthesis size in both groups was also recorded. The demographic data of both groups are given in Table 1. Both groups were predominately female, and there were no significant differences in demographic data between groups.

The collected data were organized, tabulated, and statistically analyzed using SPSS version 13 (SPSS, Inc., Chicago, IL, USA). For quantitative data, the range, mean and standard deviation were calculated. For qualitative data, comparison between groups was performed using the chi-square test. Correlation between variables was evaluated using Pearson’s correlation coefficient. Significance was adopted at p < 0.05 for interpretation of results of tests of significance.

**Results**

No patient underwent emergency surgery, and none required a procedure for aortic root enlargement. The distribution of prosthesis size in the 2 groups was not significantly different (Table 2). The overall incidence of PPM was 25% (24/96), and a moderate degree of PPM was noted in these cases (indexed EOA between 0.65 and 0.85 cm²·m⁻²). The mean indexed EOA in patients with a 19-mm valve prosthesis was similar in both groups, whereas in patients with a 21-mm valve prosthesis or larger, the indexed EOA was significantly higher in those with no PPM (group A) compared to group B. The mean indexed EOA increased with valve size in group A (p < 0.0001), but there was no increase with valve size in the patients with PPM (p = 0.673; Table 3). The impact of PPM on LV function and LV mass regression is shown in Table 4. LV dimensions decreased significantly after AVR in both groups, and there was no significant difference between groups. LV ejection fraction improved significantly postoperatively in group A patients, but the improvement in group B patients was not significant. Posterior wall thickness diameter decreased significantly in both groups.

**Table 1. Demographic data of 96 patients undergoing aortic valve replacement.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A (n = 72)</th>
<th>Group B (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years) [range]</td>
<td>43.51 ± 4.31 [32–49]</td>
<td>49.36 ± 3.43 [36–55]</td>
</tr>
<tr>
<td>Male</td>
<td>27 (37.5%)</td>
<td>10 (41.7%)</td>
</tr>
<tr>
<td>Female</td>
<td>45 (62.5%)</td>
<td>14 (58.3%)</td>
</tr>
<tr>
<td>Body surface area (m²)</td>
<td>1.67 ± 0.27 [1.02–2.41]</td>
<td>1.76 ± 0.23 [1.23–2.51]</td>
</tr>
</tbody>
</table>
Interventricular septal diameter was significantly decreased after AVR in group A, but the decrease was less and not significant in group B. Postoperative transvalvular peak and mean gradients were significantly decreased in both groups of patients during follow-up, but the rate of decrease was lower in group B than in group A. The reduction of both peak and mean transvalvular gradients after AVR resulted in a significant reduction of LV mass in both groups, and a significant reduction of LV mass index in group A but not in group B; the postoperative LV mass and LV mass index were significantly higher in group B patients compared to those in group A. There was a significant positive correlation between the postoperative indexed EOA of each valve prosthesis and the rate of LV mass regression at 6 months postoperatively; this means that when the indexed EOA of the implanted valve prosthesis increased, the rate of LV mass regression also increased.

**Discussion**

Prosthesis-patient mismatch is a frequent occurrence after AVR, and it is defined as a projected indexed EOA \( \leq 0.85 \, \text{cm}^2\cdot\text{m}^{-2} \) after AVR. The PPM incidence in our study was 25%; all of these patients had a moderate degree of PPM (indexed EOA between 0.65 and 0.85 cm²·m⁻²) and none had severe PPM (indexed EOA \( \leq 0.65 \, \text{cm}^2\cdot\text{m}^{-2} \)). This is in agreement with other studies.⁴,⁹,¹⁰

We did not find any significant difference between 19- and 21-mm St. Jude Medical valve prostheses in regards to LV mass regression, but there was a significant difference between 19-mm and the larger 23- and 25-mm valves; however, this depended on the patient’s body surface area, so according to our results and other studies, not only prosthesis size but also the indexed EOA, which represents degree of PPM, were independent predictors of incomplete LV mass regression.⁴,¹¹ PPM can lead to impaired restoration of LV dimensions because the afterload on the LV and the pressure gradient are increased, as demonstrated in many studies.³,¹² Our results are in agreement with these previous studies, but some other studies found no significant impact of PPM could be demonstrated regarding the recovery of LV ejection fraction or LV hypertrophy regression.¹³

The transvalvular gradient is still widely used as a guide to AVR in aortic stenosis, and the hemodynamic advantage of AVR arises from its ability to minimize postoperative gradients and favor the normalization of LV mass and function.¹⁴,¹⁵ The increased transvalvular gradient associated with PPM has been shown to result in increased LV work, which in turn influences the regression of LV hypertrophy.¹,¹⁶ Surgical correction of stenosis by valve replacement leads to good

| Table 2. Operative data of 96 patients undergoing aortic valve replacement. |
|-------------------------------|---------------------|---------------------|
| Variable                      | Group A (n=72)      | Group B (n=24)      | p value |
| CPB time (min) [range]        | 121.86 ± 38.51 [64–214] | 108.52 ± 41.30 [65–172] | 0.358   |
| Aortic crossclamp (min)       | 93.72 ± 34.87 [45–162] | 87.63 ± 31.32 [50–145] | 0.543   |
| Valve size                    |                     |                     | 0.098   |
| 19 mm (n)                     | 8 (11.1%)           | 6 (25%)             |         |
| 21 mm (n)                     | 25 (34.7%)          | 12 (50.0%)          |         |
| 23 mm (n)                     | 33 (45.8%)          | 5 (20.8%)           |         |
| 25 mm (n)                     | 6 (8.3%)            | 1 (4.2%)            |         |
| CPB: cardiopulmonary bypass.  |                     |                     |         |

| Table 3. Indexed effective orifice area according to size of aortic valve prosthesis. |
|---------------------------------------------|---------------------|---------------------|
| Valve size                                  | Group A (n=72)      | Group B (n=24)      | p value |
| Indexed effective orifice area (cm²·m⁻²) [range] |                     |                     |         |
| 19 mm                                       | 0.87 ± 0.06 [0.85–0.90] | 0.82 ± 0.07 [0.76–0.87] | 0.846   |
| 21 mm                                       | 0.92 ± 0.09 [0.86–1.22] | 0.80 ± 0.04 [0.73–0.84] | 0.0001  |
| 23 mm                                       | 0.97 ± 0.07 [0.92–1.19] | 0.77 ± 0.02 [0.76–0.79] | 0.0001  |
| 25 mm                                       | 1.14 ± 0.16 [1.02–1.41] | 0.79 ± 0.00 [0.78–0.80] |         |
regression of LV mass, regardless of the type of valve inserted, with the bulk of the hypertrophy regressing within the first 6 months after the operation.\textsuperscript{13,17,18} The time course of regression in LV hypertrophy after AVR is controversial. The earliest documented evidence of consistent LV mass regression after AVR varies between 6 weeks and 1 year.\textsuperscript{12}

The results of our study agree with the findings of other studies showing significant LV mass regression early postoperatively (after 3 months), and the extent of LV mass regression was maximal during the first 6 postoperative months.\textsuperscript{19} From this study we can conclude that PPM is a frequent problem in patients undergoing AVR due to aortic valve stenosis. It leads to a higher transprosthetic gradient and impaired LV mass regression. A small-sized valve prosthesis does not necessarily result in PPM, and may be perfectly adequate in a patient with a small body size.

**Conflict of interest statement**

None declared.

**References**


