Stability of Ascending Aortic Dilatation Following Aortic Valve Replacement

Bruce W. Andrus, MD; Daniel J. O’Rourke, MD; MS; Lawrence J. Dacey, MD, MS; Robert T. Palac, MD, MS

Background—Replacement of the ascending aorta (Asc Ao) at the time of aortic valve replacement (AVR) is controversial because the risk of progressive dilatation following valve replacement is uncertain. Our aim was to determine the natural history of ascending aortic dilatation following AVR.

Methods and Results—We studied 185 patients undergoing AVR at our institution between 1992 and 1999. Clinical and echocardiographic data were obtained by merging our institutional echocardiographic database with the DHMC component of the Northern New England Cardiovascular Disease Study Group database. Baseline Asc Ao measurements obtained from intraoperative transesophageal echocardiograms or early (<8 weeks) postoperative transthoracic echocardiograms were compared with late follow-up measurements (mean follow-up 30.0±23.4 months). During follow-up, there was no increase in the mean Asc Ao diameter (3.6±0.6 cm versus 3.6±0.6 cm, p=NS). Progressive aortic dilatation, defined as an increase in diameter >0.3 cm, occurred in 27/185 patients (15%). Baseline Asc Ao dilatation (≥3.5 cm) was present in 107/185 patients (58%). In this subset of patients, there was no increase in mean Asc Ao diameter (4.0±0.4 versus 3.9±0.6 cm, p=NS) and progressive aortic dilatation occurred in only 10 patients (9.3%). No patients with baseline aortic dilatation (range, 3.5 to 5.3 cm) dilated beyond 5.5 cm on follow-up (range, 2.4 to 5.5 cm). There were no clinical or valvular characteristics that predicted progressive Asc Ao dilatation.

Conclusions—An increase in Asc Ao dilatation occurs infrequently following AVR and therefore, argues against routine Asc Ao replacement at the time of AVR. (Circulation. 2003;108[suppl II]:II-295-II-299.)

Key Words: aneurysm ■ aorta ■ remodeling ■ valves

Patients referred for aortic valve replacement (AVR) often have accompanying ascending aortic (Asc Ao) dilatation. However, the decision to extend the surgical procedure to include ascending aortic replacement is difficult because of the increase in surgical risk and the uncertain natural history of ascending aortic dilatation following AVR. The existing body of literature regarding ascending aortic dilatation focuses on patients who did not undergo valve surgery. These studies have consistently documented progressive aortic dilatation with expansion rates ranging from 0.12 cm to 0.42 cm/year. A frequently observed predictor of expansion rate is baseline aortic diameter such that larger aneurysms grow more rapidly than smaller ones.1–4 To date, there have been few studies addressing the natural history of aortic dilatation following AVR.5,6 In some patients with aortic valve disease, the pathogenesis of ascending aortic dilatation likely involves an accompanying intrinsic defect in connective tissue.7–11 However, in patients without apparent connective tissue disease or congenital heart disease, the flow patterns of aortic valve disease may play a role in the pathogenesis.12–15 Because AVR often corrects these hemodynamic derangements, surgery may alter the natural history of aortic dilatation.

The primary aim of this study was to examine the natural history of ascending aortic dilatation following aortic valve replacement. Additionally, we sought to identify predictors of progressive aortic dilatation.

Methods

Study Population

The Northern New England Cardiovascular Disease Study Group (NNE) database has been fully described elsewhere.16 Using this database, we searched for patients who underwent AVR surgery without ascending aortic replacement at Dartmouth Hitchcock Medical Center (DHMC) between January 1, 1992 and December 31, 1999. This search identified 696 patients. We next searched the DHMC echocardiographic laboratory database to identify patients who had an echocardiogram performed within the same time period with referral diagnoses of “aortic stenosis,” “aortic insufficiency,” and “aortic prosthetic follow-up.” This yielded 6362 echocardiograms of which 2312 were performed on patients in the surgical registry.

The final study population consisted of 185 patients with technically adequate echocardiograms performed early after surgery (<8 weeks) and late after surgery (>8 weeks). When multiple follow-up studies were available, the last complete study was selected. Of these 185 patients, 123 had Asc Ao measurements prospectively recorded in the database. The remaining 62 patients were lacking either a baseline and/or follow-up ascending aortic measurement (ie, the sonographer did not enter a dimension in his or her report). The missing information was obtained by reviewing the tapes and using...
“off-line” digital calipers to measure the diameter of the ascending aorta. The measurements were made by one of the investigators (BWA) who was blinded to the comparison measurement (eg, the follow-up diameter in the case of a missing baseline value).

Aortic Measurements
The ascending aortic diameter was measured 2 cm above the sinotubular ridge in the parasternal long axis view in transthoracic (TTE) studies. In transesophageal (TEE) exams, the ascending aortic diameter was measured at the same location. Intraoperative TEE measurements were validated by comparing them with preoperative transthoracic measurements done less than 4 months earlier. There was a close correlation between the preoperative and intraoperative measurements of Asc Ao diameter (Pearson $r$ =0.83).

Statistical Analysis
All data are presented as mean±SD. Separate populations were compared using the Student’s t-test for continuous variables and Chi-square for nominal variables. Baseline and follow-up measurements were compared by the Student’s t-test for paired samples. Associations between continuous variables were evaluated by linear regression. Univariate analysis of clinical predictors of aortic dilatation was performed using the Student’s t-test for dichotomous variables, ANOVA for categorical variables, and linear regression for continuous variables. Probability values <0.05 were considered significant. Microsoft EXCEL 97® (Microsoft Corporation, Redmond, WA) and STATA (Release 6.0, Stata Corporation, College Station, TX) software were used to perform statistical analyses.

Results

Baseline Characteristics
The characteristics of the study population are presented in Table 1. The mean age of the population was 65.8±13.6 years and was predominately male (69.2%). While relatively few patients were active smokers (17%), hypertension and coronary artery disease (CAD) were frequent comorbidities (43% and 52%, respectively). Moderate to severe aortic valve stenosis was the most common valve lesion (79%), most often secondary to calcific or degenerative valve disease (87%). Most patients received mechanical prostheses (58%). At baseline, Asc Ao diameters ranged from 2.2 to 5.3 cm with a mean of 3.6±0.6. There were 58% (107/185) of the patients who had an Asc Ao diameter ≥3.5 cm at baseline (Figure 1).

Change in Asc Ao Diameter
The mean duration of follow-up was 30.0±23.4 months. There was no significant difference between mean Asc Ao diameter at baseline and at follow-up (3.6 cm ±0.6 versus 3.6 cm ±0.6). The distribution of change in Asc Ao diameter is displayed in Figure 2. There were 15% (27/185) of the patients who demonstrated a postoperative increase in aortic dilatation ≥0.3 cm. The mean Asc Ao expansion rate in the entire study population was $-0.03±1.09$ cm/year.

Limiting analysis to those patients with more than 1 year (N=131) and more than 3 years follow-up (N=67) yielded expansion rates similar to the entire study population (Table 2).

Subgroup Analysis: Patients With Baseline Asc Ao Dilatation
In the population of patients with baseline Asc Ao diameter ≥3.5 cm, aortic size remained stable over a mean follow-up period of 33.6 months (4.0±0.4 cm versus 3.9±0.5 cm). The distribution of change in Asc Ao diameter among these patients is displayed in Figure 3. The characteristics of these patients are displayed in Table 3. Only 10/107 (9.3%) displayed an increase in diameter exceeding 0.3 cm. No patients with baseline aortic dilatation (range 3.5 to 5.3 cm) dilated beyond 5.5 cm on follow-up (range 2.4 to 5.5 cm). The mean Asc Ao expansion rate in patients with baseline dilatation was $-0.10±0.70$ cm/year.

Clinical Predictors of Aortic Dilatation
No statistically significant univariate association was found between Asc Ao dilatation and any of the clinical variables.
examined. These included age, gender, smoking, hypertension, and coronary artery disease. Likewise, no significant association was found between any valvular characteristic and Asc Ao dilatation. These characteristics included the presence of moderate/severe AS, moderate/severe AR, valve pathology (congenital, degenerative, endocarditis, rheumatic, and other), and prosthesis type (Carpentier, Hancock, Medtronic-Hall, St. Jude, and other). The difference in expansion rate between mono- and bicuspid valves (n/H11005 21) and that of trileaflet valves (n/H11005 164) nearly reached statistical significance (0.14±0.36 cm/year versus −0.05±1.16 cm/year, P=0.06 for one tailed t-test). There was no statistically significant association between the baseline Asc Ao diameter and the annual rate of expansion (r=0.14).

Discussion

Our findings suggest that Asc Ao dilatation is prevalent in patients who undergo AVR. Furthermore, our study documents that Asc Ao dilatation rarely progresses following AVR. We noted no increase in mean Asc Ao diameter during a mean follow-up interval of 30.0 months. In the subpopulation with baseline aortic dilatation, we observed stability in mean aortic diameter with a mean expansion rate of 0.10±0.70 cm/year during a follow-up period of 33.6 months. An absolute increase in Asc Ao diameter exceeding 0.3 cm was infrequent, seen in 15% of the entire study population and in 9.3% of the population with baseline Asc Ao dilatation.

Other investigators have noted a similar prevalence of Asc Ao dilatation in association with aortic valve disease. Hahn et al10 reported on 83 patients with bicuspid aortic valves. In this diverse population comprised of patients with varying degrees of valvular dysfunction, the overall prevalence of aortic dilatation was 60%. Among patients with mild to moderate

TABLE 2. Comparison of Expansion Rate Stratified by Follow-up Duration

<table>
<thead>
<tr>
<th>Study Cohort</th>
<th>Length of Follow-up (months)</th>
<th>Expansion Rate (cm/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients (n=185)</td>
<td>30.0 (±23.4)</td>
<td>−0.03 (±1.09)</td>
</tr>
<tr>
<td>Patients with &gt;1 year follow-up (n=131)</td>
<td>39.6 (±20.9)</td>
<td>−0.02 (±0.16)</td>
</tr>
<tr>
<td>Patients with &gt;3 years follow-up (n=67)</td>
<td>56.7 (±14.2)</td>
<td>0.01 (±0.08)</td>
</tr>
</tbody>
</table>

AS, the prevalence was 63%. Crawford and Roldan14 compared the Asc Ao diameter of 118 patients with AS to 108 age-matched controls with normal or sclerotic valves. They reported a significant difference in sinotubular diameter in patients with all degrees of AS (mean diameter 3.5 to 3.6 cm) compared with those with normal (3.0 cm) or sclerotic valves (3.2 cm) (P<0.001).

Several studies have evaluated the natural history of Asc Ao dilatation in the absence of AVR. Coady4 reported a rate of 0.12 cm/year in a cohort of 79 patients followed for a mean of 25.9 months. Hirose3 reported a mean growth rate of 0.28 cm/year based on a sample of 11 patients with ascending

TABLE 3. Comparison of Baseline Characteristics of Patients With Baseline Ascending Aortic Dilatation

<table>
<thead>
<tr>
<th></th>
<th>Expanders (n=10)</th>
<th>Nonexpanders* (n=97)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean age</td>
<td>65.7</td>
<td>64.6</td>
</tr>
<tr>
<td>Gender (%)</td>
<td>90</td>
<td>77</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>10</td>
<td>19</td>
</tr>
<tr>
<td>Hypertension</td>
<td>50</td>
<td>44</td>
</tr>
<tr>
<td>Coronary artery disease (%)</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Aortic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline ascending aortic diameter (cm, ±SD)</td>
<td>3.8±0.4</td>
<td>4.1±0.4</td>
</tr>
<tr>
<td>Valvular</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve type (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carpentier</td>
<td>10.0</td>
<td>5.2</td>
</tr>
<tr>
<td>Hancock</td>
<td>30.0</td>
<td>29.9</td>
</tr>
<tr>
<td>Medtronic-Hall</td>
<td></td>
<td>50.5</td>
</tr>
<tr>
<td>St. Jude</td>
<td>0.0</td>
<td>13.4</td>
</tr>
<tr>
<td>Other</td>
<td>0.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Valve pathology (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>30.0</td>
<td>14.4</td>
</tr>
<tr>
<td>Degenerative</td>
<td>70.0</td>
<td>63.9</td>
</tr>
<tr>
<td>Endocarditis</td>
<td>0.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Rheumatic</td>
<td>0.0</td>
<td>13.4</td>
</tr>
<tr>
<td>Other</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Moderate or severe AS† (%)</td>
<td>80.0</td>
<td>14.4</td>
</tr>
<tr>
<td>Moderate or severe AR‡ (%)</td>
<td>40.0</td>
<td>71.1</td>
</tr>
</tbody>
</table>

*P=NS for all comparisons. †AS=aortic stenosis. ‡AR=aortic regurgitation.
aortic aneurysm followed for a mean of 34 months. Masuda described another nonoperative series of 14 patients with ascending aortic aneurysm followed by computed tomography (CT) scan for a mean of 36 months. The mean expansion rate was 0.13 cm/year with no significant differences between the ascending, transverse, and descending aorta. Finally, Dapunt reported a rate of 0.43 cm/year for a series of 67 patients with thoracic or thoracoabdominal aneurysm followed by 3-D reconstruction of CT scans. These studies are summarized in Table 4. In contrast to these studies, we found an expansion rate of –0.10 cm/year. We suspect that in patients without congenital heart disease or abnormal connective tissue, the hemodynamic effects of AS and AR may contribute to progressive ascending aortic dilatation. We further speculate that by correcting these flow patterns, AVR may modify the natural history of ascending aortic dilatation. Further investigation to test this hypothesis is required.

Previous studies have identified several different predictors of progressive dilatation. Dapunt identified initial aortic size and smoking as independent predictors. Masuda found diastolic blood pressure, renal failure and initial aortic size to be predictors of expansion by univariate analysis. However, after adjusting for differences by multivariate analysis, only initial aortic size was predictive. Using logistic regression, Palmieri reported male gender, fibrocalcific changes in the aortic valve, and left ventricular wall motion abnormalities to be correlated with aortic root dilatation. Other investigators have noted that ascending aortic dilatation is over-represented in patients with bicuspid valves and in those with Marfan’s syndrome leading to speculation that these conditions may be manifestations of a common developmental defect. In our study, we did not identify any variables associated with Asc Ao expansion, though there was a trend toward more rapid expansion in patients with mono- or bicuspid aortic valves. It is tempting to speculate that with a larger study population or a longer period of follow-up this difference would have reached statistical significance. This trend is consistent with the previously cited studies which have linked aortic dilatation to structural abnormalities in the connective tissue of congenitally abnormal valves. Other explanations for the absence of clinical or valvular predictors include the possibility that the impact of correcting abnormal flow patterns outweighed their comparatively minor effect or that we did not specifically evaluate the relevant variables.

Our study has potential limitations. First, there is the possibility that selection bias exists because our study population was not a consecutive series or a randomly selected population. However, comparing the study population with the total surgical population revealed only minor differences in age and gender distribution. The study population was younger (65.8 versus 69.8 years, P=0.001) and more often male (69.2% versus 57.1%, P=0.003). There were no other statistically significant differences between the populations. Second, the possibility exists that there was observer bias resulting from the need to perform retrospective echocardiographic measurements in 81 study patients. However, all measurements were blinded to the comparison value. In addition, the mean change in Asc Ao diameter was similar in prospectively and retrospectively measured aortas (–0.028 cm and –0.003 cm, respectively).

In summary, our findings have important clinical implications. In patients requiring aortic valve replacement who have accompanying mild or moderate ascending aortic dilatation (3.5 to 4.9 cm), aortic valve replacement alone may be reasonable. Exceptions to this would include patients with a mono- or bicuspid aortic valve, an underlying connective tissue disease, endocarditis, a family history of ascending aortic aneurysm, or a rapidly dilating aorta.

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References


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