High Failure Rate After Valve-sparing Aortic Root Replacement Using the “Remodeling Technique” in Acute Type A Aortic Dissection

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**Background**—Valve-sparing surgery including the replacement of the sinus of valsalvae were initially meant to be promising approaches in the treatment of acute type A aortic dissection. However, the long-term outcome after valve-sparing aortic root replacement in acute type A dissection is currently the subject of intense debate, and the evidence reported in the literature is sparse. Here we report on our experience on valve sparing aortic root replacement inpatients with acute type A dissection.

**Methods**—From August 1995 to November 2000, 30 patients with acute type A dissection received valve-sparing aortic root replacement. Two different techniques were performed: the “remodeling” technique, first described by Yacoub in 1983 (8 patients) and the “reimplantation” technique, initially described by David and Feindel, in 1992 (22 patients). Endpoints of the study were early and late mortality, as well as aortic valve-related complications and reoperations.

**Results**—The mean follow-up time was 22.6±15.4 months. The overall 30 day mortality was 17% (5/29) and the late mortality 4% (1/24). During the observation period, 4 patients had to be reoperated (n=3) for acute aortic valve regurgitation after aortic root remodeling and for acute aortic valve endocarditis (n=1) after aortic root reimplantation. In the 3 patients with acute aortic valve regurgitation, symptoms occurred 44, 24, and 17 months after the initial operation in these patients. Intraoperatively prolapsing aortic leaflets because of commissural detachment was found in all 3 cases. In all other patients the latest echocardiographic follow-up examination revealed freedom from aortic regurgitation higher than grade 1.

**Conclusions**—The high failure rate of aortic root remodeling inpatients with acute type A aortic dissection is discouraging. Whether this technique should be applied in acute type A aortic dissection is questionable. In contrast, aortic root reimplantation lead to favorable midterm outcome. Thus, we recommend consideration of this technique for surgical treatment of patients with acute type A aortic dissection. *(Circulation. 2002;106[suppl I]:I-229-I-233.)*

**Key Words:** aneurysm ■ cardiovascular diseases ■ complications ■ valves

Aortic redissection and aneurysm formation are common indications for reoperation inpatients after surgery for acute type A aortic dissection. Insufficient replacement of the aorta during the initial operation and residues of the diseased aortic wall may contribute to the high number of reoperations in these patients. Therefore, a more aggressive surgical resection down to the diseased aortic root may probably help to reduce the number of late reinterventions after surgery for acute type A dissection.1 Nevertheless, the current standard surgical therapy for acute type A dissection is the supracommissural replacement of the ascending aorta by a tube graft.2,3 Alternatively, replacement of the entire aortic root with a valve baring composite graft can be performed.4,5 However, both techniques are associated with a certain long-term morbidity. In the literature, the incidence of reoperation of the aortic root following supracommissural replacement of the ascending aorta ranges between 3.3% and 16% after 5 years6–8 and up to 20% after 10 years.9 Most of these patients develop aneurysms, redissection, or a combined lesion of the aortic root, and present with clinical symptoms that ultimately require reoperation. However, the total number of symptomatic and nonsymptomatic aortic root aneurysms may reach as high as 33%.10 Furthermore, clinically important aortic valve regurgitation is reported in 20% to 45% of patients after supracommissural tube graft replacement.11,12 Composite graft replacement is associated with an increased risk of thromboembolic events, hemorrhage because of anticoagulation, and reoperation for rereplacement of degenerated biological valve substitutes.4,5,13 Taking the evidence from the literature into account and considering the reported hospital mortality of 13% to 33% after reoperation of the aortic root following previous surgery for acute type A dissection,2,7 valve-sparing...
TABLE 1. Clinical and Operative Data of Patients Receiving Valve-Sparing Aortic Root Replacement for Acute Type A Dissection

<table>
<thead>
<tr>
<th>Variable</th>
<th>Reimplantation Technique (n=22)</th>
<th>Remodeling Technique (n=8)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>52±15</td>
<td>62±16</td>
<td>0.08</td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>4</td>
<td>0.3</td>
</tr>
<tr>
<td>Follow-up (month)</td>
<td>22.2±15.5</td>
<td>32.7±12.8</td>
<td>0.07</td>
</tr>
<tr>
<td>Marfan syndrome</td>
<td>2</td>
<td>1</td>
<td>0.6</td>
</tr>
<tr>
<td>Cystic medial necrosis</td>
<td>8</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Aortic root dissection</td>
<td>19</td>
<td>7</td>
<td>0.7</td>
</tr>
<tr>
<td>Concomitant procedures</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial arch replacement</td>
<td>16</td>
<td>6</td>
<td>0.6</td>
</tr>
<tr>
<td>Total arch replacement</td>
<td>6</td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>CABG</td>
<td>0</td>
<td>2</td>
<td>0.06</td>
</tr>
<tr>
<td>Bypass time (min)</td>
<td>212±56</td>
<td>212±20</td>
<td>0.5</td>
</tr>
<tr>
<td>Aortic cross clamp time (min)</td>
<td>157±24</td>
<td>143±18</td>
<td>0.07</td>
</tr>
<tr>
<td>Circulatory arrest time (min)</td>
<td>35±18</td>
<td>29±9</td>
<td>0.2</td>
</tr>
</tbody>
</table>

CABG indicates coronary artery bypass grafting.

aortic root replacement may be an appealing approach to reduce the need for reoperation and, moreover, late mortality. Recently, we and others have proven the safety and efficacy of both the reimplantation and remodeling technique in the treatment of acute type A dissection.\(^{15,16}\) To our knowledge there are no follow-up data reported in the literature regarding the rate of surgical reintervention following valve-sparing operation for acute type A dissection.

Here we report on our experience on valve-sparing aortic root replacement (remodeling/reimplantation) inpatients with acute type A dissection.

Patients and Methods

Between August 1995 and November 2000, 30 patients with acute type A aortic dissection received valve-sparing aortic root replacement according to the techniques described by David and Feindel (reimplantation technique; n=22)\(^{16}\) and Yacoub et al\(^{17}\) (remodeling technique; n=8). The technical details are described elsewhere.\(^{15-16}\)

Nineteen males and 11 females (age 55±16 years; range 20 to 79 years) were included in this analysis. All patients were operated on urgently after admission to the hospital. Until 1999 all procedure were conducted using moderate hypothermic cardiopulmonary bypass support with deep hypothermic circulatory arrest, with or without hypothermic retrograde cerebral perfusion for open arch anastomoses or aortic arch replacement. After 1999 moderate hypothermic circulatory arrest with antegrade hypothermic cerebral perfusion for open arch anastomosis or aortic arch replacement was used. In all patients, gelatin-resorcine-formol (GRF) glue was applied to reinforce the dissected tissue before the Dacron prosthesis was sewn in. When the aortic root and aortic valve commissures were involved in the dissection process, GRF glue was also used to reconstitute the aortic root wall before excision of the sinuses of valsalva. The decision for aortic root remodeling or reimplantation was based on the surgeon’s preference. Clinical data are depicted in Table 1. The overall 30-day mortality was 17% (5/30) and the late mortality 4% (1/25); thus, we had n=24 long-term survivors (n=18 reimplantation technique, n=6 remodeling technique). One patient died 9 months after surgery from ventricular fibrillation. During the observation period, 4 of our patients required reoperation. One patient underwent reoperation for acute aortic valve endocarditis after aortic root reimplantation, and 3 patients with aortic root remodeling had to be reoperated for acute severe aortic valve regurgitation. One of these 3 patients was reoperated elsewhere in an emergency situation. During the same observation period another patient with acute severe aortic valve insufficiency, who received an aortic root remodeling for acute type A dissection elsewhere, was reoperated at our institution. Since this patient was initially not operated at our institution, she was excluded from all statistical analyses in this study.

Aortic valve function in all survivors was assessed by transthoracic echocardiography before discharge from the hospital and every 12 months thereafter.

Statistical Analysis

Data are expressed as the mean±SD. Demographic and baseline variables were analyzed by using the Student’s t test for continuous variables and the Fisher exact test for qualitative variables. The Kaplan-Meier survival estimates were used to analyze mortality at 30 days, long-term survival, freedom from reoperation, as well as freedom from reoperation because of structural aortic valve failure. Statistical differences in Kaplan-Meier survival estimates were determined by using the log-rank test. A probability value of <0.05 was considered statistically significant. Statistical analysis was performed using the SPSS for windows software package (SPSS Inc).

Results

Comparison of clinical data between patients after aortic root remodeling or reimplantation showed no relevant differences (Table 1). Follow-up time of the 24 long-term survivors was 22.6±15.4 months (range 3 to 65 months). The time period between the initial operation and the reoperation was 44, 24, and 17 months (remodeling technique), and 4 months (reimplantation technique). Another patient that received the initial operation (remodeling technique) for acute type A aortic dissection in another hospital underwent reoperation 24 months later at our institution for severe aortic valve regurgitation. Indications for reoperation were acute severe aortic valve regurgitation inpatients after aortic root remodeling. The patient after aortic root reimplantation developed acute aortic valve endocarditis, and, therefore, required reoperation. In all cases of acute aortic valve regurgitation, including the patient who received the initial operation elsewhere, the intraoperative finding was a prolapsing commissure because of commissural disruption off the remaining aortic wall, in 2 patients between the left and noncoronary sinus, and in 2 patients between the right and noncoronary sinus (Figure). There were no aortic leaflet tears per se. On transesophageal echocardiography none of the patients showed annular dilation with lack of coaptation and central aortic regurgitation. The observed aortic regurgitation jet patterns seen in transesophageal echocardiography examinations were noncentral and frequently appeared in the area of commissural disruption. The data of patients requiring reoperation are summarized in Table 2.

Histological examination at the time of the initial operation for type A dissection showed typical features of cystic medial necrosis of the aortic wall in all patients who developed severe acute aortic valve regurgitation after aortic root remodeling. However, there was no difference in the incidence of cystic medial necrosis of the aortic wall between the remodeling and the reimplantation patients after aortic root remodeling or reimplantation (Table 1).

Hospital survival and long-term survival were similar in group comparison. Freedom from overall reoperation was
higher in the reimplantation group but failed to reach statistical significance (95 ± 5% versus 38 ± 23%, \( P = 0.13 \)). However, freedom from reoperation because of structural aortic valve failure was significantly higher in the reimplantation group (100% versus 38 ± 23%, \( P = 0.04 \)).

**Discussion**

Here we report on a high failure rate of aortic root remodeling in patients with acute type A dissection within the first 4 postoperative years. Our preliminary results from this study suggest that the incidence of premature failure after aortic root remodeling in acute type A dissection is associated with the type of initial valve-sparing operation.

The high failure rate of aortic root remodeling in acute type A dissection in this study is astonishing as well as discouraging, because the reported freedom from reoperation after valve-sparing aortic root replacement in general, regardless of the applied technique, varies between 97 ± 2% after 6 years \(^{18} \) and 89 ± 0.5% after 10 years \(^{19} \) in the literature. Theoretical considerations may favor aortic root remodeling rather than aortic root reimplantation. We have shown previously that the normal anatomy and function of the aortic root is better preserved after aortic root remodeling compared with aortic root reimplantation.\(^{20} \) It was discussed that this could impact on the longevity of the repair, because the normal anatomy of the aortic root promotes normal valvular function, and reduces leaflet stress and strain.\(^{21,22} \) Thubrikar et al\(^{21} \) showed that the aortic leaflets and sinuses form a functional unit that reduces leaflet stress by transferring the stress from the valvular leaflets to the sinuses. However, Grande-Allen et al\(^{23} \) demonstrated in a finite element model that this stress transfer is reversed in valves after any valve-sparing root replacement operation. After aortic root remodeling, these changes, however, were not as pronounced as they were after aortic root reimplantation, and leaflet stress was close to physiological measures. Despite these theoretical advantages of aortic root remodeling, acute severe aortic regurgitation occurred in 3 of our patients in this study, whereas none was observed after aortic root reimplantation.

The mechanism for severe acute aortic valve regurgitation was identical in all patients after aortic root remodeling, including the patient who was primarily operated on elsewhere. We cannot explain the underlying mechanism for the development of the observed regurgitation. Considering the 2 valve-sparing techniques, there are defined differences between the 2 approaches: in the reimplantation technique the aortic valve is reimplanted insight a straight dacron tube. This is very much similar to the implantation of a subcoronary aortic homograft; thus, all of the remnants of the aortic root including the aortic annulus are secured within a dacron tube graft. In comparison, in the remodeling technique a tailored dacron tube with 3 tongue shape extensions for sinus of valsalvae replacement is sutured to the remnants of the aortic valve.

### TABLE 2. Data of Patients Requiring Reoperation After Valve-sparing Aortic Root Replacement for Acute Type A Dissection

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Type of Operation</th>
<th>Marfan’s Syndrome</th>
<th>AI</th>
<th>Endocarditis</th>
<th>Time Between Initial and Reoperation</th>
<th>Reoperation (Technical Data)</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^*)</td>
<td>Remodeling</td>
<td>Yes</td>
<td>Severe</td>
<td>No</td>
<td>24 months</td>
<td>1. Composite graft replacement 2. Total arch replacement 3. RIMA bypass to RCA 4. MVR</td>
<td>Alive</td>
</tr>
<tr>
<td>2</td>
<td>Remodeling</td>
<td>Yes</td>
<td>Severe</td>
<td>No</td>
<td>44 months</td>
<td>1. Composite graft replacement 2. Total arch replacement</td>
<td>Alive</td>
</tr>
<tr>
<td>3</td>
<td>Remodeling</td>
<td>No</td>
<td>Severe</td>
<td>No</td>
<td>17 months</td>
<td>1. Composite graft replacement 2. CABG to RCA</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>Remodeling</td>
<td>No</td>
<td>Severe</td>
<td>No</td>
<td>26 months</td>
<td>1. Composite graft replacement 2. CABG to RCA</td>
<td>Alive</td>
</tr>
<tr>
<td>5</td>
<td>Reimplantation</td>
<td>No</td>
<td>None</td>
<td>Yes</td>
<td>4 months</td>
<td>1. Homograft replacement of the aortic root and ascending aorta 2. Homograft replacement of the aortic arch 3. CABG to LAD, RCX, RCA</td>
<td>Alive</td>
</tr>
</tbody>
</table>

AI indicates aortic valve insufficiency; RIMA, right internal mammary artery; RCA, right coronary artery; MVR, mitral valve replacement; and CABG, coronary artery bypass grafting.

\(^*\)Patient who received initial aortic root remodeling for acute type A dissection elsewhere.
root close to the insertion of the leaflets, thus, leaving the commissural tissue between the neo sinuses and the aortic annulus not stabilized by an external dacron tube. These technical differences may indeed contribute to the high failure rate of the aortic root remodeling technique. Another factor that could possibly cause aortic valve regurgitation is malplacement of the proximal suture line with subsequent injury to the aortic leaflets and commissure attachment. It cannot be clearly answered whether the proximal suture line came too close or even crossed the attachment line at the leaflet hinge level in our patients that required reoperation. However, during reoperation we were not able to detect any suture line crossing of this leaflet hinge attachment line. In fact, Yacoub et al\textsuperscript{19} recommended previously that the suture line to be placed “in the firm aortic anulus along the line of attachment of the cusps.”

In a significant number of patients with acute type A dissection, cystic medial necrosis was found indicating that the entire aortic root is affected by the underlying disease.\textsuperscript{24} Therefore, the weakened tissue between the neo sinuses may be the starting point for additional dilation or resection. Recently, Luciani et al\textsuperscript{25} showed a devastating failure after aortic root remodeling in patients with aortic cystic medial necrosis within the first 2 years. Our findings are in concert with those of Luciani et al\textsuperscript{25} in as much as all patients who underwent reoperation after aortic root remodeling showed histological features of cystic medial necrosis of the aortic wall.

Pre- or postoperative development of annuloaortic dilation is associated with an increased risk of premature failure of the remodeling technique for aortic root replacement.\textsuperscript{24} This might be pronounced in patients with Marfan’s syndrome. These patients frequently present with some degree of annuloaortic dilation at the time of acute type A dissection, which might further increase if no surrounding dacron tube is implanted.\textsuperscript{2,26} However, the aortic annulus was judged to be within normal limits in 1 of these patients and reduced in diameter in the other patient during the initial operation. Furthermore, at the time of reoperation the aortic annulus was found to be within normal ranges in these 2 Marfan patients and in the 2 non-Marfan patients.

Recently, several reports questioned the safety of GRF glue in acute type A aortic dissection.\textsuperscript{27,28} Bingley et al\textsuperscript{27} described so-called “blackened tissue,” which has been explained as tissue degeneration after using GRF glue because of chemical reactions. In addition, we have shown recently that gluing dissected aortic wall tissue carries a high risk of resection, particularly when the proximal part of the aorta is affected.\textsuperscript{28} In the majority of our cases GRF glue was used for aortic root reconstruction before valve-sparing aortic root remodeling or reimplantation. Thus, it cannot be excluded that commissural detachment after aortic root remodeling is the result of deficient structural integrity following gluing of the aortic wall. However, in our patients there were no signs of blackened tissue in the aortic root during reoperation.

Certain limitations of this study have to be acknowledged: the small number of study patients and the fact that patients were not randomized to the surgical technique. However, to our knowledge this is the largest cohort of patients comparing the results of different valve-sparing aortic root replacement techniques for acute type A dissection in the literature.

In summary, based on our findings we conclude that valve-sparing aortic root replacement is safe and efficient in acute type A dissection. However, the preliminary results of our study indicate that aortic root remodeling is associated with a high failure rate within the first 4 years after the initial operation, ultimately requiring reoperation. This is discouraging. In contrast, aortic root reimplantation leads to favorable long-term outcome. For definite conclusions on the meaning of different valve-sparing aortic root replacement techniques in the treatment of acute type A dissection prospective randomized studies are mandatory.

References


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