Survival Comparison of the Ross Procedure and Mechanical Valve Replacement With Optimal Self-Management Anticoagulation Therapy
Propensity-Matched Cohort Study

M. Mostafa Mokhles, MSc; Heinrich Körtke, MD; Ulrich Stierle, MD; Otto Wagner; Efstratios I. Charitos, MD; Ad J.J.C. Bogers, MD, PhD; Jan Gummert, MD; Hans-Hinrich Sievers, MD; Johanna J.M. Takkenberg, MD, PhD

Background—It is suggested that in young adults the Ross procedure results in better late patient survival compared with mechanical prosthesis implantation. We performed a propensity score–matched study that assessed late survival in young adult patients after a Ross procedure versus that after mechanical aortic valve replacement with optimal self-management anticoagulation therapy.

Methods and Results—We selected 918 Ross patients and 406 mechanical valve patients 18 to 60 years of age without dissection, aneurysm, or mitral valve replacement who survived an elective procedure (1994 to 2008). With the use of propensity score matching, late survival was compared between the 2 groups. Two hundred fifty-three patients with a mechanical valve (mean follow-up, 6.3 years) could be propensity matched to a Ross patient (mean follow-up, 5.1 years). Mean age of the matched cohort was 47.3 years in the Ross procedure group and 48.0 years in the mechanical valve group (P=0.17); the ratio of male to female patients was 3.2 in the Ross procedure group and 2.7 in the mechanical valve group (P=0.46). Linearized all-cause mortality rate was 0.53% per patient-year in the Ross procedure group compared with 0.30% per patient-year in the mechanical valve group (matched hazard ratio, 1.86; 95% confidence interval, 0.58 to 5.91; P=0.32). Late survival was comparable to that of the general German population.

Conclusions—In comparable patients, there is no late survival difference in the first postoperative decade between the Ross procedure and mechanical aortic valve implantation with optimal anticoagulation self-management. Survival in these selected young adult patients closely resembles that of the general population, possibly as a result of highly specialized anticoagulation self-management, better timing of surgery, and improved patient selection in recent years. (Circulation. 2011;123:31-38.)

Key Words: aorta • aortic valve • autograft • coagulation • surgery • survival • valves

Survival after aortic valve replacement is reported to be significantly lower compared with the general age-matched population, especially in younger adult patients.1–3 An exception is survival after the Ross procedure, which seems to be comparable to that of the general age-matched population.4 It remains unclear whether this excellent survival is a consequence of the autograft attributes5 (living valve with superior hemodynamics and low valve-related event occurrence rates) or the careful selection of patients for the Ross procedure.6 To obtain an answer to this puzzling question, the method of choice would be a randomized controlled trial. However, few centers are willing to randomize young adult patients among the Ross procedure, a mechanical prosthesis, a stentless bioprosthesis, or a stented bioprosthesis. Most surgeons or young adults have a clear preference for a particular prosthesis in young adult patients, and only a handful of surgeons are experienced with the Ross procedure.

Clinical Perspective on p 38

In the absence of a randomized trial, we performed a propensity score–matched study that assessed late survival in young adult patients after a Ross procedure compared with mechanical aortic valve replacement. Given that optimal postoperative anticoagulation treatment can potentially contribute to a better patient survival, we have included in this study patients with mechanical valves who receive a specialized self-management anticoagulation treatment.
Methods

Source of Study Data
For this study, we used data from the German-Dutch Ross Registry7–10 and the Early Self Controlled Anticoagulation Trial-II (ESCAT II) trial.11,12 The German-Dutch Ross Registry is a prospective multicenter cohort study with 1742 patients. Started in February 1991, the registry includes data from 12 cardiothoracic surgery departments in the Netherlands and Germany7–10 (see the online-only Data Supplement for a list of participating centers). The ESCAT II trial is a prospective randomized multicenter study. A total of 2162 patients were enrolled in the ESCAT II trial between 1994 and 2002. Follow-up of all patients was assessed for the last time in 2006. Patients were randomized between a conventional group (international normalized ratio [INR] target range, 2.5 to 4.5) and a low-dose group (for aortic valve recipients, the INR target range was 1.8 to 2.8). The Bad Oeynhausen concept of INR self-management consists of a postoperative training, a second training ~6 months later, and a 24-hour telemedicine care and consultation. The center provides the patients with an anticoagulation monitor with test strips and lancets. A weekly determination and feedback to the telemedicine center allow sensitive INR adjustment during the long-term anticoagulation therapy. Two large randomized prospective studies have demonstrated that the Bad Oeynhausen concept works well in trained patients with a high percentage of their measured INR values lying within the predetermined therapeutic range, thus resulting in a low rate of complications such as bleeding and thromboembolism.13,14 Six different centers across Germany participated in the ESCAT II study.11,12 In this study, we included only patients from the Bad Oeynhausen center (881 patients) because this was the only center that had collected the detailed patient and perioperative information that we needed for our study. During patient selection for the propensity score analysis, we did not make a distinction between the 2 groups in the ESCAT II trial because there were no differences between the groups that were relevant for this study.14 The authors had full access to and take full responsibility for the integrity of the data and the present article.

Study Population
Patients with isolated aortic valve pathology who were 18 through 60 years of age at the time of operation and were operated on between 1994 and 2008 were included. Patients who underwent an urgent operation (within 24 hours after admission), patients with an aortic dissection or aortic aneurysm, and those with concomitant mitral valve replacement were excluded from this study. Concomitant mitral valve reconstruction and concomitant coronary artery bypass graft were not considered exclusion criteria. The remaining study population consisted of 406 patients in the mechanical valve group and 918 patients in the Ross procedure group. The baseline characteristics of this initial cohort are shown in Table 1.

Study Outcomes
The outcome of interest was late mortality (defined as any death occurring >30 days after surgery). The occurrence of events during follow-up and the cause of death were registered and reported according to the guidelines for reporting mortality and morbidity after cardiac valve interventions.15 Only grade III thromboembolism and grade III bleeding complications were used for the analyses. Briefly, grade III thromboembolism was defined as heart valve prosthesis thrombosis or severe thromboembolism requiring patient treatment or causing long-term impairment (including transient ischemic attacks). Grade III bleeding was defined as severe bleeding requiring transfusion, surgical or endoscopic intervention, or patient care or causing long-term impairment. Each death and its cause were documented during follow-up.11

Propensity Score Construction and Analyses
In our initial cohort, most baseline characteristics were significantly different between the Ross procedure group and the mechanical prosthesis group (Table 1). To achieve a more balanced group, we used propensity score balancing. Propensity score matching offers a way to achieve more balanced groups by matching treatment and control units on the basis of a set of baseline characteristics.16–18 Before matching the 2 treatment groups, we excluded all hospital mortality. The overall early mortality in the German-Dutch registry was 8.8% (7 deaths). The overall early mortality in mechanical prosthesis group was 5.2% (2 deaths). After exclusion of hospital mortality, the cohort consisted of 918 patients in the Ross procedure group and 406 patients in the mechanical prosthesis group (Figure 1). The propensity score for our combined cohort of 1324 patients (with the Ross procedure or mechanical prosthesis) was constructed with the use of a nonparsimonious multivariable logistic regression model. In the model, the choice of operation (Ross procedure or mechanical prosthesis) was used as the dependent variable, and all statistically significant baseline characteristics displayed in Table 1 except left ventricular end-systolic diameter were included as covariates. Left ventricular end-systolic diameter was not included as a covariate in the propensity model because it was highly correlated with left ventricular end-diastolic diameter (Spearman correlation coefficient = 0.815).

The propensity score was entered into a Cox proportional hazards model for late mortality, together with the variable Ross procedure versus mechanical prosthesis. Additionally, the patients were matched according to the method of nearest neighbor matching.19 Patients within the mechanical valve group were assigned a random number. Then, starting with lowest random number, the first patient with a mechanical valve was matched with the patient with the closest propensity score. A propensity score difference of 0.25 was used as a maximum caliper width for matching the 2 treatment groups. If no Ross patients could be found as a match to a patient with a mechanical prosthesis, then this patient with mechanical prosthesis was left unmatched and was not used in subsequent analyses. Ross patients who could be matched to patients with a mechanical prosthesis were no longer considered a possible match for subsequent patients with a mechanical prosthesis. This process was repeated until all possible matches were formed. The baseline characteristics of this final matched cohort are shown in Table 2.

Statistical Analyses
Using survival analysis power calculation (Power and Precision version 2.1), we estimated that ~238 patients in each group were needed to reject the null hypothesis that there is no late survival difference between the groups. The required sample size of 238 patients in each treatment group was based on the use of a 2-tailed value of P=0.05 to indicate statistical significance for late survival with a minimum power of 0.80. We assumed a late mortality rate of 0.45%/y for patients with the Ross procedure20 and of 1.00%/y for patients with a mechanical prosthesis21 with a study duration of 14 years (1994 to 2008) and a constant accrual of patients. Continuous data are presented as means (SD and range), and comparison in the unmatched cohort was done with the unpaired t test unless the data were not normally distributed (Kolmogorov-Smirnov test); in these instances, we used the Mann-Whitney U test for comparison. Categorical data are presented as proportions, and comparison in the unmatched cohort was done with the χ² test or the Fisher exact test when appropriate. All tests were 2 sided with an α level of 0.05. Comparison in the matched cohort was done with the McNemar test and paired sample t test or Wilcoxon signed-rank test when appropriate. A Cox regression model, taking pair into account (by correcting the SEs), has been used to compare survival between the different surgical techniques. The Cox proportional hazards model was also used for univariate and multivariate analyses of late survival. Comparison of patient survival with the general age- and gender-matched population was done with the German population life tables.21 All statistical tests were 2 sided, and tests with a value of P=0.05 were considered significant. Survival comparison of the matched cohort was done with R statistical software (R, version 2.11.1. 2010; R Development Core Team 2006, R Foundation for Statistical Computing, Vienna, Austria). All other statistical analyses were done with SPSS for Windows, version 15 (SPSS Inc, Chicago, IL).

Results
Outcomes in the Unmatched Cohort
In the initial unmatched cohort of 1324 patients, 36 late deaths occurred during a follow-up of 8066 patient-years (0.45% per
Late mortality occurred in 0.49% per patient-year (n=27) in the Ross procedure group compared with 0.32% per patient-year (n=9) in the mechanical prosthesis group (unmatched hazard ratio, 1.33; 95% confidence interval, 0.61 to 2.91; P=0.47; Table 3). Addition of the propensity score to the Cox regression model resulted in a propensity-matched hazard ratio of 3.64 (95% confidence interval, 1.22 to 10.88). Exploration of the propensity score distribution of the 2 treatment groups revealed extreme skewness of the propensity score of Ross patients.

<table>
<thead>
<tr>
<th>Outcomes in the Propensity Score–Matched Cohort</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct matching of patients according to propensity score resulted in a cohort that consisted of 253 patients in the Ross procedure group (mean follow-up time, 5.1 years) and of 253 patients in the mechanical valve group (mean follow-up time, 6.3 years). The baseline characteristics of this final matched cohort are shown in Table 2. Absolute standardized differences for all measured covariates were &lt;10%, suggesting substantial covariate balance across the groups (Figure 2).</td>
</tr>
</tbody>
</table>

Table 1. Baseline Characteristics: Unmatched Cohort

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Cohort</th>
<th>Mechanical AVR</th>
<th>Ross Procedure</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male gender, n (%)</td>
<td>1001 (75.6)</td>
<td>310 (76.4)</td>
<td>691 (75.3)</td>
<td>0.672</td>
</tr>
<tr>
<td>Mean age at surgical intervention, y</td>
<td>44.0±11.3</td>
<td>49.5±10.3</td>
<td>41.6±11.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cause, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rheumatic</td>
<td>60 (4.5)</td>
<td>23 (5.7)</td>
<td>37 (4.0)</td>
<td>0.054</td>
</tr>
<tr>
<td>Missing</td>
<td>58 (4.4)</td>
<td>58 (14.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcified/degenerative</td>
<td>644 (48.6)</td>
<td>311 (76.6)</td>
<td>333 (36.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Missing</td>
<td>55 (4.2)</td>
<td>55 (13.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endocarditis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active endocarditis</td>
<td>32 (2.4)</td>
<td>0 (0)</td>
<td>32 (3.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hemodynamic manifestation, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stenosis</td>
<td>339 (25.6)</td>
<td>129 (31.8)</td>
<td>210 (22.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Regurgitation</td>
<td>401 (30.3)</td>
<td>102 (25.1)</td>
<td>299 (32.6)</td>
<td>0.028</td>
</tr>
<tr>
<td>Mixed</td>
<td>554 (41.8)</td>
<td>155 (38.2)</td>
<td>399 (43.5)</td>
<td>0.270</td>
</tr>
<tr>
<td>Missing</td>
<td>30 (2.3)</td>
<td>20 (4.9)</td>
<td>10 (1.1)</td>
<td></td>
</tr>
<tr>
<td>Preoperative NYHA grade, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I/II</td>
<td>813 (61.4)</td>
<td>202 (49.8)</td>
<td>611 (66.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>III/IV</td>
<td>463 (35.0)</td>
<td>191 (47.0)</td>
<td>272 (29.6)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>48 (3.6)</td>
<td>13 (3.2)</td>
<td>35 (3.8)</td>
<td></td>
</tr>
<tr>
<td>Preoperative creatinine, μmol/L</td>
<td>83.8±60.4</td>
<td>93.6±89.1</td>
<td>76.7±20.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Preoperative rhythm, n (%)</td>
<td></td>
<td></td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Sinus</td>
<td>1268 (95.8)</td>
<td>374 (92.1)</td>
<td>894 (97.4)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>24 (1.8)</td>
<td>15 (3.7)</td>
<td>9 (1.0)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>32 (2.4)</td>
<td>17 (4.2)</td>
<td>15 (1.6)</td>
<td></td>
</tr>
<tr>
<td>Preoperative DM, n (%)</td>
<td>46 (3.5)</td>
<td>20 (4.9)</td>
<td>26 (2.8)</td>
<td>0.055</td>
</tr>
<tr>
<td>Preoperative hypertension, n (%)</td>
<td>406 (30.7)</td>
<td>161 (39.7)</td>
<td>245 (26.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Preoperative lung disease, n (%)</td>
<td>29 (2.2)</td>
<td>7 (1.7)</td>
<td>22 (2.4)</td>
<td>0.441</td>
</tr>
<tr>
<td>Preoperative LVEF, %</td>
<td>64.0±12.3</td>
<td>65.3±13.8</td>
<td>63.2±11.2</td>
<td>0.013</td>
</tr>
<tr>
<td>Preoperative LVH, n (%)</td>
<td>156 (11.8)</td>
<td>24 (5.9)</td>
<td>132 (14.4)</td>
<td></td>
</tr>
<tr>
<td>Preoperative LVESD, mm</td>
<td>55.9±10.6</td>
<td>57.2±10.7</td>
<td>55.2±10.4</td>
<td>0.009</td>
</tr>
<tr>
<td>Preoperative CABG, n (%)</td>
<td>183 (13.8)</td>
<td>145 (35.7)</td>
<td>38 (4.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Concomitant MV reconstruction, n (%)</td>
<td>16 (1.2)</td>
<td>0 (0.0)</td>
<td>16 (1.7)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

AVR indicates aortic valve replacement; NYHA, New York Heart Association; DM, diabetes mellitus; LVEF, left ventricular ejection fraction; LVH, left ventricular hypertrophy; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; CABG, coronary artery bypass grafting; and MV, mitral valve.
In the cohort of 253 matched pairs, during 2899 patient-years of follow-up, 12 participants (2.4%) died (Table 3). Valve-related mortality was observed only in patients who underwent a Ross procedure. The 4 valve-related deaths were 2 sudden, unexplained, unexpected deaths without further clinical data or autopsy, 1 death resulting from a coronary embolus and subsequent myocardial infarction, and 1 death resulting from stroke.

During follow-up, 8 Ross patients in the matched cohort required an aortic valve replacement. None of the patients with a mechanical valve required reoperation in the matched cohort. Linearized all-cause reoperation rate was 0.61% per patient-year in the Ross procedure group compared with 0.00% per patient-year in the mechanical valve group (P < 0.01). Two bleeding events were observed in the matched cohort of Ross patients, and 6 bleeding events were observed in the matched cohort of the patients with a mechanical valve. The linearized bleeding rate was 0.15% per patient-year in the Ross procedure group compared with 0.36% per patient-year in the mechanical valve group (P = 0.15). During follow-up, 5 Ross patients and 1 patient with a mechanical valve experienced a thromboembolic event. The linearized thromboembolism rate was 0.38% per patient-year in the Ross procedure group compared with 0.06% per patient-year in the mechanical valve group (P = 0.10). Endocarditis was diagnosed in 2 patients who underwent a Ross procedure and in none of the patients who underwent a mechanical aortic valve replacement. The linearized endocarditis rate was 0.15% per patient-year in the Ross procedure group compared with 0.00% per patient-year in the mechanical valve group (P = 0.16).

All-cause mortality occurred in 0.54% per patient-year (n = 7) in the Ross procedure group compared with 0.31% per patient-year (n = 5) in the mechanical prosthesis group (matched hazard ratio, 1.86; 95% confidence interval, 0.58 to 5.91; P = 0.32; Table 3). Cumulative survival is displayed in Figure 3. Age- and gender-matched late survival for young adult patients after aortic valve replacement was comparable to that of the general German population (96% versus 95% at 8 years).

**Discussion**

Our study results suggest that survival of mechanical valve patients with highly specialized anticoagulation self-management is comparable to that of Ross patients. It also illustrates the vast differences in patient characteristics between the 2 patient groups. Finally, the present study shows that late survival after both the Ross procedure and mechanical prosthesis implantation is excellent and comparable to that of the general population.

The choice for particular valve prosthesis for aortic valve replacement in young adults has an important impact on the lives of these patients. Both the Ross procedure and mechanical prosthesis implantation have important advantages and disadvantages. Because of the increased thrombogenicity of mechanical prostheses, the choice for this valve substitute implies lifelong anticoagulation and is associated with an increased risk for thromboembolic and bleeding events. The use of anticoagulation may also complicate pregnancy because of the fetal and maternal complications of taking warfarin and may require lifestyle adjustments in this relatively young and active patient group. The clinical association between microemboli, generated by mechanical valves, and neurocognitive dysfunction is still a source of controversy. Furthermore, compared with autograft valves, the hemodynamic performance of mechanical valves is less favorable and mechanical valve noise can negatively affect the patient’s quality of life. The advantage of a mechanical prosthesis is the excellent durability and low reoperative hazard. The choice for a Ross procedure, on the other hand, would mean a limited durability of the aortic valve autograft and pulmonary valve allograft and implies a certain risk of reoperation during the patient’s life.

**Figure 1.** Flowchart of patient selection. AVR indicates aortic valve replacement.
life, depending on the technique used and the follow-up time. The advantages of the Ross procedure are the superior hemodynamic performance, low valve-related event occurrence rates, and no need for lifelong anticoagulation.

Surprisingly, we found not only that there was no survival advantage for the Ross procedure over the use of mechanical prosthesis with optimal anticoagulation self-management but also that there was even a tendency toward a survival advantage in patients who received a mechanical prosthesis. Of course, given the few late deaths in these series, this observation should be interpreted cautiously, and a hazard ratio up to 5.91 cannot be excluded.

Possible explanations for our findings include the highly specialized anticoagulation self-management treatment that patients receive in Bad Oeynhausen and the advances in recent years in the selection and timing of treatment in this young adult patient group. To receive anticoagulation self-management treatment, mechanical valve patients have to be psychically and mentally able to attend the anticoagulation self-management training session and able to control their INR. Theoretically, this may have caused selection bias, although the effect of such bias is expected to be very small in the present study because we have included only patients between the age of 18 and 60 years. It should be stated explicitly that our study results cannot automatically be generalized to all mechanical valve recipients.

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entire ESCAT II cohort (linearized occurrence rate, 2.90 per year). This suggests that the innovative postoperative management of patients in Bad Oeynhausen is extraordinarily effective in terms of complication and survival rates.

Of note, in the mechanical prosthesis group, none of the late deaths were valve related, whereas 4 (2 valve related with acute myocardial infarction and stroke, 2 unknown but attributed to valve related according to the guidelines) of the 7 late deaths in the Ross group were. This observation suggests that the optimized anticoagulation self-management treatment that mechanical prosthesis patients receive in Bad Oeynhausen has resulted in a minimization of thromboembolic and bleeding events and decreased valve-related mortality compared with older reports.

The definition of previous cured endocarditis differed between the mechanical prosthesis cohort and the Ross patient cohort. In the cohort of patients with a mechanical prosthesis, the pathologist classified in explanted valves any sign of inflammation that might indicate previous endocarditis as cured endocarditis (71% of explanted valves). In the cohort of Ross patients, only those who experienced clinically manifest endocarditis were classified as having cured endocarditis (12% of the patients). Because of this significant discrepancy in the definitions of previous cured endocarditis between the cohorts, we decided not to include this variable in the analyses of the present study.

Without the use of an additional statistical strategy to achieve more comparable treatment groups, it was not possible to compare late survival between young adults undergoing a Ross procedure and young adults receiving a mechanical prosthesis. Ross patients, for example, were on average 7 years younger, more often had aortic valve stenosis, and were in better physical condition than patients who received a mechanical prosthesis. Patients who received a mechanical prosthesis more often had diabetes, hypertension, and, besides aortic valve disease, other cardiac conditions requiring concomitant cardiac surgery. All these differences have an important impact on late survival in these patient groups. The fact that only 253 of 406 mechanical valve patients (62%) could be matched to a Ross patient illustrates that there is strict selection of patients for these 2 treatment options. This is also reflected by the distribution differences of propensity score between the 2 groups.

Table 3. Association of Procedure With Late Mortality

<table>
<thead>
<tr>
<th>Events, n/Total Follow-Up, y</th>
<th>Mechanical Valve</th>
<th>Ross Procedure</th>
<th>Hazard Ratio (95% Confidence Interval)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before matching, n</td>
<td>406</td>
<td>918</td>
<td>1.33 (0.61–2.91)</td>
<td>0.47</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>9/2574</td>
<td>27/5492</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve-related mortality</td>
<td>0</td>
<td>13/5492</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non–valve-related cardiac mortality</td>
<td>6/2574</td>
<td>6/5492</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non–valve-related noncardiac mortality</td>
<td>1/2574</td>
<td>7/5492</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>2/2574</td>
<td>1/5492</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After matching, n</td>
<td>253</td>
<td>253</td>
<td>1.86 (0.58–5.91)</td>
<td>0.29</td>
</tr>
<tr>
<td>All-cause mortality</td>
<td>5/1682</td>
<td>7/1310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valve-related mortality</td>
<td>0</td>
<td>4/1310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non–valve-related cardiac mortality</td>
<td>3/1682</td>
<td>1/1310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non–valve-related noncardiac mortality</td>
<td>1/1682</td>
<td>2/1310</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1/1682</td>
<td>0</td>
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</tr>
</tbody>
</table>
It is remarkable that for the duration of the follow-up period, survival after aortic valve replacement was comparable to that of the age-matched German population in both Ross patients and mechanical prosthesis patients. This observation supports the hypothesis that late mortality after aortic valve replacement is driven mainly by patient characteristics and that prosthesis selection plays only a minor role, if any.

This observation implies that in patients who are good candidates for both a Ross procedure and mechanical aortic valve replacement, the choice for a particular treatment strategy should be determined by patient preferences. One patient’s unacceptable risk may be another patient’s acceptable risk; for some, a reoperation in the distant future may be more acceptable than the limitations and risks imposed by anticoagulant treatment, whereas others prefer the opposite.

With the ongoing improvement in the current anticoagulant treatment and the introduction of novel anticoagulant drugs, the rates of bleeding and thromboembolic events may decrease further. As a consequence, in the future, patient preference may more often shift toward a mechanical valve.

Of course, it needs to be taken into account that the results from the present study apply only to the first postoperative decade. The effect on late survival of the increasing reoperative hazard for the Ross procedure in the second postoperative decade still needs to be determined.

Limitations
This study was performed in the setting of elective European patients without aortic dissection, aortic aneurysm, and concomitant mitral valve replacement. It is possible that some baseline differences between the groups were not taken into account (and thus are not included in the propensity score). Because the 2 treatment groups were treated in different centers, the possible existence of “center effect” cannot be ruled out. However, the purpose of this study was to compare these 2 patient populations in the setting of optimal treatment, and we managed to obtain and use data from very dedicated centers. Although the power calculation was based on literature, it might have been too optimistic because we have observed fewer deaths than expected. An additional limitation is that mechanical valves are from a single center, whereas the Ross patients were from several centers. Finally, the generalizability of our study results requires further investigation.

Conclusions
In comparable patients, there appears to be no late survival advantage in the first postoperative decade for the Ross procedure over mechanical aortic valve implantation with highly specialized anticoagulation self-management treatment. In contrast to older reports, relative survival in these selected young adult patients closely resembles that of the general population, possibly a result of highly specialized self-management anticoagulation treatment, better timing of surgery, and improved patient selection in more recent years. Careful prosthetic valve selection remains an important issue to ensure optimal patient-tailored quality of life.

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Disclosures
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References
CLINICAL PERSPECTIVE

Survival in young adult patients after mechanical aortic valve replacement is reported to be significantly reduced compared with the general age- and gender-matched population, whereas survival after the Ross procedure is excellent and comparable to that in the general population. There is ongoing debate about whether the excellent survival rates observed in Ross patients are a consequence of a hemodynamically superior valve and low valve-related complication rates or of patient selection. This is the first study to compare survival in young adult patients after mechanical aortic valve replacement and the Ross procedure using propensity score matching. In comparable patients, there was no late survival advantage in the first postoperative decade for the Ross procedure over mechanical aortic valve implantation with optimal anticoagulation self-management. In contrast to older reports, the relative survival in these selected young adult patients closely resembles that of the general population, possibly a result of better timing of surgery, improved patient selection, and highly specialized self-management anticoagulation treatment in more recent years. In the absence of late mortality differences between comparable patients who received either a mechanical prosthesis or the Ross procedure, the weight of the prosthetic valve selection decision making process shifts toward quality of life and patient preference. Clinicians are therefore encouraged to systematically elicit patient preferences when discussing prosthetic valve selection in this young adult population.

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Survival Comparison of the Ross Procedure and Mechanical Valve Replacement With Optimal Self-Management Anticoagulation Therapy: Propensity-Matched Cohort Study


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SUPPLEMENTAL MATERIAL

Participating Centers Ross Registry

University of Luebeck, Department of Cardiac and Thoracic Vascular Surgery, Luebeck, Germany, Registry Site
Thorsten Hanke, MD
J.F Matthias Bechtel, MD
Armin Gorski, MD

Erasmus University Medical Center, Department of Cardiothoracic Surgery, Rotterdam, The Netherlands
Ad JJC Bogers, MD PhD
Johanna JM Takkenberg, MD PhD

Sana Herzchirurgische Klinik, Stuttgart, Germany
Wolfgang Hemmer
Juergen O. Boehm, MD
Joachim G. Rein, MD

Herzzentrum Bodensee, Konstanz, Germany
Cornelius A. Botha, MD

Robert-Bosch-Hospital, Stuttgart, Germany
Ulrich F. W. Franke, MD
Marc Albert, MD

University Heart Center Hamburg, Hamburg, Germany
Ali Dodge-Khatami, MD

German Heart Center, Munich, Germany
Ruediger Lange, MD
Juergen Hoerer, MD

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Thorsten Wahlers, MD PhD

Friedrich-Schiller-University, Jena, Germany
Martin Breuer, MD
Katharina Ferrari-Kuehne, MD

German Heart Center, Berlin, Germany
Roland Hetzer, MD PhD
Michael Huebler, MD

Eberhard-Karls-University Tuebingen, Germany
Gerhard Ziemer, MD