Very Long-Term Results (More Than 20 Years) of Valve Repair With Carpentier’s Techniques in Nonrheumatic Mitral Valve Insufficiency

E. Braunberger, MD; A. Deloche, MD; A. Berrebi, MD; F. Abdallah, MD; J.A Celestin, MD; P. Meimoun, MD; G. Chatellier, MD; S. Chauvaud, MD; J.N. Fabiani, MD; A. Carpentier, MD

Background—Mitral valve repair is considered the gold standard in surgery of degenerative mitral valve insufficiency (MVI), but the long-term results (>20 years) are unknown.

Methods and Results—We reviewed the first 162 consecutive patients who underwent mitral valve repair between 1970 and 1984 for MVI due to nonrheumatic disease. The cause of MVI was degenerative in 146 patients (90%) and bacterial endocarditis in 16 patients (10%). MVI was isolated or, in 18 cases, associated with tricuspid insufficiency. The mean age of the 162 patients (104 men and 58 women) was 56±10 years (age range 22 to 77 years). New York Heart Association functional class was I, II, III, and IV in 2%, 39%, 52%, and 7% of patients, respectively. The mean cardiothoracic ratio was 0.58±0.07 (0.4 to 0.8), and 72 (45%) patients had atrial fibrillation. Valve analysis showed that the main mechanism of MVI was type II Carpentier’s functional classification in 152 patients. The leaflet prolapse involved the posterior leaflet in 93 patients, the anterior leaflet in 28 patients, and both leaflets in 31 patients. Surgical technique included a Carpentier’s ring annuloplasty in all cases, a valve resection in 126 patients, and shortening or transposition of chordae in 49 patients. During the first postoperative month, there were 3 deaths (1.9%) and 3 reoperations (2 valve replacements and 1 repeat repair [1.9%]). Six patients were lost to follow-up. The remaining 151 patients with mitral valve repair were followed during a median of 17 years (range 1 to 29 years; 2273 patient-years). The 20-year Kaplan-Meier survival rate was 48% (95% CI 40% to 57%), which is similar to the survival rate for a normal population with the same age structure. The 20-year rates were 19.3% (95% CI 11% to 27%) for cardiac death and 26% (95% CI 17% to 35%) for cardiac morbidity/mortality (including death from a cardiac cause, stroke, and reoperation). During the 20 years of follow-up, 7 patients were underwent surgery at 3, 7, 7, 8, 8, 10, or 12 years after the initial operation. Valve replacement was carried out in 5 patients, and repeat repair was carried out in 2 patients. At the end of the study, 65 patients remained alive (median follow-up 19 years). Their median age was 76 years (age range 41 to 95 years). All except 1 were in New York Heart Association functional class I/II.

Conclusions—Mitral valve repair using Carpentier’s technique in patients with nonrheumatic MVI provides excellent long-term results with a mortality rate similar to that of the general population and a very low incidence of reoperation.

Key words: regurgitation ■ valves ■ mitral valve ■ heart diseases ■ surgery ■ rheumatic heart disease

The natural history of severe mitral valve insufficiency (MVI) is now well known. Medically treated patients had a 10-year survival rate between 27% and 60%, which represents excess mortality compared with the expected survival rate. A comparison of prognoses in medically and surgically treated patients shows a trend in favor of surgical treatment, especially early surgery.

Through preservation of the normal valvular tissue and subvalvular apparatus, valve repair is preferable to valve replacement. Compared with prosthetic replacement, mitral valve repair has a lower surgical mortality rate and provides both better survival rates and left ventricular function. Therefore, valve repair is the gold standard for surgical correction of MVI. For MVI in patients with nonrheumatic heart disease, repair is almost always possible.

The midterm survival rates for patients with early surgery are identical to age- and sex-expected survival rates for the general population, but the very long-term results (>20 years) remain unknown.

Methods

Patient Selection
This retrospective study included the first 162 consecutive adult French patients operated on between January 1970 and December 1984 for mitral reconstruction with the use of an annuloplasty ring. Patients with a history of rheumatic fever, with operative aspect of
Preoperative data included age, cardiothoracic ratio, cardiac rhythm, New York Heart Association (NYHA) functional class, and systolic insufficiency treated with tricuspid valve reconstruction were included, and 16 patients (10%) had previous bacterial endocarditis.

**Data Analysis**

Preoperative data included age, cardiothoracic ratio, cardiac rhythm, New York Heart Association (NYHA) functional class, and systolic insufficiency treated with tricuspid valve reconstruction were included, and 16 patients (10%) had previous bacterial endocarditis.

Valve analysis (Table 1) showed a leaflet prolapse in 152 patients (94%) (type II Carpentier’s functional classification). The leaflet prolapse involved the posterior leaflet in 93 patients (61.2%), the anterior leaflet in 28 patients (18.4%), and both leaflets in 31 patients (20.4%). Ten patients had normal leaflet motion (6%) (type I Carpentier’s functional classification).

The surgical procedures have been described previously. In type I mitral valve incompetence, a prosthetic ring remodeling annuloplasty was used alone or associated with closure of leaflet perforation. In type II mitral valve incompetence, leaflet prolapse was treated with leaflet resection in 126 patients (83%) or chordal shortening or transposition in 49 patients (32%), and the annulus dilatation and deformation were treated with prosthetic ring remodeling annuloplasty in 152 patients (100%). Prosthetic ring sizes ranged from 28 to 36 (mean 32.8 ± 2.1).

Of the 162 patients, 3 died within the first month, for a hospital mortality rate of 1.9% (95% CI 0.5% to 5.7%). Three patients were reoperated on for persistent MVI. Two patients required valve replacement, and 1 required repeat repair.

Of the 157 patients with a mitral valve repair who were available for follow-up, 6 (3.8%) were lost to follow-up. Eighty-nine patients (54.9%) died during the 29-year follow-up period (including the 3 early deaths) and 65 patients (41.4%) were alive at the end of the study period, for Kaplan-Meier survival rates of 73.4% (95% CI 66% to 80%) at 10 years and 48% (95% CI 39% to 55%) at 20 years (Figure 1). Median follow-up was 17 years (range 1 to 29 years), corresponding to 2273 patient-years. The rates for freedom from cardiac death were 8% (95% CI 4% to 13%) at 10 years and 19.3% (95% CI 11% to 27%) at 20 years (Figure 1). The cardiac morbidity/mortality rates (including death of cardiac cause, stroke, and reoperation) were 91% (95% CI 86% to 96%) at 10 years and 74% (95% CI 65% to 83%) at 20 years (Figure 2).

**Results**

**Preoperative Data**

There were 104 (64%) men and 58 (36%) women. Mean age ranged from 22 to 77 years (mean age 56 ± 10 years). The patients were of NYHA functional class I (n = 3, or 2%), class II (n = 63, or 39%), class III (n = 85, or 52%), or class IV (n = 11, or 7%). The cardiothoracic ratio ranged from 0.4 to 0.8 (mean 0.58 ± 0.07). Seventy-two patients (45%) had atrial fibrillation.

After a median sternotomy and bivalve and aortic cannulation, the mitral valve was exposed through left atriotomy. Valve analysis (Table 1) showed a leaflet prolapse in 152 patients (94%) (type II Carpentier’s functional classification). The leaflet prolapse involved the posterior leaflet in 93 patients (61.2%), the anterior leaflet in 28 patients (18.4%), and both leaflets in 31 patients (20.4%). Ten patients had normal leaflet motion (6%) (type I Carpentier’s functional classification).

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Table 2 provides a summary of the causes of death and shows that 65 deaths were not related to a cardiac cause and 24 were related to a cardiac cause.

**Reoperation**

Of 153 patients, 10 required reoperation, for a linearized rate of 0.4% patient-year. One patient was reoperated on for aortic

**TABLE 1. Valve Analysis**

<table>
<thead>
<tr>
<th>Valve</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I (normal leaflet motion)</td>
<td>10 (6)</td>
</tr>
<tr>
<td>Type II (leaflet prolapse)</td>
<td>152 (94)</td>
</tr>
<tr>
<td>Posterior leaflet</td>
<td>93</td>
</tr>
<tr>
<td>Anterior leaflet</td>
<td>28</td>
</tr>
<tr>
<td>Both leaflets</td>
<td>31</td>
</tr>
<tr>
<td>Type III (restricted leaflet motion)</td>
<td>0</td>
</tr>
</tbody>
</table>

**TABLE 2. Causes of Death**

<table>
<thead>
<tr>
<th>Cause</th>
<th>No. of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td></td>
</tr>
<tr>
<td>Heart failure</td>
<td>11</td>
</tr>
<tr>
<td>Sudden death</td>
<td>10</td>
</tr>
<tr>
<td>Cerebrovascular accident</td>
<td>2</td>
</tr>
<tr>
<td>Reoperation</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
</tr>
<tr>
<td>Noncardiac</td>
<td></td>
</tr>
<tr>
<td>Malignancy</td>
<td>19</td>
</tr>
<tr>
<td>Neurologic</td>
<td>9</td>
</tr>
<tr>
<td>Motor vehicle accident</td>
<td>5</td>
</tr>
<tr>
<td>Infection</td>
<td>4</td>
</tr>
<tr>
<td>Cirrhosis</td>
<td>3</td>
</tr>
<tr>
<td>Respiratory disease</td>
<td>3</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>2</td>
</tr>
<tr>
<td>Suicide</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
</tr>
<tr>
<td>Overall total</td>
<td>89</td>
</tr>
</tbody>
</table>

**Statistical Analysis**

All values are given as mean and 95% CI. Independent t tests were used to test differences between groups. Survival curves were estimated by the Kaplan-Meier product-limit method and compared by the Mantel (log-rank) test. P<0.05 was considered to be significant.
valve replacement with a continent mitral valve and was not included as a reoperation. Three reoperations were required early (before day 30), and 7 reoperations were required at 3, 7, 7, 8, 8, 10, and 12 years, respectively. One patient died at reoperation (10%). For these 10 patients, there were 7 valve replacements and 3 repeat repairs (30%). Of the 3 repeat repairs, 1 was performed postoperatively on day 3 with good long-term results, and 2 patients who underwent repeat repair at 7 and 12 years were reoperated on at 7 and 1 year, respectively.

For the 10 patients who underwent reoperation for recurrent mitral valve regurgitation, valve analysis at the time of the first operation showed 2 of type I (annulus dilatation, perforation of leaflet) and 8 of type II (leaflet prolapse): 1 posterior leaflet, 3 anterior leaflet, and 4 complex anterior and posterior leaflet combination.

Figure 3 shows the freedom from reoperation according to valve analysis in type II patients.

In type II involving the posterior leaflet alone (n=93), 98.5% of patients at 10 years and 96.9% of patients at 20 years were free from reoperation; in type II involving the anterior leaflet alone (n=28), 86.2% and 86.2% were free from reoperation, respectively; and in type II involving both leaflets, 88.1% and 82.6% were free from reoperation, respectively.

There was a significant difference in the risk for reoperation among the 3 groups (P<0.03, log-rank test).

There was no difference in survival among the 3 groups. The overall survival rates at 10 and 20 years were 81.2% and 46% for type II involving the posterior leaflet alone, 70.8% and 45.8% for type II involving the anterior leaflet alone, and 69.6% and 50.4% for type II involving both leaflets, respectively.

For the 7 patients who underwent late reoperation, 5 had a significant murmur at discharge, indicating that an incomplete repair probably was the cause of reoperation.

At 10 and 20 years, 94% (95% CI 90% to 98%) and 92% (95% CI 87% to 97%) of the patients were free from reoperation. The mitral valve reoperation rate was 0.4% patient-year. Only 1 patient had postoperative bacterial endocarditis and had been treated medically with success, for a linearized rate of 0.04% patient-year.

Six patients had a stroke: 4 patients had a thromboembolic episode (of whom 3 were in atrial fibrillation), for a linearized rate of 0.17% patient-year, and 2 patients had bleeding, for a linearized rate of 0.09% patient-year. Two patients (1 with embolic stroke and 1 with hemorrhagic stroke) died after the stroke.

Recent Doppler echocardiographic studies (within 2 years) available for 26 patients as part of routine follow-up showed that 17 (65%) had no mitral regurgitation, 5 (19%) had mild regurgitation, and 4 (15%) had moderate or important regurgitation.

At the end of the study, 65 patients were alive (median follow-up 19 years). The age of the survivors ranged from 41 to 95 years (median 76 years). All except 1 were in NYHA functional class I/II.

Discussion

Controversy remains as to the predictability of the techniques and the stability of the results in valve reconstruction. Contradictory data have been reported in the literature with opposing conclusions. Some authors have found a striking superiority of mitral valve reconstruction over valve replacement, whereas others have noted little difference between these 2 approaches. This diversity of opinion reflects the variety of the techniques that are used. Several authors have reported results with different and sometimes contradictory techniques, although it is now clear that a narrowing annuloplasty differs from a remodeling annuloplasty and that a chordal plication differs from a chordal shortening repair. Contradictory results can also be explained by heterogeneous patient populations, resulting from a mix of adults and
children or of patients with degenerative valve disease and those with rheumatic valve disease in the same analysis. To avoid these drawbacks, we included only adult patients with degenerative or bacterial endocarditis who were operated on with the same surgical technique.

Particular attention has been placed on not including patients with rheumatic heart disease by selecting French patients older than 20 years who had no history or surgical aspect of rheumatic disease.

The study population represents 1% of all cardiac operations (n=20,000), 2% of all mitral valve operations (n=8000), and 8% of all mitral valve repairs (n=2000) for this time period. The relatively low number of mitral valve repairs for degenerative valve disease is explained by a dominant number of patients with rheumatic valve disease at this time and by the fact that degenerative valvular disease was thought to be a contraindication to valve repair.

A prosthetic ring was judged necessary in all patients who had annulus dilatation or deformation. There were no pediatric cases, so the use of an annuloplasty ring was always possible.

The predictability of the technique is demonstrated by the low incidence (1.9%) of early reoperations that are likely to result from technical errors or intraoperative misjudgment. The current incidence of early reoperations is even lower because intraoperative transesophageal echocardiography is now performed routinely.

Degenerative valvular disease is known to occur in elderly patients, and this accounts for only 48% of operated patients being alive at 20 years. However, the comparison between the life expectancy of the general population of the same age and the patients who were operated on shows that in the first decade, the 2 curves diverge due to the few operative deaths and persistent poor ventricular function, whereas in the following decade, the 2 curves are parallel, demonstrating a comparable evolution (Figure 1).

Conclusions
The low incidence of reoperation and complications in this study confirms the data from our previous reports concerning the predictability and the stability of the results achieved with this method of valve reconstruction. The remarkably durable improvement in functional class is due to both the optimal correction of the valve and the conservation of the subvalvular apparatus. The fact that 74% of patients are free from any cardiac event at 20 years indicates that in degenerative valvular disease, the gold standard operation should be a valve repair with Carpentier’s techniques.

References
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Correction to: Very Long-Term Results (More Than 20 Years) of Valve Repair With Carpentier’s Techniques in Nonrheumatic Mitral Valve Insufficiency

In the article by Braunberger et al, “Very Long-Term Results (More Than 20 Years) of Valve Repair With Carpentier’s Techniques in Nonrheumatic Mitral Valve Insufficiency,” which published in the September 18, 2001, Supplement 1 issue of the journal (Circulation. 2001;104:i8-i11. DOI: 10.1161/hc37t1.094780), a correction to an author’s name is needed. The fourth author’s name should have read: A. Fayssoil, MD.

This correction has been made to the current online version of the article, which is available at http://circ.ahajournals.org/content/104/suppl_1/I-8.