Very Long-Term Survival and Durability of Mitral Valve Repair for Mitral Valve Prolapse

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Background—Mitral regurgitation (MR) due to mitral valve prolapse (MVP) is often treatable by surgical repair. However, the very long-term (>10-year) durability of repair in both anterior leaflet prolapse (AL-MVP) and posterior leaflet prolapse (PL-MVP) is unknown.

Methods and Results—In 917 patients (aged 65±13 years, 68% male), surgical correction of severe isolated MR due to MVP (679 repairs and 238 replacements [MVRs]) was performed between 1980 and 1995. Survival after repair was better than survival after MVR for both PL-MVP (at 15 years, 41±5% versus 31±6%, respectively; P=0.003) and AL-MVP (at 14 years, 42±8% versus 31±5%, respectively; P=0.003). In multivariate analysis adjusting for predictors of survival, repair was independently associated with lower mortality in PL-MVP (adjusted risk ratio [RR] 0.61, 95% CI 0.44 to 0.85; P=0.0034) and in AL-MVP (adjusted RR 0.67, 95% CI 0.47 to 0.96; P=0.028). The reoperation rate was not different after repair or MVR overall (at 19 years, 20±5% for repair versus 23±5% for MVR; P=0.4) or separately in PL-MVP (P=0.3) or AL-MVP (P=0.3). However, the reoperation rate was higher after repair of AL-MVP than after repair of PL-MVP (at 15 years, 28±7% versus 11±3%, respectively; P=0.0006). From the 1980s to the 1990s, the RR of reoperation after repair of AL-MVP versus PL-MVP did not change (RR 2.5 versus 2.7, respectively; P=0.58), but the absolute rate of reoperation decreased similarly in PL-MVP and AL-MVP (at 10 years, from 10±3% to 5±2% and from 24±6% to 10±2%, respectively; P=0.04).

Conclusions—In severe MR due to MVP, mitral valve repair compared with MVR provides improved very long-term survival after surgery for both AL-MVP and PL-MVP. Reoperation is similarly required after repair or replacement but is more frequent after repair of AL-MVP. Recent improvement in long-term durability of repair suggests that it should be the preferred mode of surgical correction of MVP whether it affects anterior or posterior leaflets and is an additional incentive for early surgery of severe MR due to MVP. (Circulation. 2001;104[suppl I]:I-1-I-7.)

Key Words: follow up studies ▪ mitral valve ▪ regurgitation ▪ surgery

Mitral valve prolapse (MVP) is frequent, and is the most common cause of surgical severe mitral regurgitation (MR) in the United States. In view of the poor outcome of patients with MVP and severe MR with or without flail leaflet, early surgery (ie, surgery performed before the occurrence of severe symptoms or left ventricular dysfunction) is often considered. MVP is also the most reparable of the lesions causing MR. Previous studies have suggested that mitral valve repair should be the preferred procedure for surgical correction of MR because compared with valve replacement, it provides an improved outcome. Therefore, there is a general trend to consider patients with MVP and severe MR as the best surgical candidates for early surgery.

However, many questions regarding the very long-term outcome of surgery that are crucial to patients with MVP remain unresolved. Most previous studies comparing mitral valve repair and mitral valve replacement (MVR) did not focus on MVP. In the comparative studies including mostly MVP, posterior leaflet prolapse (PL-MVP) was the predominant lesion, and the reported superiority of repair essentially reflects the results in treating this lesion. It is unclear whether the superiority of results after repair apply equally to anterior leaflet prolapse (AL-MVP), in which repair appears more challenging. More important, even in large series, information beyond 10 years of follow-up is absent or minimal. Because reoperation is mostly motivated by the development of new degenerative lesions, the very long-term outcome of repair, in particular, the need for reoperation, is questionable. Deterioration beyond 10 years of follow-up may negate the initial survival benefit of valve repair and would be a major limitation to the concept of early surgery. Therefore, it is essential to analyze at 10 years and beyond the very long-term durability of repair of both AL-MVP and PL-MVP. In addition, new surgical techniques...
of repair have been developed recently to treat all types of lesions, but whether these surgical improvements can be extrapolated into improved long-term outcome after repair is unclear.

Accordingly, we examined the very long-term outcome after surgical correction of MR due to MVP and analyzed (1) the persistence of an independent survival advantage associated with mitral valve repair beyond the first decade after surgery separately in patients with PL-MVP and AL-MVP, (2) the very-long-term durability of repair compared with replacement in terms of reoperation in PL-MVP and AL-MVP, and (3) the potential recent improvement in surgical results.

Methods

Eligibility Criteria

The present study was based on our consecutive experience with valve repair and replacement for the surgical correction of MR due to MVP.

Inclusion criteria were (1) pure isolated MR that was due to (2) MVP as defined by surgical observation, with (3) mitral valve repair or MVR performed between January 1, 1980, and December 31, 1995; MVP was defined as failure of leaflet coaptation due to partial or complete systolic displacement of mitral leaflets beyond the mitral annulus in the left atrium. Preoperative echocardiography (within 6 months before surgery) was obtained in 83% of patients and confirmed MVP in all patients.

Exclusion criteria were as follows: mitral stenosis, aortic valve disease and/or aortic valve repair or replacement before or simultaneous to mitral surgery, previous mitral repair or replacement, congenital or pericardial heart disease, tricuspid valve replacement (but not tricuspid repair), and MR due to ischemic heart disease with or without ruptured papillary muscle. Associated incidental coronary artery disease (CAD) was not an exclusion criterion.

Surgical Procedure

Surgical repair of the mitral valve involved subvalvular (chordal shortening or artificial chord insertion), valvular (mostly resection or plication), and annular (mostly ring insertion) interventions as previously described. The decision to perform repair was based on the surgeon's examination of the lesions. Extensive calcifications or thickening or ruptured chords were frequent reasons for not considering the valve repairable, but no specific decision model was enforced. Intraoperative assessment of MR was based on double-sampling dye curves and/or transesophageal echocardiography, which was performed in 550 patients.

Statistical Methods

Group statistics were expressed as mean ±1 SD. Group comparisons were performed with standard t test or χ2 test as appropriate. The end points of the study, the rate of reoperation, and the cumulative probability of survival were estimated by the Kaplan-Meier method and compared between groups by using the 2-tailed log-rank test. Comparison with expected survival used US Census Bureau data and was based on the 1-sided log-rank test. Reoperations were determined on an intention-to-treat basis irrespective of the reason for reoperation. Patients were grouped according to the leaflet involved, ie, MVP with exclusive PL-MVP or with AL-MVP, on the basis of previous outcome data. Comparison of outcome was stratified according to (1) performance of mitral valve repair or MVR, (2) the MVP type, (3) the period of surgery (defined as the 1980s [1980 to 1989] and the 1990s [1990 to 1995]), and (4) the presence of residual MR after repair. Multivariate analysis of survival and reoperation were performed by using the Cox proportional hazards method, and the initial candidate independent variables were age, sex, New York Heart Association (NYHA) functional class, atrial fibrillation (AF), preoperative ejection fraction (EF), and associated CAD. Then, the variables of interest were the type of surgery performed, the MVP type, and the period of surgery (1980s versus 1990s), which were added to the models. A value of P§0.05 was considered significant.

Results

During the study period, 917 patients had mitral valve surgery for severe MR due to MVP. Follow-up was 7.7±4.1 (up to 19.5) years and was 97% complete up to death or 1999. The surgical procedure performed was mitral valve repair in 679 patients (74%) and MVR in 238 patients (26%); MVR was accomplished by mechanical prosthesis in 124 patients (52%) and a bioprosthesis in 114 patients (48%). In 516 patients (56%), the MVP was limited to the posterior leaflet, and in 401 patients (44%), it involved the anterior leaflet. Ruptured chordae were noted in 72% of the patients. Overt CAD was noted in 28% of the patients, and 27% had a coronary bypass procedure performed simultaneously with the mitral surgery. The overall baseline characteristics (Table 1) demonstrate the frequent severe symptoms, with AF and left ventricular dilatation attesting to the severity of MR.

Baseline Characteristics

Patients with AL-MVP and PL-MVP showed significant differences in the prevalence of hypertension, angina, and AF, in the EF level and repair rate, and in the duration of the bypass (Table 1). Within each lesion group (AL-MVP and PL-MVP), baseline characteristics differences between mitral valve repair and MVR are shown in Table 2. Among patients with AL-MVP, those who had replacement were more severely symptomatic (NYHA class III to IV) and had more AF and less hypertension. Bypass duration was longer after MVR than after repair. Similarly, patients with PL-MVP who underwent MVR were more symptomatic, and bypass duration was longer than in those who underwent repair.

Long-Term Survival

Overall survival rates after valve repair were 86±1%, 68±2%, and 37±5% at 5, 10, and 15 years, respectively, which were slightly but significantly lower than the expected survival rates of 86%, 70%, and 54% (P=0.03). However, survival rates after repair were better than those observed after MVR (71±3%, 49±3%, and 29±4%, respectively) (P<0.0001). At the latest follow-up (ie, 19.5 years after surgery), survival was 30±7% for repair and 22±4% for MVR. After adjustment for age, sex, presence of AF, presence of CAD, EF, NYHA class, and creatinine level, mitral repair was associated with better survival (adjusted risk ratio [RR] 0.68, 95% CI 0.54 to 0.87; P=0.002).

Survival of patients with AL-MVP was higher after repair than after MVR (P=0.003), with respective 5-, 10-, and 14-year survival rates of 87±2%, 63±5%, and 42±8% (repair) and 74±4%, 49±4%, and 31±5% (MVR) (Figure 1, left). In multivariate analysis, independent determinants of survival were age, CAD, EF (all P<0.01), and after adjustment for these variables, mitral repair was independently predictive of improved survival (RR 0.67, 95% CI 0.47 to 0.96; P=0.028).

In patients with PL-MVP, survival rates were higher after repair than after MVR: 85±2%, 70±3%, and 41±5% for repair versus 65±5%, 49±5%, and 31±6% for MVR at 5,
and 15 years was 7\% 11\%, 16\% 3\%, respectively, after MVR.

In patients who underwent surgery during the 1980s, reoperation rates were not different after repair (8\% 6\% and 13\% 1\% respectively) were lower than after repair (6\% 2\% and 10\% 0\% lower for PL-MVP (5\% 3\% at 5 and 10 years, respectively) than for AL-MVP (15\% 6\% 6\% 6\% at 5 and 10 years, respectively) did not reach statistical significance (P=0.3) (Figure 3, right). However, among patients who underwent repair, the reoperation rate was higher in AL-MVP than in PL-MVP (RR 2.5, 95% CI 1.48 to 4.27; P=0.0006).

**Temporal Changes in Outcome of Surgery for MR due to MVP**

In patients who underwent surgery during the 1980s, reoperation rates were not different after repair (8\% 2\% and 14\% 3\% at 5 and 10 years, respectively) and after MVR (6\% 5\% and 13\% 3\% at 5 and 10 years, respectively) (P=0.7). In contrast, in patients who underwent surgery in the 1990s, the reoperation rates at 5 years and close to 10 (9.96) years after repair (6\% 1\% and 7\% 1\%, respectively) were lower than those after MVR (13\% 6\% and 19\% 8\%, respectively) (P=0.02).

After repair performed in the 1980s, reoperation rates were lower for PL-MVP (5\% 2\% and 10\% 3\% at 5 and 10 years, respectively) than for AL-MVP (15\% 5\% and 24\% 6\% at 5 and 10 years, respectively), with RR 2.5 and 95% CI 1.2 to 5.7 (P=0.003) (Figure 4).

After repair performed in the 1990s, reoperation rates at 5 years and close to 10 (9.94) years were lower for PL-MVP

**Long-Term Reoperation Rates**

Reoperation was performed in 86 patients during follow-up, in 58 after repair, and in 28 after MVR. The decision of reoperation was clinical and used information from postoperative transthoracic echocardiography, performed at our institution in 815 patients (89\%) at 3 years after surgery.

In the overall population, the need for reoperation at 5, 10, and 15 years was 7\% 11\%, 16\% 3\%, respectively, after repair and 6\% 2\%, 15\% 4\%, and 24\% 5\%, respectively, after MVR (P=0.3) (Figure 3, left). In patients with PL-MVP, the difference in reoperation rates at 5, 10 and 15 years between mitral repair (4\% 1\%, 8\% 2\%, and 11\% 3\%, respectively) and MVR (9\% 4\% 14\% 5\%, and 21\% 8\%, respectively) did not reach statistical significance (P=0.3) (Figure 3, right). However, among patients who underwent repair, the reoperation rate was higher in AL-MVP than in PL-MVP (RR 2.5, 95% CI 1.48 to 4.27; P=0.0006).

**TABLE 1. Baseline Characteristics of 917 Patients Who Underwent Surgery for Severe MR due to MVP Overall and Comparison Between PL-MVP and AL-MVP**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall</th>
<th>PL-MVP</th>
<th>AL-MVP</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>917</td>
<td>516</td>
<td>401</td>
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</tr>
<tr>
<td>Preoperative characteristics</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>65±13</td>
<td>66±12</td>
<td>63±14</td>
<td>0.1</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>68</td>
<td>70</td>
<td>66</td>
<td>0.2</td>
</tr>
<tr>
<td>NYHA class III–IV, %</td>
<td>51</td>
<td>49</td>
<td>53</td>
<td>0.2</td>
</tr>
<tr>
<td>Angina class III–IV, %</td>
<td>9</td>
<td>8</td>
<td>11</td>
<td>0.06</td>
</tr>
<tr>
<td>Overt CAD, %</td>
<td>28</td>
<td>28</td>
<td>28</td>
<td>0.9</td>
</tr>
<tr>
<td>AF at presentation, %</td>
<td>42</td>
<td>37</td>
<td>48</td>
<td>0.001</td>
</tr>
<tr>
<td>Creatinine, mg/dL</td>
<td>1.2±0.6</td>
<td>1.3±0.7</td>
<td>1.2±0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>31</td>
<td>34</td>
<td>27</td>
<td>0.05</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>5</td>
<td>6</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>LV and LA characteristics</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>LVD, mm</td>
<td>62±9</td>
<td>62±8</td>
<td>61±17</td>
<td>0.4</td>
</tr>
<tr>
<td>LVS, mm</td>
<td>38±8</td>
<td>37±8</td>
<td>38±9</td>
<td>0.3</td>
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<td>LA, mm</td>
<td>55±10</td>
<td>55±10</td>
<td>55±10</td>
<td>0.6</td>
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<tr>
<td>EF, %</td>
<td>62±10</td>
<td>63±10</td>
<td>61±10</td>
<td>0.02</td>
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<td>Operative and postoperative characteristics</td>
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<tr>
<td>Bypass duration, min</td>
<td>89±44</td>
<td>86±42</td>
<td>93±46</td>
<td>0.04</td>
</tr>
<tr>
<td>CABG, %</td>
<td>27</td>
<td>27</td>
<td>27</td>
<td>0.8</td>
</tr>
<tr>
<td>IMA, %</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>0.9</td>
</tr>
<tr>
<td>Repair, %</td>
<td>74</td>
<td>83</td>
<td>63</td>
<td>0.001</td>
</tr>
</tbody>
</table>

LV indicates left ventricle; LA, left atrium; LVD, LV dimension in diastole; LVS, LV dimension in systole; and IMA, internal mammary artery bypass. Values are mean±1 SD or as indicated.
TABLE 2. Comparison of Baseline Characteristics Between Patients Who Had Mitral Repair and MVR in AL-MVP and PL-MVP Subgroups

<table>
<thead>
<tr>
<th></th>
<th>AL-MVP Repair</th>
<th>AL-MVP MVR</th>
<th>P</th>
<th>PL-MVP Repair</th>
<th>PL-MVP MVR</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>251</td>
<td>150</td>
<td></td>
<td>428</td>
<td>88</td>
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<tr>
<td>Preoperative</td>
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<tr>
<td>Age, y</td>
<td>63±14</td>
<td>65±13</td>
<td>0.2</td>
<td>65±12</td>
<td>67±11</td>
<td>0.2</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>69</td>
<td>61</td>
<td>0.1</td>
<td>69</td>
<td>72</td>
<td>0.7</td>
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<tr>
<td>NYHA class III–IV, %</td>
<td>42</td>
<td>71</td>
<td>0.001</td>
<td>46</td>
<td>67</td>
<td>0.001</td>
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<tr>
<td>Angina class III–IV, %</td>
<td>10</td>
<td>13</td>
<td>0.3</td>
<td>7</td>
<td>13</td>
<td>0.1</td>
</tr>
<tr>
<td>Overt CAD, %</td>
<td>29</td>
<td>26</td>
<td>0.5</td>
<td>27</td>
<td>33</td>
<td>0.2</td>
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<tr>
<td>AF at presentation, %</td>
<td>43</td>
<td>57</td>
<td>0.004</td>
<td>36</td>
<td>43</td>
<td>0.2</td>
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<td>Creatinine, mg/dL</td>
<td>1.16±0.26</td>
<td>1.22±0.31</td>
<td>0.03</td>
<td>1.25±0.75</td>
<td>1.29±0.35</td>
<td>0.63</td>
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<td>Hypertension, %</td>
<td>31</td>
<td>21</td>
<td>0.03</td>
<td>3</td>
<td>27</td>
<td>0.2</td>
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<tr>
<td>Diabetes, %</td>
<td>4</td>
<td>7</td>
<td>0.2</td>
<td>6</td>
<td>6</td>
<td>0.9</td>
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<td>LV and LA</td>
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<td>characteristics</td>
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<tr>
<td>LVD, mm</td>
<td>61±9</td>
<td>62±9</td>
<td>0.5</td>
<td>62±9</td>
<td>63±8</td>
<td>0.2</td>
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<tr>
<td>LVS, mm</td>
<td>38±8</td>
<td>39±10</td>
<td>0.8</td>
<td>37±8</td>
<td>38±8</td>
<td>0.9</td>
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<tr>
<td>LA, mm</td>
<td>54±9</td>
<td>56±11</td>
<td>0.1</td>
<td>55±10</td>
<td>54±10</td>
<td>0.9</td>
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<td>EF, %</td>
<td>62±9</td>
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<td>63±9</td>
<td>63±11</td>
<td>0.5</td>
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<tr>
<td>Bypass duration, min</td>
<td>88±47</td>
<td>100±43</td>
<td>0.001</td>
<td>82±41</td>
<td>108±41</td>
<td>&lt;0.001</td>
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<tr>
<td>CABG, %</td>
<td>30</td>
<td>23</td>
<td>0.2</td>
<td>26</td>
<td>31</td>
<td>0.4</td>
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<tr>
<td>IMA, %</td>
<td>19</td>
<td>8</td>
<td>0.003</td>
<td>17</td>
<td>6</td>
<td>0.009</td>
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</table>

Values are mean±1 SD or as indicated. Abbreviations as in Table 1.

(4±1% and 5±2%, respectively) than for AL-MVP (9±2% and 10±2%, respectively), with RR 2.7 and 95% CI 1.3 to 5.6 (P=0.01) (Figure 4).

After adjustment for MVP type, repair in the 1990s (versus the 1980s) was independently associated with lower absolute reoperation rate, with RR 0.56 and 95% CI 0.31 to 0.99 (P=0.04) (Figure 4).

Effect of Residual MR at End of Surgery
Intraoperative residual MR presence after repair could be determined in 669 (98.5%) of 679 patients, and 122 had MR judged to be mild or mild to moderate (none was severe).

Reoperation rates were higher after repair with residual MR (14±3%, 8±4%, and 21±5% at 5, 10, and 15 years, respectively) than without residual MR (5±1%, 9±2%, and 14±4%, respectively) (P=0.002), as shown in Figure 5.

In AL-MVP, reoperation rates with residual MR (21±6% and 35±10% at 5 and 10 years, respectively) were higher than without residual MR (8±2% and 14±4% at 5 and 10 years, respectively) (P=0.005).

Similarly, in PL-MVP, reoperation rates with residual MR (10±4% at 5 and 10 years, respectively) were higher than without residual MR (2±1% and 6±2% at 5 and 10 years, respectively) (P=0.01).

Figure 1. Long-term survival after surgical correction of MR due to MVP (repair, dashed lines; replacement [MVR], solid lines) in patients with AL-MVP (left) and PL-MVP (right). Numbers at bottom of each graph indicate number of patients at risk for the interval. Survival estimates (mean±SE) are indicated at 5 and 10 years.

Figure 2. Long-term reoperation rate after mitral valve repair (dashed line) and replacement (MVR, solid line). Reoperation rate estimates (mean±SE) are indicated at 5, 10, and 15 years.
After adjustment for MVP type and surgery period, residual MR was independently associated with a higher risk of later reoperation (adjusted RR 2.2, 95% CI 1.2 to 3.8; \(P = 0.009\)).

Discussion

The present study, to our knowledge, represents the first large series of patients with MVP who underwent surgery for isolated MR and in whom the very long-term follow-up beyond 10 years can be analyzed. This series shows that mitral valve repair for MR due to MVP is associated with excellent long-term survival, which remains superior to MVR beyond 10 years and up to 20 years after surgery. This long-term survival advantage is separately noted in patients with PL-MVP and with AL-MVP, independent of all other predictors of mortality.

After a very long time, there is no excess risk of reoperation after valve repair compared with after MVR. However, after valve repair, the reoperation rate was and remains higher for AL-MVP than for PL-MVP but has markedly decreased in the most recent period compared with the 1980s. Therefore, very long-term follow-up shows that mitral valve repair for severe MR due to MVP provides superior survival and excellent and improving durability in all types of MVP.

Very Long-Term Survival Advantage of Mitral Valve Repair

Mitral valve repair for correction of severe MR is often considered the procedure of choice for patients with MR due to MVP. Previous studies comparing outcomes after mitral repair and replacement have suggested that repair provides lower operative, short, and mid-term mortality. However, conclusions of these direct comparisons were obscured by differences in baseline characteristics also observed in the present study. We have shown previously, by use of multivariate analysis, that after adjustment for baseline differences, valve repair, compared with replacement, was independently associated with improved ventricular function and survival. On this basis, valve repair was considered the preferred procedure for surgical correction of MR. However, this general conclusion may not be applicable for MVP involving the anterior leaflet, because MVP limited to the posterior leaflet was the predominant lesion in most studies and is the only lesion with a relatively low rate of reoperation. Importantly, no comparison between repair and MVR could examine follow-up beyond 10 years, when the full survival impact of reoperation may appear. Hence, it remains unclear whether the survival advantage of repair is applicable to patients with MVP involving the anterior leaflet and persists beyond 10 years and in all types of MVP.

In the present study, with follow-up extending up to almost 20 years, after adjustment for all predictors of survival, mitral valve repair is independently associated with survival advantage after surgery. This survival benefit of valve repair specifically applies to severe MR due to MVP, is present whether the posterior or anterior leaflets are involved in the MVP, and is of comparable magnitude (mortality risk ratios versus MVR) in all types of MVP. Hence, notwithstanding the mortality risk of reoperation, in view of the superior survival that it provides, mitral repair should be the preferred mode of correction of severe MR due to all types of MVP, whether the anterior or posterior leaflet is involved. However, in the growing consideration for early surgery, the very long-term durability and reoperation rate of repair for all types of MVP remain major issues and potential limitations.

Very Long-Term Durability of Mitral Valve Repair for MVP

The perennial concern with mitral valve repair is its long-term durability, which can be assessed by the need for reoperation. The feasibility of repair depends mainly on the cause of MR. MVP is generally considered the most repair-
able lesion, in particular, when the posterior leaflet is prolapsed. Conversely, with anything but simple posterior leaflet MVP (ie, when the anterior leaflet is involved), reoperation rates in major centers were reported at \( \approx 20\% \) at 10 years. These reoperation rates after anterior leaflet repair do not preclude repair in patients symptomatic or with left ventricular dysfunction in view of its survival advantage but would be a major hindrance to early surgery in such patients. Because patients who undergo surgery early (ie, when they are asymptomatic) enjoy postoperative survival identical to that of the general population, there has been wide acceptance of such indications in patients with repairable leaflets, if long-term durability is acceptable. Therefore, determining long-term durability of repair in series with very long follow-up is of critical importance in the present management of patients with severe MR.

In the present study, no significant differences in reoperation rates after repair and after MVR were noted for anterior or posterior prolapse. Therefore, the type of MVP cannot be used as a reason to preferentially perform MVR, which has no advantage either in term of survival or of durability. Nevertheless, patients with AL-MVP had a higher rate of reoperation than did those with posterior prolapse, with an RR \( \approx 2.5 \). Such continued lower durability of repair in AL-MVP than in PL-MVP underscores the technical challenges of AL-MVP repair, which requires advanced experience and technical skills. However, an important finding of the present study is that the absolute need for reoperation has significantly decreased in the 1990s, compared with the 1980s, for both AL-MVP and PL-MVP, with an RR of 0.56. Remarkably, the current rate of reoperation after repair of AL-MVP is 10\% at almost 10 years after surgery, a rate similar to that observed after repair for PL-MVP in the 1980s. Even in patients with PL-MVP, the rate of reoperation has declined considerably to a very low level.

Development of new surgical methods (particularly, AL-MVP repair, including chordal transposition and chordal replacement rather than chordal shortening) has probably contributed to the improvement of long-term results. Intraoperative transesophageal echocardiography allows control of the quality of repair before chest closure and may have contributed to the improvement of surgical results. Irrespective of these mechanistic issues, the improved durability of repair is an additional incentive to perform early repair in patients with either AL-MVP or PL-MVP.

Clinical Implications

The present study, which is the first large report of very long-term outcome of repair of severe MR due to MVP, has demonstrated that compared with MVR, mitral valve repair for MVP provides for a very long time a superior survival without an excess reoperation rate for both AL-MVP and PL-MVP. Therefore, valve repair should be favored over valve replacement for all types of severe MR due to MVP, including those involving AL-MVP.

For early surgical indications, in the absence of symptoms or left ventricular dysfunction, the very long-term durability of repair is essential. Although excellent very long-term durability of repair in PL-MVP clearly allows early surgery, a more careful approach is required with AL-MVP. In that subset, state-of-the-art repair recently resulted in markedly improved long-term outcome, which is an additional incentive for the consideration of early surgery for both AL-MVP and PL-MVP. However, because compared with PL-MVP, AL-MVP continues to be associated with a higher risk of reoperation, a careful individualized assessment of such patients is necessary before offering early repair.

In the present study, residual MR was associated with higher risk of reoperation independent of the type of MVP repaired. Although it is not possible to ascertain in patients with residual MR whether the correction performed was the best possible in view of the lesions or whether such a modest degree of regurgitation was considered acceptable, the present results suggest that such cases should be reviewed critically, particularly under conditions as physiological as possible, to assess the need for a second pump run.

Potential Limitations of the Study

The present data were analyzed on an intention-to-treat basis. Therefore, we did not exclude biological or mechanical prostheses, which have specific complications. However, compared with mechanical prostheses, repair provided an improved survival (adjusted RR 0.70, \( P=0.037 \)) and a similar reoperation rate (\( P=0.29 \)) and, compared with bioprostheses, provided improved survival (adjusted RR 0.60, \( P=0.0003 \)) and a lower reoperation rate (\( P=0.008 \)). Similarly, we did not exclude reoperations based on the alleged reason for reoperation (ie, mitral dysfunction or not) because of the possible bias of such an approach. Most reoperations (71 [83\%] of 86) reportedly were due to mitral dysfunction. Restricting reoperation to these indications would lead to 10-year rates of 9\% after repair and 13\% after MVR (\( P=0.40 \)). Therefore, the intention-to-treat approach does not notably affect our results.

Grouping patients according to the type of MVP can be performed by using various classifications. For example, patients may be classified as having or not having ruptured chordae, but no differences in survival or reoperations were observed between these groups (all \( P>0.29 \)). Also, patients with AL-MVP may be subdivided into patients with bileaflet prolapse and patients with purely anterior MVP. However, these 2 groups at 15 years have similar survival rates (34\% versus 24\% \( P=0.22 \)) and identical reoperation rates (27\% and 28\%, \( P=0.5 \)). Furthermore, because previous reports have emphasized mediocre results of repairs when they were not limited to isolated MVP of the posterior leaflet, the impact MVP type analyzed in this format is essential.

Improvement in long-term outcome may be the result of better selection for repair or of better quality of repair. The increase in the 1990s versus the 1980s of repair performance for both AL-MVP (85\% versus 35\%, \( P<0.0001 \)) and PL-MVP (97\% versus 66\%, \( P<0.0001 \)) suggests that the improved durability is not the result of more stringent selection. We did not analyze the role of specific repair procedures (such as artificial chord insertion) in the improvement of long-term outcome. This determination would require appropriately sized clinical trials. Conversely, we examined the long-
term results of state-of-the-art repair performed in routine practice, allowing conclusions to be drawn about improvements observed in this setting that are applicable to patients evaluated by practicing cardiologists and surgeons.

Conclusions of the Study
Mitral valve repair for severe MR due to MVP provides better survival and similar durability than does MVR for all types of MVP. Higher reoperation rates are observed in patients with AL-MVP and in patients in whom a residual MR, even mild, is noted during surgery. However, there has recently been a marked improvement in long-term durability of repair for all types of MVP, which suggests that repair of MR due to MVP should be the favored approach for all types of MVP and allows consideration of early surgery, even in patients with AL-MVP.

References
Very Long-Term Survival and Durability of Mitral Valve Repair for Mitral Valve Prolapse
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