Observations on the Timing of Operative Intervention for Aortic Regurgitation

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We examined the application and timing of valve replacement in 105 cases of aortic regurgitation, from the aspect of etiology, clinical findings and prognosis.

The mortality for patients after aortic valve replacement was 12.9%. This was lower than that for the patients not operated up on, which was 35.0%. The mortality after valve replacement for patients having acute aortic regurgitation due to active endocarditis was as high as 80%, which showed the limitations of medical and surgical therapy.

In cases of chronic aortic regurgitation, if valve replacement is performed within 3 years of the appearance of heart failure symptoms, the mortality is 0. Even after three years, valve replacement is applicable if there are no ventricular premature contractions. CTR 65%, %FS 21%, R/Th 2.9 and EF 38% were considered to be the critical factors for postoperative prognosis.

The range of application of surgery for patients with aortic valve disease has been widened due to advances in cardiac surgery such as the newer operative techniques designed to preserve myocardial function. But many problems remain such as infective endocarditis, postoperative heart failure and arrhythmias. We have reviewed the results of surgery for aortic regurgitation, the problems after operation and the prognosis. We will discuss the application and timing of surgery for patients with aortic regurgitation.

METHODS AND PATIENTS

The subjects were 105 patients with aortic regurgitation (AR) and who had been hospitalized during the 5 years between January, 1977 and July, 1982; 85 patients underwent aortic valve replacement (AVR group) and 20 patients did not (non-operated group). The AVR group consisted of 66 males and 19 females with an average age of 39.9 years. The non-operated group consisted of 16 males and 4 females, with an average age of 51.1 years.

Each group was examined for case history, clinical findings, CTR, point score system for the ECG diagnosis of left ventricular hypertrophy (Ronhilt Estes score¹), the presence or absence of arrhythmias, end-diastolic dimension (EDD) and end-systolic dimension (ESD), % fractional shortening (%FS), mean systolic radius/thickness (R/Th), cross-sectional wall area (CSA) by echocardiographic evaluation, and cardiac catheterization findings (Table I). Echocardiographic indexes:

\[ %FS \text{ derived as } \frac{\text{EDD}-\text{ESD}}{\text{EDD}} \times 100 \]
\[ R/\text{Th} \text{ derived as } \frac{\text{EDD}}{2\text{Thd}} \]
\[ \text{CSA derived as } \pi \left[ \frac{(\text{EDD}/s) + \text{Thd}}{2} \right]^2 \]

RESULTS

I. Prognosis of AR

The prognosis of AR for the AVR group was
TABLE 1 PREOPERATIVE FACTORS EXAMINED

1 ~ 2 Age, Sex
3 Period of observation
4 Infective endocarditis
5 Mode of onset of aortic regurgitation (acute or chronic)
6 Duration of significant aortic regurgitation
7 ~ 9 Duration of dyspnea, angina, syncope
10 Initial, final, and increase in CTR
11 ECG abnormalities
   i) Left ventricular hypertrophy
   ii) Rhythm disturbance
12 Echocardiographic evaluation
   EDD, ESD, %FS, R/Th, CSA
13 Hemodynamic examination

TABLE II CLINICAL SYMPTOMS AND PERIOD TO AVR

<table>
<thead>
<tr>
<th>Symptom</th>
<th>No.</th>
<th>Mean period (months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOB</td>
<td>53</td>
<td>29.3</td>
</tr>
<tr>
<td>Dyspnea (CHF)</td>
<td>29</td>
<td>27.3</td>
</tr>
<tr>
<td>Chest pain</td>
<td>25</td>
<td>25.7</td>
</tr>
<tr>
<td>Syncope</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

The table shows the results of various clinical tests before and after valve replacement. At one month after surgery, significant improvement was already seen in various thoracic markers such as CTR on chest X-ray, EDD, ESD, R/Th, CSA, EDVI, ESVI, CI and pcv pressure. More marked improvement was seen at a later time, 34.6 months on average after surgery.

There was no change in the ECG left ventricular hypertrophy score at one month after surgery, but a significant improvement was seen at a later date.

The %FS by UCG was, conversely, significantly reduced one month after surgery and normalized later. The cause of such a reduction is unknown, but it may be due to abnormal septal motion occurring immediately after surgery. EF by cardiac catheterization was unchanged. This finding is coincident with that reported by Pantely et al.17
### TABLE III COMPARISON OF PRE- AND POST-OPERATIVE STUDIES

<table>
<thead>
<tr>
<th></th>
<th>Preope.</th>
<th>1 Mos. postope.</th>
<th>Follow up</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTR (%</td>
<td>59.6 ± 5.7</td>
<td>54.6 ± 5.2*</td>
<td>51.7 ± 5.7*</td>
</tr>
<tr>
<td>ECG score</td>
<td>6.5 ± 2.4</td>
<td>6.1 ± 2.3</td>
<td>5.3 ± 3.0*</td>
</tr>
<tr>
<td><strong>Echo</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDD (mm)</td>
<td>70.5 ± 9.1</td>
<td>53.6 ± 9.4*</td>
<td>47.6 ± 6.3*</td>
</tr>
<tr>
<td>ESD (mm)</td>
<td>51.7 ± 9.4</td>
<td>43.9 ± 11.1*</td>
<td>33.1 ± 6.8*</td>
</tr>
<tr>
<td>% FS (%)</td>
<td>27.0 ± 7.4</td>
<td>20.6 ± 8.2*</td>
<td>30.2 ± 8.6*</td>
</tr>
<tr>
<td>R/Th</td>
<td>2.32 ± 0.61</td>
<td>1.83 ± 0.55*</td>
<td>1.83 ± 0.45</td>
</tr>
<tr>
<td>CSA (cm²)</td>
<td>43.6 ± 12.5</td>
<td>35.6 ± 11.5*</td>
<td>26.6 ± 8.7*</td>
</tr>
<tr>
<td><strong>Hemodynamics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EDVI (ml/m²)</td>
<td>228.1 ± 66.0</td>
<td>134.0 ± 64.0*</td>
<td></td>
</tr>
<tr>
<td>ESVI (ml/m²)</td>
<td>128.9 ± 49.0</td>
<td>76.6 ± 49.4*</td>
<td></td>
</tr>
<tr>
<td>EF (%)</td>
<td>46.6 ± 10.4</td>
<td>45.0 ± 12.0</td>
<td></td>
</tr>
<tr>
<td>CI (l/min/m²)</td>
<td>2.75 ± 0.64</td>
<td>3.09 ± 0.45*</td>
<td></td>
</tr>
<tr>
<td>PCW (mmHg)</td>
<td>13.8 ± 7.0</td>
<td>8.5 ± 4.2*</td>
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</table>

* = p < 0.001

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b) Non-operated group (20 patients)

The average observation period for the non-operated group was 47.0 months.

Figure 2 shows the fluctuation in NYHA function class. At hospitalization, 12 patients were in NYHA classes I-II, and 8 patients were in classes III-IV, while of a later date, 10 patients were in NYHA classes I-II, 1 patient was in NYHA classes III-IV, 7 patients had died, and the prognosis of 2 patients was unknown. The mortality was 35.0%. The cause of death was heart failure in 4 patients, arrhythmia in 1 patient, sudden death in 1 patient, and gastrointestinal bleeding in 1 patient. They died on average 4.9 years after the onset of clinical symptoms.

The prognosis of patients in the AVR group was clearly better than that of patients in the non-operated group.

2. Examination on Valve Replacement

Of the 85 cases in which valve replacement was performed, 11 cases had acute aortic regurgitation due to infective endocarditis and 74 patients had chronic aortic regurgitation such as

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is caused by rheumatism. These two groups were examined separately.

a) 11 cases of acute AR

After valve replacement, 4 of the 11 patients with acute AR died, the mortality being 36.4%. Five of the 11 patients had active infective endocarditis and refractory heart failure which could not be managed by medical therapy. Valve replacement was performed as a last resort in these patients. Four of the 5 patients died within 1 year of surgery, and the mortality was therefore 80% (Fig. 3). The remaining patient had NYHA function in class IV. At operation all 5 patients had a mycotic aneurysm as well as coronary cusp perforation, and the major cause of death was leakage and heart failure after valve replacement (Table IV).

On the other hand, in 6 cases in which infective endocarditis and heart failure could be managed by medical treatment, the mortality after valve replacement was 0. However, in 1 of 6 patients, mycotic aneurysm was detected at surgery, and Re-AVR had to be performed 1 year later because of leakage.

b) Seventy four cases of chronic aortic valve regurgitation

Seven of the 74 patients with chronic died after valve replacement, a mortality of 9.5%.

The relationships between the time after appearance of the symptoms and surgery, and the long-term mortality were examined in 29 patients who had clear symptomatic heart failure before surgery (Fig. 4). Of these 29 patients, none of the 18 patients who underwent valve replacement within 3 years of the appearance of heart failure died. One of the 6 patients who had valve replacement 3–5 years after the symptoms appeared died suddenly 2 years after surgery. Of the 5 patients who had valve replacement 5 years after the appearance of symptoms, 1 patient died of arrhythmia 2 years after surgery, 1 patient died suddenly 3 years after surgery, and 1 patient died of heart failure 5 years after surgery. In all 4 cases resulting in death, ven-
tricular premature contractions were detected along side heart failure before surgery.
On the other hand, the 2 patients without ventricular premature contractions, although they had a history of heart failure for 5 years or more before surgery, were still alive and had NYHA function in class II.
The complications of ventricular premature contractions and heart failure are considered to worsen the prognosis after valve replacement in cases of chronic AR.

3. Comparison of Preoperative Test Results between Patients who Died and Survivors
The preoperative test results of the 5 patients who died or had NYHA function in classes III–IV even after valve replacement were compared with those of the 69 patients who were alive and had function in classes I–II after valve replacement. As shown in Table V, the prognosis was clearly poor for the patients with a CTR of 65% or more, %FS of 21% or less, R/Th of 29% or more, and EF of 38% or less. These values were significantly different from the values for patients who survived. Interestingly, a difference was detected in R/Th which reflects the degree to which the LV muscle mass is appropriate for a given chamber volume as well as in %FS and EF which express contraction potential.

**TABLE V COMPARISON OF PREOPERATIVE DATA WITH SURGICAL RESULTS**

<table>
<thead>
<tr>
<th></th>
<th>Alive with NYHA Class I ~ II</th>
<th>Died or alive with NYHA Class III ~ IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTR (%)</td>
<td>58.7 ± 5.8</td>
<td>64.9 ± 7.6</td>
</tr>
<tr>
<td>% FS (%)</td>
<td>28.3 ± 7.9</td>
<td>20.9 ± 6.3</td>
</tr>
<tr>
<td>R/Th</td>
<td>2.2 ± 0.6</td>
<td>2.9 ± 0.6</td>
</tr>
<tr>
<td>EF (%)</td>
<td>49.0 ± 9.8</td>
<td>38.0 ± 7.2</td>
</tr>
</tbody>
</table>

*p < 0.05*

DISCUSSION
In general, it is said that cases of chronic AR are asymptomatic for 5–10 years, but once symptoms begin to appear, they get rapidly worse. The patient may die unless surgery is...
performed within 5 years of the appearance of angina pectoris and within 2 years of the appearance of heart failure.8,9

Although there is no need to stress that surgery is necessary when clinical symptoms such as angina pectoris or heart failure appear, it is extremely important to determine the appropriate time for surgery in cases of asymptomatic AR and cases with only mild symptoms.5

Henry et al.3,4,18 stated that the contraction potential of the left ventricle determines the prognosis after surgery, and reported the importance of ESD and %FS. Benow et al.10,11 reported the usefulness of exercise studies of left ventricular function.

In our study, we could not perform left ventricular function exercise tests before surgery, but a clear difference in prognosis was detected depending on CTR, %FS, R/Th and EF. But there is a limit to electrocardiographic examinations, as reported by Linhart et al.12 as the dimensions can be underestimated and %FS overestimated. Other problems remain such as inaccuracy in evaluating LV function due to abnormal septal motion after surgery.13,14,15

Even if there are symptoms of cardiac insufficiency, the prognosis after surgery can be said to be relatively good if it is performed within three years of the appearance of cardiac insufficiency. Moreover, even when the symptoms have persisted for 3–5 years, the prognosis was relatively good if there were no ventricular premature contractions. That is, the postoperative prognosis can be said to be influenced by the presence or absence of ventricular premature contractions in addition to heart failure.5,16 Conversely, if there is only heart failure, surgery is beneficial even when the course of the illness has been long. This owes much to recent advances in surgical technique and in medical treatment.19,20 Hereafter, 24-hour Holter ECG tests may be valuable in the early diagnosis of ventricular premature contractions.

On the other hand, the mortality after valve replacement for acute AR is strikingly high. This reflects the limits of medical and surgical therapy against infective endocarditis. Medical treatment of infective endocarditis with prolonged administration of antibiotics could worsen heart failure and cause distention of the infected area, forming a mycotic aneurysm. Therefore, early valve replacement surgery is recommended. The surgical techniques need to be further improved.

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