Reoperation for Mitral Stenosis
A Discussion of Postoperative Deterioration and Methods of Improving Initial and Secondary Operation

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SIGNIFICANT clinical improvement after valvuloplasty for mitral stenosis can be anticipated in 70 per cent of group III patients followed 5 years and 52 per cent of those in group IV. Nevertheless, the first 1,000 patients in our series have been followed from 2 to 9 years, and some degree of deterioration after an initially favorable result was found in 228. Critical scrutiny of the factors involved in this deterioration should lead to better selection of patients, to the evolution of better operations, and perhaps to the prevention of "restenosis." In the analysis of the results, 3 factors appeared to be particularly responsible for deterioration: inadequate initial surgical correction (45 per cent); mitral insufficiency preexisting or following operation (22 per cent); and recurrence of rheumatic fever (17 per cent).

Many of these patients have seemed suitable for reoperation. Experience gained at these second operations has not only emphasized the seriousness of an inadequate initial operation but has underlined the difficulties and hazards of the usual method of reoperation. Dissatisfaction with the safety and results of the old method of reoperation prompted the development of the new procedure, presented here. This new technic has been chosen after careful consideration and trial of the right-sided approach as advocated by Neptune and Bailey, open operation as suggested by Kay and Zimmerman, by Lillehei et al., transventricular valvotomy as proposed by Logan and Turner, Tubbs, Cooley and Stoneburner, and Gerbode, and the transaortic dilator valvotomy suggested by Dubost and Blondeau.

Material

The first 80 reoperations on 79 of our patients are analyzed here. One patient had 2 reoperations. All but 5 were from the first 1,000 above. The operative findings and clinical observations have been analyzed in order to reconstruct as accurately as possible the cause of failure of the primary effort. Patients whose first operation was performed elsewhere are not included, since comparable technical and pathologic documentation is not possible.

There were 12 male and 67 female patients. The average age of 39.7 years at the time of the first operation closely approximates that of the entire series.

At the first operation 64 patients classified as group III by our classification; 16 were in group IV. At the time of the second operation 21 of the original group III patients were classified as group IV, and 4 of the former group IV patients were in group III. Therefore there were 47 group III and 33 group IV patients at the time of reoperation.

Classification of Patients and Results

The opportunity to palpate the valve a second time and to compare the findings with a detailed diagram and operative note made at the time of the first operation permits a retrospective analysis of factors responsible for deterioration that can be gained in no other way. In an analysis of these data all but 2 of the patients were arbitrarily classified in 3 main groups: (1) unsatisfactory initial operation without significant insufficiency; (2) restenosis without insufficiency; (3) mitral insufficiency.
1. Unsatisfactory Initial Operation without Significant Insufficiency

This group was defined as one in which the valve area after manipulation was estimated to measure 2.5 cm.² or less, or in 5 instances where the postoperative area of 3.0 cm.² or more had been accomplished more by dilatation than by separation of the commissures.* Advanced scarring was the chief reason for such unsatisfactory operations. Whether this resulted in fracture-dilatation only, the opening of only one commissure, or from a failure to appreciate and manage secondary stenosis due to fusion of chordae, the result was the same, i.e., inadequate mobilization. Although the patient might be relieved rather dramatically of symptoms by the resulting increment in valve area, the stage was set for gradual loss of mobility and restriction of leaflets or actual refusion of the commissures by fibrin.

There were 18 patients in whom it was judged that an unsatisfactory valvuloplasty had been effected initially but in whom mitral insufficiency of greater than minimal extent was not present (table 1).

Leaflet calcification sufficient to limit the initial operative opening was present in 5 of the patients with unsatisfactory procedures and developed or increased between operations in 2 others.

2. Restenosis without Insufficiency

This category was used in 28 patients in whom the valve had been opened to 3.0 cm.² or more at the initial procedure but was found to be 1.0 cm.² or less at reexploration. In 4 additional instances the valve area was estimated to be between 1.2 and 1.5 cm.² at the time of the second operation. This group differs only in degree from those classified as "unsatisfactory initial operation" and the factors responsible for their failure to maintain improvement are the same. It is of interest that in this group of 32 patients only 1 commissure was fractured in 23, marked fusion of the chordae tendineae was present 18 times, and in 15 patients marked valvular calcification was present at the first operation or developed or increased between operations. In only 2 patients did restenosis occur in the absence of any of these factors. Thus in 30 of the 32 patients, conditions conducive to an unsatisfactory valvuloplasty were present.

A recurrence of acute rheumatic fever occurred between the first and second operations in 8 patients. It was thought to have been an important causative factor in the deterioration of 1 patient with an initially unsatisfactory operation and of 5 in the restenosis category.

3. Mitral Insufficiency

This group has been previously shown to be second only to inadequate initial surgery as a cause of deterioration after mitral valvuloplasty.¹ In this series of patients who were reexplored it was thought to be of significant degree (moderate or marked) in 28 of the 80. In all of these patients significant mitral stenosis was clinically diagnosed preoperatively, although in 26 a clinical diagnosis of significant associated insufficiency was also made. It was considered preoperatively, however, that operation for the relief of the stenosis present should give substantial clinical improvement. Now most of these patients would be operated upon by open technic under cardiopulmonary bypass to correct the associated mitral insufficiency.

Of these 28 there were 9 in whom the regurgitation was present at the time of the first operation, 11 in whom it was increased by the surgeon, and 8 in whom it appeared to have developed in the interval between operations. In half of these patients some restenosis had occurred between operations. In all of the patients with restenosis, factors leading to an unsatisfactory valvuloplasty were present.

Two of the patients are not included in the foregoing categories. In 1 it was thought in retrospect that she suffered predominantly from hypertensive heart disease at the time of both the first and second operations, although a small amount of restenosis had occurred. In the other a diagnosis of recurrent mitral stenosis was supported by catheterization findings. At operation, however, very minor stenosis was present (valve area greater

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*This figure refers to the effective hemodynamic size.
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Table 1

Factors Involved in the Findings at Two Operations (two or more factors usually present in any given patient)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Unsatisfactory</th>
<th>Restenosis</th>
<th>Mitral insufficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Without significant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>With restenosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>reoperation</td>
</tr>
<tr>
<td>1 Commissure only fractured</td>
<td>3</td>
<td>23</td>
<td>-</td>
</tr>
<tr>
<td>Fracture dilatation or poor fracture</td>
<td>15</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Immobile or poor flexibility</td>
<td>2</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Chordae fusion plus 2 or more</td>
<td>9</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Calcification plus 2 or more at first operation</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Calcification increased or developed</td>
<td>2</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Mitral insufficiency plus 2 or more at first operation</td>
<td>5</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Mitral insufficiency increased</td>
<td>5</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Mitral insufficiency developed</td>
<td>4</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Rheumatic fever</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>None</td>
<td>2</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Total patients</td>
<td>18</td>
<td>32</td>
<td>14</td>
</tr>
<tr>
<td>Grand total - 78</td>
<td></td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

There were 2 additional patients; one with hypertensive heart disease at both operations who had some degree of restenosis due to a poor fracture at the first operation, and another who had very little restenosis.

than 2 cm.) and no insufficiency. Her symptoms were presumably largely functional in nature, occurring at the time of the onset of atrial fibrillation several months before the second operation.

The median time for the duration of maximum improvement fell between 2 and 3 years. On the average, patients came to reoperation about 2 years after they had begun to deteriorate.

When the patients are analyzed according to their place in the series of the first 1,000 valvuloplasties for mitral stenosis, a decreasing incidence of reoperation is found. Fifty-four of the first 500 underwent a second operation as contrasted with 21 of those between 501 and 1,000. In order to eliminate the factor of natural attrition with time, the incidence of reoperation within 5 years of the first procedure has been analyzed. The first 800 patients were all operated upon at least 5 years prior to the date of this report. Therefore the number of patients reoperated upon in these 5 years in the 1 to 400 part of the series has been compared to those in the 401 to 800 category; namely, 26 versus 19. Chi-square analysis indicates no significant difference. If patients in whom a second operation has been done elsewhere within 5 years are included, the numbers would be 30 versus 22, still not significant. Nevertheless as experience has been gained in selection, technical proficiency, and the application of the newer principles of mobilization, as in the second 1,000, one would anticipate that fewer patients will require reoperation in future years.

Results Following Reoperation

Following reoperation, the patients as a group have not done as well as patients in the initial series of 1,000 operations. This is not surprising. Patients who have deteriorated often pose special technical problems for the surgeon, since many of the valves have defied the surgeon's best efforts originally. The group is thus specifically preselected with an emphasis on badly scarred valves. Reoperation is complicated not only by difficulty of access through pleural and pericardial adhesions that obscure the left atrial wall plus an amputated atrial appendage, but also by a more difficult pathologic valve process. Finally and most important is the fact that with all of the handicaps outlined above, 60 of the 80 operations were the original or standard direct atriotomy. In this, deliberate, well-controlled,
versatile intracardiac manipulation was impossible owing to poor hemostatic controls.

In this series of 80 reoperations, 60 were performed by the outmoded technic. In the group of 60 there were 6 operative deaths. The remaining 20 were operated by the new technic with 1 death. Of the 60 original-type reoperations with 6 deaths, 51 have been followed a year or more, 1 has been lost to follow-up, 1 was operated on less than 1 year ago, and 1 hypertensive patient, has been removed from the series. The operative mortality of this original group was 10 per cent, with no mortality in group III and 19 per cent in group IV. These mortality figures are comparable to the operative mortality figures for the first 1,000 patients undergoing primary valvuloplasty in our series.

Of the 51 having the original type of reoperation, only 22 or 43 per cent, were significantly improved 1 or more years later. However, when the patients are divided according to the reason for reoperation as outlined above, interesting differences appear. Of the patients with mitral insufficiency only 2 of 9, or 22 per cent, are improved, although 4 of 10 patients with mitral insufficiency plus restenosis were helped. Of those in whom the first operation was unsatisfactory, 4 of 14, or 28 per cent, are improved. Of those in whom restenosis was thought to have occurred, however, 14 of 18, or 78 per cent, are improved. This difference in the results of patients with restenosis compared to those with an unsatisfactory operation and mitral insufficiency is significant ($p<0.01$).

There was no relation between the length of follow-up after the second operation and the percentage of patients improved.

In short, these results demanded changes in selection and in technic. Those with mitral insufficiency are now operated upon with cardiopulmonary bypass. Those with stenosis are operated on by the better-controlled, more deliberate new tunnel technic. The tunnel technic allows emphasis of separation of posteromedial fusion zone and mobilization of subjacent chordae.

In the 20 operated upon by this technic in this series of 80 reoperations, there has been 1 operative death, a group IV patient with mitral insufficiency. The technic was instituted as a routine in October 1958. Only 2 of the patients have been followed over 1 year and both are markedly improved.

Although the follow-up observation of the remaining 17 patients is not long, the short-term course has been favorable. The surgeon's prognosis at operation in the first 1,000 valvuloplasties was remarkably accurate after long-term follow-up. Therefore the operator's estimates are likely to be valid in this group of tunnel reoperations with anterior and posterior medial mobilization.

**General Consideration for Reoperation**

In planning the approach for a reoperation for mitral stenosis one is attracted by the possibility of using the adhesion-free right pleural space and the right side of the left atrium as advocated by Bailey. Experience with this technic points up its inadequacy for managing the anterior commissure because of its distance from the atriotomy and the inability to apply effective counterpressure on the ventricular wall, at and below the annulus.

The right-sided approach does have validity insofar as it reemphasizes crescentic posteromedial commissural opening rather than direct posterior valvotomy. It appears to be common practice throughout the world to open only the anterior commissure because this is simpler and results in significant clinical improvement. Indeed the vast majority of our first 1,000 patients had only anterior fusion bridge fracture. Where there is extensive thickening or calcification of the posteromedial half of the stenotic orifice it is apparent that anterior commissural opening alone may correct the stenosis very little. This rigid horseshoe that limits the orifice from opening disappears with posteromedial opening.

Where the fractures occur in the methods of Logan, Tubbs, and Dubost, inserting a valvulotome through the ventricle or atrium and guided by a finger in the left atrium must depend in part on luck rather than control. Furthermore, this maneuver can only initiate...
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the fracture. Optimal mobilization still necessitates finger dissection of the chordae, one from another and away from the wall of the ventricle.

Open operation with cardiopulmonary bypass has a certain validity, particularly when significant mitral insufficiency must also be corrected or when the pathologic process is known to be impossible to correct by closed technic. The bypass procedure is certainly more cumbersome, however, and exposes the patient to a greater operative risk. At the same time leaflet mobility and the degree of insufficiency produced are less easily evaluated at open operation. Experience with open correction of mitral stenosis has, paradoxically enough, been very disappointing. It seems possible that advocacy of "routine open operation" may indicate a lack of familiarity with really good closed valvuloplasty or limited experience with open-heart surgery.

On 2 occasions superior pulmonary veins were used. This approach was a "strategic retreat" in the face of an inadequate appendage, a hold-over from our very early experience. This proved unsatisfactory because of the position of the valve and the danger of serious damage to the venous drainage of the left upper lobe. In one patient these limitations defeated the second attempt, and a third operation was necessary, which was successful.

The New Technic of Reoperation

With the patient in the lateral decubitus position with the left side up, the fourth or fifth interspace is opened. If there is heavy calcification in the valve, the head vessels are isolated. The pericardium is reopened and the surface of the left atrium exposed. It was our former practice to place 2 or 3 concentric purse-string sutures on this flat surface of the atrial wall. Following this a stab wound was made in the center of the circumscribed area. The fifth finger was inserted carefully to open the atriotomy enough to accept the index finger. The valvuloplasty was then carried out with the finger alone or aided by one of the breadknife valvulotomes described previously. Hemostatic control was precarious. There were harrowing experiences with hemorrhage and tears of the atrium. Fortunately there were no deaths, but the valve manipulation was hurried. Thus a new technic has been developed and used in the last 20 operations of this report.

The new operation is entirely similar up to entry into the left atrium. At this point instead of placing concentric purse-string sutures, an Ivalon tunnel similar to that used in transaortic valvuloplasty is sewed to the exposed atrial wall. While an assistant controls the tunnel with a Rumel tourniquet, the surgeon makes an incision in the atrial wall with the tunnel and inserts his finger. Once in the atrium he has excellent control and any necessary manipulations can be undertaken without fear of an uncontrollable hemorrhage or tear into the atrium.

A cardinal advantage in this new technic is the opportunity it affords the operator to have an assistant occlude the atriotomy with his finger while the surgeon goes to the opposite side of the table (facing the patient's anterior chest wall) in order to open the posterior commissure. This commissure is recognized by all experienced in the field as the more difficult to fracture. From a position in front of the patient it is possible, however, to open virtually all the adherent components. The bare finger generally initiates the fracture posteromedially by following up the chordae to the major leaflet and fracturing it with a counterclockwise motion. If this fails, the concave posteromedial fusion zone can often be incised, stretched, then fractured with a fingernail and finger preparing for the counterclockwise motion to open the commissure. In such situations there is commonly fusion of the chordae to each other and to the posterior wall of the ventricle that limits adequate leaflet mobility. This must be corrected by meticulous finger dissection. At times considerable force is necessary and attention must be given to the point of insertion of the left pulmonary veins into the left atrium, lest a tear occur. If the surgeon's left hand is passed to the posteromedial aspect of the heart, counterpressure can be exerted. Rarely will
the valvulotome on the finger or inserted through the left ventricle be necessary.

This meticulous, complete leaflet mobilization, directed first toward the anterior commissure and its subvalvular components as the surgeon stands behind the patient and then to the posteromedial fusion zone and subvalvular components with the surgeon in front of the patient, is just as important at initial operations as at reoperations. It is described here simply because it has not been emphasized in previous publications and was not routinely possible during reoperation until the operating tunnel was used.

The more adequate mobilization of these difficult valves afforded by this technic will certainly improve the results in reoperations. Indeed, application of these concepts to primary operation may reduce the incidence of reoperation. Open procedures for these problems have been disappointing; at the same time closed technic has improved. Unless insufficiency is the dominant lesion or valve replacement is contemplated, there has been a recent trend away from open operation.

Summary

A series of 80 reoperations for mitral stenosis in 79 patients is reported and analyzed.

The most important causes of deterioration after valvuloplasty for mitral stenosis are inadequate initial operation, restenosis, and mitral insufficiency. Generally more than one of these factors pertain.

An adequate mitral valvuloplasty requires the complete opening of both the anterior and posteromedial commissures and the mobilization of the chordae tendineae from each other and from the wall of the ventricle.

The advantages and limitations of closed reoperation, open reoperation, the right-sided approach, and the use of the transventricular valvulotome are reviewed.

More complete correction of stenosis with mobilization of posteromedial, anterior, and subvalvular chordae is emphasized. This is attained by operating from both the ventral and dorsal aspects of the patient through a left posterolateral thoracotomy incision.

An Ivalon operating tunnel sutured to the left atrial wall at reoperation makes it possible to carry out the more extensive valvuloplasty at reoperations.

A lower operative mortality, better long-term results, and fewer instances of deterioration are anticipated when this concept of improved valvuloplasty is effected initially.

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