SURGERY FOR ACQUIRED HEART DISEASE

REOPERATION AFTER VALVE REPAIR FOR MITRAL REGURGITATION: EARLY AND INTERMEDIATE RESULTS

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To better understand late outcomes of mitral valve repair, we reviewed the cases of 49 consecutive patients who underwent reoperation between January 1974 and May 1992 for recurrent valve dysfunction after previous valvuloplasty for mitral regurgitation. There were 27 men (55%) and 22 women, with a median age of 63 years (range 20 to 84 years). Original procedures included annuloplasty and posterior leaflet repair in 15 patients (31%), annuloplasty and anterior leaflet repair in 15 (31%), commissural plication in 13 (27%), and complex bileaflet repairs in six (12%). Median time between initial mitral repair and reoperation was 2.4 years (range 2 months to 25.3 years). Indications for reoperation included recurrent severe mitral regurgitation in 34 patients (70%), hemolytic anemia from mitral regurgitation in seven (14%), mixed mitral regurgitation and stenosis in seven (14%), and isolated mitral stenosis in one (2%). Before reoperation, 36 patients were in New York Heart Association functional class III and 11 were in class IV. Initial repairs were intact at the second operation in 32 patients (65%), and the etiology of recurrent mitral regurgitation in these patients was fibrosis or calcification of the anulus or leaflets in 22 patients, newly ruptured chordae in seven, and perforated leaflets in three. The causes of mitral regurgitation in the 17 patients whose initial repair had failed included dehiscence of commissural repairs in nine patients, dehiscence of ring annuloplasty in four, and breakdown of chordal or leaflet repair in four. Patients with original repairs involving the anterior leaflet had a significantly shorter time between operations ($p = 0.006$). In eight patients (16%), the mitral valve was repaired again; in the remaining 41 patients (84%), prosthetic replacement was performed. Operative mortality rate was 4% (two patients). All eight patients who underwent mitral valve rerepair had no mitral regurgitation, trivial regurgitation, or mild regurgitation at discharge from the hospital. Follow-up was 100% complete at a mean of 5.1 years (range 1 to 19 years). Forty-one patients (87%) were in New York Heart Association functional class I or II, and survival at 5 years was 75.3%. Of the eight patients who underwent a second repair, seven had no regurgitation, trivial regurgitation, or mild regurgitation at a median of 4 years' follow-up. The low mortality associated with reoperation supports an aggressive approach toward mitral regurgitation with initial repair. A second repair can be performed in selected patients with durable results at 4 years. (J Thorac Cardiovasc Surg 1996;111:1177-84)

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Read at the Twenty-first Annual Meeting of The Western Thoracic Surgical Association, Coeur d'Alene, Idaho, June 21-24, 1995.

Received for publication June 21, 1995; revisions requested Oct.

5, 1995; revisions received Dec. 29, 1995; accepted for publication Jan. 5, 1996.

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0022-5223/96 \$5.00 + 0 12/6/71627

Because of the advantages of valvuloplasty over prosthetic replacement, the number of patients who undergo mitral valve repair is increasing. Techniques of leaflet resection, annuloplasty, and chordal replacement have steadily evolved,¹⁻⁵ and most patients with regurgitation caused by degenerative causes are candidates for mitral valve repair. It is therefore likely that in the future cardiologists and cardiac surgeons will encounter more patients with residual or recurrent mitral valve dysfunction after a previous repair.⁶ To better understand causes of late failure of mitral valve repair, we reviewed our experience with reoperation in these patients and focused on surgical findings and operative results.

Patients and methods

Between January 1974 and May 1992, 49 consecutive patients who had undergone previous mitral valve repair underwent reoperation at the Mayo Clinic for recurrent or residual mitral valve dysfunction. Patients with previous commissurotomy, congenital mitral valve disease, regurgitation from cardiac or valvular masses, and previous balloon mitral valvuloplasties were excluded from this study. Patient characteristics were obtained from clinic records; some of the 33 preoperative variables used in this analysis are listed in Table I.

Follow-up was obtained for all patients through records of most recent examination at the Mayo Clinic, letters from home health care providers, and reports of the most recent echocardiograms. Follow-up information included New York Heart Association (NYHA) functional class, the presence and degree of mitral valve dysfunction, and any subsequent complications related to the repaired valve.

Operative mortality was defined as including any deaths occurring before discharge from the hospital or within 30 days after the operative procedure; late mortality included any subsequent deaths. Late complications were defined as those that occurred after discharge from the hospital. Data are expressed as medians with ranges. Continuous variables were compared with unpaired or paired Student's *t* tests (two-sided) and analysis of variance; discrete variables were compared with the χ^2 test. Survival was estimated by the Kaplan-Meier method, with the date of last operation as the beginning date. Values of *p* less than 0.05 were considered statistically significant.

Results

Initial valve repair. The group studied was composed of 27 men and 22 women with a median age at first mitral valve procedure of 58 years (range 19 to 84 years). Three patients had undergone cardiac operations before this first mitral valve repair; two patients had undergone coronary artery bypass grafting and one patient had undergone aortic valve replacement. In this latter patient, the prosthetic aortic valve was competent at initial mitral valve

Table I. Patient characteristics before first mitral valve operation

	No. of patients
Initial mitral valve repair at Mayo Clinic	42
Initial mitral valve repair elsewhere	7
Symptoms	
Dyspnea on exertion	41
Shortness of breath at rest	38
Angina	11
Previous hospitalization for CHF	8
History of endocarditis of mitral valve	3
History of rheumatic fever	12
Atrial fibrillation	17
NYHA Class	
II	4
III	39
IV	6
MR by echocardiography	
Moderately severe	4
Severe	45
Severe tricuspid regurgitation	3

CHF, Congestive heart failure; MR, mitral regurgitation.

Table II. Types of initial mitral valve repair

Procedure	No. of patients
Annuloplasty and posterior leaflet repair	15
Annuloplasty and anterior leaflet repair	15
Commissural plication	13
Complex bileaflet repair	6

repair. Forty-two patients underwent initial valve repair at the Mayo Clinic.

In 43 cases, the indication for initial operation was pure mitral regurgitation; in six, it was mixed stenosis and regurgitation. Methods used during initial repair of the mitral valve are listed in Table II. At initial repair, 17 patients (35%) underwent 19 concomitant cardiovascular procedures: coronary artery bypass grafting in 13 patients, tricuspid valve repair in three, aortic valve replacement in two, and closure of a ventricular septal defect in one.

Intraoperative transesophageal echocardiographic assessment of this initial mitral valve repair was performed in the last 10 patients. The degree of mitral valve regurgitation after initial repair was estimated as trivial or none in four patients, mild in five, and moderate in one. Seventeen patients had postoperative transthoracic echocardiograms before discharge from the hospital after the initial operation. There was no mitral regurgitation or only trivial regurgitation in five patients, mild regurgitation in eight, moderate regurgitation in two, and moderately severe or severe regurgitation in two.

Table III. Patient characteristics before second mitral valve operation

	No. of patients
Symptoms	
Dyspnea on exertion	40
Shortness of breath at rest	38
Previous hospitalization for CHF	9
Anemia/lethargy	7
History of mitral valve endocarditis	3
History of rheumatic fever	12
Atrial fibrillation	28
NYHA Class	
II	2
III	36
IV	11
MR by echocardiography	
None	1
Moderate	3
Moderately severe	6
Severe	39
Severe tricuspid regurgitation	9

CHF, Congestive heart failure; MR, mitral regurgitation.

The presence of at least mild mitral valve regurgitation in these latter twelve patients did not predict the need for earlier reoperation.

Reoperation. The interval between initial valve repair and reoperation ranged from 2 months to 25 years (median 2.4 years), and median age at reoperation was 63 years (range 20 to 84). Patient characteristics before reoperation are shown in Table III.

Indications for reoperation were recurrent severe mitral regurgitation alone in 34 patients (69%), hemolytic anemia in seven (14%), mixed mitral regurgitation and stenosis in seven (14%), and isolated mitral stenosis in one (2%). The seven patients with hemolytic anemia represent a unique subgroup of patients, as shown in Table IV. In the three patients who had undergone previous aortic valve replacement, the prosthetic valve was normal at time of reoperation. Preoperative echocardiography demonstrated annular dilatation in 41 patients, thickened leaflets in 26, an eccentric jet in 16, ruptured chordae tendineae in 13, mitral valve prolapse in 12, and calcification of the annulus in seven.

As seen in Table V, annular dilatation and the presence of a central jet were observed more commonly in valves that were repaired again than in those that were replaced. Also, thickened leaflets and ruptured chordae were more commonly seen in valves that were replaced. All patients with a clinical

Table IV. Patient characteristics of seven patients with hemolytic anemia

	No. of patients
Degree of mitral regurgitation	
Mild	4
Moderately severe	2
Severe	1
Type of initial mitral valve repairs	
Carpentier-Edwards ringed valvuloplasty	4
Duran ringed valvuloplasty	2
Commissural annuloplasty	1

Time to reoperation ranged from 1.6 to 10.3 months (median 3.3 months).

history of rheumatic fever underwent mitral valve replacement at reoperation.

Operative methods were generally uniform: the heart was approached through a median sternotomy in 48 patients and through a right thoracotomy in one patient; the mitral valve was exposed through the left atrium in 45 patients and through an atrial septotomy after right atriotomy in four patients. In 32 patients, the original valve repairs were found to be intact; in 17 patients, recurrent regurgitation was caused by failure of the original repair. Causes of mitral regurgitation are shown in Fig. 1. The 22 cases of fibrotic or calcified leaflets or anuli also include those valves described as thickened or retracted at reoperation. Two of the three patients with newly perforated leaflets had documented endocarditis. The median time between initial valvuloplasty and reoperation for patients with intact repair was 3.2 years (range 0.16 to 25.3 years), and the median time between operations for patients with failure of the initial repair was 1.0 year (range 0.2 to 12.3 years).

At reoperation, 41 patients underwent mitral valve replacement (30 with mechanical prostheses, 11 with bioprostheses) and eight patients underwent a second repair. Methods of second repair were wedge resection of the posterior leaflet with posterior annuloplasty in four patients, wedge resection of the posterior leaflet only in two, and annuloplasty and wedge resection of the posterior and anterior leaflets in one patient each. During reoperation, 19 patients underwent concomitant cardiovascular procedures: coronary artery bypass grafting in seven, tricuspid valve repair in seven, tricuspid valve replacement in two, closure of atrial septal defect in two, and aortic valve replacement in one. For all 49 patients, duration of cardiopulmonary bypass ranged from 42 to 212 minutes (median 91 minutes),

Fig. 1. Causes of mitral valve dysfunction at reoperation.

and duration of aortic occlusion ranged from 15 to 125 minutes (median 58 minutes).

Operative mortality rate was 4% (two patients). One patient died of multiorgan failure and bilateral adrenal hemorrhage. The other death was caused by renal failure and gram-negative septicemia. Nonfatal complications included new-onset atrial fibrillation in three patients, hemorrhage necessitating exploration in two patients, respiratory failure in two patients, and ischemic colitis in one patient.

All patients who underwent a second repair of the mitral valve underwent echocardiography at discharge from the hospital. Six of these eight patients had no regurgitation or only trivial valve leakage; two had mild residual mitral valve regurgitation.

Late follow-up. Follow-up was complete for all patients and ranged from 1 to 19 years (median 5.1 years). At last assessment, 15 patients were in NYHA functional class I, 24 were in NYHA class II, eight were in NYHA class III, and none were in NYHA class IV. Five-year actuarial survival was 75.3%.

Serial echocardiograms were available for all patients who underwent a second mitral valve repair; median follow-up for these eight patients was four years (range 3 to 11 years). Six patients continue to have no mitral regurgitation or trivial regurgitation, and one patient who had mild mitral regurgitation at discharge from the hospital had an echocardiogram obtained elsewhere 8 years after operation that demonstrated moderate regurgitation. The other patient who had mild mitral regurgitation at discharge from the hospital has no evidence of progression at 11-year follow-up.

Late complications have occurred in 12 patients: five new rhythm disturbances, five bleeding episodes requiring hospitalization, and two strokes. Eleven of those 12 late complications occurred in the group of 41 patients who underwent mitral valve replacement. The only late cardiac complication among the group of patients who underwent second repair of the mitral valve was onset of intermittent atrial fibrillation in one patient.

There were 16 late deaths; eight patients died of cardiac causes, including four sudden deaths of presumed arrhythmia (all with autopsies). Three patients died of progressive congestive heart failure, and one died of endocarditis. Two of the late deaths were those of patients who underwent mitral valve second repair; one died of hepatic failure and the other of severe chronic obstructive pulmonary disease.

Discussion

Valvuloplasty for mitral regurgitation has clear advantages over prosthetic replacement.⁷⁻¹⁰ First, the procedure carries a low operative risk.^{11, 12} In a recent report from our institution, the operative mortality rate for mitral valve repairs performed from 1979 to 1992 was 1.7%.³ Left ventricular function appears to be better in patients who have repair of mitral regurgitation rather than valve replacement.¹³ Most important, late survival after mitral valve repair is improved with respect to that after mitral valve replacement.¹⁴⁻¹⁶ In this study, the 5-year survival for patients who underwent second repair was 100%, whereas it was 71% for those who underwent mitral valve replacement. Few studies,

Table V. Preoperative echocardiographic characteristics before second mitral valve reoperation

	Ruptured papillary muscle or chord		Annular dilatation		Central jet		Leaflet prolapse		Thickened leaflets		Annular calcification	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
MV reoperation (<i>n</i> = 8)	0	0	8	100	4	50	2	25	3	38	1	13
MV replacement (<i>n</i> = 8)	12	32	33	80	12	29	10	24	23	56	6	15

MV, Mitral valve.

For all six echocardiographic variables, *p* not significant.

however, have examined the causes of late failure of mitral valve repair.^{6, 17}

The incidence and cause of failure of mitral valvuloplasty vary with the cause of mitral regurgitation. For example, 5 years after repair of mitral regurgitation in a young population with rheumatic heart disease, 34% of patients have had valve failure and 25% have undergone reoperation.¹⁸ In contrast, among North American patients, most of whom have degenerative mitral valve disease, risks of reoperation after valvuloplasty were only 5% at 8 years in one study¹⁹ and 17% at 10 years in another report.²⁰ Although our study was not designed to determine incidence of reoperation, the patients reviewed seem representative of North American patients undergoing mitral valve repair. In this study, initial valvuloplasties were performed between December 1960 and September 1991. During this time 1548 patients underwent mitral valve repair (exclusion criteria were the same as described previously, in this article). The estimated reoperation rate for mitral valve repair during this interval is 2.7% (seven had initial repairs elsewhere), although we cannot be certain that all patients undergoing reoperation returned to our clinic.

An important aspect of the present study is the finding that original repairs were intact in over half of patients undergoing reoperation. Thus, late valve dysfunction is often due to new degenerative lesions, and this finding is similar to that reported by Marwick and colleagues.¹⁷ Echocardiography is an indispensable tool for determining which patients are candidates for mitral valve repair²¹ and is valuable during operation to assess valvuloplasty.²² There were, however, no obvious echocardiographic features that would have predicted late failure in patients who had intact repairs at reoperation.

Dehiscence of initial repair may be avoidable, and the incidence of this late complication would be expected to diminish with increasing operative ex-

perience. Also, current methods of posterior ring annuloplasty that more evenly distribute tension and protect leaflet reconstruction may carry lower incidences of dehiscence than that of commissural plication.^{3, 23} Certainly, judgment is necessary in applying valvuloplasty to leaflet tissue thinned by fibroelastic deficiency and to valves with excessive calcification of leaflets or annulus. Grossi and colleagues²⁰ advocate decalcification of the annulus or leaflet. Although operative mortality rate was 6.2% in their series, there was no adverse effect of decalcification on long-term freedom from reoperation. Our clinical experience suggests that calcification of the mitral valve annulus does complicate valve repair, especially construction of a secure annuloplasty.

Noticeably absent from this report was left ventricular outflow obstruction²⁴⁻²⁷ as a cause of reoperation. Intraoperative echocardiographic studies show that in almost every instance outflow obstruction as a result of systolic anterior motion of the mitral valve early after mitral valve repair is associated with hyperdynamic left ventricular function and intravascular volume depletion.²² When this situation is identified, intravascular volume augmentation and discontinuation of inotropic agents produce dramatic reduction in both mitral regurgitation and left ventricular outflow obstruction. This study gives further support to the notion that outflow obstruction is transient and does not mandate revision of the repair.

In seven patients, reoperation was necessary because of hemolytic anemia. This is a rare but well-recognized complication of both valve replacement and valve repair.²⁸⁻³¹ The diagnosis is made by a low serum haptoglobin level, high serum lactate dehydrogenase level, schistocytosis, and lack of any identifiable cause of anemia or hemolysis other than mitral regurgitation. In this study, hemolytic anemia occurred relatively early after valve repair, and in most instances the degree of mitral regurgitation

was only mild or moderate. The mechanism was an eccentric jet of blood directed against a nonendothelialized portion of an annuloplasty ring or pledget. In all cases, hemolysis was corrected by reoperation; in one case, the regurgitation was eliminated by removal of a section of annuloplasty ring.

There are few published data on long-term results of second repair of the mitral valve. The echocardiographic follow-ups of our eight patients who underwent second repair showed little or no progression of mitral valve regurgitation, and the results seem durable at 4 years. Certainly, care should be exercised in performing a second valvuloplasty, and prosthetic replacement is preferable unless valvular tissue is quite sturdy and the cause of failure is easily identified and corrected.

In conclusion, reoperation after mitral valve repair is relatively safe, and intermediate-term results are satisfactory; operative risk was only slightly higher than that observed for initial valve repair (4% vs 1.7%). In most patients who undergo reoperation, initial repairs are intact and recurrent mitral regurgitation is the result of new degenerative lesions. Patients with failure of initial valvuloplasty usually require reoperation earlier than do patients with new degenerative lesions. Reoperation for left ventricular outflow obstruction is distinctly uncommon, certainly less common as a late complication of valvuloplasty than mechanical hemolytic anemia.

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Discussion

Dr. R. Scott Mitchell (*Stanford, Calif.*). I congratulate you on an excellent presentation. You and your associates at the Mayo Clinic once again have brought valuable information from your vast clinical experience to this meeting. From a total of more than 1500 patients undergoing mitral valve repair in a 30-year interval, 49 patients, or just more than 2%, required second mitral valve operations. The interval between initial valve repair and reoperation ranged from 2 months to 25 years, which allows us a truly long-term view of mitral valve repair. As you mentioned, patients with left ventricular outflow tract obstruction, which you note to be transient and really associated only with the acute phase, were noticeably absent.

Of the eight patients who underwent mitral valve reoperation, annular dilatation was noted in eight patients, a central regurgitant jet was noted in four, thickened leaflets were noted in three, and leaflet prolapse was noted in two. No patient with a ruptured papillary muscle or cord underwent reoperation, although that echocardiographic variable failed to achieve statistical significance. Do you think that would become a significant factor with a greater number of patients?

Dr. Cerfolio. As more patients come to mitral valve repair, there will be a greater number with mitral regurgitation. The surgical and echocardiographic experience and expertise are increasing, and I believe that with more patients examined the echocardiographic variables pertaining to the ability to perform reoperation will become significant.

Dr. Mitchell. Posterior leaflet resection with or without annuloplasty accounted for seven of the eight reoperations. I think that the method of failure is instructive. Sixty-five percent of your repairs were intact with progressive calcification, with ruptured chordae accounting for these failures. Seventeen of your patients, however, had dehiscence of the repair. Because most of

these operations were done at the Mayo Clinic, we might learn something. Because that the annulus undergoes active deformation, was there any correlation between the type of ring, flexible versus rigid, and the propensity for dehiscence?

Dr. Cerfolio. This experience did not contain a significant number of patients to evaluate annuloplasty techniques. This was a topic of another project in which commissural, "full-ring," and posterior annuloplasty were compared and there was no difference (Odell JA, Schaff HV, Orszulak TA. Early results of a simplified method of mitral valve annuloplasty. *Circulation* In press.). However, those methods were performed as part of an evolutionary process, and the follow-up was shortest for the most recent, posterior annuloplasty.

Dr. Mitchell. The patients with hemolytic anemia represent a very interesting subset, and I wondered whether you could clarify this for us. These patients seemed to require reoperation rather early. Was reoperation possible in these patients? I could not really determine that from the manuscript.

Dr. Cerfolio. Since acceptance of the abstract, we have encountered two more patients with this finding. We were able to reoperate the valve in three of those nine patients, and their time to reoperation was much different from that of the other patients in this study. Their median time to reoperation was 3 months, with a range of 1 to 10 months, and their amount of mitral regurgitation before operation was indeed significantly less than that of the other patients in this study. The patients with hemolytic anemia after mitral valve repair had only mild or moderate mitral regurgitation instead of the severe mitral regurgitation seen in others. All of these patients have mechanically induced hemolytic anemia from recurrent mitral regurgitation after mitral valve repair.

Dr. Carlos Gomez Duran (*Missoula, Mont.*). This is a very interesting and timely presentation. We have also had cases of hemolysis, particularly in very young patients, forcing reoperation independently of the degree of regurgitation. My question is whether you have experience with the use of β -blockers. We have found that slowing down the heart rate significantly reduced the need for reoperation.

Dr. Cerfolio. The median age of the nine patients who had hemolytic anemia was 59 years, with a range of 35 to 84 years, so I cannot comment on a younger population with this problem. Moreover, it is difficult to determine the number of patients with hemolytic anemia after mitral valve repair. The degree of hemolysis is variable and may be subclinical in some.

Dr. Gomez Duran. We know that the two main causes of reoperation are technical aspects and etiology. From a technical point of view, we believe that chordal transfer is easier to perform than chordal shortening. It does not require any judgment to do it properly.

My second question is related to etiology. Our standard finding is that rheumatic valves are more difficult to repair and less stable than valves in degenerative cases. Do your findings support this view?

Dr. Cerfolio. We statistically reviewed the etiologic impact of rheumatic fever. None of the patients with a clinical history of rheumatic fever were judged to be

candidates for rerepair. Most of these leaflets were described as either thickened or retracted, and this is probably the reason that they were not repaired.

Dr. Gomez Duran. Another point I would like to make is that we recently have found another cause of early reoperation that has not been mentioned before and of which we were not aware. This is the very fast remodeling of the left ventricle after operation. Some patients with successful chordal shortening to the anterior leaflet and no residual regurgitation required reoperation for anterior prolapse within 3 months after operation. We could show echocardiographically that these ventricles had come down in size by about 30% in a few days. Probably our patient population is different from yours.

Dr. Cerfolio. There may be one patient in our series who had this phenomenon that you have described.

Dr. George Kafrouni (*LaCanada, Calif.*). Of the more

than a thousand patients, what percentage have been completely followed up to the present?

Dr. Cerfolio. We are in the process of accumulating that information but have no figures at this time.

Dr. Kafrouni. So you do not know how many were possibly reoperated on elsewhere?

Dr. Cerfolio. That is correct. The 2.7% figure is an estimate of the reoperation rate. This number is derived from the total number of cases done during the same time period as the first mitral valve repair with the same exclusion criteria, and since only 42 patients' initial mitral valve repairs were performed at the Mayo Clinic, we used this as the numerator to achieve our rough estimate. It is possible and likely that some patients who underwent their first mitral valve repair at the Mayo Clinic required a second mitral valve procedure elsewhere.

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