Clinical Investigation

Mitral Valve Reconstruction

Early Results of a Modified Cooley Technique

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One hundred fifty consecutive patients (71 female, 79 male) underwent mitral valve reconstruction from February of 1987 through February of 1991 for mitral regurgitation, with or without mitral stenosis. Of these patients, 134 had rheumatic mitral disease and required 1 or more procedures for correction. One hundred twenty-eight patients were age 30 or under. A posterior semicircular annuloplasty was performed, with the repair buttressed by a collar of Teflon felt; in addition, commissurotomy, papillary muscle splitting, chordal shortening, chordal and papillary fenestration, and closure of acquired clefts were performed as needed. Pre- and postoperative assessment of mitral regurgitation was carried out with the aid of echocardiography. Operative mortality was 3.3% (5 patients), and late mortality was 1.3% (2 patients). There were 3 episodes of thromboembolism at follow-up (mean time of occurrence, 16 months). ***(Texas Heart Institute Journal 1992;19:107-11)***

From June 1974 to January 1990, our approach to treating mitral regurgitation tended toward replacement: during this period, 1,077 patients underwent mitral valve replacement. However, in recent years we have approached this problem more and more with a view toward reconstruction, both because 85% of our patients with stenosed and regurgitant mitral valves are under 30 years of age, and because we have observed at surgery that a large number of these young patients have pliable anterior cusps. This paper describes our early results with valve reconstruction in these patients, using a posterior collar for support, in a technique similar to that described by Cooley.[1]

Patients and Methods

From February of 1987 through February of 1991, we performed reconstructive surgery for mitral regurgitation in 150 consecutive patients (71 female, 79 male) in whom the procedure was indicated (see below). Table I shows the age distribution. Eighty-four patients (56%) were under 20 years of age. The causes of regurgitation and the severity of the condition are shown in Table II. Preoperatively, all patients were in New York Heart Association (NYHA) functional class III or IV.

Key words: *Chordal shortening; echocardiography, Doppler; mitral valve insufficiency; mitral valve prolapse; mitral valve reconstruction; mitral valve stenosis*

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Indications for Reconstruction

If calcification was not extensive, mitral valve reconstruction was performed on symptomatic patients with pure mitral regurgitation or with regurgitation in combination with mitral stenosis. The decision to reconstruct rather than replace was made at surgery, upon direct visual assessment of the valve.

Echocardiography

Conventional transthoracic echocardiography (TTE) was performed preoperatively on all 150 patients in the parasternal, apical, and subcostal positions, using ATL Ultramark 8 or 9 equipment (Advanced Technology Laboratories; Bothell, Washington, USA). Mitral regurgitation was quantified from both the parasternal long-axis and apical 4-chamber views by mapping the regurgitant jet in the left atrium, using pulsed Doppler or color-flow mapping, or both. The jet was eccentric in some cases. Mitral valve area was calculated by Doppler, using the pressure half-time method.

Single-plane transesophageal echocardiography (TEE) using Hewlett-Packard Sonos 1000 equipment (77030A Ultrasound System, Hewlett-Packard Co.; Andover, Massachusetts, USA) was also performed preoperatively in the most recent 25 patients, after they had fasted for 6 hours. Topical Xylocaine (4%) was used to

TABLE I. Age Distribution of 150 Mitral Valve Reconstruction Patients

Age Group (Years)	Number of Patients	
0-10	12	128 (85%)
11-20	72	
21-30	44	
31-40	12	
41-50	9	
51-60	1	

anesthetize the hypopharynx. The 5-MHz single-plane transducer was introduced with the patient in the left lateral position; it was advanced between 20 and 25 cm, until the short-axis scan at aortic valve level was visualized. Scans in various other cardiac planes were obtained by rotating and tilting the transducer. After obtaining the 4-chamber scan (Fig. 1), we studied blood-flow patterns through the mitral valve by color-flow Doppler mapping. For subsequent review and analysis, we made a video recording of each patient's color-flow Doppler procedure. Each of these procedures was completed in 10 to 15 minutes, and there were no complications.

TABLE II. Causes and Severity of Mitral Regurgitation in 150 Patients Who Underwent Valve Reconstruction

Cause of Regurgitation	Number of Patients
Rheumatic fever	134
Congenital defect (ASD + MR)	10
Myxomatous prolapse	4
Infective endocarditis	2
Severity of Condition	**Number of Patients**
Severe regurgitation	41
Severe regurgitation with moderate stenosis	74
Moderate regurgitation with severe stenosis*	35

ASD = atrial septal defect; MR = mitral regurgitation

*Mitral valve area <1 cm^2

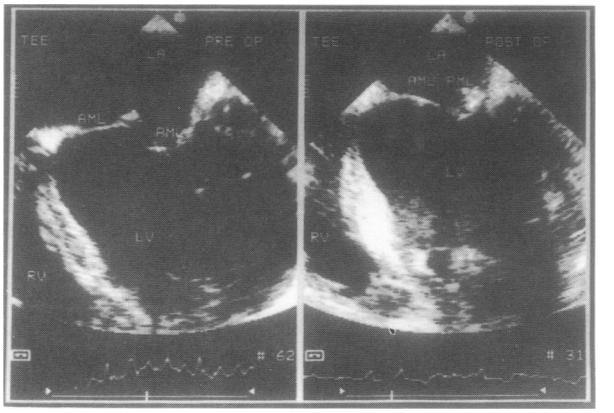

Fig. 1 *Preoperative (left panel) and postoperative (right panel) echocardiograms (transesophageal 4-chamber views) showing anatomic correction. In the postoperative panel, the dense echoes behind the posterior mitral leaflet are from the Teflon felt.*

AML = anterior mitral leaflet; LA = left atrium; LV = left ventricle; PML = posterior mitral leaflet; RA = right atrium; RV = right ventricle

The severity of the regurgitation was assessed during systole by measuring the maximum area in the left atrium affected by the regurgitant jet. The following scale was used to grade severity: Trivial (grade I) = jet affecting an area less than 1 cm above the valve; Mild (grade II) = jet affecting less than one-third of the left atrium; Moderate (grade III) = jet affecting from one-third to one-half of the left atrium; Severe (grade IV) = jet affecting more than one-half of the left atrium. An average of 3 beats was taken for patients in sinus rhythm and 5 beats for those with atrial fibrillation. The mitral valve apparatus itself was studied for leaflet thickening, mobility, and subvalvular structural details.

Pulmonary Hypertension

In 17 patients with tricuspid regurgitation, right ventricular systolic pressure was calculated echocardiographically by measuring the velocity of the regurgitant jet: pressures ranged from 29 to 58 mmHg (mean, 45 mmHg). Not all 150 patients undergoing mitral valve surgery were catheterized. (We now accept, without catheterization, patients with single-valve lesions.) In the 56 patients who did undergo cardiac catheterization, pulmonary artery pressures ranged from 24 to 63 mmHg (mean, 37.7 mmHg). In the remaining 94 patients, pulmonary artery pressures at surgery ranged from 25 to 68 mmHg (mean, 39.1 mmHg).

Surgical Technique

Surgery was performed through a median sternotomy, with ascending aortic and bicaval cannulation. Systemic hypothermia, cold blood cardioplegia, and

topical ice slush were used for myocardial protection.

A few minutes were spent in assessing the condition of the mitral valve. Thrombus, if any, was removed. Once a decision was made to reconstruct, the procedure was carried out in the following order (as necessary): 1) release of fused commissurae and chordae; 2) splitting of papillary muscle; 3) assessment of anterior cusp mobility; 4) correction of prolapse or chordal lengthening by chordal shortening at the cusp level;[2] 5) closure, with interrupted 2-0 sutures, of acquired clefts in the posterior cusp; and 6) posterior annuloplasty using a semicircular piece of Teflon felt with interrupted 2-0 sutures (Fig. 2).

Table III lists the lesions that were corrected in association with mitral valve reconstruction.

Follow-up

For assessment of residual mitral regurgitation and stenosis, all surviving patients underwent postoperative 2-dimensional and color-flow Doppler echocardiography at 1, 3, and 6 months, and at yearly intervals thereafter. In addition, 25 of the most recent patients have undergone transesophageal echocardiography 6 to 14 days postoperatively. All patients received acenocoumarin and dipyridamole in the postoperative period. Acenocoumarin was discontinued after 6 weeks, and dipyridamole after 6 months.

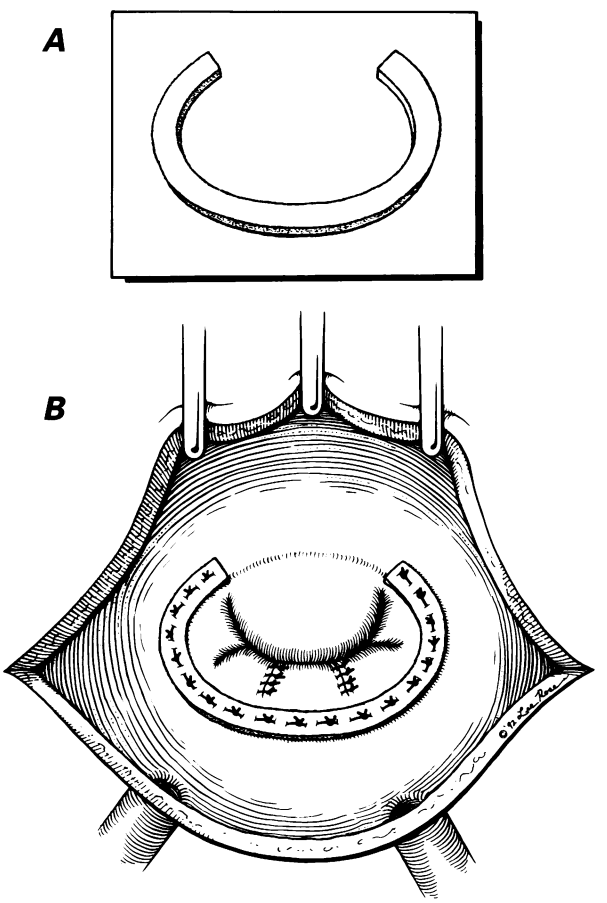

Fig. 2 ***A)*** *The semicircular Teflon collar;* ***B)*** *the completed posterior annuloplasty.*

TABLE III. Mitral Valve Reconstruction: Operative Procedures in 150 Patients

Reconstructive Procedures	Number of Patients
Commissurotomy	109
Annuloplasty (Teflon felt, n = 128; other, n = 5)	133
Papillary muscle splitting	37
Chordal and/or papillary fenestration	12
Closure of acquired clefts	62
Chordal shortening	28
Left atrium clot removal	3
Decalcification	3
Associated Procedures	
Tricuspid valve repair (DeVega)	12
Tricuspid valvotomy and repair	2
Aortic valve replacement	9
Closure of atrial septal defect	10

Results

There were 5 hospital deaths (within 30 days), for a 3.3% operative mortality. In addition, there were 2 late deaths, 1 of which was caused by thromboembolism at 2 postoperative months (Table IV). Two other patients had clinically manifest thromboembol-

TABLE IV. Mitral Valve Reconstruction: Results

Cause of Death	Number of Patients	
Early Mortality	5	(3.3%)
Pledget embolism	1	
Low output	3	
Cerebral infarction (air)	1	
Late Mortality	2	(1.3%)
Thromboembolism (at 2 months)	1	
Transfusion hepatitis (at 2 months)	1	

ic episodes: 1 was a 5-year-old who recovered without residual deficit, and the other was a 20-year-old who suffered left hemiparesis. The mean time of occurrence for these 3 thromboembolic episodes was at 16 postoperative months.

In 4 of the 150 patients (2.6%), the initial attempt at repair failed. In 2 patients, the repair was revised within 6 weeks, with satisfactory correction. In 2 other patients, the native valve was replaced at 1 and 4 postoperative years; both of these patients were symptomatic at reoperation. With the exception of 6 patients who remain in NYHA functional class II due to persistent atrial fibrillation, all surviving patients with repaired mitral valves have shown satisfactory clinical improvement and have progressed to functional class I.

Postoperative echocardiographic assessment has shown mitral regurgitation, in most instances, to be trivial or mild (Table V). Moreover, when the most recent 25 patients underwent TEE 6 to 14 days postoperatively, assessments of their regurgitation by that technique correlated well with assessments by TTE. Nor has there been any indication of significant mitral stenosis in these patients, when mitral valve area has been calculated by Doppler echocardiography (Table V).

Discussion

Combined mitral regurgitation and stenosis has always been a technical challenge. Although controversy exists regarding long-term results in repair of combined lesions, particularly in rheumatic valves, we have been encouraged by the results of other clinicians.[3-7] We consider that careful observation of anterior mitral leaflet movement in the apical 4-chamber view (not to exclude the importance of other views) is extremely helpful in preoperative assessment of a valve's reparability (Fig. 1). It has been our observation that release of fused commissurae and chordae improves mobility considerably; fenestration of fused chordae and papillary muscles helps in debulking the anterior mitral leaflet. Follow-up results at 3 years have been satisfactory, with no progression of mitral regurgitation.

The customary technique of repairing elongated chordae, described by Carpentier and associates,[8] involves shortening the chorda or chordae at the level of the papillary muscle. Frater and colleagues[9] were the first to describe the technique of shortening at the cusp level. Cusp-level chordal shortening can be performed easily in rheumatic mitral disease, since the chordae are thickened; indeed, this technique may not be suitable when chordae are thin.[2]

The use of a posterior collar for annuloplasty has been previously described. The technique used here is essentially that described by Cooley's group.[1] The difference is in the collar prosthesis itself: Cooley, in 1976, described an open C-ring constructed of titanium wire covered by a Dacron double-velour knitted material that was chosen to encourage tissue ingrowth; we have used a collar of low-porosity Teflon felt (USCI, Division of C.R. Bard, Inc.; Billerica, Massachusetts, USA). We have not ob-

TABLE V. Postoperative Echocardiography (TTE): Results

Severity of Mitral Regurgitation	No. of Patients (1 month)	No. of Patients (6 months)	No. of Patients (12 months)	No. of Patients (24 months)	No. of Patients (36 months)
No mitral regurgitation	20	—	—	—	—
Trivial	35	29	13	3	1
Mild	95	81	69	28	11
Moderate	—	5	8	4	2
	—	—	—	—	—
	150	115	90	35	14

Mitral Valve Area (Unindexed)	No. of Patients
>3.1 cm^2	24
2.6 cm^2 - 3.0 cm^2	120
2.0 cm^2 - 2.5 cm^2	3
<2.0 cm^2	1

served any serious complications in our follow-up with the use of Teflon felt.

Acknowledgment

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