Results of Operation for Coexistent Obstructive Hypertrophic Cardiomyopathy and Coronary Artery Disease

IRA L. SIEGMAN, MD, BARRY J. MARON, MD, FACC, LESTER C. PERMUT, MD, CHARLES L. McINTOSH, MD, PHD, RICHARD E. CLARK, MD
Bethesda, Maryland

This study describes the operative management and outcome of 28 patients with obstructive hypertrophic cardiomyopathy and hemodynamically significant coronary artery disease. Each patient underwent coronary artery bypass grafting and concomitant left ventricular myotomy-myectomy or mitral valve replacement. The mean age at operation was 59 years (range 42 to 74).

Five patients (18%) died as a result of operation, four in the immediate postoperative period and one at 2 months postoperatively. Three patients died after the immediate postoperative period of causes unrelated to the operation. The mean follow-up period for the 20 currently surviving patients was 4.8 years (range 4 months to 10.8 years). Nineteen of these patients have experienced substantial functional improvement; all are currently asymptomatic or only mildly symptomatic.

Twenty-one patients underwent cardiac catheterization before and after operation; each experienced relief of left ventricular outflow tract obstruction after operation. Twelve patients had a preoperative outflow gradient ≥50 mm Hg (average 86 ± 7) under basal conditions, which decreased to 3 ± 1.8 mm Hg postoperatively (p < 0.001). Nine patients had a severe preoperative gradient only with a provocative maneuver (average 93 ± 6 mm Hg), which decreased to 24 ± 8 mm Hg postoperatively (p < 0.001). Five of the 24 patients undergoing left ventricular myotomy-myectomy incurred an iatrogenic ventricular septal defect. This operative complication occurred primarily in patients with a relatively thin ventricular septum (<20 mm) and contributed importantly to postoperative death in two of the patients.

Marked symptomatic and hemodynamic benefit can be achieved in patients requiring operation for obstructive hypertrophic cardiomyopathy and coronary artery disease. Operative mortality was higher than that in patients operated on for either disease alone, in part because of an increased frequency of iatrogenic ventricular septal defect. Consequently, mitral valve replacement may be preferable to left ventricular myotomy-myectomy in some patients with obstructive hypertrophic cardiomyopathy, coronary artery disease and relatively thin ventricular septum.

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Operation has constituted an important component of the therapeutic management of severely symptomatic patients with obstructive hypertrophic cardiomyopathy since the first procedure for this condition was performed by Cleland (1) in 1958. Experience at several centers (2–14) with left ventricular myotomy-myectomy or mitral valve replacement during the past 30 years indicates that most patients benefit symptomatically from relief of left ventricular outflow tract obstruction and concomitant reduction of the elevated intraventricular systolic pressure.

Clinical awareness and recognition of hypertrophic cardiomyopathy in patients of all ages has been enhanced over the past 15 years, largely due to the widespread application of diagnostic echocardiography. Consequently, increasing numbers of patients with both obstructive hypertrophic cardiomyopathy and concomitant angiographically documented coronary artery disease are being identified (15–20). The presence of these two major cardiac diseases in a single patient may necessitate operative treatment for both. Short-term results (<2 year follow-up) for such operations have been previously reported (18–20) in a small number of patients. The present report documents the long-term clinical outcome of a large group of patients who underwent operation for both obstructive hypertrophic cardiomyopathy...
and coronary artery disease. Assessment of the hemodynamic and functional status of these patients may serve to clarify the role of operative therapy in this subgroup of patients.

Methods

Selection of patients. The records of 466 patients undergoing operation for obstructive hypertrophic cardiomyopathy at the National Heart, Lung, and Blood Institute between 1960 and 1987 were reviewed. In each, left ventricular myotomy-myectomy or mitral valve replacement was performed to relieve left ventricular outflow tract obstruction. Twenty-eight (6%) of these patients also underwent concomitant coronary artery bypass and comprise the present study group.

The mean age at the time of operation was 59 years (range 42 to 74); 17 (61%) were men and 11 were women. The clinical condition of each patient was evaluated as of January 1, 1988. The mean follow-up period for those 23 patients who were discharged from the hospital after operation was 4.8 years (range 4 months to 10.8 years).

Patient characteristics. Each of the 28 patients was initially referred for evaluation and treatment of hypertrophic cardiomyopathy. All met the following criteria for the diagnosis of the obstructive form of hypertrophic cardiomyopathy (21): 1) echocardiographic demonstration of asymmetric hypertrophy of the ventricular septum and a nondilated left ventricle; 2) obstruction to left ventricular outflow resulting from marked systolic anterior motion of the mitral valve; and 3) absence of an associated cardiac or systemic disease capable of producing left ventricular hypertrophy of the magnitude identified in that patient. Eleven patients (39%) had mild systemic hypertension (systolic blood pressure 140 to 170 mm Hg or diastolic pressure 90 to 100 mm Hg, or both) that was documented by history or physical examination. In each, hypertension had been well controlled by drug therapy. During the course of diagnostic evaluation, significant atherosclerotic narrowing (>50% of luminal diameter) of one or more extramural coronary arteries was documented by coronary arteriography in each patient.

The study patients were recommended for operative treatment based on the following: 1) severe cardiac symptoms and functional limitation (New York Heart Association functional class III or IV); 2) left ventricular outflow tract gradient of ≥50 mm Hg under basal conditions or with provocative interventions (Valsalva maneuver, amyl nitrite inhalation or isoproterenol infusion); and 3) angiographically significant coronary artery disease, as previously defined.

Left ventricular myotomy-myectomy is the preferred operative procedure for patients with hypertrophic cardiomyopathy at this institution and was performed in 24 of the 28 study patients. The remaining four patients underwent mitral valve replacement because the basal ventricular sep-

Operative Techniques

Ventricular septal myotomy-myectomy. The operative technique was that described by Morrow (22). Briefly, the operation is performed through a vertical aortotomy; a bar of muscle is excised from the basal portion of the anterior septum creating a rectangular trough 1 cm wide, 1 cm deep, 4 cm in length and extending from just below the aortic anulus to a point distal to the region of systolic mitral valve-septal contact. This results in enlargement of the cross-sectional area of the left ventricular outflow tract. The average mass of resected septal muscle in 17 of the 24 patients was 1.9 g (range 0.8 to 4.3).

Mitral valve replacement. This was performed in four patients utilizing standard techniques (23). The small left ventricular cavity of patients with obstructive hypertrophic cardiomyopathy required implantation of a low profile tilting-disc prosthesis (Björk-Shiley model MBRP; two were 23 mm and two were 25 mm).

Coronary artery bypass grafting. Bypass grafts were constructed with reversed saphenous veins in all 28 patients. Myocardial revascularization was performed after myotomy-myectomy. Coronary bypass grafts were constructed before valve implantation in all four patients who underwent mitral valve replacement.

Eleven patients received a single bypass graft, 10 received two grafts, 6 received three grafts and 1 patient received four grafts. The left anterior descending coronary artery was most frequently bypassed artery (in 18 patients); other bypassed arteries were the right coronary artery (in 14), obtuse marginal branch (in 13), diagonal branch (in 4) and posterior descending artery (in 2). Five of these 53 arteries required endarterectomy before bypass grafting. Of the 28 study patients, 21 underwent bypass of all significantly diseased arteries and were therefore considered to have had complete myocardial revascularization. In the other seven patients, it was not possible to bypass one diseased artery because of the small caliber of the vessel; these patients were considered to have had incomplete revascularization.

Myocardial protection. Two methods of myocardial protection were used. Before July 1983, left ventricular myotomy-myectomy was performed with 30°C total body hypothermia and ischemic arrest (18 patients); intermittent coronary perfusion with cold crystalloid cardioplegic solution was employed during myocardial revascularization. Since July 1983, induction of cardioplegic arrest has been carried out before myotomy-myectomy or mitral valve replacement with the use of a cold, oxygenated, hyperkalemic crystalloid solution (10 patients). The cardioplegic solution
was administered every 20 min throughout the operative procedure. In addition, topical myocardial cooling was carried out with iced slush. The mean duration of aortic cross clamping was 92 min (range 34 to 211).

Echocardiography. Two-dimensional echocardiograms were performed with either an Advanced Technology Laboratory Mark 500 or a Diasonics CV-400 real-time mechanical sector scanner and a 2.25 MHz transducer. M-mode echocardiograms were recorded with a dedicated Irex System III ultrasound unit or derived from two-dimensional images under direct anatomic visualization. Left ventricular dimensions were measured in accordance with the recommendations of the American Society of Echocardiography (24).

Statistical methods. Data are expressed as mean values ± standard error. Differences between group means were analyzed using the unpaired Student’s t test. Nonparametric data were analyzed using the chi-square test.

Results

Mortality (Fig. 1). Operative mortality. Four (14%) of the 28 patients died in the immediate postoperative period (≤30 days) because of low cardiac output (two patients), iatrogenic ventricular septal defect (one patient) and mediastinitis (one patient). One other patient died 2 months postoperatively of left ventricular failure that occurred immediately after patch closure of a ventricular septal defect created during the initial operation. Hence, 5 (18%) of the 28 patients died as a consequence of operation. These five patients did not differ from those who survived operation with respect to the method of myocardial preservation or the duration of aortic cross clamping. The mortality rate was 16% (3 of 19) in patients undergoing operation with ischemic arrest and 22% (2 of 9) in patients without ischemic arrest. Mean cross-clamp time was 116 min in patients who died as a result of operation and 103 min in those who survived.

Late mortality. One patient who had a mitral valve replacement died after a cerebrovascular accident 4 months after operation. A second patient died from lung cancer 2 years after operation and a third from progressive congestive heart failure 7 years after operation.

Echocardiography. Preoperative echocardiograms were available for analysis in 27 of the 28 patients. Ventricular septal thickness was measured at end-diastole at mitral valve level where systolic anterior motion was evident. Mean septal thickness was 21 mm (range 15 to 38); it was <18 mm in four patients and >30 mm in three. The mean left ventricular posterior wall thickness was 12 mm (range 8 to 18); the mean left ventricular transverse end-diastolic dimension was 42 mm (range 34 to 52).

Hemodynamics (Fig. 2 and 3). Complete preoperative and postoperative cardiac catheterization was performed in 21 patients. Ventricular septal thickness was measured at end-diastole at mitral valve level where systolic anterior motion was evident. Mean septal thickness was 21 mm (range 15 to 38); it was <18 mm in four patients and >30 mm in three. The mean left ventricular posterior wall thickness was 12 mm (range 8 to 18); the mean left ventricular transverse end-diastolic dimension was 42 mm (range 34 to 52).

Figure 1. Flow diagram showing clinical outcome in 28 patients undergoing coronary artery bypass grafting and either left ventricular myotomy-myectomy or mitral valve replacement. Ca = cancer; CHF = congestive heart failure; CVA = cerebrovascular accident.
Each of the 28 patients had severe functional limitation due to exertional dyspnea and fatigue; 21 of the 28 patients were alive. Twenty of these had improved at least one functional class compared with their preoperative condition, including 19 patients who were asymptomatic or had only mild symptoms. In the remaining two patients there was little or no functional improvement after operation, and both remained in functional class III. The lack of improvement in these latter patients appeared to be due to an iatrogenic ventricular septal defect in one and to occlusion of the single coronary bypass graft constructed in the other. Both patients became asymptomatic after reoperation (patch repair of septal defect and coronary bypass grafting, respectively). All patients described improvement in the severity of their chest pain, including 15 with complete relief. This improvement in chest pain occurred even though 10 of these patients had occlusion of one or two bypass grafts demonstrated by the postoperative catheterization.

**Short-term follow-up.** Six months after operation, 22 of the 28 patients were alive. Twenty of these had improved at least one functional class compared with their preoperative condition, including 19 patients who were asymptomatic or had only mild symptoms. In the remaining two patients there was little or no functional improvement after operation, and both remained in functional class III. The lack of improvement in these latter patients appeared to be due to an iatrogenic ventricular septal defect in one and to occlusion of the single coronary bypass graft constructed in the other. Both patients became asymptomatic after reoperation (patch repair of septal defect and coronary bypass grafting, respectively). All patients described improvement in the severity of their chest pain, including 15 with complete relief. This improvement in chest pain occurred even though 10 of these patients had occlusion of one or two bypass grafts demonstrated by the postoperative catheterization.

**Long-term follow-up.** At most recent follow-up, 20 patients were alive, 19 of whom were asymptomatic or only mildly symptomatic (functional class I or II). One patient's condition deteriorated from class II, 6 months after operation to class III at long-term follow-up. Seventeen (85%) of the 20 patients had minimal or no chest pain, whereas three experienced recurrence of angina. The four patients with syncope before operation did not experience this symptom after operation.

**Complications.** Ventricular septal perforation occurred as a consequence of the resection of septal muscle in 5 (21%) of the 24 patients who underwent myotomy-myectomy. In one patient, the ventricular septal defect was detected intraoperatively and repaired with a Teflon patch. This patient died on the 2nd postoperative day; disruption of the repair and a persistent septal defect was identified at necropsy. In the four other patients, the ventricular septal defect was detected after operation. Pulmonary to systemic flow ratio was measured at cardiac catheterization and ranged from 2.0:1 to 3.4:1. In two of these four patients the ventricular septal defect was detected early after operation (2 days and 12 days, respectively) when clinical deterioration occurred and a holosystolic murmur was heard. Both patients underwent patch repair of the defect shortly thereafter; one had a 1.2 cm defect and died the day after repair and the other was found to have a large defect surrounded by an area of necrosis. This latter patient experienced marked symptomatic and hemodynamic improvement after repair. In the two remaining patients, the ventricular septal defect was first recognized at the 6 month postoperative catheterization. Patch repair of a 1.5 cm defect was performed in one of these patients who subsequently showed marked clinical improve-
ment. The other patient was asymptomatic and the septal defect was not closed.

Preoperative echocardiographic data were available in four of five patients who had an iatrogenic ventricular septal defect. The basal septal thickness was significantly less in these 4 patients (mean 18.5 mm; range 15 to 22) than in the 19 who did not incur this complication (mean 23.1 mm; range 17 to 38; p < 0.05). In those patients who underwent mitral valve replacement, septal thickness was similar to that in those patients who incurred a ventricular septal defect after myotomy-myectomy (mean 18.0 versus 18.5 mm).

There did not appear to be a relation between occurrence of ventricular septal defect and either distribution of coronary artery stenosis or completeness of myocardial revascularization. Only 2 (40%) of the 5 patients with a septal defect had significant stenosis of the proximal left anterior descending coronary artery whereas 14 (73%) of 19 patients without a septal defect had stenosis of this artery. Myocardial revascularization was considered to be incomplete in 1 (20%) of the 5 patients with a septal defect and in 6 (32%) of 19 patients without a septal defect.

Complete heart block necessitating implantation of a permanent pacemaker appeared postoperatively in 2 of the 24 patients who underwent left ventricular myotomy-myectomy. Heart block resulted from the resection of septal muscle in one and appeared after patch repair of a ventricular septal defect (performed 1 month after myotomy-myectomy) in the other. Preoperatively, neither patient had right bundle branch block or other conduction defects.

Discussion

The results of the present study show that important long-term symptomatic benefits can be achieved in patients with obstructive hypertrophic cardiomyopathy and coronary artery disease undergoing concomitant operation for both conditions. The 28 patients studied comprise the largest reported series of patients treated operatively for both diseases simultaneously. Twenty of the 28 patients survived the overall follow-up period (mean 4.8 years; maximum 11 years) and 95% of these patients showed substantial and persistent improvement in symptoms and functional capacity.

Results of operation. Operation for obstructive hypertrophic cardiomyopathy (left ventricular myotomy-myectomy or mitral valve replacement) was undertaken to relieve dynamic obstruction to left ventricular outflow. Hemodynamic results after operation in these patients are similar to those previously reported for patients with obstructive hypertrophic cardiomyopathy unassociated with other cardiac diseases (1-14). After operation, each patient had complete or substantial reduction of the basal outflow tract gradient to \( \leq 20 \text{ mm Hg} \). Almost 90% of patients operated on primarily for relief of provokable obstruction (with no or small gradient under basal conditions) had a provokable gradient \( \leq 40 \text{ mm Hg} \) after operation. In addition, about two-thirds of all patients who had elevated left ventricular end-diastolic pressure preoperatively had a normal value after operation.

It is difficult to assess the relative contributions of hypertrophic cardiomyopathy and coronary artery disease to the symptoms described by patients in whom these two diseases coexist. This is due, in large part, to the complex and often overlapping pathophysiologic processes involved and the different mechanisms by which myocardial ischemia occurs in these two diseases (25-27). Consequently, it is also difficult to assess the relative contributions made by the relief of left ventricular outflow obstruction and myocardial revascularization to the symptomatic and functional improvement reported by our patients after operation. Nevertheless, given the serious potential consequences of either unrelied outflow obstruction or of unrelied hemodynamically significant coronary artery stenosis, it would appear advisable to treat both diseases operatively at the same time.

Operative complications. Despite the favorable symptomatic and hemodynamic results obtained in the majority of our patients, the mortality and morbidity directly related to combined myotomy-myectomy and bypass grafting were somewhat greater than those previously reported in patients undergoing operation for either condition alone (11,27-29). The operative mortality for coronary artery bypass grafting at this institution (including those patients with impaired left ventricular function) has been 2.5%, whereas that for left ventricular myotomy-myectomy has been 2.7% during the same time period as the present study. We do not believe that there is reason to implicate the technique of myocardial preservation during operation for the mortality experienced in the present study group; for example, the mean aortic cross-clamp time of 92 min was not excessive for this combined procedure. In addition, the mortality rate when myotomy-myectomy was performed with ischemic arrest before 1983 did not differ from that when the technique of myocardial protection was modified to avoid arrest after 1983.

Ventricular septal defect. This complication occurred in 5 of the 24 patients undergoing left ventricular myotomy-myectomy and was the cause of death in 3 of these patients. This frequency of septal defect is greater than the 4% incidence previously reported (10) in a series of patients undergoing only myotomy-myectomy (without myocardial revascularization). There are several possible explanations for the increased occurrence of ventricular septal defect in the present study group. Resection of muscle from the ventricular septum during myotomy-myectomy obviously poses a greater risk when septal thickness is only mildly increased (i.e., 15 to 19 mm) than when the septal thickness is \( \geq 20 \text{ mm} \). Indeed, those patients who incurred a ventricular septal defect had a significantly thinner septum before operation than did those patients without a septal defect. Neverthe-
less, about one-third of our patients without a ventricular septal defect had septal thickness ≤19 mm, suggesting that other factors may be important in determining if a ventricular septal defect will result from operation. In this regard, one potential factor is septal ischemia. This could result from extramural coronary artery stenoses or the small artery abnormalities that are common in patients with hypertrophic cardiomyopathy (27). The presence of septal ischemia could alter tissue consistency and cause the septal myocardium to be less firm, thereby predisposing it to perforation. The presence of septal ischemia could alter tissue consistency and cause the septal myocardium to be less firm, thereby predisposing it to perforation.

**Role of mitral valve replacement.** Left ventricular myotomy-myectomy remains the procedure of choice in the majority of patients with obstructive hypertrophic cardiomyopathy requiring operation. The data presented here, however, suggest that mitral valve replacement might be a preferable operation in certain patients with obstructive hypertrophic cardiomyopathy and coronary artery disease. Mitral valve replacement eliminates the risk of septal perforation associated with myotomy-myectomy while providing relief of left ventricular outflow tract obstruction as effectively as myotomy-myectomy (3,13). Indeed, four of our patients, each of whom had a relatively thin ventricular septum, underwent mitral valve replacement with such consideration in mind. The long-term outcome of patients with hypertrophic cardiomyopathy after mitral valve replacement is not certain, although short-term data (30) would suggest that most patients experience symptomatic and hemodynamic improvement.

The risks of mitral valve replacement in patients with hypertrophic cardiomyopathy are those that are characteristic of mechanical prosthesis implantation in general; these include mechanical dysfunction, thromboembolism and complications associated with anticoagulant therapy. The risk of mitral valve replacement and concomitant myocardial revascularization in patients with hypertrophic cardiomyopathy should not, however, be equated with the relatively high risk of this procedure in patients with coronary artery disease and coexisting mitral regurgitation (31). The latter patients generally have poor left ventricular function, which is largely responsible for operative mortality; in contrast, patients with obstructive hypertrophic cardiomyopathy usually have a hyperdynamic left ventricle.

**Conclusions.** Marked hemodynamic benefit and long-term symptomatic improvement can be achieved in most patients with coexistent coronary artery disease and obstructive hypertrophic cardiomyopathy who undergo operation for both conditions at the same time. Combined left ventricular myotomy-myectomy and coronary artery bypass grafting was associated with greater morbidity and mortality than those reported after either operation alone. These findings warrant consideration of mitral valve replacement as an operative alternative to myotomy-myectomy in patients with both coronary artery disease and obstructive hypertrophic cardiomyopathy.

### References


