Hypertrophic Obstructive Cardiomyopathy
Initial Results and Long-term Follow-up After Morrow Septal Myectomy

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Background This study was performed to assess the initial results and long-term follow-up of Morrow septal myectomy for patients with hypertrophic obstructive cardiomyopathy (HOCM). Methods and Results We studied 38 consecutive patients with HOCM (age, 13 to 74 years) who underwent a Morrow septal myectomy between 1977 and 1992. There were no perioperative deaths, and the postoperative course was uneventful for all except 2 of the patients. One patient required implantation of a pacemaker due to a complete heart block, and in 1 patient a small ventricular septal defect was caused. Follow-up (mean, 6.8 years) was 100% complete. No patient was reoperated for recurrent HOCM. All except 1 patient experienced a major functional improvement with a decrease of the mean New York Heart Association functional class from 3.0 before operation to 1.5 at follow-up (P<.001). Symptoms persisting during follow-up were angina pectoris in 3 of 22 patients (14%), dyspnea in 6 of 30 patients (20%), dizzy spells in 2 of 12 patients (17%), and syncope in 2 of 10 patients (20%). During follow-up no HOCM related death occurred. All patients were restudied by Doppler echocardiography. The peak gradient in the left ventricular outflow tract decreased from 72±30 mm Hg (range, 31 to 144 mm Hg) to 6±4 mm Hg (range, 0 to 20; P<.001). A systolic anterior motion was seen in 8 patients (21%) compared with 32 patients (97%) before the operation (P<.001). The left ventricular outflow tract diameter increased from 17±3 mm (range, 10 to 23 mm) to 22±3 mm (range, 15 to 33 mm; P<.001), and the mean subaortic septal thickness decreased from 23±5 mm (range, 15 to 35 mm) to 15±6 mm (range, 8 to 30 mm; P<.001). Conclusions Morrow septal myectomy for patients with HOCM is a safe procedure with an excellent clinical and Doppler echocardiographic long-term follow-up. (Circulation. 1994;90:1781-1785.)

Key Words • septal myectomy • cardiomyopathy • hypertrophy • echocardiography, Doppler

Hypertrophic obstructive cardiomyopathy (HOCM) is a disease with significant morbidity and mortality.1-4 The most common causes of mortality (annual rate, 3% to 8%) are sudden cardiac death due to arrhythmias and congestive heart failure.5 Medical therapy is usually the initial treatment with proved effectiveness.6 The treatment of choice for patients with symptoms refractory to medical therapy and a significant subaortic pressure gradient is septal myectomy.7 Although mitral valve replacement has been advocated, it is not the routine except for severe mitral regurgitation due to organic valve disease.8,9 Just recently, the initial results of a new therapeutic option, eg, dual-chamber pacing, for HOCM have been reported.10-12

The present study was undertaken to assess the initial results and long-term clinical and echocardiographic follow-up of Morrow septal myectomy for patients with HOCM operated on at one institution.

Methods

Study Patients

Between 1977 and 1992, 38 consecutive patients with HOCM underwent a Morrow septal myectomy at the St Antionius Hospital, Nieuwegein, The Netherlands.

The indication for operation was based on (1) the presence of severe symptoms despite appropriate doses of beta-blockers, calcium antagonists, or both, and (2) a peak gradient in the left ventricle of ≥50 mm Hg under basal conditions. Patients who underwent an aortic valve replacement because of aortic stenosis with concomitant septal myectomy were excluded from this study. Before surgical intervention, all patients were studied by Doppler echocardiography, catheterization, or both. Thirty-one patients underwent both Doppler echocardiography and catheterization. In 5 patients, the diagnosis was made by catheterization only, and in 2 patients, by Doppler echocardiography only.

Echocardiography

Mitral and aortic regurgitant jets were visualized in multiple orthogonal planes by color flow Doppler. Care was taken to demonstrate the maximum regurgitant jet by transducer angulation and nonstandard transducer positions. Mitral regurgitation was graded by determining the maximum regurgitant area relative to the left atrial area using multiple acoustic windows.13 Aortic regurgitation was graded through determination of the regurgitant jet width at the orifice of the aortic valve relative to the diameter of the left ventricular outflow tract in the parasternal or apical long-axis view.14 The Doppler echocardiograms were analyzed by two independent cardiologists.

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Surgical Procedure

All patients underwent a Morrow septal myectomy. Through the opened aorta, a U-shaped bar of muscle is excised from the anterior septum, the first incision is made just beneath the nadir of the right coronary cusp, and the second incision about 1 cm to the left both extending into the apex. A third incision is made with a Turkish knife, which is pulled from the apical to the basal septum, cutting a U-shaped bar of muscle and creating a sort of tunnel. Attention was paid to not extend the tunnel to the right since this is the site of the conduction pathways. Additional cardiac surgery was performed when necessary.

Patient Evaluation

All patients were seen at the outpatient department at regular intervals or immediately when symptoms reoccurred. Between November 1992 and January 1993, the patients were restudied both clinically and by Doppler echocardiography at our institution.

Statistical Analysis

Mean±SD values were given for continuous variables and were analyzed using the Student’s t test for paired variables where appropriate. The χ² or Fisher’s exact test was used to compare discontinuous variables.

Results

Morrow septal myectomy was performed in 19 women and 19 men with a mean age of 50±15.6 years (range, 13 to 74 years). Only 1 patient had undergone a previous septal myectomy in combination with a mitral valve replacement in another hospital. The most prevalent symptoms before operation were dyspnea in 30 of the patients (79%) and angina pectoris in 22 of the patients (58%). The mean New York Heart Association (NYHA) functional class before operation was 3.0±0.6. Doppler echocardiography in 33 patients showed a peak gradient in the left ventricular outflow tract of 72±30 mm Hg. A systolic anterior movement was present in 32 of the 33 patients (97%). The mean gradient in the left ventricular outflow tract measured by catheterization in 36 patients was 85±37 mm Hg (Table 1).

Additional cardiac surgery was performed in 12 patients. Mitral valve replacement was necessary in 4 patients. Two patients were operated for HO CM and active mitral valve endocarditis. The other 2 patients had severe mitral regurgitation. Additional aortic valve replacement due to severe aortic regurgitation was performed in 4 patients, and another 4 patients required coronary artery bypass graft surgery.

The perioperative course was not complicated by any deaths. The postoperative course was uneventful except for a complete heart block in 1 patient who required placement of a permanent pacemaker and a small ventricular septal defect in another patient, who is still asymptomatic.

The long-term follow-up was 100% complete, and all of the patients were restudied clinically and by Doppler echocardiography. The mean follow-up period was 6.8 years (range, 0.5 to 14 years). During this follow-up, none of the patients were reoperated for recurrent HO CM, and there was a significant decrease in symptomatology. The mean NYHA functional class decreased from 3.0±0.6 before surgery to 1.5±0.6 (P<.001) at the time of follow-up (Fig 1). Angina pectoris persisted in 3 of the 22 patients (14%), dyspnea in 6 of the 30 patients (20%), dizzy spells in 2 of the 12 patients (17%), and syncope in 2 of the 10 patients (20%). After an asymptomatic follow-up of 5 years, 1 patient died due to an acute myocardial infarction. Another patient had a myocardial infarction 2 years after septal myectomy and underwent successful percutaneous transluminal coronary angioplasty. Only 1 patient had a sustained ventricular tachycardia 4 years after septal myectomy, which was successfully treated with amiodarone. One patient had a syncope 6 years after the operation due to a complete atrioventricular block that required a permanent pacemaker. Last, 1 patient experienced dizzy spells and syncope, but no organic cardiac disease could be detected.

Follow-up Doppler echocardiography showed a significant decrease of the peak gradient in the left ventricular outflow tract gradient from 72±30 mm Hg (range, 31 to 144 mm Hg) to 6±4 mm Hg (range, 0 to 20

Patient, Echocardiographic, and Catheterization Characteristics at Baseline of 38 Patients With Hypertrophic Obstructive Cardiomyopathy

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, y</td>
<td>50±15.6 (range, 13-74)</td>
</tr>
<tr>
<td>Male sex, n (%)</td>
<td>19 (50)</td>
</tr>
<tr>
<td>Symptoms (n=38), n (%)</td>
<td></td>
</tr>
<tr>
<td>Dyspnea</td>
<td>30 (79)</td>
</tr>
<tr>
<td>Angina</td>
<td>22 (58)</td>
</tr>
<tr>
<td>Dizzy spells</td>
<td>12 (32)</td>
</tr>
<tr>
<td>Syncpe</td>
<td>10 (26)</td>
</tr>
<tr>
<td>Tiredness</td>
<td>28 (74)</td>
</tr>
<tr>
<td>Palpitations</td>
<td>18 (47)</td>
</tr>
<tr>
<td>Mean NYHA functional class</td>
<td>3.0±0.6</td>
</tr>
<tr>
<td>Echocardiography (n=33)</td>
<td></td>
</tr>
<tr>
<td>Peak subaortic gradient, mm Hg</td>
<td>72±30 (range, 31-144)</td>
</tr>
<tr>
<td>Mean septal thickness, mm</td>
<td>23±5 (range, 15-35)</td>
</tr>
<tr>
<td>Mean outflow tract diameter, mm</td>
<td>17±3 (range, 10-23)</td>
</tr>
<tr>
<td>Systolic anterior movement, n (%)</td>
<td>32 (97)</td>
</tr>
<tr>
<td>Catheterization (n=36)</td>
<td></td>
</tr>
<tr>
<td>Peak subaortic gradient, mm Hg</td>
<td>85±37 (range, 40-190)</td>
</tr>
<tr>
<td>LVEDP, mm Hg</td>
<td>14±8 (range, 2-28)</td>
</tr>
</tbody>
</table>

NYHA indicates New York Heart Association; LVEDP, left ventricular end-diastolic pressure.

*Patients can have more than one symptom entity.
mm Hg; \( P < 0.001 \). The left ventricular outflow tract diameter increased from 17±3 mm (range, 10 to 23 mm) to 22±3 mm (range, 15 to 33 mm; \( P < 0.001 \)), and the mean subaortic septal thickness decreased from 23±5 mm (range, 15 to 35 mm) to 15±6 mm (range, 8 to 30 mm; \( P < 0.001 \)) with a decrease of the ratio between septal thickness and posterior wall thickness from 2.1 to 1.2 mm (\( P < 0.01 \)). A systolic anterior movement was seen in 8 of the 38 patients (21%) compared with 32 of the 33 patients (97%) before the septal myectomy (\( P < 0.001 \)).

There was a decrease in mitral regurgitation after operation with a mean decrease of 0.5 grade (95% confidence limits, \(-0.873 \) to \(-0.0466\); \( P = 0.03 \)). Almost 50% of the patients had no mitral regurgitation, and the other 20 patients had trivial to moderate mitral regurgitation. There was no severe mitral regurgitation during follow-up (Fig 2). As is shown in Fig 3, there was some increase in aortic regurgitation after myectomy, with a mean increase of 0.4 grade (95% confidence limits, 0.0099 to 0.75; \( P = 0.05 \)). In 14 patients, trivial aortic regurgitation, in 8 patients moderate, and 1 patient moderately severe aortic regurgitation was noted.

**Discussion**

HOCM is a disease with a high rate of morbidity and mortality.\(^1\)\(^-\)\(^4\) Medical therapy usually leads to a decrease of the symptoms. Nevertheless, approximately 15% of patients remain symptomatic despite optimal drug therapy.\(^6\) Surgical intervention is indicated in patients with a demonstrative severe left ventricular outflow tract gradient and symptoms refractory to medical therapy.\(^15\) There is still controversy as to what is the best surgical treatment, ie, septal myectomy, mitral valve replacement, or both.

The present study was undertaken to evaluate the initial results and long-term clinical and echocardiographic follow-up of Morrow septal myectomy in patients with HOCM. This study shows that transaortic septal myectomy is a safe procedure as there were no perioperative deaths and only 2 patients had a minor surgical complication.

The Doppler echocardiographic follow-up results show that the excision of a small muscle mass from a critical site in the left ventricular outflow tract leads to a decrease of the septal thickness and an increase of the outflow tract diameter, giving a significant reduction of the mean gradient in the left ventricular outflow tract from 72 to 6 mm Hg. In this study, a decrease in the pressure gradient is associated with an improved quality of life with 92% of the patients becoming asymptomatic or mildly symptomatic (NYHA functional class I and II) and a significant improvement in the mean NYHA functional class from 3.0 to 1.5. Also, septal myectomy not only improves the functional status of patients with HOCM but also safeguards an excellent late survival in this study. Only 1 late non–HOCM-related death occurred (annual overall mortality rate, 0.4%), and there was no HOCM-related mortality.

Why the long-term follow-up results of this study are this good cannot be fully explained. In the literature, a postoperative annual mortality rate of 2.2% to 4.4% has been reported.\(^5\) Selection of a lower-risk group does not appear to be the reason in this study, since the mean NYHA functional class was 3.0±0.6. Furthermore, medical therapy had eventually failed in all of these patients. In our view, the main explanation is that one surgeon performed the surgery on all of the study patients. Whether septal myectomy actually decreases long-term mortality remains unknown. To compare the patients who have had a septal myectomy with those who are being treated medically is of dubious validity, since the operated patients constitute a different subgroup than the nonoperated patients. Nevertheless, the fact that the annual mortality rate in this study is so much lower than that for patients who are treated medically suggests a more favorable course after surgery.\(^3\) This is especially true if one takes into consideration that the operated patients usually are the most severely symptomatic patients, as was the case in our study.

During long-term follow-up, the HOCM-related event rate was very low: only 1 patient had a syncope due to a complete atrioventricular block that required a pacemaker and another patient had a late sustained ventricular tachycardia that was successfully treated with amiodarone.

Mitril regurgitation in HOCM is a functional phenomenon that regresses after adequate septal myectomy as was also noted in our study, even taking into account that 4 patients underwent a mitral valve replacement.\(^16\)\(^-\)\(^18\) Therefore, mitral valve replacement is necessary only in cases of organic valve disease. McIntosh and Maron advocate performing a mitral valve replacement in selected patients in whom the risk of resection is too
high ie, patients with an interventricular septal thickness <18 mm.13 This opinion contrasts with our results since the 3 patients with a septum <18 mm thick had no perioperative complications and had an uneventful long-term follow-up. The septal thickness of the patient with a small postoperative ventricular septum defect was 20 mm. In the study of McIntosh and Maron, 48 of a total of 156 HOCM patients (31%) underwent a mitral valve replacement. The operative mortality in the mitral valve group was 6.2% compared with 2.7% in the septal myectomy group. In addition, in the valve group there were 5 late deaths, with an annual mortality rate of 4.7%, which was higher than the overall annual mortality rate of 2.2%.14 Also, complications due to prosthetic valve implantation and anticoagulant therapy have to be considered.

In this study, Doppler echocardiography showed an increase in aortic regurgitation after the operation. Trivial or moderate aortic regurgitation was noted in 22 of the patients (59%), and moderately severe aortic regurgitation was noted in 1 of the patients (3%). There was no severe aortic regurgitation during follow-up. An increase in aortic regurgitation after septal myectomy is also reported in the literature.19,20 Sassen et al20 detected aortic regurgitation of trivial to a moderate degree in 28 of the 54 patients (54%) who had undergone septal myectomy. The increase in aortic regurgitation after septal myectomy is probably related to resection of the very proximal septum that supports the aortic valve annulus, as was suggested by McIntosh and Maron.13 Whether their suggestion to start the resection below the proximal septum (5 to 10 mm) to avoid iatrogenic regurgitation is of clinical significance is still an issue open for discussion. In the study of Sassens et al,20 with a mean follow-up of 7.8 years, as well as in our study, the aortic regurgitation was well tolerated and did not lead to aortic valve replacement.

Currently, intraoperative echocardiography is used routinely in some institutions.11,15,18 Intraoperative echocardiography has been advocated to reduce the risk of making a ventricular septal defect and of leaving too much septal wall hypertrophy. In our institution, intraoperative echocardiography is not routinely used. Nevertheless, in this study only one small ventricular septal defect was made, and the subaortic rest gradient (6±4 mm Hg) is as low as or even lower than in the studies in which intraoperative echocardiography was routinely or frequently used.1,5,18 It is our opinion that the operative results depend largely on the skills of the surgeon, and a high-quality preoperative echocardiogram is usually sufficient to supply all the necessary information for the septal myectomy. Recently, the initial results of dual-chamber pacing for patients with HOCM have been published.10-12 The investigators state that the main reasons for a new therapy for HOCM are a high operative mortality rate of septal myectomy (2% to 11%) and inadequate relief of the left ventricular outflow tract gradient, as well as the occurrence of a total heart block (up to 5%) or a ventricular septal defect due to the septal myectomy.10 Our study refutes these data and conclusions. First, in this study there is no operative mortality, and generally the perioperative mortality rate has decreased to acceptable ranges due to improved surgical skills and methods of myocardial preservation.5,15,21,22 Second, this study shows that transection of the conduction pathways can be avoided by paying careful attention to the anatomic structures, only one patient (3%) in our study needed a permanent pacemaker after septal myectomy. Third, the reduction of the left ventricular outflow tract gradient to 6±4 mm Hg in this study is far better when compared with the mean rest gradient of 40 mm Hg after dual-chamber pacing.10,11 Last, in our study only one hemodynamically insignificant ventricular septal defect was caused. Fananapazir et al10,11 conclude that dual-chamber pacing should be tried in all patients with HOCM in whom symptoms are refractory to medical therapy. However, their conclusions appear to be premature. Even though their short-term follow-up results are promising, the follow-up of pacing studies is still too short (1.5 to 14 months) to make any definite conclusions. The effect of a high rest gradient with dual-chamber pacing on left ventricular function must to be awaited. A rest gradient of ≥15 mm Hg has been shown to be an independent predictor of mortality after myectomy.21

In conclusion, on the basis of the results of this study, we believe that transaortic septal myectomy is still the treatment of choice for patients with HOCM with a significant gradient in the left ventricular outflow tract and symptoms refractory to medical therapy. It is a very safe and effective procedure with an excellent long-term clinical and echocardiographic follow-up. Although the initial results of dual-chamber pacing seem promising, prospective studies are needed to compare Morrow septal myectomy with dual-chamber pacemaker therapy to evaluate the most effective form of therapy.

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