Curr Probl Cardiol 49 (2024) 102134

Contents lists available at ScienceDirect

Current Problems in Cardiology

journal homepage: www.elsevier.com/locate/cpcardiol

Invited Review Article

Adding Surgical Edge-to-Edge Mitral Valve Repair to Myectomy in Hypertrophic Obstructive Cardiomyopathy: Long-Term Functional and Echocardiographic Outcome

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A B S T R A C T

This study evaluates the early and long-term clinical and echocardiographic outcome of edge-to-edge (E2E) mitral valve repair (MVr) concomitant to septal myectomy (SM) in patients with symptomatic hypertrophic obstructive cardiomyopathy (HOCM). A retrospective single-center analysis was performed of patients who underwent isolated SM or SM with E2E MVr from 2011 to 2022. Exclusion criteria were primary mitral valve (MV) disease or concomitant valve surgery. Early and long-term safety, functional and echocardiographic outcomes were compared between groups. Between January 2011 and April 2022, 76 consecutive patients underwent SM for HOCM: 42 patients (55%) underwent SM without additional E2E MVr (Group 1) and 34 patients (45%) underwent SM with additional E2E MVr (Group 2). At latest follow-up, 87% of patients were in New York Heart Association (NYHA) class I-II with no significant differences in NYHA class between groups. Incidence of safety events was comparable between groups. Echocardiographic relief of left ventricular outflow tract (LVOT) obstruction was comparable at early follow-up ($P = 0.68$), with a significant but small difference in maximum LVOT pressure gradient at latest follow-up in favor of E2E MVr ($P = 0.04$). Furthermore, patients who underwent SM with E2E MVr showed less residual systolic anterior motion at early and latest follow-up ($P = 0.020$; $P = 0.178$). Reintervention on the MV was absent in both groups at 1 year and equally low at follow-up ($P = 0.27$). This study demonstrates that adding E2E MVr to septal myectomy is as safe as isolated myectomy for the treatment of HOCM. Moreover, the addition of E2E MVr is associated with similar excellent functional improvement and freedom from MV reintervention.

Introduction

Hypertrophic cardiomyopathy (HCM) is the most common inherited heart disease, with a prevalence of 0.03 to 0.2%.[1,2] It is characterized by increased left ventricular (LV) wall thickness (≥15 mm) that cannot be attributed solely to abnormal loading conditions.[3] Left ventricular outflow tract obstruction (LVOTO) is observed in about two-thirds of HCM patients and can result from proximal septal hypertrophy (PSH) or most often a combination of PSH and systolic anterior motion (SAM) of the mitral valve (MV)[4-6]

Funding: This research received no specific grant from any funding agency in the public commercial or not-for-profit sectors.
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https://doi.org/10.1016/j.cpcardiol.2023.102134

Available online 17 October 2023

(Fig 1). SAM is often associated with MV apparatus abnormalities found in many HCM patients, such as elongated MV leaflets or abnormal papillary muscle insertion, contributing to significant LVOTO. Hemodynamically significant LVOTO is defined by a pressure gradient exceeding 50 mmHg in the LVOT and typically necessitates invasive treatment for patients with moderate to severe drug-refractory symptoms (ie, New York Heart Association (NYHA) functional Class III-IV).[3] Surgical septal myectomy (SM) has been the gold-standard therapy for HOCM patients for over 5 decades and primarily aims to reduce septal thickness.[7-9] However, due to the variability of septal hypertrophy (ie, both the degree of septal hypertrophy and the extent of hypertrophy from the base to apex of the interventricular septum) and mitral leaflet anatomy in patients with LVOTO, it can be challenging to determine both the cause and optimal treatment strategy of LVOTO. MV surgery can be added to SM not only to specifically treat SAM but also to maximally relieve LVOTO.[10] In line with this, edge-to-edge mitral valve repair (MVr) according to the Alfieri technique can be combined with SM to effectively relieve LVOTO.[11-16] To date, the use of the edge-to-edge MVr technique has been described in only a limited number of case series and small cohort studies[16] that lack a comparative control group (ie, isolated myectomy) and show large heterogeneity in terms of underlying MV pathology and concomitant surgical procedures in addition to SM with edge-to-edge MVr.

This study aims to evaluate the early- and long-term outcomes of our strategy of adding edge-to-edge MVr to SM in HOCM patients with symptomatic severe LVOTO and SAM performed in our high-volume center for the treatment of HOCM.

Materials and Methods

Patients

All HOCM patients who underwent SM with or without MVr in our hospital between January 2011 and April 2022 were retrospectively assessed. A dedicated HOCM heart team, including cardiac surgeons, interventional cardiologists and imaging cardiologists, conducted the baseline assessment and determination of treatment strategy of all patients.

Patients with a history of alcohol septal ablation (ASA), SM, mitral or aortic valve surgery or resection of the subvalvular aortic membrane were excluded from analysis. In addition, we excluded patients with intrinsic or degenerative mitral valve disease, mid-ventricular obstruction or indication for concomitant surgery other than coronary artery bypass grafting (CABG) and/or ablation for atrial fibrillation (AF).

Operative Technique

All procedures were conducted via a median sternotomy and with transoesophageal echocardiographic (TOE) guidance. Standard cardiopulmonary bypass (CPB) on moderate hypothermia and crystalloid cardioplegic arrest were applied with central arterial and 2-stage venous cannulation in patients who underwent SM without MVr. In case of additional MVr, bicaval cannulation was applied. MVr was performed first by transseptal approach prior to SM and consisted of an edge-to-edge (E2E) repair according to Alfieri with Prolene 4-0 (Fig 2). A saline test with inking of the leaflet was used in E2E repairs to identify the mitral coaptation surface. E2E repair according to Alfieri classically involves mitral scallops A2 and P2 and is performed within the - non-inked - coaptation surface. A final saline test is used to check for potential distortion of the valve and any induced mitral residual regurgitation.

Transaortic SM is performed in 2 stages: an initial resection was made with a long-shafted No 15-blade, after which a second deeper adjusted complementary resection was made with the use of angulated scalpels. We aimed to leave a residual septal thickness of 1 cm and aimed to extend the resection towards the LV apex as far as possible. Standard TOE after weaning of CPB and under normal hemodynamic conditions is used to evaluate relief of LVOTO, MV function (ie, residual SAM, residual mitral regurgitation and transvalvular gradient) and check for a ventricular septal defect (VSD).

Our selection of operative strategy was based on echocardiography at baseline. If SAM was visible on baseline echocardiography, the E2E technique was applied as described above. In case SAM was present only during exercise or provocation, then only a myectomy was performed. If residual LVOTO with SAM was present after isolated myectomy, a bail-out E2E was also performed.

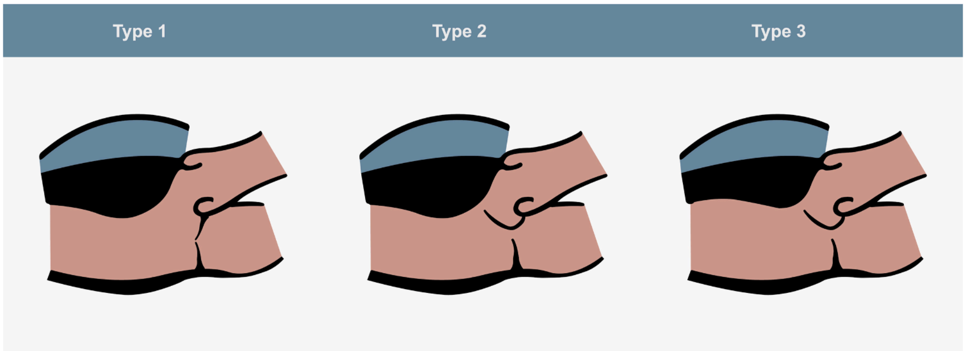

Fig 1. Types of pathology underlying left ventricular outflow tract obstruction. Type 1. Severe PSH in the absence of SAM of the mitral valve. Type 2. Severe PSH with SAM of the mitral valve. Type 3. Mild PSH with SAM of the mitral valve. SAM, systolic anterior motion; PSH, proximal septal hypertrophy. (Color version of figure is available online.)

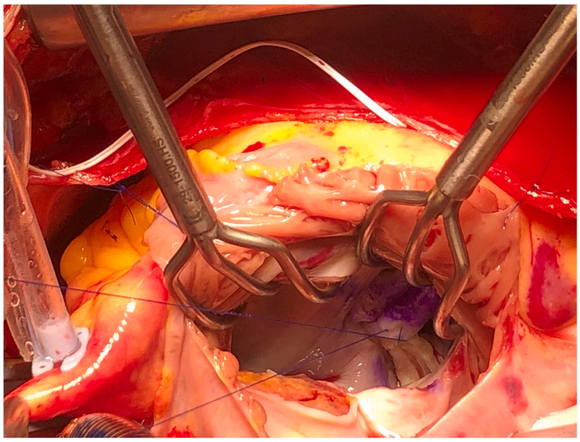

Fig 2. Intraoperative image of edge-to-edge mitral repair with Prolene 4-0 by transseptal approach prior to septal myectomy, after a saline test with leaflet-inking is performed to identify the mitral coaptation surface. (Color version of figure is available online.)

Data Collection and Patient Follow-Up

Preoperative, intraoperative, postoperative, and follow-up data were obtained from electronic medical records and entered into an internally maintained database.

In case patients were referred to another hospital after the procedure, all files and echocardiograms were requested. At the end of study, telephone follow-up was conducted to complete long-term follow-up.

Echocardiographic Analysis

Preoperative and postoperative assessment was based on transthoracic echocardiography (TTE). Postoperative echocardiographic data were assessed at early follow-up and latest available follow-up with a minimum required late follow-up of 1 year in order to be included in analysis. Standard analysis of all echocardiograms was conducted for all patients. LV septal hypertrophy was assessed. Peak and mean LVOT gradient was measured with continuous and pulsed wave Doppler at rest and after provocation or during exercise when possible. SAM of the mitral valve was evaluated and classified as valvular SAM, nonvalvular or chordal SAM or both if present. Severity of mitral regurgitation was semi-quantitively graded as none-to-trivial (grade 0), mild (grade 1), moderate (grade 2), moderate to severe (grade 3) or severe (grade 4).

Statistical Analysis

To evaluate the role of adding MVr to SM, patients were divided into 2 study groups: patients who underwent isolated SM (Group 1) and patients who underwent SM with additional MVr by the E2E technique (Group 2).

Continuous data are presented as mean $\pm$ standard deviation (SD) or as median (interquartile range (IQR)). Categorical outcomes were summarized with numbers and percentages. Pre- and postoperative continuous data were compared within each group using the paired Student's T-test or Wilcoxon signed rank test depending on data distribution. Between-group comparisons of continuous data were investigated using the unpaired T-test or Mann-Whitney U test, as appropriate. Categorical outcomes in each group were analyzed using the McNemar test. Group comparisons of categorical data were made using the Chi-Square test or Fisher's exact test. The incidence of major adverse events was visualized and compared between groups using Kaplan-Meier analyses and the log-rank test. Contingency tables were created to visualize transitions between NYHA classes pre- and postoperatively.

SPSS Statistics 26.0 (IBM Corp, Armonk, NY) was used for analysis. Statistical significance was acknowledged at a *P*-value less than 0.05.

Results

Patient Characteristics

Baseline characteristics of all included patients are presented in Table 1. Patients presented with a mean NYHA class of 2.4 $\pm$ 0.6, despite optimal medical therapy with beta-blockers (82%) or calcium-antagonists (32%). There were no statistically significant differences in preoperative clinical or echocardiographic characteristics between groups. Median peak LVOT pressure gradient (PG) during provocation or exercise was 112 (79-137) mmHg. Most patients (80%) had valvular SAM as important contributor to their LVOTO at baseline.

Table 1
Baseline characteristics

Characteristic	All patients (n = 76)	Group 1: SM (n = 42)	Group 2: SM + MVr (n = 34)	*P*-value
Age at surgery (y)	58.5 ± 13.5	57.5 ± 13.6	59.8 ± 13.6	0.469
Male	45 (59%)	24 (57%)	21 (62%)	0.684
Cardiovascular risk factors				
• Hypertension	41 (54%)	23 (55%)	18 (53%)	0.874
• Diabetes mellitus	9 (12%)	5 (12%)	4 (12%)	0.985
• Renal failure	11 (14%)	6 (14%)	5 (15%)	0.959
• Smoking (or very recent history of smoking ≤ 8 weeks)	11 (14%)	7 (17%)	4 (12%)	0.581
History of:				
• PCI	4 (5%)	3 (7%)	1 (3%)	0.415
• Stroke	7 (9%)	4 (10%)	3 (9%)	0.916
• Atrial fibrillation	25 (33%)	12 (29%)	13 (38%)	0.373
• Ventricular tachycardia	2 (3%)	1 (2%)	1 (3%)	0.879
• Ventricular fibrillation	2 (3%)	1 (2%)	1 (3%)	0.879
ICD	9 (12%)	3 (7%)	6 (18%)	0.159
RBBB	1 (1%)	0 (0%)	1 (3%)	0.263
LBBB	4 (5%)	3 (7%)	1 (3%)	0.415
Medical therapy				
• Beta-blocker	62 (82%)	35 (83%)	27 (79%)	0.661
• Calcium-antagonist	24 (32%)	14 (33%)	10 (29%)	0.715
NYHA Class				
• I	4 (5%)	2 (5%)	2 (6%)	0.828
• II	37 (49%)	23 (55%)	14 (41%)	0.239
• III	33 (43%)	15 (36%)	18 (53%)	0.132
• IV	2 (3%)	2 (5%)	0 (0%)	0.197
Symptoms				
• Dyspnea	66 (87%)	38 (91%)	28 (82%)	0.298
• Angina	44 (58%)	27 (64%)	17 (50%)	0.210
• Palpitations	24 (32%)	14 (33%)	10 (29%)	0.715
• Syncope	18 (24%)	7 (17%)	11 (32%)	0.110
LVF				
• Reasonable (3)	1 (1%)	1 (2%)	0 (0%)	0.365
• Good (4)	75 (99%)	41 (98%)	34 (100%)	0.365
Peak LVOT PG at rest (mmHg)	51 (24-79)	45 (18-78)	62 (32-89)	0.104
Peak LVOT PG Valsalva/exercise (mmHg)	112 (79-137)	110 (75-137)	113 (79-139)	0.828
MR grade				
• 0	17 (22%)	11 (26%)	6 (18%)	0.411
• 1	35 (46%)	21 (50%)	14 (42%)	0.514
• 2	12 (16%)	5 (12%)	7 (21%)	0.275
• 3	6 (8%)	4 (10%)	2 (6%)	0.583
• 4	5 (7%)	1 (2%)	4 (12%)	0.093
Valvular SAM	61 (80%)	32 (76%)	29 (85%)	0.321

Values are mean ± SD, median (interquartile range) or n (%).
Abbreviations: ICD, implantable cardioverter defibrillator; LBBB, left bundle branch block; LVF, left ventricular function; LVOT PG, left ventricular outflow tract pressure gradient; MR, mitral regurgitation; MVr, mitral valve repair; NYHA, New York Heart Association; PCI, percutaneous coronary intervention; RBBB, right bundle branch block; SAM, systolic anterior motion; SD, standard deviation; SM, septal myectomy.

Procedural Data

From January 2011 to April 2022, 76 consecutive patients underwent SM with or without additional MVr for HOCM without significant primary degenerative MV disease in our center. Of the total cohort of 76 patients, 42 patients (55%) received SM without additional MVr (Group 1) and 34 patients (45%) underwent SM with additional MVr (Group 2). The technique used to perform MVr in Group 2 concerned an E2E repair in all patients (100%). Two of these patients (6%) underwent an E2E MVr during a second pump run due to residual SAM and MR after SM had already been performed.

Concomitant procedures were performed in 29 patients (38%). In Group 1, concomitant surgery included CABG in 7 (17%) and AF-ablation in 6 patients (14%). In Group 2, concomitant CABG was performed in 5 (15%) and AF-ablation in 9 patients (27%). Combined CABG and AF-ablation was performed in 2 patients (6%) in Group 2, including 1 CABG due to anterolateral wall-rupture.

Median aortic cross-clamp (ACC) times were 37 (27-58) and 51 (37-72) minutes in respectively Group 1 and 2 (P= 0.012), cardiopulmonary bypass (CPB) times were 66 (53-94) and 90 (64-119) minutes ($P = 0.007$). When no other concomitant procedures were performed, median duration of ACC was 30 (25-48) minutes in Group 1 and 39 (31-55) minutes in Group 2 ($P = 0.13$), with CPB times of respectively 58 (47-78) and 69 (59-86) minutes ($P = 0.054$).

Early Safety Outcomes

Mean length of stay (LOS) of patients discharged home or to a referring hospital was respectively 7 (5-9) and 8 (6-13) days in Group

1 and Group 2 respectively ($P = 0.05$). There were no significant differences in adverse safety events between groups within 30-days and 1-year postoperatively (Table 2). SM was complicated by 2 VSD's in Group 1 and 1 VSD in Group 2. One anterolateral wall rupture occurred in Group 2, followed by repair, CABG and placement of veno-arterial ECMO. Hereafter multiorgan failure occurred, and the patient died.

Follow-Up Safety Outcomes

Patients in Group 1 were operated relatively earlier in time and hence followed for a longer period, corresponding to a total follow-up of 6.8 (4.7-8.0) years in Group 1 and 2.7 (1.1-4.4) years in Group 2 ($P < 0.001$). There were no differences in any complication rates between both intervention groups during follow-up (Supplemental File 1). Total postoperative device-implantation (ie, Implantable Cardioverter Defibrillator (ICD) or pacemaker implantation) was n = 8 (19%) and n = 7 (21%) for Group 1 and Group 2 respectively (log-rank $P = 0.187$). None of the patients who underwent pacemaker implantation had a preoperative right bundle branch block.

Two patients (2.7%) underwent MV replacement during follow-up. Indication for MV replacement was severe MR due to A2- and partial A1-prolapse 3 years after isolated SM in Group 1 (n = 1) and rupture of the E2E repair (n = 1) in Group 2 19 months post-operatively. One patient in Group 1 required reoperation for VSD closure because of tearing of the first patch within the first year postoperatively.

In total, 5 patients (12%) of Group 1 died after 30 days. Causes of death were cancer (n = 2), brainstem bleeding/hemorrhagic stroke (n = 1) 6 months postoperatively and death during sleep 4 years postoperatively (n = 1). Data on cause of death was unretrievable for 1 patient in Group 1. In Group 2, 2 patients (6%) died after 30 days: 1 patient died after 30 days due to cancer and 1 patient died 7 years postoperatively after in-hospital resuscitation.

Functional Outcomes

At latest follow-up of 5.1 (2.7-7.9) years, a significant reduction of NYHA class was found ($P < 0.001$) in the entire cohort, corresponding to 87% of living patients in NYHA class I-II. There was no significant difference in postoperative NYHA class between Groups ($P = 0.95$ for NYHA class I, $P = 0.91$ for NYHA class II, $P = 0.52$ for NYHA class III and $P = 0.19$ for NYHA class IV, respectively). Table 3 shows the specific changes in NYHA class for each patient per Group. All 4 patients who were in NYHA class III postoperatively were also in class III preoperatively. Two patients in Group 1 deteriorated from class III to IV.

Echocardiographic Outcomes

Echocardiographic outcomes at early and latest follow-up (ie, latest follow-up after a minimum follow-up period of 1 year postoperatively) are summarized in Table 4. Maximum postoperative LVOT PG was effectively reduced to 10 (8-20) mmHg and 10 (8-14) mmHg at early follow-up respectively in Group 1 and Group 2 ($P = 0.68$). At latest follow-up, a significant difference was found in maximum LVOT PG between groups, with a lower gradient in Group 2 compared to Group 1 (6 (4-7) mmHg) vs 10 (5-16) mmHg; $P = 0.041$). At early follow-up, valvular SAM was still present in 8 patients (21%) in Group 1 and only 1 patient (3%) in Group 2 ($P = 0.020$). This significant difference in favor of the E2E technique was not present anymore at latest follow-up ($P = 0.18$). At both early and latest follow-up, there were no patients with more than moderate MR in both groups. At latest follow-up, patients in Group 2 showed none or a trace of MR more often compared to Group 1 ($P = 0.029$). Patients in Group 2 showed higher mean and maximum transvalvular MV gradients at early follow-up compared to Group 1 ($P = 0.004$; $P = 0.006$), whereas this difference diminished at latest follow-up ($P = 0.83$ and $P = 0.48$).

Discussion

Addition of MVr to SM for HOCM is a source of controversy.[10,14,17] Many advocate that adequate SM alone is sufficient for the relief of LVOTO and will restore the normal function of the MV in case of absence of intrinsic or degenerative MV disease.[14,18-20] Indeed, isolated SM has been proven to substantially reduce LVOT gradients and SAM-related MR and improve functional capacity.[3] However, many patients with HCM have MV apparatus abnormalities that predispose them to SAM. As SAM can be an important contributor to

Table 2
Clinical outcomes within 30 days and 1-year follow-up (since 30 days)

Variable	Within 30 days Group 1 (n = 42)	Group 2 (n = 34)	*P*-value	1-year follow-up Group 1 (n = 42)	Group 2 (n = 33)	*P*-value
Mortality	0 (0.0%)	1 (2.9%)	0.447	1 (2.4%)	0 (0.0%)	>.99
Stroke	0 (0.0%)	0 (0.0%)	-	1 (2.4%)	0 (0.0%)	>.99
Myocardial infarction	0 (0.0%)	0 (0.0%)	-	0 (0.0%)	0 (0.0%)	-
Reoperation*	0 (0.0%)	0 (0.0%)	-	0 (0.0%)	0 (0.0%)	-
New ICD	2 (4.8%)	1 (2.9%)	>.99	2 (4.8%)	0 (0.0%)	0.501
New PM	1 (2.4%)	2 (5.9%)	0.579	1 (2.4%)	4 (12.1%)	0.163

Values are n (%). *Abbreviations*: ICD, implantable cardioverter defibrillator; PM, pacemaker; SD, standard deviation;
* Remyectomy or reoperation for mitral repair/replacement.

Table 3
Contingency table with changes in NYHA class in Group 1 and Group 2 at latest follow-up

Group 1 Preoperative NYHA class	Postoperative NYHA class	I	II	III	IV	Total
	I	1	1	0	0	2
	II	8	10	2	0	20
	III	6	4	1	2	13
	IV	2	0	0	0	2
	Total	17	15	3	2	37
Group 2 Preoperative NYHA class	**Postoperative NYHA class**	**I**	**II**	**III**	**IV**	**Total**
	I	2	0	0	0	2
	II	5	6	1	0	12
	III	7	7	3	0	17
	IV	0	0	0	0	0
	Total	14	13	4	0	31

Values are number of patients.
Abbreviations: NYHA, New York Heart Association.

Table 4
Echocardiographic outcomes at early and latest follow-up (minimum of 12 months available follow-up)

Variable	Early follow-up **Group 1 (n = 38)**	**Group 2 (n = 34)**	***P*-value**	Latest follow-up **Group 1 (n = 34)**	**Group 2 (n = 18)**	***P*-value**
Follow-up (months)	0 (0-1)	0 (0-0)	0.010	52 (39-68)	24 (18-70)	0.039
LVF						
• Poor	0 (0%)	1 (3%)	0.280	0 (0%)	0 (0%)	-
• Moderately reduced	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	-
• Reasonable	3 (8%)	0 (0%)	0.104	4 (12%)	5 (28%)	0.161
• Good	35 (92%)	32 (97%)	0.104	29 (88%)	13 (72%)	0.161
Peak LVOT PG at rest (mmHg)	9.4 (6.0-15.4)	10.1 (8.2-14.0)	0.678	6.1 (4.8-12.8)	5.9 (4.0-7.4)	0.364
Maximum reported LVOT PG (mmHg)	10.6 (7.5-20.3)	10.1 (8.2-14.0)	0.684	9.5 (4.9-16.0)	5.9 (4.0-7.4)	0.041
Mitral regurgitation grade						
• 0	18 (49%)	17 (52%)	0.811	9 (27%)	10 (59%)	0.029
• 1	16 (43%)	13 (39%)	0.744	19 (58%)	6 (35%)	0.136
• 2	3 (8%)	3 (9%)	0.833	5 (15%)	1 (6%)	0.339
• 3	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	-
• 4	0 (0%)	0 (0%)	-	0 (0%)	0 (0%)	-
Valvular SAM	8 (21%)	1 (3%)	0.020	3 (10%)	0 (0%)	0.178
Mitral valve PG (mmHg)						
• Mean PG	1.3 (0.0-3.0)	3.1 (2.3-4.0)	0.004	1.3 (0.0-3.2)	2.0 (0.0-2.6)	0.834
• Max PG	3.4 (0.0-7.8)	8.2 (4.9-11.9)	0.006	1.0 (0.0-11.1)	5.4 (2.6-7.1)	0.477

Latest follow-up of patients with a minimum follow-up of 12 months. Values are median (interquartile range) or n (%).
Abbreviations: LVF, left ventricular function; LVOT, left ventricular outflow tract; mmHg, millimeters of mercury; PG, pressure gradient; SAM, systolic anterior motion.

LVOTO, it would make sense not only to target septal hypertrophy but also to directly target SAM.

With this study we evaluated the early- and late clinical, functional and echocardiographic outcomes of our strategy of adding E2E MVr to SM in patients without significant intrinsic or degenerative MV disease but with important SAM on preoperative echocardiographic evaluation. To our knowledge this is the largest report—including long-term follow-up—of the outcome of additional E2E MVr during SM. Importantly, no statistically significant differences between the 2 groups were observed in the long-term outcomes except for a small difference in maximum reported LVOT gradients in favor of the E2E technique. Although the presence of SAM only differed significantly between the 2 groups at early follow-up and not at late follow-up, it is relevant to note that valvular SAM was not fully eliminated in all patients who underwent isolated myectomy, in contrary to patients who underwent concomitant E2E MVr. In line with our results, previous studies[11,13,14] have demonstrated that adding E2E MVr to SM effectively reduced LVOT gradients, resolved SAM and diminished (SAM-related) MR. However, these results were mostly described in the context of intrinsic or degenerative MV disease[11-13] and can therefore not be generalized for all HOCM patients.

Although some colleagues have questioned whether additional MVr unnecessarily complexifies the surgical procedure and adds to the surgical risk,[20] the E2E technique especially could offer a simple solution for both the treatment and prevention of LVOTO and SAM in addition to SM. Mean ACC and CPB times for SM with E2E MVr without any other concomitant procedure were 39 (31-55) and 69 (59-86) minutes respectively in our study, underscoring only a small mean difference of 9 and 11 additional minutes when the E2E repair is concomitantly performed. These relatively small increases in CPB and ACC times are in line with those reported in a recent study by Lapenna and colleagues[13] and are a testimony of the limited technical complexity of the concomitant procedure. Furthermore, it is important to underscore that MVr is sometimes performed as a bail-out procedure in case of inadequate relief of LVOTO, SAM and/or significant residual MR after SM.[12,21] However, this does require the need for a second pump run and therefore would prolong the surgical times after all when this could have been prevented in the first place.

No significant differences were identified in any safety outcomes at both 30 days and during follow-up. In particular, SM was complicated by iatrogenic VSD's in 2 cases in Group 1, whereas 1 VSD was detected in Group 2. In all studies combined that investigated E2E MVr in addition to SM in cohorts comparable to Group 2, only 1 VSD occurred.[11-14]

During follow-up, 2 patients (3%) underwent MV replacement as a reoperation because of MV-dysfunction. Interestingly, 1 patient developed A2-prolapse after isolated SM. It is important to note that in the patient who developed severe MR after SM with concomitant MVr, the Alfieri stitch had torn through the MV leaflet tissue. In order to prevent this complication from happening in the future, we now secure the stitch with small patches of bovine pericardium in case of relatively tin or fragile tissue.

Study Limitations

This is a retrospective single-center study with its corresponding restrictions. Although all patient files and echocardiograms were retrieved, the follow-up period differed between groups due to referral of patients to other hospitals.

Moreover, not all patients with valvular SAM have consistently received a concomitant MVr, as the application of the E2E technique in our center has been developed as a treatment strategy for patients with HOCM and important SAM over the past decade, so selection bias is present. Nevertheless, echocardiographic characteristics at baseline are comparable. Most importantly, valvular SAM was present in 80% of the total cohort and did not statistically differ between both groups ($P = 0.32$).

Another limitation of this study is formed by the lack of particular echocardiographic parameters such as interventricular septum thickness (IVSt). As anticipated due to the retrospective character of our study, IVSt was not always recorded repeatedly in the same echocardiographic plane on the level of myectomy and therefore could not be analyzed properly in retrospect. With regard to future studies, measurements of anterior and posterior mitral leaflet length, mitro-aortic angle and coaptation-septum distance would also further complement insight into the outcomes of adding an MVr.

Finally, this study contains a relatively small sample size, partly due to the strict exclusion criteria. The presentation of this cohort should therefore be interpreted with caution and serve as hypothesis-generation for future randomized studies to further power these results. Nevertheless, this study represents the largest cohort to date that describes and compares both the 30-day and follow-up clinical, functional and echocardiographic outcomes of edge-to-edge MVr concomitant to SM in patients without intrinsic MV pathology.

Conclusions

This study demonstrates that adding E2E MVr to septal myectomy is as safe as isolated myectomy for the treatment of HOCM. Moreover, the addition of E2E MVr is associated with similar excellent functional improvement and freedom from MV reintervention.

Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Ethical Statement

Approval of the study was obtained from the Medical Research Ethics Committee and Local Hospital Committee on 14 July 2020 (Z20.082). Written informed consent was collected for all patients.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Acknowledgments

The authors gratefully acknowledge that Figure 1 was designed for publication of this manuscript by Daniël Hegeman.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.cpcardiol.2023.102134.

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