The Impact of Unrepaired versus Repaired Mitral Regurgitation on Functional Status of Patients with Ischemic Cardiomyopathy at One Year after Coronary Artery Bypass Grafting

Jolanta Vaskelyte, Neris Stoskute, Egle Ereminiene, Remigijus Zaliunas[1], Rimantas Benetis, Edmundas Sirvinskas[1]

Institute of Cardiology and [1]Heart Center of the Kaunas University of Medicine, Kaunas, Lithuania

Background and aim of the study: **The issues regarding the appropriate management of patients with ischemic mitral regurgitation (MR) and advanced left ventricular (LV) dysfunction are controversial and limited. The present study was undertaken to evaluate the mid-term dynamics of MR, LV dimensions, function and NYHA functional class in patients with ischemic cardiomyopathy (ICM) and MR who underwent coronary artery bypass grafting (CABG) either alone or combined with mitral valve (MV) repair.**

Methods: **A total of 199 patients with LV ejection fraction (LVEF) <35% were included in the study. Of these patients, 73 had MR grade 2+ (group 1), 66 had 0 or 1+ MR (group 2) and underwent isolated CABG, and 60 had MR >2+ and underwent CABG with MV repair (group 3).**

Results: **At one year after surgery, the severity of MR was unchanged from preoperative grade in group 1 (2.1 ± 0.5 vs. 1.97 ± 0.8), and increased in group (0.76 ± 0.43 vs. 1.44 ± 0.77; p <0.05), but was significantly lower in group (2.8 ± 0.5 vs. 1.6 ± 0.7; p <0.05). In group 1, the LV end-systolic volume index (LVESVI) tended to increase, the LV end-diastolic volume index (LVEDVI) increased from 69.6 ± 22.6 to 79.6 ± 23.2 ml/m^2 with an increase in LVEF (from 27.9 ± 5.9 to 31.3 ± 9.4%), and pulmonary artery pressure (PAP) increased from 31.9 ± 7.0 to 39.5 ± 17.4 mmHg. In group 2, the LV volumes tended to increase, LVEF increased from 30. 3 ± 4.1 to 34.9 ± 9.1%, and PAP remained unchanged. In group 3, the LVESVI decreased from 55.4 ± 16.9 to 47.1 ± 21.7 ml/m^2, LVEDVI tended to decrease, LVEF increased from 31.4 ± 8.6 to 36.5 ± 11.3%, and PAP decreased from 35.5 ± 6.0 to 32.8 ± 8.3 mmHg.**

Conclusion: **Isolated CABG in patients with ICM had no favorable effect on MR reduction, and did not prevent its development. MR grade 2+ in patients with ICM at one year after isolated CABG had a deleterious effect on LV functional status, with progression of LV dilatation and increased PAP. A significant reduction or elimination of MR after combined surgery had a marked positive impact on reverse LV remodeling, including regression of LV dilatation, an increased LVEF, and decreased PAP.**

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Ischemic cardiomyopathy (ICM) is frequently associated with mitral regurgitation (MR), since functional ischemic MR is a consequence of left ventricular (LV) regional and global remodeling (1). The presence of ischemic MR was proved to be associated with excess mortality, independently of baseline characteristics and the degree of LV dysfunction (1). Ischemic MR is also associated with poor long-term survival after coronary artery bypass grafting (CABG) (2,3); thus, moderate-to-severe and severe ischemic MR became obligatory contraindications to surgery while performing CABG (4). To date, however, no randomized studies have been conducted to identify the best management strategy for moderate ischemic MR. In fact, the available data are conflicting, with several reports supporting CABG alone (5-8), but several suggesting that CABG should be combined with mitral valve repair (9-13). The majority of studies have debated the advantages and limitations of isolated CABG or CABG combined with mitral valve repair for moderate ischemic MR, and have analyzed data relating to patient survival and mortality, operative risk, and MR dynamics (2,8,9,13,14).

To date, very few studies have reported the functional status of patients undergoing CABG alone for moderate ischemic MR (15) and CABG with mitral valve repair (12). Moreover, in patients with ICM the data are very scarce (15-17). Thus, the present study

Address for correspondence:
Jolanta Vaskelyte MD, PhD, Heart Center, Kaunas University of Medicine, Eiveniu 2, 50009, Kaunas, Lithuania
e-mail: jvaskelyte@hotmail.com

was undertaken to evaluate the postoperative dynamics of ischemic MR, LV dimensions and function, and NYHA functional class in patients with ICM and MR at one year after CABG was performed alone or in combination with mitral valve repair.

Clinical material and methods

Patients

A total of 199 patients with ICM (LV ejection fraction (LVEF) <35%) and MR who had undergone surgery at the authors' institution between 1998 and 2001 and attended follow up examinations were included retrospectively into the study. Among these patients, 73 with ICM and functional ischemic MR (grade 2+) underwent isolated CABG (group 1), while 66 with ICM and 0 or 1+ MR underwent isolated CABG (group 2), and 60 with ICM and MR >2+ underwent CABG combined with successful mitral valve repair (group 3).

The study group comprised the survivors of surgery. Early (in-hospital) mortality (between 1998 and 2001) among patients with ICM (mean LVEF 29.8 ± 4.9%) after isolated CABG was 11.8%, and after CABG + mitral valve repair was 12.5%. In the same series of patients the rate of successful mitral valve repair was 96-97%.

The etiology of MR was based on preoperative, intraoperative echocardiographic findings and operative data. Functional ischemic MR was defined as MR that occurred with a structurally normal valve due to LV dysfunction and remodeling: Carpentier type I (predominant annular dilation), type II (leaflet prolapse), or type IIIb (posterior leaflet restriction in systole) (18,19).

The clinical exclusion criteria were: (i) intrinsic valvular heart disease (including non-ischemic MR); (ii) acute myocardial infarction (MI); (iii) comorbid conditions (previous CABG, resection of ventricular aneurysm (endoventricular repair), valve replacement, etc.); and (iv) suboptimal echocardiographic windows.

All patients received medical therapy for congestive heart failure, including ACE inhibitors, diuretics, and beta blockers. Atrial fibrillation was diagnosed in 31% of patients; the remainder were in sinus rhythm.

Surgical approach

All patients underwent conventional multivessel CABG using mild hypothermic- normothermic cardiopulmonary bypass and antegrade cold crystalloid cardioplegia. All mitral valve repairs were performed by the same surgeon. The decision to treat the valve was at the discretion of the surgeon, the general indication being a LV end-diastolic diameter (LVEDD) ≥50 mm and MR grade >2+. The mitral valve was approached via the right atrium and interatrial septum. The repair consisted of an annuloplasty combined with papillary muscle/chord translocation; chord shortening was performed in 29 patients (48.3%) and isolated annuloplasty in 31 (51.7%). The annuloplasty technique included ring implantation in 20 patients (33.3%) and double semi-purse-string suture in 40 (66.6%), and was performed using a semi-rigid or a flexible complete ring (mean size 25 mm). The double semi-purse-string suture technique consisted of plication and compression of the mitral valve annulus using Ethibond 2/0 parallel sutures, buttressed with perpendicular pledgets (each 0.8-1 cm long), starting from the fibrous trigones, along both commissures and meeting at the posterior mid-annulus. The annulus diameter achieved was measured with standard valve sizers. This double semi-purse-string suture technique allowed the surgeon to ensure asymmetric remodeling of the annulus and to achieve better accommodation of the posterior leaflet P2, P3 scallops.

For papillary muscle/chord shortening, compression was applied in seven patients with ischemic damage of the inferior papillary muscle, its elongation resulting in posterior leaflet prolapse (Carpentier type II dysfunction). In order to achieve even (equal) tension on the commissural and paracommissural areas, the elongated chord and corresponding segment of the papillary muscle was identified and isolated from the remainder of the papillary muscle by performing a longitudinal papillotomy. This enabled only segmental partial shortening of the elongated part by placing longitudinal compressing 2/0 Ethibond pledget-reinforced sutures from the tip to the base of the corresponding part of the papillary muscle. Careful tying of the suture provided equalization of the leaflet edges and the commissure, shortening of the elongated part of the muscle, and reduction of the prolapse.

Repositioning of the posterior papillary muscle was also performed in the case of Carpentier type IIIb dysfunction (tethered posterior leaflet), accompanied with strong tethering of the strut chord; this resulted in a concave deformation (the 'seagull' configuration) of the anterior leaflet in 22 patients. In general, in these cases the interpapillary distance is increased, and displacement of papillary muscles from the mitral valve ring area (from the surgeon's view, while inspecting papillary muscles from the cavity of left atrium via the mitral valve orifice) with a coaptation area deep within the LV cavity is present. In the latter case, annuloplasty proved to be insufficient for reducing the MR, and an additional procedure was performed on the subvalvular structures; this technique was similar to the Hvass papillary muscle sling (20). Pledget-reinforced Prolene 2/0 sutures were placed at the basal insertion of part of the papillary muscles and passed deep within the posterior LV wall, between both pap-

Table I: Demographic and clinical data.

Characteristic	Group 1 (n = 73)	Group 2 (n = 66)	Group 3 (n = 60)
Age (years)*	63.2 ± 9.3	60.4 ± 7.4	65.4 ± 7.9
CA involved (n)*	2.9 ± 0.4	2.8 ± 0.5	3.0 ± 0.2
Stable angina (NYHA III-IV) (%)	25.7	24.6	48.0
History of MI (%)	67.6	72.3	72.0
NYHA class III-IV (%)	66.2	55.4	86.0+
CABG per patient*	3.4 ± 0.8	3.5 ± 0.8	3.3 ± 0.6

*Values are mean ± SD.
+p <0.05 versus group 1 or 2.
CA: Coronary artery; CABG: Coronary artery bypass grafting; MI: Myocardial infarction.

illary muscles. By tying these sutures, a slight repositioning of both papillary muscles and shortening of the interpapillary muscle distance was achieved (there was no fixed interpapillary muscle distance measurement, but papillary muscle projection at the level of the mitral valve annulus had to be seen within annulus area). This procedure allowed the permitted the tension on the strut and posterior leaflet chords to be alleviated, and the concavity of the anterior leaflet to be reduced, thus providing a more optimal leaflet coaptation area and tenting length.

Echocardiography

The echocardiographic investigations were performed preoperatively, within 10 days postoperatively, and at one year after surgery, and included: (i) quantification of MR; (ii) evaluation of LV dimensions and function; and (iii) measurement of pulmonary artery pressure (PAP). The clinical evaluation included assessment of NYHA functional class preoperatively and at one year after surgery.

MR was graded by color Doppler mapping by measuring the regurgitant jet area in the left atrium, the size (r) of the proximal jet area, and the effective regurgitant orifice (ERO). Initially, MR was considered to be mild when the regurgitant jet area in the left atrium was <4 cm^2 and r <4 mm; moderate with jet area 4-8 cm^2 and r = 4-9 mm; and severe with jet area >8 cm^2 and r ≥9 mm (21). Taking into account the ischemic origin of MR and its different grading (4), the degree of MR was estimated with quantitative measurements using the proximal isovelocity surface area method for ERO calculations. ERO was the ratio of regurgitant flow to regurgitant velocity. MR was considered mild (1+) when the ERO was <10 mm^2, mild to moderate (2+) with ERO 10-20 mm^2, moderate (3+) with ERO 20-29 mm^2, and severe (4+) with ERO ≥30 mm^2 (1,4,22).

The LV end-diastolic diameter index (LVEDDI) and end-systolic diameter index (LVESDI) were measured according to recommendations of the American Society of Echocardiography. The LV volumes and LVEF were measured using the biplane Simpson disk

Table II: Preoperative echocardiographic data.

Index	Group 1 (n = 73)	Group 2 (n = 66)	Group 3 (n = 60)
LVESDI (mm/m^2)	24.7 ± 3.8	22.4 ± 2.5	24.5 ± 3.9
LVEDDI (mm/m^2)	29.6 ± 4.4	27.2 ± 3.4	30.8 ± 3.2*
LVESVI (ml/m^2)	51.4 ± 18.5	48.0 ± 11.7	55.5 ± 16.9*
LVEDVI (ml/m^2)	69.6 ± 22.6	68.0 ± 12.7	82.3 ± 18.8*
MMI (g/m^2)	135.8 ± 32.9	125.4 ± 25.5	168.0 ± 29.5*
LVEF (%)	27.9 ± 5.9	30.3 ± 4.1	31.4 ± 8.6
Mean PAP (mmHg)	31.9 ± 7.0+	27.3 ± 4.3	35.5 ± 6.0*

All values are mean ± SD.
*, p <0.05 versus group 1 or 2; +, p <0.05 versus group 2.
LVEDDI: Left ventricular end-diastolic diameter index; LVEDVI: Left ventricular end-diastolic volume index; LVEF: Left ventricular ejection fraction; LVESDI: Left ventricular end-systolic diameter index; LVESVI: Left ventricular end-systolic volume index; MMI: Myocardial mass index; PAP: Pulmonary artery systolic pressure.

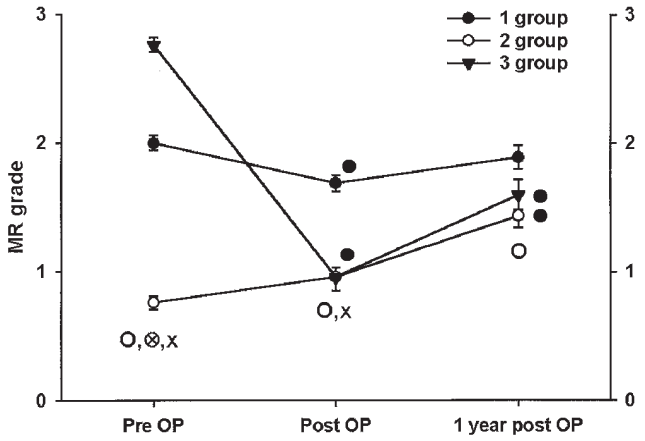

Figure 1: Dynamics of mitral regurgitation (MR) grade. Pre OP: Preoperatively; Post OP: Postoperatively. ○, p <0.05 group 1 versus group 2; ×, p< 0.05 group 1 versus group 3; ⊗, p <0.05 group 2 versus group 3; •, p <0.05 preoperatively versus postoperatively.

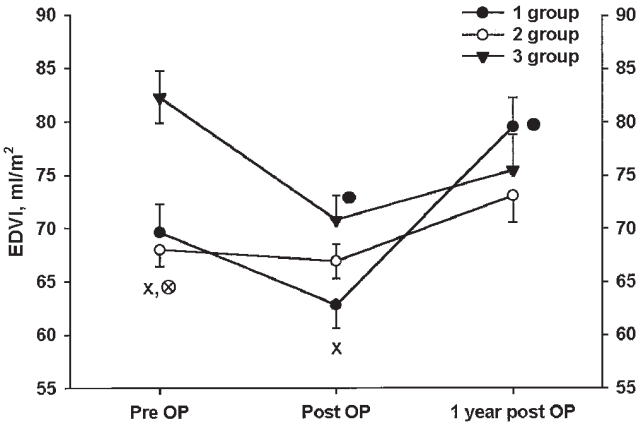

Figure 2: Dynamics of left ventricular end-diastolic volume index (EDVI). Abbreviations as Figure 1. ×, p <0.05 group 1 versus group 3; ⊗, p <0.05 group 2 versus group 3; •, p <0.05 preoperatively versus postoperatively.

method (23), while mean PAP was evaluated using conventional methods (24).

Statistical analysis

All data were expressed either as mean ± SD (text and tables) or mean ± SEM (figures). The preoperative and postoperative data were compared using a one-way ANOVA and Dunnett's test. Between-group data were compared using a one-way ANOVA and a (non-parametric) Bonferroni test. A p-value <0.05 was considered to be statistically significant.

Results

Baseline data

Preoperatively, the groups were substantially homogeneous except for a higher proportion of patients in NYHA class III-IV in group 3 (Table I). All patients had advanced heart conditions, mainly three-vessel coronary artery disease (CAD). The majority of patients had a history of MI. The echocardiographic variables (LV dimensions, volumes and function) did not differ between groups 1 and 2, except for PAP, which was lower in group 2 (Table II). In general, group 3 patients had significantly higher LV dimensions, volumes and PAPs (Table II).

Postoperative data

There were no inter-group differences with regard to the number of grafts performed (Table I).

During the early postoperative period, the MR grade was slightly decreased in group 1, remained

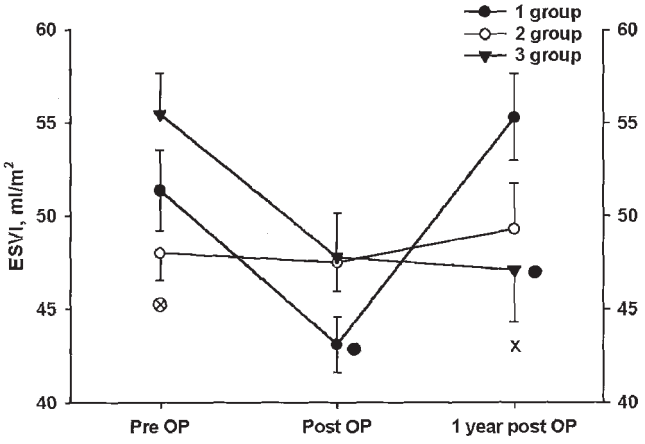

Figure 3: Dynamics of left ventricular end systolic volume index (ESVI). Abbreviations as Figure 1. ×, p <0.05 group 1 versus group 3; ⊗, p <0.05 group 2 versus group 3; •, p <0.05 preoperatively versus postoperatively.

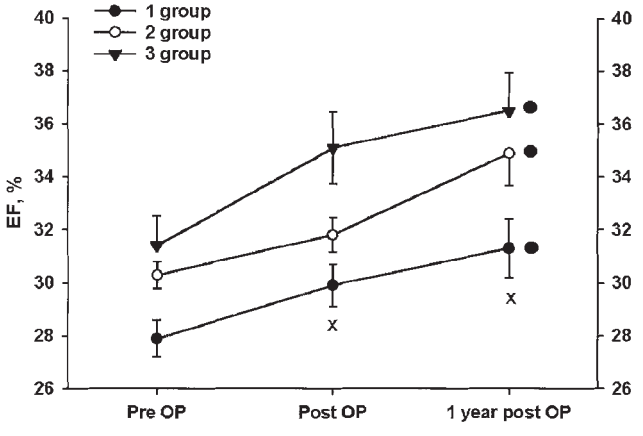

Figure 4: Dynamics of left ventricular ejection fraction (EF). Abbreviations as Figure 1. ×, p <0.05 group 1 versus group 3; •, p <0.05 preoperatively versus postoperatively.

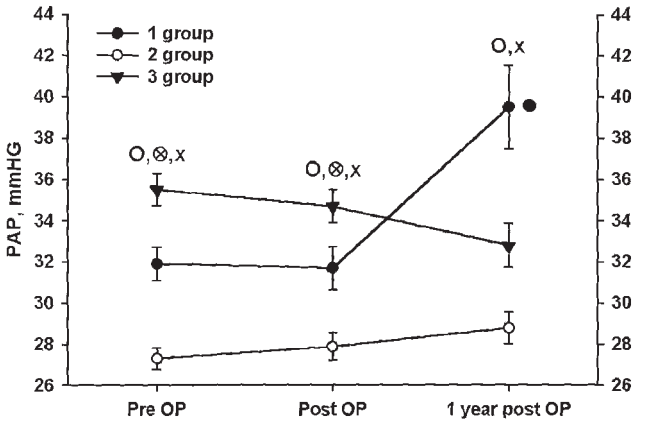

Figure 5: Dynamics of mean pulmonary artery pressure (PAP). ○, p <0.05 group 1 versus group 2; ×, p <0.05 group 1 versus group 3; ⊗, p <0.05 group 2 versus group 3; •, p <0.05 preoperatively versus postoperatively.

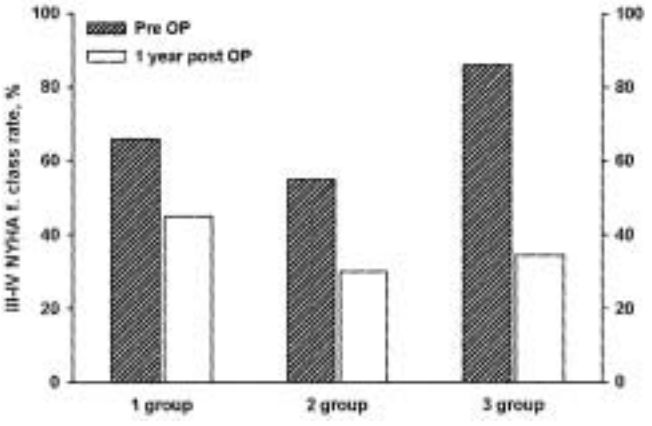

Figure 6: Changes in NYHA functional class. Abbreviations as Figure 1.

unchanged in group 2, and was markedly decreased in group 3. At one year after surgery the MR grade in group 1 remained unchanged compared to preoperative values, but in group 2 it was increased significantly. In group 3, the MR grade was increased compared to the early postoperative period, but remained markedly lower compared to preoperative values (Fig. 1). In group 3 the MR grade deteriorated from 0/1+ to 2+ in nine patients (15%).

At early follow up, the LVEDVI in group 3 and LVESVI in group 1 were decreased, but changes in the other indices were not statistically significant (Figs. 2-5).

At one year after surgery the LVEDVI had increased in group 1, but showed tendencies to increase in group 2 and to decrease in group 3 (Fig. 2). By comparison, the LVESVI was decreased in group 3 and tended to increase in groups 1 and 2 (Fig. 3). The LVEF was seen to increase in all groups (Fig. 4), while the PAP increased in group 1 and tended to decrease in group 3 (Fig. 5).

At one year after surgery in group 1, the LVESVI was significantly higher compared to group 3, but was similar to that in group 2. The PAP in group 1 was significantly higher and the LVEF lower compared to groups 2 and 3.

At one year after surgery, the NYHA functional class was markedly improved in all groups: the proportion of patients in NYHA classes III and IV had fallen from 66.2 to 45% in group 1, from 55.4 to 30% in group 2, and from 86 to 32% in group 3 (Fig. 6).

Discussion

In spite of a growing body of evidence in favor of surgical correction for MR, issues regarding the appropriate management of patients with ischemic MR and advanced LV dysfunction remain both controversial and limited. Although it has been reported that intervention on the mitral valve appears to benefit those with advanced heart failure (10,13), other studies support the benefit of isolated CABG in terms of survival and MR grade (5,6,15,16). The natural history of mild or trivial MR in patients with a dilated and poorly functioning left ventricle following CABG has not been fully investigated. Indeed, few data have been reported relating to the subset of patients with ICM and MR and, especially, relating to the evaluation of the patients' functional status after surgery. Thus, the present study was undertaken to evaluate the dynamics of ischemic MR, LV function and NYHA functional class in patients with ICM and MR at one year after CABG alone compared to CABG combined with mitral valve repair.

The dynamics of functional status in patients with ICM and MR (grade 2+) at one year after CABG was compared to that in patients who had 0 or 1+ MR early after surgery, including patients with 0 or 1+ MR preoperatively, those not requiring intervention on the mitral valve, and those with MR >2+, who underwent successful combined surgery. It was also possible to evaluate the natural history of MR 1+ after isolated CABG.

The aim of the present study did not include an assessment of perioperative mortality, operative risk and survival of ICM/MR patients, as this analysis had been conducted previously (5,6,15). Rather, attention was focused on the impact of MR on LV functional status in ICM patients at one year after surgery.

The preoperative clinical data in terms of severity of CAD (number of involved coronary arteries, angina

class, MI rate, etc.) did not differ substantially between the groups, except for a higher proportion of NYHA class III-IV among patients with MR >2+.

The CABG technique utilized was the same in all patients. For those with MR >2+, mitral valve repair was performed using conventional (ring implantation) and original (double semi-purse-string suture) techniques, with both approaches ensuring remodeling of the annulus and achieving better leaflet coaptation, without increasing the transmitral gradient and risk of systolic anterior motion of the anterior leaflet. The double semi-purse-string suture annuloplasty was performed in 89% of patients with ischemic MR, with an intraoperative success rate of 98.7%. Adjunct subvalvular procedures, including papillary muscle/chord shortening, were performed in order to increase the leaflet coaptation length in the case of ischemic damage of papillary muscle and its elongation, resulting in leaflet prolapse. The repositioning of both papillary muscles with shortening of the interpapillary muscle distance was performed in the case of Carpentier type IIIb dysfunction (tethered posterior leaflet) accompanied with strong tethering of the strut chord, which resulted in concave deformation (the 'seagull' configuration) of the anterior leaflet when an isolated annuloplasty was insufficient. A procedure similar to the Hvass papillary muscle sling (20) allowed the tension on the strut and posterior leaflet chords to be alleviated, and the concavity of the anterior leaflet to be diminished, thus providing a more optimal leaflet coaptation area and tenting length

At one year after isolated CABG, the MR 2+ remained stable compared to preoperative values, whereas 0 or 1+ MR was significantly worsened. At one year after combined surgery, the MR grade remained significantly better compared to preoperative values, but was slightly higher than early postoperative values. It should be noted, that the early postoperative data may have been affected by the procedures used. On the other hand, a detailed analysis of postoperative MR grade dynamics after mitral valve repair indicated a recurrence of MR 2+ in 15% of patients (in four of 40 (10%) of those who underwent original annuloplasty, in three of 20 (15%) undergoing ring annuloplasty, and in two of 29 (7%) of those with annuloplasty and subvalvular procedures). The present results do not exceed the MR recurrence rate reported by others, where conventional annuloplasty techniques were applied in patients with ICM (25,26). Moreover, the lowest rate of recurrent MR following annuloplasty combined with subvalvular procedures suggests that a combined technique ensures a more durable repair, though this must be proved during a longer follow up.

At one year after isolated CABG in patients with MR 2+, the LV volume, LVEF and PAP were each increased. The LV function, in terms of LV dimensions and PAP in patients with unrepaired MR 2+, became markedly worse, while the LVEF remained worse compared to patients with MR >2+ and more pronounced LV dysfunction preoperatively in those who underwent combined surgery. In the latter group, the left ventricle was reverse-remodeled to a smaller ventricle with an increased LVEF and tendency towards a decreased PAP, though preoperatively the LVEDVI and PAP were worse compared to the other groups.

A worsening of 0 or 1+ MR after isolated CABG coincided with an increase in LVEF and a tendency for an increased LV volume.

Despite the same trend in changes for LVEF, the postoperative dynamics of LV volume differed between the groups: the LV volume was increased or tended to increase after isolated CABG, but decreased or had a tendency to decrease after CABG combined with mitral valve repair.

The increase in LVEF in all groups may be attributed to revascularization of the ischemic regions. However, the measured LVEF may be affected by the presence of MR and LV overload. Therefore, an increase in LVEF among patients with unrepaired MR, coinciding with LV dilation, should be assumed to be a sign of improved LV function, albeit with certain precautions. In patients with unrepaired MR, the increase in LVEF may be related to a more marked increase in LVEDVI than in LVESVI at one year after surgery. In patients with repaired MR, the improvement in LVEF coincided with a reduction in LV volume, and may in part be attributed to a less-pronounced reduction in LVEDVI than LVESVI.

The NYHA functional class was improved in all groups, most markedly in patients after concomitant mitral valve repair, though one-third of patients remained in NYHA class III-IV, presumably owing to advanced CAD, a low LVEF and a to a certain degree of non-viable, non-functioning myocardium. The end-stage ischemic hearts may have less potential for remodeling (16), and for this reason some of the patients with ICM may remain in a higher NYHA class, even after MR correction. At one year after surgery, the worst proportions of NYHA class III-IV were in patients with unrepaired, moderate MR.

Thus, the present data demonstrated a negative impact of unrepaired MR 2+ on LV function, further LV remodeling, and increased PAP, whilst a significant reduction or elimination of MR >2+ after combined surgery had a marked positive impact on LV reverse remodeling, regression of LV dilatation, increased LVEF and decreased PAP.

It remains unclear why, following isolated CABG surgery, 0 or 1+ MR progresses, while MR 2+ remains sta-

ble, but impacts on further LV dilation. It is possible that, in the latter group LV dilatation will result in the progression of MR 2+ and later, as unrepaired MR leads to a vicious circle with increasing volume overload to the dilated LV leading to further worsening of MR (27,28). The progression of 0 or 1+ MR may be the result of further LV remodeling and tethering of the mitral valve subvalvular apparatus. Worsening of 0 or 1+ MR in the present study group coincided with a tendency for the LV volume to increase. Moreover, subtle echocardiographic parameters reflecting alterations in the mitral valve subvalvular apparatus (papillary muscle tethering distance, papillary muscle angle, mitral valve tenting area, etc.) before and after surgery were not evaluated in the present study. It is assumed that the follow up period was insufficiently long to observe LV remodeling dynamics in patients with MR 1+, as well as a worsening of unrepaired MR 2+.

Although only limited information is available in the literature on the mid-term or late functional status of patients undergoing CABG alone for ischemic MR 2+ (6,7, 10,12), the present data were in agreement with those of several studies, which suggest that CABG alone has an inconsistent and relatively weak impact on moderate ischemic MR 2+ (10,11), and that residual MR has a deleterious effect on hemodynamic parameters (12). Very few reports have been made relating to ischemic MR in the presence of severe LV dysfunction, and majority of these supported the benefits of isolated CABG in terms of survival and MR grade (5,6,16). A recent report addressed the late functional status of patients with ICM and MR 2+ undergoing CABG alone (15), and presented results that were in opposition to the present findings, concluding that isolated CABG is sufficient in patients with MR 2+, and produces improvements in both MR grade and LVEF. Although the patient populations in the report by Tolis et al. (15) and the present study seemed not to differ substantially with respect to LVEF and MR grade, it is possible that the present patients had more advanced (end-stage) CAD and MR as a result of post-MI remodeling and LV dilatation, but not ischemia.

Despite differences in terms of LV functional dynamics, the results of the present study were similar to those of others (5,15), proving that CABG alone offers an improvement in symptomatic status that can be attributed directly to myocardial revascularization.

Clinical implications

On the basis of these proven positive changes of LV functional status at one year after surgery in patients with corrected MR >2+ compared to those with uncorrected MR, mitral valve repair is strongly recommended for patients with ICM and grade 2+ MR.

Study limitations

The present study was neither prospective nor randomized, which might represent a major limitation. Moreover, while the degree of MR differed between patient groups with and without mitral valve repair, the study aim was to evaluate the impact of MR 2+ on the functional status of patients after CABG alone compared to those with 0 or 1+ MR soon after surgery; this included patients who underwent CABG combined with mitral valve plasty. It should also be noted that the preoperative evaluation of viability might help to distinguish between irreversible and reversible LV wall motion abnormalities, and may indicate which patients would benefit most from this approach. It remains unclear as to how long the positive impact of mitral valve repair might persist, and what further changes in LV geometry would occur in patients with repaired as well as unrepaired MR. Thus, the clinical value of the present study could be augmented by a longer follow up and an evaluation of late mortality.

In conclusion, isolated CABG in patients with ICM neither reduced the effects of MR, nor prevented its development. In fact, MR grade 2+ in patients with ICM at one year after isolated CABG had a deleterious effect on LV functional status, with progressive dilatation and an increase in PAP. A significant reduction or elimination of MR after combined surgery has a marked positive impact on reverse LV remodeling, which is seen as a regression of ventricular dilatation, an increase in LVEF, and a decrease in PAP.

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