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Preoperative left ventricular dimensions predict reverse remodeling following restrictive mitral annuloplasty in ischemic mitral regurgitation☆

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Abstract

Objective: Ischemic mitral regurgitation can be treated with a restrictive mitral annuloplasty, with or without coronary revascularization. In this study, the extent of reverse remodeling of the left ventricle following this strategy is assessed, as well as the factors that influence it. **Methods**: Eighty-seven consecutive patients with ischemic mitral regurgitation and a mean ejection fraction of $32\pm10\%$ underwent restrictive mitral annuloplasty (downsizing by two ring sizes, median ring size 26), with additional coronary revascularization in 75 patients. All underwent transthoracic echocardiography 18 months after surgery to assess residual mitral regurgitation, mitral valve gradient and left ventricular end-systolic and end-diastolic dimensions. Univariate and multivariate analysis was performed to identify predictors for reverse remodeling, defined as a 10% reduction in left ventricular dimension. Receiver-operating characteristic analysis was used to identify cut-off values for preoperative left ventricular dimensions in predicting reverse remodeling. **Results**: Early mortality was 8.0% (seven patients, three non-cardiac), late mortality was 7.5% (six patients, four non-cardiac). There were two reoperations (redo annuloplasty), and four readmissions for heart failure. At 29 months follow-up, NYHA class improved from 3.0 ± 0.9 to 1.3 ± 0.5 ($P<0.01$). Mitral regurgitation grade decreased from 3.1 ± 0.5 to 0.6 ± 0.6 at 18 months, left ventricular end-systolic dimension decreased from 52 ± 8 to 44 ± 11 mm ($P<0.01$), and end-diastolic dimension from 64 ± 8 to 58 ± 10 mm ($P<0.01$). Multivariate analysis identified preoperative left ventricular end-diastolic dimension as the single best factor in predicting occurrence of reverse remodeling. For end-systolic dimension, 51 mm was the optimal cut-off value to predict reverse remodeling (specificity and sensitivity 81%, area under curve 0.85); for end-diastolic dimension, the cut-off value was 65 mm (specificity and sensitivity 89%, area under curve 0.92). **Conclusions**: Stringent restrictive mitral annuloplasty with or without revascularization provides excellent clinical results with acceptable mortality. At 18 months follow-up, there is no significant residual mitral regurgitation. Reverse remodeling occurs in the majority of patients, but is limited by preoperative left ventricular dimensions. In patients with a left ventricular end-diastolic dimension exceeding 65 mm, additional surgical procedures are necessary to try and obtain reverse remodeling in this subgroup.

Keywords: Ischemic mitral regurgitation; Restrictive annuloplasty; Ischemic cardiomyopathy; Heart failure; Coronary artery bypass grafting

1. Introduction

Chronic ischemic mitral regurgitation (IMR) should be defined as mitral regurgitation (MR) resulting from coronary artery disease (CAD) [1,2]. This definition excludes all cases in which MR merely coincides with CAD. Regional wall motion abnormalities secondary to ischemia, whether persistent—following myocardial infarction—or transient, give rise to functional MR [3]. Echocardiographically, functional MR is characterized by leaflet coaptation failure due to systolic restrictive motion of one or both valve leaflets (Carpentier type IIIb [4]), often combined with annular dilatation.

In the past, revascularization alone was believed to correct IMR by improving LV function [5,6]. This may seem attractive, since isolated CABG carries a lower peri-operative risk than a combined procedure. Nowadays, there are convincing arguments that negate a conservative approach.

First, IMR is not a benign condition, but instead carries a two-fold excess mortality of 62% at 5 years in post-infarction patients irrespective of other risk factors [1]. In addition, it is a progressive disorder in which MR-related LV volume overload promotes further LV remodeling, leading to worsening of MR. Follow-up in moderate chronic IMR patients has shown that isolated CABG does not always cure MR [7]. Intervention on the mitral valve can be limited to a stringent 'restrictive' (down-sized) ring annuloplasty,

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which is a relatively simple technique with an acceptable mortality even in high-risk end-stage heart failure patients with dilated cardiomyopathy [8].

There is still controversy regarding the outcome of chronic IMR patients treated with combined CABG and restrictive mitral annuloplasty (RMA). We describe our experience with this approach in 87 consecutive patients with respect to clinical outcome and echocardiographic follow-up. We focus on durability of the annuloplasty technique by assessment of MR, and on LV reverse remodeling, especially in relation to the extent of preoperative LV dilatation. In an earlier report [9] we demonstrated that not all patients show reverse remodeling following successful RMA with or without CABG. In this study, we assessed the influence (and predictive value of) several preoperative variables on reverse LV remodeling.

2. Materials and methods

2.1. Patient population

Between January 2000 and March 2004, 87 consecutive patients with chronic ischemic mitral regurgitation underwent coronary revascularization and restrictive mitral annuloplasty. Mean age was 66.0±10.0 years (range 36.8-84.6 years), and 57 (65.5%) patients were male. All patients had coronary artery disease and previous myocardial infarction. Patients with signs and symptoms of heart failure and/or evidence of mitral regurgitation on LV angiography underwent preoperative transthoracic echocardiography (TTE) to assess severity of MR. All patients with MR grade 2+ or more underwent outpatient preoperative transesophageal echocardiography (TEE) to establish the mechanism of MR. Criteria for IMR were presence of systolic restrictive leaflet motion, with or without annulus dilatation and absence of other mitral valve pathology. Patients with ischemic MR grade 3+ or 4+ were scheduled for RMA with or without CABG. In patients who were scheduled for CABG anyway, with MR grade 2+ or fluctuating MR, an intraoperative loading test was performed by canulation of the ascending aorta and increasing the pulmonary capillary wedge pressure with 15 mmHg compared to baseline value [2,10] by rapid filling through the aortic cannula, prior to the institution of cardiopulmonary bypass. If MR increased to grade 3+ or 4+ patients underwent RMA.

Patients with coexisting aortic valve disease or previous aortic valve surgery and patients who had concomitant surgery for LV aneurysm were excluded from this study, as were patients with functional MR based on idiopathic dilating cardiomyopathy. Patients with organic mitral valve abnormalities were also excluded. There were no patients excluded based on critical preoperative status; mean logistic EuroSCORE was 11.0±10.7 (range 2–63). Fourteen (16.1%) patients had their last myocardial infarction 6 weeks or less before surgery, three patients were ventilator-dependent preoperatively, three had IABP support and eight had intravenous inotropic drugs. Preoperative clinical and angiographic characteristics are presented in Table 1.

Mean preoperative MR grade was 3.1±0.5 (86.2% of patients had grade 3+ or 4+). Mean LV ejection fraction was 32±10%, baseline LV end-systolic dimension (LVESD) was 52±8 mm, LV end-diastolic dimension (LVEDD) was 64±8 mm.

Table 1
Preoperative clinical and angiographic data

NYHA functional class	3.0±0.9
<=II	16 (18.4%)
III	44 (50.6%)
IV	27 (31.0%)
CCS score	2.3±1.3
Logistic EuroSCORE	11.0±10.8 (range 2-63)
Previous myocardial infarction	87 (100%)
Inferior/posterior/lateral	75 (86.2%)
Last MI<6 weeks	14 (16.1%)
Duration of symptoms (yrs)	5.2±6.7 (range 0.5-23)
IABP	3
Intravenous inotropes	8
Ventilator dependency	3
Previous CABG	6 (6.9%)
Preoperative CAD	87 (100%)
1-vessel	7 (8.0%)
3-vessel	65 (74.7%)
Wall motion abnormality	
Regional	71 (81.6%)
Global (dilated cardiomyopathy)	16 (18.4%)

NYHA, New York Heart Association; CCS, Canadian Cardiovascular Society; MI, myocardial infarction; IABP, intra-aortic balloon pump; CABG, coronary artery bypass grafting; CAD, coronary artery disease.

2.2. Operative technique

All operations were performed through midline sternotomy on normothermic cardiopulmonary bypass with intermittent antegrade warm blood cardioplegia. An intraoperative loading-test was performed in 16 (18.4%) patients with grade 2+ or fluctuating MR, and showed increase to grade 3+ or 4+ in all cases.

CABG was performed in 75 (86.2%) patients; 12 patients did not undergo revascularization because of absence of angina and of ischemia on myocardial scintigraphy or because of patent coronary artery bypass grafts in redo operations. Revascularization of the anterior myocardium was always achieved with the LITA. For other territories, the RITA was used in patients under the age of 65 with good target vessels—either as an in situ graft or as a free graft with proximal anastomosis to the LITA. In other cases, the saphenous vein was used. In one patient, the gastroepiploic artery was used for the inferior wall.

Exposure of the mitral valve was through a vertical transseptal approach. Mitral annuloplasty ring size (Carpentier Edwards Physioring, Edwards Lifesciences, Irving, CA, USA) was determined by standard measurement of the intertrigonal distance and anterior leaflet height, and then stringent downsizing by two ring sizes was performed. The rings were anchored using multiple (14–16) deep u-shaped stitches of Ethibond 2-0 (Ethicon, Inc., Somerville, NJ, USA) or Ti-Cron 2-0 (Syneture, Norwalk, CT, USA). Ninety-three percent of the rings were size 28 or less (mean size 26). Tricuspid ring annuloplasty was performed in 16 (18.4%) patients when annulus enlargement had been observed on echocardiography (≧40 mm), or was present on intraoperative inspection. A Carpentier Edwards Classic annuloplasty ring or Edwards MC3 annuloplasty ring (both

Table 2
Surgical data

Positive loading test	16 (18.4%)
CABG	75 (86.2%)
No. of distal anastomoses/patient	3.3±1.3
Mitral annuloplasty ring size	median 26
24	13 (14.9%)
26	32 (36.8%)
28	36 (41.4%)
30	3 (5.7%)
32	1 (1.1%)
Tricuspid valve annuloplasty	16 (18.4%)
Median ring size	28
CPB time (min)	189±52
Aortic cross-clamp time (min)	125±37

CPB, cardiopulmonary bypass.

manufactured by Edwards Lifesciences, Irving, CA, USA) was used. In six (6.9%) patients with persistent or chronic atrial fibrillation endocardial unipolar radiofrequency ablation was done with the Cardioblate device (Medtronic, Inc., Minneapolis, MN, USA), as described by Melo et al. [11]. One patient underwent simultaneous left upper lobe lobectomy for non-small cell lung carcinoma. Mean cardiopulmonary bypass time and aortic cross-clamping time were 189±52 and 125±37 min, respectively. Surgical aspects are summarized in Table 2.

2.3. Intra- and post-operative echocardiography and clinical follow-up

Intra-operative TEE was used in all patients to evaluate residual MR, mitral valve gradient, mitral valve area and leaflet coaptation height (defined as the length of coaptation of the anterior and posterior leaflet at the level A2-P2 in end-systole), residual tricuspid regurgitation (TR) and LV function. We aimed at no MR and a minimum coaptation height of 8 mm.

Before discharge, TTE was used to determine left atrial and LV dimensions, severity of MR and TR, and mitral valve gradient. All patients were rescheduled for TTE between 3 and 6 months following surgery and after 18 months. All echocardiograms were analyzed in random order by two combined readers, blinded to clinical data and to the timing of the study. Clinical follow-up was achieved at the outpatient clinic concurrent with TTE, and by telephone interviews in August 2004. NYHA functional class was assessed, events scored included reoperation; balloon angioplasty; myocardial infarction; readmission for heart failure; thrombo-embolic complications and endocarditis. Surface electrocardiograms were made to assess cardiac rhythm.

2.4. Statistical analysis

Continuous data are expressed as mean±standard deviation unless otherwise stated, and compared using Student's *t*-test for paired and unpaired data when appropriate. Proportions were compared by χ^2 analysis with Yates' correction. Actuarial survival over time and event-free survival were analyzed using the method of Kaplan–Meier. Univariate and multivariate logistic regression analyses were performed to characterize predictors of reverse left ventricular remodeling. Variables considered were: gender, age, baseline NYHA class, left ventricular ejection fraction, severity of MR, left atrial dimension, left ventricular end-systolic and end-diastolic dimensions. Optimal cut-off values of LVESD and LVEDD to predict reverse remodeling were determined by receiver-operating characteristic (ROC) curve analysis. The optimal cut-off value was defined as that providing maximal accuracy to distinguish between responders and non-responders. For all tests, a P value <0.05 was considered significant. SPSS statistical software (SPSS version 11.5, SPSS, Inc., Chicago, IL, USA) was used for calculations.

3. Results

Mitral valve repair could be achieved in all patients, irrespective of the degree of leaflet tethering. Intra-operative post-repair TEE showed absence of MR in 78 (90%) patients and trace or grade 1+ MR in 9 (10%); mean MR grade was 0.2±0.3. Leaflet coaptation height was 8±2 mm; no patient showed mitral stenosis (mean transvalvular gradient 2.9±1.1 mmHg, mean valvular area 2.8±0.6 cm^2).

3.1. Immediate outcome

There were no intra-operative deaths. In the post-operative course, three (3.7%) patients required intra-aortic balloon counterpulsation because of low cardiac output. Six (6.9%) patients needed temporary dialysis for renal failure. One patient sustained a myocardial infarction (for which he underwent emergency redo coronary revascularization). There were no neurologic complications. One (1.1%) patient developed mediastinitis. Mean ICU stay was 5±3 days.

Early mortality (30-day mortality and in-hospital mortality when length of stay after surgery exceeded 30 days) was 8.0% (seven patients). Causes of death were: intractable ventricular arrhythmia ($n=2$), multi-organ failure (MOF) following myocardial infarction (1), intractable vasoplegia (1), septicemia and MOF following duodenal perforation after insertion of feeding tube (1), RV rupture following mediastinitis (1) and pneumonia following exacerbation of leukemia (1).

3.2. Long-term follow-up

Follow-up for surviving patients was complete. Mean duration of clinical follow-up was 29±14 months (range 6–54 months). Six patients (7.5%) died during follow-up of congestive heart failure (1), ventricular arrhythmia (1), traumatic intracranial hemorrhage (1) and malignant disease (3). Therefore, actuarial survival at 2 years was 85.6% (Fig. 1).

Two patients needed reoperation for recurrent MR. The first patient, with dilated ischemic cardiomyopathy had no MR directly after surgery with 6 mm leaflet coaptation (initial ring size 28). Over time, MR gradually increased with progressive heart failure. After 12 months, she was reoperated and a size 26 annuloplasty ring was inserted,

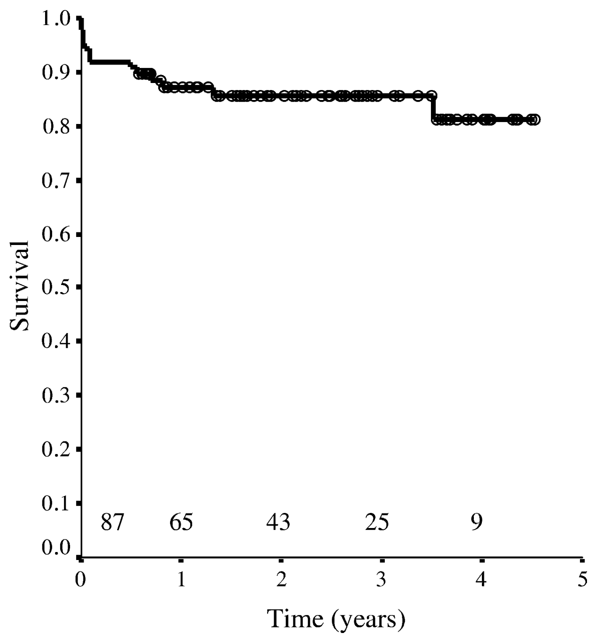

Fig. 1. Kaplan–Meier plot showing actuarial survival. Number of patients at risk is added above the time axis.

with no MR 17 months after her second operation. The other patient, an acromegalic man, had a size 32 ring without regurgitation initially. After 6 months, he was readmitted for congestive heart failure with massive MR. On reoperation, a partial ring dehiscence was observed at the posterior commissure. Refixation of the ring was successful and the patient is asymptomatic 17 months later. Two patients underwent PTCA during the follow-up period, and four were readmitted for congestive heart failure. NYHA class improved from 3.0±0.9 to 1.3±0.5 ($P<0.01$), with 18 patients in NYHA class II and 1 patient in class III.

3.3. Mitral regurgitation and LV remodeling at long-term follow-up

At 18 months follow-up, mean MR grade was 0.6±0.6 (MR trace or grade 1+ in 28 patients and grade 2+ in 5).

Left atrial dimension decreased from 54±6 mm at baseline measurement to 48±6 mm at 18 months ($P<0.01$). LVESD decreased from 52±8 to 44±11 mm ($P<0.01$), and LVEDD decreased from 64±8 to 58±10 mm ($P<0.01$).

Forty-six (60.5%) surviving patients demonstrated significant reverse LV remodeling, considering a 10% reduction in LVEDD as significant. In this subset of patients, LVEDD decreased from 60±5 to 51±4 mm ($P<0.01$), whereas LVESD changed from 47±6 to 37±5 mm ($P<0.01$). Echocardiographic data are presented in Table 3.

Baseline characteristics for patients with and without LV reverse remodeling were comparable, except for baseline LVEDD (71±6 versus 60±5 mm, $P<0.01$) and LVESD (58±8 versus 47±6 mm, $P<0.01$).

ROC curve analysis showed that the optimal cut-off value for LVESD to predict reverse remodeling was 51 mm; application of this cut-off value yielded a predictive sensitivity and specificity of 81% (area under the curve 0.85, see Fig. 2). ROC curve analysis on LVEDD identified

Table 3
Echocardiography data before surgery and at late follow-up

	Baseline	Late follow-up (18 months)	
MR grade	3.1±0.5	0.6±0.6	$P<0.01$
None	-	30	
Trace or 1+	-	28	
2+	12 (13.8%)	5	
3+	56 (64.4%)	-	
4+	19 (21.8%)	-	
Coaptation height (mm)	3±1	8±1	$P<0.01$
Left atrial dimension (mm)	54±6	48±6	$P<0.01$
LV end-systolic dimension (mm)	52±8	44±11	$P<0.01$
LV end-diastolic dimension (mm)	64±8	58±10	$P<0.01$
LV ejection fraction (%)	32±10	-	

MR, mitral regurgitation; LV, left ventricular.

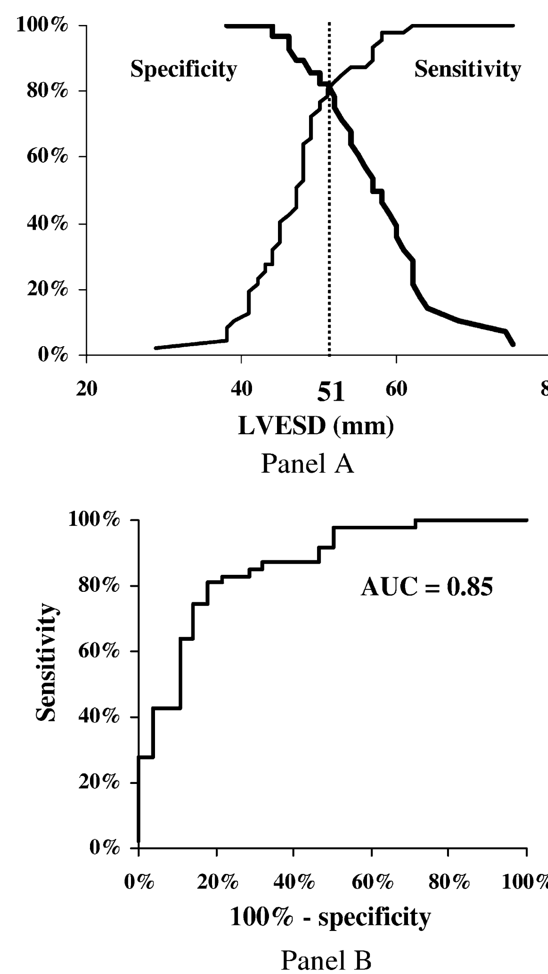

Fig. 2. ROC curve analysis (panel A, left) demonstrated that the optimal cut-off value for LV end-systolic dimension (LVESD) was 51 mm to predict reverse LV remodeling (dashed line crossing at intersection of sensitivity and specificity curves). Using this cut-off value, a sensitivity and specificity of 81% were obtained. Panel B (right) shows that the area under the curve (AUC) was 0.85.

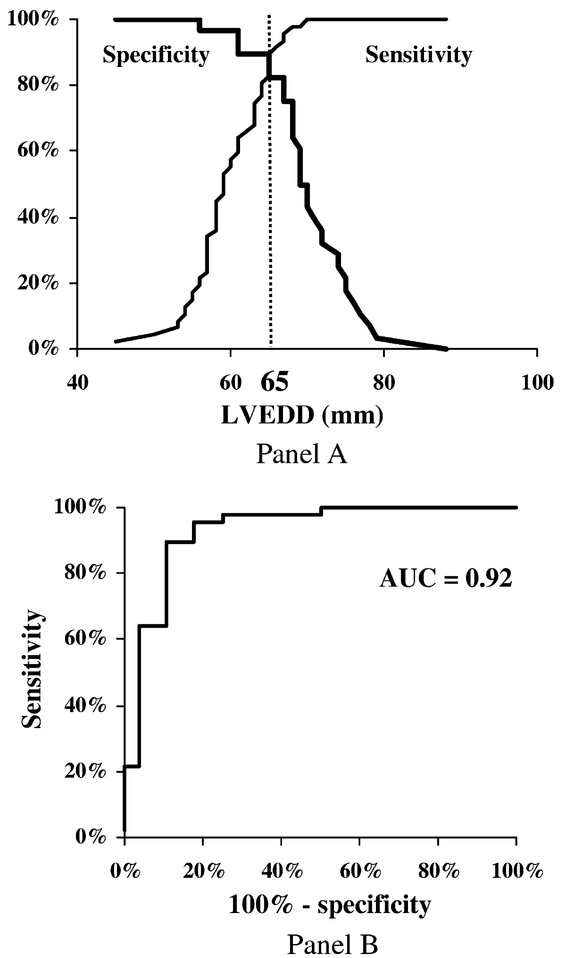

Fig. 3. ROC curve analysis (panel A, left) demonstrated that the optimal cut-off value for LV end-diastolic dimension (LVEDD) was 65 mm to predict reverse LV remodeling. Using this cut-off value, a sensitivity and specificity of 89% were obtained. Panel B (right) shows that the area under the curve (AUC) was 0.92.

an optimal cut-off value of 65 mm, which yielded a sensitivity and specificity of 89% (area under the curve 0.92, see Fig. 3) to predict reverse left ventricular remodeling. Multivariate analysis demonstrated that LVEDD was the single best predictor of reverse remodeling.

4. Discussion

IMR is a complication of coronary artery disease that is frequently overlooked, in spite of its prevalence of 19% in post-infarction patients [12]. The high prevalence of IMR combined with a dismal prognosis warrants a search for its presence in patients at risk. Since IMR is a form of functional MR, preload and afterload conditions influence the severity of MR present on echocardiographic examination. Therefore, patients with CAD who present with signs and symptoms of heart failure, especially following (infero-posterior) myocardial infarction, should undergo a sound workup to exclude IMR.

Patients with chronic IMR represent a heterogeneous group when it comes to LV dysfunction; the spectrum of LV performance comprises both well-preserved ventricles with near-normal ejection fractions, and dilated cardiomyopathies with ejection fraction below 10%. However, echocardiographic studies from the Mayo Clinic have shown that the presence and degree of IMR is unrelated to the severity of LV dysfunction; local LV remodeling leads to excess valvular tenting independent of global LV remodeling [13].

IMR should be treated with mitral valve surgery. Earlier reports from a cohort of 58 patients [5,6] who received CABG alone in the presence of grade 3+ MR between 1977 and 1983, compared with 20 patients who underwent CABG and mitral valve replacement, showed worse outcome in the latter group. This study has given many surgeons an argument against an intervention on the valve rather than CABG alone in IMR. However, the cohorts were not comparable, as there were large differences between ischemia being the cause of MR (74% versus 30% in the control group), the mean ejection fraction was very high (53%) and only 10% of patients were in NYHA class III or IV.

A report by Tolis et al. [14] suggests that MR grade is reduced following isolated CABG in patients with 'mild-to-moderate' IMR and ischemic cardiomyopathy (mean EF 22.4%, range 10–30%). However, 18 out of 49 patients had grade 1+ MR, and 6 had grade 3+. Follow-up is based on 26 out of 49 patients, and gives only a mean value for residual MR without a distribution. Aklog et al. [7] have shown that CABG alone for moderate IMR leaves many patients with significant residual MR and is therefore an inadequate approach. Harris [15] has reported on 176 patients with CAD and grade 2+ or 3+ IMR, of whom 142 underwent CABG alone and 34 CABG with mitral valve repair or replacement. Patients in NYHA class III or IV showed superior late survival when the mitral valve was operated, and MR grade was increasing over time in the CABG group while it was stable in the CABG+valve group. However, operative mortality was lower in the CABG group (9 versus 21%).

The reverse LV remodeling observed in this study is obvious, and largely a consequence of the disappearance of mitral regurgitation and LV volume overload. The design of our study does not allow to differentiate between the effects of revascularization (of hibernating myocardium) versus those of mitral valvuloplasty on reverse LV remodeling. Preoperative medical therapy was continued without modification after surgery for the duration of the study. In particular, the use and dosage of ACE-inhibiting agents was not changed during the course of follow-up, and therefore its influence on LV reverse remodeling in this patient group is negligable. Additional tricuspid annuloplasty—performed whenever annulus diameter equalled or exceeded 40 mm—is thought to be beneficial in that it optimizes the filling of the left ventricle which is particularly useful in patients with impaired diastolic function.

Our operative and 30-day mortality of 8.0% is acceptable, when related to EuroSCORE and to other series. Comparing operative mortality scores for treatment of IMR requires again a strict look at patient selection. Strictly speaking, IMR can also be applied to patients with papillary muscle rupture, a patient group with an obviously dismal prognosis. A large series from Cleveland [16] has shown 13% overall 30-day mortality in all IMR cases (including ruptured papillary muscle and including MV replacement); in a 'better-risk' group, mortality with MV repair was 6%. Grossi [17] has reported from a similar group of patients, showing 10% operative mortality for repair. Our series is restricted to patients with functional MR only, although we did not exclude patients because of critical preoperative state as can be seen from the number of patients requiring ventilatory or inotropic support preoperatively. We have reported on the use of restrictive mitral annuloplasty in the emergency setting in IMR patients with acute deterioration with intact papillary muscle [18].

Calafiore [19] recently reported a 3.9% 30-day mortality (2.4% for MV repair) in IMR. Long-term follow-up shows excellent survival and improvement in functional status.

Several studies report the use of restrictive mitral annuloplasty in functional IMR [8,16]. Calafiore chooses a posterior annuloplasty only [19], whereas he promotes MV replacement in cases with extensive leaflet tethering (as measured by the distance from the coaptation point up to the mitral annulus). We prefer a true annuloplasty to really reduce the anterior–posterior distance of the annulus and enforce at least 8 mm coaptation height. In all cases, even in the presence of extensive tethering, this approach was successful with stringent downsizing by two ring sizes. The technique is simple and does not add much time to myocardial ischemia. The durability of this technique is illustrated by the sequential echocardiograms showing absence of residual MR at 18 months. We never performed mitral valve replacement. The fear of systolic anterior motion following downsizing is unnecessary, because of the widened aorto-mitral angle in this type of pathology. We never encountered elevated transmitral gradients, because the leaflet tissue is normal in this type of pathology.

The most important finding in this study is, that preoperative LV dimensions predict the likelihood of reverse remodeling, which is the ultimate goal of the surgeon. Reverse remodeling decreases the stress on the valvular and subvalvular apparatus and therefore consolidates the result. In our series, the chance of reverse remodeling to occur is low when preoperative LVEDD exceeds 65 mm and/or LVESD is more than 51 mm. Even in the absence of recurrent MR, a left ventricle with dilatation beyond these cut-off values does not achieve reverse remodeling, suggesting that the extent of disease of the left ventricle is the limiting factor in the process of reverse remodeling. Of interest, 8 of 13 (61.5%) patients who died in this series had an LVEDD > 65 mm, and 7 of 13 patients (53.8%) had an LVESD > 51 mm.

Restrictive mitral annuloplasty with or without CABG can be applied in patients with ischemic mitral regurgitation with an acceptable operative risk. Clinical outcome at 2 years follow-up remains favorable. Recurrent MR is seldom observed if proper stringent downsizing is performed, and LV reverse remodeling occurs within the limitations set by the extent of preoperative LV dilatation.

The finding that baseline LV dimensions seem to play a key role in the likelihood of reverse remodeling indicates that CABG with RMA are not sufficient to ensure a favorable long-term outcome in patients with LV dimensions beyond the cut-off value. We now apply a CorCap cardiac support device (Acorn Cardiovascular, Inc., St Paul, MN, USA) in all patients with IMR and dilated cardiomyopathy with LVEDD > 65 mm. Another approach to these patients might be found in a more aggressive left ventricular restoration surgery, especially when LVEDD > 80 mm [20]. Future follow-up will show whether this strategy will contribute to LV reverse remodeling in this subset of patients. A close follow-up of patients that approach these LV dimensions on preoperative evaluation is necessary to observe further dilatation.

References

[1] Grigioni F, Enriquez-Sarano M, Zehr KJ, Bailey KR, Tajik AJ. Ischemic mitral regurgitation long-term outcome and prognostic implications with quantitative Doppler assessment. Circulation 2001;103:1759–64.

[2] Dion R, Benetis R, Elias B, Guennaoui T, Raphael D, Van Dyck M, Noirhomme Ph, Van Overschelde JL. Mitral valve procedures in ischemic regurgitation. J Heart Valve Dis 1995;4:124–31.

[3] Boltwood CM, Tei C, Wong M, Shah PM. Quantitative echocardiography of the mitral complex in dilated cardiomyopathy: the mechanism of functional mitral regurgitation. Circulation 1983;68:498–508.

[4] Carpentier A. Cardiac valve surgery—the 'French correction'. J Thorac Cardiovasc Surg 1983;86:323–37.

[5] Arcidi Jr JM, Hebeler RF, Craver JM, Jones EL, Hatcher Jr CR, Guyton RA. Treatment of moderate mitral regurgitation and coronary disease by coronary bypass alone. J Thorac Cardiovasc Surg 1988;95:951–9.

[6] Duarte IG, Shen Y, MacDonald MJ, Jones EL, Craver JM, Guyton RA. Treatment of moderate mitral regurgitation and coronary disease by coronary bypass alone: late results. Ann Thorac Surg 1999;68:426–30.

[7] Aklog L, Filsoufi F, Flores KQ, Chen RH, Cohn LH, Nathan NS, Byrne JG, Adams DH. Does coronary artery bypass grafting alone correct moderate ischemic mitral regurgitation? Circulation 2001;104(Suppl 1):I-68–I-75.

[8] Bolling SF, Pagani FD, Deeb GM, Bach DS. Intermediate-term outcome of mitral reconstruction in cardiomyopathy. J Thorac Cardiovasc Surg 1998; 115:381–8.

[9] Bax JJ, Braun J, Somer ST, Klautz R, Holman ER, Versteegh MIM, Boersma E, Schalij MJ, Van der Wall EE, Dion RA. Restrictive annuloplasty and coronary revascularization in ischemic mitral regurgitation results in reverse left ventricular remodeling. Circulation 2004;110(Suppl I):I.

[10] Byrne JG, Aklog L, Adams DH. Assessment and management of functional or ischaemic mitral regurgitation. Lancet 2000;355:1743–4.

[11] Melo JQ, Santiago T, Gouveia RH, Martins AP. Atrial ablation for the surgical treatment of atrial fibrillation: principles and limitations. J Card Surg 2004;19:207–10.

[12] Lamas GA, Mitchell GF, Flaker GC, Smith Jr SC, Gersh BJ, Basta L, Moye L, Braunwald E, Pfeffer MA. Clinical significance of mitral regurgitation after acute myocardial infarction. Circulation 1997;96: 827–33.

[13] Yiu SF, Enriquez-Sarano M, Tribouilloy C, Seward JB, Tajik AJ. Determinants of the degree of functional mitral regurgitation with systolic left ventricular dysfunction a quantitative clinical study. Circulation 2000;102:1400–6.

[14] Tolis JA, Korkolis DP, Kopf GS, Elefteriades JA. Revascularization alone (without mitral valve repair) suffices in patients with advanced ischemic cardiomyopathy, and mild-to-moderate mitral regurgitation. Ann Thorac Surg 2002;74:1476–81.

[15] Harris KM, Sundt TM, Aeppli D, Sharma R, Barzilai B. Can late survival of patients with moderate ischemic mitral regurgitation be impacted by intervention on the valve? Ann Thorac Surg 2002;74:1468–75.

[16] Gillinov AM, Wierup PN, Blackstone EH, Bishay ES, Cosgrove DM, White J, Lytle BW, McCarthy PM. Is repair preferable to replacement for ischemic mitral regurgitation? J Thorac Cardiovasc Surg 2001;122:1125–41.

[17] Grossi EA, Goldberg JD, LaPietra A, Ye X, Zakow P, Sussman M, Delianides J, Culliford AT, Esposito RA, Ribakove GH, Galloway AC, Colvin SB. Ischemic mitral valve reconstruction and replacement: comparison of long-term survival and complications. J Thorac Cardiovasc Surg 2001;122:1107–24.

[18] Braun J, Voigt PG, Versteegh MIM, Dion RAE. Restrictive mitral annuloplasty in refractory cardiogenic shock with acute postinfarction mitral insufficiency and intact papillary muscle. J Thorac Cardiovasc Surg 2003;126:284–6.

[19] Calafiore AM, Di Mauro M, Gallina S, Di Giammarco G, Iacò AL, Teodori G, Tavarozzi I. Mitral valve surgery for chronic ischemic mitral regurgitation. Ann Thorac Surg 2004;77:1989–97.
[20] Isomura T, Suma H, Yamaguchi A, Kobashi T, Yuda A. Left ventricular restoration for ischemic cardiomyopathy—comparison of presence and absence of mitral valve procedure. Eur J Cardiothorac Surg 2003;23: 614–9.

Appendix A. Conference discussion

Dr J. Melo (*Carnaxide, Portugal*): I have two comments. This is a very difficult group of patients, usually they have large atria. What is your current treatment regarding concomitant atrial fibrillation? Are you doing anything for those patients regarding atrial fibrillation?

The other comment is, concerns is your present policy when you are undersizing the mitral ring? You do that regardless of the size of the posterior leaflet. You don't care about the possibility of SAM, or do you take any precautions?

Dr Braun: To answer your first question, Professor Melo, atrial fibrillation in our hospital is treated rather aggressively. In this patient group we had six patients with chronic or paroxystic atrial fibrillation and they all had an endocardial unipolar ablation with an irrigated radiofrequency probe. So it is treated regardless of the left atrial size.

As to the second question, we measure the ring size in the standard fashion, by measuring the intertrigonal distance and the length of the anterior leaflet. Then we simply downsize the ring by two ring sizes. And, in fact, SAM is not observed in this patient group in any case because of the widened angle between the planes of the aorta and the mitral annulus. Therefore, even the use of a size 24 ring has never resulted in a SAM in this subset of patients.

Dr R. De Simone (*Heidelberg, Germany*): I have two questions. First, when you downsize your annulus reduction, do you include in your decision-making also some dynamical information, like the shortening of the annulus? Second, when you judge the remodeling, you just take one diameter. Did you try to quantify this, for example, with three-dimensional techniques?

Dr Braun: Well, the sizing of the ring is, as I described, just based on the anatomical measurement.

Dr De Simone: You can do it preoperatively just looking at the shortening in a dynamical way.

Dr Braun: We do measure the annulus preoperatively, but it does not influence our intra-operative decision.

Dr De Simone: Do you include in your judgment of reverse remodeling also other diameters, because if you just take one diameter, you can miss some other information due to the three-dimensional geometry of the annulus.

Dr Braun: You mean the diameter of the left ventricle?

Dr De Simone: Yes, of the left ventricle.

Dr Braun: We measure the LV diameters with M-mode in the parasternal long axis view at the level of the papillary muscle.