Predictors of moderate ischemic mitral regurgitation improvement after off-pump coronary artery bypass

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ABSTRACT

Objective: The aim of this study was to explore the predictors of improvement of moderate ischemic mitral regurgitation after off-pump coronary artery bypass grafting.

Methods: A prospective study was performed among 109 patients (aged 66.6 ± 8.6 years, 34.6% were female) with prior myocardial infarction and moderate ischemic mitral regurgitation undergoing off-pump coronary artery bypass grafting. Preoperative and follow-up clinical characteristics and echocardiography data were analyzed, focusing on left ventricular global/regional remodeling and function. Patients were grouped by postoperative ischemic mitral regurgitation at 1 year postoperatively: the improved group with no or mild ischemic mitral regurgitation and the failure group with moderate or severe ischemic mitral regurgitation. Data were compared between the 2 groups to explore the predictors of ischemic mitral regurgitation improvement after off-pump coronary artery bypass grafting.

Results: Five patients died within 1 year and were excluded. At the 1-year follow-up, there were 55 patients in the improved group and 49 patients in the failure group. Before surgery, the improved group had smaller left ventricular end-systolic volume, greater left ventricular ejection fraction, greater posterior-inferior volume ratio, and earlier operation timing after infarction than the failure group. Posterior-inferior volume ratio ($P < .001$), ejection fraction ($P = .003$), and duration between infarction and operation ($P < .001$) were independent predictors of preoperative moderate ischemic mitral regurgitation improvement.

Conclusions: In selected patients, preoperative moderate ischemic mitral regurgitation was relieved by off-pump coronary artery bypass grafting. Greater ejection fraction, greater posterior-inferior volume ratio, and early operation timing after infarction may predict the improvement of moderate ischemic mitral regurgitation after off-pump coronary artery bypass grafting, suggesting that posterior-inferior regional remodeling, reserved ventricular function, and early revascularization are important to the outcome. (J Thorac Cardiovasc Surg 2015;149:1606-12)

Postoperative survival estimates for patients with moderate IMR undergoing OPCAB. OPCAB, Off-pump coronary artery bypass.

Central Message

In patients with moderate IMR undergoing OPCAB, greater EF, greater posterior-inferior volume ratio, and early operation timing after infarction may predict postoperative improvement of IMR, suggesting that posterior-inferior regional remodeling, reserved ventricular function, and early revascularization are important to the outcome.

Perspective

To date, identified predictors of IMR improvement after revascularization are scattered, especially in the LV regional remodeling aspect. The present study indicates that for patients with significant posterior-inferior regional remodeling and relatively reserved LV function, early OPCAB would be a benefit for IMR improvement and the outcome. These findings provide a novel perspective in predicting the improvement of IMR. Further studies with a larger sample volume and longer follow-up could establish a rational algorithm, which would combine all these factors with cutoff points and allow optimizing surgical strategies.

See Editorial Commentary page 1613.

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Ischemic mitral regurgitation (IMR) occurs frequently after myocardial infarction (MI) due to left ventricular (LV) global or regional remodeling.¹ So far, the optimal strategy for moderate IMR is still controversial. Some studies had reported that combined mitral valve annuloplasty (MVA) and coronary artery bypass grafting (CABG) could reduce IMR immediately after surgery and at follow-up^{2,3}; however, others have shown that recurrent IMR did occur after CABG plus MVA, and no benefit for long-term

Abbreviations and Acronyms

CABG	= coronary artery bypass grafting
CI	= confidence interval
EF	= ejection fraction
IMR	= ischemic mitral regurgitation
LV	= left ventricular
LVEDV	= left ventricular end-diastolic volume
LVEF	= left ventricular ejection fraction
LVESV	= left ventricular end-systolic volume
MI	= myocardial infarction
MR	= mitral regurgitation
MVA	= mitral valve annuloplasty
NYHA	= New York Heart Association
OPCAB	= off-pump coronary artery bypass
OR	= odds ratio

survival was observed.^{4,5} A recent randomized trial showed no greater LV reverse remodeling or clinical advantage of adding MVA to CABG at 1 year.⁶ There was also a tendency toward higher complication rates and mortality in CABG plus MVA compared with CABG alone in high-risk patients.^{2,6} Therefore, it is of concern whether moderate IMR can be reduced after CABG alone.

To date, identified predictors of IMR improvement after CABG are scattered. Penicka and colleagues⁷ recommended the presence of viable myocardium and the absence of dyssynchrony between papillary muscles as predictors for IMR improvement. Braun and colleagues⁸ demonstrated that preoperative LV dimension was related to reverse remodeling with IMR changes after CABG plus MVA. Jeong and colleagues⁹ and Fattouch and colleagues¹⁰ suggested that in patients with moderate IMR with a left ventricular ejection fraction (LVEF) 40% or less, CABG alone is not recommended because of a high incidence of recurrent mitral regurgitation (MR) and cardiac-related mortality. However, as an important mechanism of IMR, LV regional remodeling is barely studied, and the relationship between regional remodeling and IMR changes after revascularization has not been identified. The aim of this study was to identify the predictors of IMR improvement after off-pump coronary artery bypass (OPCAB) by focusing on regional remodeling.

MATERIALS AND METHODS

Study Population

Between May 2008 and May 2013, 939 patients with left main or proximal 3-vessel disease underwent isolated CABG at Huashan Hospital of Fudan University, including 918 OPCAB cases. All patients with moderate IMR undergoing OPCAB were assessed for study eligibility by checking the following criteria: (1) prior MI by electrocardiogram or regional wall motion abnormalities by echocardiography; (2) structurally normal mitral valve; (3) available echocardiography image quality allowing 3-dimensional quantitative analysis; and (4) sinus rhythm. Patients with

clinical and echocardiography evidence of other cardiac structural disease, organic abnormality of the mitral apparatus, atrial fibrillation, and unstable clinical conditions were excluded. A total of 109 patients who were enrolled in the study underwent OPCAB as the only surgical procedure and accepted the same anti-ischemic and heart failure therapies. The study was approved and monitored by the institutional review board of Huashan Hospital. Each patient provided written informed consent before participation in the study. All authors had full access to and take full responsibility for the integrity of the data.

Study Protocol

At Huashan Hospital of Fudan University, patients with moderate IMR or less underwent OPCAB unless it was combined with aorta or aortic valvular lesions, whereas those with severe IMR underwent CABG and MVA. For patients with moderate IMR, preoperative clinical characteristics and echocardiography data were collected. Patients were followed up clinically and by echocardiography regularly and were grouped according to postoperative changes of IMR at 1 year after surgery: the improved group with no or mild IMR and the failure group with moderate or severe IMR. Preoperative and postoperative data were compared between the 2 groups, and predictors of IMR improvement were explored. Clinical data and 2-dimensional and 3-dimensional echocardiography were separately studied in a blind manner by 3 researchers to avoid selection bias.

Preoperative Echocardiography

Two-dimensional echocardiography. Preoperative echocardiography was performed 1 week before surgery. All patients underwent standard transthoracic echocardiogram with the Philips IE 33 system (S5-1 probe, 2.5-5.5 MHz; Philips Healthcare, Andover, Mass). MR severity was evaluated by measuring the ratio of MR color flow jet area to the left atrium area using color mapping of the apical 4-chamber view during cardiac systole, graded as mild (<20%), moderate (20%-40%), or severe (>40%).¹¹ Moderate MR was further verified by the width of the vena contracta (0.3-0.7 cm). The tenting area, mitral annular area,¹² displacement of papillary muscles, and sphericity index were measured.

Real time 3-dimensional echocardiography. By using the X 3-1 probe, datasets of each subject were stored and analyzed by QLAB 3D-Advanced Quantification software (Philips Healthcare). The software traced the endocardium border during the whole cardiac cycle and calculated the LV volume and regional volumes of 17 segments, gaining global and regional volume and function, such as the left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), LVEF, volume, and EF of the posterior-inferior 5 segments (basal, mid, apical inferior segments and basal, mid inferolateral segments). The ratio of regional segments volume to LVEDV was calculated. All echocardiography parameters were standardized by body surface area.

Surgical Procedures

All surgical procedures were performed through a midline sternotomy. The left internal thoracic arteries were harvested and grafted to the left anterior descending coronary arteries in patients aged less than 75 years. Saphenous vein grafts and radial arteries (in patients aged <60 years) were harvested, and sequential aorto-coronary bypass grafting was performed in the remaining coronary arteries. Starfish and Octopus (Medtronic Inc, Minneapolis, Minn) devices were used in all cases. Proximal silastic snare sutures and carbon dioxide blowers were used to obtain a bloodless field. Intraluminal shunts were used during grafting. The left internal thoracic artery to left anterior descending anastomoses were performed with 7-0 Prolene sutures, and other anastomoses were performed with 6-0 Prolene sutures. Complete revascularization was performed in all cases regardless of the number or quality of lesion vessels.

Follow-up

All clinical follow-up work was performed in a blind manner by 1 researcher from an echocardiography assessment via phone interview and outpatient visits. Patients were clinically followed up at 3 months and 6 months after surgery, and thereafter at 6-month intervals. Postoperative clinical status was prospectively determined by in-hospital and late death, latest New York Heart Association (NYHA) class during follow-up, cardiac hospitalization, and complications as follows: newly detected atrial fibrillation, stroke, respiratory failure, and chronic renal failure. The Kaplan–Meier survival curve was drawn to describe the survival condition. Early postoperatively, echocardiography was performed before discharge, and the echocardiography results of every patient at 1 year postoperatively (within 2 weeks before or after exactly 1 year) were gathered and analyzed.

Statistical Analysis

All statistical analyses were performed using SPSS Statistics Base 17.0 for Windows (SPSS Inc, Chicago, Ill). Continuous data were expressed as mean $\pm$ standard deviation, and group comparisons were analyzed by unpaired and paired Student *t* test as appropriate. The categorical variables were compared using the chi-square test. To determine the predictors of IMR improvement, binary logistic regression analysis was used. Receiver operating characteristic curve analysis was created from the obtained predictor to determine its discrimination with the highest sum of sensitivity and specificity. The actuarial survival curves were estimated by the Kaplan–Meier method, and differences between curves were analyzed by log-rank statistics.

RESULTS

There were no in-hospital deaths. Five patients died before the 1-year postoperative echocardiography assessment (1 died in 1 month, and 4 died after 1 month but before the 1-year postoperative assessment). The remaining 104 patients were followed up for a median of 33.0 months (Percent₂₅ = 21.0 month and Percent₇₅ = 46.0 month). At 1 year postoperatively, 55 patients showed no or mild IMR and 49 patients showed moderate or severe IMR. The baseline and surgical characteristics showed no significant difference between the 2 groups except for duration between infarction and operation (Table 1).

Echocardiography

Baseline and follow-up echocardiography parameters are shown in Table 2. The 1-year postoperative echocardiography detected 45 mild cases of MR and 10 cases of no obvious MR in the improved group, and 36 moderate MR cases and 13 severe MR cases in the failure group. At baseline, patients in the improved group had significantly smaller LVESV and greater posterior–inferior volume ratio than patients in the failure group. After OPCAB, patients in the improved group showed a reduction of LVEDV, LVESV, and posterior-inferior volume and its ratio, which was not observed in the failure group. For LV global and regional function, LVEF was greater in the improved group at baseline and further improved at follow-up. Although posterior-inferior EF was similar at baseline, it increased only in the

TABLE 1. Baseline and surgical characteristics in improved and failure groups

Characteristics	Improved group (n = 55)	Failure group (n = 49)	P value
Age, y	67.7 $\pm$ 8.1	65.4 $\pm$ 9.0	.167
Female, n (%)	17 (30.9)	18 (36.7)	.541
NYHA class, n (%)			
Class 2	8 (14.5)	6 (12.2)	
Class 3	45 (81.8)	41 (83.7)	.939
Class 4	2 (3.6)	2 (4.1)	
Smoking, n (%)	11 (20.0)	12 (24.5)	.640
Diabetes, n (%)	20 (36.4)	16 (32.7)	.837
Chronic renal failure, n (%)	5 (9.1)	4 (8.2)	1.000
Hypertension, n (%)	22 (40.0)	24 (49.0)	.430
COPD, n (%)	5 (9.1)	5 (10.2)	1.000
CHF, n (%)	4 (7.3)	6 (12.2)	.511
IABP application, n (%)	5 (9.1)	3 (6.1)	.719
Prior MI, n (%)			
Inferior or posterior	23 (41.8)	14 (28.6)	.218
Anterior	20 (36.4)	24 (49.0)	.235
Both	12 (21.8)	11 (22.4)	1.000
Grafted coronary vessels (n, %)			
LAD	51 (92.7)	44 (89.8)	.732
LCX	30 (54.5)	26 (53.1)	1.000
RCA	33 (60)	23 (46.9)	.227
Duration between infarction and operation, mo	3.1 $\pm$ 2.2	4.8 $\pm$ 1.6	<.001
LITA used, n (%)	51 (92.7)	44 (89.8)	.732
Grafted vessels, n (%)			
3 vessels	13 (23.6)	13 (26.5)	
4 vessels	36 (65.5)	27 (55.1)	.462
5 vessels	6 (10.9)	9 (18.4)	
Completeness index (%)	55 (100)	49 (100)	
Operation time, min	220.0 $\pm$ 34.0	231.9 $\pm$ 35.8	.082
ICU stay, h	41.2 $\pm$ 6.1	40.8 $\pm$ 4.5	.687
In-hospital stay, d	10.7 $\pm$ 1.8	10.6 $\pm$ 2.0	.829

NYHA, New York Heart Association; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; IABP, intra-aortic balloon pump; MI, myocardial infarction; LAD, left anterior descending artery; LCX, left circumflex artery; RCA, right coronary artery; LITA, left internal thoracic artery; ICU, intensive care unit.

improved group postoperatively, and not in the failure group. Although leaflet tenting areas, left atrial surface areas, and papillary muscle distance were similar at baseline, they were all smaller in the improved group than in the failure group postoperatively.

Predictors of Ischemic Mitral Regurgitation Improvement

Preoperative factors with differences between groups were involved in the binary logistic regression analysis. Posterior-inferior volume ratio (odds ratio [OR], 1.815; *P* < .001; 95% confidence interval [CI], 1.391-2.369), EF (OR, 1.212; *P* = .003; 95% CI, 1.066-1.378), and duration between infarction and operation (OR, 0.521; *P* < .001; 95% CI, 0.368-0.740) were independent predictors of

TABLE 2. Two- and three-dimensional echocardiographic data in the improved and failure groups at baseline and 1 year postoperatively

	Improved group (n = 55)	Failure group (n = 49)	P value
LVEDV (mL/m ²)			
Baseline	71.4 ± 15.8	75.3 ± 15.7	.205
Follow-up	65.0 ± 8.5*	72.9 ± 11.8	<.001
LVESV (mL/m ²)			
Baseline	40.5 ± 8.8	47.2 ± 12.1	.002
Follow-up	33.0 ± 4.7*	44.5 ± 8.5	<.001
LVEF (%)			
Baseline	43.2 ± 4.9	37.6 ± 7.4	<.001
Follow-up	49.1 ± 4.2*	38.9 ± 6.0	<.001
Posterior-inferior volume (mL/m ²)			
Baseline	23.9 ± 6.0	22.4 ± 5.2	.156
Follow-up	19.4 ± 3.7*	21.6 ± 5.2	.016
Posterior-inferior volume/LVEDV (%)			
Baseline	33.5 ± 3.0	30.0 ± 2.5	<.001
Follow-up	29.9 ± 4.6*	29.6 ± 5.0	.738
Anterior-septal volume (mL/m ²)			
Baseline	22.1 ± 5.1	23.2 ± 5.2	.286
Follow-up	21.6 ± 4.8	24.0 ± 5.5	.018
Anterior-septal volume/LVEDV (%)			
Baseline	33.0 ± 13.0	34.3 ± 11.3	.588
Follow-up	34.0 ± 9.3	34.0 ± 9.8	.974
Posterior-inferior EF (%)			
Baseline	37.2 ± 4.9	37.9 ± 4.6	.460
Follow-up	48.2 ± 4.4*	39.2 ± 7.1	<.001
Anterior-septal EF (%)			
Baseline	40.2 ± 8.4	37.5 ± 6.8	.073
Follow-up	47.8 ± 5.4*	39.7 ± 4.7*	<.001
Left atrial surface area (cm ²)			
Baseline	20.3 ± 4.1	20.6 ± 4.7	.815
Follow-up	18.7 ± 4.4	23.8 ± 5.6*	<.001
Sphericity index			
Baseline	1.27 ± 0.07	1.30 ± 0.08	.095
Follow-up	1.27 ± 0.10	1.30 ± 0.09	.183
Leaflet tenting area (cm ²)			
Baseline	2.5 ± 0.6	2.6 ± 0.7	.311
Follow-up	1.7 ± 0.6*	3.0 ± 1.4	<.001
Mitral annular area (mm ²)			
Baseline	830.6 ± 192.6	767.6 ± 226.1	.128
Follow-up	755.0 ± 178.4	904.3 ± 190.3*	<.001
Papillary muscle distance (cm)			
Baseline	20.6 ± 3.4	19.1 ± 4.4	.055
Follow-up	16.6 ± 4.5*	18.4 ± 4.1	.042
IMR jet area/LA area (%)			
Baseline	29.5 ± 6.3	31.0 ± 5.0	.205
Follow-up	14.7 ± 3.1*	37.4 ± 4.6*	<.001

LVEDV, Left ventricular end-diastolic volume; LVESV, left ventricular end-systolic volume; LVEF, left ventricular ejection fraction; EF, ejection fraction; IMR, ischemic mitral regurgitation; LA, left atrial. *P < .05 (preoperative vs follow-up).

moderate IMR improvement after OPCAB (Table 3). Receiver operating characteristic curves defined a posterior-inferior volume ratio of 31.6%, EF of 37.1%, and duration between infarction and operation of 3.25 months as the cutoff values (Figure 1).

TABLE 3. Predictors of ischemic mitral regurgitation improvement by binary logistic regression analysis

Determinants	Coefficient and SE	OR	95% CI	P value
EF	0.192 ± 0.065	1.212	1.066-1.378	.003
Posterior-inferior volume ratio	0.596 ± 0.136	1.815	1.391-2.369	<.001
Duration between infarction and operation	-0.651 ± 0.178	0.521	0.368-0.740	<.001

SE, Standard error; OR, odds ratio; CI, confidence interval; EF, ejection fraction.

Clinical Outcomes

Clinical outcomes are shown in Table 4. Four patients in the improved group and 11 patients in the failure group died during follow-up. As shown in Figure 2, patients in the improved group had greater actuarial survival than patients in the failure group at 3 years, 4 years, and 5 years postoperatively. The patients in the improved group had less newly detected atrial fibrillation and better NYHA class compared with those in the failure group.

DISCUSSION

The present study demonstrated 3 independent predictors of IMR improvement after OPCAB, including preoperative posterior-inferior volume ratio, preoperative LVEF, and duration between infarction and operation. Our results suggest that early revascularization by well-timed OPCAB would relieve the moderate preoperative IMR in selected patients, especially those with significant posterior-inferior regional remodeling and reserved LV function. Furthermore, IMR improvement was accordant with the reversion of LV remodeling, improvement of the LV global and regional function, and better clinical outcomes during follow-up, which contrast finely with the patients with residual IMR. Our study might be helpful to identify the proper patients with moderate IMR who would benefit from OPCAB, which should be important to clinical decision-making, optimization of the operation strategy, and the prognosis.

Left Ventricular Regional Remodeling

Two forms of LV remodeling are involved in the pathogenesis of IMR: global remodeling and regional remodeling. The former is frequently secondary to anterior or multisegment infarction, and dilatation of the global LV and mitral annulus are common.¹³ Although the latter appears more often in inferior or posterior infarction, chordae tendineae tethering due to papillary muscle displacement is the main mechanism of IMR.¹ Because these 2 forms of remodeling may coexist in the same patient, identifying which is the dominant one and which is more likely to be reversed after OPCAB remains a clinical challenge.

FIGURE 1. Receiver operating characteristic curves for predictors. A, Posterior-inferior volume ratio: area under the curve = 0.833 (95% CI, 0.756-0.910). Cutoff value is 31.6% with a sensitivity of 80.0% and specificity of 79.6%; EF: area under the curve = 0.737 (95% CI, 0.631-0.843). Cutoff value is 37.1% with sensitivity of 92.7% and specificity of 61.2%. B, Duration between infarction and operation: area under the curve is 0.744 (95% CI, 0.645-0.842). Cutoff value = 3.25 months with a sensitivity of 79.6% and specificity of 67.3%. ROC, Receiver operating characteristic; EF, ejection fraction.

Patients in the improved group showed the characteristic of dominant posterior-inferior regional remodeling rather than global remodeling compared with the failure group. Soleimani and colleagues¹⁴ demonstrated that after posterolateral MI, LV global volumes and sphericity gradually increase, suggesting that regional remodeling may be considered as an early stage of LV global remodeling in certain cases. After OPCAB, the posterior-inferior segment volumes and mitral tenting areas both decreased at follow-up in the improved group, suggesting that revascularization of the posterior-inferior segments might resolve IMR by gradually improving regional wall motion, reversing regional dilatation, and lessening posterior papillary muscle tethering. Our study is consistent with many previous studies. Poh and colleagues¹⁵ reported that revascularization therapy after posterior-inferior ST-segment elevation MI was associated with a lower

incidence of IMR. Hwang and colleagues¹⁶ proved that right coronary territory revascularization resolved IMR early postoperatively.

Left Ventricular Global Function

Patients in the improved group had significantly smaller LVESV and higher LVEF, indicating reserved LV functions; preoperative LVEF greater than 37.1% was another predictor of IMR improvement. Jeong and colleagues⁹ showed

TABLE 4. Clinical outcomes in improved and failure groups

	Improved group (n = 55)	Failure group (n = 49)	P value
Clinical follow-up, mo	36.7 ± 15.5	32.9 ± 14.9	.208
Early mortality, n (%)	0 (0)	0 (0)	
NYHA class, n (%)			
Class 2	51 (92.7)	13 (26.5)	
Class 3	3 (5.5)	32 (65.3)	<.001
Class 4	1 (1.8)	4 (8.2)	
Complications, n (%)			
Newly detected atrial fibrillation	3 (5.5)	11 (22.4)	.019
Stroke	2 (3.6)	4 (8.2)	.417
Respiratory failure	5 (9.1)	6 (12.2)	.752
Chronic renal failure	3 (5.5)	6 (12.2)	.301
Cardiac hospitalization, n (%)	5 (9.1)	7 (14.3)	.542

NYHA, New York Heart Association.

FIGURE 2. Postoperative survival estimates for patients with moderate IMR undergoing OPCAB by Kaplan-Meier. OPCAB, Off-pump coronary artery bypass; IG, improved group; FG, failure group.

that for the patients with IMR and LVEF greater than 40%, OPCAB was similar to CABG plus MVA regarding the freedom from recurrent IMR after 8 years. In another study conducted by Fattouch and colleagues,¹⁰ patients with moderate IMR and LVEF 40% or less usually underwent postoperative deterioration of IMR, with a high incidence of cardiac-related deaths and events.

Early Opportunity for Revascularization

In the present study, duration between infarction and operation was also an independent predictor of IMR improvement, highlighting the importance of early revascularization to the evolution of IMR and prognosis. Myocardial viability of the segments adjacent to papillary muscles warrants postoperative relief of IMR.⁷ The earlier revascularization is performed, the more myocardial viability is preserved. On the contrary, an animal experiment showed that for sheep models of MI and IMR over 3 months, mitral repair could not stop LV remodeling and IMR progression,¹⁷ which might explain why many studies failed to demonstrate a long-term survival benefit of CABG plus MVA compared with CABG alone.¹⁸

Change in Ischemic Mitral Regurgitation and Clinical Outcomes

Patients in the improved group had better long-term actuarial survival, improved NYHA classes, and less complications than patients in the failure group. This is in accordance with the previous study, which stated that residual and recurrent IMR after surgery negatively affected the late mortality,⁹ whereas moderate IMR improved after OPCAB and showed favorable survival and functional outcomes.¹⁹ This suggests that OPCAB might reverse IMR and enhance clinical outcomes for selected patients. Identifying these patients preoperatively is extremely important.

Study Limitations

First, the severity of IMR was evaluated by a semiquantitative assessment of MR color flow jet area ratio, but not by a more accurate assessment of the effective regurgitant orifice area. However, semiquantitative assessment performed by an experienced echocardiographer is still the most common method to identify significant IMR, and a combination of methods could increase the accuracy. Second, as a potential factor influencing IMR improvement after revascularization,⁷ myocardial viability assessment will help to enact treatment strategies. Although the post-MI period is closely associated with preserved myocardial viability, a direct assessment of myocardial viability should be performed in the future. Third, although complete revascularizations were performed in all subjects, the exact information of grafts to ischemic regions was not evaluated. Finally, the evaluation of mitral valve deformation and dysfunction in this study is relatively simple and

insufficient, which could be explored in the future by real-time 3-dimensional echocardiography.

CONCLUSIONS

OPCAB could improve IMR and outcomes for selected patients with moderate IMR. Posterior-inferior regional remodeling (posterior-inferior volume ratio >31.6%), reserved LV function (EF >37.1%), and early revascularization (within 3 months after MI) can predict the improvement of moderate IMR. Thus, for patients with significant posterior-inferior regional remodeling and relatively reserved LV function, early OPCAB would help; however, for the patients with dominant LV global dilatation, severe dysfunction, and a long history of MI, concomitant MVA might be suggested for unpredictable IMR changes. Further studies with a larger sample size and longer follow-up term are warranted to establish a rational algorithm in the future, which would combine all the factors with cutoff points and allow optimizing surgical strategies. To accomplish this, each patient should be evaluated comprehensively and treated individually.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: coronary artery bypass grafting, mitral regurgitation, myocardial infarction, myocardial remodeling

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