CLINICAL STUDY

Risk Factors for Moderate or More Residual Regurgitation in Patients with Moderate Chronic Ischemic Mitral Regurgitation Undergoing Surgical Revascularization Alone

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Summary

Few reports have focused on which patients with moderate ischemic mitral regurgitation (IMR) were not good candidates for coronary artery bypass grafting (CABG) alone. This single-center study aimed to assess risk factors for moderate or more residual regurgitation within two years after CABG alone for the treatment of moderate chronic IMR to optimize the operation strategy and prognosis.

A total of 189 eligible patients were entered into a failure group (n = 108) or an improved group (n = 81) according to whether moderate or more residual regurgitation occurred within two years after surgery. Baseline and surgical characteristics were analyzed, and clinical outcomes were compared between groups.

Prior myocardial infarction (MI)/chronic myocardial ischemia and region wall motion abnormality (anterior/inferior-posterior wall) were two independent risk factors for moderate or more residual regurgitation, following CABG alone, for the treatment of moderate chronic IMR (OR = 3.15, 95% CI 1.66-5.75, and OR = 2.45, 95% CI 1.36-4.84, respectively). During a median follow-up of 40 months, compared with the improved group, the failure group was more likely to present with New York Heart Association (NYHA) class III-IV and cardiac re-hospitalization (57.4% versus 11.1%, P < 0.001, and 13.9% versus 4.9%, P = 0.043, respectively) and had worse cumulative survival (χ² = 4.259, log-rank P = 0.039).

Patients suffering from moderate chronic IMR secondary to prior MI (rather than chronic ischemia) with anterior wall motion abnormalities (rather than inferior-posterior wall motion abnormalities) may not be good candidates for CABG alone, and may have a poor prognosis after CABG alone.

Key words: Residual mitral regurgitation, Myocardial infarction, Region wall motion abnormality

Ischemic mitral regurgitation (IMR) is a complication of myocardial infarction (MI) and/or myocardial ischemia, causing left ventricular remodeling.1-3) The development of IMR is associated with increased risk of heart failure and mortality, and these risks increase with the severity of regurgitation.4) Surgical correction of moderate IMR at the time of coronary revascularization is still an unresolved controversy.1-15) Although it cannot be sufficient to eliminate IMR, CABG alone improves preoperative moderate IMR in selected patients.16) It is crucial to determine which patients with moderate IMR are more likely to benefit from CABG alone and which patients with moderate IMR were not good candidates for CABG alone.

The overwhelming majority of previous studies have investigated the effects of CABG alone or the concomitant mitral valve procedure for the treatment of moderate chronic IMR.1-15) However, few reports have focused on determining which patients with moderate chronic IMR are more likely to benefit from CABG alone and which patients with moderate IMR may be good candidates for combined CABG and mitral valve procedures. Penicka and colleagues have reported that patients with moderate IMR were more likely to develop moderate or more residual MR after CABG alone in the case of the absence of viable myocardium and the presence of dyssynchrony between papillary muscles.16) Another report showed that patients with left ventricular dysfunction may be not good candidates for CABG alone due to high incidences of recurrent MR and cardiac-related death.17) However, the relationship between prior MI or chronic ischemia (initiating factors of IMR) and IMR changes after CABG alone re-
mains to be determined. Additionally, the relationship between region wall motion abnormalities (anterior wall/ inferior-posterior wall) and IMR changes after CABG alone has received little attention.

This single-center study reviewed 189 eligible patients with moderate chronic IMR who underwent CABG alone in our institute from January 2009 to June 2016 and aimed to evaluate risk factors for moderate or more residual regurgitation after surgery, and to determine which patients may be not good candidates for CABG alone to optimize the operation strategy and prognosis.

Methods

Grade of MR: Preoperative echocardiography was performed within 3 days before surgery to determine the etiology and severity of MR. MR grade was defined as mild (small central jet area < 20% LA on Doppler, and vena contracta < 3.0 mm), moderate (effective regurgitant orifice area (EROA) < 20 mm², regurgitant volume < 30 mL, and regurgitant fraction < 50%), or severe (EROA ≥ 20 mm², regurgitant volume ≥ 30 mL, and regurgitant fraction ≥ 50%).

MR was graded independently by 2 level-3 readers (discrepancies were resolved by a third reader as needed), as suggested by current guidelines, with an integrated approach using all available parameters.

Study protocol: This study protocol was approved by the ethics committee of Zhongshan Hospital Fudan University and was consistent with the Declaration of Helsinki.

All patients with moderate chronic IMR who underwent CABG alone during the study period (from January 2009 to June 2016) were assessed for study eligibility by checking the following criteria: (1) regional wall motion abnormalities by transthoracic echocardiography; (2) structurally normal mitral valve; and (3) sinus rhythm. Patients who received follow-up of fewer than two years (including death and loss to follow-up) were excluded from this study. Patients with clinical and echocardiography evidence of other cardiac structural diseases, organic abnormalities of the mitral apparatus, concomitant tricuspid annuloplasty or emergency surgery, and unstable clinical conditions were excluded. Additionally, patients with abnormal thyroid function were not candidates for this study.

Peri-operative clinical characteristics and echocardiography data of included patients were obtained from our institutional database and reviewed using a standard data collection form. Patients were regularly followed up at three and six months following surgery and thereafter at six-month intervals. If patients developed symptoms of MR or coronary heart disease at follow-up, then a clinical visit should be performed at the time. Follow-up data were obtained via a clinic visit, WeChat, or telephone. Data collection was performed by trained staff (two people). The trained staff, however, was not informed of the purpose of this study.

 Patients were grouped according to IMR changes within two years after surgery: the failure group (moderate or more residual MR) and the improved group (mild or less residual MR). Baseline and surgical characteristics were analyzed, and independent risk factors for moderate or more residual MR following CABG alone were obtained from baseline and surgical data. Additionally, in-hospital and follow-up outcomes were compared between groups.

Clinical data: The relevant data of all selected patients was investigated and analyzed. Preoperative information included age, gender (male or female), obesity (body mass index of greater than 30 kg/m²), smoking, hypertension, diabetes mellitus, hyperlipemia, chronic obstructive pulmonary disease, renal dysfunction (creatinine more than 2.5 mg/dL or requiring dialysis), prior cerebrovascular accident, IMR secondary to prior MI or chronic myocardial ischemia, region wall motion abnormality (anterior wall, inferior-posterior wall, or both), double/triple vessel disease, left main trunk disease, New York Heart Association (NYHA) class II/III/IV, left ventricular dysfunction (LVEF of 40% or less), and left ventricular enlargement (left ventricular end-diastolic diameter of more than 65 mm). Surgical variables were on-pump or off-pump CABG, number of distal anastomoses, use of left and/or right internal mammary arteries, use of radial artery, use of saphenous vein, and application of intra-aortic balloon pump (IABP). Additionally, for patients suffering from prior MI with definite attack time, the elapsed time from MI until subsequent surgery was recorded.

The in-hospital outcomes of interest consisted of MI associated with CABG, new onset of atrial fibrillation, prolonged ventilation (> 24 hours), stroke, renal failure requiring hemodialysis, and deep sternal wound infection. Follow-up outcomes included all-cause mortality (beyond two years after surgery), cardiac rehospitalization, NYHA class, repeat revascularization, and repeat mitral surgery. All-cause mortality, rather than cardiac mortality, was chosen because it was the most robust and unbiased index that exempted us from misreading the cause of death with the subjective and sometimes inaccurate medical records.

Surgical procedures: In our institute, off-pump CABG was introduced in 1998 and has been the first choice in patients who were referred for surgical revascularization over the years with an annual off-pump CABG procedure volume of over 500 cases, whereas on-pump CABG was conducted in patients with severely impaired left ventricular function, deeply intramyocardial target vessels, previous cardiac surgery, or concomitant open-heart surgery.

All surgical procedures were performed through a midline sternotomy. The internal mammary artery was harvested in a skeletonized or pedicled fashion, and the left internal mammary artery grafting to the left anterior descending artery was the first choice. Saphenous veins and radial arteries were harvested with an open technique, and sequential or separate aortocoronary bypass grafting was performed in the remaining coronary arteries. The quality of anastomosis was assessed after grafting with a transit-time flow probe (Medistim Butterfly Flowmeter, Oslo, Norway) during the operation. The details of the off-pump and on-pump CABG procedure were consistent with those of previous studies.

Statistical analysis: Normally distributed continuous variables were expressed as the mean ± standard deviation and were compared between groups using Student’s t-test.
Non-normally distributed continuous variables were expressed as median and interquartile range and were compared between groups with the Wilcoxon rank sum test. Categorical variables were expressed as frequency distributions and single percentages and were compared between groups using the \( \chi^2 \) test or Fisher’s exact test, when appropriate. The baseline and operative variables with \( P < 0.10 \) obtained through univariate analysis were then entered into multivariable logistic regression analysis using the backward method (the failure group or the improved group as independent variables, variables with \( P < 0.10 \) obtained through univariate analysis as dependent variables) to identify the independent risk factors for moderate or more residual regurgitation after CABG alone. The cumulative survival curve was conducted by the Kaplan-Meier method with log-rank test for group comparisons. Statistical analysis was performed with SPSS statistical package version 22.0 (SPSS Inc., Chicago, IL, USA). A value of two-sided \( P \) less than 0.05 was considered statistically significant.

**Results**

**Study population:** A total of 4863 consecutive patients received CABG alone or concomitant open-heart surgery at our institute from January 2009 to June 2016. Among these patients, 210 patients with moderate chronic IMR undergoing CABG alone who met the inclusion criteria were reviewed. Twenty-one patients were excluded due to in-hospital death (3 patients), death or loss to follow-up within two years after surgery (12), concomitant moderate aortic insufficiency (2), concomitant hyperthyroidism (1), concomitant tricuspid annuloplasty (2), which left 189 eligible patients for data analysis. Among these patients, 108 patients who were diagnosed with moderate or more residual MR within two years after CABG alone were included in the failure group, and the remaining 81 patients who were diagnosed with mild or less residual MR within two years after CABG alone were entered into the improved group. In the failure group, 13 patients (12.0%) were identified as having severe residual regurgitation within two years after CABG alone.

**Baseline and procedure characteristics:** Baseline characteristics are shown in Table I. Patients in the failure group, compared with the improved group, were younger and more likely to present with left ventricular dysfunction and left ventricular enlargement (65.5 ± 6.7 years versus 67.6 ± 7.7 years, \( P = 0.047 \), 33.3% versus 19.8%, \( P = 0.039 \), and 35.2% versus 21.0%, \( P = 0.033 \), respectively). Patients in the failure group, compared with the improved group, had a greater effective regurgitant orifice area (\( P = 0.039 \)). Patients in the failure group, compared with the improved group, were more likely to have a history of MI (rather than chronic myocardial ischemia) (\( P = 0.002 \)). Additionally, patients in the failure group were more likely to present with anterior wall motion abnormalities, whereas those in the improved group were more likely to present inferior-posterior wall motion abnormalities (\( P < 0.001 \)).

As presented in Table II, patients in the two groups received comparable grafts (\( P > 0.05 \)). No significant differences were found between the two groups with regard to the proportions of use of the on-pump/off-pump technique and the IABP.

Additionally, the elapsed time from MI until subsequent surgery was recorded in 122 patients suffering from prior MI with definite attack time (72 patients in the failure group and 50 in the improved group). As shown in Figure 1, the failure group, compared with the improved group, had a longer elapsed time from MI until subsequent surgery (3.9 ± 1.8 months versus 2.6 ± 1.5 months, \( P < 0.001 \)).

**Risk factors for moderate or more residual regurgitation after surgery:** Baseline and procedure variables (as listed in Tables I, II) with \( P < 0.10 \), obtained via univariate analysis, were then entered into a multivariable logistic regression analysis using the backward method (the failure group or the improved group as independent variables, baseline and procedure variables with \( P < 0.10 \) obtained through univariate analysis as dependent variables). As shown in Table III, independent risk factors for moderate or more residual regurgitation following CABG alone for the treatment of moderate chronic IMR included prior MI/chronic myocardial ischemia and region wall motion abnormalities (anterior/inferior-posterior wall) (OR=3.15, 95% CI 1.66-5.75, \( P = 0.008 \), and OR = 2.45, 95% CI 1.36-4.84, \( P = 0.011 \), respectively).

**Clinical outcomes:** In-hospital outcomes are listed in Table IV. Patients in the failure group, compared with the improved group, received a higher incidence of new onset of atrial fibrillation (18.5% versus 6.2%, \( P = 0.013 \)) but experienced similar incidences of MI associated with CABG, prolonged ventilation, stroke, renal failure requiring hemodialysis, and deep sternal wound infection.

All patients received a follow-up visit with a median duration of 40 months (follow-up outcomes are presented in Table IV). Nineteen patients (15 in the failure group versus 4 in the improved group, \( P = 0.043 \)) experienced one or more cardiac re-hospitalization incidents. Ten patients received repeat revascularization, and the repeat revascularization rate was 6.5% for the failure group and 3.7% for the improved group (\( P = 0.520 \)). Two patients in the failure group experienced combined repeat surgical revascularization and mitral valve surgery, and the remaining 8 patients preferred percutaneous coronary intervention. Patients in the failure group, compared with the improved group, were more likely to present with NYHA class III-IV (57.4% versus 11.1%, \( P < 0.001 \)). As presented in Figure 2, patients with moderate or more residual regurgitation after CABG alone had worse cumulative survival than those with mild or less residual regurgitation after CABG alone (\( \chi^2 = 4.259 \), log-rank \( P = 0.039 \)).

**Discussion**

This study showed two independent risk factors for moderate or more residual MR after CABG alone for the treatment of moderate chronic IMR, including prior MI/chronic myocardial ischemia and region wall motion abnormality (anterior/inferior-posterior wall). For patients suffering from prior MI with definite attack time, early surgical revascularization may contribute to postoperative
Table I. Baseline Characteristics

| Demographics                  | Failure group (n = 108) | Improved group (n = 81) | P    |
|-------------------------------|------------------------|-------------------------|------|
| Age (years)                   | 65.5 ± 6.7             | 67.6 ± 7.7              | 0.047|
| Gender (female)               | 30 (27.8%)             | 18 (22.2%)              | 0.385|
| Obesity                       | 18 (16.7%)             | 13 (16.0%)              | 0.910|
| Smoking                       | 48 (44.4%)             | 32 (39.5%)              | 0.497|
| Concomitant diseases          |                        |                         |      |
| Hypertension                  | 60 (55.6%)             | 42 (51.9%)              | 0.613|
| Diabetes mellitus             | 42 (38.9%)             | 34 (42.0%)              | 0.668|
| Hyperlipidemia                | 26 (24.1%)             | 18 (22.2%)              | 0.766|
| COPD                          | 14 (13.0%)             | 8 (9.9%)                | 0.513|
| Prior CVA                     | 9 (8.3%)               | 8 (9.9%)                | 0.714|
| Renal dysfunction             | 11 (10.2%)             | 10 (12.3%)              | 0.640|
| Cardiac status                |                        |                         |      |
| Wall motion abnormalities     |                        | < 0.001                 |      |
| Anterior                      | 75 (69.4%)             | 10 (12.3%)              |      |
| Inferior or posterior         | 16 (14.8%)             | 60 (74.1%)              |      |
| Both                          | 17 (15.7%)             | 11 (13.6%)              |      |
| MI or chronic ischemia        |                        |                         | 0.002|
| Prior MI                      | 98 (90.2%)             | 60 (74.1%)              |      |
| Myocardial ischemia           | 10 (9.8%)              | 21 (25.9%)              |      |
| Extent of CAD                 |                        |                         | 0.844|
| 2-vessel                      | 13 (12.0%)             | 9 (11.1%)               |      |
| 3-vessel                      | 95 (88.0%)             | 72 (88.9%)              |      |
| LM                            | 34 (31.5%)             | 23 (28.4%)              | 0.647|
| NYHA class                    |                        |                         | 0.826|
| II                            | 90 (83.3%)             | 66 (81.5%)              |      |
| III                           | 13 (12.0%)             | 12 (14.8%)              |      |
| IV                            | 5 (4.6%)               | 3 (3.7%)                |      |
| LV dysfunction                | 36 (33.3%)             | 16 (19.8%)              | 0.039|
| LV enlargement                | 38 (35.2%)             | 17 (21.0%)              | 0.033|
| ERO (mm²)                     | 17 (13-19)             | 15 (11-17)              | 0.039|

Failure group indicates patients with moderate or more residual mitral regurgitation within 2-year after surgery; Improved group, patients with mild or less residual mitral regurgitation within 2-year after surgery; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; MI, myocardial infarction; CAD, coronary artery disease; LM, left main trunk disease; NYHA, New York heart association (classification); LV, left ventricle; and ERO, effective regurgitant orifice area. LV dysfunction was defined as left ventricular ejection fraction of 40% or less. LV enlargement was defined as left ventricular end-diastolic diameter of more than 65 mm.

Table II. Procedure Characteristics

| On-pump/Off-pump | Failure group (n = 108) | Improved group (n = 81) | P    |
|------------------|------------------------|-------------------------|------|
| On-pump/Off-pump | 8/100                  | 10/71                   | 0.252|
| CPB time (minutes) | 66.5 ± 12.2          | 62.8 ± 11.5             | 0.518|
| ACC time (minutes) | 45.6 ± 8.4           | 44.8 ± 7.2              | 0.831|
| Number of grafts | 3.4 ± 0.5             | 3.3 ± 0.5               | 0.175|
| 2                | 6 (5.6%)              | 4 (4.9%)                | 0.722|
| 3                | 48 (44.4%)            | 43 (53.1%)              |      |
| 4                | 50 (46.3%)            | 32 (39.5%)              |      |
| 5                | 4 (3.7%)              | 2 (2.5%)                |      |

Use of LIMA: 107 (99.1%) | 79 (97.5%) | 0.401
Use of RIMA: 7 (6.5%) | 6 (7.4%) | 0.803
Use of vein graft: 100 (92.6%) | 76 (93.8%) | 0.740
Use of RA: 3 (2.8%) | 5 (6.2%) | 0.291
IABP support: 3 (2.8%) | 4 (4.9%) | 0.464

CPB indicates cardiopulmonary bypass; ACC, aortic cross-clamping; LIMA, left internal mammary artery; RIMA, right internal mammary artery; RA, radial artery; and IABP, intra-aortic balloon pump.

Figure 1. Elapsed time from MI until subsequent surgery. MI indicates myocardial infarction; Failure group, patients with mild or less residual regurgitation within two years after surgery; and improved group, patients with moderate or more residual regurgitation within two years after surgery.
improvement of IMR. Additionally, patients who developed moderate or more residual MR within two years after CABG alone were more likely to present with NYHA class III-IV and cardiac re-hospitalization at follow-up and had worse cumulative survival. This study might be helpful to identify patients with moderate chronic IMR who were not good candidates for CABG alone, which is important for clinical decision-making, optimization of the operation strategy, and prognosis.

An important finding of this study was that patients with prior MI, compared with those with chronic myocardial ischemia, were more likely to develop moderate or more residual MR after CABG alone for the treatment of chronic moderate IMR. In this study, patients in the failure group were more likely to have a history of MI, whereas those in the improved group were more likely to present with chronic ischemia via univariate analysis. Furthermore, the result was confirmed by multivariable logistic regression analysis. This study suggested that left ventricular remodeling, secondary to prior MI, was less likely to be reversed after CABG alone, and thus patients with previous MI and moderate chronic IMR were more likely to develop moderate or more residual MR after CABG alone; nevertheless, left ventricular remodeling secondary to chronic myocardial ischemia was more likely to be reversed after CABG alone, and thus patients with chronic ischemia and moderate chronic IMR were less likely to develop moderate or more residual MR after CABG alone. The reason for this difference may have been the differences in severity and extent of left ventricular remodeling caused by MI or chronic ischemia.

Another important finding of this study was that anterior wall motion abnormalities, compared with inferior-posterior wall motion abnormalities, had negative effects on the improvement of preoperative moderate IMR after CABG alone. Two forms of left ventricular remodeling are involved in the pathogenesis of IMR: global remodeling and regional remodeling. The former was frequently combined with a large anterior wall motion abnormality with a reduced left ventricular function secondary to anterior wall infarction or extensive anterior wall ischemia, and dilatation of the global left ventricle and mitral annulus were common. Although the latter appeared more often inferior-posterior wall motion abnormalities with normal or near normal left ventricular function, chordae tendineae tethering due to papillary muscle displacement was the main mechanism of IMR. This study suggested that left ventricular remodeling with left ventricular global dilatation related to anterior wall motion abnormalities secondary to anterior wall infarction or extensive anterior wall ischemia was less likely to be reversed after CABG alone, and thus patients with anterior wall motion abnormalities and moderate chronic IMR were more likely to develop moderate or more residual MR after CABG alone; nevertheless, left ventricular regional remodeling related to inferior-posterior wall motion abnormalities secondary to inferior-posterior wall infarction or chronic inferior-posterior wall ischemia was more likely to be reversed after CABG alone, and thus patients with inferior-posterior wall motion abnormalities and moderate IMR were less likely to develop moderate or more residual MR after CABG alone. Previously, Poh and colleagues stated that revascularization therapy after inferior-posterior ST-segment elevation MI was associated with a lower inci-

Table III. Risk Factors for Moderate or More Residual MR

| Factors | OR  | 95% CI | P    |
|---------|-----|--------|------|
| Age     | 0.95| 0.91-1.26 | 0.204|
| Prior MI/chronic myocardial ischemia | 3.15| 1.66-5.75 | 0.008|
| Region wall motion abnormalities (anterior/inferior-posterior) | 2.45| 1.36-4.84 | 0.011|
| LV dysfuction (Yes/No) | 1.91| 0.80-4.51 | 0.253|
| LV enlargement (Yes/No) | 1.73| 0.84-4.15 | 0.158|
| ERO     | 1.43| 0.93-3.02 | 0.085|

MR indicates mitral regurgitation; OR, odds ratio; CI, confidence interval; MI, myocardial infarction; LV, left ventricle; and ERO, effective regurgitant orifice area.

Table IV. Clinical Outcomes after Surgery

| Factors                        | Failure group (n = 108) | Improved group (n = 81) | P    |
|-------------------------------|-------------------------|-------------------------|------|
| In-hospital                   |                         |                         |      |
| MI associated with CABG       | 4 (3.7%)                | 2 (2.5%)                | 0.702|
| New onset of atrial fibrillation | 20 (18.5%)            | 5 (6.2%)                | 0.013|
| Stroke                        | 6 (5.6%)                | 2 (2.5%)                | 0.470|
| Prolonged ventilation         | 9 (8.3%)                | 3 (3.7%)                | 0.196|
| RF requiring hemodialysis     | 5 (4.6%)                | 2 (2.5%)                | 0.701|
| Deep sternal wound infection  | 2 (1.9%)                | 2 (2.5%)                | 1.000|
| Follow-up                     |                         |                         |      |
| Duration (months)             | 40.6 ± 8.3              | 41.3 ± 9.6              | 0.609|
| Cardiac re-hospitalization    | 15 (13.9%)              | 4 (4.9%)                | 0.043|
| Repeat revascularization      | 7 (6.5%)                | 3 (3.7%)                | 0.520|
| Mitral valve surgery          | 2 (1.9%)                | 0                       | 0.218|
| NYHA class                    |                         | <0.001                  |      |
| II                             | 46 (42.6%)              | 72 (88.9%)              |      |
| III                            | 54 (50.0%)              | 9 (11.1%)               |      |
| IV                             | 8 (7.4%)                | 0                       |      |

MI indicates myocardial infarction; CABG, coronary artery bypass grafting; RF, renal failure; and NYHA, New York heart association (classification).
This study showed that patients in the failure group were more likely to present with NYHA class III-IV and had worse cumulative survival than those in the improved group. These results suggested that moderate or more residual MR after CABG alone had negative effects on survival and cardiac function; nevertheless, improved MR within two years after CABG alone showed favorable survival and cardiac functional outcomes. These outcomes were in line with evidence from previous studies.

This study also found that patients suffering from prior MI with definite onset time in the failure group, compared with the improved group, had a longer elapsed time from MI until subsequent CABG. This result emphasized the importance of early revascularization to the evolution of IMR. Previously, Penicka and colleagues recommended the presence of viable myocardium adjacent to papillary muscles as predictors for postoperative relief of IMR. These authors found that the earlier revascularization was conducted, the more myocardial viability was preserved. In an animal experiment conducted by Beaudoin and colleagues, approximately twelve sheep models of MI and IMR over three months indicated that late correction of moderate volume overload after MI did not improve left ventricular remodeling and IMR progression. This evidence was in line with the outcomes of this study.

This study suggested that patients with prior MI, compared with those with chronic ischemia, were more likely to develop moderate or more residual MR after CABG alone for the treatment of moderate chronic IMR. The results from this study also showed that patients with inferior-posterior wall motion abnormalities with regional left ventricular remodeling rather than anterior wall motion abnormalities with left ventricular global dilatation were less likely to develop moderate or more residual MR at follow-up. Therefore, patients suffering from moderate chronic IMR secondary to chronic myocardial ischemia with inferior-posterior wall motion abnormalities may benefit from CABG alone and receive a favorable prognosis after surgery; nevertheless, for moderate chronic IMR patients suffering from prior MI and anterior wall motion abnormalities with dominant left ventricular global dilatation, CABG alone may be not recommended, and concomitant mitral valve procedure (for example, mitral valve repair at the time of CABG) might be recommended. However, left ventricular global remodeling and inferior-posterior regional remodeling may coexist in the same pa-

**Figure 2.** Cumulative survival curves. Failure group indicates patients with mild or less residual regurgitation within two years after surgery; and improved group, patients with moderate or more residual regurgitation within two years after surgery.
tient, identifying which was the dominant one remained a clinical challenge. To accomplish this procedure, each patient should be evaluated comprehensively and treated individually. Additionally, the results from this study showed that early surgical revascularization may contribute to postoperative improvement of IMR.

A single-center retrospective study with a small sample size was the main limitation of this study, which may influence the generalizability of the results. A relatively large number of cases may be helpful for readers to understand long-term results of CABG alone in the management of moderate IMR. However, this study only included patients with moderate chronic IMR who underwent CABG alone in a single center and received follow-up of more than two years, and excluded patients with mild or severe IMR who underwent combined CABG and mitral valve procedure. Based on the above criteria, only 189 out of 4863 patients were included in this study. Important findings may be achieved by reviewing and following up with the 189 included patients. A multicenter study with a larger sample size would be required before final confirmation. Second, as a potential factor influencing IMR improvement after surgery, myocardial viability assessment will help to enact treatment strategies. A direct assessment of myocardial viability should be performed in the future. Third, although complete revascularization was performed in all subjects, the exact information for grafts to ischemic regions was not evaluated. Finally, the duration of follow-up was relatively short, and longer observation is needed to confirm our findings.

Conclusions

Patients suffering from moderate IMR secondary to prior MI (rather than chronic myocardial ischemia) with anterior wall motion abnormalities (rather than inferior-posterior wall motion abnormalities) may not be good candidates for CABG alone and may have a poor prognosis after surgical revascularization alone. Additionally, early surgical revascularization may contribute to postoperative relief of IMR. Further studies with a larger sample size and longer follow-up are warranted to establish a rational algorithm in the future, which would combine all the factors with cutoff points and allow the optimization of surgical strategies.

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Disclosure

Conflicts of interest: The authors have declared that no competing interest exists.

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