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Concomitant CABG, Left Ventricular Restoration and Mitral Valve Repair for Ischemic Heart Disease

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ABSTRACT

Aim: To evaluate the effects of combined coronary artery bypass grafting (CABG), surgical left ventricular restoration (LVR), and mitral valve repair (MVP) in treating ischemic heart disease combined with mitral regurgitation; and to evaluate the different strategies of LVR and MVP.

Methods: From January 2001 to December 2015, 61 consecutive patients with left ventricular aneurysm and ischemic mitral regurgitation underwent concomitant CABG, LVR and MVP. We evaluated the clinical and echocardiographic outcomes of the patients. The mean follow-up was 5.8 ± 3.3 years.

Results: The operative mortality was 4.9%. One-, five-, and ten-year survival rates were 95.1%, 86.9%, and 80.3%, respectively. Mitral regurgitation, left ventricular ejection fraction (LVEF), and left ventricular end diastolic diameter (LVEDD) improved significantly after surgery ($P < .001$). During follow-up, 3 patients (5.2%) had moderate mitral regurgitation and 1 patient (1.9%) had severe mitral regurgitation. The clinical outcomes were not influenced by the LVR technique and MVP approach.

Conclusion: Combined CABG, LVR, and MVP was effective for ischemic left ventricular aneurysm with mitral regurgitation. The procedure was associated with acceptable operative risk and clinical outcomes.

INTRODUCTION

Coronary artery disease (CAD) is a major cause of heart failure [Mozaffarian 2015]. Remodeling of the left ventricle frequently leads to subsequent ischemic mitral regurgitation (IMR). Selected patients may benefit from coronary artery bypass grafting (CABG) surgery and mitral valve intervention. Also, left ventricular restoration (LVR) has played an important role in treating ischemic heart disease. In patients with left ventricular aneurysm and IMR, LVR is combined with mitral valve repair (MVP) or less frequently, valve replacement [Grigioni 2001; Mihos 2016; Di Salvo 2010].

Associated IMR is an important risk factor in CABG and LVR surgery for ischemic heart disease. The outcomes of the combined procedures have been reported in several studies [Jones 2009; Dor 2004]. However, controversies still exist in the role of MVP and strategies of LVR, and there are no guidelines [Suma 2009; Smith 2014; Acker 2014; Crabtree 2008; Di Donato 2007; Levine 2005]. In this study, we reviewed our 15-year experience in combined CABG, LVR, and MVP. The aims of this study were to 1) study the outcomes of combined CABG, LVR, and MVP in treating ischemic heart failure and mitral regurgitation; and 2) evaluate the different strategies of LVR and MVP.

MATERIALS AND METHODS

From 2000 to 2015, 61 consecutive patients with CAD complicated by mitral regurgitation and left ventricular aneurysm were treated with combined CABG, LVR, and MVP at Fuwai Hospital. Preoperative parameters are shown in Table 1. There were 53 males (86.9%) and 8 females (13.1%) with a mean age of 57.5 ± 10.4 (34-78) years. Preoperative New York Heart Association (NYHA) was grade II in 19 cases (31.1%), grade III in 25 cases (41.0%), grade IV in 14 cases (23.0%), and unclear in 3 cases (4.9%). Preoperative mitral regurgitation was mild in 12 cases (19.7%), moderate in 41 cases (67.2%), and severe in 8 cases (13.1%). 60 patients (98.4%) underwent first-time surgery, while 1 patient (1.6%)

Table 1. Baseline Patient Characteristics*

Age, y	57.5 ± 10.4
Female, n (%)	8 (13.1)
NYHA class, n (%)	
III	25 (41.0)
IV	14 (23.0)
Mitral regurgitation, n (%)	
Moderate	41 (67.2)
Severe	8 (13.1)
LVEF, %	38.8 ± 8.6
LVEDD, mm	63.0 ± 8.9

*Data are presented as the mean ± SD where indicated. LVEF indicates left ventricular ejection fraction; LVEDD, left ventricular end diastolic diameter.

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underwent a second-time surgery, the previous surgery being aortic valve replacement. Preoperative left ventricular ejection fraction (LVEF) was 38.8 ± 8.6%, and left ventricular end diastolic diameter (LVEDD) was 63.0 ± 8.9 mm.

Surgical Procedure

For the surgical procedure, operations were performed routinely using hypothermic cardiopulmonary bypass (CPB), aortic cross-clamping, and intermittent antegrade cold-blood cardioplegia. The surgical technique of CABG, LVR, and MVP was described in earlier studies. Concomitant myocardial revascularization was performed in 60 patients (98.4%). One patient (1.6%) did not have CABG because there was no need for revascularization after aneurysm resection. The number of distal anastomoses was 2.6 ± 1.3 (0-5). The number of artery graft was 0.77 ± 0.46 (0-2), and the number of venous graft was 1.9 ± 1.2 (0-5). LVR was done before coronary artery anastomoses and mitral valve repair. LVR was carried out in 3 ways: linear stitch in 34 cases (55.7%); endoventricular circular patch plasty (EVCPP) described by Dor in 12 cases (19.7%); and endocardial circular plasty (ECP) in 15 cases (24.6%). The ECP procedure was described by Hu et al [Hu 2010]. A suture was tied to rebuild the ventricular shape and created an opening (artificial neck) about 2-3 cm in diameter without a patch. The techniques of LVR were selected based on the location and size of the scarred myocardium and the shape of the left ventricle. Mitral valve reconstruction was done through either atrial approach (31 cases; 50.8%) or ventricular approach (30 cases; 49.2%). Surgical technique of valve repair included restrictive mitral annuloplasty (RMA), edge-to-edge procedure, artificial chordae, shortening of chordae, and leaflet resection. All patients had intraoperative transesophageal echocardiography (TEE) during the operation. Mitral valve competency and left ventricular shape and function were assessed. Concomitant left ventricular thrombectomy was performed in 5 cases (8.2%). Concomitant tricuspid annuloplasty was performed in one patient (1.6%) with significant tricuspid regurgitation. Concomitant aortic valve replacement was performed in 2 cases (3.3%).

Follow-Up

The mean follow-up duration was 5.8 ± 3.3 years (0.1-14.6 years). Medical therapy recommended after operation was generally according to the guidelines. Follow-up information was obtained during outpatient clinic appointments, supplemented by telephone interview. Transthoracic echocardiography (TTE) is suggested routinely at 3 months, 6 months, and then annually after operation, or when clinical symptoms or signs suggest mitral valve dysfunction or heart failure. LVEF, LVEDD, and mitral valve function were recorded during examination.

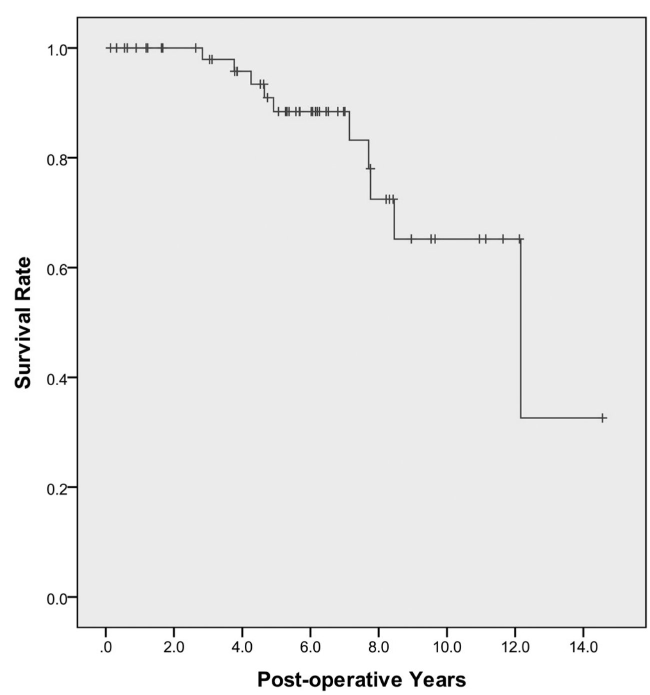
Statistical Analysis

Continuous variables were shown as the mean ± standard deviation or as the median (range). Categorical variables were shown as frequency (percentage). Independent-sample t test or Mann-Whitney U test was used to compare the continuous variables between different groups of LVR technique and MVP approaches. Pearson chi-square test, Fisher exact test, or Mann-Whitney U test was used to compare the non-continuous variables between the two groups. Survival analysis was used to analyze long-term outcomes. A *P* value of less than .05 was considered statistically significant. All statistic analysis was performed with SPSS version 19 software.

RESULTS

The mean aortic cross-clamp time was 105.3 ± 35.2 minutes and the CPB time was 153.2 ± 48.3 minutes. Table 2 shows the operative outcome and choice of procedure. The operative mortality was 4.9% (3/61), including 1 case (1.6%) of heart failure and 2 cases (3.3%) of stroke. After surgery, intraaortic balloon pump (IABP) was used in 5 patients (8.2%) and extracorporeal membrane oxygenation (ECMO) device was used in 1 patient (1.6%). More than moderate mitral regurgitation was found in intraoperative TEE in 2 patients (3.3%). Second MVP was performed in both cases in the same operation and there was no residual mitral regurgitation. One patient underwent MVR because of recurrent mitral regurgitation 18 days after the primary surgery and died of perioperative stroke.

Mean ventilation time was 62.2 ± 64.0 hours (14-221 hours). Mean ICU length of stay was 5.9 ± 6.1 days (1-36 days). Mean postoperative hospital stay was 21.0 ± 19.5 days (7-102 days). Postoperative TTE was performed before hospital discharge and there was no regurgitation in 46 cases (65.4%), mild regurgitation in 14 cases (23.0%), and severe regurgitation in 1 case (1.6%), which was significantly improved after



Survival curve after hospital discharge.

Table 2. Operative Outcome and Choice of Procedure*

CPB time, min	153.2 ± 48.3
Cross-clamp time, min	105.3 ± 35.2
LVR procedure, n (%)	
<<2 OPTION SPACES>>Linear stitch	34 (55.7)
<<2 OPTION SPACES>>EVCPP	12 (19.7)
<<2 OPTION SPACES>>ECP	15 (24.6)
MVP approach, n (%)	
<<2 OPTION SPACES>>Ventricle	30 (49.2)
<<2 OPTION SPACES>>Right atrium-septum	30 (49.2)
<<2 OPTION SPACES>>Interatrial groove	1 (1.6)
In-hospital death, n (%)	3 (4.9)
Ventilation time, h	62.2 ± 64.0 (14-221)
ICU stay, d	5.9 ± 6.1 (1-36)
Hospital stay, d	21.0 ± 19.5 (7-102)
Postoperative LVEF, %	45.4 ± 8.8
Postoperative LVEDD, mm	54.2 ± 7.7
Long-term death, n (%)	10 (17.2)

*Data are presented as the mean ± SD where indicated. CPB indicates cardiopulmonary bypass; LVR, left ventricular restoration; EVCPP, endoventricular circular patch plasty; ECP, endocardial circular plasty; MVP, mitral valve repair; LVEF, left ventricular ejection fraction; LVEDD, left ventricular end diastolic diameter.

surgery ($P < .001$). The patient with severe regurgitation had MVR as described above. Postoperative LVEF was 45.4 ± 8.8% and LVEDD was 54.2 ± 7.7 mm, both significantly improved from preoperative parameters ($P < .001$).

A total of 58 patients were discharged and followed up. The mean follow-up duration was 5.8 ± 3.3 years (0.1-14.6 years). Long-term mortality was 17.2% (10/58). One-, five-, and ten- year survival rates were 100% (58/58), 91.4% (53/58), and 84.5% (49/58), respectively (Figure). The causes of death were cardiac in 3 cases, cerebrovascular in 2 cases, malignancy in 1 case, and unclear in 4 cases. The estimated survival curve is shown in the Figure. During follow-up, 3 patients (5.2%) had moderate mitral regurgitation and 1 patient (1.9%) had severe mitral regurgitation. More than moderate mitral regurgitation was not observed in other patients. The 4 patients with more than moderate mitral regurgitation had severe mitral regurgitation in 2 cases and moderate in 2 cases. At last contact, the mean LVEF was 45.3 ± 11.6%, and the mean LVEDD was 56.6 ± 9.4%. The readmission rate was 24.1% (14/58). The most common cause for readmission was lung infection (3/14). One patient underwent revascularization (PCI) during follow-up.

MVP was performed through an atrial approach (31 cases; 50.8%) or ventricular approach (30; 49.2%). The atrial approach included right atrium-septum in 30 cases and interatrial groove in 1 case. The mean aortic cross-clamp time was 112.8 ± 31.0 minutes in the right atrium-septum group and 99.6 ± 38.0 minutes in the ventricular group (P = .153). The mean CPB time was 164.1 ± 44.0 minutes in the right atrium- septum group and 145.6 ± 50.1 minutes in the ventricular group (P = .142). There was no significant difference in postoperative LVEF (P = .097) and LVEDD (P = .438) between different MVP approaches. There was no significant difference in the early and late mortality of the 2 groups (P = .815 and 0.733, respectively). There was also no significant difference in mitral regurgitation during follow-up (P = .797).

LVR was carried out in 3 strategies: linear stitch in 34 cases (55.7%); EVCPP of Dor in 12 cases (19.7%); and ECP in 15 cases (24.6%). The mean cross-clamp time was 99.2 ± 31.9 minutes, 112.1 ± 34.5 minutes, and 114.3 ± 42.4 minutes, respectively, without significant difference. The mean CPB was 146.4 ± 51.9 minutes, 157.3 ± 35.4 minutes, and 165.9 ± 47.2 minutes, respectively, also without significant difference. There was no significant difference in the early and late mortality of the 3 groups (P = .724 and .828, respectively). The mean postoperative LVEF was 43.8 ± 8.9%, 43.9 ± 5.4%, and 50.3 ± 9.3% for the 3 groups respectively. The ECP group had significantly improved postoperative LVEF compared with linear stitch (P = .044), but no significant difference was found between the ECP and EVCPP groups (P = .066). The postoperative LVEDD was 55.6 ± 8.3 mm, 49.8 ± 5.8 mm, and 54.4 ± 6.7 mm, respectively. The LVEDD of the EVCPP group was significantly different compared with the linear stitch group (P = .047).

DISCUSSION

Chronic ischemic heart failure after acute myocardial infarction is a major public health problem worldwide [Mozaffarian 2015]. As an alternative to heart transplantation, surgical left ventricular reconstruction restores LV shape, reduces LV volume, and improves pump function in these patients [Mickleborough 2004; Mickleborough 2001]. In patients with IMR, LVR is frequently combined with mitral valve surgery, and most frequently, repair. However, the outcome of the combined procedure of CABG, LVR, and MVP has still been controversial [Dor 2004; Klein 2012; Menicanti 2004]. The major findings of the present study are 1) combined CABG, LVR, and MVP procedure is effective in treating ischemic heart failure and mitral regurgitation, with acceptable early and late outcome; and 2) a selection of existing strategies of LVR and approaches of MVP did not affected the outcome.

According to the STICH trial, adding surgical ventricular reconstruction to CABG reduced the left ventricular volume, as compared with CABG alone. However, this anatomical change was not associated with a greater improvement in symptoms or exercise tolerance or with a reduction in the rate of death or hospitalization due to cardiac causes. Whether LVR really improves the clinical outcome of CABG is still under debate [Jones 2009]. Some studies showed that in select patients, LVR significantly improved clinical status and survival. Another study showed that when combined with restrictive mitral annuloplasty, SVR provided a greater reduction of LV end-diastolic and end-systolic volume indexes. Our study focused mainly on patients with left ventricular aneurysm with mitral regurgitation. In this sub-group of patients, LVR had acceptable outcomes.

The presence of mitral regurgitation is an independent marker of mortality. As shown before, LVR and concomitant MVP results in favorable late clinical and echocardiographic outcome. Correcting IMR by mitral valve repair, especially restrictive mitral annuloplasty, results in satisfying clinical outcomes. Except RMA, additional procedures such as artificial chordae, shortening of chordae, and leaflet resection should be considered to provide further reconstruction of the subvalvular apparatus. Edge-to-edge procedure can be used when other procedures do not appear to provide a durable successful outcome. Mitral valve replacement should be evaluated when repair is difficult. In our study, the early and late outcomes of MVP were satisfying in IMR. A randomized clinical trial found that although replacement provided a more durable correction of mitral regurgitation, there was no significant between-group difference in clinical outcomes [Acker 2014]. However, treatment algorithm for mitral valve repair was only RMA in the clinical trial. In our study, a pathophysiologic-guided strategy incorporating subvalvular and leaflet repair techniques, as well as RMA, was used.

In patients with moderate ischemic mitral regurgitation, mitral valve repair was associated with a reduced prevalence of moderate or severe mitral regurgitation but survival was not improved [Smith 2014; Drake 2015]. In our study, patients with moderate and even mild mitral regurgitation were enrolled. In some of these patients, significant annular enlargement or other structural abnormities not cured by revascularization were found in surgical exploration. In others, the degree of mitral regurgitation was moderate or more after LVR in intraoperative TEE.

In conclusion, combined CABG, LVR, and MVP procedure had satisfying clinical and echocardiographic outcomes in treating ischemic heart failure and mitral regurgitation. Strategies of LVR and MVP should be individualized, based on ventricular size and motion, the mechanism of mitral regurgitation, and the individual's experience.

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