Original Article

Reconstructive Surgery for an Akinetic Anterior Ventricular Wall in Ischemic Cardiomyopathy

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Background: The purpose of this prospective study is to analyze the postoperative outcome after only left ventricular reconstruction (LVR) versus LVR combined with coronary artery bypass grafting (CABG) and/or mitral valve (MV) procedure in ischemic cardiomyopathy (ICM) as a result of an akinetic anterior ventricular wall.
Methods and Results: Nineteen patients underwent only LVR, and 37 underwent a concomitant LVR procedure. In both groups, New York Heart Association (NYHA) classification improved significantly from 3.5 ± 0.6 to 2.2 ± 0.5 (LVR group) and 3.4 ± 0.7 to 2.5 ± 0.5 (combined LVR group). Ejection fraction improved significantly from 25.1 ± 3.2 to 35.3 ± 4.5% in the LVR group and 28.1 ± 2.2 to 37.6 ± 5.5% in the combined LVR group. Cardiac index improved significantly from 1.8 ± 0.6 to 2.3 ± 0.5 l/min/m^2 in the LVR group and 1.6 ± 0.4 to 2.2 ± 0.6 l/min/m^2 in the combined LVR group. An additional concomitant procedure increased the mortality rate only slightly. The overall 1- and 5-year actuarial survival rates were 90% and 75% in the LVR group and 80% and 70% in the combined LVR group.
Conclusions: The LVR for akinetic ventricular wall shows very satisfactory early and long-term results. The LVR, with or without concomitant procedures, has considerable benefits for operative therapy. (Ann Thorac Cardiovasc Surg 2009; 15: 227–232)

Key words: ischemic cardiomyopathy, left ventricular reconstruction, akinetic anterior ventricular wall

Introduction

In patients with ischemic cardiomyopathy (ICM), anterior myocardial infarction is a common initiating event that leads to the loss of function of the anterior left ventricle and parts of the interventricular septum. As necrotic muscle is slowly replaced by fibrous tissue, significant scarring occurs, and there is often an area of relative thinning following the distribution of the occluded artery. A left ventricular (LV) aneurysm has been reported to occur in 4% to 20% of patients following transmural myocardial infarction.[1)]

In areas remote from the initial infarct, progressive LV remodeling occurs to compensate for the loss of contractile function in the infracted segment. The consequences of LV chamber dilatation are heart failure, associated ventricular arrhythmias, repeated hospitalizations, and, ultimately, death. Since the 1980s, LV aneurysmectomy has been performed and is recognized as a better therapeutic option for end-stage ischemic heart failure. Previous studies have demonstrated that

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dyskinetic aneurysms, in contrast to akinetic LV anterior wall, are associated with better postoperative improvement in the LV function and lower operative mortality.[2,3]

However, there has been no discussion for comparing LV performance or the results reveal short- and long-term survivals of patients treated with only volume reduction surgery versus volume reduction combined with coronary artery bypass grafting (CABG) and/or mitral valve (MV) procedure for akinetic LV aneurysm.

The purpose of this prospective study was to analyze the preoperative and operative predictors of the outcome after LV volume reduction surgery in patients who underwent only volume reduction surgery versus those who underwent volume reduction combined with CABG and/or MV procedure resulting from LV akinesis.

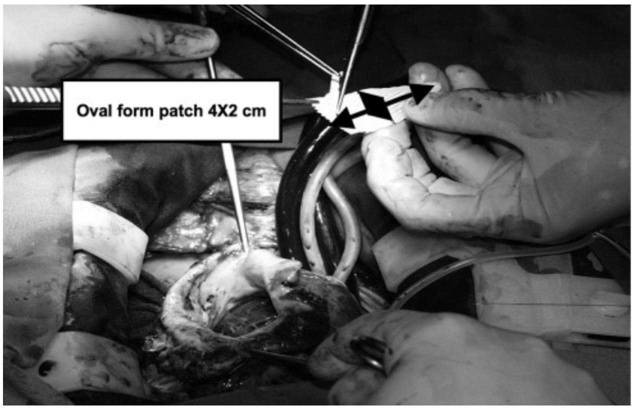

Fig. 1. Oval-shaped patch using a vascular prothese.
The patch is 2 cm wide in the extended direction and 4 cm wide in the nonextended direction.

Methods

Fifty-six patients underwent LV volume reduction for anterior ventricular wall akinesis. Nineteen underwent only LV reconstruction (LVR group), and the remaining 37 underwent LVR combined with another procedure (combined LVR group).

Patients with right ventricular (RV) hypokinesis, dyskinesis, or severe pulmonary hypertension (pulmonary artery pressure at the systemic level or pulmonary vascular resistance over 6 woods) were considered to be inadequate for this type of operation.

An angiogram provides no information regarding the extent or distribution of wall scarring and thinning. For all patients, we used magnetic resonance imaging (MRI) to preoperatively assess the ventricular shape, volume, regional wall motion, and thinning. Further, we evaluated the myocardial viability and stunning of the ventricular wall with positron-emission computed tomography (PET) preoperatively. This allowed us to determine whether akinesis or dyskinesis in the free wall corresponding to an area of hibernating myocardium that may benefit from revascularization or to an area of scarred, thinned wall should be resected.

Use of the clinical records for research was approved by the Institutional Ethics Review Board. Our committee waived the need for patient consent.

Operative technique

The procedure employed at our institution is similar to Cooley's operation method.[4]

Surgery is performed under ventricular fibrillation with mild hypothermia. The MV is examined by transesophageal echography. If necessary, coronary revascularization and/or MV procedure are carried out first, and volume reduction surgery is then performed.

CABG is performed with the intermittent aortic cross-clamping method as follows: cooling down to 27°C during preparation of the coronary arteries and inducing ventricular fibrillation.

In a case of MV insufficiency, the valve is examined for MV reconstruction or replacement by the left atrial approach. A simple annular dilation without valvular prolapse is treated by annuloplasty, according to Wooler's technique.[5] However, if an associated degenerative lesion is observed, it should be corrected by quadrangular resection with annuloplasty.

Next, we create an oval-shaped patch using a vascular prothese for volume reduction surgery. The patch is 2 cm wide in the extended direction and 4 cm in the nonextended direction (Fig. 1). It is secured with a 3-0 continuous polypropylene suture in the firm fibrous tissue, and the LV volume is measured by a water balloon (volume is 70 ml) inserted into the left ventricle during patch suturing.

The remaining scarred tissue is then plicated with polyester felt strips to cover the intraventricular patch (Fig. 2). Air is evacuated from the left ventricle apex.

The patch is usually attached at the line of one half of the septum and at the basis of the anterior and posterior papillary muscles.

We minimize the patch as much as possible to maintain sufficient morphology of the left ventricle and to maximize the fraction of a contractile ventricular wall.

The ideal LV size can be estimated preoperatively by

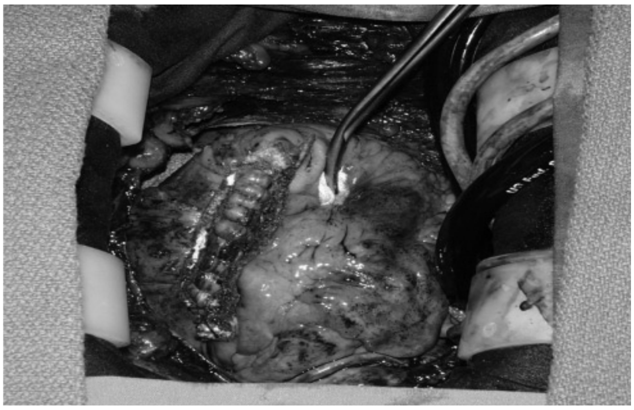

Fig. 2. The remaining scarred tissue is plicated with polyester felt strips to cover the intraventricular patch.

Table 1. Preoperative and postoperative hemodynamic data

	Only LVR group		Combined LVR group	
	Preop.	Postop.	Preop.	Postop.
NYHA	3.5 ± 0.6	2.2 ± 0.5†	3.4 ± 0.7	2.5 ± 0.5‡
LVEDD (mm)	67.2 ± 8.0	57.3 ± 6.2†	66.8 ± 7.6	58.5 ± 7.1‡
LVEF (%)	25.1 ± 3.2	35.3 ± 4.5†	28.1 ± 2.2	37.6 ± 5.5‡
CI ($l/min/m^2$)	1.8 ± 0.6	2.3 ± 0.5†	1.6 ± 0.4	2.2 ± 0.6‡
PCWP (mmHg)	20.1 ± 1.5	12.9 ± 3.4†	21.2 ± 1.9	13.1 ± 2.9‡
MPAP (mmHg)	38 ± 5	30 ± 4†	40 ± 6	35 ± 5‡

No significant difference between the LVR and combined groups.
†P <0.05 versus preoperative data in only the LVR group.
‡P <0.05 versus preoperative data in the combined LVR group.
LVR, left ventricular reconstruction; preop., preoperative; postop., postoperative; NYHA, New York Heart Association; LVEDD, left ventricular endodiastolic dimension; LVEF, left ventricular ejection fraction; CI, cardiac index; PCWP, pulmonary capillary wedge pressure; MPAP, mean pulmonary arterial pressure.

using levography.

Statistical analysis

All data are expressed as the mean ± standard deviation. A univariate analysis was done in cases of discrete variables using Fisher's exact test, and in cases of continuous variables, using the Mantel-Haenszel χ^2 test. Actuarial survival curves were used to assess differential late mortality between the two groups.

Results

In the combined LVR group, 10 patients underwent LVR + MV procedure, 22 underwent LVR + CABG, and 5 underwent LVR + MV procedure + CABG. The aim of CABG to the left anterior descending artery in three patients was the revascularization of proximal septal branches. These groups were not significantly different according to the New York Heart Association (NYHA) classification: mean pulmonary artery pressure, pulmonary capillary wedge pressure (PCWP), LV endodiastolic dimension (LVEDD), LV ejection fraction (LVEF), and cardiac index (CI) in the preoperative period (Table 1). Distributions of severe coronary artery obstruction and MV regurgitation classification were significantly higher in the combined LVR group.

In both groups, the NYHA classification improved significantly from 3.5 ± 0.6 to 2.2 ± 0.5 (LVR group) and 3.4 ± 0.7 to 2.5 ± 0.5 (combined LVR group) between the pre- and 1-year postoperative periods (no significant difference between the LVR and combined LVR groups).

LVEF improved significantly from 25.1 ± 3.25% to 35.3 ± 4.5% in the LVR group and from 28.1 ± 2.2% to 37.6 ± 5.5% in the combined LVR group (no significant

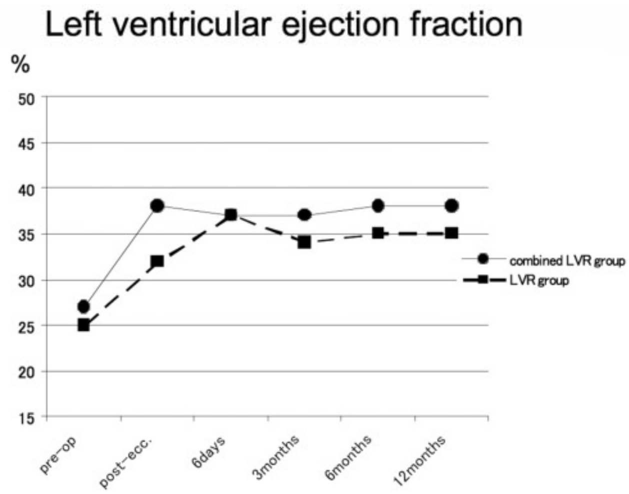

Fig. 3. Preoperative and postoperative left ventricular ejection fraction (no significant difference between the LVR and combined LVR groups).
LVR, left ventricular reconstruction; pre-op, preoperative; post-ecc., post-extracorporeal circulation.

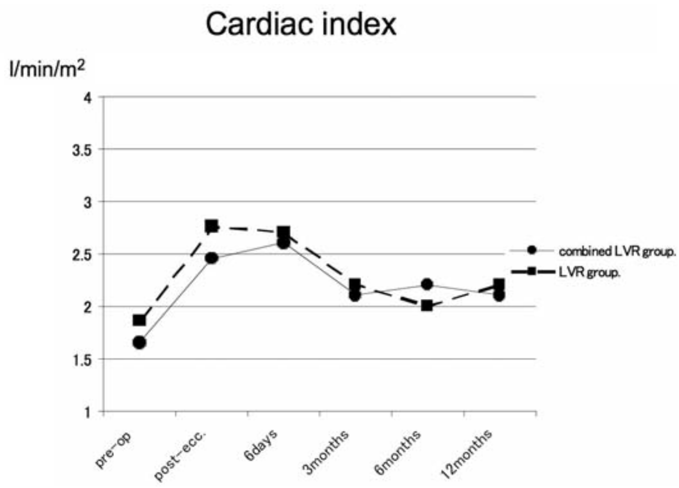

Fig. 4. Preoperative and postoperative cardiac index (no significant difference between the LVR and combined LVR groups).
LVR, left ventricular reconstruction; pre-op, preoperative; post-ecc., post-extracorporeal circulation.

difference between the LVR and combined LVR groups) (Fig. 3). CI improved significantly from 1.8 ± 0.6 l/min/m^2 to 2.3 ± 0.5 l/min/m^2 in the LVR group and from 1.6 ± 0.4 l/min/m^2 to 2.2 ± 0.6 l/min/m^2 in the combined LVR group (no significant difference between the LVR and combined LVR groups) (Fig. 4).

Echocardiography showed that LVEDD reduced significantly from 67.2 ± 8.0 mm to 57.3 ± 6.2 mm in the LVR group and from 66.8 ± 7.6 mm to 58.5 ± 7.1 mm in the combined LVR group.

In both groups, PCWP decreased significantly, from 20.1 ± 1.5 mmHg to 12.9 ± 3.4 mmHg in the LVR group, and from 21.2 ± 1.9 mmHg to 13.1 ± 2.9 mmHg in the combined LVR group (Table 1). The overall 1- and 5-year actuarial survival rates were 90% and 75% in the LVR group, and 80% and 70% in the combined LVR group (no significant difference between the LVR and combined LVR groups) (Fig. 5).

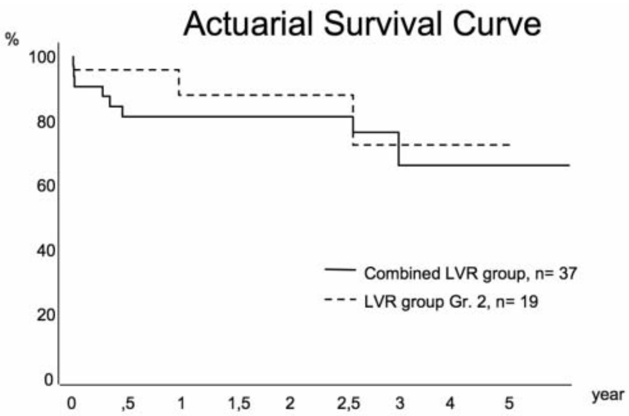

Fig. 5. The overall actuarial survival rates (no significant difference between the LVR and combined LVR groups).
LVR, left ventricular reconstruction; Gr., group.

Discussion

In patients with ICM, anterior myocardial infarct is a common initiating event that leads to the loss of function of the anterior LV and parts of the interventricular septum. This initiates progressive LV remodeling, leading to well-known manifestations and consequences of congestive heart failure.

The first standard operation for LV aneurysm was linear aneurysmectomy, as first reported by Cooley et al.[6] This is performed by excision of the glossy thinned LV segment and subsequent linear closure of the two edges.[7] The results with this technique were a perioperative mortality of 7%–18% in the 1980s and 3%–5% in the recent series, with most having symptomatic improvements.[7–9] In 1985, Jatene[10] and Dor et al.[11] reported repair techniques that exclude the dysfunctional segment of the ventricular septum, as well as the free ventricular wall. This restored LV geometry to as close to normal as possible. After changing his technique, Jatene[10] reduced his hospital mortality from

11.6% to 4.3% and late mortality from 12.6% to 3.5%. Di Donato et al.[12] applied their techniques to areas of akinesia as well as dyskinesia. Although operative mortality was 12% for patients with large areas of akinesia, it was only 2.2% for patients with small akinetic wall motion abnormalities. However, in the subgroup of survivors with large akinetic areas, LVEF increased to 41%, from 25%. Although several contemporary reports suggest an inferior outcome after reconstruction of the akinetic segment as compared to a dyskinetic segment (aneurysm), those surgeons used traditional methods of aneurysm resection and linear closure.[3] In our institute, patients having an akinetic area of relative thinning anterior walls and scarred septum were treated using a patch septoplasty technique. The major advantages of patch septoplasty are (i) exclusion of the nonresectable scarred areas in the septum, (ii) reconstruction of the ventricular shape from spherical to spindle form, and (iii) reduction of ventricular cavity size.

Further, we have used expanding material such as vessel prothese for patch septoplasty. This patch has the following advantages: (i) if the endocardial muscle is necrotic, the suture line may split because of tension; the expanding patch softens this tension. Moreover, (ii) it is possible to shorten the long axis of the expanded ventricle; this leads to better coaptation of the MV.

Some degree of mitral regurgitation is often present, and it often occurs through the central part of the valve in patients with LV aneurysms.

Advanced enlargement leads to an altered ventricular shape and papillary muscle orientation that restrain mitral leaflet coaptation from producing regurgitation. In our cases, 15 patients had moderate MV regurgitation and required MV procedure, but mild MV regurgitation (under grade II) did not require repair using the expanding patch.

In this study, the actuarial survival at 5 years was 75% in only the LVR group and 70% in the LVR and CABG and/or MV procedure groups. Perioperative mortality was insignificant, but the long-term mortality was higher in the LVR and CABG and/or MV procedure groups.

Athanasuleas et al.[3] reported that the following are risk factors for early mortality: increasing degree of congestive heart failure as classified by NYHA levels, congestive heart failure, arrhythmia, emergency surgery or urgent surgery within 30 days of myocardial infarction, depressed EF, preoperative intra-aortic balloon pump (IABP), and presence of severe mitral regurgitation.

Schenk et al.[13] reported that surgical improvement of the EF and LV end diastolic volume indexes after LVR was accompanied by an improvement of both neuroendocrine activity and functional status in patients with congestive heart failure.

In our study, we could not clarify risk factors because of the small patient population. However, we demonstrated that the long-term survival rate of LVR combined with CABG and/or MV procedure was slightly inferior in comparison to those patients receiving only LVR. Similar results such as those of Cosgrove et al.[14] have reported left main disease, and Yamaguchi et al.[15] identified multivessel disease to be associated with higher risk. Others have reported incomplete revascularization associated with higher operative mortality.[16]

In conclusion, the volume reduction surgery for akinetic anterior ventricular wall shows very satisfactory early and long-term results. Additional concomitant procedures increase the mortality rate only slightly. Volume reduction surgery, with or without concomitant procedures, has considerable benefits of operative therapy in terms of improved life expectancy and performance status.

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