Early and Mid-Term Results of Left Ventricular Volume Reduction Surgery for Dilated Cardiomyopathy

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ABSTRACT ***Objective:*** **To evaluate structure-oriented left ventricular volume reduction surgery (LVVRS). The purpose of this study was to report the early and mid-term results of left volume reduction surgery for dilated cardiomyopathy (DCM).** ***Methods:*** **We performed LVVRS on 29 patients with DCM. The age of the patient ranged from 8 to 73 years (mean 58 ± 18 years). There were 19 male patients (63%). Twenty-three patients were ischemic, 5 were non-ischemic, and 1 had salcoidosis. Twenty-three patients were in New York Heart Association class III or IV. Fourteen patients underwent the Dor operation, 11 underwent a septal anterior ventricular exclusion operation, and 6 underwent a modified Batista operation. Fifteen patients underwent mitral annuloplasty and 2 patients had mitral valve replacement. All patients were divided into two groups, a Dor group (n = 14) and non-Dor group (n = 15). Postoperative early results and mid-term survival rate were compared between the two groups.** ***Results:*** **Hospital mortality was 13.8% (4/29). The causes of death were low-output syndrome (n = 3) and septic shock (n = 1). Survival rate was 80% at 1 year and 72% at 3 years. Two-year survival rate of Dor and non-Dor groups were 69.8% and 93.8%, respectively (p = 0.099).** ***Conclusions:*** **Early and mid-term results of LVVRS were satisfied, and the non-Dor operation tended to be superior in mid-term survival to the Dor operation. Long-term follow-up is warranted.** doi: 10.1111/j.1540-8191.2005.00156a.x *(J Card Surg 2005;20: S39-S42)*

Heart transplantation is the most effective surgical therapy for end-stage heart failure of dilated cardiomyopathy (DCM). Batista et al. introduced left ventricular volume reduction surgery (LVVRS) as an alternative surgical therapy for DCM patients in 1996.[1] However, early mortality was relatively high, and quite a few patients experienced complication of re-congestive heart failure.[2-7] On the other hand, Dor et al. expanded the indication of the Dor operation for ischemic cardiomyopathy. Their early and late outcomes were satisfactory.[8,9] Recently, Suma et al. reported excellent results of LVVRS for ischemic and non-ischemic cardiomyopathy. They detected the most damaged area in the LV with a volume reduction test, and selected a procedure of choice from the Batista operation, the septal anterior ventricular exclusion (SAVE), and mitral annuloplasty (MAP).[10]

We reported the importance of preserving the LV apex and reducing the base in LVVRS in an animal study, and introduced the modified Batista operation.[11] By the time we started to perform the modified Batista and SAVE operation, we were familiar with performing the Dor operation. After inducing the non-Dor operation (SAVE or modified Batista operation), we have selected one of the LVVRS from the modified Batista, Dor, and SAVE procedure by using volume reduction test. We report the early and mid-term results of our LVVRS for DCM, and compare the outcome between Dor and non-Dor operation.

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MATERIALS AND METHODS

Patient selection

We operated on 43 consecutive patients for LVVRS from April 1998 to March 2004. The criteria of DCM are: LV ejection fraction (LVEF) is less than 40% or LV diastolic dimension (LVDd) is greater than 55 mm, and 29 of 43 patients met these criteria. The age of patient was 8 to 73 years (mean 58 ± 18 years). There were 19 male patients (63%). Twenty-three patients were ischemic, 5 were non-ischemic, and 1 had salcoidosis. Six patients were in the New York Heart Association (NYHA) class II, 12 were in class III, and 11 were in class I. Urgent operation was performed on 5 patients (17.2%). Fourteen patients underwent a Dor operation, 11 underwent a SAVE operation, and 6 underwent a modified Batista operation. Two of these patients underwent two different LVVRS simultaneously. One patient underwent both a modified Batista operation and SAVE operation, the other underwent modified Batista and Dor operations. Of the 29 patients, 18 patients underwent coronary artery bypass grafting, 15 patients MAP, 3 patients tricuspid annuloplasty, 2 patients mitral valve replacement, and 1 patient a Maze operation. All patients were divided into following two groups, a Dor group (n = 14) and non-Dor group (n = 15). Postoperative early results and mid-term survival rate were compared between the two groups.

Surgical procedure

Transesophageal echocardiography (TEE) was inserted in all patients after induction of general anesthesia to evaluate pre- and postoperative heart valves and LV function. The most damaged part of the LV was also detected with TEE after reducing preload under cardiopulmonary bypass (CPB), as reported by Suma et al.[9] Through a median sternotomy, heart was exposed in a pericardial cradle. After general heparinization, the patients were placed on a CPB, and LVVRS was performed on the beating heart. Mitral valve surgery was performed on the beating heart as far as possible. MAP was accomplished by putting a Duran ring on the posterior mitral annulus between the right and left trigone or by placing a Physio ring on the anterior and posterior mitral annulus. In a case of performing a MAP under cardiac arrest, myocardial protection was achieved with antegrade cold blood cardioplegia. The systemic temperature of the patients was lowered to approximately 32°C during cross-clamping of the ascending aorta. We did the following three types of LVVRS. The Dor operation was performed in a usual manner (Fontan suture and oval Dacron patch). The SAVE operation was completed through an anterior longitudinal incision of the LV, reshaping the LV by using an oval Dacron patch with interrupted horizontal mattress suture of 4-0 Prolene (Ethicon, Inc.) and pledget. Two patients underwent a SAVE-type LVVRS through the posterior wall to exclude the posteroseptal wall. A modified Batista operation was performed by cutting out the LV lateral wall between two papillary muscles while preserving the geometry of the original apex, and plicating the LV base.

Follow-up

Patients were studied before and after the operation (from 3 to 4 weeks) with echocardiography, and after that, evaluated on a monthly basis at an outpatient clinic. Patients continued to use diuretics and angiotensin-converting enzyme inhibitor or angiotensin-receptor blocker. Amiodarone was used in patients who had episodes of sustained ventricular tachycardia. All patients were completely followed up, and the period was 24.6 ± 17.6 (5 to 60) months.

Statistical analysis

Data are presented as mean ± SD. Unpaired 2-tailed *t*-test was used to compare the two different groups, and cumulative survival rates were calculated by the Kaplan-Meier method. A p value of <0.05 was considered significant.

TABLE 1
Comparison Between Pre- and Postoperation Data

	Preoperation	Postoperation	p Value
LVDd (mm)	66 ± 11	56 ± 8.7	<0.01
LVEF (%)	30 ± 12	38 ± 13	<0.01
MR	2.2 ± 1.4	0.6 ± 0.7	<0.01
NYHA class	3.2 ± 0.8	1.6 ± 0.6	<0.01

LVDd = left ventricular diastolic dimension; LVDs = left ventricular systolic dimension; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; NYHA = New York heart association.

RESULTS

Early outcome

Pre- and postoperative data are shown in Table 1. LVDd, LVEF, and mitral regurgitation (MR) were measured by transthoracic echocardiography. LVDd decreased from 66 ± 11 to 56 ± 8.7 mm, and LVEF increased from 30 ± 12% to 38 ± 13% after LVVRS. Also, MR and the NYHA class were improved. There were four hospital deaths (13.8%) in the entire series; 2 from the 24 scheduled cases (8.3%), and 2 hospital deaths of the 5 emergency operations (40%). The causes of death were low-output syndrome (n = 3) and septic shock (n = 1). Table 2 shows a comparison between the Dor group and non-Dor group in pre- and postoperative echocardiographic data and NYHA class. Although the preoperative LVEF in the Dor group was higher than that of the non-Dor group, there was no significant difference in the postoperative LVEF between the two groups. Also, there was no significant difference in any other pre- or postoperative data between the two groups.

Late outcome

Overall survival rate is illustrated in Figure 1. Survival rate was 80% at 1 year after operation, and 72% at 3

TABLE 2
Comparison Between Dor and non-Dor Operation

	Dor	Non-Dor	p Value
Pre-LVDd	63 ± 6.4	68 ± 14	0.238
Post-LVDd	56 ± 7.1	56 ± 10	0.828
Pre-LVEF	36 ± 12	25 ± 10	0.016
Post-LVEF	41 ± 12	36 ± 15	0.571
Pre-MR	2.2 ± 1.2	2.1 ± 1.6	0.877
Post-MR	0.7 ± 0.7	0.6 ± 0.8	0.736
Pre-NYHA	3.1 ± 0.8	3.2 ± 0.8	0.844
Post-NYHA	1.7 ± 0.5	1.6 ± 0.8	0.555

LVDd = left ventricular diastolic dimension; LVEF = left ventricular ejection fraction; MR = mitral regurgitation; NYHA = New York Heart Association.

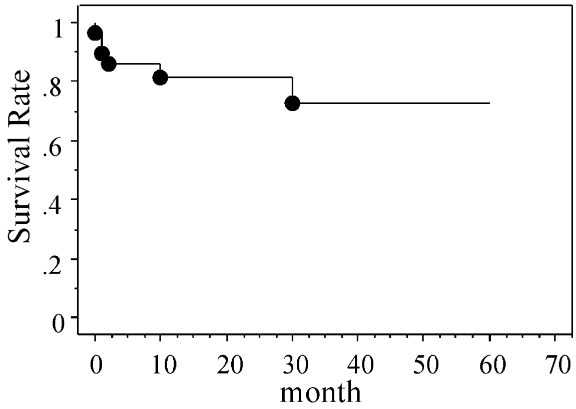

Figure 1. *Actual survival rate.*

years. Figure 2 shows the survival rate of Dor and non-Dor groups. Survival rates of Dor and non-Dor groups at 2 years after operation are 69.8% and 93.8%, respectively ($p = 0.099$).

DISCUSSION

We retrospectively analyzed 29 patients of LVVRS for DCM. Overall outcomes were satisfactory in the early and mid-term, though the hospital mortality of emergency cases was high (2/5, 40%). The LV function before LVVRS was more depressed and the LV size tended to be greater in the patients of non-Dor operation than that of Dor operation. But after LVVRS, the function and dimensions of the LV were not different between the two groups. The mid-term survival rate of the non-Dor operation was superior to that of the Dor operation.

One of the factors contributing to our good results may be the volume reduction test. We detected the most damaged part of the LV by preoperative echocardiography, LV imaging by magnetic resonance angiography, and biplane LV angiography by catheterization. Ultimately, we chose the appropriate type of LVVRSs according to the results of volume reduction test with TEE in the operating room. In almost every case, preoperative evaluation was compatible with the result of the volume reduction test. But it was difficult to evaluate the most damaged part of the heart in some cases of non-ischemic DCM. A volume reduction test would be very useful in these cases. Another reason for our good results may be due to restoration of the LV toward a more ellipsoid shape. By the time we started to do the SAVE operation, we had been doing the Dor operation for a while. The Dor operation restores the LV geometry by using a Fontan suture in the LV aneurysm.[12] However, the LV suffers from a severe remodeling due to a large akinetic area in ischemic cardiomyopathy. In these cases, the LV shape can be distorted by cinching up the Fontan suture. Di Donato and his colleagues reported that the LV dimension in the short axis was almost the same before surgery and 1 year later, while the LV dimension in long axis post surgery became shorter in comparison with that before surgery.[13] We did not tie Fontan suture tightly to avoid the shortening of the LV dimension in the long axis if the scar expands from the base to the apex of the LV. On the other hand, the SAVE operation can avoid the shortening of the LV dimension in the long axis by using an oval-shaped patch without the Fontan suture. Also, the LV is not shortened in the long axis after the modified Batista operation. Consequently, LV shape can be restored to a more ellipsoid shape after the SAVE operation and modified Batista operation than after the Dor operation. Furthermore, we preserved the original apex except in the cases of apical aneurysm. The LV apex is an important part of the cardiac cycle, because the cardiac muscle band converts its direction at the apex, and the apex is the center of the motion of coil/recoil.[14,15] We did not cut out the whole apex, in that the incision line did not extend to the summit of the apex, to preserve the geometry of the apex. We reported in an animal study[11] that preserving the apex in LVVRS made the left ventricular end-diastolic pressure lower postoperatively than with sacrificing the apex. Reducing the base and preserving the apex may be efficient not only for systolic function but also for diastolic function for LVVRS.

MR was present in 26 patients (25/29, 86.2%) before the operation in this study. In all these cases it was a functional MR, and MR decreased from 2.2 ± 1.4 to 0.6 ± 0.7 after MAP. To prevent MR from developing in the near future, we regularly perform MAP even if the MR is trivial. MR often presents at the end-stage of DCM, and most of these cases were a functional MR. Dilation of the LV and mitral annulus lowers the coaptation zone of the mitral valve, and these are the main causes of functional MR.[16,17] DCM patients have a risk of developing MR due to increasing preload or afterload on the heart in daily life. Once MR has developed, the prognosis of the patient is poor.[18,19] We believe that it is important for maintaining the LV function to eliminate any possibility of MR after LVVRS.

In conclusion, 29 patients underwent LVVRS with restoration of the LV shape for DCM. Early and mid-term results of those were satisfactory, and the non-Dor operation (SAVE, modified Batista) tended to be superior in mid-term survival rate to the Dor operation.

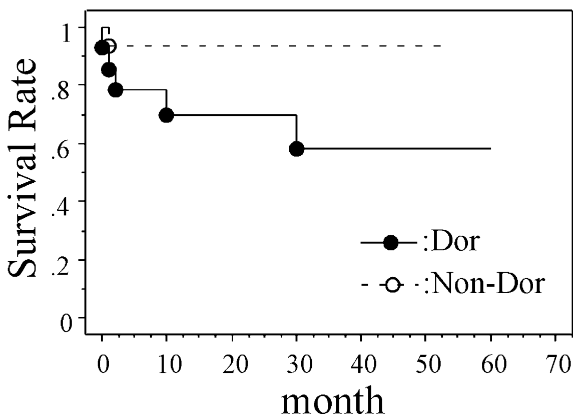

Figure 2. *Actual survival rate: Comparison between Dor and non-Dor.*

Long-term follow-up and a greater number of cases are warranted.

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