

# Volume Reduction Surgery for End-Stage Heart Failure: Experience in Korea

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**ABSTRACT** Partial left ventriculectomy (PLV) is regarded as one of the alternatives to heart transplantation for idiopathic dilated cardiomyopathy (d-CMP). Between June 1996 and March 2000, 20 patients underwent left ventricular volume reduction surgery at five major cardiac centers in Korea. PLV was performed in 16 patients with d-CMP and in 1 patient with ischemic CMP. The modified Dor procedure was performed in three patients; two patients with d-CMP and one patient with ischemic CMP. Median age was 35 years (range 3–64 years). There were 13 male and 7 female patients; there were 4 patients in Class III and 16 patients in Class IV. Among the 16 patients in Class IV, 5 patients were inotropic dependent, 2 patients were resuscitated from cardiac arrest or shock in hospital, and 1 patient was treated with intra-aortic balloon pumping. Operative technique for PLV was the same as described by Batista and colleagues. For the modified Dor procedures, the apical left ventricle was opened and a circumferential pursestring suture was placed at the base of both papillary muscles to reduce the diameter of the left ventricle concomitant with mitral annuloplasty. Mitral valve repair was performed in 15 patients and mitral valve replacement was performed in 1 patient. Moderate-to-severe tricuspid regurgitation was noted in 12 patients (with tricuspid annuloplasty in 11 of these patients and replacement in 1 patient). Postoperatively, there were seven operative deaths after PLV and one death after the modified Dor procedure. Cause of death after PLV was right heart failure in four of the seven cases, sepsis in one case, and ventricular tachyarrhythmia in the remaining two cases. After the modified Dor procedure, there was one operative death with left ventricular failure. Postoperatively, mean ventricular end-diastolic dimension markedly decreased from 75.3 mm to 50.9 mm. However, this dimension had increased slightly to 58.2 mm, an average observed 22 months later. Mean left ventricular ejection fraction (LVEF) improved significantly from 20.6% to 33.5% ( $p < 0.0001$ ), but decreased to 28.5% on average 22 months later ( $p = 0.058$ ). Eleven patients were discharged from the hospital and followed-up for a mean of 20.2 months (range 1–41 months). During the early postoperative period, most were in good condition. However, heart failure progressed with mitral regurgitation in four patients, two of whom underwent heart transplantation. In conclusion, PLV for d-CMP seems to be an effective

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**tive alternative surgical procedure to heart transplantation in Korea. The modified Dor procedure may be another alternative to transplantation for left ventricular volume reduction. However, in patients showing progression of heart failure, early intervention with ventricular assist or heart transplantation will be necessary. Also, further studies will be necessary for selection criteria and for prevention of ventricular tachyarrhythmia. (*J Card Surg* 2001;16:159-164)**

Recent developments in medical management of dilated cardiomyopathy (d-CMP) have increased not only the survival rate but also exercise tolerance.<sup>1</sup> For patients with end-stage heart failure and less than 6 months life expectancy, heart transplantation is the only proven therapeutic modality; long-term results have been excellent. However, heart transplantation is available only to a minority of patients because of the limited supply of donor organs. Especially in Asian countries, heart transplantation is not widely accepted for religious and socioeconomic problems in addition to donor organ shortage.

Partial left ventriculectomy (PLV) for d-CMP has been available since August 1994. Reduction of the left ventricular radius should reduce wall stress, increase efficiency, and correct imbalances between left ventricular diameter and thickness.<sup>2</sup> In Korea, PLV in idiopathic d-CMP and ischemic cardiomyopathy (CMP) was introduced in 1996. Since then, 20 patients have undergone cardiac volume reduction surgery including a modified Dor procedure<sup>3</sup> at five major cardiac surgery centers in South Korea. In this report, we analyze long-term results of left ventricular volume reduction surgery in end-stage heart failure and try to identify risk factors associated with the procedure.

## MATERIALS AND METHODS

Between June 1996 and March 2000, 20 patients with end-stage heart failure from idiopathic d-CMP (n = 18) or ischemic CMP (n = 2) underwent left ventricular volume reduction surgery. In the early stages of volume reduction surgery, PLV was performed in most of the patients; more recently the modified Dor procedure was performed in three patients. PLV was performed in 16 patients with idiopathic d-CMP and in 1 patient with ischemic CMP. In one patient with d-CMP, total correction of tetralogy of Fallot had been performed 17 years previously. The modified Dor procedure with mitral annuloplasty was per-

formed in a total of three patients, two patients with d-CMP and one patient with ischemic CMP. Patient age ranged from 3 to 64 years with a median of 35 years of age. Thirteen patients were male and seven patients were female.

Preoperatively, 4 patients were in New York Heart Association (NYHA) functional Class III and 16 patients were in functional Class IV. Among the 16 patients in Class IV, 5 patients were inotropic dependent, 2 patients were resuscitated from cardiac arrest or cardiogenic shock in hospital, and 1 patient was on intra-aortic balloon pumping (Table 1).

For PLV, the operative technique was the same as described by Batista and colleagues.<sup>3</sup> The operation was performed either with a beating heart or cardioplegic arrest according to the surgeon's preference. For the modified Dor procedure,<sup>4</sup> the apical left ventricle was opened vertically and a circumferential pursestring suture<sup>5</sup> was placed at the base of both papillary muscles to reduce left ventricular diameter. Mitral regurgitation was repaired in 15 patients; ring annuloplasty was performed in 9 patients and Alfieri suture was performed in 7 patients.<sup>6</sup> Mitral valve replacement

**TABLE 1**  
**Left Ventricular Volume Reduction Surgery in Korea**

Diagnosis	Number of Patients
Idiopathic dilated cardiomyopathy	18
VSD with cardiomyopathy	1
Cardiomyopathy after TOF correction	1
Ischemic dilated cardiomyopathy:	2
Preoperative Status	
NYHA functional Class III	4
NYHA functional Class IV	16
Inotropic dependent	5
Resuscitation	2
IABP	1

VSD = ventricular septal defect; TOF = tetralogy of Fallot; NYHA = New York Heart Association; IABP = intra-aortic balloon pumping.

**TABLE 2**  
**Combined Procedures for Left Ventricular  
Volume Reduction Surgery**

Procedure	Number of Patients
Partial left ventriculectomy	17
Mitral valve	
Ring annuloplasty	13
Alfieri (with ring)	9 (3)
Replacement:	1
Tricuspid valve	
Annuloplasty:	10
Replacement:	1
Others	
VSD repair	1
Modified Dor procedure	3
Mitral valve annuloplasty	2
Tricuspid annuloplasty	1

VSD = ventricular septal defect.

with a Carbomedics prosthetic valve was performed in one patient with severe fibrosis. Moderate-to-severe tricuspid regurgitation was noted in 11 patients. Of these patients, tricuspid annuloplasty was performed with the DeVega type in nine patients, the Kay method in one patient, and annuloplasty with autologous pericardial strip in one patient. Tricuspid valve replacement was done in one patient with a Carpentier-Edwards prosthesis (Table 2).

## RESULTS

### Early results

After PLV was performed in 16 patients with idiopathic d-CMP, there were eight complications and seven surgical deaths. Right heart failure occurred in four patients. In these four patients who experienced right heart failure, tricuspid regurgitation preoperatively was severe in two and moderate in two; tricuspid annuloplasty was performed in three and replacement in one. Hepatic and renal failure progressed and eventually the four patients with right heart failure died. Wound infection and sepsis occurred in another patient who subsequently died. Sudden ventricular tachyarrhythmia occurred in two other patients at 2 and 7 postoperative days. In the first patient, postoperative course was uneventful until day 2 when sudden fatal ventricular arrhythmia developed. In the other patient, an intra-aortic balloon pump was necessary to wean from the pump, but the balloon could be removed at the sixth

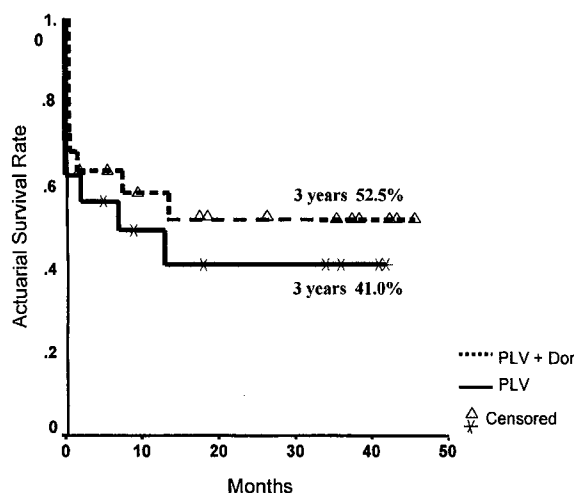
postoperative day; ventricular tachyarrhythmia occurred on postoperative day 7.

The average size of excised left ventricular mass was 94.0 mm × 60.9 mm in 16 patients. The patient with ischemic CMP recovered uneventfully.

After the modified Dor procedure in three patients, one patient could not be weaned from cardiopulmonary bypass and died in left ventricular failure. This 13-year-old girl was operated as an emergency due to cardiogenic shock while waiting for heart transplantation. The ventricular septum was very thin without contraction before operation. In the other two patients, postoperative course was uneventful.

### Late results

Nine patients were discharged from the hospital. All patients were followed completely from 1 to 41 months (mean 20.2 ± 15.5 months) after discharge from the hospital. During follow-up, four of the nine redeveloped heart failure and of these four, two patients underwent heart transplantation 9 and 18 months after PLV. However, the two other patients died of heart failure 5 and 14 months after operation. One in NYHA functional Class II died suddenly, probably from ventricular tachyarrhythmia 7 months postoperatively. Figure 1 shows a Kaplan-Meier actuarial survival estimate for patients who underwent



**Figure 1.** Actuarial survival rate after volume reduction surgery. PLV = partial left ventriculectomy; Dor = modified Dor procedure.

**TABLE 3**  
**Changes in Left Ventricular Dimension After PLV in Patients with Idiopathic Dilated Cardiomyopathy**

	Preoperative	Postoperative (1 week)	Late Postoperative (mean 22 months)
Number of patients	16	9	9
LVEDD	75.3 ± 9.5*	50.9 ± 8.3*	58.2 ± 6.1*
LVESD	66.9 ± 8.0*	42.9 ± 9.2*	49.2 ± 6.8*
LV ejection fraction	20.6 ± 4.4*†	33.5 ± 8.6*	28.5 ± 9.8†

\* p < 0.001 with paired t test, †p = 0.015 with paired t test.  
PLV = partial left ventriculectomy; LVEDD = left ventricular end-diastolic dimension; LVESD: left ventricular end-systolic dimension; LV = left ventricular.

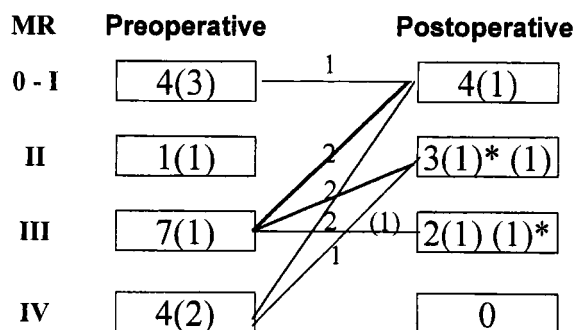
PLV with idiopathic d-CMP. The estimated 3-year survival rate after PLV in patients with idiopathic d-CMP was 41.0%. For patients with the modified Dor procedure, two were discharged without event from the hospital and are doing well with medication (one in NYHA functional Class I and the other in Class II). The estimated 3-year survival rate in all patients including ischemic CMP was 52.5%.

In patients with idiopathic d-CMP, postoperative mean ventricular end-diastolic dimensions were significantly decreased from 75.3 mm ± 9.5 mm to 50.9 mm ± 8.3 mm (p < 0.001). However, dimensions increased to 58.2 mm ± 6.1 mm during the follow-up period (mean 22 months). Mean LVEFs were markedly improved from an initial 20.6% ± 4.4% to 33.5% ± 8.6% (p < 0.001), but decreased to 28.5% ± 9.8% during the follow-up period (Table 3).

In patients with idiopathic d-CMP, postoperative mitral regurgitation was evaluated by follow-up echocardiography. Mild-to-moderate degree mitral regurgitation was noted in five patients, of these five patients, four developed heart failure and two underwent heart transplantation (Fig. 2). In patients treated with the modified Dor procedure, there was no or minimal mitral regurgitation.

**DISCUSSION**

In this series, volume reduction surgery in d-CMP in Korean patients was analyzed in terms of early and long-term results. Heart transplantation is the standard surgical technique for end-stage heart failure. In Korea, heart transplantation has been done since 1992.<sup>7</sup> However, heart transplantation is not widely accepted because of religious reasons, especially Confucianism, and also because of socioeconomic reasons. Further-



**Figure 2.** Echocardiographic evaluation for mitral regurgitation before and after partial left ventriculectomy (PLV) in patients with idiopathic dilated cardiomyopathy. The numbers within parentheses represent the number of patient deaths; numbers within parentheses with asterisks represent the number of patients undergoing transplants (2 total) 9 and 18 months after PLV. MR = mitral regurgitation.

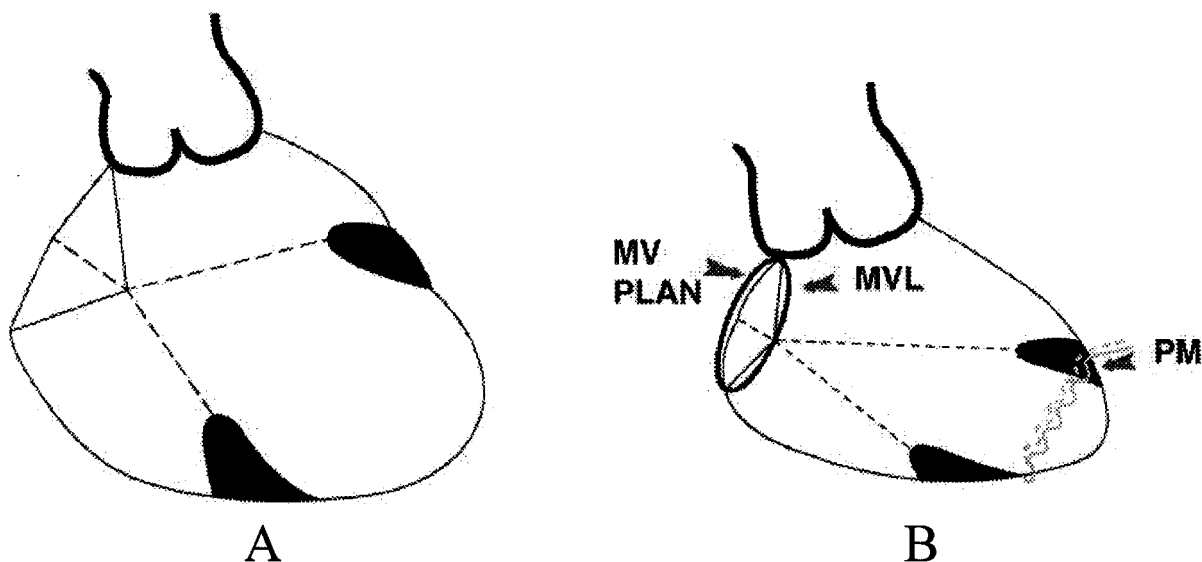
more, a law concerning brain death was not established in Korea until 1999. As a result, only 120 heart transplantations have been performed during the last 8 years. Limitations of heart transplantation in Korea encouraged us to use other kinds of surgical modalities for patients with end-stage heart failure. PLV was introduced in 1994 by Batista et al.<sup>2,3</sup> Their idea was based on Starling's law of the heart. What is certain is that left ventricular failure and cavity dilatation coexist and that stress increases in a linear fashion, whereas myocardial mass and oxygen requirements are proportional to the third power of the ventricular diameter.<sup>2</sup> Initially, the operation was the focus of world-wide attention, but this initial enthusiasm waned because of high early mortality and late failure.<sup>8</sup> Meanwhile, mitral valve reconstruction for mitral regurgitation in patients with end-stage d-CMP was found to result in improved symp-

omatic status on early follow-up, accompanied by evidence of improvement in left ventricular performance.<sup>9,10</sup> We have performed mitral valve reconstruction in d-CMP with good results, but this report excludes mitral valve reconstruction as a sole procedure. Heart failure resulting from myocardial infarction or idiopathic d-CMP is often associated with transformation of the left ventricular chamber from an ellipsoidal shape to one that more closely approximates a sphere.<sup>11</sup> In this report, we included three patients who received the modified Dor procedure for left ventricular volume reduction surgery. This procedure reduces the ventricular dimensions and changes chamber configuration from an ellipsoid shape to one more spherical. If the involved area is primarily the septum, PLV is not likely to be successful, because the contracting lateral left ventricular muscle is eliminated. The modified Dor procedure changes the left ventricular shape, and the pursestring suture modified by Jatene in 1995<sup>5</sup> at the base of both papillary muscles reduces the circumferential diameter of the left ventricle. The pursestring suture is placed with U-shaped deep bite stitches that are externally anchored to Teflon felt. In addition, mitral annuloplasty with a tight prosthetic ring further reduces the base of the left ventricular cavity (Fig. 3). The early results of the modified

Dor procedure appear to be excellent. However, long-term follow-up with a significant number of patients is necessary.

Early results after PLV showed that mitral valve regurgitation had improved markedly in almost all patients. The double orifice repair for mitral regurgitation was performed with good results in all but one patient. During follow-up, mitral regurgitation had increased slightly in some; up to moderate levels in two patients and up to mild levels in three patients. Among these five patients, four developed congestive heart failure and required other modalities. Finally, two patients underwent heart transplantation and the other two patients died. According to these observations, recurrence of mitral regurgitation seems to be an important predictor of recurrent heart failure.<sup>12,13</sup>

Because of the shortage of donors and socio-economic problems in Korea, alternative surgical interventions other than heart transplantation are necessary. Initial outcomes after PLV were encouraging and PLV was extended to patients with right heart failure; but in our series, patients with preoperative severe right heart failure and those with cardiogenic shock did not survive PLV. After PLV, ventricular tachyarrhythmia occurred in two patients early in postoperative history and in another patient at 6 months. Sudden death, probably



**Figure 3.** Modified Dor procedure with mitral annuloplasty for dilated cardiomyopathy. B: The pursestring suture is placed with U-shaped deep bite stitches externally anchored on Teflon felt. In addition, mitral annuloplasty with tight prosthetic ring reduces the base of the left ventricular cavity. MV = mitral valve; MVL = MV leaflets; PM = papillary muscle.

from ventricular tachyarrhythmia, remains a major complication of PLV. Ventricular arrhythmias and sudden death are both common features of d-CMP. Ambulatory 24-hour electrocardiographic monitoring has detected asymptomatic nonsustained ventricular tachycardia in approximately 40 percent of the patients.<sup>1</sup> After PLV, the large ventriculotomy incision can be a site of origin of intractable ventricular tachycardia. To prevent postoperative sudden death from ventricular tachyarrhythmia, implantation of an automatic implantable cardioverter-defibrillator (AICD) has been reported<sup>14</sup> to effect a difference in long-term survival rates in patients. Although implantation of AICD seems of great value for long-term survival, there are limitations associated with cost for routine use and the refractory nature of ventricular tachyarrhythmia in some.

PLV for d-CMP is an effective surgical alternative procedure to heart transplantation in Korea. The modified Dor procedure may be another modality as an alternative to transplantation for left ventricular volume reduction, especially in patients with poor myocardial contraction of the ventricular septum. Clearly, some patients with idiopathic d-CMP or ischemic CMP show significant symptomatic and functional improvement following left ventricular volume reduction. However, in patients with progressive heart failure, early postoperative intervention with ventricular assist or heart transplantation may be necessary. Further studies are necessary for improved preoperative patient selection, adequate mitral valve reconstruction, and adequate management or prevention of ventricular tachyarrhythmia.

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