

Partial Left Ventriculectomy

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Batista introduced the partial left ventriculectomy (PLV), which is based on physics alone. With experience, it has been found that the extent of myocardial disease and viability of retained muscle is an important determinant of early and late survival. Although the PLV has been almost abandoned in many countries following the negative message from the Cleveland Clinic, it is still alive in Japan with a refined concept, surgical technique and patient selection. In a series of 63 patients undergoing PLV for idiopathic dilated cardiomyopathy since 1996, operative mortality was 9.5%, and 1-, 3- and 5-year survival rates were 71.1%, 56.2% and 45.9%, respectively. Improved survival has obtained by using appropriate patient selection and concomitant restrictive mitral annuloplasty (1-, 3- and 5-year survival rate=86.5%, 78.6% and 59.4%, respectively, in the most recent 33 patients). Because of insufficient availability of donors for heart transplantation, nontransplant cardiac surgery for medically refractory heart failure is important. Ventricular restoration procedures, including PLV, should be seriously considered as an important option for endstage heart failure. (*Circ J* 2009; **Suppl A**: A-19–A-22)

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Surgical treatment for nonischemic cardiomyopathy is difficult because of the mixed etiology of the underlying cardiac damage, uncertain course of clinical progression, and unclear myocardial viability. Because heart transplantation is not often available because of the shortage of donors, particularly in Japan (>20,000 in USA vs 52 in Japan in the past 10 years), we seriously need to find an effective treatment, the so-called “nontransplant” cardiac surgery for endstage cardiomyopathy with advanced heart failure.

In the past decade, the partial left ventriculectomy (PLV: Batista operation) emerged under keen attention and then almost disappeared because of high operative mortality and frequent return of heart failure. My group, however, has continued to apply and modify it with a major change in the concept, technique and patient selection. Here, the historical background and experience with PLV are described.

Batista's PLV

Batista developed the PLV by using a very simple concept based on physics. The procedure aims to improve LV function by reducing the LV wall tension, achieved by decreasing the LV diameter with a wide excision of the LV free wall (generally the posterolateral wall between the anterior and posterior papillary muscles). This concept was based on Laplace's law as $T=PR/2d$, where T =wall tension, P =pressure, R =radius, and d =wall thickness. Batista himself explained that he began to use the PLV to treat human dilated cardiomyopathy in the mid 1980s in Brazil. It became well known internationally when he presented

his experience at the STS meeting in 1997! In 120 patients who underwent PLV, most patients had New York Heart Association (NYHA) class IV heart failure because of dilated cardiomyopathy of various causes. The 30-day mortality was 22% and the 2-year survival rate was 55%. Nearly 90% of the survivors were in NYHA class I or II after surgery.

Following Batista presentation, many cardiac surgeons in several countries began using PLV for endstage cardiomyopathy, regardless of the etiology of the disease, ischemic or nonischemic and valvular or idiopathic.

International Reports

PLV for endstage cardiomyopathy has been performed since 1996–97 in several countries. In 1997, McCarthy et al² of the Cleveland Clinic performed the PLV in 53 patients with idiopathic dilated cardiomyopathy selected from the heart transplantation list in that year; 1 patient (1.9%) died and 8 required a LV assist device, and the 1-year survival rate was 87%. Their conclusion was “The operation may become a biologic bridge, or even alternative, to transplantation”. In the same year, Angelini et al³ of Bristol, UK, reported 14 patients (8 idiopathic, 5 ischemic, 1 valvular cardiomyopathy with NYHA class IV heart failure in the main); 3 patients (21%) died during hospitalization. Their comment was “Our preliminary findings encourage the belief that surgical remodeling of the patient's own heart can cause sustained improvement in ventricular function”.

In 1998, Gradinac et al⁴ reported 22 patients with idiopathic dilated cardiomyopathy who underwent PLV, with 3 (13.6%) early and 4 (18.1%) late deaths. Their comment was “PLV could become an alternative for patients ineligible for transplantation or LV assist devices”. From Brazil in the same year, Moreira et al⁵ reported 27 patients who underwent PLV for idiopathic dilated cardiomyopathy, with 4 (14.8%) hospital deaths. They concluded that “PLV performed with preservation of the mitral valve improves left ventricular function and congestive heart failure in patients with dilated cardiomyopathy. Nevertheless, the high incidences of heart failure progression and arrhythmia-

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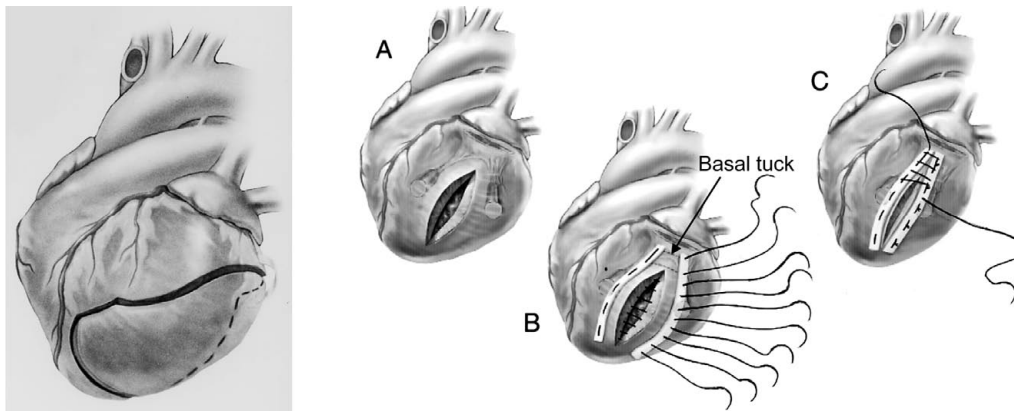


Figure 1. Batista's original incision for partial left ventriculectomy (PLV). The lateral wall including the apex is widely excised. (Left) Apex-sparing PLV (Right A–C). (A) The lateral wall of the left ventricle is not excised widely. (B) With observation of the inside of the ventricle through the lateral wall incision, the myocardium between the anterior and the posterior papillary muscles is plicated with large mattress sutures to approximate the papillary muscles together. Note the top mattress suture (basal tuck) above the incision close to the mitral annulus. This is important for reducing the basal dilatation. (C) The apex is preserved.

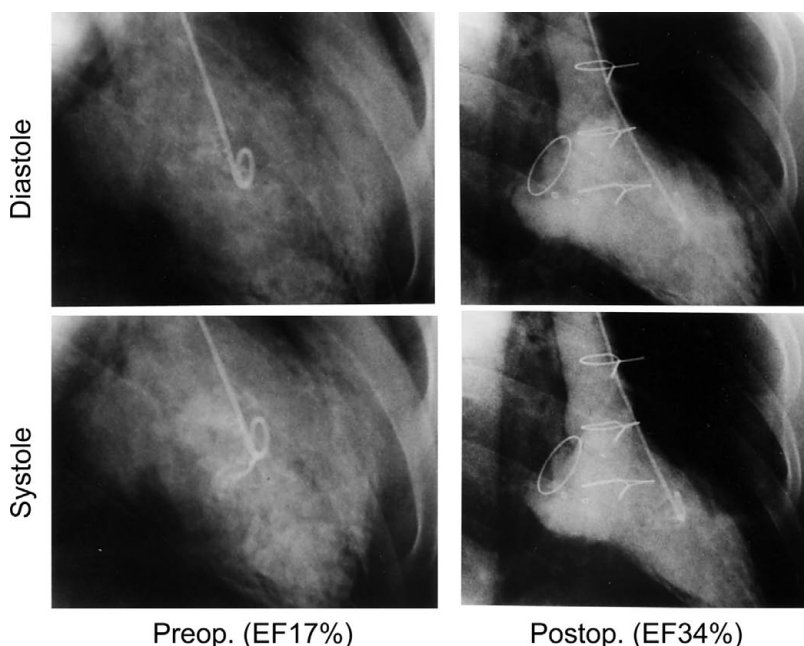


Figure 2. Left ventriculograms before and after the apex-sparing partial left ventriculectomy in a 24-year-old man with idiopathic dilated cardiomyopathy. EF, ejection fraction.

related deaths observed after this procedure preclude its wide clinical application”.

In 1999, Etoch et al⁶ in the USA compared PLV (n=16) and heart transplantation (n=17) in patients with idiopathic dilated cardiomyopathy on the transplantation list. Although surgical mortality was as low as 6% in both groups, and the 1-year survival rate was 86% in the PLV group and 93% in the transplant group, return of heart failure was higher in the PLV group. They concluded that PLV should be considered as a bridge to transplantation, rather than a definitive therapy. The same year, Konertz et al⁷ in Berlin reported 30 patients with ischemic cardiomyopathy in 18 patients and idiopathic dilated cardiomyopathy in 12 patients, who underwent PLV, with 2 (6.7%) early deaths and a 1-year survival rate of 85%. Their conclusion was “Left ventricular reduction surgery improves objective and subjective parameters of cardiac performance significantly in early and intermediate follow-up”.

In 2000, Suma et al⁸ reported 40 PLV procedures for idiopathic dilated cardiomyopathy with severe heart failure, and 9 patients (22%) died in hospital. However, when they introduced site selection for the LV excision using intraoperative echocardiography to detect the weakest area, the hospital mortality rate was reduced significantly from 29% (7/24) to 6% (1/16). They commented that “A proper selection of operative procedure and an avoidance of emergency surgery improved operative mortality and morbidity in PLV for idiopathic dilated cardiomyopathy”. The same year, Frazier et al⁹ compared PLV results in 2 groups of 21 patients each, in whom mean duration of heart failure was either 60 months or 26 months. They found that a shorter preoperative history of heart failure allowed better postoperative improvement of ventricular function. Moreira et al¹⁰ again reported that hospital mortality was 20.9% and the 5-year survival rate was 43.9% in 43 patients undergoing PLV. They noted considerable LV redilatation in survivors

Table. Preoperative Characteristics

Preoperative variables	
No. of patients	63
Age (years)	53.1±6.3
Female	5 (8%)
New York Heart Association class IV	36 (57%)
Inotropes (+)	26 (41%)
Ejection fraction (%)	23.1±8.2
Diastolic dimension (mm)	80.5±8.0
Enddiastolic volume index (ml/m ²)	208.9±34.3
Endsystolic volume index (ml/m ²)	157.7±36.2
Systolic pulmonary artery pressure (mmHg)	49.6±18.1
Mitral regurgitation ≥3+	52 (83%)
In-hospital death	6 (9.5%)

at 4 years, and observed that myocyte diameter larger than 22 μ m indicated poor postoperative outcome.

In those early clinical investigations, most authors expressed a positive and enthusiastic impression of PLV, and it was generally thought that surgical mortality can be reduced with experience.

In 2001, however, Franco-Cereceda et al¹¹ of the Cleveland Clinic presented very negative results for PLV. They reported a 3-year study of PLV in 62 patients with idiopathic dilated cardiomyopathy who were listed for heart transplantation. The 1- and 3-year survival rates were 80% and 60%, and event-free (cardiac transplantation, ventricular assist device, class IV heart failure, or death) rates were 49% and 26%, respectively. The ejection fraction increased from 16% to 31.5% early after the surgery and remained nearly the same at the end of 3 years. The LV diastolic dimension and end-diastolic volume index both decreased without significant redilatation at 3 years. Elevated pulmonary artery pressure and low peak oxygen consumption were found to be preoperative high-risk factors. Consequently, they abandoned the PLV procedure because of its poor postoperative outcome. However, they delivered an important message by showing that 25% of PLV patients can survive without cardiac events at 3 years. If the patients are selected carefully, a number of individuals on the cardiac transplant list can be successfully saved. Following the message from the Cleveland Clinic, most cardiac surgeons discontinued performing PLV, although a few institutes have continued to use it.

In 2005, Wilhelm et al¹² in Germany reported 12 patients with nonischemic dilated cardiomyopathy who underwent PLV and mitral valve repair. The 1-year survival rate was 83.3% and all 10 surviving patients were free from failure of the procedure 1 year postoperatively. Their conclusion was that "In carefully selected patients, PLV combined with mitral valve reconstruction achieves short-term results comparable to that after heart transplantation. However, long-term results and multicenter evaluation will be needed to define its place in the treatment of advanced heart failure".

As an important modification, Koyama et al¹³ have demonstrated in their experimental model that an apex-sparing PLV results in better LV function in both the systolic and diastolic phases than apex-sacrificing volume reduction surgery. This modified PLV technique is our current routine procedure as shown in **Figures 1, 2**. Another important aspect is that PLV is generally combined with mitral valve reconstruction, so it is difficult to estimate its isolated effect on LV function. Suma et al¹⁴ and Dowling et al¹⁵ have shown its positive effect in their rare cases who have no

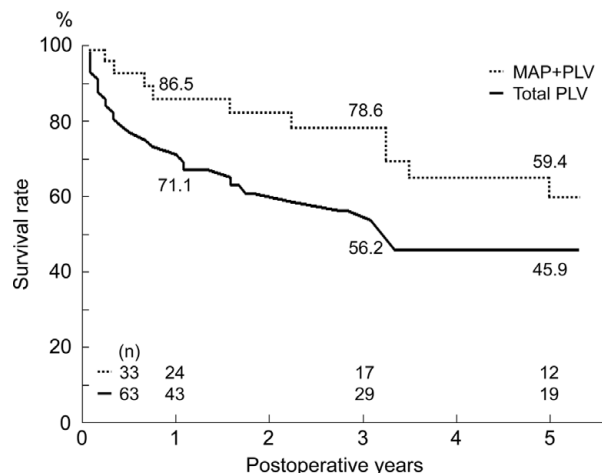


Figure 3. The 5-year survival curve in patients undergoing partial left ventriculectomy (PLV). MAP, restrictive mitral annuloplasty.

mitral regurgitation despite very dilated LV undergone PLV without mitral procedure.

Selected Ventriculoplasty

In Suma et al's article entitled "Nontransplant cardiac surgery for endstage cardiomyopathy" published in 2000⁸ they pointed out the heterogeneous extent of myocardial damage in advanced idiopathic cardiomyopathy and clearly suggested that LV excision site selection is very important for obtaining better results for cardiac volume reduction surgery.

Consequently, in 2007, Suma et al¹⁶ reported the results of "selected ventriculoplasty" for idiopathic dilated cardiomyopathy. The choice of the site of LV excision or exclusion is an important decision because it determines if the procedure for the lateral wall (PLV) or septal-anterior wall (SAVE: septal anterior ventricular exclusion) will be undertaken. In the early period of PLV experience, it was thought that the extent of myocardial disease was homogeneous in nonischemic cardiomyopathy, so the excision area was always the lateral wall as Batista indicated, and the anterior wall and ventricular septum were retained. However, it was found that echocardiography evaluation showed a certain number of patients with a less kinetic septum, and a relatively kinetic lateral wall in the PLV candidates. Also, pathological analysis of surgical specimens taken from both the lateral wall and the septum revealed the inhomogeneity of interstitial fibrosis in the LV. They found that the septum had more fibrosis than the lateral wall in 28% of the 36 patients who underwent PLV. Those findings strongly suggest that there will be a poor surgical result in patients with marked septal fibrosis if the lateral PLV is performed, particularly with extensive excision beyond the papillary muscles. Under those circumstances, the retained scarred septum will become most important for the postoperative LV following lateral ventriculectomy. The SAVE procedure¹⁷ should be chosen for those patients with a badly affected septum. Therefore, preoperative evaluation of the LV by UCG and MRI is very important to avoid the incorrect excision site and to select the correct mode of ventriculoplasty.

Based on this concept, Suma et al performed PLV in 63 patients with idiopathic dilated cardiomyopathy: 58 men and

5 women with a mean age of 53 years; NYHA class III–IV was 27/36, and 26 patients (41%) were inotropic dependent preoperatively. Mitral regurgitation ($\geq 2+$) was noted in all but 1 patient, and mitral reconstruction (repair 33, replacement 29) was performed concomitantly. Preoperative variables are shown in **Table**. Hospital mortality was 9.5% (6 deaths). The 1-, 3- and 5-year survival rates were 71.1%, 56.2% and 45.9%, respectively. In the 33 patients who had concomitant restrictive mitral annuloplasty instead of mitral valve replacement for associated mitral regurgitation, the 1-, 3-, and 5-year survival rates were 80.2%, 67.9% and 59.4% (**Figure 3**).

In conclusion, PLV is a useful option for patients with idiopathic dilated cardiomyopathy with an extremely dilated LV and an akinetic posterolateral wall and relatively good septum. Thus, patient selection is important and surgery should be considered before inotropic dependency occurs when prior medical treatment has failed.

References

- Batista RJV, Verde J, Nery P, Bocchino L, Takeshita N, Bhayana JN, et al. Partial left ventriculectomy to treat end-stage heart disease. *Ann Thorac Surg* 1997; **64**: 634–638.
- McCarthy PM, Starling RC, Wong J, Scalia GM, Buda T, Vargo RL, et al. Early results with partial left ventriculectomy. *J Thorac Cardiovasc Surg* 1997; **114**: 755–765.
- Angelini GD, Pryn S, Mehta D, Izzat MB, Walsh C, Wilde P, et al. Left-ventricular-volume reduction for end-stage heart failure. *Lancet* 1997; **350**: 489.
- Gradinac S, Mirić M, Popović Z, Popović AD, Nešković AN, Jovović L, et al. Partial left ventriculectomy for idiopathic dilated cardiomyopathy: Early results and six-month follow-up. *Ann Thorac Surg* 1998; **66**: 1963–1968.
- Moreira LFP, Stolf NAG, Bocchi EA, Bacal F, Giorgi MCP, Parga JR, et al. Partial left ventriculectomy with mitral valve preservation in the treatment of patients with dilated cardiomyopathy. *J Thorac Cardiovasc Surg* 1998; **115**: 800–807.
- Etoch SW, Koenig SC, Laureano MA, Cerrito P, Gray LA, Dowling RD. Results after partial left ventriculectomy versus heart transplantation for idiopathic cardiomyopathy. *J Thorac Cardiovasc Surg* 1999; **117**: 952–959.
- Konertz W, Khojenezhad A, Sidiropoulos A, Borak V, Baumann G. Early and intermediate results of left ventricular reduction surgery. *Eur J Cardiothorac Surg* 1999; **15**: 26–30.
- Suma H, Isomura T, Horii T, Sato T, Kikuchi N, Iwahashi K, et al. Nontransplant cardiac surgery for end-stage cardiomyopathy. *J Thorac Cardiovasc Surg* 2000; **119**: 1233–1245.
- Frazier OH, Gradinac S, Segura AM, Przybylowski P, Popovic Z, Vasiljevic J, et al. Partial left ventriculectomy: Which patients can be expected to benefit? *Ann Thorac Surg* 2000; **69**: 1836–1841.
- Moreira LFP, Stolf NAG, Higuchi ML, Bacal F, Bocchi EA, Oliveira SA. Current perspectives of partial left ventriculectomy in the treatment of dilated cardiomyopathy. *Eur J Cardiothorac Surg* 2001; **19**: 54–60.
- Franco-Cereceda A, McCarthy PM, Blackstone EH, Hoercher KJ, White JA, Young JB, et al. Partial left ventriculectomy for dilated cardiomyopathy: Is this an alternative to transplantation? *J Thorac Cardiovasc Surg* 2001; **121**: 879–893.
- Wilhelm MJ, Hammel D, Schmid C, Kröner N, Stypmann J, Rothenburger M, et al. Partial left ventriculectomy and mitral valve repair: Favorable short-term results in carefully selected patients with advanced heart failure due to dilated cardiomyopathy. *J Heart Lung Transplant* 2005; **24**: 1957–1964.
- Koyama T, Nishimura K, Soga Y, Unimonh O, Ueyama K, Komeda M. Importance of preserving the apex and plication of the base in left ventricular volume reduction surgery. *J Thorac Cardiovasc Surg* 2003; **125**: 669–677.
- Suma H, Isomura T, Horii T, Sato T, Kikuchi N, Hosokawa G. Isolated effect of partial left ventriculectomy for dilated cardiomyopathy: A case report. *J Cardiol* 1999; **33**: 273–277.
- Dowling RD, Koenig SC, Ewert DL, Laureano MA, Gray LA. Acute cardiovascular changes of partial left ventriculectomy without mitral valve repair. *Ann Thorac Surg* 1999; **67**: 1470–1472.
- Suma H, Tanabe H, Uejima T, Suzuki S, Horii T, Isomura T. Selected ventriculoplasty for idiopathic dilated cardiomyopathy with advanced congestive heart failure: Midterm results and risk analysis. *Eur J Cardiothorac Surg* 2007; **32**: 912–916.
- Suma H, Isomura T, Horii T, Nomura F. Septal anterior ventricular exclusion procedure for idiopathic dilated cardiomyopathy. *Ann Thorac Surg* 2006; **82**: 1344–1348.