Determinants of long-term mortality of current palliative surgical treatment for dilated cardiomyopathy

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Abstract

Objective: Dynamic cardiomyoplasty and partial left ventriculectomy have shown limited and controversial results in the treatment of dilated cardiomyopathies. This study investigates causes and determinants of long-term mortality after these procedures. Methods: Forty-three patients submitted to dynamic cardiomyoplasty and 43 who underwent partial ventriculectomy were studied. Patients were in New York Heart Association (NYHA) class III or IV before the procedures. In dynamic cardiomyoplasty group, hospital mortality was 2.2% and patients were followed for 48 ± 31 months. Nine hospital deaths occurred after partial ventriculectomy and the remaining patients were followed for 38 ± 29 months. Results: For patients submitted to dynamic cardiomyoplasty, 1-year event-free survival was 81.3 ± 5.9%; 2-year, 65.1 ± 7.2%; and 6-year, 23.1 ± 6.7%. Partial left ventriculectomy patients presented event-free survival rates of 58.1 ± 7.5%, 46.6 ± 7.6% and 21.6 ± 6.4% at the same periods, respectively. Late deaths were equally related to heart failure progression and arrhythmia events in both groups. Preoperative NYHA class IV, pulmonary hypertension and absence of left ventricular (LV) function improvement at the time of the final event were identified as independent predictors of poor long-term event-free survival and heart failure progression in cardiomyoplasty patients, while NYHA class IV, elevated serum nor-epinephrine and absence of LV function improvement were associated with these events after partial left ventriculectomy. Arrhythmia related deaths were only predicted by previous events of sustained ventricular tachycardia in partial left ventriculectomy group. Conclusions: Long-term results of dynamic cardiomyoplasty and partial left ventriculectomy are limited by patients' preoperative condition, by the loss of LV function benefits and by high incidence of sudden cardiac death. Palliative surgical treatment of dilated cardiomyopathies needs to be indicated earlier and may achieve better efficiency with the combination of different procedures to provide sustained improvement of LV function, to interrupt the progressive remodeling process and to prevent sudden cardiac death.

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Keywords: Dilated cardiomyopathy; Heart surgery; Cardiomyoplasty; Ventricular remodeling

1. Introduction

Several surgical procedures have been proposed as alternatives to heart transplantation to provide palliative treatment for patients with dilated cardiomyopathies.

Among them, dynamic cardiomyoplasty [1–3], partial left ventriculectomy [4–6] and the correction of mitral valve insufficiency [7–9] are those that were more meticulously evaluated and with longer follow-up.

Initial results with these surgical procedures in the treatment of patients with advanced cardiomyopathies have documented their positive impact on left ventricular (LV) function and on patients' quality of life [1–11]. On the other hand, the late results specially of dynamic cardiomyoplasty and partial left ventriculectomy have shown elevated long-term mortality [2–4,6] and late deterioration of LV function benefits [3,6,12,13]. Simultaneously, high incidences of sudden cardiac death have also been reported after these procedures [3,6].

The purpose of this paper was to investigate the
determinants of long-term mortality and necessity of heart transplantation after dynamic cardiomyoplasty and partial left ventriculectomy in patients submitted to these procedures for treatment of idiopathic or ischemic dilated cardiomyopathies. Factors associated with heart failure progression and with sudden cardiac death were also determined.

2. Patients and methods

2.1. Study population

Dynamic cardiomyoplasty and partial left ventriculectomy were indicated by the Heart Failure and Heart Transplantation Program of the Heart Institute, University of São Paulo Medical School, for patients at high risk of dying due to severe dilated cardiomyopathies and significant functional limitation despite attempts to optimize medical therapy with maximal doses of diuretics and angiotensin converting enzyme inhibitors or vasodilators. They also had reduced LV function characterized by radioisotopic ejection fraction of less than 25% and persistently high filling pressures. Dynamic cardiomyoplasty was predominantly indicated for patients with LV chamber not greater as 50 mm/m². Patients in use of intravenous inotropic drugs were contra-indicated to cardiomyoplasty, as well those with complex or intractable arrhythmias, pulmonary vital capacity less than 55% and any life-threatening non-cardiac disease. Patients indicated for partial left ventriculectomy had LV diastolic diameter greater than 45 mm/m² and this procedure was also contraindicated for patients with complex or intractable arrhythmias and any life-threatening non-cardiac disease. Medical or psychosocial contraindications to heart transplantation were present or this procedure was refused by all the patients. They signed a special informed consent form according to our Ethical and Scientific Review Board after discussion of risks, alternatives, and perceived benefits of the operations.

The group submitted to dynamic cardiomyoplasty included 43 patients (79% male, 44 ± 9 years, range 18–63 years) operated between May 1988 and September 1997, with the diagnosis of idiopathic (39) or ischemic (4) dilated cardiomyopathy. Eight of these patients were in persistent New York Heart Association (NYHA) functional class IV and 35 in class III immediately prior to the operation.

Partial left ventriculectomy was performed in 43 patients (84% male, 45 ± 10 years, range 28–72 years) with idiopathic dilated cardiomyopathy between April 1995 and March 1999. Eighteen patients were in NYHA class III and 25 were in persistent class IV. Fourteen of these patients also had reversible cardiogenic shock under the use of intravenous inotropic drugs. In addition, patients presented a mean plasmatic nor-epinephrine level of 611 ± 241 pg/ml⁻¹. The other preoperative laboratory characteristics of the patients are presented as follows. Data obtained by Doppler echocardiography, radioisotopic scintigraphy and right heart catheterization in the two groups are in Table 1. Among the patients submitted to dynamic cardiomyoplasty, eight patients were in atrial fibrillation, 18 patients presented left bundle branch block and 26 had non-sustained ventricular tachycardia episodes on Holter monitoring. Furthermore, one patient had moderate and 17 had mild mitral insufficiency on two-dimensional echocardiography, that also showed moderate tricuspid valve insufficiency in that patient with moderate mitral compromise. Significant one-vessel coronary artery compromise was shown in two patients, being 80% stenosis of the left anterior descending artery and 90% stenosis of the right coronary artery, respectively. Four patients in the partial left ventriculectomy group were in atrial fibrillation, 29 patients had left bundle branch block and 26 presented non-sustained ventricular tachycardia episodes on Holter monitoring. Mitral valve insufficiency was present in 35 patients, being severe in four, moderated in 13 and mild in 18 patients. Significant tricuspid valve insufficiency was observed in 11 patients, being moderated in seven and severe in four patients. Absence of significant coronary artery compromise was shown in every patient.

2.2. Surgical procedures

Dynamic cardiomyoplasty was performed as an isolated procedure without the use of extracorporeal circulation in 40 patients. It was associated with myocardial revascularization in two patients who underwent one saphenous vein aorto-coronary bypass graft to the left anterior descending artery or to the right coronary artery also without extracorporeal circulation. The other patient was submitted to dynamic cardiomyoplasty associated with mitral and tricuspid valves annuloplasty, which were performed under normothermic extracorporeal circulation and on a beating heart. All patients were assessed through two separated incisions: a lateral approach for muscle flap dissection and a subsequent medium sternotomy for cardiac access. Dissection and transposition of left latissimus dorsi muscle was performed as previously described [13]. The muscle flap was wrapped around the ventricular surfaces, providing a left posterior cardio-costal wrapping. Electrical stimulation of the skeletal muscle flap followed a progressive muscle conditioning protocol [3]. After the muscle conditioning period, the first 28 patients had the muscle flap predominantly maintained under 1:1 stimulation in relation to the heart rate. The other 11 patients who concluded that period had the left latissimus dorsi muscle constantly stimulated at every other cardiac beat (1:2 mode). The delay between the ventricular sensed event and the muscle burst was adjusted to provide an exact synchronization between the muscle flap and the ventricular systole.

Partial left ventriculectomy was performed as an isolated
procedure in eight patients. It was associated with mitral valve annuloplasty in 32 patients or with mitral replacement in three. Ten of those patients who underwent mitral valve operations were also submitted to De Vega tricuspid valve annuloplasty. The procedures were done under standard cardiopulmonary bypass, as previously described [10]. Internal cardioverter-defibrillators (ICD) were implanted in five of the 11 patients who presented episodes of sustained ventricular tachycardia or ventricular fibrillation at the immediate postoperative period and prophylactically in seven other patients.

2.3. Follow-up protocol

None of the patients in the two groups was lost to follow-up. They were prospectively studied at the first postoperative months and at every 6 months of follow-up. They continue to use the conventional pharmacological therapy for heart failure which included the use digoxin, diuretics, vasodilators and angiotensin-converting enzyme inhibitors. More recently, beta blockers agents were also introduced. Amiodarone was routinely used at the first 2 weeks in the patients submitted to partial left ventriculectomy and in patients who presented with episodes of sustained ventricular tachycardia or atrial fibrillation.

LV ejection fraction was routinely investigated at each follow-up visit by means of radioisotopic angiography. This evaluation was obtained after in vivo labeling of red blood cells by $^{99m}$Tc. Gated blood pool imaging was acquired in the left oblique view with a Siemens model LEM + camera (Siemens Corp., Union, USA). The images were analyzed in a Microvax model 3300 computer (Siemens).

2.4. Identification of predictors of outcome

The end-points considered in this study were mortality due to all causes and heart transplantation. The earliest of these end-points was account for the event-free survival. Regarding heart failure progression, all deaths associated with this event were accounted, as well as the heart transplantation performances. Cardiac sudden death was defined as the death that occurred suddenly at home, at the first 24 h after the onset of the symptoms and due to documented arrhythmia related events. For sudden cardiac death analysis, the earliest episode of appropriated shocks due to sustained ventricular tachycardia or ventricular fibrillation in those patients who underwent ICD implantation was also considered.

Potential preoperative risk factors were screened among clinical data, echocardiographic and radioisotopic assessment of LV function, hemodynamic measures, and cardiac rhythm disturbances. The variables related to the postoperative period included for this analysis were the occurrence of sustained ventricular tachycardia episodes at the immediate postoperative period and the absence of LV function improvement at the time of the final event. This parameter was based on the difference between the latest LV ejection fraction assessment and its preoperative control and was defined as a difference equal or less than 2%.

2.5. Statistical analysis

Cumulative event rates over time were determined by the Kaplan–Meier method and the curves were obtained by non-linear regression models (Blackstone method). Exploratory analysis of pre and postoperative variables, including correlation analysis, preceded the multivariable analyzes of outcomes. Multivariable analyzes were performed sequentially, first considering baseline preoperative data and postoperative variables thereafter. The association between variables and event rates was evaluated by Cox proportional hazards model. Variables with p value less than 0.10 entered into multivariable analysis. Confidence levels

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**Table 1**

Preoperative left ventricular function parameters

<table>
<thead>
<tr>
<th></th>
<th>Dynamic cardiomyoplasty</th>
<th>Partial left ventriculectomy</th>
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<tbody>
<tr>
<td>Doppler-echocardiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV diastolic diameter (mm)</td>
<td>73.4 ± 5.7</td>
<td>83.2 ± 8.7</td>
</tr>
<tr>
<td>LV segmental wall shortening (%)</td>
<td>12.5 ± 2.2</td>
<td>11.8 ± 2.6</td>
</tr>
<tr>
<td>Radioisotopic angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV ejection fraction (%)</td>
<td>19.3 ± 3.5</td>
<td>16.6 ± 4.7</td>
</tr>
<tr>
<td>RV ejection fraction (%)</td>
<td>24.3 ± 6.3</td>
<td>21.1 ± 6.3</td>
</tr>
<tr>
<td>Right heart catheterization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean right atrium pressure*</td>
<td>8.6 ± 3.6</td>
<td>9.4 ± 4.9</td>
</tr>
<tr>
<td>Mean pulmonary artery pressure*</td>
<td>33.8 ± 10.2</td>
<td>35.5 ± 9.1</td>
</tr>
<tr>
<td>Mean pulmonary wedge pressure*</td>
<td>23.1 ± 6.1</td>
<td>24.1 ± 6</td>
</tr>
<tr>
<td>Mean arterial pressure*</td>
<td>81.3 ± 12.5</td>
<td>80.5 ± 11.1</td>
</tr>
<tr>
<td>Cardiac index (l min$^{-1}$ m$^{-2}$)</td>
<td>1.98 ± 0.75</td>
<td>2.12 ± 0.46</td>
</tr>
<tr>
<td>Pulmonary vascular resistance**</td>
<td>266 ± 155</td>
<td>241 ± 132</td>
</tr>
</tbody>
</table>

* LV = left ventricular; and RV = right ventricular. * = (mmHg); and ** = dyn seg cm$^{-5}$. 

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for proportions are 68%, corresponding to 1 standard error. Left ventricular ejection fraction data, obtained before and after the operations were compared by means of Student’s paired t-test. Values of P less than 0.05 were considered significant. Data were analyzed by the Statistical Package for Social Sciences (SPSS) software.

3. Results

3.1. Patients follow-up

3.1.1. Dynamic cardiomyoplasty follow-up

There was one death (2.2%) in the hospital period among the patients submitted to dynamic cardiomyoplasty. Other two patients died during the muscle conditioning period and the causes of death were related to heart failure progression in the three patients. Another patient underwent successful heart transplantation due to heart failure progression at that period. The other patients were followed-up from 6 to 120 months, with a mean of 48.7 ± 31.6 months and representing 158.7 patient-years.

Radioisotopic angiography showed that LV ejection fraction increased 6 months after dynamic cardiomyoplasty from 19.3 ± 2.9 to 24.6 ± 6.8% (P = 0.001). Similar values of this parameter were also documented at 1 and at 2 years of follow-up in the surviving patients (26.5 ± 5.8 and 24.9 ± 6%, respectively).

During the long-term follow-up, 30 of the 39 patients who completed the muscle conditioning period died. The deaths were related to heart failure progression in 14 patients and occurred suddenly in 16. Other two patients with heart failure decompensation were submitted to elective heart transplantation at the 22nd and at the 26th postoperative months, respectively.

3.1.2. Partial left ventriculectomy follow-up

Nine of the 43 patients (20.9%) submitted to partial left ventriculectomy died during the hospital period. The causes of death were associated with LV failure in seven patients, incessant ventricular tachycardia in one patient and bleeding associated with disseminated intravascular coagulation in one patient. The other 34 patients were discharged from the hospital and were followed from 2 to 84 months (mean, 38.3 ± 29.2 months), which encompassed 108.5 patient-years.

Improvement of radioisotopic LV ejection fraction was demonstrated immediately after the partial left ventriculectomy procedure (from 16.8 ± 4.7 to 23.9 ± 7.9%, P < 0.001). The mean values of this parameter in the surviving patients were 21.7 ± 7.8 and 21.2 ± 6.5% at 1 and at 2 years of follow-up, respectively.

During the late partial left ventriculectomy follow-up, nine patients died during the first 6 months of follow-up and another 14 patients died at longer follow-up times. Five of the deaths that occurred during the first 6 months were associated to heart failure progression, while four occurred suddenly. The deaths that occurred after that period were equally divided between heart failure progression and arrhythmia related events. Other two patients were submitted to elective heart transplantation due to heart failure progression at the 7th and 44th postoperative months, respectively. Besides these facts, three patients who had ICDs presented episodes of sustained ventricular tachycardia or ventricular fibrillation reverted by appropriated shocks, whose first episode was at 30, 33 and 40 months of follow-up, respectively.

3.2. Event-free survival

Event-free survival curves of the patients submitted to dynamic cardiomyoplasty or to partial left ventriculectomy for up to 7 years of follow-up are shown in Fig. 1. In the group of patients submitted to dynamic cardiomyoplasty, 1-year event-free survival was 81.3 ± 5.9%, 2-years, 65.1 ± 7.2% and 6-years, 23.3 ± 6.7%. The event-free survival curve of patients submitted to partial left ventriculectomy shows rates of 58.1 ± 7.5, 46.6 ± 7.6 and 21.6 ± 6.4% at the same periods, respectively. While patients submitted to dynamic cardiomyoplasty presented a constant hazard phase for event-free survival, the risk of death or heart transplantation for patients who underwent partial left ventriculectomy consisted of two phases, an early phase corresponding to the first 6 months of follow-up and a constant hazard phase thereafter.

Univariate analysis of factors that adversely affected long-term event-free survival of patients submitted to dynamic cardiomyoplasty identified preoperative NYHA functional class, preoperative hemodynamic measures and absence of LV function improvement at the time of the event as significant predictors of outcome. Table 2 shows that stepwise Cox proportional hazards analysis recognized
only NYHA functional class IV and elevated pulmonary vascular resistance as independent preoperative predictors for long-term mortality or necessity of heart transplantation for these patients. When postoperative variables were considered, absence of LV function improvement was also identified as an independent powerful predictor for poor event-free survival, simultaneously with the factors previously perceived.

For patients submitted to partial left ventriculectomy, NYHA functional class IV, elevated nor-epinephrine serum levels and absence of LV function improvement at the time of the final event were the unique factors identified as significant predictors of worse prognosis at the univariate analysis. Stepwise Cox proportional hazards analysis recognized only NYHA functional class IV and elevated nor-epinephrine serum levels as independent predictors of mortality or necessity of heart transplantation after the procedure whether or not postoperative variables were included (Table 2).

### 3.3. Heart failure progression and sudden cardiac death

The incidences of death or heart transplantation performance due to heart failure progression in the long-term follow-up of patients who underwent dynamic cardiomyoplasty or partial left ventriculectomy are shown in Fig. 2. These curves show similar incidences of heart failure progression at 7 years of follow-up with the two procedures. However, while the incidence of this event presented a constant hazard phase for dynamic cardiomyoplasty patients, it consisted of two phases for patients who underwent partial left ventriculectomy, as previously described for event-free survival.

The results of Cox proportional hazards analysis identified two different models associated with the occurrence of heart failure progression in patients submitted to dynamic cardiomyoplasty (Table 3). When baseline preoperative data were considered separately, this complication was independently predicted by NYHA class IV and elevated right atrium pressure. With the inclusion of postoperative variables, absence of LV function improvement at the time of the final event and higher pulmonary vascular resistance became independent predictors for heart failure progression, simultaneously with right atrium pressure. Table 3 also shows that two different models were again identified by Cox proportional hazards analysis regarding the prediction of heart failure progression in partial left ventriculectomy follow-up. In the first model, preoperative NYHA functional class IV and elevated serum nor-epinephrine levels were recognized as independent predictors for this complication. In the other model, absence of LV function improvement at the time of the final event was also identified as an independent predictor, simultaneously with elevated serum nor-epinephrine levels.

The incidences of sudden cardiac death in the two groups are presented in Fig. 3. Similar mortality rates due to this

### Table 2

Independent predictors for long-term mortality and necessity of heart transplantation after dynamic cardiomyoplasty or partial left ventriculectomy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient ± SE</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dynamic cardiomyoplasty</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary vascular resistance</td>
<td>0.004 ± 0.001</td>
<td>0.007</td>
</tr>
<tr>
<td>Absence of LV function improvement</td>
<td>0.947 ± 0.037</td>
<td>0.011</td>
</tr>
<tr>
<td>NYHA functional class</td>
<td>1.324 ± 0.563</td>
<td>0.019</td>
</tr>
<tr>
<td><strong>Partial left ventriculectomy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYHA functional class</td>
<td>1.063 ± 0.393</td>
<td>0.007</td>
</tr>
<tr>
<td>Nor-epinephrine serum level</td>
<td>0.002 ± 0.001</td>
<td>0.033</td>
</tr>
</tbody>
</table>

### Table 3

Independent predictors for heart failure progression after dynamic cardiomyoplasty or partial left ventriculectomy

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient ± SE</th>
<th>P value</th>
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<tbody>
<tr>
<td><strong>Dynamic cardiomyoplasty</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Model</td>
<td></td>
<td></td>
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<tr>
<td>Right atrium pressure</td>
<td>0.2 ± 0.076</td>
<td>0.008</td>
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<tr>
<td>NYHA functional class</td>
<td>1.38 ± 0.556</td>
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<tr>
<td>2nd Model</td>
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<tr>
<td>Absence of LV function improvement</td>
<td>2.739 ± 0.82</td>
<td>0.001</td>
</tr>
<tr>
<td>Pulmonary vascular resistance</td>
<td>0.006 ± 0.002</td>
<td>0.003</td>
</tr>
<tr>
<td>Right atrium pressure</td>
<td>0.27 ± 0.096</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Partial left ventriculectomy</strong></td>
<td></td>
<td></td>
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<tr>
<td>1st Model</td>
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<tr>
<td>NYHA functional class</td>
<td>1.51 ± 0.551</td>
<td>0.006</td>
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<tr>
<td>Nor-epinephrine serum level</td>
<td>0.002 ± 0.001</td>
<td>0.018</td>
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<tr>
<td>2nd Model</td>
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<tr>
<td>Nor-epinephrine serum level</td>
<td>0.004 ± 0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>Absence of LV function improvement</td>
<td>2.039 ± 0.816</td>
<td>0.013</td>
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event were observed for both groups, despite the existence of a higher incidence of sudden cardiac death episodes at the first 6 months of partial left ventriculectomy follow-up.

Regarding the factors associated with the sudden cardiac death, it was not identified any variable related to this outcome for patients submitted to dynamic cardiomyoplasty. On the other hand, Cox proportional hazards analysis showed that the occurrence of episodes of sustained ventricular tachycardia at the immediate postoperative period was the unique predictor for sudden cardiac death for patients who underwent partial left ventriculectomy (coefficient $1.423 \pm 0.585, P = 0.015$).

4. Discussion

The data presented in this study exhibit similar long-term outcomes for two procedures performed as palliative surgical treatments for patients with advanced cardiomyopathies. This single-center experience showed elevated long-term mortality with dynamic cardiomyoplasty and partial left ventriculectomy in the treatment of patients with idiopathic or ischemic dilated cardiomyopathy. It was also demonstrated that the occurrence of heart failure progression in the late postoperative period of these surgical procedures was mainly related to the patients preoperative condition and to the long-term deterioration of LV function benefits, independently of the performed operation. Furthermore, elevated incidences of sudden cardiac death were observed in the follow-up of dynamic cardiomyoplasty and partial left ventriculectomy, which represents another important limitation for these procedures clinical application.

Primary objectives of any palliative surgical treatment for patients with dilated cardiomyopathies are to reduce congestive heart failure by the improvement of LV function and to halt the progression of the underlying disease. These approaches are justified by several mechanisms of action, that are especially directed to provide the increase of ventricular pumping performance and the reinforcement of ventricular walls. Improvement of LV systolic function was consistently demonstrated in the clinical experience with dynamic cardiomyoplasty [3]. This procedure may also decrease ventricular wall stress and lead to a reversal of the remodeling process [3]. Partial left ventriculectomy is also responsible for significant improvement of LV systolic function [10,14] and some studies have additionally shown evidences of decreased LV systolic and diastolic wall stresses [11]. These changes also seem to be associated with the improvement of the contractile characteristics of the failing myocardium, that occurred whether or not this procedure was associated with mitral insufficiency correction, as previously described [15]. Similar results have been reported with the isolate correction of atrioventricular valves insufficiency in patients with moderate or severe mitral regurgitation [7,8], with the use of atrial-synchronized biventricular pacing to provide the resynchronization of LV contraction in patients with heart failure who have an intraventricular conduction delay [16], and with the implantation of a passive cardiac constrain device used to halt the progressive remodeling process [17]. Furthermore, expectations exists about the possible improvement of LV systolic function with the use of different methods of cellular cardiomyoplasty [18].

The positive influences on LV function obtained by the different palliative surgical procedures justify the clinical improvement consistently reported with their use. The positive impact of some of these procedures has also been measured by detailed quality of life assessment [3,16,19] and by the decrease in hospitalizations due to heart failure decompensation [1,3,16]. On the other hand, survival improvement was not demonstrated yet with any of the current palliative surgical approaches. Only dynamic cardiomyoplasty results comprise data regarding comparison of survival outcomes in relation to those of patients maintained on medical therapy [3,19]. However, this procedure has been indicated mainly for patients in NYHA functional class III and comparative multicenter studies did not show any survival difference in relation to medical therapy [3,19].

The influence of preoperative clinical status on long-term mortality and necessity of heart transplantation after dynamic cardiomyoplasty [2,3,20] or partial left ventriculectomy [4,5] was previously recognized by other reports. For dynamic cardiomyoplasty patients, besides the impact of persistent functional class IV, significant influences of pulmonary hypertension, right ventricular failure and atrial fibrillation on this procedure late outcomes have also been reported [2,3,20]. On the other hand, the confirmation that dynamic cardiomyoplasty and partial left ventriculectomy long-term results were similarly influenced in this study by

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**Fig. 3.** Incidence of sudden cardiac death episodes in the follow-up of patients submitted to dynamic cardiomyoplasty or partial left ventriculectomy. Numbers indicated patients at risk at each time for cardiomyoplasty (upper line) and partial ventriculectomy (lower line).
patients preoperative clinical condition clearly emphasizes that the indication of palliative surgical procedures in the treatment of dilated cardiomyopathies should be performed earlier than the referral for heart transplantation. For this approach, however, the maintenance of a low operative mortality is mandatory, situation that has been observed for dynamic cardiomyoplasty [3], isolate correction of atrio-ventricular valves insufficiency [7–9], atrial-synchronized biventricular pacing implantation [16], and passive cardiac constrain device implantation [17]. Otherwise, elevated early mortality has been reported for patients submitted to partial left ventriculectomy, which seems to be associated with the absence of myocardial contractility improvement in response to LV volume reduction and with higher incidence of arrhythmia related events [5,6]. The absence of myocardial response to LV volume reduction appears to be related to a more pronounced compromise of the myocardial cells [21], while the existence of areas of fibrosis and myocardial infarction around the ventricular scar may facilitate the occurrence of new re-entrant pathways, justifying the higher incidence of ventricular arrhythmias [22]. Based on these assumptions, however, the preoperative evaluation of the myocardial contractile reserve and technical modifications to decrease the influence of the myocardial scar may potentially contribute towards a better early outcome for LV volume reduction operations.

Absence of LV function improvement at the time of the final event was the other determinant of unsatisfactory long-term outcomes identified in this study. The late decrease of LV ejection fraction in patients submitted to dynamic cardiomyoplasty is related to the decline of skeletal muscle graft power production over time [2,13]. Several studies suggested that the impairment of muscle flap blood flow is the principal cause for the deterioration of skeletal muscle integrity after the procedure [3], that includes the decrease of muscle flap thickness and an important amount of fat tissue infiltration, which are significantly related to the follow-up time [3]. On the other hand, a better preservation of the muscle graft functional performance, leading to a consequent stability of left ventricular function benefits, may be chronically obtained with low stimulation rates. This fact is suggested by the comparison of the long-term results of patients chronically submitted to skeletal muscle flap stimulation synchronized at every cardiac beat in our early experience [23] and those of other series that used the muscle flap stimulation synchronized at every other beat [1, 3]. Positive results regarding the skeletal muscle flap performance at long-term have also been obtained with the use of adaptive pulse train duration or activity-rest stimulation protocols [24]. Regarding partial left ventriculectomy, the occurrence of LV redilatation at the late postoperative period is the principal mechanism for the decrease of this procedure benefits [6,12] and the prevention of this complication can be only achieved by the association of LV volume reduction with other procedures that provide the reinforcement of ventricular walls. The successful association of partial left ventriculectomy and dynamic cardiomyoplasty was reported in anecdotal cases [3] and another procedure that has been used associated with mitral insufficiency correction to interrupt the progressive remodeling process is the implantation of the passive cardiac constrain device [17].

The observation that the incidence of arrhythmia related deaths continue to be high at the late follow-up of dynamic cardiomyoplasty and partial left ventriculectomy clearly shows that these procedures do not decrease the occurrence of this event in patients with dilated cardiomyopathies. The same fact was also described for patients who underwent isolate mitral valve reconstruction [7], opening the expectation that the prevention of sudden cardiac death needs to be always discussed in the palliative surgical treatment for dilated cardiomyopathies. On the other hand, the present study did not identify any predictor for sudden cardiac death in dynamic cardiomyoplasty patients, whose occurrence was observed in patients with or without significant LV function improvement [3]. The identification that the occurrence of episodes of sustained ventricular tachycardia at the immediate postoperative period was the unique predictor for sudden cardiac death after partial left ventriculectomy reinforces the importance of the technical aspects involved in this procedure for the improvement of its long-term outcomes. Nevertheless, the absence of other factors associated with this event was also observed in partial left ventriculectomy experience. Therefore, only the routine use of ICDs should significantly reduce the occurrence of this complication in the follow-up of the current palliative surgical treatment of dilated cardiomyopathies, as observed for patients in the heart transplantation waiting lists [25].

Controversial and limited long-term results of the clinical application of palliative surgical procedures in the treatment of dilated cardiomyopathies have precluded definitive conclusions about their value. Accordingly, dynamic cardiomyoplasty has been infrequently performed in the treatment of NYHA class III patients with dilated cardiomyopathies without important LV enlargement. In addition, partial left ventriculectomy has been rarely indicated only as an alternative for patients contraindicated for heart transplantation with the diagnosis of idiopathic cardiomyopathy and severe LV dilatation.

On the other hand, it is important to emphasize that patients with dilated cardiomyopathies have several cardiac disturbances that may be total or partially corrected by surgical approaches. Furthermore, the insights discussed in the present paper indicate that the palliative surgical treatment of dilated cardiomyopathies may achieve better efficiency with the combination of different procedures to provide not only the sustained improvement of LV function, but also the interruption of the progressive remodeling process and the prevention of sudden cardiac death. Besides the quality of life improvement observed with the different
palliative procedures in heart failure treatment, we can speculate that the combination of different procedures could potentially have a real impact on patients’ survival, when compared with medical therapy alone.

References


Appendix A. Conference discussion

Dr J. Bachet (Paris, France): I’m afraid that the real message of your paper is that neither therapeutic options that you have presented are good therapeutic options. Obviously, both methods of treatment were a failure. Did you compare, for instance, the outcome of your patients with the natural outcomes of the same kind of patients put on medical therapy? And secondly, as it is important not to mix apples and oranges, how did you include the patients either in the cardiomyoplasty group or in the left ventricular resection group?

Dr Moreira: Well, these two experiences started at different moments, and the patients submitted to dynamic cardiomyoplasty were patients with not so big hearts as those submitted to partial left ventriculectomy.

Regarding the results, it was shown in reality the failure of the procedure at long term in regard to the maintenance of a good patients’ survival.

For dynamic cardiomyoplasty patients, these results were partially compared with medical therapy alone in a group of patients submitted to the FDA phase II protocol, and it was not observed any improvement in survival.

But what is the real message? For any palliative surgical treatment for dilated cardiomyopathy, if we think only to improve left ventricular function for some period, the problems in the future will be basically the possibility of heart failure progression due to disease progression and also sudden cardiac death. Therefore, only a new vision combining different approaches may solve these problems and may open again the possibility of palliative approaches for treatment of dilated cardiomyopathies.

Dr Bachet: You didn’t tell us whether those patients had contra-
indications to heart transplantation. In other words, is there really a place for palliative treatment of this kind of disease?

Dr Moreira: Well, some of these patients had real contraindications at the time they were submitted to palliative operations, like insulin-dependent diabetes, higher age, and psychosocial problems, which are very common in our country.

Dr P. Gerometta (Bergamo, Italy): I would like to know whether you had noticed any long term difference in functional class or mortality between the patient with cardiomyoplasty with a 1-to-1 simulation mode or a 2-to-1?

Dr Moreira: Well, as I showed at this presentation, some of the problems were the loss of left ventricular function benefits at long term, which occurred mainly in patients who were submitted to 1-to-1 stimulation. This complication was not observed for all patients, especially those who were submitted to 2-to-1 stimulation in the skeletal muscle flap. Therefore, the prevention of the skeletal muscle integrity in dynamic cardiomyoplasty is an important finding, of course, for the long-term outcome of this procedure.