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Myocardial Revascularization and Ventricular Restoration through Pacopexy

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Summary

Objective: **To analyze left ventricle performance after myocardial revascularization associated to ventricular geometrics restoration by "pacopexy" in schemic myocardiopathy patients with significant ventricular dysfunction in whom ventricular restoration was obtained through special technique.**

Methods: **Myocardial revascularization associated to ventricular geometrics restoration through special technique, with no use of prosthesis or other synthetic materials.**

Results: **Patients' functional class was shown to have improved 93.10% after surgical procedure. Pre- and post-surgical comparison showed significant increase in left ventricle ejection fraction as well as decrease in left ventricle systolic diameter. No significant change was observed in left ventricle diastolic diameter or systolic volume. Post-surgical follow-up time length ranged from 1 month to 3 years and 4 months.**

Conclusion: **Ventricular dysfunction restoration technique through pacopexy showed to be effective for the management of severe ventricular dysfunction from schemic causes. Major impact was observed in the functional class of patients under study.**

Key words: **Heart failure, congestive; myocardial revascularization; ventricular function, left.**

Introduction

Cardiovascular diseases are responsible for the largest number of deaths in the Western World[1]. Among them Congestive Heart Failure (CHF) is accountable for quite a considerable share of deaths.

Approximately 23 million people are CHF carriers, and 2 million new cases are diagnosed every year worldwide[2]. Major risk factor for the development of CHF in the US is ischemic heart disease[3].

In Brazil, data from the Ministry of Health (Unified Health System – DATASUS) show that about one third of patients admitted to hospitals are diagnosed with CHF[4]. Although epidemiological data are not accurate, ischemic heart diseases can be estimated to also be accountable as a major etiologic factor in our scenario. Chagas disease, in its turn, and rheumatic fever are still posed as challenges to be overcome[5,6].

From all surgical options for ischemic myocardiopathy treatment, isolated myocardial revascularization stands out[7,8]. However, the development of refractory CHF in coronary artery disease carriers is associated to ventricular dilation and changes in ventricular sphericity, with the development of mitral regurgitation[8-14].

The concept of the helicoid heart as described by Torrent-Guasp – spiral, double helix left ventricular dynamics - emphasizes the relevance of cardiac structure for better hemodynamic performance. The loss of heart elyptical shape results in significant changes in the ventricular ability of getting filled with and/or ejecting blood. Surgical procedures carried out with the purpose to restore the cardiac architecture responsible for normal function are called "pacopexy", after Francisco Torrent-Guasp, who contributed with the bases for the surgical techniques designed to improve ventricular performance[15].

Although "pacopexy" procedures are more favorable in dilated myocardiopathies with secondary mitral failure, its utilization has been expanded for the exclusion of left ventricle fibrotic regions, especially for the treatment of the interventricular septum[12,15].

The purpose of this paper is to analyze left ventricle performance following myocardial revascularization, as well as ventricular geometrics restorarion through "pacopexy" in patients who are ischemic myocardiopathy carriers and who present significant ventricular dysfunction, and whose ventricular restoration was obtained through special technique. Left ventricle performance was analyzed through clinical and echocardiographic data, with left ventricle ejection fraction (LVEF), cavitary diameters, and systolic volume having been assessed.

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Methods

Thirty-four ischemic myocardiopathy patients were submitted to myocardial revascularization associated to "pacopexy" in the time period between February, 2000 and November, 2004. The group was made up by 27 males and 07 females, age range 43-73 years of age (mean 60.50 $\pm$ 8.86 years of age).

All patients had ischemic myocardiopathy and clinical condition compatible with CHF – current or previous. At immediate preoperative, 3 patients (8.83%) reported functional class II (FC II); 22 (64.70%) patients reported FC III; and 9 patients (24.47%) reported FC IV, following New York Heart Association (NYHA) classification, with associated congestive symptoms despite proper medication dosing. Post-surgery follow-up varied from 1 month to 3 years and 4 months (mean 9.67 $\pm$ 7.23 months).

Patients presented the following characteristics: systolic and diastolic dilation of left ventricular cavity measured by transthoracic echocardiogram; significant left ventricular contractility deficit, measured by transthoracic echocardiogram and/or left ventriculography during cinecoronariography.

All patients were submitted to myocardial revascularization associated to ventricular geometric restoration through "pacopexy". Two patients also had concurrent correction of mitral regurgitation though valvoplasty, when Carpentier-Edwards annuloplasty ring was applied.

Study protocol was approved by the Research and Ethics Committee at Escola Paulista de Medicina (UNIFESP). Patients agreed to participate by signing the informed consent.

Surgery technique - Surgery started with hemodynamic monitoring through average blood pressure measuring, central venous pressure measuring, and urinary debit, in addition to respiratory monitoring with pulse oximetry.

Surgery was carried out as routine, with access through median esternotomy, with aortic and lower cava cannulation through right atrium (or bicaval when mitral valve approach was necessary) after systemic heparinization (4 mg/kg), under moderate hypothermia at 32 °C.

Hypothermic antegrade cardioplegy was used as myocardial protection method (approximately at 18 °C), with potassium increase (15 mEq/l) at induction. Perfusion blood at 32 °C was administered in subsequent doses at 15-minute intervals and with no other substance added.

After anastomoses were carried out between revascularizable coronary arteries, and after graft was selected (left inner thoracic artery or saphena), "pacopexy" was carried out in the left ventricle.

Ventricular geometry restoration through "pacopexy" includes ventriculotomy parallel to anterior interventricular coronary artery followed by inspection of septal portion and of ventricle free wall, with the identification and delimitation of areas with fibrosis. The free ventricle wall was then sutured to septal portion with the purpose of excluding fibrosis areas in anterior wall and anterior third of septum. With free wall imbricated to septal portion, the procedure was finalized by suturing remaining septal portion over free wall through hemostatic continuous suture.

A full, 28 mm Carpentier-Edwards annuloplasty ring was applied to the two patients who reported significant mitral reflux.

After surgery, normothermic patients were taken to Post-Surgery Unit, where they were kept under full time monitoring.

Patients had the same surgery team member in charge of both in-hospital and outpatient unit follow-up. A protocol was filled out to be used for comparison between pre- and post-surgery data.

Statistical analysis - Statistical analyses compared parameters studied at three observation points in time, where data were collected from each patient. Observations were carried out in the following time periods: 1) Before surgery – Pre-Surgical Observation; 2) Prior to Discharge – Post-Surgical Observation; 3) After discharge – Current Observation.

Parameters observed were: Left Ventricle Ejection Fraction; Left Ventricle Diastolic Diameter; Left Ventricle Systolic Diameter; Systolic Volume.

With the purpose of verifying statistical relevance of parameters differences along time, non-parametric hypotheses tests were carried out by comparing the following pairs in the evolution of each parameter (pre-surgery x post-surgery; pre-surgery x current measure; post-surgery x current measure). Willcoxon (signed rank) is the appropriate test for the comparison of paired samples.

Results

Functional class - Patients' anaysis in regard to functional class evolution prior to and after surgery showed that except for deaths, 93.10% of patients had functional class improvement, while only 6.9% (2 patients) did not report improvement (Graph 1).

Ventricular function –

a) Left Ventricle Ejection Fraction (LVEF): No significant statistic difference was reported for immediate post-surgery LVEF when pre-surgery (36$\pm$11.91) and post-surgery data were compared (32$\pm$9.80) (p = 0.1349); neither for pre-surgery and current level (40$\pm$10.26) (p = 0.1854). However, in immediate post-surgery, significant increase was reported when data were compared with currrent levels (p = 0.0002) (Graph 2);

b) Systolic volume: No statistic evidence was reported for systolic volume variation at pre-operative or immediate post-operative points in time, neither in current observations (Graph 3).

Values:

• Pre-operative (118$\pm$62) – Post-operative (139.76$\pm$52.79) (p = 0.2191)

• Pre-operative (118$\pm$62) - Current (111$\pm$47.86) (p = 0.7854)

• Post-operative (139.76$\pm$52.79) – Current (111$\pm$47.86) (p = 0.2049)

c) Left ventricle diastolic diameter (LVDD):

No statistic evidence was reported for diastolic diameter

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variation at pre-operative or immediate post-operative points in time, neither in current observations (Graph 4).

Values:

• Pre-surgery (65.50±10.82) - Post-surgery (67±7.52) (p = 0.3380)

• Pre-surgery (65.50±10.82) - Current (64±7.26) (p = 0.4689)

• Post-surgery (67±7.52) – Current (64±7.26) (p = 0.0513)

c) Left ventricle systolic diameter (LVSD):

No significant variation was reported bewteen pre-operative (53.85±10.83) or post-operative (55.95±7.76) (p = 0.1931) systolic diameter, neither between pre-operative and current (50±7.92) (p = 0.5721).

Significant reduction was reported between immediate post-operative levels and current levels (p = 0.0172) (Graph 5).

Survival analysis - Data showed 5 deaths among the 34 patients: 4 deaths were related to the object of study (2 from cardiogenic shock and 2 from ventricular arrhythmia), and 1 unrelated. Surgery related deaths occurred within 8 days after procedure. No other death was reported after that point in time.

Survival analysis by Kaplan-Meier curve resulted estimated survival average probability at 88.24%, CI5%, variation between 77.41% and 99.07% (Graph 6).

Discussion

The clinical treatment of CHF is based on the knowledge of hemodynamic and neurohumoral mechanisms of this syndrome. However, the therapeutic mode is not definitive, and stands only for temporary life standard quality improvement[16]. Despite clinical treatment optimization, a considerable number of patients end up developing into more advanced stages of the disease, and heart transplant becomes elective treatment.

The increase in number of patients that develop CHF is a result of longer survival periods following acute myocardial infarction (AMI), especially from more efficacious therapeutics for the management of coronary artery disease. However, that longer survival period is often associated to some degree of myocardial impairment caused by ventricular remodelling, which triggers a vicious cycle leading to heart failure[17].

Post-infarction left ventricle remodelling is a complex phenomenon involving molecular, neurohormonal, and genetic factors. Those factors may result in cardiac chambers dilation, and ventricular change and dysfunction[18].

Ischemic disease as the cause for CHF is a result of dilation and ventricular remodelling after myocardial infarction[19]. Although early reperfusion of infarct-related artery - through thrombolysis or angioplasty – may limit ventricular dilation expansion, approximately 20% of patients may present such complication despite aggressive therapeutics[20]. In a recent study, Bolognese et al have observed that 30% of patients treated through successful primary angioplasty develop left ventricular dilation (defined as a 20% increase of final diastolic volume) within 6 months after the procedure[21].

Myocardial revascularization in itself is a therapy option for those patients. The Coronary Artery Surgery Study (CASS) showed to be highly beneficial for the survival of revascularized patients with left ventricle ejection fraction (LVEF) below 35%[22]. In addition to that study, the Veterans multicenter administration study (Veterans Administration Coronary Artery Bypass Surgery Cooperative Study Group) contributed with evidence of survival after myocardial revascularization of patients with serious ventricular dysfuncation and angina[23].
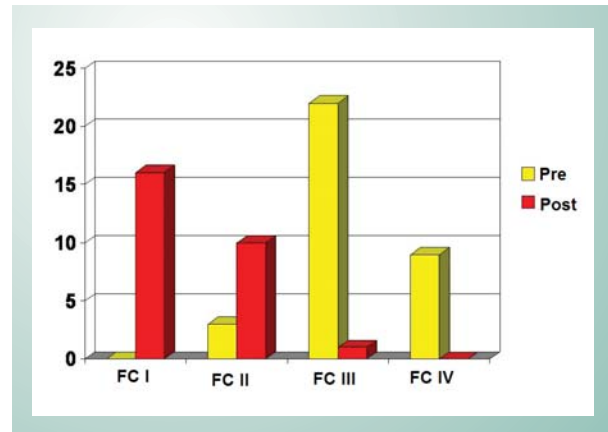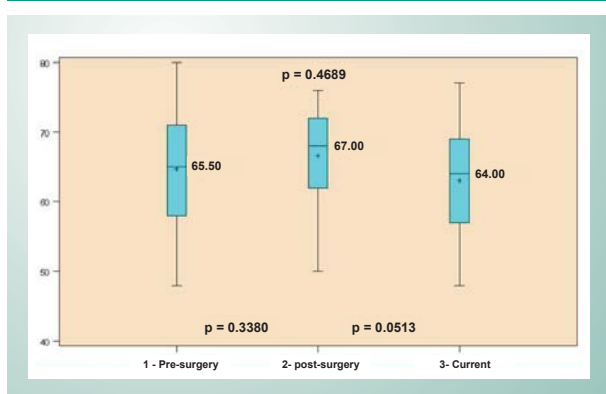

Graphic 1 - *Patients' Evolution in regard to Functional Class: pre and post-surgery, mean follow-up period - 9.67 ±7.23 months.*
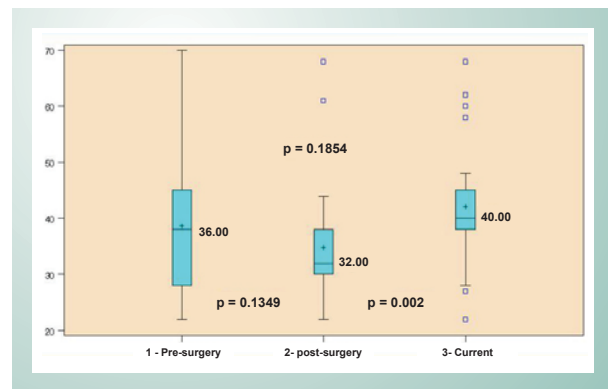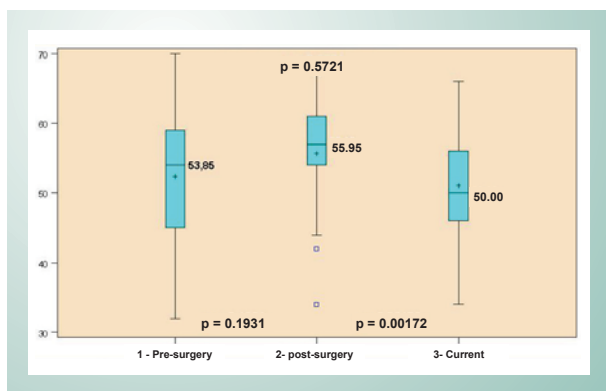

Graphic 2 - *Left Ventricle Ejection Fraction (LVEF) Distribution: median and percentile.*
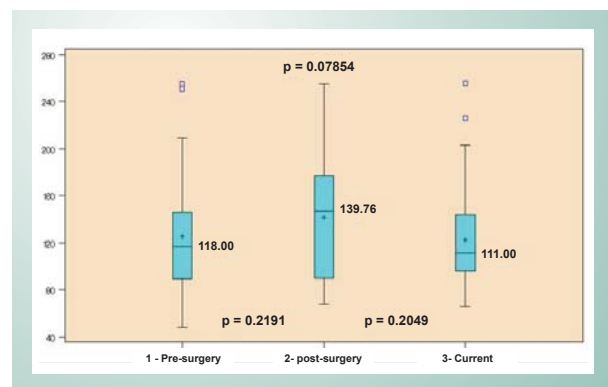
Graphic 3 - *Distribution of Systolic Volume (SV) Values: median and percentile.*

Graphic 4 - Left Ventricle Diastolic Diameter (LVDD) Values: median and percentile.

Graphic 5 - Left Ventricle Systolic Diameter (LVSD) Values Distribution: median and percentile.

Therefore, myocardial revascularization has the ability to increase LVEF, improve hemodynamic parameters, extend survival time, and reduce congestive symptoms.

However, clinical or surgical treatment of the lesion blamed for myocardial ischemia is no guarantee for cure. Ventricular size and funcation must be assessed for prognostic determination in terms of heart failure development, which includes high economic and social impact[17].

Therefore, the development of ischemic myocardiopathy is associated to ventricular dilation and possible mitral regurgitation, with changes in ventricular sphericity and resulting deterioration of systolic function. Surgical management of ischemic myocardiopathy should encompass coronary revascularization, correction of mitral regurgitation, and ventricular geometry restoration[24].

Ventricular geometry restoration with ventricular volume reduction is based on the excision of obvious scar areas in left ventricle anterior wall. Excision and linear suture of those dyskinetic scar areas has been done for quite many years, although the technique may not properly treat fibrosis areas in the interventricular septum[24]. Endoventricular repair with septal imbrication is an attempt for a better approach for the treatment of interventricular septum; the surgical ventricular restoration strategy has been used both for dyskinetic and akinetic follow-ups of cardiac muscle[14].

The principle of ventricular geometry restoration has been well described by Dor et al through endoventriculoplasty with a circular graft and the exclusion of all scar areas, with application both in discynesia and akinesia areas[13]. A multicenter study using that technique showed low mortality rate and acceptable survival after 3 years of follow-up, in addition to lower rate of repeat hospitalization due to CHF if compared to myocardial revascularization alone[24]. Another important contribution was brought up by the RESTORE group, made up of 10 international centers that have carried out ventricular restoration procedure since 1998[14].

Classical ventricular aneurysm is characterized by a diskynetic ventricular portion circumscribed by a collum that separates the scar area from contractile muscle. This sort of lesion can be corrected through Jatene's technique, which recommends ventricular geometric reconstruction by using circumferencial suture in aneurysm collum, and the exclusion of discynesia area[14]. Currently, this type of lesion is not frequent as a result of the availability of early reperfusion techniques of the coronary artery under atherosclerosis.

In the present study, ventricular geometry restoration was obtained through special technique "pacopexy", which showed to be satisfactory, particularly for the treatment of scar areas in the interventricular septum. Additionally, the technique does not involve the use of synthetic material such as prostheses or tissue bars, and may, therefore contribute with lower tissue inflammatory response. Previous studies have shown that bovine pericardium and teflon compounds are associated to mononuclear inflammatory infiltration in adjacent tissue and graft-host type immunological response induction[25].

The follow-up of those patients showed significant functional improvement, with 93.10% of them showing improvement when pre and post-surgery Funcional Class (FC) was compared (Fig. 1), with possible benefits in terms of life standard quality.

In regard to left ventricle ejection fraction, one could say it is not the best accuracy parameter in determining long-term results - ventricular volume analysis is crucial[24]. In spite of that, some LVEF decrease could be observed between pre-surgery and immediate post-surgery (before hospital discharge), showing recovery when compared to current levels.

After geometric restoration, left ventricular cavity size is a major factor in determining the survival of those patients. In the present study, except for left ventricle systolic diameter (LVSD), all other ventricular volume parameters showed no statistically significant difference when comparing pre and post-surgery points in time. The apparent lack of improvement in left ventricular preformance may be associated to the method used for assessment in the present study (transthoracic echocardiogram). That can be changed by using other methods (particularly MRI).

Despite patients' severe condition in the present study – due to pre-surgery ventricular dysfunction – post-surgery survival analysis showed to be favorable, with mean survival probability at 88.24%, in the period being considered. Survival curve was influenced by an 11% surgery mortality rate, basically related to the advanced stage of ventricular dysfunction presented by patients at the time of surgery.

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Graphic 6 - *Kaplan-Meier Curve.*

So, the ventricular restoration technique used in the present study differs from all other techniques described in the literature under research, especially for making available a wide option range for interventricular septum treatment, as well as for not making use of synthetic materials. Classical linear suture does not properly correct the septal component; all other techniques involve circular sutures and many times the use of synthetic materials.

Successful ventricular restoration procedures are based on the following aspects: full myocardial revascularization, ventricular volume reduction, and shape restoration - all fully complied with in the technique used in the present study.

Therefore, the understanding of normal heart anatomy and function will help the surgeon to use the techniques that will allow ventricular geometry to be restored as close as possible to ideal shape and size, with possible implication in ventricular function improvement.

Conclusion

1. Statistically significant left ventricle ejection fraction increase was shown when comparing immediate post-surgery (before hospital discharge) and current evaluation data.

2. Significant reduction of left ventricle systolic diameter was shown when comparing post-surgery and current values.

3. Additional prospective studies are required for long term assessment of the results obtained in the present study.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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