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# Physiologic left ventricular reconstruction: the concept of maximum ventricular reduction and minimum inflammatory reaction

## *Reconstrução fisiológica do ventrículo esquerdo: o conceito de máxima redução ventricular e mínima resposta inflamatória*

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*Abstract*

***Background:*** **The outcome of patients with heart failure, even after left ventricular reconstruction, is related to the size of the left ventricular cavity. The use of synthetic materials in ventricular reconstruction may induce a chronic myocardial inflammatory reaction. We report on a modification of the ventricular reconstruction technique that eliminates the need of intraventricular patches or the use of synthetic materials.**

***Method*: Eleven consecutive patients presenting with left ventricular aneurysms, evolving to functional classes III and IV of the New York Heart Association, underwent direct left ventricular reconstruction surgery without the use of intraventricular patches or prosthetic strips.**

***Results*: There were no operative deaths or the need of mechanical circulatory support. The postoperative hospital stay ranged from 4 to 7 days (average 5.3 ± 1.1 days). Control serial echocardiograms showed reductions of the mean left ventricular diastolic diameter (from 69.0 ± 7.5 mm preoperatively to 62.6 ± 5.1 mm postoperatively). The mean left ventricular ejection fraction increased from 47.3% ± 6.6% to 56.3% ±10.5%. One-year follow-ups revealed 8 patients in functional class I and 3 in class II.**

***Conclusion*: This technique, with the elimination of prosthetic materials, could contribute to an improvement of the clinical results in patients who undergo left ventricular reconstruction, providing virtually eliminating akinetic areas of left ventricular and potentially attenuating the long-term myocardial chronic inflammatory reaction.**

***Descriptors:*** **Heart aneurysm, surgery. Heart ventricles, surgery. Left ventricular dysfunction. Myocardial revascularization.**

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***Resumo***

***Introdução:*** **A sobrevida em pacientes com insuficiência cardíaca, assim como após a cirurgia de reconstrução do ventrículo esquerdo (VE), está relacionada ao tamanho da cavidade ventricular esquerda. Também o uso de materiais sintéticos na reconstrução ventricular poderia induzir uma reação inflamatória crônica. Relatamos a modificação da técnica de reconstrução ventricular que elimina a necessidade de retalhos intra-cavitários e de uso de material sintético no fechamento do VE.**

***Método*****: Onze pacientes consecutivos com aneurisma de VE, evoluindo em classe funcional (CF) III e IV da *New York Heart Association* foram submetidos à cirurgia de reconstrução ventricular direta sem utilização de retalhos intra-cavitários ou materiais protéticos no fechamento da incisão ventricular.**

***Resultados:*** **Não houve mortalidade cirúrgica ou necessidade de suporte circulatório mecânico. A permanência hospitalar pós-operatória variou de 4 a 7 dias (média de 5,3 ± 1,1 dias). O ecocardiograma de controle, realizado em média 4,6 ± 1,5 meses após a operação, evidenciou redução do diâmetro diastólico de VE de 69,0 ± 7,5 mm, no pré-operatório, para 62,6 ± 5,1 mm, no pós-operatório. A fração de ejeção do VE mostrou aumento de 47,3% ± 6,6% para 56,3% ±10,5%. Com um ano de seguimento, 8 pacientes encontram-se em CF I e 3 em CF II.**

***Conclusão:*** **Esta técnica, com eliminação de uso de material sintético, pode contribuir para a melhora dos resultados clínicos de pacientes submetidos à reconstrução ventricular esquerda, proporcionando virtual eliminação das áreas acinéticas do VE e potencialmente atenuando, no pós-operatório tardio, a reação inflamatória crônica do miocárdio.**

***Descritores:*** **Aneurisma cardíaco, cirurgia. Ventrículos cardíacos, cirurgia. Disfunção ventricular esquerda. Revascularização miocárdica.**

## INTRODUCTION

The foundations of surgical reconstruction of the left ventricle (LV) after aneurysms of the anterior wall are based the concepts established by JATENE [1] and DOR et al. [2].

Recent studies demonstrated that survival of patients evolving with heart failure, as well as survival after reconstruction of the LV, are related to the size of the left ventricular cavity, that is, the final systolic and diastolic volumes [3-5]. However, not using patches during LV reconstruction may contribute to an additional reduction of the left ventricular cavity.

Also the use of synthetic materials during LV reconstruction may be related to the induction of chronic inflammatory processes of the myocardium, which nowadays are recognized as the basis of physiopathology of heart failure [6].

The objective of this work is to report on the modification of a left ventricular reconstruction technique that eliminates the need of using intra-cavity patches or synthetic materials, thereby virtually eliminating akinetic areas in cases of left ventricular aneurysms and potentially attenuating, in the late postoperative period, chronic inflammatory reaction of the myocardium.

## METHOD

### Patients

Between September 2002 and April 2003, eleven patients with aneurysms of the anterior wall of the left ventricle, evolving to heart failure (six patients in functional class III and five in functional class IV according to the New York Heart Association) were submitted to surgeries for the reconstruction of the left ventricle using the technique described below. The ages of the patients ranged from 30 to 77 years old with a mean of 56.4 ± 14.2 years. All the patients were submitted to coronary cineangiography and transthoracic echocardiography prior to the operation.

### Technique

A cardiopulmonary bypass was established in the conventional way with a single cannula in the right atrium and return of the arterial blood to the ascending aorta. The operation was performed at normothermia and with the empty heart beating without aortic clamping. The left atrium was drained by passing a catheter through the right superior vena cava and located in the left ventricle through the mitral valve. Subsequently, the left ventricle was opened at the anterior wall aneurysm and any thrombi removed.

The neck of the aneurysm, that is, the region of the transition between fibrotic tissue and normal muscle was delimited both in the septum and the antero-lateral wall; a double circular purse-string suture was performed, the first using 3-0 polypropylene thread followed by 2-0 polyester thread and the sutures were tied, thereby redoing the left ventricular apex. The transitional areas of healthy muscle of the lateral and septal walls, that is, the residual orifice of the aneurysmal neck were brought together, edge-to-edge with a running suture of the same 3-0 polypropylene thread used for the purse-string suture. And this thread was also used to close the remaining walls of the aneurysm, by overlapping and using running sutures thereby reinforcing the surgical hemostasis. Thus, no synthetic materials whatsoever were used during the closure of the aneurysm (Figure 1).

The protocol of the study was approved by the Ethics Committee of the institution.

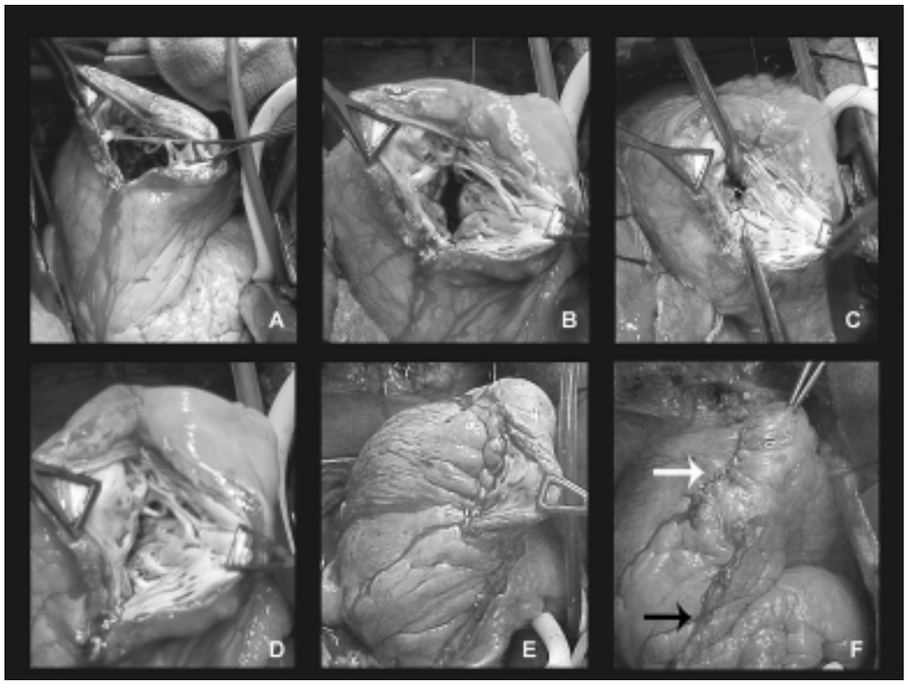


Fig. 1 - A) Left ventricle (LV) open in the region of the aneurysm of the anterior wall. B) The double purse-string suture at the neck of the aneurysm was tied leaving a residual orifice. C) The residual orifice being sutured edge-to-edge using running sutures. D) Residual orifice after suturing. E) Closure of the left ventricle with running suture of the antero-lateral wall to the septal wall. F) Closure of the left ventricle completed with an overlapping running suture of the remaining anterior wall to the lateral wall (white arrow) and anastomosis of the left internal thoracic artery to the anterior descending artery (black arrow).

## RESULTS

There was no operative mortality, nor the necessity to use mechanical circulatory support (intra-aortic balloon pump). On removal of the cardiopulmonary bypass, three patients required temporary inotropic support using dobutamine (mean of these patients 2.3 hours), and the others needed sodium nitroprusside only.

All the patients underwent simultaneous coronary artery bypass surgery (a mean of 2.4 grafts per patient). The internal thoracic artery was utilized in all patients for the revascularization of the anterior descending coronary artery. Postoperative hospital stay varied from 4 to 7 days with a mean of 5.3 ± 1.1 days.

Control echocardiograms performed on average 4.6 ± 1.5 months after surgery showed a mean reduction of the diastolic diameter of the left ventricle from 69.0 ± 7.5 mm in the preoperative period to 62.6 ± 5.1 mm in the postoperative period. The left ventricle ejection fraction showed a mean increase of from 47.3% ± 6.6% to 56.3% ± 10.5%.

At the one-year follow-up no deaths had occurred and eight patients were functional class I and three patients functional class II.

## COMMENTS

The appearance of new concepts for the surgical reconstruction of the left ventricle shows that elimination of akinetic areas, as well as diskinetic areas of the left ventricle could potentially give a better restoration of the form and function (study of Saver) [5].

The size of the left ventricular cavity, as well as the heart index and the ejection fraction, have been demonstrated to have a correlation with the survival of patients with heart failure [3,4]. The greater the size of the left ventricular cavity, the lower the expected survival is [7,8]. Progressive dilation of the heart leads to an elevation of the tension in the left ventricular wall, which is necessary to generate intracavitary systolic pressure (Laplace's Law). Additionally, it has been demonstrated that attenuation of the progression of the left ventricular dilation is associated to a reduced risk of cardiovascular events [9,10].

In the study by Saver, the final size of the left ventricular cavity after surgical correction of an anterior wall aneurysm was also a significant determining factor for survival. Thus, patients who had final left ventricle systolic volume indexes (FLVSVI) in the postoperative period of up to 80 mL/m$^2$ had

a higher 3-year survival rate than those with a final volume > 80 mL/m$^2$. These findings reinforce the idea that achieving smaller left ventricular cavities with a greater exclusion of akinetic areas, might contribute to an improved evolution of operated patients over the long term [5].

The use of synthetic materials in the reconstruction of the left ventricle induces the formation of a response to the foreign body with a consequent chronic inflammatory reaction in the heart tissue. Previous studies showed that bovine pericardium and Teflon are associated with predominantly mononuclear inflammatory infiltrations in the adjacent tissue and the induction of a graft-versus-host type immunological response. These formations constitute an active source of cytokines, which may start and maintain inflammatory processes induced by foreign substances in the organism [11-15].

It has been demonstrated that heart failure is a syndrome characterized by prolonged immune and inflammatory activation, with high levels of inflammatory cytokines (TNF-$\alpha$ and IL-1) and an increased expression of several inflammatory mediators (adhesion molecules). These inflammatory mediators are not only markers of immune activation, but also can induce myocardial dysfunction by different mechanisms, including the regulation of apoptosis and the $\beta$-adrenergic responsiveness [16,17].

Similar to other forms of heart failure, ischemic dysfunction of the left ventricle is characterized by immune inflammatory activation. There is an elevation in the serum TNF-$\alpha$ concentration and this is associated with the functional class of the patient. Additionally, there is evidence that the cytokines may contribute to the progression of arteriosclerosis [18,19].

Additionally, FLVSVI is related to the brain natriuretic peptide (BNP) serum levels [20]. High concentrations of BNP are associated with a worse prognosis in the evolution of the patients suffering from congestive heart failure [20,21]. SCHENCK et al. demonstrated that the reduction of the left ventricular cavity, with a consequent reduction in the ventricular filling pressures and wall tension, diminishes the BNP serum concentrations [22].

Elimination of the use of synthetic materials to close the incision in the left ventricle with direct suturing of the walls, helps to avoid an inflammatory reaction which would happen with the use of foreign materials. Theoretically, the continuous inflammatory reaction caused by the use of synthetic materials with the continuous release of inflammatory mediators, may contribute to the accelerated evolution of the heart failure process.

This technique does not use intra-cavitary patches, virtually eliminating the akinetic areas and maximizing the reduction of the left ventricular cavity. This complies directly with Laplace's Law, where the maximized reduction of the left ventricular cavity diminishes the tension on the left ventricular wall, reducing oxygen consumption. It is important to remember that patients submitted to this technique practically did not require pharmacological or mechanical inotropic support in the postoperative period. On the contrary, the use of vasodilators, such as sodium nitroprusside, was necessary to control the heart performance and to reduce the high arterial pressures produced by the ventricle after correction.

Also with the greater closeness between the septal and remaining lateral walls, there is a better alignment of the papillary muscles of the mitral valve, minimizing coaptation failure of the cusps and the residual regurgitation.

Coronary artery bypass grafting associated with correction of the left ventricular aneurysm is essential, contributing to the clinical improvement and better survival rate of these patients. Revascularization of the anterior descending artery, even when occluded, is particularly important to revascularize viable areas of the interventricular septum, serving as a source of collateral circulation for other areas and for the control of ventricular arrhythmias originating from the transitional region. In this technique, as all the wall of the aneurysm is preserved, revascularization of the anterior descending artery is easy and completed together with the ventricular reconstruction process.

The use of the left thoracic artery for the grafting of the anterior descending artery in patients with significant ventricular dysfunction has been demonstrated to be a predictor of better functioning in the long-term follow-up of these patients [23].

The introduction of new imaging methods of the heart, such as nuclear magnetic resonance, may contribute greatly to this field, helping in the more accurate delimitation of non-contractile areas of the heart, leading to a greater precision in the restoration of the left ventricular cavity and consequently the best possible performance.

Without doubt, part of the expressed concept in this surgical reconstruction technique of the left ventricle represents a direct application of the ideas developed in the weekly works of Brazilian authors, JATENE [1] and BATISTA et al. [24].

## CONCLUSION

With the elimination of synthetic materials, this technique may contribute to an improvement of the immediate postoperative and long-term clinical results of patients submitted to left ventricular reconstruction, providing a virtually total elimination of akinetic areas of the left ventricle, maximizing the reduction of the left ventricular cavity and attenuating in the late postoperative period the chronic inflammatory reaction of the myocardium.

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