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Left ventricular aneurysmectomy with continuous beating heart: early results

Aneurismectomia de ventrículo esquerdo com o coração batendo ininterruptamente: resultados imediatos

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Abstract

Objective: **Operative mortality after left ventricle aneurysmectomy is close to 15%. Specifically for this procedure, forms of myocardial protection have been little discussed. The purpose of this study was to evaluate immediate results of left anterior ventricular aneurysmectomy using the beating heart approach.**

Method: **We performed a retrospective analysis of 34 patients who underwent a left anterior ventricular aneurysmectomy, both with and without revascularization, from January 1997 to May 2005. The series consisted of 20 males and 14 females with a mean age of 52 years-old (range: 28 to 76). All of them were operated on using cardiopulmonary bypass and normothermia; aortic cross-clamping was not used but the open-beating heart technique was. We evaluated the perioperative mortality, thromboembolic events, duration of cardiopulmonary bypass, the length of stay in intensive care unit and the use of invasive ventilatory assistance.**

Results: **There were no perioperative mortalities or thromboembolic events. The cardiopulmonary bypass time was 85 minutes (range: 25-150 minutes). Invasive ventilatory assistance was used on average for 18 hours (range: 8-96 hours) and the mean stay in the intensive unit care was 3.1 days (range: 2-14 days).**

Conclusion: **The beating heart approach constitutes a safe and efficient cardioprotective method for anterior left ventricle aneurysmectomy procedures.**

Descriptors: **Heart aneurysm. Heart arrest, induced. Myocardial ischemia. Treatment outcome.**

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Resumo

Objetivo: **O índice médio de mortalidade operatória na aneurismectomia de ventrículo esquerdo é de 15%. Formas de proteção miocárdica especificamente para este procedimento têm sido pouco discutidas. Este trabalho tem por finalidade a avaliação dos resultados imediatos do tratamento cirúrgico do aneurisma da parede anterior de ventrículo esquerdo, sob circulação extracorpórea, com o coração batendo ininterruptamente.**

Método: **Análise retrospectiva de 34 prontuários de pacientes submetidos a aneurismectomia anterior, associada ou não à revascularização do miocárdio, no período de janeiro de 1997 a maio de 2005. Foram avaliados 20 doentes do sexo masculino e 14 do sexo feminino, com média de idade de 52 anos (28 a 76 anos). Todos os pacientes foram operados sob circulação extracorpórea em normotermia, sem pinçamento aórtico, mantendo-se o coração batendo o tempo todo. Foram analisados: mortalidade perioperatória, complicações tromboembólicas, tempo de circulação extracorpórea, tempo de assistência ventilatória invasiva e permanência na Unidade de Terapia Intensiva (UTI).**

Resultados: **Não houve mortalidade perioperatória. Não observamos complicações tromboembólicas. O tempo de circulação extracorpórea foi, em média, de 85min (25-150min). O tempo de assistência ventilatória invasiva foi, em média, de 18h (8-96h) e de permanência na UTI, 3,1 dias (2- 14 dias).**

Conclusão: **A manutenção dos batimentos cardíacos pela tática de não pinçamento aórtico para proteção miocárdica constitui-se num método eficiente e seguro para aneurismectomia de parede anterior de ventrículo esquerdo.**

Descritores: **Aneurisma cardíaco. Parada cardíaca induzida. Isquemia miocárdica. Resultado de tratamento.**

INTRODUCTION

Intervention in the acute phase of myocardial infarctions with precocious reperfusion by thromboembolic therapy or angioplasty enables a reduction in mortality due to acute coronary insufficiency. Consequently, there is an increase of patients who present with complications with the evolution of chronic myocardial ischemia [1, 2]. These events mainly emerge due to congestive heart failure (CHF) and arrhythmias. There is risk of sudden death in the complex forms of ventricular arrhythmia, but there is a high morbidity seen in patients with CHF. The quality of life of these patients is compromised with limitations and even the inability to do productive activities with frequent hospitalization.

Coronary artery bypass grafting or percutaneous surgery to treat ischemic CHF must always be considered and used for patients with coronary injuries who can not be treated by other techniques. However, these alternatives are not always adequate and it is necessary to consider other kinds of intervention, specifically in patients who are refractive to pharmacologic treatment. Heart transplantation is the radical alternative for the most severe forms of CHF; it is not used in a scale proportional to the incidence of the disease due to limitations in respect to the number of available organs, selection of candidates and even the distribution of services with the necessary infrastructure to perform this procedure. Therefore, procedures to correct ventricular contraction dissynchrony such as multifocal stimulation, assistance to improve ventricular contraction such as cardiomyoplasty and interventions related to remodeling effects such as valvar insufficiency and ventricular reduction surgeries [3] are presented as alternatives to improve the ventricular function. There are also promising therapies based on genetical engineering including stem cell transplantation, which in its current state does not allow us to come to any definitive conclusions yet.

Left ventricle aneurysmectomy to reduce the ventricular chamber, aiming at correcting and even, preventing remodeling effects, is a well-accepted procedure that has been widely applied. Left ventricle aneurysms are one complication in the evolution of myocardial infarction that frequently evolves to heart failure, which is the main reason for the indication of surgery, apart from recurrent complex ventricular arrhythmias and systemic embolization. Operative mortality is very variable, with rates from 2 to 42% and a mean of 15% being reported. Myocardial dysfunction of segments not related to the aneurysm [4] is considered to be the main predictive factor.

The post-operative period can evolve with complications such as low output syndrome and so the prolonged use of vasoactive drugs or even, mechanical circulatory assistance is necessity.

In an attempt to improve results, an association with other procedures, such as coronary artery bypass grafting,

to the surgery originally described by Cooley et al. [5] in 1958 has been considered. Variations in the technique used to reconstruct the left ventricular cavity have also been described, with the aim of reestablishing the conic format of the left ventricle and, thus, to improve the ventricular function, in the short-, mid- and long-terms [3,4].

Little attention has been paid to the forms of myocardial preservation, specifically in this procedure [4,6]. When surgeries are performed on the beating heart, whether totally independent or with partial assistance of cardiopulmonary bypass (CPB) auto-regulator mechanisms of myocardial perfusion are maintained [7]. The beating heart is essential in the physiology of these mechanisms and therefore, this is the best form of myocardial preservation. Our experience in which left ventricle anterior aneurysmectomy is performed on the beating heart confirms this hypothesis. The aim of this work is to describe the immediate results of this procedure.

METHOD

A retrospective analysis of 38 patients diagnosed as having left ventricle aneurysms, in the period from January 1997 to May 2005 in the Heart Surgery Department of Santa Casa de Misericórdia de São Paulo was performed. Of these, 34 patients underwent anterior aneurysmectomy, associated with or not to coronary artery bypass grafting, with the heart beating uninterruptedly. Patients who were submitted to procedures other than aneurysmectomy and coronary artery bypass grafting in which aortic clamping was necessary, were excluded from the study. These included repair of interventricular communication (one patient), mitral valvuloplasty and aortic valvar replacement (one patient) and mitral valvar replacement (two patients).

Twenty patients were men and 14 women, with a mean age of 52 years (range: 28 to 76 years). Thirty patients had had prior myocardial infarctions, with one being submitted to a primary angioplasty with stent placement in the anterior interventricular branch, twelve months previous to the aneurysmectomy. Four patients did not have a history of myocardial infarction (Table 1). The risk factors identified were: arterial hypertension, smoking, dyslipidemia, diabetes mellitus and family history of coronary artery disease (Table 2).

The surgical indications were heart failure associated to angina, isolated heart failure; heart failure associated to angina and arrhythmia, as well as isolated arrhythmias (Table 3). The patients were evaluated in relation to the degree of CHF and classified according to the criteria of New York Heart Association (NYHA). In respect to the angina, the patients were classified according to criteria of Canadian Cardiovascular Society (CCS) (Table 4).

Table 1. Pre-operative clinical aspects

Variable	Patients
Age	28 to 76 years (Mean - 52)
Gender	
Male	20 (59%)
Female	14 (41%)
Myocardial infarction	30 (88%)
Up to 3 months	9 (30%)
3 to 12 months	12 (40%)
12 to 36 months	8 (26.5%)
5 years	1 (3.5%)
Without history of infarction	4 (12%)

Source: Patient records from the medical archiving system of Santa Casa de São Paulo

Table 2. Risk factors

Variable	Patients
Systemic hypertension	16
Smoker	15
Dyslipidemia	7
Diabetes mellitus	5
Family history of coronary artery disease	2

Source: Patient records from the medical archiving system of Santa Casa de São Paulo

Table 3. Surgical indication

Variable	Pacientes
Heart failure and angina pectoris	21
Heart failure	9
Heart failure, angina and arrhythmia	2
Arrhythmia	2
Total	34

Source: Patient records from the medical archiving system of Santa Casa de São Paulo

Table 4 Functional Class

CHD (NYHA)	Number Patients	Angina (CCS)	Number Patients
I	-	I	11
II	10	II	15
III	19	III	6
IV	5	IV	2
Total	34	Total	34

Legend: CHD – Congestive heart disease; NYHA - New York Heart Association; CCS - Canadian Cardiovascular Society.
Source: Patient records from the medical archiving system of Santa Casa de São Paulo

Thirty-three patients presented with obstructive coronary injuries with one artery involved in twelve patients, two arteries in eleven and three or more arteries in ten patients. All presented with injuries to the anterior interventricular branch. Two patients also presented with injuries to the left coronary artery trunk. One patient did not present obstructive coronary artery injuries. The mean ejection fraction was 0.40% (Range: 0.15 to 0.75). Ventriculography imaging suggested the presence of thrombi in eleven patients.

Twenty-one patients were admitted for elective surgeries. Thirteen of them arrived in the emergency department of Santa Casa, with diagnoses of acute pulmonary edema, sustained ventricular tachycardia or instable angina. These patients were operated on during the same hospitalization.

Twenty-three patients were submitted to aneurysmectomy associated to coronary artery bypass grafting, with a mean of 2.31 grafts per patient. In eleven, aneurysmectomy was performed in isolation. Intracavitary thrombi were observed in 16 patients and removed. Closure of the ventriculotomy was achieved using the linear suture technique described by Cooley et al. [5] in eight patients and concentric reduction by the technique of Jatene [8] in 26. The choice between the techniques was based exclusively on whether the intra-operative anatomical aspects observed, were more favorable to one technical procedure or the other.

The surgery consisted in anterior mediastinotomy, with lengthwise sectioning of the sternum. After opening the pericardium any adherences were identified and were carefully removed. Concomitantly to mediastinotomy, venous grafts were prepared and, when there was a possibility of revascularization of the anterior interventricular branch, the left internal thoracic artery was dissected and prepared.

In all cases of coronary artery bypass grafting associated to the aneurysmectomy, after graft preparation, the proximal anastomoses were performed. Distal anastomoses were performed without CPB support with the utilization of an intracoronary shunt (Rivetti & Levinson®) [9]. When the anastomoses were concluded, CPB was established.

In the 34 patients operated on under CPB with perfusion of the ascending aorta and venous drainage by cannulation of the vena cavas through the right atrium, normothermia was maintained and the aneurysm was approached and treated without aortic clamping, taking care of maintaining the heart beating continuously. When ventricular fibrillation occurred, electrical defibrillation was used. Ventriculotomy was performed in the region of the aneurysm and after identifying the thrombi, careful dissection was performed. If the interventricular septum was involved, plicature was performed. Subsequently, depending on the anatomical aspects observed, closure of the ventriculotomy was performed through concentric reduction of the orifice or linear sutures.

After finishing the principal procedures, the left atrial pressure was monitored and weaning from CPB was initiated utilizing vasoactive drugs and intra-aortic balloon support when necessary.

Data related to peri-operative mortality, that is, up to the 30th post-operative day and thromboembolic complications were analysed. Times of CPB, invasive ventilatory assistance and ICU stay were recorded.

This study was submitted for the approval of the Research Ethics Committee and the Scientific Commission of the Surgery Department of the Medical School in Santa Casa de São Paulo. The confidentiality of the medical information contained in patients' hospital records was duly observed.

RESULTS

Immediate mortality and thromboembolic complications

There were no deaths up to the 30th post-operative day. One patient required mechanical circulatory assistance using an intra-aortic balloon pump for 24 hours; two patients presented with vasoplegic syndrome and one of these, due to coagulopathy required a surgical re-intervention. One patient developed with a mental disorder and psychomotor agitation over a 48-hour period. Two patients developed with pulmonary infection. The mean time of hospitalization was twelve days. Thrombi were evidenced in the aneurysmatic region in 16 patients. Symptoms or clinical signs of systemic thromboembolism were not identified in any of the 34 patients.

Times of CPB, mechanical ventilatory assistance and ICU stay

The mean time of CPB was 85.9 minutes (Range: 25 to 150 minutes). Vasoactive drugs were necessary during removal of CPB in 18 patients. The mean time of mechanical ventilatory assistance was 18 hours (Range: 8 to 96 hours) and mean ICU stay was 3.1 days (Range: 2 to 14 days).

DISCUSSION

The alternative of surgical treatment for patients with heart failure has been discussed very much but it remains a challenge.

To analyze the benefits of the left ventricular (LV) aneurysmectomy it is necessary to understand the natural history and the hemodynamical characteristics of these patients in the setting of ischemic heart disease. Both mortality and morbidity are related to the presence of the aneurysm, but are aggravated by the evolution of

obstructive heart disease, whether due to chronic ischemia or to the recurrence of ischemic episodes [10]. In spite of interventions in the acute phase of myocardial infarction, by means of thrombolytic treatment or primary angioplasty, as seen with one of the patients, a reduction in its incidence was not observed [11, 12].

The main surgical indication in this study is isolated heart failure associated with symptoms of coronary insufficiency or arrhythmia. Thirty-two (94%) of the 34 patients presented in a clinical state compatible with CHF with 24 (70.5%) of them in classes III and IV; therefore, they had a high risk of mortality. The risk was aggravated in two patients who also presented with arrhythmias, which, even in isolation, is always a severe complication.

The association of coronary artery bypass grafting plays an important role in the operative results, specifically revascularization of the anterior interventricular branch [4]. Twenty-three of 34 patients were submitted to coronary artery bypass grafting, 22 were suffering from pectoris angina and one patient, even though it was not evidence, presented critical injuries to arteries unable to be revascularized. Coronary artery bypass grafting of the anterior interventricular branch was possible in 19 of the 23 patients. In four patients, this artery was not revascularized due to its bad bed that did not allow adequate anastomoses to be performed; in these patients other arteries that presented with severe obstructive injuries were revascularized. The bad bed of the anterior interventricular branch and the absence of severe injuries in other arteries were the factors that determined that no coronary artery bypass grafting was made in nine patients. One patient who was not submitted to revascularization did not presented severe obstructive coronary injury and another patient without critical injuries was submitted to primary angioplasty with the placement of a stent in the anterior interventricular branch.

Another surgical aspect is related to the concept of ventricular reconstruction. With the aim of reestablishing the conic format of the left ventricle, variations in the technique described by Cooley et al. [5] started to be considered [8,13,14]. A particularity of the technique described by Jatene [8] is the maintenance of the heart beating during the procedure in order to define regions that present contractility by palpation of the LV wall and not only by visual criteria, so as not to resect them with the aneurysm.

Prior to Jatene's report [8], authors who performed left ventricle aneurysmectomy without aortic clamping were found, but with a different objective: not to cause ischemia of the myocardium. Operative mortality rates of up to 2% [4] were reported. Other authors mentioned the strategy of not clamping the aorta and closure of the ventriculotomy by linear sutures, also with low operative mortality rates [15].

Rivera & Delcan [16] demonstrated a highly significant difference in their results relating to left ventricle aneurysmectomy when they changed from continuous aortic clamping to no clamping of the aorta. The consequence was a drop in operative mortality from 45% to 5%.

In the current report, there were no operative deaths. In an earlier study, that included patients operated on with the use of cardioplegia for the preservation of the myocardium, a mortality rate of 12.5% was observed. The deaths occurred exclusively in a group operated on using cardioplegia [17]. For coronary artery bypass grafting, we associated the technique described by Rivetti & Gandra [8] of off-pump coronary artery bypass grafting using an intra-coronary shunt. Thus, ischemia was totally avoided and CPB was only necessary during the treatment of the aneurysm. To initially perform coronary artery bypass grafting and after to treat the aneurysm, does not interfere in the technical aspects of aneurysmectomy.

Different authors referring to the total aortic clamping technique, imposing the heart to anoxic arrest, questioned how much injury this procedure would cause to a myocardium whose functioning is severely compromised [7,17,18].

Ellefteriades et al. [19], in a multifactorial and multicentric analysis, specifically concerning with the myocardial preservation technique, highlighted the experience of Toronto, in which the procedure was performed without aortic clamping, with operative mortality of 3%.

Buckberg [20] reported keeping the heart beating as a form of preservation of the myocardium in patients with an ejection fraction of less than 20%. He observed a good hemodynamical performance, the minimum use of vasoactive drugs and that mechanical circulatory assistance was not necessary in any of the patients. He stressed that, with this tactic, the operative mortality could be reduced mainly in patients with much reduced ventricular function. Sakamoto et al. [7] considered that by keeping the heart beating a better hemodynamic performance is obtained because there is no subendocardial ischemia. With the heart open and decompressed the metabolic demands are reduced to a minimum. Additionally, in the normal heart cycle, each beat alternates between open and closed vessels. With the heart arrested, this alternation is lost and even if continuous cardioplegia is performed, only vessels that are open will be perfused and so areas of hypoperfusion will occur. In situations of chronic ischemia, this is a strong aggravating factor for poorer myocardial function.

Thus, the use of cardioplegic solutions in aneurysmectomy does not guarantee adequate myocardial preservation. According to our results, maintaining the heart beating continuously, without the use of aortic clamping,

ensuring myocardial perfusion through coronary circulation and through coronary artery bypass grafting performed prior to aneurysmectomy, is the most adequate technique of myocardial preservation. We believe that any degree of aggression imposed on a myocardium that is working at its functional limit may be a definitive factor in its lack of recovery.

An additional benefit of keeping the heart beating was to enable the safe evaluation of akinetic areas that should be resected. Frequently we observed that in the epicardium of the akinetic regions there are areas of apparently normal muscle intermingled with fibrotic regions. This is the result of interventions in the acute phase of myocardial infarction, either due to thrombolysis or angioplasty, in which the reperfusion was efficient only to partially preserve the epimyocardium in a heterogeneous manner. In this situation, different to what occurs when there is scaring reduction due to transmural necrosis, this region does not intussuscept at the moment of decompression of the heart chambers under CPB. With the maintenance of the heart beats, observation of the endocardium after the ventriculotomy and palpation of the ventricular walls, may safely define the site of the sutures. On the contrary to Maxey et al. [21], we did not consider that the heart beats made suturing more complex. Studies on linear reconstruction and geometric reconstruction techniques did not definitely prove one to be better than the other [22]. Thus, from the resulting aspect after the resection, in an attempt to reestablish the conic format of the left ventricular, the most satisfactory technique to close the ventriculotomy was defined for each patient.

The presence of mural thrombi in the left ventricle aneurysm is very common. In this study they were found in 16 patients. In spite of initial works based on autopsies having demonstrated a high prevalence of thrombi and suggested a high prevalence of systemic embolization, thromboembolism was not so frequent and care should be taken in indicating surgery only with the aim of preventing embolic events. The low probability of systemic embolization is due to the fact that, in most cases, the thrombi are found organized and firmly adhered to the wall. In our patients these characteristics were observed. There was no difficulty to perform the dissection and this was not a worrying factor to resort to aortic clamping. There are authors who perform aortic clamping to dissect and remove thrombi, releasing the clamping to the end of this procedure [8]. We do not believe that the presence of a thrombus is always indicative factor for aortic clamping. Among the post-operative complications, there were no cases of systemic thromboembolism or any embolic event.

It has been more than two-hundred years that physicians are concerned about left ventricle aneurysms. In its surgical treatment, the intra and the immediate post-operative periods are considered the most critical periods, with hospital mortality rates from 2% to 45% [4]. The worse surgical results are seen with the association of mitral valve replacement or the closure of interventricular communications to the aneurysmectomy [4]. Severely ill patients, due to the degree of advanced CHF, severely compromised ventricular function with great diskinetic or akinetic areas, have benefited from anterior aneurysmectomy [14,15,20,23,24], instead of being referred for heart transplantation. The associations of coronary artery bypass grafting and good ejection fractions of the contractile segments of the left ventricle are described as predictive factors of better results [4, 16, 25]. In our opinion, techniques of myocardial preservation such as the alternative described in our experience without aortic clamping and with the heart beating continuously are fundamental in this analysis.

REFERENCES

1. Buckberg GD. Early and late results of left ventricular reconstruction in thin-walled chambers: is this our patient population? J Thorac Cardiovasc Surg. 2004;128(1):21-6.

2. Athanasuleas CL, Buckberg GD, Menicanti L, Gharib M. RESTORE Group. Optimizing ventricular shape in anterior restoration. Semin Thorac Cardiovasc Surg. 2001;13(4):459-67.

3. Buckberg GD, Coghlan HC, Torrent-Guasp F. The structure and function of the helical heart and its buttress wrapping. VI. Geometric concepts of heart failure and use for structural correction. Semin Thorac Cardiovasc Surg. 2001;13(4):386-401.

4. Campagnucci VP. Aneurisma do ventrículo esquerdo pós-infarto do miocárdio. Análise crítica do tratamento cirúrgico. Revisão da Literatura. [Dissertação de Mestrado]. São Paulo: Faculdade de Ciências Médicas da Santa Casa de São Paulo, 1999. 134p.

5. Cooley DA, Collins HA, Morris Jr GC, Chapman DW. Ventricular aneurysm after myocardial infarction: surgical excision with use of temporary cardiopulmonary bypass. JAMA. 1958;167(5):557-60.

6. Buckberg GD. Overview: procedure versus protection: an impossible separation. Seminar Thorac Cardiovasc Surg. 2001;13(1):29-32.

7. Sakamoto Y, Mizuno A, Buckberg GD, Baretti R, Child JS, Fonarrow G. Restoring the remodeled enlarged left ventricle: experimental benefits of in vivo porcine cardioreduction in the beating open heart. J Card Surg. 1998;13(6):429-39.

8. Jatene AD. Left ventricular aneurysmectomy: resection or reconstruction. J Thorac Cardiovasc Surg. 1985;89(3):321-31.

9. Rivetti LA, Gandra SM. Initial experience using an intraluminal shunt during revascularization of the beating heart. Ann Thorac Surg. 1997;63(6):1742-7.

10. Pasini S, Gagliardotto P, Punta G, Del Ponte S, Serra M, Parisi F, et al. Early and late results after surgical therapy of postinfarction left ventricular aneurysm. J Cardiovasc Surg. 1998;39(2):209-15.

11. Athanasuleas CL, Stanley AW, Buckberg GD, Dor V, Di Donato M, Siler W, and the RESTORE Group. Surgical Anterior Ventricular Endocardial Restoration (SAVER) for dilated ischemic cardiomyopathy. Semin Thorac Cardiovasc Surg. 2001;13(4):448-58.

12. Tikiz H, Balbay Y, Atak R, Terzi T, Genç Y, Kütük E. The effect of thrombolytic therapy on left ventricular aneurysm formation in acute myocardial infarction: relationship to successful reperfusion and vessel patency. Clin Cardiol. 2001;24(10):656-62.

13. Dor V, Saab M, Coste P, Kornaszewska M, Montiglio F. Left ventricular aneurysm: a new surgical approach. Thorac Cardiovasc Surg. 1989;37(1):11-9.

14. Braile DM, Mustafá RM, Santos JLV, Ardito RV, Zaiantchick M, Coelho WMC et al. Correção da geometria do ventrículo esquerdo com prótese semi-rígida de pericárdio bovino. Rev Bras Cir Cardiovasc. 1991;6(2):109-15.

15. Mickleborough LL. Left ventricular reconstruction for ischemic cardiomyopathy. Semin Thorac Cardiovasc Surg. 2002;14(2):144-9.

16. Rivera R, Delcan JL. Factors influencing better results in operation for postinfarction ventricular aneurysms. Ann Thorac Surg. 1979;27(5):445-50.

17. Campagnucci VP. Preservação do miocárdio na aneurismectomia de ventrículo esquerdo pós-infarto do miocárdio: cardioplegia versus coração batendo ininterruptamente. Análise dos resultados imediatos [Tese de doutorado]. São Paulo: Faculdade de Ciências Médicas da Santa Casa de São Paulo, 2003. 132p.

18. Beyersdorf F, Doenst T, Athanasuleas C, Suma H, Buckberg GD. The beating open heart for rebuilding ventricular geometry during surgical anterior restoration. Semin Thorac Cardiovasc Surg. 2001;13(1):42-51.

19. Elefteriades JA, Solomon LW, Mickleborough LL, Cooley DA. Left ventricular aneurysmectomy in advanced left ventricular dysfunction. Cardiol Clin. 1995;13(1):59-72.

20. Buckberg GD. Commonality of ischemic and dilated cardiomyopathy: Laplace and ventricular restoration. J Card Surg. 1999;14(1):53-9.

21. Maxey TS, Reece TB, Ellman PI, Kern JA, Tribble CG, Kron IL. The beating heart approach is not necessary for the Dor procedure. Ann Thorac Surg. 2003;76(5):1571-5.

22. Vicol C, Rupp G, Fischer S, Summer C, Dietrich Bolte H, Struck E. Linear repair versus ventricular reconstruction for treatment of left ventricular aneurysm: a 10-year experience. J Cardiovasc Surg. 1998;39(4):461-7.

23. Di Donato M, Sabatier M, Dor V, Toso A, Maioli M, Fantini F. Akinetic versus dyskinetic postinfarction scar: relation to surgical outcome in patients undergoing endoventricular circular patch plasty repair. J Am Coll Cardiol. 1997;29(7):1569-75.

24. Dor V & Di Donato M. Ventricular remodeling in coronary artery disease. Curr Opin Cardiol. 1997;12(6):533-7.

25. Dinkhuysen JJ, Santos M, Souza LCB, Chaccur P, Abdulmassih Neto C, Arnoni AS et al. Resultados imediatos e tardios da correção do aneurisma do ventrículo esquerdo. Rev Bras Cir Cardiovasc. 1993;8(3):225-36.