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# Pericardium closure after heart operations: a safe option?

## *Fechamento primário do pericárdio em cirurgia cardíaca: uma opção segura?*

Carlos Eduardo Pereira DANTAS[1], Mauro Paes Leme de SÁ[2], Eduardo Sergio BASTOS[3], Monica M.F. MAGNANINI[4]

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***Abstract***

***Objectives:*** **The primary closure of the pericardium may reduce the risk of cardiac injury during reoperation, especially the right ventricle, aorta and coronary bypass grafts. Nevertheless, concern about adverse hemodynamic effects prevents most heart surgeons of closing the pericardium.**

***Methods:*** **We evaluated 30 patients undergoing open heart surgery consecutively who had the pericardium primarily closed, named (group A) and 18 patients, as a control group (group B) in which the pericardium was left open. All patients underwent posteroanterior and lateral chest roentgenograms before surgery and one week postoperatively. Postoperative evaluation also included echocardiograms, ECG and postoperative enzyme analysis.**

***Results:*** **There were no deaths or any complications in none of the groups (acute myocardial infarction, stroke, bleeding or cardiac tamponate). We observed statistical differences between both groups especially in echocardiogram parameters and cardiothoracic ratio without clinical impact.**

***Conclusion:*** **The primary closure of the pericardium is a simple method to facilitate resternotomy during subsequent reoperative procedures. However, cardiac surgeons should be aware of the transient deterioration in hemodynamics associated with it, even thought there was no clinical significance in this study.**

***Descriptors:*** **Pericardium. General surgery. Cardiac surgical procedures.**

***Resumo***

***Objetivo:*** **O fechamento primário do pericárdio pode reduzir o índice de lesão cardíaca durante as reoperações, principalmente do ventrículo direito, vasos da base e enxertos coronarianos. No entanto, a preocupação com as repercussões hemodinâmicas tem evitado a utilização da técnica por grande parte dos cirurgiões.**

***Métodos:*** **Foram estudados trinta pacientes operados consecutivamente que tiveram o pericárdio fechado primariamente, denominados Grupo A. O grupo controle, Grupo B, sem o fechamento do pericárdio, foi constituído de outros 18 pacientes. Foram avaliados: telerradiografia de tórax, eletrocardiograma, ecocardiograma e dosagem de enzimas cardíacas (somente no caso de revascularização do miocárdio), todos os exames, tanto pré quanto pós-operatórios.**

***Resultados:*** **Os pacientes operados, apesar de considerados de baixo risco cirúrgico, não apresentaram complicações (infarto agudo do miocárdio, AVC, sangramento ou tamponamento cardíaco). Foram observadas diferenças estatisticamente significativas entre os grupos, principalmente nos parâmetros do ecocardiograma e no índice cardiotorácico, sem repercussão clínica.**

***Conclusão:*** **O fechamento primário do pericárdio mostrou-se uma técnica simples para facilitar e reentrada no mediastino em uma reoperação. Contudo, é necessário observar as possíveis alterações hemodinâmicas inerentes ao método, embora nesta série não tenha apresentado repercussão clínica.**

***Descritores:*** **Pericárdio. Cirurgia geral. Procedimentos cirúrgicos cardíacos.**

1. Cardiovascular Surgeon; Specialist Certification from SBCCV.
2. Member of SBCCV, Chief of Cardiovascular Surgery Dept. at HUCFF UFRJ, Chief of Cardiovascular Surgery Dept. at HC Mario Lioni.
3. Member of SBCCV, Professor of Cardiovascular Surgery at HUCFF UFRJ; Surgeon of the Cardiovascular Surgery Dept. at HUCFF UFRJ.
4. Statistics from the Institute for Studies in Public Health - UFRJ.

Work performed at Hospital de Clínicas Mario Lioni - Amil, Rio de Janeiro, Brazil.

Correspondence address:
Carlos Eduardo Pereira Dantas
Av. Marechal Câmara, 160 sala 521 – Centro – Rio de Janeiro, RJ, Brazil – CEP: 20020-080.
E-mail: cadu.dantas@globo.com

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## INTRODUCTION

Routinely in most patients undergoing any cardiac surgery, the pericardial sac is left open by the belief in lower incidence of postoperative cardiac tamponade [1]. The vast majority of cardiac surgery services in Brazil and abroad only partially close the pericardium, the cranial portion above the descending aorta, which remains fully open after cardiovascular operations. Some studies, however, suggest the closure of the pericardium as an important measure for prevention of reentry injuries or cardiac reoperations [2-4].

The need for reoperation, either for coronary artery disease, valvular or aortic diseases, is increasing steadily [5]. During a sternotomy reintervention, the risk of injury to mediastinal structures, primarily the right ventricle and great vessels of the heart, is greater when it leaves the pericardium opened in the first surgery, due to the formation of firm adhesions between the right ventricle and the posterior side of the sternum [6-8].

Different techniques for protecting the structures most susceptible to injury from a re-sternotomy were suggested. Among the most relevant is the primary closure of the pericardium with interrupted continuous stitches with Vicryl® 2-0 [9], the use of synthetic fabrics, using screen PTFE [10] and membranes of bio-absorbable materials or autologous pericardium [11] with the aim of reducing the reactions that culminate in the formation of adhesions. Recently, Daroz et al. [12] suggested in an article published in the Brazilian Journal of Cardiovascular Surgery, the use of CMC as an agent for preventing adhesions following sternotomy.

The aim of this paper is to describe the experience of the Department HCML/Amil in primary closure of the pericardium, without hemodynamic compromise or other complications such as tamponade, severe pericardial effusion in the late postoperative or impairment of coronary grafts; and compare it with a control group.

This study was approved by the Research Ethics Committee of the Hospitals of Amil / Esho Network and a written consent was obtained from patients or their guardians.

## METHODS

We evaluated 48 consecutive patients who underwent coronary artery bypass grafting with cardiopulmonary bypass, with single or multiple valve surgery and isolate ascending aorta surgeries.

Separated into two groups, group A contained 30 patients, and the pericardium was closed according to the technique described below, in group B with 18 patients, the pericardium was closed only in the cranial area above the aorta, as a measure of protection of saphenous vein grafts anastomosed to the aorta against the drain placed in the anterior mediastinum.

The mean age of patients in group A was 62.54 ± 9.96 years and the control group, group B, 59.6 ± 10.7 years. The difference between the mean ages of the two groups was not statistically significant (Student's t test, $P = 0.359$). There was also no difference in gender distribution (chi-square test, $P = 0.821$).

The technique employed for primary closure of the pericardium is as follows: after sternotomy, the pericardium is opened in the classic form of inverted "T" from its portion near the aortic arch to the diaphragm, which is maintained fixed and pulled aside to the drapes or anterior surface of the sternum, to avoid its retraction resulting from dehydration. Only near the time of sternotomy, the stitches of contention are removed and the pericardium sutured with a continuous or intermittent stitches from the most cranial portion, where the remnants of the thymus are included, until its most caudal portion, along the diaphragm, keeping only two small openings parallel to the diaphragm of approximately 2 cm to 3 cm.

In cases where it is intended as a probable reoperation, we use a nonabsorbable suture (Mersilene® or Ethibond®) to guide the re-opening of the pericardium in the future re-intervention. Whenever a possible reintervention is not intended, we use the long-term absorbable suture such as Catgut®.

Drainage of the thoracic cavity is performed in cases of valve replacement, thoracic aortic surgery and some cases of bypass, where the left pleura is kept full, with a single drain placed in the anterior mediastinum after the closure of the pericardium. In other cases of revascularization (in which the pleura is left open for better placement of the pedicle of the internal thoracic artery), two chest tubes are positioned, one in the anterior mediastinum and the second at the right midclavicular line obliquely beneath the first drain introduced to the posterior region of the left hemithorax parallel to the diaphragm.

In cases of use of both thoracic arteries, the pericardium is closed in the same way, and only the right internal thoracic artery, always skeletonized, passed through a small opening in the pericardium behind the superior vena cava.

The supplementary exams used as evaluation parameters in all patients included thorax teleradiography, performed preoperatively and at six days after surgery in the posterior-anterior (PA) incidences and profile, thus, obtaining the cardiothoracic index (CTI) pre-and postoperatively, to analyze the geometry of the cardiopulmonary system.

Electrocardiogram before and after the operation, one on admission and another on the first day after surgery, still in the Intensive Care Unit (ICU) for analysis of changes that indicate myocardial ischemia.

Through unilateral or two-dimensional echocardiograms with color Doppler, performed by two independent observers in a unit Phillips Envisor C HD, USA, information was obtained as pericardial effusion, cavity diameters and global and segmental functions of the left ventricle pre- and post- operatively.

Biochemical evaluation was performed by markers of myocardial injury, CPK, MB fraction and troponin T postoperatively with dosages at admission to the ICU (0h) in 6h and 12h after surgery only in patients undergoing coronary artery bypass grafting (CABG) in group A, 21 patients and group B, 10 patients. The diagnosis of perioperative myocardial infarction was considered when values were equal or exceeding five times the normal values for CK, MB fraction (normal reference value 0-25) and ten to twenty times the values of troponin T (normal reference value of 0 to 0.10).

Continuous variables are expressed as mean and standard deviation (SD). For comparison of mean values, we used the Student's t test for paired and independent samples. For comparison of proportions, we used the chi-square test. Statistical analysis was performed with STATA 10 software (*Data Analysis and Statistical Software, Texas, USA*).

## RESULTS

Among the 48 patients analyzed, all had evolution with no major complications postoperatively (acute myocardial infarction, stroke, cardiac tamponade or low output syndrome). In this series, there was no need for exploratory mediastinostomy for homeostasis revision and the patients remained, on average, 48 hours in the intensive care unit and another 4 days in a room or ward. All patients were discharged clinically stable and asymptomatic.

Table 1 shows the comparison between the preoperative and postoperative means of groups A and B, as well as comparisons of the mean differences of these measures between groups.

Regarding the radiological tests performed preoperatively and on the sixth postoperative day, there was a difference in the cardiothoracic index (CTI) pre-and postoperatively, even with routine closure of the pericardium (group A). The preoperative CTI was 47.54 ± 1.6 mm, while the post-operative period was 54.77 ± 2.6 mm, the difference being significant ($P$ <0.0001, Student's t test). Clinically, there was no greater incidence of attrition or pericardial effusion in the immediate postoperative period. In group B, the pre-operative CTI was 48.33 ± 1.7 mm, and after surgery these values were 60.88 ± 2.5 mm ($P$ <0.0001 Student's t test). The mean increase in CTI was significantly higher in patients in whom the pericardium was left open, group B, as it was expected (Student's t test, $P$ <0.0001).

The electrocardiographic evaluation also showed no appearance of ST segment changes, signs of low voltage or conducting system changes suggesting myocardial ischemia. All ECGs were recorded and stored in medical records and were performed on admission in the postoperative ICU and before discharge.

The enzymatic evaluation performed in patients undergoing CABG in group A at admission to the ICU, 6 and 12 hours later revealed the following values of creatinophosphokinase MB fraction (CPK-MB) and troponin T: CKMB admission: 22.8 ± 5.5, CKMB 6 hours: 58.13 ± 13.12 and CKMB 12 hours: 47 ± 11.13, while troponin T was 0.95 ± 0.04 at admission, 1.06 ± 0.14 in 6 hours and 1.4 ± 0.2 in 12 hours of postoperative evaluation. None of these results was considered significant for diagnosis of postoperative infarction. In the control group, group B, there was also no enzyme changes worth noting: CKMB

Table 1. Comparison of mean values (SD) of cardiothoracic index according to group

| Index | Group A (n=30) | | | Group B (n=18) | | | Mean differences (post – pre) | | |
|---|---|---|---|---|---|---|---|---|---|
| Cardiothoracic | Pre | Post | *P*-value* | Pre | Post | p-value* | Group A | Group B | *P*-value** |
| CTI | 47.54 (1.63) | 54.77 (2.60) | <0.0001 | 48.30 (1.71) | 60.89 (2.59) | <0.0001 | 7.23 (1.50) | 12.56 (1.50) | <0.0001 |
| EF | 63.35 (10.38) | 62.50 (11.37) | 0.0120 | 60.89 (9.14) | 62.83 (8.60) | 0.0001 | -0.85 (1.59) | 1.94 (1.66) | <0.0001 |
| LVd | 54.27 (4.83) | 53.23 (5.32) | 0.0001 | 51.33 (4.00) | 53.44 (4.10) | <0.0001 | -1.04 (1.11) | 2.11 (0.90) | <0.0001 |
| LVs | 35.04 (5.65) | 34.15 (6.25) | 0.0818 | 35.22 (2.86) | 37.39 (2.77) | <0.0001 | -0.88 (2.49) | 2.17 (1.04) | <0.0001 |
| RV | 16.73 (3.24) | 15.65 (3.64) | <0.0001 | 16.44 (4.15) | 17.94 (4.26) | <0.0001 | -1.08 (0.98) | 1.50 (0.62) | <0.0001 |

** Paired Student's t test. ** Student's t test*

on admission: 23.2 ± 1.5, 6 hours: 60.9 ± 3.4, 12 hours: 47.5 ± 2.9 and troponin T on admission: 0.2 ± 0.01, 6 hours: 1.09 ± 0.05 and 12 hours: 1.57 ± 0.08.

Echocardiographic evaluation of the Group A revealed no significant difference in measured of left ventricle at end-systole (LVs) mean postoperative 34.15 ± 6.2 mm compared to LVs preoperative 35.04 ± 5.64 ($P$ = 0.08). However, in Group B, the LVs mean postoperative was 37.38 ± 2.76 mm and the preoperative was 35.22 ± 2.86 mm. This difference was significant ($P$ <0.0001). When comparing the differences of LVs postoperatively between groups A and B, this difference was also significant (Student's t test, $P$ = 0.0001).

There was also reduction of left ventricular end-diastole (LVd) in patients with closed pericardium (group A), and the mean postoperative LVd 53.23 ± 5.32 mm compared to preoperative LVd, mean pre-operative 54.26 ± 4.83 mm. In the control group (group B), the mean preoperative LVd was 51.33 ± 4.0 mm and the postoperative LVd was 53.44 ± 4.1 mm. This difference was significant (Student's t test, $P$ = 0.00001) as well as the difference between the two groups.

The mean ejection fraction (EF) preoperatively was 63.34 ± 10.38%, while the mean postoperative EF was 62.57 ± 11.37% ($P$ = 0.012) in patients with closed pericardium, and 60.88 ± 9.13% preoperatively and 62.83 ± 8.60 mm postoperatively in the control group. EF was also altered between groups (Student's t test, $P$ = 0.0001), as shown in Table 1.

There was variation in the measurements of the right ventricle (RV) in the group where the pericardium was closed. Echocardiographic measurements in group A revealed reduced right ventricular cavity. The preoperative RV 16.73 ± 3.24 mm and the postoperative RV 15.65 ± 3.63 mm ($P$ = 0.00012). Group B, open pericardium, revealed preoperative RV 16.44 ± 4.15 mm and postoperative RV 17.94 ± 4.26 mm, considered statistically significant (paired t test, $P$ = 0.00001). The mean differences of the right ventricular cavity between the two groups was also significant (Student's t test, $P$ = 0.0001).

## DISCUSSION

Although the small number of patients, the result confirms the findings of studies that suggest the advantage of protecting the mediastinal structures for an eventual second intervention by the same approach [9-11]. In this study, we used the patients own pericardium, closed with continuous stitches, giving such protection without adding additional costs and without comorbidities. Since 2000, after the observation and publication of this routine by Rao et al. [9], we now routinely close the pericardium of patients.

We observed no significant pericardial effusion in all patients, as well as no changes in segmental contractility in patients undergoing coronary artery bypass grafting, suggesting no impairment of coronary grafts by compression or bending, a concern with the closure of the pericardium.

Patients with abnormal coagulation and severe lung disease had the left internal thoracic artery skeletonized and, where possible, maintenance of the integrity of the left pleura. Revascularized patients with bilateral thoracic arteries were skeletonized and they were always placed inside the pericardial sac to avoid possible injury in interventions.

Evaluations with the use of unidimensional and bidimensional echocardiography with Doppler, preoperatively and postoperatively, showed a reduction in systolic and diastolic dimensions, with little or no effect regarding global and/or segmental function of the left ventricle. We ratified the findings of previous studies with per-operative assessment [9,14], which prove to be discrete the main hemodynamic changes after closure of the pericardium, whether the slight reduction in blood pressure and systolic output, without changes significant changes in heart rate.

Regarding the left ventricular function, it should be emphasized that other studies [9,14] also showed slight and immediate worsening in the hemodynamic parameters, especially the global function, systolic output and cardiac index, which seems to be well tolerated in patients with good ventricular function, but casts doubt on the applicability of the technique in subjects with severe dysfunction. Although patients observed here showed good LV function, the technique has been employed by the group in all patients, including those with severe dysfunction.

Another interesting observation made by echocardiographers, although subjective, is the paradoxical septal motion of lower intensity. Since the observers involved in this study also performed echocardiograms in patients operated outside the institution, they noticed a less intense paradoxical movement of the interventricular septum, commonly found in patients without closure of the pericardium after surgery.

In comparison with the work published by Rao et al. [9], we were able to note the similarities in the results of CTI in the sixth postoperative day (54.77 mm and 54mm). In this study, there is the comparison with the value obtained from CTI of patients who have not had the pericardium closed primarily (60.88 mm and 54 ± 7mm, Student's t test, $P$ = 0.0001). The difference between groups A and B did not reveal clinical difference between them, neither with the results published by the Toronto group. Despite the small sample in this study suggesting in its content that the restoration of the pericardium continuity and, therefore, the native geometry of the heart to be an attempt to preserve

ventricular function after cardiac surgery, larger series will be needed to demonstrate that these inferences. The concept of the Toronto group that closing the pericardium, although beneficial in the long term, by preserving the structures of the mediastinum in the case of a second intervention by the same approach, may initially cause a slight worsening of LV function by limiting filling, and an improvement in RV function, for the same reason, was confirmed by data from this study.

Regarding the maintenance of LV geometry, this same concern is also shown in other studies, such as the preservation of the subvalvular apparatus in mitral valve surgeries [15], preservation of the conical shape of the LV in aneurysm surgeries in the left ventricle [16] and anastomosis between the vena cavae in heart transplants [17].

Other works were written for similar purposes. In the studies with synthetic or biological membranes, most were drawn to animals that were subjected to sternotomy and closure with biological membranes (pericardium) or synthetic polytetrafluoroethylene (PTFE), after a mean period of 3 months they were reopened and it was observed the rate of re-entry injuries and the quality of adhesion formed amid the membrane, the heart and surrounding areas. Despite the quality of these studies, we used canines or swines that were not undergoing cardiopulmonary bypass, thus had no intense systemic inflammatory reaction, less bleeding and reintervention performed in a period that does not correspond to the interventions in clinical practice. The authors report that the adhesions formed were so strong or even stronger than those observed without the presence of biological or synthetic material [11-18].

When evaluating the use of synthetic material, whether in adult or pediatric patients, there is always the concern of predisposition to more intense inflammatory reactions or even serious infections. The routine use of these techniques has never been widespread as a safe and low risk in clinical practice, which led to the development of studies aiming to use a barrier with autologous material. The use of the pericardium itself has proved to be simple and uncomplicated.

Another aspect to consider is the maintenance of anatomical integrity of the chest. Previous studies [19,20] show the benefit of diastolic containment of the ventricles, especially in patients with ventricular dysfunction, suggesting improvement in right ventricular function and synchrony between the ventricles. Moreover, it avoids the development of right ventricular dysfunction consequent to the formation of adhesions between the RV free wall and posterior surface of the sternum, also documented, confirming the benefit of the closure of the pericardium [20].

Another relevant finding was no significant association of the closure of the pericardium with the incidence of ischemic events in patients undergoing CABG, where saphenous vein grafts were used, without the occurrence of folding, early occlusion and diagnosis of myocardial infarction. In addition to the vein grafts being obtained with the technique described by Souza et al. [13.21-23] as "no touch".

## CONCLUSION

The observation of this sample confirms our impression that the primary closure of the pericardium is a safe technique for showing no complications and clinical implications in the immediate postoperative period, in addition to being an easily reproducible technique. However, there is need for further studies in cases also involving patients with severe ventricular dysfunction, which represented a limitation in this study.

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