

Ministernotomy in Myocardial Revascularization Preserves Postoperative Pulmonary Function

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Abstract

Background: In coronary artery bypass graft (CABG) surgery, the need to perform a midsternotomy has been considered a factor for the decrease in postoperative pulmonary function.

Objective: To prospectively evaluate early postoperative (PO) pulmonary function in patients submitted to off-pump CABG, comparing the conventional midsternotomy with the ministernotomy approach.

Methods: A total of 18 patients were evaluated and assigned to the two groups: Group Conventional Midsternotomy (CMS, n=10) and Group Ministernotomy (MS, n=8). Spirometric results of the forced vital capacity (FVC) and the Forced Expiratory Volume in one second (FEV1) were obtained on the 1st, 3rd and 5th PO days and the arterial gasometry was obtained before and on the 1st PO day. The pulmonary shunt percentage and the pain score were also assessed.

Results: When compared in terms of percentage of the preoperative value, the FVC was higher in the MS group than in the CMS group on the 1st, 3rd and 5th PO days ($p < 0.001$). Similar results were obtained for FEV1. The recovery of the FVC between the 1st and the 5th PO days was higher in the MS than in the CMS group ($p = 0.043$). The PaO₂ decreased on the 1st PO day in both groups ($p < 0.05$), with a higher decrease in the CMS group ($p = 0.002$). The shunt increased in the two groups on the 1st PO day ($p < 0.05$); however, it was lower in the MS group ($p = 0.02$). The reported pain score was lower and the duration of the hospital stay was shorter in the MS group.

Conclusion: Patients submitted to CABG by MS present better preservation and recovery of pulmonary function than those submitted to CMS. (Arq Bras Cardiol 2010; 95(5): 587-593)

Keywords: Sternotomy; myocardial revascularization surgery; pulmonary function; internal thoracic artery.

Introduction

With the advancement in the surgical techniques for coronary artery bypass graft (CABG) surgery, the procedure can currently be carried out in selected patients through mini-incisions, while maintaining the quality of the treatment^{1,2}. A considerable number of patients that are currently referred to CABG surgery present respiratory function impairment and, consequently, is at increased risk of developing postoperative pulmonary complications. Evidence has demonstrated that in the CABG surgery, regardless of the surgical technique employed, there is a decrease in the pulmonary function in the early postoperative period³.

The use of techniques with limited operative incisions, associated with the strategy of performing off-pump surgeries, minimizing invasiveness and surgical aggression, could potentially contribute to attenuate the detriment of

the postoperative pulmonary function^{4,5}, thus becoming a beneficial alternative to the conventional technique.

Therefore, the objective of the present study was to prospectively evaluate the pulmonary function in the early postoperative (PO) period of patients submitted to off-pump CABG surgery, by comparing the conventional midsternotomy (CMS) to the ministernotomy (MS) incision.

Methods

Patients

The present study was approved by the institutional Medical Ethics Committee. Additionally, all participants signed the Free and Informed Consent Form prior to study enrollment. The inclusion criteria were the following: patients of both sexes, with coronary artery disease (CAD) demonstrated by coronary angiography and indication of elective CABG surgery; off-pump CABG and left internal thoracic artery (LITA) graft, maintaining the left pleural cavity intact; ejection fraction > 50% and normal pulmonary function test (spirometry). The exclusion criteria included: patients unable to perform the spirometry; presence of acute or chronic pulmonary disease; patients with hemodynamic

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instability and alteration of the surgical technique in the intraoperative period.

This non-controlled trial prospectively included 18 patients, which were distributed in two groups: Group conventional midsternotomy (CMS, n=10) and Group ministernotomy (MS, n=8). The clinical and demographic characteristics of the two groups are shown in Table 1.

Pulmonary function assessment

The parameters of pulmonary function, forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV₁) were assessed in the preoperative period and on the 1st, 3rd and 5th PO days, using a portable spirometer (Spirobank G, MIR, Rome, Italy), according with the standards of the American Thoracic Society (ATS) 1995⁶. Each test was carried out in triplicate and the best value was then selected. The partial pressure of arterial oxygen (PaO₂) was determined before surgery and on the 1st PO day, in ambient air, always before the spirometry. The pulmonary shunt was calculated using a specific software (Oxygen Status Algorithm, version 2.0; Mads&Ole Siggaard; Radiometer)⁷. This program used the data from the arterial gasometry and the inspired oxygen fraction to calculate the percentage of non-oxygenated blood. On the first PO day, the subjective pain sensation was quantified using an analogical scale with a modified standard score (from zero to ten), in which zero indicated absence of pain and ten, the presence of unbearable pain⁸. This assessment was carried out at rest before the spirometry.

Operative technique

All patients were submitted to the same anesthetic technique, according to the routine of the service. The patients were ventilated to maintain normocapnia, without positive end-expiratory pressure (PEEP) and FiO₂ to maintain the

arterial oxygen saturation > 90%. Heparin was administered to maintain the activated coagulation time > 250 seconds.

The conventional CABG surgery was carried out by complete midsternotomy, off-pump, using a LITA graft dissected as a skeletonized graft, complemented with additional saphenous vein grafts (Figure 1B). The occlusion of the coronary artery was achieved by using a proximal tourniquet with 4-0 polypropylene thread, passed through a malleable silicone tube. Subsequently, depending on the graft, lateral clamping of the ascending aorta was carried out to perform the proximal anastomosis.

In the ministernotomy, the cutaneous incision started on the xiphoid appendix, between 7 and 9 cm in extension, in the cephalic direction. The xiphoid appendix and the lower part of the sternum were sectioned longitudinally, with no additional bone incision sideways (Figure 1A). The LITA was dissected from the thorax wall, with sparse use of electrocauterization, up to the vicinity of its origin at the left subclavian artery, using the skeletonization technique.

Subsequently, the pericardium was partially open longitudinally and the heart was dislocated medially, with small gauze pads placed under the lateral wall of the left ventricle (LV), exposing the anterior descending artery (ADA). A tourniquet with 4-0 polypropylene thread was applied only proximally to the coronary arteriotomy location.

The anastomosis of the LITA with the ADA was carried out with a continuous suture, employing a single 7-0 polypropylene thread, off-pump. All procedures were carried out using Octopus™ 3 stabilizers (Medtronic, Inc™) to facilitate the coronary anastomosis procedure. In both groups, the pleural cavity was maintained intact and a substernal tubular drain was left in the site, exteriorized via subxiphoid approach. Figure 2 shows the ministernotomy incision in patients in the recent and late postoperative period.

Postoperative period

At the end of the surgery, the patients were transferred to the Heart Surgery Intensive Care Unit. Initially, they were ventilated with synchronized intermittent mandatory ventilation (SIMV) of 12 to 14 breaths per minute, PEEP of 5 cmH₂O, tidal volume of 8 ml/kg of weight, pressure support to maintain this volume and FiO₂ to maintain arterial oxygen saturation > 90%. Extubation was performed with the patient hemodynamically stable and alert, while ventilation was maintained and blood gas values were kept within safety levels.

All patients received the same analgesia protocol (tramadol chlorhydrate - 100 mg four times a day), administered during the subsequent PO days and were submitted to a daily physical therapy program until hospital discharge. The time of orotracheal intubation and hospital stay duration in PO period were also observed. The drains were routinely removed on the second PO day.

Statistical analysis

The data are expressed as means ± standard deviation. The pulmonary function data (FVC, FEV₁ and PaO₂) were analyzed as expressed in percentages of the preoperative values. The variables were initially compared with the Gauss curve, using the Kolmogorov-Smirnov test (K-S distance) and classified as

Table 1 - Clinical and demographic characteristics in the preoperative period of both groups

| Variables | Group CMS (n=10) | Group MS (n=8) | P |
|-------------------------------|------------------|----------------|------|
| Age (years) | 60.10 ± 5.56 | 58.50 ± 9.40 | 0.65 |
| Sex (n) | | | |
| Female/male | 1/9 | 1/7 | 0.86 |
| BMI (kg/m ²) | 25.75 ± 1.09 | 26.81 ± 3.02 | 0.31 |
| Pulmonary function | | | |
| Absolute FVC (l) | 3.81 ± 0.64 | 3.64 ± 0.78 | 0.62 |
| % of predicted | 101.40 ± 10.24 | 99.89 ± 16.54 | 0.81 |
| Absolute FEV ₁ (l) | 3.09 ± 0.67 | 2.81 ± 0.51 | 0.35 |
| % of predicted | 103.40 ± 9.95 | 97.27 ± 16.82 | 0.36 |
| PaO ₂ (mmHg) | 78.60 ± 3.53 | 80.75 ± 3.91 | 0.23 |
| PaCO ₂ (mmHg) | 38.90 ± 3.66 | 38.50 ± 4.62 | 0.84 |

Data expressed as mean ± SD. Unpaired Student's t Test / Pearson's Chi-square Test - CMS - conventional midsternotomy; MS - ministernotomy; BMI - body mass index; FVC - forced vital capacity; FEV₁ - Forced expiratory volume in one second.; PaO₂ - Partial arterial oxygen pressure; PaCO₂ - Partial pressure of carbon dioxide. * p<0.05.

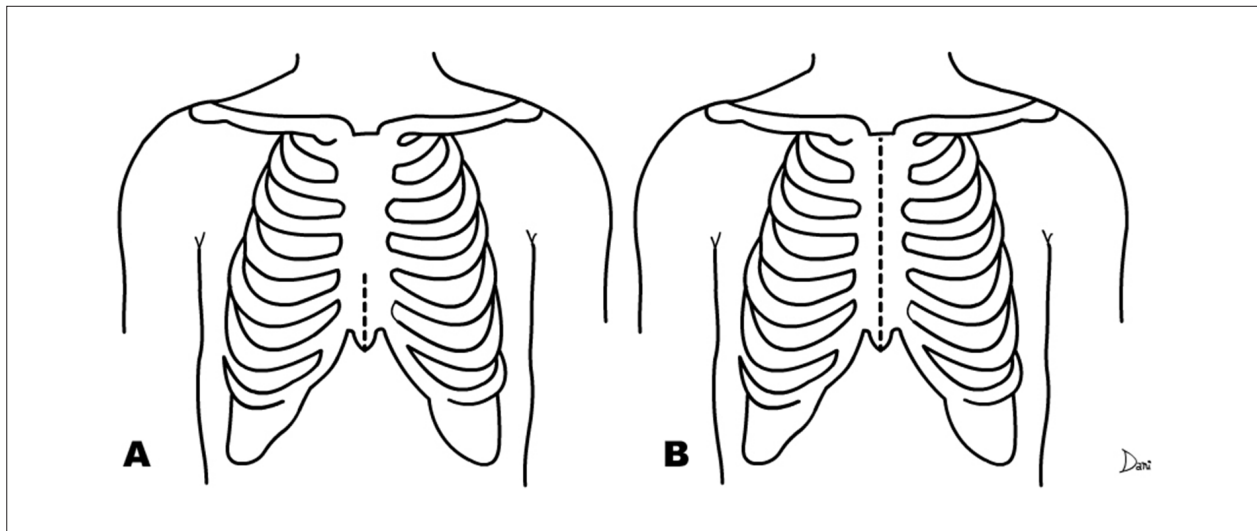


Figure 1 - Type of incision used in the procedures. A - Ministernotomy; B - Conventional midsternotomy.



Figure 2 - Patients with ministernotomy incision in the postoperative period of myocardial revascularization.

parametric or non-parametric. The categorical data were analyzed by Pearson's Chi-square test. The intragroup analysis, when comparing the preoperative versus the postoperative values, was carried out using the paired Student's *t* test and ANOVA for repeated measures. The differences between the groups were analyzed by the unpaired Student's *t* test or Mann-Whitney test, when necessary. The statistical analysis was carried out using the GraphPad Prism software release 3.0 (GraphPad Software Inc, San Diego, CA). A *p* value <0.05 was considered statistically significant.

Results

A significant decrease in FVC and FEV₁ was observed in both groups up to the 5th PO day (*p*<0.05). When compared

in percentage of the preoperative absolute value, the FVC was higher in the MS group, when compared to the CMS group on the 1st, 3rd and 5th PO days (1st PO day: 47.60 ± 7.14% vs 60.05 ± 6.34%, *p*<0.001; 3rd PO day: 60.88 ± 8.01% vs 80.21 ± 8.03%, *p*<0.001 and 5th PO day: 70.61 ± 8.79% vs 91.00 ± 6.38%, *p*<0.001). Similar results were observed for FEV₁ (1st PO day: 48.62 ± 9.23% vs 57.17 ± 8.83%, *p*<0.05; 3rd PO day: 61.05 ± 9.46% vs 78.02 ± 7.47%, *p*<0.001 and 5th PO day: 72.60 ± 10.09% vs 89.06 ± 7.70%, *p*<0.001) (Figure 3).

The recovery of the FVC between the 1st and the 5th PO days was higher in the MS group (30.9%), when compared to the CMS group (22.32%) (*p*=0.043). The PaO₂ decreased on the 1st PO day in both groups, when compared to the preoperative period (*p*<0.05), with a higher decrease in the

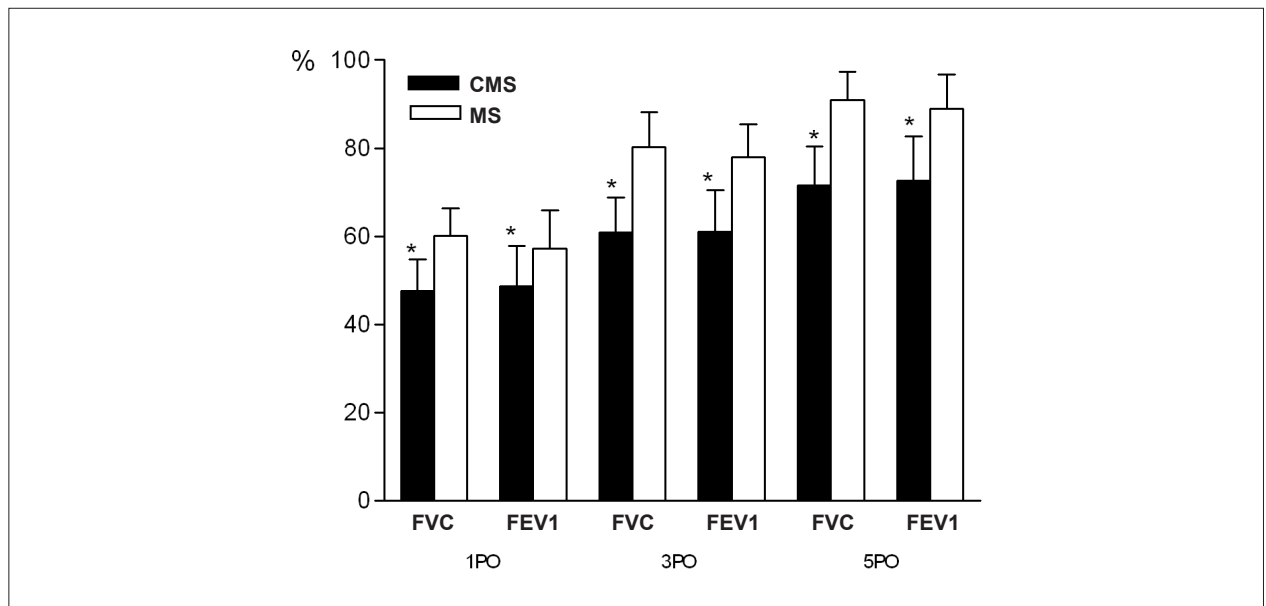


Figure 3 - Pulmonary function test results on the 1st, 3rd and 5th PO day in percentages of the preoperative values in the conventional midsternotomy and ministernotomy groups. The values of * $p < 0.05$ refer to the difference in FVC and FEV1 between the groups. (PO - postoperative; FVC - forced vital capacity; FEV1 - Forced expiratory volume in one second).

CMS group ($88.19 \pm 3.29\%$ vs $78.11 \pm 5.01\%$, $p=0.002$) (Figure 4). The shunt increased in both groups on the 1st PO day ($p < 0.05$); however, it was significantly lower in the MS group ($0.24 \pm 0.02\%$ vs $0.27 \pm 0.01\%$, $p=0.02$). The reported pain was less severe in the MS group (4.87 ± 1.12 vs 6.8 ± 1.39 , $p=0.006$). The time of orotracheal intubation (8.0 ± 0.75 vs 9.40 ± 0.96 hours, $p=0.004$) and hospital stay duration were shorter in the MS group (5.0 ± 0.53 vs 6.50 ± 1.17 days, $p=0.004$). There was no significant difference in the total time of surgery between the groups (CMS: 307.5 ± 12.75 vs MS: 305.6 ± 22.9 min; $p=0.82$). There was no change of patient from one technique to the other, regarding the treatment intention.

Discussion

The search for less invasive techniques, with a lower degree of organic aggression has been the objective of efforts by cardiovascular surgeons in the last decade. Two aspects have been especially prioritized with this purpose: smaller incisions, to limit the surgical aggression and perform off-pump surgeries, aiming at attenuating the systemic inflammatory response⁴.

The CABG surgery presents low morbidity and mortality and has safe and reliable late outcomes^{9,10}. However, the surgical aggression caused by the sternotomy and by on-pump surgeries results in longer hospital stay duration, mainly due to the PO pulmonary dysfunction¹¹.

The etiology of the significant decrease in the pulmonary function after the CABG surgery is the result of the combination of several factors, such as general anesthesia, the use of the midsternotomy, on-pump surgeries and the presence of pain^{3,11,12}. Moreover, the use of the LITA, which typically necessitates the insertion of a pleural drain, can be an adjuvant factor for PO pulmonary dysfunction¹³⁻¹⁵.

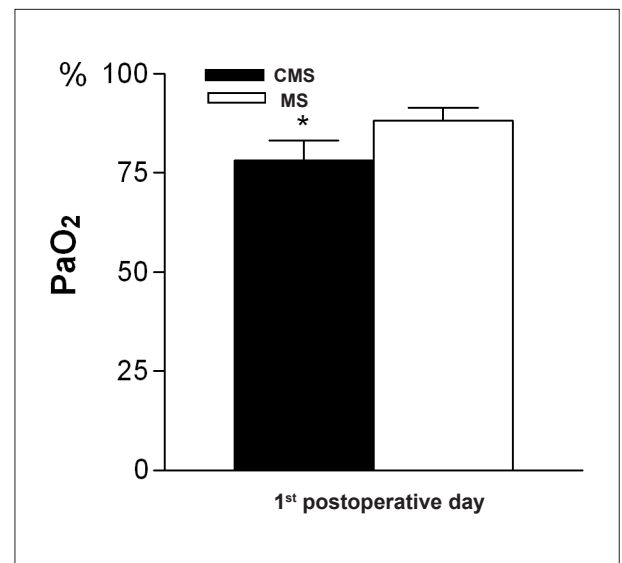


Figure 4 - Partial arterial oxygen pressure on the 1st PO day in percentages of the preoperative values in the ministernotomy and conventional midsternotomy groups. The value of * $p < 0.05$ refer to the difference between the groups. (PaO₂ - Partial arterial oxygen pressure; PO - postoperative).

The present study demonstrated that, regardless of the sternal incision, there was an evident decrease in the early PO pulmonary function in the off-pump CABG surgery, an inevitable consequence reported by previous studies, which analyzed on-pump procedures¹¹⁻¹⁴.

The spirometry variables in the present study demonstrated a significant deterioration in the FVC and FEV₁ values in both groups up to the 5th PO day. However, the patients submitted to the ministernotomy presented a significantly higher reduction

in these parameters, when compared to the sternotomy group. There was a gradual improvement in the FVC and FEV₁ values up to the 5th PO day, when the patients are usually discharged from the hospital. However, these variables did not return completely to their normal levels and remained below their preoperative values, although the levels in the MS group were closer to the preoperative values, when compared to those of the CMS group.

The increase in the FVC observed between the first and the fifth PO days was significantly higher in the ministernotomy than in the sternotomy group, which demonstrates that the ministernotomy group recovered the pulmonary function faster, probably because it presented a lower decrease in the FCV on the first PO day.

Hypoxemia, which normally occurs in the early PO period of cardiac surgery, can be the result of alveolar hypoventilation, alteration in the ventilation-perfusion ratio or decrease in the diffusion and shunt and more than one mechanism can be present at the same time¹⁶. In our study, at the oxygenation analysis, the PaO₂ showed a significant decrease in both groups on the first PO day. However, the MS group presented a lower decrease.

There was also an increase in the pulmonary shunt in both groups on the first PO day. However, the patients submitted to the ministernotomy presented a lower increase. These results demonstrate that the sternotomy had a higher negative impact on oxygenation in the early PO period, probably secondary to a higher decrease in the pulmonary volumes observed in this group.

Although abundant evidence has shown a decrease in the pulmonary function in PO period of CABG surgery¹¹⁻¹⁴, few studies had reported the influence of the dimension of the sternal incision on the pulmonary function. The important question and the objective of the study were to investigate whether the extension of the sternal incision could, alone, interfere with the pulmonary dysfunction observed in the PO period of CABG surgery. To answer this question, it was necessary to eliminate other variables that could somehow influence the decrease in the pulmonary function in the PO period.

Consequently, the protocol was designed to exclude patients with previous pulmonary diseases and ejection fraction < 50%, as these associations could contribute, direct or indirectly to the pulmonary dysfunction in the PO period^{17,18}. Moreover, all patients were submitted to the same routine of general anesthesia and the same LITA mobilization technique. Additionally, the spirometric tests were all carried out by the same physical therapist, as differences in verbal commands and stimuli given to the patients can interfere with test results.

As the results of the spirometry could also be influenced by the presence of pain in the PO period, all patients enrolled in the study received the same analgesia protocol. The patients from the MS group were patients with a single ADA lesion and received only the LITA graft revascularizing the ADA, whereas

the patients from the CMS group were multiarterial patients and were submitted to complete revascularization.

Previous studies that reported the compared influence of the sternotomy *versus* the ministernotomy on pulmonary function did not eliminate the interference of extracorporeal circulation (ECC)¹⁹. On-pump surgeries add impairment to the pulmonary function²⁰⁻²² by inducing the systemic inflammatory response syndrome (SIRS)²³. In the present study, the influence of ECC was prevented by excluding on-pump surgeries. Bauer and col. evaluated patients after on-pump CABG surgeries and when they compared the ministernotomy with the sternotomy approach, they observed that the pulmonary function (FVC and FEV₁) was similar on the fourth and tenth PO days in both groups¹⁹.

Previous studies have demonstrated that patients submitted to ministernotomy after heart surgery experienced less pain at the early postoperative period^{24,25}. In this study, the reported pain was significantly worse in patients submitted to the complete sternotomy, being associated with a decrease in pulmonary function. When the groups are compared, we observe that the ministernotomy was associated with a significant decrease in the time of orotracheal intubation and the hospitalization period, confirming previous results²⁴.

Even eliminating SIRS and the pulmonary dysfunction associated to on-pump surgeries and maintaining the pleural cavity intact, the ministernotomy resulted in a better preservation and recovery of pulmonary function, probably due to the lower trauma inflicted to the chest cavity. As a consequence, there was a shorter time of orotracheal intubation and fewer days of hospitalization were necessary. Therefore, the elimination of ECC and the limited incisions can promote a faster recovery, followed by earlier hospital discharges and potential cost-lowering implication.

Conclusion

The off-pump myocardial revascularization surgery using the LITA, regardless of the type of incision used in the procedure, showed a significant decrease in pulmonary function in the early postoperative period. However, patients submitted to the ministernotomy presented better preservation and recovery of the pulmonary function, when compared to those submitted to the midsternotomy.

Potential Conflict of Interest

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

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

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