Factors associated with pulmonary compliance in patients submitted to coronary artery bypass grafting: cross-sectional study

André Luiz Lisboa Cordeiro¹,², Adeilton Santos Santana Júnior², Lucas Landerson Souza Cruz², Sheila Christian Bastos Souza², Hayssa de Cássia Mascarenhas Barbosa¹,², André Raimundo França Guimarães³, Roberto Moreno Barros⁴

¹Escola Bahiana de Medicina e Saúde Pública, Salvador, Bahia, Brazil; ²Faculdade Nobre, Feira de Santana, Bahia, Brazil; ³Instituto Nobre de Cardiologia, Feira de Santana, Bahia, Brazil; ⁴Hospital Santo Antônio, Salvador, Bahia, Brazil

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Abstract: Background: Coronary artery bypass grafting (CABG) is one of the most studied surgical procedures worldwide and is associated with deleterious effects on respiratory function in the postoperative period, corroborating the incidence of factors that can cause a decrease in lung compliance, generating possible respiratory complications. Objective: To identify factors associated with low pulmonary compliance in patients submitted to coronary artery bypass grafting. Methods: This is a cross-sectional study. After admission to the Intensive Care Unit (ICU), the static compliance calculation was performed and the patients were divided into two groups: Low Compliance Group (LCG) and Normal Compliance Group (NCG), to verify which factors were associated with low compliance. Results: The final sample consisted of 62 patients, with male prevalence, with a mean age of 60 ± 9.5 years. Clinical variables body mass index (BMI) (P=0.04), smoking (P=0.05), chronic obstructive pulmonary disease (P < 0.001) and ejection fraction (P=0.03) were associated with reduced static pulmonary compliance. Conclusion: It is concluded that factors such as age, COPD, smoking, BMI and ejection fraction may be associated with worsening pulmonary compliance after CABG.

Keywords: Myocardial revascularization, lung compliance, post-surgical complications, physiotherapy

Introduction

Coronary artery bypass grafting (CABG) is one of the most studied medical procedures in the world, being associated with harmful effects on postoperative respiratory function and contributing to the incidence of possible and serious complications [1]. With the main objective of improving blood supply at a specific myocardial site, revascularization has been proposed to decrease adverse symptoms, improve cardiac function, increase survival and reduce the occurrence of unfavorable, larger and more prevalent situations in certain subgroups of selected patients [2].

In the postoperative period, patients undergoing cardiac surgery start to develop limited lung volumes, impaired ventilatory mechanics, pulmonary compliance deficit and increased respiratory work [3]. Postoperative pulmonary complications remain, to this day, one of the main causes of the opposite outcome after cardiac surgery and contribute significantly to morbidity and mortality, since the goal of surgery is to prolong the patient’s life, relieve symptoms and improve your functional status [4].

Importantly, pulmonary physiological change during cardiopulmonary bypass (CPB) can impair blood-brain barrier homeostasis due to alteration of the different forces affecting the parenchyma, eliminating passive diffusion gas exchange at the blood-brain barrier level, leading to problems. Ventilation-perfusion and impacting pulmonary compliance [5].

Among the pulmonary responses to the various lung-damaging factors are static and dynamic compliance changes, which are mostly reduced...
postoperatively, thus making the lungs more resilient and more difficult to ventilate, causing thus, an increase in respiratory work and a change in ventilation pattern [6].

Respiratory system compliance is established by the slope of the pressure-volume curve or the volume variation per unit of pressure change and can be measured with the patient on mechanical ventilation and under sedative effect. For its measurement, the calculation determined by dividing the tidal volume by the peak pressure minus the positive end-expiratory pressure (PEEP) is used [7].

Regarding changes in pulmonary compliance, they are directly linked to certain factors: CPB time, surgical manipulation intensity, pleural drainage numbers, surgery time and inadequate perioperative ventilation. Due to these factors, patients have a limited breathing pattern, mainly due to the incidence of pain, chest wall edema and surfactant alteration, leading to a decrease in lung capacities and volumes, a lower compliance and, therefore, an increase in the resistance of the lungs’ airways. However, certain dysfunctions may also be associated with factors present in the patient’s preoperative condition, such as age, obesity and smoking [8].

Postoperatively, there are situations related to reduced stability and static and dynamic compliance of the rib cage in the median sternotomy, exacerbated time of the supine patient and the presence of pain and drainage, which directly influence the maintenance of low pulmonary volumes [9].

Based on this information, it is possible to observe and confirm the relevance of pulmonary compliance measurement in the postoperative period of cardiac surgery, by investigating the factors that imply its decline, thus seeking effective strategies for the measurement of pulmonary compliance prevention of possible pulmonary and respiratory complications. To date, no studies have been carried out to assess the factors that contribute to the decline in complacency. This information is extremely important to outline individualized approaches for this patient profile.

The aim of this study was to observe the factors associated with low pulmonary compliance in patients undergoing coronary artery bypass grafting.

Methods

Study design

This is a cross-sectional study with a final sample of 62 patients of both sexes, conducted at the Intensive Care Unit (ICU) of the Noble Institute of Cardiology, Reference Center of Specialty in the City of Feira de Santana, State of Bahia. This study was duly approved and was filed by the Research Ethics Committee of that faculty and under Opinion No. 1,405,817, in which all participating patients signed an Informed Consent Form.

Eligibility criteria

The research consisted of adult patients, both sexes and over 18 years old, who underwent CABG via sternotomy and cardiopulmonary bypass. Exclusion criteria were emergency surgery, death during the surgical procedure, return to the operating room before 30 minutes of ICU admission, previous cardiac surgery and patient interaction with the ventilator and situations that prevented the calculation of ventilatory mechanics.

Study protocol

After surgery, the patients were referred to the ICU for anesthetic narcosis and connected to the Servo-S mechanical ventilator (Maquet Critical Care AB, Rontgenvagen, Sweden) in assisted/volume-controlled mode with a tidal volume of 8 ml/kg, respiratory rate of 15 incursions per minute, inspiratory flow corresponding to 10% of the programmed tidal volume, PEEP of 08 cmH₂O and 100% inspired oxygen fraction.

Ten minutes after admission, static compliance was calculated in the volume mode itself, offering a two-second pause at the end of inspiration and promoting a square flow wave. Static compliance calculation was performed by dividing the tidal volume by the plateau pressure subtracted from the PEEP value [5].

At this time, the patients were divided into two groups: Low Compliance Group (LCG) and Normal Compliance Group (NCG), using the compliance value according to the Brazilian Me-
Pulmonary compliance and cabg

Table 1. Representation of the clinical data analysis between the groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low Compliance Group (n=32)</th>
<th>Normal Compliance Group (n=30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>19 (59%)</td>
<td>18 (60%)</td>
<td>0,18*</td>
</tr>
<tr>
<td>Female</td>
<td>13 (41%)</td>
<td>12 (40%)</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>61 ± 7</td>
<td>59 ± 12</td>
<td>0,23k</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>27 ± 4</td>
<td>23 ± 4</td>
<td>0,04k</td>
</tr>
<tr>
<td>Comorbididades</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAH</td>
<td>24 (75%)</td>
<td>25 (83%)</td>
<td>0,75a</td>
</tr>
<tr>
<td>DM</td>
<td>19 (59%)</td>
<td>17 (57%)</td>
<td>0,55a</td>
</tr>
<tr>
<td>DLP</td>
<td>17 (53%)</td>
<td>15 (50%)</td>
<td>0,60a</td>
</tr>
<tr>
<td>Smoking</td>
<td>5 (16%)</td>
<td>1 (3%)</td>
<td>0,05a</td>
</tr>
<tr>
<td>COPD</td>
<td>4 (13%)</td>
<td>0</td>
<td>&lt; 0,001*</td>
</tr>
<tr>
<td>AMI</td>
<td>15 (47%)</td>
<td>17 (57%)</td>
<td>0,67a</td>
</tr>
<tr>
<td>EF</td>
<td></td>
<td></td>
<td>0,03a</td>
</tr>
<tr>
<td>&lt; 40%</td>
<td>25 (78%)</td>
<td>14 (47%)</td>
<td></td>
</tr>
<tr>
<td>&gt; 40%</td>
<td>7 (22%)</td>
<td>16 (53%)</td>
<td></td>
</tr>
</tbody>
</table>

*Chi-square test; *Independent Student’s t test. BMI-Body Mass Index; SAH-Systemic arterial hypertension; DM-Diabetes Mellitus; DLP-Dyslipidemia; COPD-Chronic Obstructive Pulmonary Disease; AMI-Acute myocardial infarction; EF-ejection fraction.

Results

General clinical characteristics of the sample

Throughout the study period, 62 patients were included, with male prevalence (37 patients, representing 59.7% of the evaluated universe), with a mean age of 60 ± 10 years. The average body mass index was 25 ± 4 kg/m².

Among the clinical variables analyzed, the following were significant: BMI (P=0.04), smoking (P=0.05), COPD (P < 0.001) and ejection fraction (P=0.03) associated with compliance. Respiratory system (Table 1).

General surgical characteristics of the sample

In Table 2, we have the representation of the data related to the surgical characteristics of the patients. The number of grafts was 2.5 ± 0.7, CPB time was 73.5 ± 17 min. All patients used at least one drain. Of the variables analyzed, only the CPB time was statistically significant (P=0.04). Figure 1 shows the main causes that affected lung compliance after cardiac surgery.

Discussion

In the present study, it was found that factors such as BMI, smoking, COPD, EF and CPB were permanently associated with low static compliance in the postoperative period of CABG.

It was also observed that smoking, in particular, was associated with worsening compliance, given that components with alterations in elastic and resistive load generate a decline in respiratory function, modifying the parenchyma and rib cage component. In a very relevant way, reducing pulmonary compliance, which causes a decrease in gas exchange, is influenced by comorbidities, such as pre-existing lung diseases, smoking and respiratory symptoms of changes in smoking patients.

A similar result was who pointed out the relationship of smoking as a high risk factor for the decrease of static and dynamic compliance, due to the possible picture of atelectasis or lung parenchyma injury [10]. Smoking is a pre-
Table 2. Comparison of surgical data of patients undergoing CABG between groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Low Compliance Group (n=32)</th>
<th>Normal Compliance Group (n=30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grafts Number</td>
<td>2.5 ± 0.5</td>
<td>2.4 ± 0.8</td>
<td>0.67*</td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>87 ± 20</td>
<td>60 ± 14</td>
<td>0.04*</td>
</tr>
<tr>
<td>Drain</td>
<td>2</td>
<td>1 ± 0.7</td>
<td>0.10*</td>
</tr>
<tr>
<td>Surgery time (min)</td>
<td>281 ± 44</td>
<td>232 ± 40</td>
<td>0.09*</td>
</tr>
<tr>
<td>Clamping Time (min)</td>
<td>55 ± 19</td>
<td>59 ± 22</td>
<td>0.34*</td>
</tr>
</tbody>
</table>

*Independent Student’s t test; *Mann-Whitney test. CPB-Cardiopulmonary bypass.

The duration of CPB as one of the main factors associated with the worsening of static compliance [14]. Hypoxemia is one of the main causes of pulmonary complications arising from lung injury in MV patients [15]. Several mechanisms were obtained due to its development in the postoperative period of cardiac surgery: atelectasis, increased respiratory and thoracic shunt, mechanical changes, pulmonary parenchyma, capillary and secondary changes to the left ventricle.

The presence of COPD is a risk factor for postoperative pulmonary changes, usually identified with a risk greater than 18%, and may vary with the severity of the disease [16]. They reported that, although rehabilitated and controlled before the surgical procedure, COPD patients have the same incidence of postoperative pulmonary complications as healthy patients. The limitations of this study are directly related to the insufficient data collection of the patient record, which has incomplete information: lack of follow-up from the postoperative period until discharge, and it is not possible to evaluate compliance for a longer time and length of stay in the ICU in order to check for other changes, in addition to compliance and decreased pulmonary function.

Conclusion

According to the measurement of respiratory compliance in the postoperative period of cardiac surgery, it was possible to analyze factors such as body mass index, smoking, chronic
obstructive pulmonary disease and ejection fraction, which may be associated with worsening pulmonary compliance, contributing to decreased pulmonary function in the postoperative period of CABG. Thus, it is possible to propose prevention strategies for respiratory complications acquired in the postoperative period of cardiac surgery.

Disclosure of conflict of interest

None.

Abbreviations

CABG, Coronary Artery Bypass Grafting; CPB, Cardiopulmonary bypass; PEEP, Positive End Expiratory Pressure; ICU, Intensive Care Unit; COPD, Chronic Obstructive Pulmonary Disease; BMI, Body Mass Index; EF, Ejection Fraction.

Address correspondence to: André Luiz Lisboa Cordeiro, Red Bird Street, Salvador Dali Condominium, House 47, Lagoa Salgada, Faculdade Nobre, Feira de Santana, Bahia, Brazil. Tel: +55-75-998226086; E-mail: andreslisboacordeiro@gmail.com

References


