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Original Article

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

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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

Coronay 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 cmH_2O 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-

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

Variable	Low Compliance Group (n=32)	Normal Compliance Group (n=30)	P
Gender			0,18[a]
Male	19 (59%)	18 (60%)	
Female	13 (41%)	12 (40%)	
Age (years)	61 ± 7	59 ± 12	0,23[b]
BMI (kg/m^2)	27 ± 4	23 ± 4	0,04[b]
Comorbidades			
SAH	24 (75%)	25 (83%)	0,75[a]
DM	19 (59%)	17 (57%)	0,55[a]
DLP	17 (53%)	15 (50%)	0,60[a]
Smoking	5 (16%)	1 (3%)	0,05[a]
COPD	4 (13%)	0	< 0,001[a]
AMI	15 (47%)	17 (57%)	0,67[a]
EF			0,03[a]
< 40%	25 (78%)	14 (47%)	
> 40%	7 (22%)	16 (53%)	

[a]Chi-square test; [b]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.

chanical Ventilation Directive, where the cutoff point was 50 ml/cmH_2O (below this value, the patients were part of the GBC and above it were in the NCG group).

The groups were compared by their clinical variables (age, body mass index, diabetes mellitus, systemic arterial hypertension, dyslipidemia, smoking, presence of chronic obstructive pulmonary disease, acute myocardial infarction, and left ventricular ejection fraction), grafts, drains, surgery time, cardiopulmonary bypass time and aortic forceps time. These variables were selected because they are the most commonly found in the literature associated with pulmonary complications.

Statistical analysis

For the correct evaluation of the data, the Statistical Package for Social Sciences Program (SPSS) 20.0 was used. The normality of the sample was verified by the Shapiro-Wilk test, and the categorical variables were analyzed by Chi-square and the data expressed as mean and standard deviation. For comparison between compliance groups, we used the independent Student's t test (normal sample) or Mann-Whitney (non-normal sample), which was statistically significant when $P < 0.05$.

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/m^2.

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

Variable	Low Compliance Group (n=32)	Normal Compliance Group (n=30)	P
Grafts Number	2,5 ± 0,5	2,4 ± 0,8	0,67[a]
CPB time (min)	87 ± 20	60 ± 14	0,04[b]
Drain	2	1 ± 0,7	0,10[a]
Surgery time (min)	281 ± 44	232 ± 40	0,09[b]
Clamping Time (min)	55 ± 19	59 ± 22	0,34[b]

[a]Independent Student's t test; [b]Mann-Whitney test. CPB-Cardiopulmonary bypass.

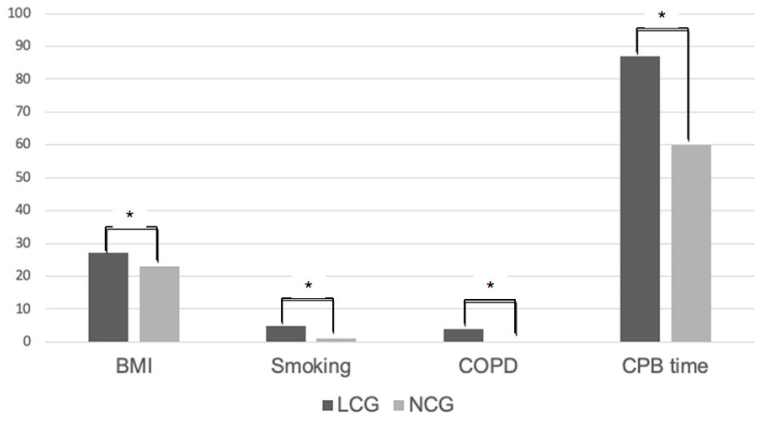

Figure 1. Factors associated with pulmonary complacence. *P < 0,01. BMI-Body Mass Index; COPD-Chronic Obstructive Pulmonary Disease; CPB-Cardiopulmonary bypass; LCG-Low Complacence Group; NCG-Normal Complacence Group.

dictor for the emergence of postoperative complications, being associated with the degradation of lung function [11].

Obesity favors the reduction of pulmonary compliance, due to the properties of the rib cage, leading to the restriction of lung capacities and volumes, producing changes in gas exchange and increasing the possibility of progression to pulmonary complications [12].

The results of this study showed significant reduction in relation to the loss of lung function associated with BMI of the individual with (P= 0.04), and can observe the risks posed by obesity after CABG, a negative impact on quality of life. This is patient profile.

The occurrence of postoperative pulmonary complications may be associated with several factors, including the region of the surgical incision, the type and duration of anesthesia and mechanical ventilation, the presence of pleural drains, the degree of preoperative pulmonary function and CPB time [13]. We found that CPB time was associated with reduced lung compliance, because it presented longer CPB time in GBC and also longer surgery time, thus increasing the length of stay as well as the length of time, the patient was being monitored by MV.

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.

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