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Influence of respiratory muscle strength in evolution of patients with heart failure after cardiac surgery

Influência da força muscular respiratória na evolução de pacientes com insuficiência cardíaca após cirurgia cardíaca

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Abstract

Objective: **To investigate the influence of preoperative respiratory muscle strength in postoperative pulmonary complications in patients with heart failure undergoing cardiac surgery.**

Methods: **From March 2009 to September 2010, 40 patients admitted to the cardiology service of the Fundação de Beneficência Hospital de Cirurgia were divided into two groups according to the values of maximal inspiratory pressure measured by manometer: Group A (n = 21), composed of patients with normal respiratory muscle strength, and Group B (n = 19), patients with reduced strength. After pre-operative evaluation, all patients underwent the surgical procedure and followed until hospital discharge by the same researcher, who recorded on data collection especially its evolution for the presence of pulmonary complications after surgery, which was divided general and specific.**

Results: **19% of patients in group A and 31.6% of patients in group B had pulmonary complications overall, this difference was not statistically significant (*P* = 0.29). Regarding the presence of specific complications, group A was 14.3% and 10.5% group B (*P* = 0.55). There was also no difference in the days of ICU stay and total (ICU + ward) between groups.**

Conclusion: **In this study, preoperative respiratory muscle dysfunction does not seem to influence the evolution of heart failure patients for the presence of pulmonary complications after cardiac surgery.**

Descriptors: **Heart Failure. Muscle Strength. Respiratory Muscles. Cardiac Surgical Procedures. Postoperative Complications.**

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Resumo

Objetivos: **Verificar a influência da força muscular respiratória pré-operatória na incidência de complicações pulmonares no pós-operatório de cirurgia cardíaca em pacientes com insuficiência cardíaca.**

Métodos: **De março de 2009 a setembro de 2010, 40 pacientes internados no serviço de cardiologia da Fundação de Beneficência Hospital de Cirurgia foram distribuídos em dois grupos, de acordo com os valores da pressão inspiratória máxima avaliada por meio da manovacuometria: Grupo A (n=21), composto de pacientes que apresentaram força muscular respiratória normal; e grupo B (n=19), pacientes com redução da força. Após a avaliação pré-operatória, todos foram submetidos ao procedimento cirúrgico e acompanhados até o momento da alta hospitalar pelo mesmo pesquisador, que anotava na ficha de coleta de dados sua evolução, especialmente quanto à presença de complicações pulmonares no pós-operatório, que foi dividida em geral e específica.**

Resultados: **Dezenove por cento dos pacientes do grupo A e 31,6% dos pacientes do grupo B apresentaram complicações pulmonares gerais, sendo esta diferença não significativa estatisticamente (*P*=0,29). Quanto à presença de complicações específicas, o grupo A teve 14,3% e o grupo B 10,5% (*P*= 0,55). Também não houve diferença quanto aos dias de internação em UTI e total (UTI + enfermaria) entre os grupos.**

Conclusão: **Nesse trabalho, a disfunção muscular respiratória no pré-operatório de cirurgia cardíaca não foi considerada um fator de risco para desenvolvimento de complicações pulmonares no pós-operatório.**

Descritores: **Insuficiência Cardíaca. Força Muscular. Músculos Respiratórios. Procedimentos Cirúrgicos Cardíacos. Complicações Pós-Operatórias.**

INTRODUCTION

The cardiovascular system's function is to provide and maintain adequate, continuous and variable flow of blood to different tissues of the body according to their metabolic needs [1]. When the heart becomes unable to maintain adequate cardiac output to meet the demand of the body, there is the clinical syndrome of heart failure (HF). The main symptoms of this syndrome is the feeling of muscle fatigue and dyspnea on exertion, culminating with an important limitation to the activities of daily living [1,2].

The relationship between heart failure and changes in the musculoskeletal system is already well established in the literature. More recently, it was discovered that the structure of the respiratory muscles, particularly the diaphragm, is also committed to the HF, causing loss of strength and endurance of these muscles and leading to a loss in its function and is directly related to the worsening of dyspnoea, a characteristic this syndrome [3,4].

Studies have shown decreased respiratory muscle strength (MS), evidenced by assessment of maximal respiratory pressures in patients with heart failure. Hammond et al. [5] found 50% of maximal inspiratory pressure (Ipmax) in patients with biventricular HF compared with normal controls. Forgiarini Jr. et al. [6] assessed patients with heart failure in functional class II and III and found both changes in respiratory muscle strength and lung function in these patients, being the greater loss in those who were in functional class III.

Patients with refractory to drug therapy may be indicated for surgical treatment. Despite advances in surgical care, pulmonary complications in the postoperative period of cardiac surgery remains the leading cause of morbidity and mortality of this procedure, besides contributing to the increased length of stay and hospital costs [7,8].

Currently, research has been undertaken in order to learn whether prior respiratory muscle dysfunction could act as a risk factor for postoperative pulmonary complications. Bellinetti & Thomson [9] observed that patients who had reduced respiratory muscle strength showed relative risk for these complications of 5.5 compared to unexposed (normal muscle strength) in elective upper thoracotomies and laparotomies. Guedes et al. [10] found a negative correlation between MIP and length of hospital stay after surgery in elective thoracic surgery and suggested that the MIP over 75% of the predicted value could be considered a protective factor and reduce the time of postoperative hospital stay in this type of surgery.

This study aims to determine the influence of respiratory muscle strength in pre-operative pulmonary complications in the postoperative period of cardiac surgery in patients with HF.

METHODS

Characterization of the study

The study was prospective cohort (longitudinal, analytical), with data collection performed from March 2009 to September 2010, using a convenience sample.

Ethical Considerations

The research project was approved by the Ethics in Research involving human subjects at the Federal University of Sergipe (UFS) (CAAE - 3224.0.000.107-09) according to the resolution 196/96 of the National Health Council (CNS) and all patients signed a Written Informed Consent (WIC).

Inclusion Criteria

The present study included individuals diagnosed with compensated systolic/diastolic heart failure admitted for elective cardiac surgery. The diagnosis of HF was, in all cases, confirmed on admission by the sum of 8 or more points according the Boston criteria.

Exclusion Criteria

Patients who had some risk factor that could affect the results of the assessment of respiratory muscle strength did not paticipate in the study, such as:

- use of psychotropic drugs, muscle relaxants and immunosuppressants;
- malnutrition, as evidenced by a body mass index (BMI) <20 kg/m2;
- history of prior cerebrovascular accident (CVA);
- people with neuromuscular diseases and/or disorders related to the thyroid.

They were also excluded those with risk factors for pulmonary complications postoperatively, such as:

- pulmonary disease;
- active or ceased smoking less than two months.

And yet those who participated in the survey were unable to perform the manometer.

Protocol

On the day of admission, the patient was received by the physiotherapist researcher who collected his data and performed the testing respiratory muscle strength. This was evaluated by means of an analog manometer of WIKA brand, with values †from - - 300cmH_2O to + 300cmH_2O, factory calibrated. The measurement of maximal respiratory pressures were performed with the patient in the sitting position, firmly holding the mouthpiece in his mouth with his elbows bent. For the evaluation of maximal inspiratory pressure (MIP), the individual was asked to expire to residual volume and then perform a sustained maximal inspiration (Müller maneuver). As for evaluating the maximal expiratory pressure (MEP), he performed a maximal inspiration to total lung capacity, followed by a forced expiration (Valsalva maneuver). The procedure was performed three times for each operation, with 1 minute rest between them, and the highest value was chosen since it does not exceed 10% difference between the other measures. If that happened, a new measurement would be performed [11]. The values obtained were compared with the normal to the Brazilian population, and expressed in percentage (% MIP and % MEP). For each parameter, the lower limit of normality was obtained by subtracting the value predicted by the product (1.645 x EPE), if not surpass the difference thus calculated, the measured value would at most 5% chance of being normal and, therefore, would be considered decreased [12].

Data collection was performed by a schedule established by the researcher which was completed in two phases: in the preoperative period, with identification data, medical history, physical examination, laboratory tests and pulmonary evaluation, and postoperative with data related to surgery, postoperative and possible pulmonary and hemodynamic complications.

Design Groups

All patients who came to the service to undergo elective cardiac surgery were evaluated by physiotherapist researcher. Those who had the diagnosis of heart failure confirmed by the Boston criteria underwent preoperative manometer. They were then divided into two groups according to respiratory muscle strength, those who had normal respiratory muscle strength, according to the methodology presented, were allocated to group A, whereas those who had reduced this parameter were allocated to group B.

Postoperative follow-up

All patients were followed from admission until hospital discharge or death by the same researcher. After heart surgery, this researcher recorded in the data collection form the postoperative evolution of those patients, especially in regard to pulmonary complications.

Postoperative physiotherapy

After surgery, all patients received conventional treatment of the physiotherapy team, which consisted of two sessions daily, morning and another one in the afternoon, from the 1st postoperative day (POD). In the sessions, it was prioritized early mobilization of the patient, transferring from bed to chair, when the clinical conditions permit, combined with breathing exercises, positive expiratory pressure and metabolic kinesiotherapy active exercises for upper limbs and lower limbs. Although it was emphasized during the service the importance of cough and deep breathing exercises during the day.

Variables studied

Variables collected preoperatively

In order to verify the homogeneity between the groups still in the preoperative period, the following variables were studied in patients participating in the survey:

• anthropometric characteristics: gender, age, body mass, height and BMI;

• clinical features: systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), oxygen saturation ($SatO_2$), ejection fraction (LVEF), functional classification (FC) of New York Heart Association (NYHA);

• Etiology of heart failure: ischemic, valvular or another.

Length of surgery and CPB time

The variables time of surgery and CPB time were recorded and analyzed in order to verify the homogeneity between the groups during surgery and postoperatively.

Pain assessment

The collection of pain was performed using a Numerical Scale ofMeasurement of Pain (NEP), a rule that has a numerical scale from 0 to 10, the first value referring to the complete absence of pain and the last, the greatest pain imaginable. Patients were asked about that feeling in the first three days after surgery.

Postoperative pulmonary complications

The presence of pulmonary complications was evaluated daily by researchers throughout the postoperative period until the time of discharge, through the evaluation by the team of clinical and complementary exams of the patients. Any important information was recorded on the postoperative data collection.

General postoperative pulmonary complications were considered as occurrence of pneumonia (presence of increased white blood cell count, fever, productive cough and pulmonary consolidation on chest-X), unilateral or bilateral atelectasis with evident clinical repercussion (dyspnea, desaturation, fever), acute respiratory failure (requiring invasive or noninvasive mechanical ventilation), prolonged mechanical ventilation (> 48 hours), bronchospasm (wheezing on auscultation), pneumothorax, pleural effusion (resulting in thoracentesis). We also performed a statistical analysis considering the pulmonary complications that could be directly related to respiratory muscle dysfunction preoperatively, being this variable called specific pulmonary complication. They were taken into account the presence of pneumonia, unilateral or bilateral atelectasis with a clear clinical impact, acute respiratory failure, prolonged mechanical ventilation (> 48h) and pleural effusion.

ICU length of stay and total

As for variable of length of stay in ICU and total hospitalization time, the researcher wrote down the data collection form the day of patient discharge from the ICU and day of hospital discharge, after accounting for the number of hospital days.

Statistical analysis

The data and the results were stored in a database using Excel software, version 2003, and analyzed according to calculations using the statistical software SPSS, version 18.0. We considered the significance level as 5%, confidence interval 95%, power of 0.80 and two-tailed tests. Quantitative variables were summarized by mean and standard deviation or median and interquartile range, depending on the most appropriate. As for the categorical variables they were summarized by means of simple and relative frequencies.

For the analysis of different quantitative variables between groups it was performed using the Student's t test for independent data, assuming homogeneity of variances and to compare the groups for analysis of categorical variables we used the chi-square test and Fisher exact test.

RESULTS

Sample characterization

During the period of the study, 129 elective cardiac surgery were performed in the service, 64 valve, 56 coronary, and 9 aortic disease, congenital diseases and endo/ cardiomyopathy. Of these patients, 48 were initially eligible to participate in research because they have a confirmed diagnosis of IC by the criterion of Boston, but three were excluded for not performing a manometer, two because they are suffering from lung disease, two because of history of stroke and one was active smoker. Thus, we obtained a total sample by convenience of 40 patients who were divided into groups according to the assessment of inspiratory muscle strength. Group A comprised 21 patients who had normal MIP, and group B of 19 patients with reduced MIP.

Anthropometric characteristics

In Group A, 15 (71.4%) patients were female and 6 (28.6%) were male, while in Group B, 11 (57.9%) were female and eight (42.1 %), male. Although a higher frequency of women in both groups, there was no statistical difference between groups regarding gender (P = 0.28). There was also no difference between groups regarding age (P = 0.60), body mass (P = 0.53), height (P = 0.63), BMI (P = 0.29). Table 1 depicts the anthropometric characteristics of the groups.

Clinical characteristics

Table 2 shows the values related to clinical variables. Just in relation to the SBP it is observed difference between the groups, with P = 0.02. In relation to DBP (P = 0.06), HR (P = 0.49), $SatO_2$ (P = 0.97), LVEF (P = 0.85) and FC-NYHA (P = 0.65) the groups continued homogeneous.

Thus, it was found that both groups were similar in the preoperative period, which proved to be important for analysis of respiratory muscle strength.

Table 1. Distribution between groups A and B of values regarding preoperative anthropometric characteristics of the sample.

	Group A (n = 21)	Group B (n = 19)	*P* Value
Gender			
Female, n (%)	15 (71.4)	11 (57.9)	
HF(95%)	52.07 – 90.73	35.70 – 80.10	0.28
Male, n (%)	6 (28.6)	8 (42.1)	
HF(95%)	9.27 – 47.93	19.90 – 64.30	
Age (years)	42.76 ± 14.15	45.05 ± 12.94	
HF(95%)	36.32 – 49.20	38.82 – 51.29	0.60
Body Mass(kg)	65.24 ± 12.66	62.87 ± 10.51	
HF(95%)	59.48 – 71.00	57.81 – 67.94	0.53
Height(cm)	162.19 ± 10.13	163.82 ± 10.96	
HF(95%)	157.58 – 166.80	158.53 – 169.10	0.63
BMI, kg/m^2	24.55 ± 2.78	23.44 ± 3.77	
HF(95%)	23.28 – 25.82	21.62 – 25.25	0.29

BMI= Body Mass Index; HF= Heart Failure

HF etiology

Regarding the type of surgery, 38 patients underwent a procedure to repair or valve replacement, and only in two, one in each group, coronary artery bypass grafting (CABG) was performed. This result reflects the data collected preoperatively in the etiology of HF, as in group A, 90.5% and in group B, 94.7% of patients had valvular etiology.

Length of surgery and CPB time

The average time of surgery in group A was 285.95 ± 142.27 minutes and group B 259.74 ± 81.37 minutes, with no statistical difference (P = 0.48). As for the duration of CPB, the mean group A was 115.81 ± 63.28 minutes and in group B, 97.74 ± 37.23 minutes, P = 0.28.

Table 2. Distribution between groups A and B of the values related to preoperative clinical characteristics of the sample.

	Group A (n = 21)	Group B (n = 19)	*P* Value
SAP (mmHg)	117.14 ± 14.21	129.21 ± 16.52	0.02
CI(95%)	110.68 – 123.61	121.25 – 137.17	
DAP (mmHg)	72.90 ± 8.96	79.47 ± 11.77	0.06
CI(95%)	68.83 – 76.98	73.80 – 85.15	
HR (bpm)	79.52 ± 14.31	83.16 ± 18.55	0.49
CI(95%)	73.01 – 86.04	74.22 – 92.10	
$SatO_2$ (%)	97.38 ± 0.87	97.37 ± 1.46	0.97
CI(95%)	96.99 – 97.77	96.66 – 98.07	
LVEF (%)	56.78 ± 16.77	57.70 ± 13.83	0.85
CI(95%)	49.15 – 64.41	51.03 – 64.37	
NYHA FC			
II, n(%)	4 (19.0)	6 (31.6)	0.65
CI(95%)	2.22 – 35.78	10.70 – 52.50	
III, n(%)	14 (66.7)	11 (57.9)	
CI(95%)	46.54 – 86.86	35.70 – 80.10	
IV, n(%)	3 (14.3)	2 (10.5)	
CI(95%)	0 – 29.27	0 – 24.28	

SAP = systolic arterial pressure, DAP = diastolic arterial pressure, HR = heart rate; $SatO_2$ = oxygen saturation; LVEF = left ventricular ejection fraction, NYHA-FC = functional class according to the New York Heart Association, CI = confidence interval

Postoperative pain

Table 3 shows the means and standard deviations, and *P* values in the two groups in relation to pain in the 1st, 2nd and 3rd postoperative day (POD). As can be seen in both groups, that feeling was smaller by the day and between groups there was not statistically difference (*P* = 0.39, *P* = 0.43, *P* = 0.89 for the 1st, 2nd and 3rd POD, respectively).

Table 3. Distribution between groups A and B of the mean and standard deviation regarding the Numerical Measurement Scale of Pain (END) in the 1st, 2nd and 3rd postoperative days.

	Group A (n = 21)	Group B (n = 19)	*P* Value
Day 1	6.50 ± 1.73	6.94 ± 1.30	0.39
CI(95%)	5.69 – 7.31	6.27 – 7.61	
Day 2	4.00 ± 1.81	4.41 ± 1.18	0.43
CI(95%)	3.15 – 4.85	3.81 – 5.02	
Day 3	2.00 ± 1.62	2.06 ± 0.97	0.89
CI(95%)	1.24 – 2.76	1.56 – 2.56	

CI= confidence interval

Pulmonary complications after cardiac surgery

Regarding the presence of postoperative pulmonary complications (PPC), Table 4 shows that in group A, 19% of patients (four patients) had some type of PPC, and in group B, this percentage was 31.6% (six patients).

However, when we analyze the specific PPC, we can identify that in group A, three (14.3%) patients had lung complications and two (10.5%) in group B. In both tests, however, one can not observe statistically significant difference.

Time in ICU and total hospital stay time

The average number of days that patients in group A were admitted to the ICU was 3.24 ± 3.10 days versus 2.94 ± 2.44 days in group B (*P* = 0.75). In relation to the total time of hospital stay (ICU ward +), the group A presented 10.53 ± 8.17 days of average, and group B, 9.18 ± 5.32 days, also with no statistical difference (*P* = 0.57).

Two (10.5%) patients in group A and two (10%) in group B died due to various reasons and not related to the presence of pulmonary complications.

Table 4. Distribution between groups A and B of the frequencies regarding the presence or not of general and specific pulmonary complications in the studied sample, according to the MIP.

	Group A (n = 21)	Group B (n = 19)	*P* Value
General Pulmonary Complication			
No, n (%)	17 (81.0)	13 (68.4)	0.29
CI(95%)	64.22 – 97.78	47.50 – 89.30	
Yes, n (%)	4 (19.0)	6 (31.6)	
CI(95%)	2.22 – 35.78	10.70 – 52.50	
Specific Pulmonary Complication			
No, n (%)	18 (85.7)	17 (89.5)	0.55
CI(95%)	70.73 - 100	75.72 – 100	
Yes, n (%)	3 (14.3)	2 (10.5)	
CI(95%)	0 – 29.27	0 – 24.28	

CI= confidence interval

DISCUSSION

The presence of pulmonary complications after cardiac surgery is considered one of the major morbidity of this procedure [13-15]. It is also known that patients with heart failure are more likely to have reduced respiratory muscle strength [6.16].

From these data, this study aimed to determine the influence of respiratory muscle strength preoperatively in the presence of pulmonary complications after cardiac surgery in patients with HF.

Several studies in humans and animals have demonstrated that patients with HF are more likely to develop respiratory muscle dysfunction, although this mechanism is still not well elucidated in the literature [16-18].

In this survey, 47.5% of HF patients confirmed by the Boston criteria showed inspiratory muscle dysfunction, a much lower incidence than that found by Meyer et al. [19], who reported a reduction of MIP in all 244 patients assessed with HF. In addition, they observed that 57 (25%) persons who died during follow-up study had a greater reduction of these values, and considered the assessment of this variable as independent risk factor in heart failure.

However, when analyzing the severity of the syndrome of patients in two studies, we observed that Meyer et al.

[19] were much more severe than ours, with mean LVEF 22 ± 10% compared to an average 56.78 ± 16.77% in group A and 57.70 ± 13.83% in Group B of this research.

In another study, Neto et al. [20] evaluated the MIP of 47 hospitalized patients diagnosed with IC and found that 66% had respiratory muscle weakness, diagnosed by the value of MIP 70% lower than predicted.

The presence of pulmonary complications has been described in literature as the main cause of morbidity and mortality after cardiac surgery and its incidence may vary from 10 to 90% [7,8,15].

The rate of pulmonary complications in this study, considering both groups was 25%, not unlike the results found by Schnaider [21], who had a clinically significant incidence of PPC in his postoperative sample of cardiac surgery 38%.

By studying the prevalence of pleural effusion after cardiac surgery, Labidi et al. [22] also found that only 192 (6.6%) of 2892 patients had significant pleural effusions requiring thoracentesis.

In contrast, Ortiz et al. [13] found an incidence of 87% of pulmonary complications in the postoperative period of cardiac surgery, and 65% had atelectasis and 84% pleural effusion. However, the authors state in their discussion that this high percentage was because the criteria used to establish PPC was very comprehensive, without necessarily considering the clinical relevance.

A similar result was found by Jensen & Yang [23], who had a prevalence of 99.4% of PPC in the postoperative of coronary artery bypass grafting. Atelectasis and pleural effusion were the most frequent complications and the diagnosis was given only by radiological examination.

Vargas et al. [24] studied by computed tomography (CT) the presence of atelectasis and pleural effusion in the postoperative period of CABG and found that all patients on the 2nd POD presented some degree of atelectasis or pleural effusion. However, they also state that the vast majority of the pleural effusions observed by CT were minimal and the atelectasis were laminar, or that is, most of these findings can not be observed on radiographs.

It is observed that there is great disagreement in the literature about what are postoperative pulmonary complications and how this diagnosis is given, and perhaps why there is this wide variation in incidence. In this study, we chose to perform two tests: one general and one specific.

In the overall analysis, 19% of patients in group A and 31.6% of patients in group B showed a PPC, with no statistical difference ($P = 0.29$). In the specific analysis showed that Group A had 14.3% of PPC, while the group B, 10.5%. Similarly, there was no difference between groups ($P = 0.55$).

A similar result was found recently by Schnaider [21], when assessing whether respiratory muscle strength before surgery could influence the outcome after coronary artery bypass grafting. It was found an increased risk for the patients with respiratory muscle dysfunction (n = 11) in developin PPC compared to control (n = 13) with relative risk (RR) of 2.364 and odds ratio (OR) 4, but without statistical confirmation, probably due to the reduced sample.

Riedi et al. [25] also concluded that respiratory muscle strength preoperatively could not be used as a predictor of respiratory complications in the postoperative period of cardiac surgery in their study.

On the other hand, when assessing 70 patients who underwent elective upper laparotomy and thoracotomy, Bellinetti & Thomson [9] found an RR of 5.5 for PPC in patients with respiratory muscle dysfunction compared with those who had normal muscle strength, with a difference statistically significant.

There were also no statistical differences observed in this study about the time of ICU stay and total time of hospitalization (ICU + ward), confirming the results of Schnaider [21], which also has not verified this difference when comparing patients with respiratory muscle dysfunction who underwent CABG in the control group.

Again, Bellinetti & Thomson [9] found opposite results. They observed marked difference in mean number of days, although it was statistically significant only in the total number of days of hospitalization. Guedes [10] found a negative correlation between MIP and length of postoperative hospital stay in elective thoracic surgery ($r = -0.64$, $P = 0.02$).

The low percentage of patients who progressed to PPC in this study may be related to a positive role of physiotherapy staff of the hospital that as early as the 1st POD acts encouraging early mobilization of the patient, breathing exercises, cough and lung expansion. Generally, from the 2nd POD, the patient is already out of bed and it contributes significantly to reducing rates of hypoventilation to improve diaphragmatic mobilization and, consequently, reduces the chances of patients developing pulmonary complications. A physiotherapeutic approach thus assumes a major role in postoperative cardiovascular surgery, aiming to reduce the incidence of postoperative pulmonary complications [26-32].

Added to this factor there is the fact that we only took into account the clinically important complications, which further reduces the incidence of PPC. As already discussed, the study does not have uniform criteria for analyzing these complications, some only by considering the radiological image, other, as in this study, taking into account only when present any signs of clinical importance associated with the exams.

Given the importance of the issue and the divergence of results it is very important to perform further research to investigate the role of respiratory muscle dysfunction as a risk factor for developing pulmonary complications in the postoperative period of several surgeries.

CONCLUSION

The preoperative muscle dysfunction, verified by maximal inspiratory pressure in patients with heart failure undergoing cardiac surgery does not appear to influence the incidence of postoperative pulmonary complications.

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