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ORIGINAL RESEARCH

Respiratory muscle strength no influence the need for noninvasive ventilation after heart surgery

Força muscular respiratória não influencia no uso da ventilação não invasiva após cirurgia cardíaca

La fuerza muscular respiratoria no influye en el uso de la ventilación no invasiva tras cirugía cardíaca

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ABSTRACT | The aim of this study was to investigate the relation between preoperative respiratory muscle strength and indication and performance of noninvasive ventilation in the planned heart surgery. We conducted a retrospective study using data collected from clinical records and analyzed 109 medical records and noninvasive ventilation accompanying paper. We analyzed the values of respiratory muscle strength, peak flow and respirometry, as well as the postoperative respiratory complications, correlating them with indication and performance of the noninvasive ventilation. The *t* test was performed for continuous variables; the chi-square was used to investigate the influence of preoperative respiratory muscle strength values in the indication of noninvasive ventilation. Noninvasive ventilation was used in 32 (29%) subjects and the prime motive indication was hipercapy (44%). The successful use of noninvasive ventilation was observed in 94%. The decrease in preoperative strength, despite having a lower performance, showed no significant difference in relation to its use and outcome (p=0.73). The preoperative respiratory muscle strength was not able to provide for the use of noninvasive ventilation or its performance.

Keywords | Thoracic Surgery; Noninvasive Ventilation; Muscle Strength.

RESUMO | O objetivo deste estudo foi verificar a relação entre a força muscular respiratória pré-operatória e a indicação e o desempenho da ventilação não invasiva em pacientes submetidos à cirurgia cardíaca eletiva. Foi realizado um estudo retrospectivo por levantamento e análise de 109 prontuários e fichas de acompanhamento da ventilação não invasiva. Foram analisados força muscular respiratória, pico de fluxo e ventilometria e complicações pós-operatórias, correlacionando-as com a indicação e o desempenho da ventilação não invasiva. Foi utilizado o teste *t* de Student para as variáveis contínuas e teste quiquadrado para investigar a influência dos valores da força muscular respiratória pré-operatória com a indicação de desfecho da ventilação não invasiva. A ventilação não invasiva foi utilizada em 32 (29%) dos indivíduos, sendo a principal indicação a hipercapnia (44%). O sucesso com o uso da ventilação não invasiva foi de 94%. A diminuição da força muscular pré-operatória, apesar de ter apresentando um menor desempenho, não demostrou diferença significativa em relação à sua utilização e desfecho (p=0,73). A força muscular respiratória pré-operatória não foi capaz de prever a utilização da ventilação não invasiva nem seu desempenho.

Descritores | Cirurgia Torácica; Ventilação Não Invasiva; Força Muscular.

RESUMEN | El objetivo de este estudio fue verificar la relación entre la fuerza muscular respiratoria preoperatoria y la indicación y el desempeño de la ventilación no invasiva en pacientes sometidos a cirugía cardíaca electiva. Se llevó a cabo un estudio retrospectivo por encuesta y análisis de 109 registros hospitalarios y formularios de acompañamiento de la ventilación no invasiva. Se analizaron la fuerza muscular respiratoria, el pico de

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flujo y ventilometría, y complicaciones postoperatorias, correlacionándolas con la indicación y el desempeño de la ventilación no invasiva. Se utilizó el test t de Student para las variables continuas y el test chi-cuadrado para investigar la influencia de los valores de la fuerza muscular respiratoria preoperatoria con la indicación de resultado de la ventilación no invasiva. La ventilación no invasiva fue utilizada en 32 (29%) de los individuos, siendo la principal indicación la hipercapnia (44%). El éxito en la utilización de la ventilación no invasiva fue de 94%. La disminución de la fuerza muscular preoperatoria, aunque haya presentado un menor desempeño, no demostró diferencia significativa en cuanto a su utilización y resultado (p=0,73). La fuerza muscular respiratoria preoperatoria no fue capaz de prever el uso de ventilación no invasiva o su desempeño.

Palabras clave | Cirugía Torácica; Ventilación no Invasiva; Fuerza Muscular.

INTRODUCTION

The prior condition of the patient undergone cardiac surgery — such as the presence of chronic lung disease, which may be associated with other co-morbities and living habits — contributes to the intensity of the respiratory alterations in the postoperative period (PO), being the atelectasis, the infections and the respiratory failure, the most common alterations found[1-3].

In addition to these preoperative conditions, there are also some perioperative factors which have a direct impact on the increased risk of morbidity and mortality and in the time length and costs of hospitalizations[1,3-5]. Among the factors related to the procedure are surgical trauma, pain, anesthesia and extracorporeal circulation (ECC), resulting in diaphragmatic dysfunction, decrease of pulmonary function and expansion, hypoxia and accumulation of secretions[5].

Thus, the preoperative evaluation becomes important, aiming to identify possible risks for respiratory complications. In this evaluation, one shall analyze the respiratory muscle strength, since the weakness of these muscles in preoperative stage is related to pulmonary complications in PO[1].

One of the ways to reduce these complications is the intervention of preoperative physical therapy, which includes inspiratory muscle training. Patients who receive this intervention present shorter hospitalization time in the myocardial revascularization PO[6,7]. Besides the preoperative stage, physical therapy aims at preventing and treating PO complications. Within therapeutic alternatives, the noninvasive ventilation (NIV) has been used in order to improve respiratory function as a result of the deterioration of the cardiac function[8,9].

The NIV is indicated in the prevention and solution of respiratory failure, reducing the PO's reintubation rates, pneumonia and hypoxemia, impacting directly on hospitalization time length and at the intensive care unit (ICU) [3,10-12]. The NIV also improves gas exchange and shunt, decreasing muscle work, pre- and afterload, reflecting in ventricular performance[3,11].

The aim of this study was to investigate the relation between preoperative respiratory muscle strength and the recommendation and performance of NIV in elective cardiac surgery. Secondarily, it aimed at comparing the types of surgical interventions, the characteristics of the procedures (time of extracorporeal circulation, anesthesia, surgery, hospitalization and hospital discharge) as well as the characteristics of the individuals provided with respiratory muscle strength.

METHODOLOGY

A retrospective, observational study developed through the survey and analysis of hospital records and NIV monitoring charts from individuals who have undergone cardiac surgery from January to December 2011. The study was approved by the Ethics Committee of the Assis Gurgaz College, protocol 221/2007.

Sample

193 medical charts of patients who have undergone myocardial revascularization, who had their valves replaced, and who had their aneurysms and atrial septal defect corrected, were found, between January and December 2011. Of these, 84 were excluded for being emergency surgeries, for being patients with unstable angina, who were not in proper physical nor cognitive condition for the fulfillment of the breathing tests, or who died postoperatively. Thus, 109 charts were analyzed; as they were standard charts, all records possessed the necessary information.

Preoperative evaluation

All subjects were evaluated at hospital admission, when their medical records were registered, along with their respiratory strength, flow peak and ventilometry.

The respiratory tests were performed with the patients sitting down, with their feet being supported and their nostrils occluded with a nose clip.

The respiratory muscle strength was measured using the analog manovacuometer (Wika, 300 MV), with a range of ±300 cmH_2O. The maximum inspiratory pressure (MIP or PImax) was measured starting with three respiratory cycles in tidal volume (VT), and an expiration, to residual volume (RV), was requested. In the sequence, the patient performed a maximum inspiration to total lung capacity (TLC), sustaining the intake force for two seconds[13]. In order to evaluate the expiratory pressure (MEP or PEmax), the patient was oriented to perform intakes in VT followed by a deep intake until TLC and then perform a maximum expiration at VT level, sustaining it for two seconds[13]. Both maneuvers were performed three times, in intervals determined by the patients, the best measures being recorded then. In order to calculate the projected pressure, the equations proposed by Neder *et al*.[14] were used. For the comparison of the preoperative respiratory muscle strength with the use of NIV, and its outcomes, it was considered MIP of 80 cmH_2O. According to the guidelines of the American Thoracic Society/European Respiratory Society (ATS/ERS)[15], in pulmonary function tests, values below this one may indicate muscle weakness.

In order to check the peak of the flow, the patient was oriented to perform an intake up to the TLC, followed by a forced, short and explosive maximum expiration in a peak flow gauge device. The highest value out of the three consecutive maneuvers was registered, and in case the difference between them was higher than 20 L/min, the test would be repeated.

For the conducting of the respirometry (Inspire Wright Mk 8) a heat exchanger filter was used as an intermediate, which was attached to the patient's mouth. For the measurement of the minute volume (Vmin), the volunteer would perform a calm ventilation for one minute and, at the end, the value found and the number of breaths in the period would be registered. For the measuring of the VT, the Vmin was divided by the respiratory rate (RR) found. The measurement of the vital capacity (VC) was evaluated by an expiration to the RV followed by an inspiration to the TLC.

Physiotherapeutic intervention

After surgery, the physiotherapeutic interventions were conducted three times a Day, with respiratory and motor exercises, from the immediate PO to the medical discharge. It was the responsibility of the physical therapist to manage mechanical ventilation, extubation, evaluation and recommendation of NIV, in consensus with the multidisciplinary team.

Noninvasive ventilation

The recommendation of the NIV was based on the hospital's protocol, which included: presence of acute respiratory failure (ARF), characterized by the presence of respiratory effort; tachypnea; need for fractions of inspired oxygen (FiO_2) higher than 40% with peripheral oxygen saturation (SpO_2) lower than 90%; acute pulmonary edema (APE) defined by the presence of respiratory effort associated to cough with pinkish sputum and the presence of pulmonary noise on auscultation; hypoxemia (alterations in PO_2 without manifestation of respiratory effort) or hypercapnia alone; bronchospasm (respiratory effort associated to expiratory wheezing on auscultation); radiological alterations (atelectasis and pleural effusion); or prophylactic post-extubation (patients with respiratory disease, in mechanical ventilation for longer than 24 hours).

Patients would be continuously reassessed, taking as parameter the signs of respiratory effort, and SpO_2 level of consciousness. After two hours of NIV initiation, a new analysis of the arterial gasometry was performed. The patients who presented good response to the NIV (improvement of oxygenation and/or hypercapnia) would remain in treatment, performed three times a day, for a period of two hours, until the favorable closure of the clinical condition.

Were considered as indicative of failure in the use of NIV: need for a FiO_2 higher than 0.6, decrease in pH and/or increase of the $PaCO_2$, respiratory frequency higher than 35ipm, agitation or decreasing of consciousness level, hemodynamic instability, arrhythmias, myocardial ischemia, abdominal distention, intolerance to the mask and respiratory worsening.

For the classification of postoperative pulmonary complications of cardiac surgery, the proposal of Hulzebos *et al*.[16] was used, subdividing them into four classification categories:

- Type 1: dry cough, microatelectasis and temperature higher than 37.5ºC without documented cause, dyspnea without documented cause;
- Type 2: productive cough not associated to the right cause, bronchospasm (wheezing) and the need for change in the treatment, hypoxemia with wheezing

and dyspnea signs and symptoms, atelectasis with radiological confirmation associated to temperature higher than 37.4ºC or abnormal lung findings, hypercapnia in need of treatment;

- Type 3: pleural effusion requiring thoracentesis, suspected pneumonia (radiologic evidence without bacterial confirmation), pneumonia with both radiologic and bacterial confirmation), pneumothorax, reintubation (with mechanical ventilation period of no more than 48h).
- Type 4: ventilation failure: postoperative ventilator dependency exceeding 48h, intubation with subsequent dependence on mechanical ventilation for more than 48h.

Table 1. Sample characterizationCaracterização da amostra

	PImáx<80 cmH_2O n=70 n (%)	PImáx>80 cmH_2O n=39 n (%)	p-value
Average age (years)#	59.2±12.1	57.3±12.9	0.45
Gender			
Male	47 (67)	19 (49)	0.09
Female	23 (33)	20 (51)	
BMI (kg/m²)	28.3 (5.6)	28.2 (4.2)	0.87
Abdominal circunference (cm)	99.2 (12.5)	98.1 (11.6)	0.65
Smoking habit			
Non smoker	35 (50.0)	20 (51.2)	
Smoker	5 (7.2)	5 (12.8)	0.55
Former smoker	30 (42.8)	14 (36.0)	
Diabetes	27 (38.5)	13 (33.3)	0.73
Dyslipidemia	32 (46)	15 (38.5)	0.59
Hypertension	54 (77)	27 (69)	0.49
Respiratory diseases	5 (7.1)	7 (17.9)	0.16

MIP: maximum inspiratory pressure; BMI: Body mass index; #Mean±standard deviation

Statistical analysis

In order to differentiate the groups according to muscle strength, the Student's t-test for the continuous variables was used, while the χ^2 test was used for the categorical ones. The χ^2 test was also used to investigate the influence of the values of preoperative respiratory muscle strength with the recommendation for NIV. The choice of MIP > or <80 cm H_2O for the comparison of the muscular strength with the use of NIV was given because this value was determined by the ATS/ERS[15] within the guidelines for pulmonary function testing, with values indicating muscle weakness. The rest of the data were presented in tables with the distribution of the frequency, the average and the standard deviation. The level of significance was set at 5%. The analysis were performed using the GraphPad Instat 3.0 software.

RESULTS

109 charts, of patients who had undergone cardiac surgery, were consulted, from which the patients' characteristics (Table 1) and the performed surgical procedures' characteristics were extracted (Table 2).

The NIV was used in 32 (29%) patients, from which 30 (94%) were successful and 2 (6%) were unsuccessful, both being re-intubated because of worsening in the respiratory condition (Table 3).

From the 109 investigated patients, 35 (32%) have presented postoperative respiratory complications, and

Table 2. Characteristics of the performed surgical procedures

	MIP<80 cmH_2O n=70 n (%)	MIP>80 cmH_2O n=39 n (%)	p-value
Kind of surgery			
Myocardial revascularization	43 (61)	23 (60)	
Replacement of the mitral valve	4 (6)	8 (20)	
Replacement of the aortic valve	11 (16)	4 (10)	0.17
Associated surgeries	9 (13)	3 (8)	
Other surgeries	3 (4)	1 (2)	
Surgical risk			
ASA I	3 (4)	2(6)	
ASA II	9 (13)	6(15)	0.97
ASA III	5 (73)	27(69)	
ASA IV	7 (10)	4(10)	
Time of extracorporeal circulation (min)#	88.1±49.9	88.1±48.4	0.99
Anesthesia time (min)#	300.7±97.7	295.8±81.5	0.79
Surgery time (min)#	267.7±71.7	254.0±69.0	0.34
Hospitalization time (days)#	10.8±6.1	9.8±5.7	0.22
Time of PO in hospital discharges (days)#	7.5±5.5	6.0±3.6	0.12

MIP: maximum inspiratory pressure; PO: postoperative period; ASA: American Society of Anesthesiologists; #Mean±standard deviation

from those, 19 (54%) made use of the NIV. It is noteworthy that not all patients who used NIV had postoperative pulmonary complications, according to the classification of Hulzebos *et al.*[16].

The average maximal inspiratory and expiratory pressures assessed preoperatively were 62.8±25.7 and 68.6±22.5 cmH_2O, respectively. Meanwhile, the peak of expiratory flow found was 346.7±125.8 L/min.

The findings in respirometry were: minute volume average of 11,375.0±10,546.4 mL, tidal volume of 749.3±396.3 mL and inspiratory capacity of 2,761.4±1,328.2 mL, with no significant difference between patients who used NIV (p=0.47) and the results of it (p=0.09).

Significant differences were not found when comparing the muscle strength, the use of NIV and its results (Table 4).

Table 3. Indications and outcomes of noninvasive ventilation

Indication	Outcome of noninvasive ventilation		
	Frequency n=32 n (%)	Sucess n=30 n (%)	Failure n=2 n (%)
Hypercapnia	14 (44)	13 (93)	1 (7)
Radiographic alterations	7 (22)	7 (100)	-
ARF	5 (16)	5 (100)	-
BCE	2 (6)	2 (100)	-
Hypoxemia	2 (6)	1 (50)	1 (50)
Post-extubation	2 (6)	2 (100)	-

ARF: Acute pulmonary respiratory failure; BCE: bronchospasm; NIV: Noninvasive ventilation

Table 4. Relationship between respiratory muscle strength, use and outcome of noninvasive ventilation

MP	Use of NIVI n=109			Results of NIV n=33		
	Yes n (%)	No n (%)	p-value	Sucess n (%)	Failure n (%)	p-value
>80 cmH_2O	14 (13)	26 (24)	0,54	13 (40)	1 (3)	0,73
<80 cmH_2O	19 (17)	50 (46)		17 (51)	2 (6)	

NIV: noninvasive ventilation; MIP: maximum inspiratory pressure

DISCUSSION

The rate of respiratory complications in the postoperative period of cardiac surgery is between 7 and 49%[3,17]. These complications are one of the main causes of morbidity and mortality in patients who have undergone myocardial revascularization surgery[18]. In this study, 60% of the individuals have been revascularized, and from those, 32% presented respiratory complications. These results are similar to another study's[3], which reported a 30% rate of postoperative complications.

The NIV is used as a tool for reversing of these PO complications, which may reduce the need for re-intubation, rates of mobidity, mortality and ICU hospitalization time lenght[19]. Its use is recommended by the International Consensus Conferences in Intensive Care Medicine[11].

In a literature review[7], it was found that the use of NIV in PO patients has a level II degree of recommendation. Fact that differs from another study[6], and also from this one, in which was observed a 94% success rate.

There was a total of 29% of patients who had undergone cardiac surgery and made use of NIV. This frequency is similar to another study's[20], in which the use of NIV was investigated in patients with PO respiratory insufficiency after cardiac surgery, and the authors have observed that 33% of them needed this ventilator support. However, in the Hospital Ministro Costa Cavalcanti's protocol, the recommendation was not only for the cases of respiratory insufficiency, as referred in the study.

The highest use frequency of NIV was observed in patients with hypercapnia (44%), whose success was 93%. The use of NIV for this purpose is widely spread. A study[12] has invetigated the factors associated to the response factors of NIV on the fisrt day of ICU hospitalization, in hypercapnic patients, despite the success being lower than in the present study (66%), it was possible to identify that patients who needed higher support pressures were the ones who presented higher chances of failures or unsuccess[12].

Lee *et al.*[21] demonstrated that patients with PO complications can be treated with NIV, reducing both hospitalization and ICU time length, the most common complications being pneumonia and atelectasis. Olper *et al.*[22] achieved 85% success in the use of NIV PO cardiac surgery, where the causes of respiratory insufficiency were mainly atelectasis and pleural effusion. Although the main indication of this study being hypercapnia (44%), the performance of NIV was similar, with 94%[14,22].

Bellinetti e Thomson[23] describe that patients with MIP and MEP 75% below what was predicted develop more respiratory complications[12]. These groups having greater incidence of respiratory complications also require greater use of NIV, which occured in this study, with no significant difference however. Schnaider *et al.*[1] and Bastos *et al.*[24] did not find any significant difference in pulmonary complications in patients with preoperative reduced respiratory muscle strength, however, in both studies the complications were more frequent

in these patients[15]. The data found in this study were similar, because the use of NIV was higher in patients with MIP <80 cmH_2O, but without significant difference. Hulzebos *et al*.[16] demonstrated that patients who received inspiratory muscle training before surgery had 30% fewer respiratory complications. In the present study, the use of NIV showed no significant difference in patients with MIP <80 cmH_2O, but all unsuccessful cases were patients with MIP <80 cmH_2O.

The use of NIV prophylactically, i.e. with no signs or symptoms of respiratory insufficiency, has been used in order to prevent respiratory complications. A literature review[25] has highlighted that NIV, associated with respiratory physical therapy, is a safe and effective resource to reduce and treat PO complications. In this study, 22% of NIV occured in patients who had been radiologicaly involved, however, without clinical manifestations, and 6% immediately after extubation, due to preoperative risk factors. Thus, 28% have used it in a preventive way. A randomized study[26] used NIV in a prophylactic way in 500 patients, and demonstrated that NIV improves oxygenation, reduces respiratory complications and hospital readmissions. The preventive use of NIV within 48 hours after cardiac surgery, improves the values of ventilometry, respiratory muscle strength and peak of expiratory flow, which can prevent respiratory complications[5,25,26].

The subjects studied were characterized overweight (average BMI 28 kg/m^2). According to the BMI classification, 33% presented with some degree of obesity, and of these, 36% made use of NIV. The use of NIV in obese patients with hypercapnia is effective, however, there is a need for a higher level of PEEP, resulting in improved oxygenation, and decreased carbon dioxide and alveolocapillar difference[12]. Another anthropometric factor evaluated was the waist circumference, which had an average of 98 cm, being more prone to common respiratory complications in obese patients.

As a consequence of cardiac surgery, individuals have lung alterations that favor the development of postoperative pulmonary complications[22]. From these complications and from respiratory muscle strength, it is known that their weakness increases the respiratory work load, which may result in different clinical consequences, such as dyspnea and the need of use of accessory muscles of respiration[27]. It is believed that preoperative factors can minimize or worsen this condition, and these have been widely investigated, mainly the influence of these factors on postoperative complications[22].

The studies of Riedi *et al*.[28] and Bastos *et al*.[24] showed a decrease in postoperative respiratory muscle strength, when compared to the pre values, however, it was found no relation between preoperative dysfunction of respiratory muscles with postoperative pulmonary complications, and these are similar results to those found in this study.

In contrast to all, the study of Savci *et al*.[29] found that preoperative respiratory muscle training, with the goal of improving muscle strength, decreased the length of hospitalization in the ICU and led to the recovery of respiratory muscle more quickly. In another study, Hulzebos *et al*.[16] investigated preoperative factors that could influence the appearence of postoperative pulmonary complications, and found no relation to respiratory muscle weakness, however, it was verified that the maintenance of MEP 75% above what was predicted, was a protective factor.

Based on this, it is believed that perhaps the weakness of the respiratory muscles is not directly related to postoperative pulmonary complications, however, adequate respiratory muscle strength may contribute to a better and faster reestablishment of respiratory functions, lost due to the surgical procedure.

This study was limited to a sample of people who had undergone cardiac surgery at a hospital in Foz do Iguaçu, Paraná. It is suggested for the study to be continued, however longitudinally, including follow-up studies, seeking to better identify the factors which affect quality of life and the functional status of these patients.

CONCLUSION

The use of NIV was effective and safe for patients in the PO of cardiac surgery. However, no relation between preoperative decreased respiratory muscle strength and the recommendation and result of NIV was found.

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