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Evaluation of maximal inspiratory and sniff nasal inspiratory pressures in pre- and postoperative myocardial revascularization

Avaliação das pressões inspiratória máxima e inspiratória nasal sniff no pré e pós-operatório de revascularização do miocárdio

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Abstract

Objective: **The objective of this study was to evaluate and correlate inspiratory muscle strength using maximal inspiratory pressure (MIP) and sniff nasal inspiratory pressure (Pnsn) in patients with coronary artery disease in pre- and postoperative of myocardial revascularization surgery.**

Methods: **Thirty-eight men were studied, divided into a control group (CG) comprised of healthy individuals (n=18), age 55.52 ± 7.8 years and a myocardial revascularization group (MRG), comprised of patients with coronary artery disease submitted to myocardial revascularization (n=20), age 58.44 ± 9.3 years. All volunteers were submitted to MIP and Pnsn measurement, and the MRG was evaluated in the preoperative period and on the first postoperative day (PO1).**

Results: **MRG presented MIP (80.60 ± 26.60 cmH_2O) and Pnsn (74.70 ± 31.80 cmH_2O) values inferior to CG (MIP: 112.22 ± 32.00 cmH_2O; Pnsn: 103.70 ± 34.10 cmH_2O), and there was significant reduction of these values on PO1 (MIP: 40.05 ± 15.70 cmH_2O; Pnsn: 40.05 ± 16.60 cmH_2O). There was correlation and concordance between evaluation methods in both groups studied, as well as in pre- and postoperative MRG conditions.**

Conclusions: **The results showed that the studied patients presented reduced MIP and Pnsn pre- and post-operative myocardial revascularization. Also, the Pnsn correlated with MIP and can be considered suitable for assessing inspiratory muscle strength in this population.**

Descriptors: **Myocardial revascularization. Muscle strength. Respiratory muscles. Coronary Artery Disease.**

Resumo

Objetivo: **O objetivo deste estudo foi avaliar e correlacionar a força muscular inspiratória, pelas medidas da pressão inspiratória máxima (PImáx) e pressão inspiratória nasal sniff (Pnsn), em pacientes com doença arterial coronariana no pré e pós-operatório de revascularização do miocárdio.**

Métodos: **Foram estudados 38 homens, divididos em grupo controle (GC), composto por indivíduos saudáveis (n=18), idade 55,52 ± 7,8 anos, e grupo revascularização do miocárdio (GRM), composto por pacientes com doença arterial coronariana submetidos à revascularização do miocárdio (n=20), idade 58,44 ± 9,3 anos. Todos os voluntários**

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Abbreviations, acronyms & symbols	
CAD	Coronary artery disease
BMI	Body mass index
CG	Control group
COPD	Chronic obstructive pulmonary disease
CS	Cardiac surgery
FCR	Functional residual capacity
IMS	Inspiratory muscle strength
MIP	Maximal inspiratory pressure
MR	Myocardial revascularization
MRG	Myocardial revascularization group
Pnsn	Sniff nasal inspiratory pressure
PO1	First postoperative day

foram submetidos à mensuração da PImáx e da Pnsn, sendo o GRM avaliado no pré (pré-op) e primeiro pós-operatório (PO1).

Resultados: **O GRM apresentou valores de PImáx (80,60 ± 26,60 cmH_2O) e Pnsn (74,70 ± 31,80 cmH_2O) inferiores ao GC (PImáx: 112,22 ± 32,00 cmH_2O; Pnsn: 103,70 ± 34,10 cmH2O), ocorrendo ainda redução significativa destes valores no PO1 (PImáx: 40,05 ± 15,70 cmH_2O; Pnsn: 40,05 ± 16,60 cmH_2O). Houve correlação e concordância entre os métodos de avaliação nos dois grupos estudados, assim como nas condições pré e pós-operatória do GRM.**

Conclusão: **Os resultados demonstraram que os pacientes estudados apresentaram redução da PImáx e da Pnsn no pré e pós-operatório de revascularização do miocárdio, e que a Pnsn correlacionou-se com a PImáx, sendo adequada para avaliar a força muscular inspiratória nessa população.**

Descritores: **Revascularização miocárdica. Força muscular. Músculos respiratórios. Doença da artéria coronariana.**

INTRODUCTION

Cardiovascular diseases are the main causes of morbi-mortality and currently represent the highest costs for the health care system. Among these diseases, coronary artery disease (CAD) stands out. Alterations in muscular function have been described in cardiac patients, particularly in those with congestive heart failure, and include reductions in resistance and respiratory muscle strength that can lead to muscle failure [1-3].

Cardiac surgery (CS) has been used to treat these patients and presents expressive postoperative complication rates [4,5], particularly respiratory complications such as decreased oxygenation, pulmonary function and respiratory muscle strength, which increases the risk of postoperative morbi-mortality [6-8]. Respiratory mechanics are also affected in postoperative CS and may promote mechanical disadvantage which, being associated with pain, reduces the ability of respiratory muscles to generate tension [9]. In addition, this factor, which is promoted by reflex inhibition of the phrenic nerve and diaphragmatic paresis, is associated with diaphragmatic dysfunction and impairs respiratory function [10].

Maximal inspiratory pressure (MIP), which is used to measure inspiratory muscle strength (IMS), is an objective measurement of diaphragmatic dysfunction [11]. Alterations in ventilatory mechanics and IMS may cause difficulties in performing this procedure and, consequently, lead to inadequate results [12,13].

Sniff nasal inspiratory pressure (Pnsn) is a noninvasive, accurate and reproducible alternative for evaluating IMS [14]. Some studies has used this technique for the evaluation of different populations, such as chronic obstructive pulmonary disease (COPD), spinal cord injuries and neuromuscular diseases because It is a simple measurement and requires no sustained effort, thus allowing muscle recruitment [13, 15-17]. However, no reports were found in the literature regarding IMS measurement by means of Pnsn in cardiac patients submitted to myocardial revascularization (MR).

Therefore, the objectives of the present study were to evaluate and compare IMS obtained using the MIP and Pnsn measurements of volunteer cardiac patients in pre- and postoperative stages of MR surgery and to evaluate the concurrent validity of Pnsn for measuring IMS by correlating it with MIP.

METHODS

This study was approved by the Research Ethics Committee of the Methodist University of Piracicaba (protocol 75/09). Volunteer selection was based on sample calculations performed in GraphPad StatMate, v.1.01i and applied to the MIP variable. For a confidence level of 95% and a power of 85%, the number of volunteers suggested for each group was 18.

Thirty-eight male volunteers participated in the study (Table 1) in Hospital Fornecedores de Cana de Piracicaba and were divided into two groups: a control group (CG) including 18 apparently healthy volunteers, and a MR group (MRG) including 20 volunteers with CAD who were scheduled for MR. There was a sample loss of two MR group volunteers in the post-operative period due to hemodynamic instability, and so the total number of participants in this group was 18. CG volunteers were selected from the community and evaluated in the institution's laboratory where the study was carried out. Volunteers with CAD were selected based on the weekly surgery map provided by the hospital unit where the patients were admitted and evaluated.

Inclusion criteria for the CG were: a body mass index (BMI) between 18 and 29.9 kg/m², a sedentary life style according to the International Physical Activity Questionnaire [18], no history of respiratory and respiratory disorders, assessed by spirometry, no cardiac or neuromuscular diseases, no thoracic deformities, rhinitis or sinusitis, no nasal septal deviation, no fever for at least three weeks and no cold/flu in the week previous to the evaluation, as well as no use of oral corticosteroids, central nervous system depressants, barbiturates or muscle relaxants. Subjects who were smokers or were incapable of performing the procedures were excluded from the study.

Inclusion criteria for the GRM comprised, in addition to those described for GC: coronary insufficiency diagnosed by scintigraphy and confirmed by catheterization, elective MR surgery and clinical and hemodynamic stability. Exclusion criteria included: the development of postoperative respiratory complications, and difficulty understanding the procedures.

Application of the evaluation methods was randomized. At the end of the first measurement, the subject rested for 15 minutes before proceeding to the next method. CG patients were evaluated once and MRG patients were evaluated twice: once during the preoperative period and again on the first postoperative day (PO1).

MIP was measured in cmH_2O using an MVD 300 digital vacuum gauge (GlobalMed, Porto Alegre, RS, Brazil) according to the methodology proposed by Black & Hyatt [19].

Measurements for CG and MRG during the preoperative period were carried out with volunteers seated on a chair. On PO1 of the MRG, the measurements were taken with the volunteers seated on their beds since they could not be moved for the evaluation. Their nostrils were occluded with a nose clip to prevent air leakage. MIP was measured during maximal inspiratory effort, which was based on functional residual capacity (FRC) [13].

Volunteers performed at least five technically satisfactory maximal inspiratory efforts, i.e., without nasal air escape and with similar values among efforts (≤ 10%). The highest value in which inspiration was maintained for at least one second was used for analysis [19,20].

Inspiratory pressure generated at nose level was measured using the same equipment and with the volunteers in the same position. Measurement was carried out with one nostril occluded by a silicone nasal plug, which was connected to the vacuum gauge by an approximately 1 mm diameter catheter [21]. The maneuver consisted of a maximal sniff performed by the contralateral (free) nostril with the mouth closed, and was based on FRC values. The sniff test included ten repetitions [22] with a 30-second interval between each. A sniff was considered acceptable when there was gradual elevation of pressure until a peak lasting between 0 and 5 seconds was reached [13]. All values were recorded in each individual's file and the highest pressure value was used for data analysis.

The predicted values of MIP were calculated using the equation proposed by Neder et al. [20]: Predicted MIP = (-0.8 x age) + (0.48 x weight) + 119.7; and for the predicted values of Pnsn, the equation proposed by Uldry & Fitting [13] was used: Pnsn predicted = -0.42 x age + 126.8.

Data distribution analysis was performed with the Shapiro-Wilk test. The hypothesis of normality was rejected for all variables, so non-parametric tests were used: Mann-Whitney for unpaired samples and Wilcoxon for paired samples. Spearman's correlation coefficient was used to verify the relation between variables and the Bland-Altman method [23] was used to analyze the agreement between methods. The significance level for all statistical tests was 5%. Statistical procedures were carried out with GraphPad InStat v.3.05 and Medcalc v.11.5.0.

RESULTS

Table 1 presents the characteristics of the volunteers studied in the CG and the MRG in the preoperative period. There is no significant difference for any variable.

MIP and Pnsn values obtained were below predicted values only in the MRG (Table 2).

Table 1. Baseline characteristics of participants.

Characteristics	CG (n=18)	RMG Pre (n=20)
Age (years)	55.52±7.8	58.44±9.3
Anthropometric characteristics		
Body mass (kg)	81.34±15	77.00±11.3
Height (cm)	171.76±7.8	171.94±7.6
BMI (kg/m2)	27.4±3.5	25.98±3.7
Risk factors		
Smoking (n, %)	-	3 (15)
SAH (n, %)	-	8 (40)
Diabetes Mellitus (n, %)	-	8 (40)
Life style		
IPAQ	irregularly active	irregularly active
Medications		
Beta-blockers (n, %)	-	11 (55)
ACE inhibitors (n, %)	-	10 (50)
Hypolipidemics (n, %)	-	9 (45)
Hypoglycemics (n, %)	-	3 (15)
Diuretics (n, %)	-	1 (5)
Antiplatelet (n, %)	-	18 (90)

BMI: body mass index; SAH: systemic arterial hypertension; IPAQ: international physical activity questionnaire; ACE: angiotensin converting enzyme. Mann-Whitney test

Table 2 also shows that there was no significant difference between the MIP and Pnsn variables in the intragroup analysis. In the intergroup analysis, the MRG evaluated in the preoperative period presented lower MIP and Pnsn values than the CG.

Table 2. Predicted and obtained values of maximal inspiratory pressure (MIP) and sniff nasal inspiratory pressure (Pnsn) for the control group (CG) and myocardial revascularization group (MRG) during the preoperative period. Values expressed in mean and standard deviation.

Variables	GC (n=18)	RMG (n=20)
Predict MIP (cmH_2O)	114.30±9.8	109.66±10.2
Obtained MIP (cmH_2O)	112.22±32	80.60±26.6*#
Predict Pnsn (cmH_2O)	103.47±3.2	101.82±3.9
Obtained Pnsn (cmH_2O)	103.70±34.1	74.70±31.8*#

** P<0.05 predicted vs. obtained values (Wilcoxon test). # p<0.05 values obtained for the CG vs. values obtained for the RMG (Mann-Whitney test)*

Comparing the preoperative and PO1 periods, the MRG presented a significant decrease in MIP and Pnsn values. However, when MIP and Pnsn variables were compared, both in the preoperative period and on PO1, no significant differences were observed (Table 3).

The values obtained between MIP and Pnsn presented positive and significant correlation in both groups studied. For the MRG, the relation was present in both the preoperative and postoperative conditions (Figures 1 to 3).

Table 3. Values of maximal inspiratory pressure (MIP) and sniff nasal inspiratory pressure (Pnsn) of the myocardial revascularization group (MRG) (n=18), in the preoperative period (Pre) and on the first postoperative day (PO1).

Variables	Pre	PO1
MIP (cmH_2O)	82.61±27.3	40.05±15.7*
Pnsn (cmH_2O)	76.77±32.7	40.05±16.6*

** P<0.05 Pre vs. PO1 (Wilcoxon test)*

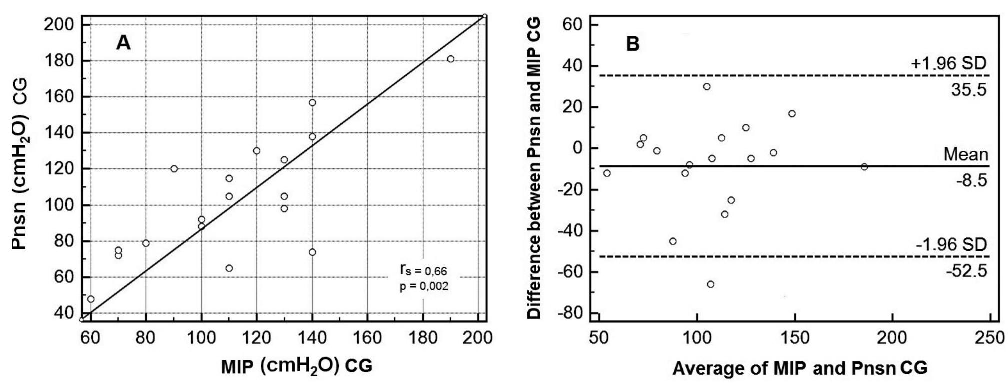

Fig 1 - A: Graph representing correlation analysis between the variables maximal inspiratory pressure (MIP) and sniff nasal inspiratory pressure (Pnsn). B: scatter graph for the difference and average between the variables MIP and Pnsn of the control group (CG)

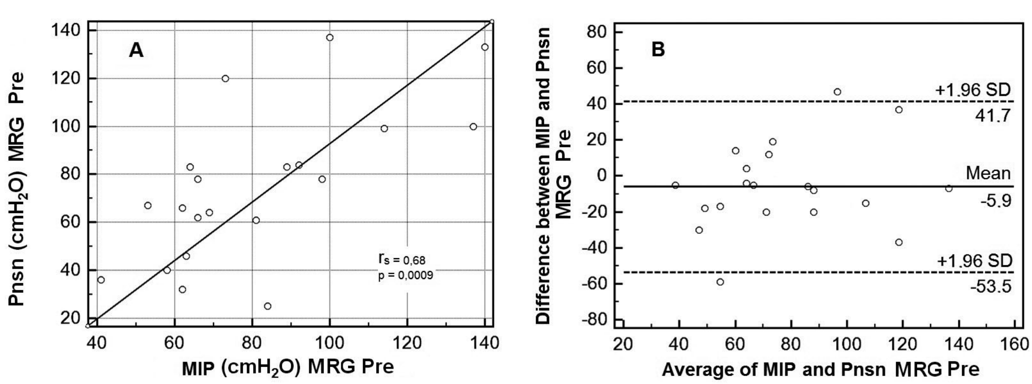

Fig 2 - A: Graph representing correlation analysis between the variables maximum inspiratory pressure (MIP) and sniff nasal inspiratory pressure (Pnsn). B: scatter graph for the difference and average between the variables MIP and Pnsn of the myocardial revascularization group on the preoperative period (MRG Pre)

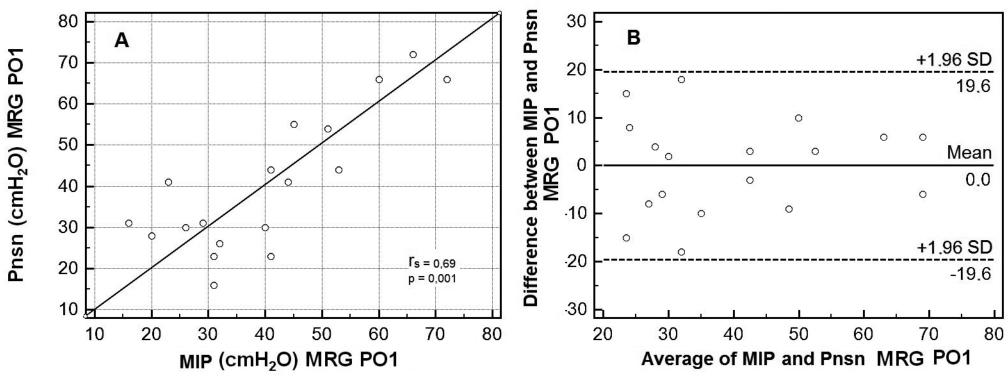

Fig 3 - A: Graph representing correlation analysis between the variables maximum inspiratory pressure (MIP) and sniff nasal inspiratory pressure (Pnsn). B: scatter graph for the difference and average between the variables MIP and Pnsn of the myocardial revascularization group on the first postoperative day (MRG PO1)

DISCUSSION

This results of this study revealed lower IMS in the MRG than the CG in the preoperative period and showed agreement between the MIP and Pnsn evaluation methods. In the preoperative period, the MIP and Pnsn values in MRG were lower than both the predicted values and those of the CG. The findings of this study are further reinforced by the significant negative correlation between MIP and Pnsn and the presence of CAD, suggesting that the disease can lead to decreased values of the variables studied.

MRG patients presented ischemic cardiomyopathy, particularly acute myocardial infarction (50% of the patients) and multivessel disease. Of the volunteers in this group, 18.75% had been submitted to unsuccessful angioplasty, which led to the recommendation of MR surgery. Thus, a probable justification for the reduced IMS found in this study is decreased blood supply to skeletal musculature in cardiopathies, including respiratory muscles [1,24], due to impairment of myocardial perfusion by coronary problems [1] and to reduced myocardial contraction, which is caused by myocardial ischemia [25].

Despite the lack of investigations on respiratory muscle strength in CAD patients, our results agree with those of studies on congestive heart failure, in which reduced IMS was observed in this population [1,26]. Furthermore, the literature reports that reductions in capillary density and oxidative enzymes in cardiopathies can lead to generalized muscular hypotrophy [25] and can even compromise the diaphragm muscle [27]. Another relevant factor is the chronic systemic inflammatory process caused by atherosclerosis and present in ischemic cardiomyopathy. This process can affect the respiratory system and lead to decreased respiratory function [28].

The significant decrease of both MIP and Pnsn after MR compared to preoperative values could have been due to direct or indirect injury of respiratory muscles during the surgery, as well as to diaphragm dysfunction as a result of phrenic nerve injury, which can be detected by x-ray and electromyography [6]. Such injury can promote reflex inhibition and diaphragm paresis, which impair ventilatory dynamics and pulmonary function [6,9,10,29,30].

According to Borghi-Silva et al. [9], respiratory mechanics presents damage after CS, which may lead to mechanical disadvantage that, being associated with pain, reduces the capacity of respiratory muscles to generate tension. Another negative factor is the low cardiac output found after MR, which can cause muscle fatigue, decreased thoracic mobility and superficial breathing [30]. General anesthesia should also be considered as a contributing factor because it depresses the respiratory system and can lead to alveolar hypoventilation, decreased FRC, alveolar collapse, and development of atelectasis during the postoperative period [6,9,31].

These factors are associated with median sternotomy and the presence of chest drains and may cause unsatisfactory performance of the MIP measurement maneuver [12]. For this reason, in order to minimize the difficulties of measuring IMS in postoperative MR patients, new evaluation methodologies should be proposed for situations in which conventional measurement is difficult for the patient.

Pnsn is among the measurement methods used and validated for evaluating IMS. It is a simpler technique than that used to measure MIP, involving less risk of fatigue since it is a natural, easy and short maneuver that demands less time at peak pressure [32].

Several studies have applied this methodology to healthy subjects [13] and to patients with neuromuscular diseases [14,17,22], spinal cord injury [16] and chronic obstructive pulmonary disease [17,33]. However, no studies measuring the IMS of CAD and postoperative MR patients by means of Pnsn were found.

Pnsn correlated with a simultaneous criterion, MIP, which was used as a parameter to analyze the accuracy of Pnsn, for concurrent validity. MIP was used because it is a noninvasive reference standard for measuring IMS. The high correlations between MIP and Pnsn and the agreement between methods demonstrated by the Bland-Altman [23] analysis identify Pnsn as an accurate method for measuring the IMS of these volunteers.

The results of this study, in demonstrating that IMS is better expressed by esophageal pressure during a maximal sniff (sniff POES) than by MIP [13], make an important contribution to the literature. However, even though sniff POES has limited clinical use because it is invasive and demands an esophageal balloon catheter system, Uldry & Fitting [13] demonstrated that it can be estimated in a noninvasive form by means of Pnsn.

Even though no studies with cardiac patients were found in the literature, Prigent et al. [32] affirm that Pnsn can be used as a first-choice method for evaluating IMS in healthy subjects due to the fact that it reproduces predicted values.

Therefore, the relation between MIP and Pnsn values is advantageous for IMS measurement, particularly in postoperative CS patients. Whereas MIP demands sustained effort, Pnsn requires only a quick effort, and its performance is easy and natural. Furthermore, Nava et al. [34] demonstrated in a study of diaphragm muscle peak EMG amplitude in both methods that Pnsn allows recruitment of 100% of the diaphragm muscle fibers, whereas only 61% are recruited in MIP performance.

It is important to point out the significant correlation between the MIP and Pnsn values obtained on PO1, considering that when Plmax values are low, Pnsn provides a way to distinguish inspiratory muscle weakness from difficulty performing sustained and continuous effort against an occluded airway [13]. Therefore, we can infer from this that pre- and postoperative CAD patients, in fact, presented reduced maximum inspiratory pressure since the values were reduced even during a maneuver that demanded less effort.

This study also gathered patient feedback about Pnsn. Their responses indicated that Pnsn was more comfortable and easier to perform than MIP, which reinforces its advantages, particularly in postoperative MR. However, scales for evaluating pain and the degree of satisfaction were not applied. Thus, we suggest that these variables be investigated in future studies.

The results demonstrate that both methodologies present similar values when evaluating this population. This study, therefore, can serve as starting point for other investigations.

CONCLUSION

In conclusion, the results demonstrated that the patients evaluated in this study showed reduced IMS in pre-and post-operative myocardial revascularization, and that the Pnsn correlated with MIP, which can be considered, therefore, the first-choice method when it aims to assess IMS in this population.

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