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Original article

Peripheral muscle strength and functionality as predictors of extubation success after myocardial revascularization

Força muscular periférica e funcionalidade como preditores de sucesso para extubação após revascularização do miocárdio

André Luiz Lisboa Cordeiro[1], Hayssa de Cássia Mascarenhas[1], Lucas Oliveira Soares[1], Vitória de Oliveira Pimentel[1], Layla Souza e Souza[1], Arthur Marchesini[1], Gabriel Velloso Dantas Batista Andrade Ferreira[1], André Raimundo Guimarães[2]

1. Centro Universitário Nobre, Feira de Santana, BA, Brazil
2. Instituto Nobre de Cardiologia, Feira de Santana, BA, Brazil

ABSTRACT

Introduction: Maximum inspiratory pressure (MIP) and the rapid and shallow breathing index are predictors for successful extubation. Peripheral muscle strength and functionality appear as possible predictors of success for extubation in other patient profiles, however, there is little evidence in patients undergoing to Coronary Artery Bypass Grafting (CABG). **Objective:** To assess peripheral muscle strength and functionality as predictors of success for extubation in patients undergoing to CABG. **Methods:** Prospective cohort study. At the time of hospital admission, patients were assessed for MIP, maximum expiratory pressure (MEP), Medical Research Council (MRC), peak of expiratory flow (PEF) and Functional Independence Measure (FIM). Patients were divided into two groups: Success Group (SG), which remained on spontaneous ventilation for more than 48 hours, and failure group (FG) that required invasive support in less than 48 hours. We compared the influence of muscle strength, cough and functionality variables between these groups. **Results:** 74 patients, Success Group (n = 59) and Failure Group (n = 15), were evaluated. The CI 95% was -1 (-5.33 to 3.33) in MIP, 4 (2.14 to 5.86) in MEP, 13 (-35.31 to 61.31) in PEF, 7 (6.27 to 7.73) in the MRC and 9 (8.08 to 9.92) in the FIM. **Conclusion:** Peripheral, expiratory muscle strength and functionality demonstrated a statistically significant influence on the success of extubation in patients after CABG.

Keywords: airway extubation; thoracic surgery; muscle strength.

RESUMO

Introdução: A pressão inspiratória máxima ($PI_{máx}$) e o índice de respiração rápida e superficial são preditores de extubação bem-sucedida. A força muscular periférica e a funcionalidade aparecem como possíveis preditores do sucesso da extubação em outros perfis de pacientes, mas há poucas evidências em pacientes submetidos à cirurgia de revascularização do miocárdio (RM). **Objetivo:** Avaliar a força muscular periférica e a funcionalidade como preditores do sucesso da extubação em pacientes submetidos à cirurgia de revascularização do miocárdio. **Métodos:** Estudo de coorte prospectivo. No momento da admissão hospitalar, os pacientes foram avaliados quanto à $PI_{máx}$, pressão expiratória máxima ($PE_{máx}$), *Medical Research Council* (MRC), pico de fluxo expiratório (PFE) e Medida de Independência Funcional (MIF). Os pacientes foram divididos em dois grupos: Grupo Sucesso (GS), que permaneceu em ventilação espontânea por mais de 48 horas, e grupo fracasso (GF), que necessitou de suporte invasivo em menos de 48 horas. Comparamos a influência das variáveis de força muscular, tosse e funcionalidade entre esses grupos. **Resultados:** Foram avaliados 74 pacientes, Grupo Sucesso (n = 59) e Grupo Falha (n = 15). O IC 95% foi de -1 (-5,33 a 3,33) na $PI_{máx}$, 4 (2,14 a 5,86) na $PE_{máx}$, 13 (-35,31 a 61,31) no PFE, 7 (6,27 a 7,73) na MRC e 9 (8,08 a 9,92) na MIF. **Conclusão:** A força muscular periférica, expiratória e a funcionalidade demonstraram uma influência estatisticamente significativa no sucesso da extubação em pacientes após a cirurgia de revascularização do miocárdio.

Palavras-chave: extubação das vias aéreas; cirurgia torácica; força muscular.

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Correspondence: André Luiz Lisboa Cordeiro, andrelisboacordeiro@gmail.com

Introduction

Cardiac surgery, even though it is a complex procedure, is the most used for treatment aimed at reducing mortality and symptoms in patients with coronary artery disease (CAD) [1]. Coronary Artery Bypass Grafting (CABG) covers 54.1% of cases and is the standard for patients with CAD [2].

Some complications can be caused after the surgical procedure. During the use of cardiopulmonary bypass (CPB), an inflammatory response is produced in the systems that generates movement of fluids from the intravascular space to the interstitial space, with this there is alteration in the blood fluid, injury or even myocardial cell necrosis, pulmonary dysfunction and, the longer it is used the more physiological imbalance the patient will have [3].

Other factors such as anesthesia, time and type of surgery, intensity of manipulation of the surgery, sternotomy and drains predispose to altered pulmonary function, which may progress to postoperative respiratory complications [4,5]. In addition to reduced pulmonary capacity, the surgical procedure can develop loss of peripheral muscle strength [6]. These complications may be associated with the negative outcomes of the surgery, one of which is the increase in the time of Mechanical Ventilation (MV), which consequently has an impact on extubation.

Due to such complications, the Functional Independence Measure (FIM) scale is used to assess these patients, which verifies the functional restriction of patients and the Medical Research Council (MRC) score that analyzes peripheral muscle strength [7,8].

Early extubation has already been used as a standard in several hospitals and some benefits are reported, such as reduced length of stay in the Intensive Care Unit (ICU) and decreased hospital stay [9,10].

It is necessary to evaluate accurately to identify the patient who is able to be extubated. Maximum inspiratory pressure (MIP) and the rapid and shallow breathing index are predictors for successful extubation [11,12]. Peripheral muscle strength and functionality appear as possible predictors of success for extubation in other patient profiles, however, there is little evidence in patients undergoing to CABG. Therefore, the aim of this study is verify whether there is an association between functionality and muscle strength with successful extubation in patients after myocardial revascularization.

Methods

Study design

This is a prospective cohort study conducted with the group of patients admitted to the Intensive Care Unit at the Instituto Nobre de Cardiologia (INCARDIO) in Feira de Santana, BA, from September 2017 to May 2019. The study was approved by the Research Ethics Committee of Faculdade Nobre de Feira de Santana, BA, under

the number 917.294. All patients were informed about the objectives of the study and signed a free and informed consent form.

Eligibility criteria

Patients of both sexes, aged over 18 years, who underwent to CABG with median sternotomy and cardiopulmonary bypass, undergoing the first spontaneous breathing test, awake and cooperative, were included. Patients with hemodynamic instability with a heart rate greater than 120 beats per minute, systolic blood pressure greater than 150 mmHg, use of vasoactive drugs at high flow, with signs of cardiac arrhythmia, excessive bleeding through the drains and pneumopathy were excluded.

Preoperative evaluation

At the time of hospital admission, patients were assessed for ventilatory, peripheral muscle strength, cough effectiveness and functionality. Muscle strength corresponded to MIP and maximum expiratory pressure (MEP), the peripheral was assessed through the Medical Research Council (MRC), cough by the peak of expiratory flow and functionality by the Functional Independence Measure (FIM). In addition to this information, clinical data such as comorbidities, body mass index, left ventricular ejection fraction and surgical risk were collected at this time.

Perioperative

CABG was performed through median sternotomy and cardiopulmonary bypass. Graft from the left internal thoracic artery or saphenous vein was used. The surgical procedure was always carried out by the same team and ended with the positioning of a subxiphoid drain, intercostal on the left and sternorrhaphy. Analgesia was optimized for all patients and was referred to the Intensive Care Unit.

Postoperative

Upon arrival at the ICU, the patients were connected to the Servo-S mechanical ventilator (Maquet Critical Care AB, Sweden) in volume-controlled ventilation mode, tidal volume of 6 to 8 ml/kg, respiratory rate of 15 incursions per minute, flow of 40 L / min, positive pressure at the end of expiration (PEEP) of 5 cmH_2O and fraction of inspired oxygen (FiO_2) at 60%. After that moment, all were managed by the team according to the unit's rules and conduct, without any influence from the researchers.

With the start of the ventilatory drive, the ventilation mode was changed to ventilation with pressure support (PSV) with sufficient support to generate a volume of 6 to 8 ml / kg, PEEP 5 cmH_2O and minimum FiO_2 that maintained peripheral saturation between 94-97%. At that moment, variables were evaluated to start MV interruption, such as hemodynamic stability (without or with minimal flow of vasoactive drugs), respiratory stability (arterial oxygen pressure above 60 mmHg, with PEEP < 8% and FiO_2 < 50%), absence of active bleeding through the drains, absence of postoperative arrhythmias and acid-base balance.

With these criteria and a satisfactory level of consciousness (Glasgow > 8), weaning was carried out and extubation was performed. Low-flow oxygen support was promptly instituted with sufficient concentration to maintain target saturation (94-97%). All patients were followed up for 48 hours to assess the success or failure of weaning. Return to invasive MV was considered unsuccessful within the first 48 hours after extubation. At that time, patients were divided into two groups: Success Group, which remained on spontaneous ventilation for more than 48 hours, and failure group that required invasive support in less than 48 hours. We compared the influence of muscle strength, cough and functionality variables between these groups.

Assessment tools

Preoperative assessment of inspiratory muscle strength, MIP, was performed using an Indumed® (São Paulo, Brazil) analogue manovacuometer. During the evaluation, a maximal expiration until the residual volume was requested, and then a maximal and slow inspiration to the total lung capacity was required. This test was done using the unidirectional valve method, being possible a flow through a hole of one millimeter, aiming to exclude the action of the buccinator, and repeated for three times, being used the highest value reached, as long as this value was not the last. MEP was evaluated using the same apparatus and the patient was instructed to perform a maximal inspiration until he reached his total pulmonary capacity, the mask was placed, and after that a maximum expiration was requested until the residual capacity was reached. The test was repeated three times and it was considered the highest value result, as long as this value was not the last [13]. Both tests were performed with the patient seated, lower limbs resting on the ground.

The Functional Independence Measurement that aims to measure what the person really accomplishes, regardless of the diagnosis, generating valid score for limitation or not. This scale assesses the patient's ability to develop body care, sphincter control, transfer and locomotion, as well as cognitive function such as communication and memory. A score from 1 to 7 is attributed, with the lowest value corresponding to the patient totally dependent and the maximum value was that patient completely independent from the functional point of view, reaching a maximum value of 126 points when all variables were added together [7].

The Medical Research Council (MRC) assesses peripheral muscle strength through the ability to overcome the load of six muscle groups (shoulder abductors, elbow flexors, wrist extensors, hip flexors, knee extensors and ankle dorsiflexors), scoring bilaterally each group from 0 to 5, where zero represents absence of contraction and five the patient wins the maximum resistance imposed by the examiner. The minimum score for this test is 0 (quadriplegia) and can reach up to 60 points (muscle strength preserved). A value less than 48 can be suggestive of a polyneuromyopathy [8].

Peak expiratory flow was evaluated using the peak flow of the Mini Wright® brand. During the evaluation, the patient was seated, with his head in a neutral position and a nasal clip to prevent air from escaping through the nostrils. The patient took a deep breath, until total pulmonary capacity, followed by forced expiration with the mouth in the device. After three measurements, the highest value was chosen and there could be no difference > 40 liters between measurements [14].

Statistical analysis

For data analysis, the Statistical Package for Social Sciences (SPSS) version 20.0 was used. Normality was verified using the Shapiro-Wilks test. Data were expressed as mean and standard deviation or median and interquartile range. For the analysis of categorical variables, Chi-square was used. For comparison between groups, the independent Student's T-test or Mann-Whitney was used. Pearson's correlation test was used to correlate the data. Statistical significance was set at $p < 0.05$.

Results

The research was carried out with seventy-four individuals. With a predominance of males with 49 (68%) patients, aged between 63 ± 5 years and having an average Body Mass Index (BMI) of 26 ± 3 kg/m². The prevalent comorbidity was Systemic Arterial Hypertension in 45 (76%). The other values are shown in table I.

Table I - Clinical characteristics of the studied patients

Variable	Sucess group (n = 59)	Failure Group (n = 15)	p-value*
Age (years)	62 ± 6	64 ± 5	0.74
Gender			0.41
Male	40 (68%)	9 (60%)	
Female	19 (32%)	6 (40%)	
BMI (kg/m²)	25 ± 3	27 ± 3	0.32
Comorbidities			
SAH	45 (76%)	10 (67%)	0.23
DLP	29 (49%)	8 (53%)	0.46
DM	36 (61%)	9 (60%)	0.86
AMI	7 (12%)	3 (20%)	0.61
Sedentary lifestyle	19 (32%)	7 (47%)	0.29

*Student's T test for independent samples; BMI = body mass index (weight / height²); SAH = systemic arterial hypertension; DLP = dyslipidemia; DM = diabetes mellitus; AMI = acute myocardial infarction

Among the surgical variables, it can be seen that there was no difference in the characteristics evaluated (Table II).

Table III shows the functional characteristics of the sample. Strength variables and PEF showed no statistical difference between groups. However, the MRC and MIF variables showed a statistically significant difference, with Group Success (GS) 58 ± 1 vs Group Failure (GI) 51 ± 2; ($p = 0.03$) and GS 125 ± 1 vs GI 116 ± 3; ($p = < 0.001$), respectively.

Table II - Surgical characteristics of the studied patients

Variable	Sucess Group (n = 59)	Failure Group (n = 15)	p-value*
CPB time (min)	92 (77 - 107)	89 (74 - 104)	0.75#
VM time (hours)	6 ± 2	7 ± 4	0.43
LVEF (%)	53 ± 3	55 ± 2	0.65
Number of bridges	2 ± 1	2 ± 1	0.92
Number of drains	2 ± 1	2 ± 1	0.94
Aortic clamping time (min)	79 (61 - 97)	85 (70 - 100)	0.27#
Surgery time (min)	231 (206 - 256)	245 (226 - 264)	0.18#

*Student's T test for independent samples; # Mann-Whitney test; CPB = cardiopulmonary bypass; V = mechanical ventilation; LVEF = left ventricular ejection fraction

Table III - Functional characteristics of the studied patients

Variable	Sucess Group (n = 59)	Failure Group (n = 15)	Difference between means CI 95%
MIP (cmH_2O)	115 ± 8	116 ± 5	-1 (-5.33 a 3.33)
MEP (cmH_2O)	118 ± 3	114 ± 4	4 (2.14 a 5.86)
PEF (L/min)	432 ± 87	419 ± 69	13 (-35.31 to 61.31)
MRC	58 ± 1	51 ± 2	7 (6.27 to 7.73)
FIM	125 ± 1	116 ± 3	9 (8.08 to 9.92)

*Student's T test for independent samples; CI 95% = confidence interval 95%; MIP = Maximum inspiratory pressure; MEP = maximum expiratory pressure; PEF = Peak Expiratory Flow; MRC = Medical Research Council; FIM = Functional Independence Measure

The blood gas values are expressed in the table below and show that there was a similarity between the groups, not influencing their final result (Table IV). Other correlation analysis is displayed in Table V.

Table IV - Pre-extubation gasometric variables of the studied patients

Variable	Sucess Group (n = 59)	Failure Group (n = 15)	p-value
pH	7.36 ± 0.4	7.34 ± 0.3	0.75
PaO_2 (mmHg)	99 ± 12	94 ± 7	0.56
$PaCO_2$ (mmHg)	37 ± 4	39 ± 5	0.65
HCO_3 (mEq)	23 ± 2	21 ± 3	0.45
FiO_2	0.4 ± 0.5	0.37 ± 0.4	0.49
PaO_2/FiO_2	248 ± 24	254 ± 18	0.54

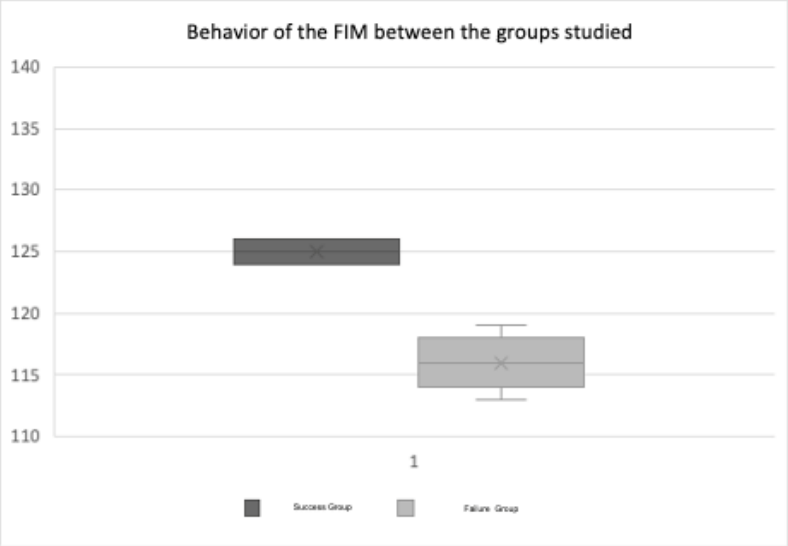
*Student's T test for independent samples; pH = Hydrogen potential; PaO_2 = Partial Oxygen Pressure; $PaCO_2$ = Partial Pressure of Carbon Gas; HCO_3 = Bicarbonate; FiO_2 = Inspired Oxygen Fraction; PaO_2/FiO_2: Partial Oxygen Pressure and Inspired Oxygen Ratio

Table V - Correlation between extubation success and functional characteristics

Variable	Extubation success*	
	r	p
MIP (cmH_2O)	0.07	0.64
MEP (cmH_2O)	0.55	0.02
PEF (L/min)	0.13	0.45
MRC	0.79	<0.001
FIM	0.84	<0.001

*Pearson correction test; MIP = maximum inspiratory pressure; MEP = maximum expiratory pressure; PEF = peak expiratory flow; MRC = Medical Research Council; MIF = functional independence measure

The FIM had a variation in its mean score of 125 ± 1 in the Success Group vs 116 ± 3 in the Failure Group and half of the patients in the Failure Group had a score less than 116 (Figure 1).



FIM = Functional Independence Measure
Figure 1 - FIM behavior between the groups studied

Discussion

Based on our results, peripheral muscle strength, expiratory force and functionality demonstrated a statistically significant influence on the success of extubation in patients after CABG.

The influence of ventilatory muscle strength as a predictor of failure in the weaning and extubation process is already known [15], but the participation of peripheral muscle strength in this process in patients undergoing cardiac surgery was still questioned. We found that the highest MRC score was associated with the success of extubation and there may be a direct relationship with the ventilatory force. There are studies that correlate these two forces, showing that the increase in ventilatory muscle function is reflected as improvement in peripheral strength [16,17].

Patients with lower values on the functionality scale were more dependent since the preoperative period may have influenced a later mobilization in the postoperative period and are associated with worse results on extubation. It is known that the late start of this therapy has a direct impact on the ventilatory and peripheral muscle strength of patients in the postoperative period [18-20].

The ventilatory muscle strength did not show statistical difference between the groups and this is justified by the fact that this evaluation was performed before the surgical process and, consequently, before the possible intraoperative damages. A reduction in the strength values is expected after the procedure, however, as these patients were not evaluated in the postoperative period, there is a gap regarding the decline of this variable and its possible contribution to the outcome.

Thille *et al*. [16] considered the muscle weakness acquired in the ICU assessed from the MRC as one of the important characteristics that influence extubation failure. In addition to reduced muscle strength, ineffective coughing was also associated with extubation failure in this study. Peak expiratory flow is a sign of the effectiveness of cough, with values below 60 L / min associated with an inability to protect the airways [17].

In our study, we found that peak flow was not associated with a worse extubation outcome, but maximum expiratory pressure, which also corresponds to coughing capacity, was reduced. This could represent a confounding variable, however, as PEF had no influence on the result, we cannot attribute the ineffective cough to the failure of extubation.

Kutchak *et al*. [21] mention in their research carried out with neurological patients, that there are differences in the motor activation of expiratory and accessory muscles during voluntary and reflex cough and that this could generate significant differences at the time of the extubation procedure. The data concluded that the PEF is a potential predictor of the success or failure of extubation in patients who pass the Spontaneous Breath Test.

Even the study presented some limitations, such as risk of bias in the lack of performing the sample calculation, lack of evaluation of the pain and the lack of follow-up in relation to functional outcomes. It was possible to obtain a positive result with regard to peripheral muscle strength and mainly functionality, however, we suggest further studies with a complete evaluation aiming to avoid complications and thus lead to extubation failure.

Conclusion

We concluded that peripheral and expiratory muscle strength and functionality demonstrated a statistically significant influence on the success of extubation in patients after coronary artery bypass grafting.

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Conflicts of interest
There are no conflicts of interest.

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Authors' contribution
Conception and design of the research, obtaining data and writing the manuscript: Cordeiro ALL, Mascarenhas HC, Soares LO, Pimentel VO, Pinto LMM, Mota MTS, Souza LS, Marchesini A, Ferreira GV-DBA; **Critical review of the manuscript for important intellectual content:** Guimarães ARF

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