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Preoperative maximal expiratory pressure is associated with duration of invasive mechanical ventilation after cardiac surgery: An observational study

Maurice Zanini, MSc, PT[a,*], Rosane Maria Nery, PE, ScD[b], Raquel Petry Buhler, PT[c], Juliana Beust de Lima, PE[a], Ricardo Stein, MD, ScD[d]

[a] Federal University of Rio Grande do Sul, Hospital de Clínicas de Porto Alegre, Brazil
[b] Physical Medicine and Rehabilitation Division, Hospital de Clínicas de Porto Alegre, Brazil
[c] Federal University of Rio Grande do Sul, Brazil
[d] Department of Medicine, Federal University of Rio Grande do Sul, Brazil

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ABSTRACT

Objective: To evaluate the association of maximal expiratory pressure (MEP), maximal inspiratory pressure (MIP), and peak expiratory flow (PEF) with total duration of invasive mechanical ventilation (IMV) in subjects undergoing cardiac surgery.
Background: Prolonged IMV is associated with respiratory infections, prolonged hospitalization, and increased mortality. Pulmonary function tests can help predict postoperative outcomes after cardiac surgery.
Methods: We recruited subjects admitted for cardiac surgery. All MIP, MEP, and PEF measurements were performed before surgery. Multivariable analysis was performed using a multiple linear regression model to control for possible confounders and test for association of MIP, MEP, and PEF with IMV duration.
Results: Overall, 125 subjects were included in the study. Higher MEP was associated with reduced duration of IMV after adjustment for confounders ($P = 0.015$), but no such association was observed between MIP or PEF and IMV.
Conclusions: In subjects undergoing elective cardiac surgery, preoperative MEP is associated with IMV duration.

Introduction

Pulmonary complications after heart surgery are a leading cause of postoperative morbidity[1] and are responsible for prolonged mechanical ventilation, longer hospitalization, disability[2] and higher mortality.[3] Identifying subjects who are at increased risk allows feasible preoperative interventions aiming to minimize adverse postoperative outcomes. Preoperative lung evaluation can be performed to stratify the risks related to changes in pulmonary function and respiratory muscle strength.[4] Low cost devices such as peak flow meters and pressure transducers are applicable in this setting, and the information derived from their measurements may be of prognostic significance.[5]

The aging process is accompanied by physiological muscle atrophy, and this impairment causes a reduction in respiratory muscle strength.[6] Alterations in neuromuscular function, reductions in physical activity levels, changes in nutritional state, and hormonal factors are all associated with this major muscular change.[7] The decrease in respiratory muscle strength may affect ventilatory drive, as well as other functions, such as coughing, speaking, and swallowing.[8]

The purpose of this study was to examine whether peak expiratory flow and respiratory muscle strength, measured preoperatively, were associated with duration of invasive mechanical ventilation (IMV) following coronary artery bypass grafting (CABG) and valve replacement surgery (VRS).

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* Corresponding author. Physical Medicine and Rehabilitation Division, Hospital de Clínicas de Porto Alegre, Rua Ramiro Barcelos, 2350 Porto Alegre, RS, CEP 90035-903, Brazil.
E-mail address: mauricezanini@gmail.com (M. Zanini).

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Methods

This prospective cohort study was conducted at a southern Brazilian hospital between April 2013 and March 2014. The findings are reported in accordance with the STROBE statement of transparency in observational study reporting. Subjects were consequently recruited who were listed for elective CABG and/or VRS. The inclusion criteria were age >18 years and elective cardiac surgery. We excluded those subjects who refused or were unable to provide informed consent; those with cognitive impairment, neuromuscular disorders, unstable angina, motor disability from stroke (Rankin score 3 or higher), severe lung disease (emphysema, grade 2 or worse chronic obstructive pulmonary disease, or malignancy), thoracic deformities; and those unable to perform respiratory muscle function testing.

The sample size calculation was based on a statistical power of 90% and a minimum correlation of 0.4 between the inspiratory pressure and primary outcome (duration of IMV), with an α of 5%. The final sample consisted of 124 subjects.

The primary outcome was the amount of time that subjects were under IMV (duration of IMV). We also evaluated need for supplemental oxygen after extubation, as well as length of intensive care unit (ICU) and overall hospital stay.

One day before surgery, subjects were admitted to the hospital for preoperative tests, risk assessment by European System for Cardiac Operative Risk Evaluation (EuroSCORE) and American Society of Anesthesiologists score (ASA) and preparation for the procedure. Respiratory muscle function was tested by measuring maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). Both MIP and MEP were obtained using a pressure transducer (Globalmed MVD300, Porto Alegre, Brazil). Peak expiratory flow (PEF) was obtained using an Assess Peak Flow Meter (Respironics, Pittsburgh, USA), following guidelines for pulmonary function testing. These procedures were repeated at least five times and the three highest measurements were selected for analysis, provided that the variation between them was not more than 10%.[9]

Subjects underwent surgery after baseline evaluation and were transferred to the intensive care unit. CABG and VRS were always performed under general anesthesia, using the following drugs: midazolam, fentanyl, pancuronium, and isoflurane. The team responsible for the postoperative care of subjects was blinded to respiratory assessments performed preoperatively.

The same weaning method was used for all subjects. When subjects awoke from anesthesia and had stable hemodynamic parameters and arterial blood gases, they were transferred for pressure support ventilation. After completed the stage, the subjects progressed to a trial of spontaneous breathing (through a T-piece) and, finally, were extubated. Extubation was performed after checking adequate clinical tolerance to the spontaneous breathing trial through a T-piece. This was defined as follows: a respiratory rate <38 breaths per minute, arterial oxyhemoglobin saturation (SaO_2) >90%, heart rate <130 beats per minute, no evidence of hemodynamic instability (<20% change in systolic or diastolic pressure), no change in mental status (drowsiness, coma, anxiety), no signs of respiratory discomfort, no diaphoresis, and no signs of increased work of breathing at the end of the trial. Progression to extubation was only interrupted or delayed if the patient exhibited respiratory or hemodynamic instability.

The surgical variables analyzed were cardiopulmonary bypass time, aortic clamping, type of prosthetic valve (for VRS), and number of grafts (for CABG). All data were gathered prospectively from patient charts and through information provided by medical staff. Subjects were followed up until discharge from hospital.

Statistical analyses were performed in the PASW Statistics, Version 18.0 software environment. Analysis of variance (ANOVA) was used to compare IMV duration between the types of surgeries. Multivariable analysis was performed using a multiple linear regression model to control for possible confounders and test for association of MIP, MEP, and PEF with IMV duration. We used multiple linear regression with hierarchical models, one unadjusted and one adjusting for variables with $P < 0.20$ in univariate analysis: gender, age, smoking index (packs/year), diagnosis of respiratory disease (asthma and grade 1 chronic obstructive pulmonary disease), peripheral vascular disease, diabetes, American Society of Anesthesiologists score, cardiopulmonary bypass time, type of surgery (CABG, VRS, both). All analyses used two-tailed tests, and P-values ≤ 0.05 were deemed significant.

The Research Ethics Committee of Hospital de Clínicas de Porto Alegre approved this study (judgment number 110154). Each participant provided written informed consent before data collection.

Results

A preliminary sample of 128 subjects was consecutively enrolled for the study at the time of hospital admission. Three subjects died before extubation and were excluded from analysis; hence, 125 patients were assessed for the primary outcomes. Five other subjects died after extubation but before hospital discharge, and were thus excluded from the analysis of the secondary outcomes. The remaining 120 subjects were followed until the end of the study (i.e., the day of discharge) (Fig. 1). Causes of death were endocarditis, perioperative acute myocardial infarction, pulmonary embolism, sepsis, and mesenteric ischemia.

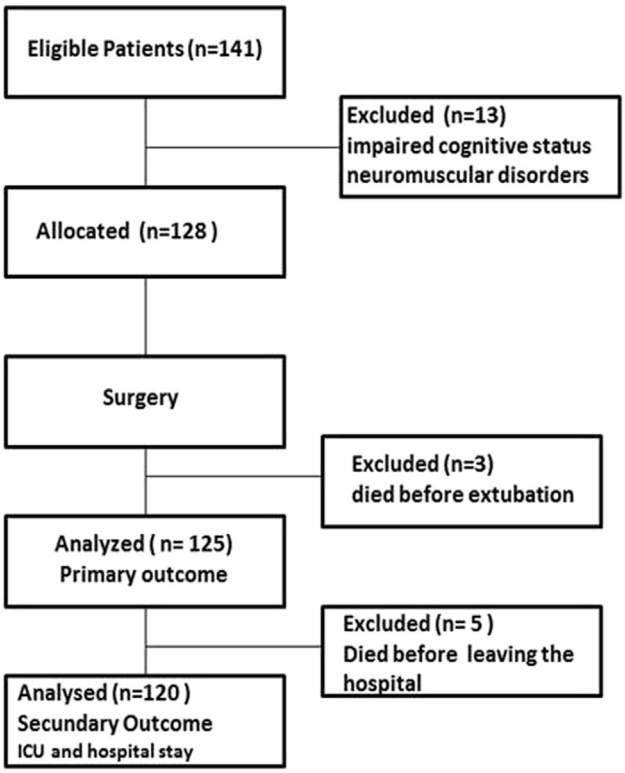

Fig. 1. Flow chart of study design.