Journal of Clinical Anesthesia (2016) **32**, 172–180

Journal of Clinical Anesthesia

Original contribution

Comparative analysis of respiratory muscle strength before and after bariatric surgery using 5 different predictive equations[☆,☆☆,☆☆☆]

Sjaak Pouwels MD[a,b,*], Marc P. Buise MD, PhD[c], Frank W.J.M. Smeenk MD, PhD[d,e], Joep A.W. Teijink MD, PhD[a,b], Simon W. Nienhuijs MD, PhD[a]

[a]*Department of Surgery, Catharina Hospital, Eindhoven, the Netherlands*
[b]*Department of Epidemiology, CAPHRI Research School, Maastricht University, Maastricht, the Netherlands*
[c]*Department of Anesthesiology, Catharina Hospital, Eindhoven, the Netherlands*
[d]*Department of Respiratory Medicine, Catharina Hospital, Eindhoven, the Netherlands*
[e]*SHE School of Health Professions Education, Maastricht University, Maastricht, the Netherlands*

Received 7 April 2015; revised 28 September 2015; accepted 7 March 2016

Keywords:
Bariatric surgery;
Respiratory muscle strength;
Inspiratory pressure;
Predictive equations

Abstract

Study objective: Obesity has detrimental effects on general health and respiratory function. This study aimed to evaluate respiratory muscle strength in the morbidly obese population, before and after bariatric surgery, and to compare these estimates with the predictive values using different mathematical equations available.
Design: Prospective cohort study.
Setting: Outpatient clinic for the treatment of obesity.
Patients: Patients scheduled for elective bariatric surgery.
Intervention: Bariatric surgery.
Measurements: The maximal inspiratory pressure (MIP) was measured at screening and 3, 6, and 9 months postoperative. Predictive values were calculated using 5 different mathematical equations. Visual inspection of Bland-Altman plots was performed to determine the agreement between the equations studied.
Main results: In total 125 patients were found eligible and 122 patients were available for the final analysis, among them were 104 women and 18 men, with a mean age of 43.02 ± 11.11 years and mean BMI of 43.10 ± 5.25 kg/m^2. In the preoperative period, the predicted MIPs according to the Harik-Khan, Neder, Costa, and Wilson equations were significantly different compared with the actual MIP ($P < .05$). The predicted MIP according to the Enright equation was not significantly different ($P > .05$). Postoperatively, there was a significant difference between the MIP values after 3 and 6 months and the predicted MIP values according to Harik Khan, Neder, and Enright equations. After 9 months, all predicted MIP values were significantly different from the predicted values. Bland-Altman analysis showed that the Enright equation was best suitable for predicting the MIP.

☆ Conflict of interest: None.
☆☆ Financial disclosure statement: All authors have nothing to disclose.
☆☆☆ Contributions: *Initial idea and design of the study*: S.P., M.B., F.S., J.T., S.N. *Data collection*: S.P., M.B., F.S., S.N. *Drafting and finalizing the manuscript*: S.P., M.B., F.S., J.T., S.N.

* Corresponding author at: Department of Surgery, Catharina Hospital, Michelangelolaan 2, P.O. Box 1350, 5602 ZA Eindhoven, the Netherlands. Tel.: +31 40 239 9850; fax: +31 40 239 9859.
E-mail address: sjaak.pouwels@catharinaziekenhuis.nl (S. Pouwels).

http://dx.doi.org/10.1016/j.jclinane.2016.03.005

Conclusion: Of the 5 mathematical equations studied, that of Enright and colleagues was found best suitable for predicting the MIP in the obese population studied.

1. Introduction

Obesity is the most common chronic metabolic disease worldwide and its prevalence has been strongly increasing [1]. Obesity is a risk factor for various conditions like, cardiovascular disease, type 2 diabetes, rheumatoid arthritis, and neoplasms. It is also associated with respiratory dysfunction often leading to obstructive sleep apnea and obesity hypoventilation syndrome [1].

1.1. Obesity and respiratory function

Over the last years, the effect of obesity on respiratory function has been studied; however, there is no consensus as to the physiological mechanisms that lead to respiratory dysfunction and/or complications. Respiratory dysfunction is associated with restrictive lung function disorder. Restrictive pulmonary dysfunction could be explained by the alterations in ventilatory mechanics experienced in the obese [2].

An increased deposition of fat on the chest wall causes a reduction in thoracic compliance and lung volumes [3–5]. The distorted balance in the interaction between the lung, chest wall, and diaphragm in this patient population causes impairment in respiratory mechanics and gas exchange [6].

To evaluate pulmonary function, spirometry is the first step. A pattern of restriction includes the following: (a) reduced forced vital capacity, (2) reduced forced expiratory volume in 1 second, (3) a normal ratio between these 2 (Tiffeneau Index, which is reduced forced expiratory volume in 1 second/forced vital capacity), and (4) reduced total lung capacity. In case of unexplained respiratory dysfunction, the measurement of maximal inspiratory pressure (MIP) can be of value in the evaluation of the differential diagnosis.

Studies on the behavior of respiratory muscle strength in morbidly obese patients have showed conflicting results [4–12]. Magnani and Cataneo [6] concluded that neither excess of body mass nor fat distribution on the thorax cage promotes respiratory muscle dysfunction. On the other hand, respiratory dysfunction is reported in this patient population, which might be due to an increased tensile strength caused by excessive adipose tissue in the thorax region and the abdomen. This can lead to a potential disadvantage in respiratory muscle mechanics [4,13].

1.2. Assessment of respiratory pressures

Assessing the maximal static respiratory pressure generated in the mouth, after complete inhalation and exhalation, carries out the measurement of respiratory muscle strength, divided in the MIP and maximal expiratory pressure (MEP), which are indicative of the strength of the inspiratory and expiratory muscle groups [14]. MIP is a measure of inspiratory muscle strength, whereas MEP measures the strength of the abdominal and intercostal muscles [15–17]. In cardiothoracic surgery, decreased respiratory muscle strength is associated with higher incidence of postoperative pulmonary complications [18,19]. Preoperative inspiratory muscle training can significantly reduce these postoperative pulmonary complications [18,19]. Obese patients have an altered pulmonary function and gas exchange and are therefore prone to postoperative pulmonary complications [3,20].

1.3. Predictive equations

Measuring MIP values can give valuable information about the respiratory muscle strength in the obese and can be used as a reference value for training of respiratory muscle strength. To set adequate training goals, the use of predictive equations is mandatory to set training goals [14,16,21–23]. However, the current predictive equations and reference values (of MIP and MEP) are based on the normal populations and less is known about the recommended reference values for respiratory muscle strength in the morbidly obese population. Also, there is no consensus on the best suitable mathematical equation for predicting respiratory muscle strength in this population.

1.4. Objectives

- Primary objective of this study is to identify which of the existing predictive equations is the most suitable for the morbidly obese patient.
- Secondary objective is to evaluate respiratory muscle strength in the morbidly obese population, before and after bariatric surgery, and to compare these estimates with the predictive values using different mathematical equations available.

1.5. Hypotheses

- Predictive equations that include anthropometric variables will either predict correctly or overestimate the MIP.
- Predictive equations without anthropometric variables will underestimate the MIP.

2. Methods

This study was approved by the Medical Ethics Committee of the Catharina Hospital Eindhoven and adheres to the