TITLE: Pulmonary function after weight loss in obese women undergoing Roux-en-Y gastric bypass: one year follow up.

INTRODUCTION:

Obesity is a condition that causes damage to the various body functions, such as cardiovascular, musculoskeletal, and metabolic functions amongst others (1). The respiratory function is also affected by obesity, as excess fat deposited on the chest wall and the abdominal cavity affects the chest mechanics. This results in increased work of breathing, reduced lung volumes, dysfunction of the respiratory muscle, impairment in gas exchange and reduced exercise tolerance (2-8).

A few studies have demonstrated that weight loss due to bariatric surgery has resulted in a huge improvement in some functions, such as decrease in hemoglobin and hematocrit (9), decreased heart rate and oxygen consumption (9), and reduction of insulin resistance (10). In addition, especially improved lung function with increased forced vital capacity (FVC) (3,11,12) and forced expiratory volume in one second (FEV₁), improved alveolar-capillary diffusion capacity (9) and improvement in gas exchange (11,12) have also been observed.

There is strong evidence supporting the increase in FVC and ERV (expiratory reserve volume) after weight loss caused by the bariatric surgery (3,11,12). However, controversy still persists regarding the behavior of the respiratory muscle strength and IRV (inspiratory reserve volume) after weight loss caused by the Roux-en-Y gastric bypass surgery.

The objective of the present study was to evaluate the effect of weight loss, after 1 year of the Roux-en-Y gastric bypass surgery (RYGB), on the lung volumes and the respiratory muscle strength in obese women.
METHODS AND PROCEDURES:

Patients

Were recruited 58 obese women candidates for RYGB at the XXXXXXX Hospital. However, only 14 of them participated in the entire study, since the other patients did not attend the assessment 1 year after surgery, because they quit or other personal difficulties. So, the final sample consisted of 14 obese patients. It was included patients with body mass index (BMI) 35 – 50 kg/m² and if they met the minimal criteria for bariatric surgery proposed by the World Health Organization (WHO) report of 2000\(^1\). The following were not included in the study: patients suffering from pulmonary diseases or those unable to carry out the pulmonary function tests adequately, smokers, patients who did not attend the re-evaluation 1 year after surgery and patients refusing to sign the Informed Consent Term. The present study was approved by the XXXXXXX Ethics Committee (protocol number 01/07).

Pulmonary Function Tests

The evaluation of the pulmonary function was carried out by conventional spirometry using a personal computer version of the NDD EasyOne™ Spirometer Model 2001 (Medizintechnik AG, Zurich, Switzerland). Parameters, such as volume, capacity, and flow of the lungs were directly evaluated by using the slow vital capacity (SVC), the forced vital capacity (FVC), and the maximum voluntary ventilation (MVV) tests, with volunteers in a sitting position and a minimum of three repetitions, as recommended by the American Thoracic Society (ATS) and the European Respiratory Society (ERS) (13). The obtained results were expressed in absolute values and as percentages of the predicted reference values for the Brazilian population (14). The SVC test produced the following variables: vital capacity (VC), tidal volume (VT), inspiratory reserve volume (IRV), and expiratory reserve volume (ERV). The FVC test allowed the determination of the forced expiratory volume in 1 s (FEV\(_1\)) and the FEV\(_1\).
FVC ratio. The MVV (variable that evaluates the respiratory endurance), was expressed in liters per minute and as a percentage of the predicted reference value for the Brazilian population (14).

The respiratory muscle strength was determined through the maximal static respiratory pressures measured during forced inspiration and expiration — maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP). The measurement was carried out using an aneroid manometer (Wika®, Ipero-SP, Brazil), calibrated in centimeter H₂O (±300 cm H₂O) and equipped with a 2-mm hole to relieve the oral pressure. The procedure was carried out as described by ATS/ERS (15). MIP and MEP were determined using the residual volume and the total lung capacity, respectively, with the subjects in a sitting position. The inspiratory and expiratory efforts were held for at least 1 second. Patients carried out at least three acceptable inspirations/expiration wearing a nose clip for determining the two reproducible inspirations/expiration. The highest values were used in the analysis. The MIP and MEP values were also expressed as percentages of the predicted values, according to the equation proposed by Neder et al (16).

One year after surgery, the patients were asked to return for a re-evaluation of the pulmonary function tests, spirometry and respiratory muscle strength, as it was done in the preoperative period.

**Statistical Analysis**

The data collected were expressed as mean ± standard deviation and analyzed by the Shapiro-Wilk test. After verifying the normal distribution of the variables, the paired t test was used to compare the preoperative and 1 year postoperative results.

The sample size had an 80% power at the 0.05 level of significance with IRV as the main variable.
RESULTS

The characteristics of the patients, such as age, BMI, weight and W/H ratio are shown in Table 01. There was a significant reduction in the values of weight, BMI, and W/H ratio 1 year after the surgery. However, these results were already expected. The BMI value returned to normal in 7 patients and in the other 7, it lowered to the range of overweight (25-30 kg/m²). Before surgery, 6 patients had hypertension, 4 had dyslipidemia and 2 had diabetes. One year after the surgery, 3 patients continued with hypertension and 1 with dyslipidemia. However, the diseases were less severe than in the preoperative period.

On analyzing the variables that measure lung volumes was observed that there was a significant increase in the VC, FVC and FEV₁. However, when examining the components of the VC separately, an increase in ERV and reduction of IRV, keeping the VT unchanged after 1 year of surgery was observed. Furthermore, respiratory endurance assessed by MVV also increased after weight loss (Table 01).

Moreover, in assessing respiratory muscle strength, it was recorded a reduction in the values of MIP and MEP. However, only statistically significant for MEP (Table 01).

DISCUSSION

Based on the obtained results, it was established that 1 year after the RYGB surgery, the patients showed a significant reduction in the measures of weight, BMI and W/H ratio, and especially changes in the lung function tests, such as spirometry and respiratory muscle strength.

Studies by some authors (11,17) have shown an improved lung function in patients evaluated after 1 year following weight loss induced by bariatric surgery, and others have attributed this improvement mainly to the reduction in the W/H ratio. El-
Gamal et al. 2005 (18), found that the patients showed an improvement in dyspnea and a reduction in the respiratory drive after weight loss induced by bariatric surgery. In the present study, after one year of surgery, the patients showed increased lung volumes and a tendency to decrease the respiratory muscle strength.

With respect to the volumes, an increase in VC, FVC and FEV, could be observed after weight loss. Other authors have also found similar results in previous studies (11,17,19-21). However, in this study, it was noted a finding still not published and discussed in the literature: the IRV reducing associated with an increase of ERV.

The reduction of ERV is a major known change in the respiratory function caused by obesity. According to Koenig 2001 (3), this fact is attributed to the reduction of the diaphragm mobility in the chest. This is because the diaphragm is pressed upwards due to the expanded abdominal volume of the obese individuals, which is a mechanical disadvantage for this muscle. Besides these detrimental mechanical aspects to the pulmonary function of obese individuals, Young et al 2003 (22) also suggested that the reduction of the ERV could lead to an increase in areas of atelectasis. As a result the ventilation/perfusion mismatch could be harmed, thereby leading to arterial hypoxemia in those individuals.

Weiner et al 1998 (21), also revealed an increase of ERV after weight loss. However, there is no report related to the reduction in IRV. Costa et al 2008 (23) compared the pulmonary function in the obese and non-obese subjects. A higher IRV and lower ERV in the first and the opposite in the other, with no significant changes in the VC values between the groups were observed. According to the authors, this is due to the problems in the chest mechanics of obese individuals, which could have resulted in a compensatory increase in IRV by reducing the ERV caused by obesity, while retaining an unchanged CV. Thus, in the present study there was a tendency to return to the patterns of distribution of the lung volumes of the non-obese individuals in
studied patients. Therefore, the obtained results suggested that the weight loss induced by bariatric surgery altered the chest mechanics, by a rearrangement of the volumetric lung compartments inside the rib cage, especially for abdominal descompression after weight loss of these obese patients.

El-Gamal et al 2005 (18), evaluated obese patients in the preoperative and 1 year after bariatric surgery, and found that the low value of ERV is related to increased of respiratory drive and dyspnea, with improvement in these parameters after weight loss. These results help to consolidate the hypothesis that obesity, by reducing ERV, leads to a respiratory overload (inspiratory mainly), verified by the increase in dyspnea and respiratory drive (18), leading to increased of IRV. And finally, after weight loss these changes are reversed.

Another important variable that influences the lung function is the respiratory muscle strength, and the available data in the literature are still few and controversial about this variable after weight loss. Dávila-Cervantes et al 2004 (11) and Weiner et al 1998 (21) also measured MIP and MEP after bariatric surgery and found an increase in these variables. Wadstrom et al 1991 (24), found a reduction in the respiratory muscle strength after weight loss induced by bariatric surgery, in agreement with the results of the present study. One explanation for this finding could be the loss of lean body mass after bariatric surgery, as described by some authors (24-27).

The average weight loss with RYGB is 30% (28), which is similar to the results of the present study. However, this loss is not only fat mass but also lean body mass. Stegen et al (29) found a reduction in the lean body mass associated with a reduction of static and dynamic muscle strength, whereby the authors suggested that physical activity prevents the reduction of muscle strength after bariatric surgery. However, one limitation of the present study was that it did not evaluate the lean body mass of the patients.
Another hypothesis is that the reduced work of breathing in the obese individuals achieved with weight loss (18), no longer exerted “training” on the respiratory muscles of these individuals, thereby reducing the values of the respiratory muscle strength.

Despite a trend to decrease the maximal static respiratory pressures - MIP and MEP - there was an increase in MVV (a variable that evaluates the respiratory endurance). This fact can be justified as the weight loss promotes an improvement of the chest mechanics, increases the lung volumes (21), and reduces the work of breathing (18).

Based on the obtained findings, it was concluded that weight loss induced by bariatric surgery provides an improvement in the ventilatory mechanics, as evidenced by the increase in lung volumes (ERV, VC, FVC and FEV₁) and respiratory endurance (MVV) of obese women. Furthermore, the reduction in IRV appears to show a trend distribution of static lung volumes in the pattern as seen in the non obese patients. Additionally, there was also a tendency of reduction in the respiratory muscle strength, which could be caused by a loss of lean body mass and a reduction in the work of breathing after weight loss. However, further studies are warranted to confirm this hypothesis.

ACKNOWLEDGMENTS

The authors would like to thank the XXXXXXXXX, the Laboratory of Respiratory Therapy of XXXXXXXXX University – XXXXX and the XXXXXXX.

DISCLOSURE
The authors declare that there is no conflict of interest or competing financial interest related to the work described.

REFERENCES


7 - Jones RL, Nzekwu MMU. The effects of body mass index on lung volumes. Chest. 2006; 130: 827-33.


Additional files provided with this submission:

Additional file 1: BMC_table.doc, 39K
http://www.biomedcentral.com/imedia/1942277279614800/supp1.doc
Additional file 2: BMC_titlepage.doc, 29K
http://www.biomedcentral.com/imedia/7733282096148104/supp2.doc