Long-term effect of bariatric surgery on respiratory function in severe uncomplicated obesity

Mauro Maniscalco[1,2†], Anna Zedda[1], Stanislao Faraone[1], Maria Rosaria Cerbone[3], Valentina Antognozzi[3], Stefano Cristiano[3], Cristiano Giardiello[3] & Matteo Sofia[2]

†Author for correspondence
[1]Section of Respiratory Medicine, Hospital S. Maria della Pietà Casoria, Naples, Italy
Tel.: +39 817 411 457;
Fax: +39 815 453 213;
Email: mauromaniscalco@hotmail. com
[2]Dept of Respiratory Medicine, A.O. Monaldi, University Federico II of Naples, Italy
Tel.: +39 817 062 377;
Fax: +39 815 453 213;
Email: matsouni@libero.it
[3]Dept of Surgery, Hospital S. Maria della Pietà Casoria, Naples, Italy
Tel.: +39 815 804 042;
Fax: +39 815 453 213.

Background: Obesity can have profound adverse effects on the respiratory system. The long-term effects of weight loss attained by bariatric surgery on pulmonary function tests (PFT) are not well known. The aim of the study was to find out whether weight reduction induced by laparoscopic adjustable gastric banding is associated with a sustained improvement of the pulmonary functional parameters in the severely obese. **Materials & methods:** A consecutive series of 32 obese patients who had laparoscopic adjustable gastric banding were studied. BMI, walking distance, dyspnea and PFT were evaluated at baseline and after 12, 24 and 30 months after surgery. **Results:** 32 patients (24 females, age mean 36 ± 11 years) were evaluated. Mean BMI (kg/m^2) decreased from 43 ± 6 before to 35 ± 5 12 months postoperatively. The BMI remained decreased 24 and 30 months after surgery. In obese PFT increased 12 months postoperatively and it remained increased 24 and 30 months after bariatric surgery. Similarly, the distance walked increased from 453 m (range: 360–590) before operation to 626 m (range: 435–830) 1 year post-operatively ($p < 0.0001$) and the dyspnea score after the 6-min walk test was significantly reduced after operation. Both of these functional variables remained improved at 24 and 30 months after surgery. **Conclusion:** Weight loss induced by bariatric surgery consistently improves functional lung parameters and walking ability in severe uncomplicated obese individuals and this improvement is maintained over a long period. Long-term effects of consistent weight loss on functional capacity in severely obese subjects warrants further studies.

Obesity, the most common nutritional disorder in humans, is a major cause of mortality and morbidity for associated disorders [1,2]. Obesity can have profound adverse effects on the respiratory system, causing alterations in respiratory mechanics, respiratory muscle endurance and strength, pulmonary gas exchange, control of breathing, pulmonary function tests and exercise capacity [3–6].

Weight loss improves lung volume, function, gas exchange and ventilation perfusion matching in morbidly obese adult patients [7,8]. Bariatric surgery provides an effective means of weight loss and sustained weight control for the morbidly obese [9]. Only few studies have evaluated the influence of weight loss induced by bariatric surgery on respiratory function in severely obese subjects. The majority of them evaluated pulmonary function after a short period of time following surgery, usually between 6–12 months [10–14]. Moreover, there are few data on the long-term effect of bariatric surgery on respiratory function in severely obese subjects without considering cardiorespiratory comorbidities. However, in such subjects, subclinical cardiorespiratory dysfunction sensitive to weigh loss has recently been reported [14].

Therefore, the aim of this study was to assess the long-term effect of weight loss induced by bariatric surgery on respiratory function tests in uncomplicated patients with class III obesity.

Materials & methods

Subjects

Patients were enrolled between 2001–2004 and included 32 consecutive patients with class III obesity evaluated in that period for bariatric surgery (24 females, age mean ± standard deviation [SD] 36 ± 11 years). Strict exclusion criteria included the following: smoking history; respiratory infection within the past 3 weeks; atopy and/or chronic respiratory diseases; forced expiratory volume at 1 s (FEV_1)/forced vital capacity (FVC) ratio <0.7; heart disease and regular medications. The patients underwent laparoscopic adjustable gastric banding by pars flaccida technique for weight reduction [15] and after 12, 24 and 30 months from surgery, the same respiratory

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parameters and clinical questionnaires were re-evaluated. The study protocol was approved by the local ethics committee.

Surgical techniques

The Lap-Band® device (Inamed Health, Santa Barbara, CA) was secured around the proximal stomach, creating a 10–20-ml gastric pouch using the pars flaccida technique, which minimized perigastric dissection and kept the device out of the lesser sac. The band was secured around the stomach by three or four craniocaudal gastric-to-gastric sutures. The tubing was then brought out through the abdominal wall fascia via the 12-mm trocar site. The incision was extended to accommodate the port, which was secured to the abdominal wall using permanent sutures. Patients were evaluated for a band-fill at 6 weeks postoperatively.

Anthropometry

All anthropometric measurements were determined between 9 and 11 am with the subject barefoot and dressed in very light clothing. From these, the BMI was calculated as the ratio of weight to height squared for each subject.

Pulmonary function evaluation

Lung volumes, flow rates and single breath carbon monoxide diffusing capacity (DLCO) were determined using automated equipment (V Max 22 System SensorMedics, Milan, Italy). Forced inspiratory and expiratory maneuvers were performed three times and the best value obtained from the maximum inspiratory and expiratory flow-volume curves were used for comparison. Functional residual capacity (FRC) was measured by the nitrogen washout technique and residual volume (RV) was obtained as FRC minus expiratory reserve volume. Total lung capacity (TLC) was calculated as RV plus vital capacity (VC). Recommendation for standardized procedures for various lung function tests was followed [16].

6-min walk test, dyspnea & discomforts

The 6-min walk test (6mWT) was conducted according to a standardized protocol [17]. Subjects were instructed to walk from one end to the other of a 30 m hallway at their own pace, while attempting to cover as much ground as possible in the allotted 6 min. Subjects were allowed to stop and rest during the test, but were instructed to resume walking as soon as they felt able to do so. Oxygen saturation (SpO_2) was assessed both at the beginning and the end of the 6mWT by an oximeter (SIMS-BCI 3303, WI, USA). Subjects were also asked at the beginning and at the end of the walk whether they had experienced dyspnea. The dyspnea was rated by the Borg rating scale of perceived exertion [18]. Distance walked in meters at the end of the test was recorded.

Statistics

Data are presented as means ± SD. Analysis of variance (ANOVA) for repeated measures was used to evaluate differences between obese subjects before and after the surgery. Pearson correlation coefficients were used to assess the association between anthropometric measures, spirometric data and 6mWT parameters.

Results

Anthropometric characteristics & spirometric data

In obese patients, weight and BMI were significantly reduced 12 months after surgery and remained reduced at 24 and 30 months (**Table 1**).

All pulmonary parameters were within normal range before the operation. There was a significant increase in FVC, TLC, FRC and RV after the surgery at 12 months and these remained increased at 24 and 30 months following surgery (**Table 2**).

No correlation was found between the reduction of BMI and either maximal static, dynamic lung volumes or SpO_2.

6-min walk test & dyspnea

6mWT was completed by all the subjects without premature end or breaks.

The distance achieved by obese subjects after surgery during the 6mWT was significantly longer than before surgery (**Table 2**). The distance achieved after surgery at 12 months was not different than that achieved at 24 and 30 months following surgery.

A significant difference was found between the reduction in BMI and the increase in the walked distance ($r = 0.67$; $p < 0.05$).

The score of dyspnea is reported in **Table 2**. None of the patients were dyspnoeic at rest. Both the dyspnea score at rest and after the 6mWT were significantly higher in obese subjects before surgery than 12 months after surgery. The dyspnea score at rest and after the 6mWT recorded 12 months following surgery were no different to those achieved at 24 and 30 months after surgery (**Figure 1**).

No significant difference for SpO_2 was observed before and after surgery, neither at rest, nor during the 6mWT (**Table 2**).

Table 1. Weight and respiratory function tests in obese subjects before surgery and 12, 24 and 30 months after bariatric surgery.

	Presurgery	12 months	24 months	30 months	p-value
n	32	31	25	21	
Weight (kg)	116.2 (17)	88.3 (16)	86.0 (17)	88.2 (15)	<0.001
BMI	43.1 (6.4)	35.1 (5.2)	34.0 (6.4)	35.7 (5.0)	<0.001
FVC (% pred)	101.1 (11.2)	111.3 (13.4)	107.2 (10.5)	108.1 (11.1)	<0.01
FEV_1 (% pred)	99.5 (12.9)	108.0 (10.5)	109.1 (12.4)	111.4 (11.5)	<0.001
FVC /FEV_1	84.6 (2.9)	84.5 (4.1)	84.7 (3.9)	84.9 (4.4)	0.3
TLC (% pred)	93.2 (16.5)	102.2 (20.1)	104.1 (17.4)	103.2 (22.1)	<0.001
FRC (% pred)	67.0 (29.9)	91.4 (27.3)	93.4 (28.0)	93.1 (24.1)	<0.001
RV (% pred)	76.2 (34.7)	82.2 (36.5)	81.6 (26.4)	87.4 (24.5)	<0.001

Data represent mean (SD). BMI: Body mass index; FEV_1: Forced expiratory volume at 1 s; FRC: Functional residual capacity; FVC: Forced vital capacity; RV: Residual volume; TLC: Total lung capacity.

Discussion

Our study demonstrated long-term improvements in both functional lung parameters and walking ability in obese patients after weight loss induced by bariatric surgery. To assess the effect of weight loss we have enrolled subjects in the absence of comorbidities such as smoking exposure, cardiovascular and respiratory diseases.

The improvement in functional lung parameters after surgery is in agreement with other studies that showed an increase in pulmonary function during the first year after surgically induced weight loss [10,11,19]. Interestingly, we found a maximum increase 12 months after surgery, which persisted after 24 and 30 months from bariatric surgery.

Increases in lung volume after weight loss is not surprising as obesity is associated with an impaired ventilatory function in adults. Increasing BMI is typically associated with a reduction in FEV1, FVC, TLC, functional residual capacity and expiratory reserve volume [3,20]. Thoracic restriction associated with obesity is usually mild and attributed to the mechanical effects of fat on the diaphragm and chest wall, with diaphragm excursion impeded and thoracic compliance reduced.

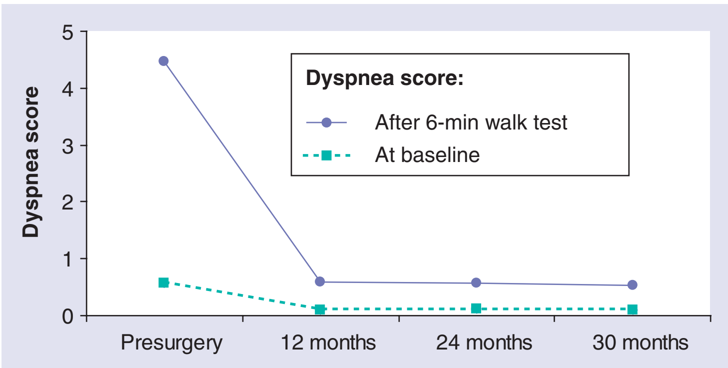
We did not find a significant correlation between lung volume increase and weight loss. This may be explained by several factors: first, baseline lung volumes were within normal ranges according to age and height, which could have caused the lack of correlation between weight loss and volume increase; indeed clinically significant restrictive pattern (TLC <85% predicted) is usually observed only in massive obesity [21]. However, a restrictive disorder may still be attributed to obesity when the weight-to-height ratio is less than 0.9 kg/cm. This typically occurs in the presence of central fat deposition, which is indicated by a waist-to-hip ratio of 0.95 or greater [22]. Furthermore, a low FEV1/FVC ratio (<70%), the spirometric signature of airflow obstruction, is not a feature of respiratory diseases

Table 2. 6-min walk test results.

	Presurgery	12 months	24 months	30 months	p-value
n	32	31	25	21	
6mWD (min)	453 (360–590)	626.3 (435–830)	621 (435–770)	643 (435–780)	<0.0001
Baseline SpO_2 (%)	97 (93–99)	97 (94–99)	97 (93–98)	97 (94–98)	0.2
SpO_2 after 6mWT (%)	96 (91–97)	97 (94–98)	97 (94–98)	97 (94–98)	0.1
Baseline dyspnea score	0.57 (0–2)	0.10 (0–0.5)	0.10 (0–0.5)	0.10 (0–0.5)	0.003
Dyspnea score after 6mWT	3.9 (1–6)	0.49 (0–2)	0.46 (0–2)	0.55 (0–1)	<0.0001

Distance walked, oxygen saturation and dyspnea score during 6mWT in obese subjects before surgery and 12, 24 and 30 months after bariatric surgery. Data represent mean (range).
6mWT: 6-min walk test; SpO_2: Oxygen saturation.

Figure 1. Dyspnea score at baseline and after six-minute walk test in obese patients before the surgery and at 12, 24 and 30 months after bariatric surgery.



associated with obesity, although evidence of small-airway diseases has been reported in this context [5]. Actually, despite the nonsignificant correlation between the absolute values of lung volumes and total weight loss, bariatric surgery could have exerted an effect on the operational lung volumes like end expiratory lung volume or inspiratory capacity, which might be responsible for the steady-state amelioration of ventilation assessed at second and during third year.

Interestingly, the most significant and sustained effect of weight loss was related to improvement of functional capacity assessed by 6mWT. In our study we found an increase of nearly 180 m in the distance walked after surgery, which represents a noticeable modification to the functional status [23].

Walking is one of the normal activities of life, reflecting the capacity to undertake daily activities [24]. Although the 6mWT did not provide specific information on the function of each system or mechanism implicated in exercise limitations, it has, however, two advantages: first, its simplicity and its low cost and second, it is a submaximal exercise that can be performed by obese and those who do not tolerate maximum exercise [25]. Consequently, subjects manage better with walking than other methods [26].

The distance achieved after the 6mWT was associated with the decrease in BMI after surgery; the smaller the BMI in obese subjects, the faster they walked. This is in agreement with previous studies on walking capacity in obese patients [27,28]. This seems evident, since obese people transport a larger body mass. However, as both the distance and the product of distance to weight have been reported to increase in obese subjects after weight loss [29], it is likely that the amelioration of of 6mWT is related to pulmonary and nonpulmonary factors involved in respiratory function and oxygen transport. In uncomplicated obese subjects, decreased right ventricular performance and reduced exhaled nitric oxide, an important regulatory of physiological ventilation/perfusion relationship, have been reported with significant improvement after bariatric surgery [14,30].

The effort perception estimated by the Borg scale was significantly reduced following the surgery. Our interpretations concerning dyspnea agree with the study of Langenfeld *et al.*, who validated the 6mWT following its correlation with power output, heart rate, SpO_2 and dyspnea evaluated during bicycle ergometry [31]. The increased dyspnea on exertion in the obese might be due to the transportation of the larger body weight, demanding a larger percentage of peak oxygen consumption [32].

Dyspnea in obese subjects is also due to deposition of fat mass under the diaphragm and on the chest wall, reducing lung volumes and decreasing compliance of the chest [33].

In conclusion, our results demonstrate that bariatric surgery consistently improves functional lung parameters and walking ability in uncomplicated obese subjects and this improvement is maintained over long periods following bariatric surgery.

Executive summary

- We have evaluated the effects of weight loss attained by bariatric surgery on pulmonary functional parameters in 32 consecutive severe obese patients.
- BMI, walking distance, dyspnea and pulmonary function tests (PFT) were evaluated at baseline and after 12, 24 and 30 months following surgery.
- A significant decrease in BMI 12 months post-operatively was observed, which remained decreased at 24 and 30 months after surgery.
- All the respiratory parameters and walking ability, including dyspnea during walking test, significantly improved 12 months postoperatively and remained increased 24 and 30 months after bariatric surgery.

Future perspective

The field of weight loss surgery is changing at an accelerating rate, which makes it incumbent to establish best practice standards for this area.

Patients will be well served by the development of standards and systems that will make it easier to track high incidences of complications or mortality.

Beyond standardizing the technical aspects, the study of the impact of the various weight loss surgical procedures on respiratory and cardiovascular systems will be well served by future research that focuses on and compares the efficacy and safety of surgical procedures.

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