Relationship of Dyspnea to Respiratory Drive and Pulmonary Function Tests in Obese Patients Before and After Weight Loss*

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Background: **Dyspnea is a common complaint in obese patients, who also frequently have abnormal pulmonary function test (PFT) results without evidence of lung disease. We studied the relationship between dyspnea, PFT results, and respiratory drive in morbidly obese patients before and after weight loss.**

Method: **Twenty-eight obese patients underwent PFTs including spirometry, lung volume measurements, and ventilatory drive assessment using the carbon dioxide rebreathing technique. The score of the dyspnea portion of the Chronic Respiratory Disease Questionnaire (CRQ) was used to assess dyspnea. CRQ and respiratory drive measurements were repeated in 10 patients after induced weight loss by gastroplasty**

Results: **Mean ± SD body mass index (BMI) prior to surgery was 47 ± 6.5 kg/m^2. Patients were then classified into two groups: group 1, mild-to-moderate dyspnea (dyspnea score > 4); and group 2, severe dyspnea (dyspnea score < 4). Group 2 had higher respiratory drive parameters and significantly lower lung volumes compared to group 1. After gastroplasty, there were significant reductions in BMI (p = 0.000), dyspnea score (p = 0.000), occlusion pressure 100 ms after the start of inspiration (P_{100}) at end-tidal carbon dioxide ($ETCO_2$) of 60 mm Hg (p = 0.011), minute ventilation ($\dot{V}E$) at $ETCO_2$ of 60 mm Hg, and $\dot{V}E$ slope (0.017). P_{100} slope was reduced, but it did not reach statistical significance.**

Conclusion: **The degree of dyspnea commonly observed in obese patients can be explained, in part, by increased ventilatory drive and reduced static lung volumes. Gastroplasty results in a significant reduction in BMI and respiratory drive measurements as well as significant improvement in dyspnea.** ***(CHEST 2005; 128:3870–3874)***

Key words: dyspnea; obesity; pulmonary function tests

Abbreviations: BMI = body mass index; CRQ = Chronic Respiratory Disease Questionnaire; DLCO = diffusion capacity of the lung for carbon monoxide; ERV = expiratory reserve volume; $ETCO_2$ = end-tidal carbon dioxide; FRC = functional residual capacity; MVV = maximum voluntary ventilation; $P_{0.1}$ = slope of the pressure; P_{100} = occlusion pressure 100 ms after the start of inspiration; PFT = pulmonary function test; TLC = total lung capacity; $\dot{V}E$ = minute ventilation; $\dot{V}O_2$ = oxygen consumption

Obese patients often complain of dyspnea despite not having demonstrable lung disease.[1,2] It has been hypothesized that increased chest wall mass along with increased abdominal size imparts a restrictive ventilatory defect, which then imposes an increased work of breathing.[2] Dyspnea is often attributed to this change in pulmonary physiology as well as the patient's increased weight and deconditioning. However, there is no evidence that definitively links dyspnea to the body mass index (BMI) or the percentage of ideal body weight. One study[3] correlated dyspnea in this population with maximum voluntary ventilation (MVV), which was also linked with a more pronounced lowering of static lung volume.

It has been demonstrated that normocapneic obese individuals have an increased respiratory drive when compared to normal subjects.[4] Also, normal individuals who have weight placed on their chest

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walls also exhibit an increased drive when measured by carbon dioxide rebreathing and by diaphragmatic electromyogram responses.[5–7] The severity of dyspnea has been shown to correlate with increased ventilatory drive in pregnancy,[8,9] asthma,[10] and COPD.[11] Therefore, we hypothesize that the dyspnea in obesity is related to an increased respiratory drive similar to those pulmonary disorders, and we want to establish if weight loss induced by gastroplasty has any effect on respiratory drive. We also studied if a reduction in lung volumes could also be a surrogate marker for increased respiratory load and therefore predict the severity of dyspnea.

Materials and Methods

Patients ≥ 18 old who were being evaluated for gastric bypass aimed at weight reduction at the New England Medical Center between March 2000 and October 2002 and who underwent routine pulmonary function tests (PFTs) as part of their preoperative screening were asked to participate in the study. The study was approved by the Human Investigation Review Committee at our institution, and all patients gave informed, written consent. Patients were excluded if they had one of the following: a history of chronic lung disease, smoking, hypoventilation syndrome, obstructive lung disease, or changes in PFT results inconsistent with changes seen in obesity (such as a FEV_1/FVC ratio < 70, or a low diffusion capacity of the lung for carbon monoxide [DLCO]). Patients were also excluded if they had a history of sleep-disordered breathing or any symptoms suggesting obstructive sleep apnea. BMI was recorded in all subjects before and after weight loss.

Patients underwent PFTs as part of a routine preoperative evaluation that included spirometry, MVV, static lung volumes measured by nitrogen washout, and single-breath DLCO (Vmax229; SensorMedics; Yorba Linda, CA). Results were recorded as percentage of predicted using the European Respiratory Society 1997 regression equations. Patients enrolled in the study also underwent ventilatory drive assessment, using carbon dioxide rebreathing technique described by Read[12] using 7% carbon dioxide as initial concentration. The occlusion pressure 100 ms after the start of inspiration (P_{100})[13,14] was measured in a random fashion with software provided with a metabolic cart (Vmax; SensorMedics). Minute ventilation ($\dot{V}E$) was also measured using a pneumotachograph, and end-tidal carbon dioxide ($ETCO_2$) was measured directly with an infrared analyzer. The test was terminated when $ETCO_2$ reached 65 mm Hg or if the patient was too uncomfortable to continue. Both P_{100} and $\dot{V}E$ were plotted against $ETCO_2$, and a "best fit" line was calculated using statistical software (version 9; SPSS; Chicago, IL). The slope of the line from this calculation and the $ETCO_2$ value of 60 mm Hg extrapolated from the line equation were then reported as the parameters of respiratory drive. Patients were also asked to take the Chronic Respiratory Disease Questionnaire (CRQ),[15] which has four domains: fatigue, mastery, dyspnea, and emotional function. The average response to the dyspnea domain questions was considered the dyspnea score. We then performed CRQ and respiratory drive measurements on a total of 10 patients 12 months after gastroplasty.

All statistics were computed using statistical software (version 9; SPSS). Linear regression was performed to look for correlations between physiologic parameters and dyspnea score. Patients were also classified into two groups based on their dyspnea score (mild or no dyspnea vs moderate or severe dyspnea) for analysis. For all recorded parameters, the mean value and SEM were calculated. Means of the two groups were compared using the Student *t* test, and the values for the CRQ and respiratory drive before and after weight loss were compared using a paired *t* test.

Results

Originally, a total of 29 patients participated in the study, but 4 patients were excluded because they could not tolerate respiratory drive testing. The mean BMI was 47 ± 6.5 kg/m^2; Table 1 lists mean PFT results. All patients had an FEV_1/FVC ratio > 70%. All patients showed some degree of dyspnea. When using a linear regression model, dyspnea score did not correlate with BMI, weight, MVV, resting oxygen consumption ($\dot{V}O_2$), and $\dot{V}O_2$/kg. We did find weak correlations (R^2 < 0.3) between expiratory reserve volume (ERV) and functional residual capacity (FRC) and the dyspnea score. Comparing those with mild dyspnea (group 1, dyspnea score > 4) with those with moderate-to-severe dyspnea (group 2, dyspnea score ≤ 4), lung volumes (ERV, FRC, total lung capacity [TLC]) were significantly lower in group 2 than in group 1 (Table 2). BMI, $\dot{V}O_2$, $\dot{V}O_2$/kg, and MVV did not differ significantly between the two groups. The patients in group 2 were found to have a significantly higher $\dot{V}E$ slope than group 1. However, the $\dot{V}E$ at $ETCO_2$ of 60 mm Hg was not significantly different between the groups. The slope of the pressure ($P_{0.1}$) and the $P_{0.1}$ at an $ETCO_2$ of 60 mm Hg were increased in group 2, but this did not reach statistical significance.

After gastroplasty, 10 patients underwent repeat respiratory drive measurements and repeat CRQ; there was a significant reduction in BMI and an improvement in the dyspnea score (Table 3). All of the respiratory drive parameters were significantly reduced except for the slope of the P_{100}, which did not reach statistical significance. Unfortunately, the small numbers did not allow comparison between the originally defined groups.

Table 1—*Baseline Measurements of All Patients*

Parameters	Mean ± SD
BMI	47 ± 6.5
FVC, % predicted	105 ± 14
FEV_1, % predicted	97.2 ± 22.65
FEV_1/FVC ratio	81 ± 4
TLC, % predicted	97.8 ± 13.3
FRC, % predicted	71.4 ± 19.5
ERV, % predicted	48.9 ± 24.6
Residual volume, % predicted	87.6 ± 25.22
DLCO, % predicted	93.3 ± 15.2
MVV, % predicted	95.2 ± 15