Effects of Bariatric Surgery on Indices of Obstructive Sleep Apnea and Pulmonary Function Tests

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ABSTRACT

**Background:** Obesity reaches the epidemic situation. Obstructive sleep apnoea is a major concern in obese patients.

**Aim of the work:** To analyse apnoea hypopnea index and to evaluate changes in pulmonary functions before and after bariatric surgery in obese patients.

**Patients and Methods:** We identify 160 patients who met our inclusion criteria. However, 121 patients returned for follow up evaluation. They were 98 women and 23 men. 84 had Raux-en-Y gastric bypass and 37 had sleeve gastrectomy. They were subjected to full history taking, clinical examination, objective measures of obstructive sleep apnoea [apnoea hypopnea index, body mass index, mean oxygen saturation, low oxygen saturation, nasal continuous positive airway pressure and Pulmonary function tests]. In addition, all patients were submitted to a sleep study.

**Results:** Statistically significant improvement was obtained postoperative for apnoea hypopnea index, body mass index, nasal continuous positive airway pressure requirement, mean oxygen saturation and low oxygen saturation. The spirometry and lung volume finding showed statistically significant improvement in lung function parameters after surgery. There was a significant positive correlation between body mass index and apnoea hypopnea index, with significant negative correlation between body mass index and forced vital capacity.

**Conclusion:** Bariatric surgery is associated with significant improvement in pulmonary functions and obstructive sleep apnoea indices.

**Keywords:** Obstructive sleep apnea; Pulmonary functions; Obesity; Gastric bypass; Sleeve gastrectomy.

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* Main subject and any subcategories have been classified according to researchers' main field of study.
INTRODUCTION

Obstructive sleep apnea (OSA) is a common condition in morbidly obese patients with prevalence ranging from 12-78%[1].

Two percent of middle-aged women and 4% of middle-aged men have obstructive sleep apnea, a condition linked to obesity [2]. Weight loss improves symptoms associated with OSA[3].

Although, physicians advocate weight loss to their patients. However, only a minority of patients maintain their attained diet-weight reduction and only 3% of patients with OSA, who had a marked improvement in their sleep apnoea symptoms as a consequence of diet-weight reduction, maintained their weight after 5 years. However, many patients regained and even exceeded their baseline weight[4].

Bariatric surgery may help these morbidly obese patients. Gastric bypass [GB] surgery has confirmed to be an effective procedure used to reduce body mass index [BMI][5].

GB has been shown to be an effective modality to help treat OSA[6].

A little data exists concerning long-term result of GB induced weight reduction on indices of OSA[7].

Obesity also exerts important and complex effects on the respiratory system, excessive body weight may lead to impairment in the respiratory function and can cause a restrictive or an occasionally an obstructive pulmonary disorder[8,9].

We hypothesize that in morbidly obese patients, marked weight reduction obtained by bariatric surgery would offer an effective improvement in pulmonary functions and sleep quality.

AIM OF THE WORK

The purpose of this study was to analyze apnea hypopnea index [AHI], one year after bariatric surgery and evaluate the changes in pulmonary function tests before and after bariatric surgery in obese patients

PATIENTS AND METHODS

A list of patients who underwent Raux-en-Y GB and sleeve gastrectomy surgery was referred to sleep disorders center and pulmonary function test laboratory to identify patients who had been received a diagnosis of OSA during preoperative assessment.

We identified 160 patients who met our criteria, and 121 patients returned for follow up evaluation.

Inclusion criteria:

Patients with the following criteria were included in the study: 1] Morbid obesity with BMI between 40-60kg/m²; 2] Diagnosis of OSA prior to surgery with split-night polysomnography and prescription of nasal continuous positive airway pressure [CPAP]; 3] Split-night polysomnography “defined as combined diagnostic and CPAP titration study during same night” and 4] Patients at least 18 years of age.

Exclusion criteria:

On the other side, patient with one or more of the following were excluded from the study: 1] Any active malignancy; 2] Active alcohol or drug abuse; 3] Dementia or treatment refractory psychotic disease leading to inability to provide informed consent; 4] Use of medications that may interfere with the sleep structure; 5] History of chronic or active lung disease.

All patients provided an informed consent after full explanation of the study aim and its methods, before joining the study and before surgery.

In addition, the study protocol was approved by the local ethics and research committee of International Medical Canter [Jeddah, KSA] and Al-Azhar Faculty of Medicine [Damietta].

A 121 patients returned for follow up testing and were included in the subsequent analysis. They were 98 females and 23 males.

They were subjected to full history taking, clinical examination, objective measures of OSA [AHI, BMI, mean oxygen saturation, low oxygen saturation, nasal CPAP] and Pulmonary function tests. In addition, all patients were submitted to a sleep study as the following.

Sleep study:

Patients underwent split-night polysomnography during one night of sleep disorders before and after surgery and at least one year postoperative using Philips Respironics Alice 6 system [Royal Philips Electronics, USA, www.philips.com/ healthcare]. Patients attended the sleep disorders centre
two hours before their usual bedtime. Technicians attached transducers to measure: electroencephalogram [EEG] [central and occipital leads]; Electrooculography [left and right eyes]; electrocardiogram [ECG [V2]; Electromyography [geniohyoid, intercostal, and anterior tibialis] activities; measurement of nasal-oral airflow using a thermistor and oxygen saturation using a pulse oximeter. Sleep stages were visually scored in 30-second epochs. Each polysomnography [PSG] recording was analyzed manually.

Apnea was scored when air flow ceased for 10s or longer. Hypopnea was recorded when the airflow was below 50% for at least 10s followed by >3% oxyhemoglobin desaturation. The apnea/ hypopnea index [AHI] was calculated as the number of [apnea +hypopnea] episodes/hour of sleep time. Patients with an AHI more >20 were titrated to CPAP during split-night polysomnography.

In addition to apnea criteria, patient needed a minimum of 180 minutes of recording time and a period of rapid eye movement sleep, if no rapid eye movement sleep [REMS] occurred, titration begin after 180 min and an oxygen desaturation of <85%. The CPAP pressure started at 5 cmH2O and increase by 2.5 cm H2O increment every 15 min. In order to eliminate snoring and any remaining upper airway resistance syndrome [URRS] activity

Pulmonary function tests:

Pulmonary function tests [PFTs] were performed before and at least one year after bariatric surgery. The PFTs were performed using Geratherm Respiratory Spirometry [Geratherm Respiratory GmbH Sparkassen passage 1 97688 Bad Kissingen GERMANY] and Plethysmography.

All tests had been performed according to the recommendations of the American Thoracic Society /European Respiratory Society.

Each participant had been performed 3 tests [with 2 reproducible and acceptable maneuvers] in the setting position with a nose clip in place. The measurement included the forced vital capacity [FVC], forced expiratory volume in the first second [FEV1], FEV1/FVC %, residual volume and total lung capacity.

Statistical analysis of data: The collected data were collected in an excel sheet, then coded and analysed by statistical package for social science [SPSS] version 16 [SPSS Inc., Chicago, USA]. Numerical data were expressed as mean and standard deviation and groups compared by student [t] test, while qualitative data were expressed as number and percent distribution and groups were compared by Chi square test. P value < 0.05 was the cut-off for statistical significance.

Results

In the present work, 121 patients were evaluated with split-night poly-somnography and pulmonary function tests [spirometry and lung volumes] preoperatively and at 19+3.5 months postoperatively, 98 women [81%] and 32 men [19%]. 84 patients had Raux-en-Y GB and 37 patients had sleeve gastrectomy. Age, BMI and AHI preoperative were 41+10, 51+9 and 53+21 respectively.

Using the parametric paired T-test, statistically significant improvement was obtained postoperative for AHI, BMI, nasal CPAP pressure requirement, mean oxygen saturation and low oxygen saturation [p<0.05] with mean reduction of AHI by 72%, decreasing the AHI by 40+31 events per hour, mean reduction of BMI by 32% decreasing BMI by 17+9. Mean nasal CPAP requirement was reduced in 83% of patients and 70 of 121 patients no longer need nasal CPAP [57%] and 30 patients [24%] show significant reduction of CPAP pressure. The mean oxygen saturation improved by 3%, the low oxygen saturation improved by 16% from 75% to 91%. The values of pulmonary function tests before and after surgery can be seen in the table [1].

The spirometry and lung volume finding were expressed in absolute values and as a percentage of predicted values and shows statistically significant improvement in lung function parameters after surgery. The patients then divided to responders [BMI <30] 75 patients and non-responders [BMI >30] 46 patients table [2], and using parametric paired T-test show statistically significant improvement of studied parameters as shown in the table [2]. There was a significant positive correlation between BMI and AHI, and significant negative correlation between BMI and FVC%.
Table [1]: Patients characteristic data [n=121]

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preoperative</th>
<th>Follow up</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at time of surgery, years ± SD</td>
<td>41.60 ± 10.65</td>
<td>35.75 ± 10.50</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Sex [males, females]</td>
<td>23 males, 98 females</td>
<td>92 males, 35 females</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Weight [Kg] ± SD</td>
<td>125.35 ± 21.65</td>
<td>105.40 ± 18.20</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>BMI [kg/m²] ± SD</td>
<td>51.50 ± 9.35</td>
<td>51.75 ± 10.50</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>AHI</td>
<td>53 ± 21</td>
<td>13 ± 9</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Type of surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastric Bypass</td>
<td>84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeve gastrectomy</td>
<td>37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleep study after surgery [days]</td>
<td>580.16 ± 106.5</td>
<td>48.8 ± 15.8</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Pretest O₂ saturation %</td>
<td>96.5 ± 2.2</td>
<td>97.1 ± 1.9</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Mean O₂ saturation %</td>
<td>94.5 ± 3.2</td>
<td>97.4 ± 2.7</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Low O₂ saturation</td>
<td>75.5 ± 7.4</td>
<td>91.2 ± 3.7</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>CPAP pressure required</td>
<td>9.5 ± 2.5</td>
<td>4.5 ± 3.5</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Sleep time below 90% O₂ saturation [min]</td>
<td>138.4 ± 92.6</td>
<td>48.8 ± 15.8</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>

**P** value < 0.05 indicates significant difference

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preoperative</th>
<th>Follow up</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FEV1 [L]</td>
<td>2.81 ± 0.62</td>
<td>2.97 ± 0.55</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>FEV1% of predicted</td>
<td>79.6 ± 13.4</td>
<td>94.5 ± 7.5</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>FVC [L]</td>
<td>3.75 ± 0.73</td>
<td>3.93 ± 0.92</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>FVC % of predicted</td>
<td>81.5 ± 11.5</td>
<td>95.6 ± 10.7</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>FEV1/FVC %</td>
<td>80.5 ± 6.6</td>
<td>81.6 ± 5.7</td>
<td>0.35</td>
</tr>
<tr>
<td>TLC [L]</td>
<td>5.93 ± 1.4</td>
<td>6.43 ± 1.2</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>TLC [% of predicted]</td>
<td>75.4 ± 11.5</td>
<td>84.5 ± 10.5</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>RV [L]</td>
<td>1.56 ± 0.7</td>
<td>1.71 ± 0.8</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>RV [% of predicted]</td>
<td>80.35 ± 9.5</td>
<td>95.1 ± 10.3</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>

Table [2]: data of responders versus non-responders after 1 year

<table>
<thead>
<tr>
<th>Variables</th>
<th>Responders</th>
<th>Non-responders</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at time of surgery, years ± SD</td>
<td>35.20 ± 4.25</td>
<td>40.50 ± 11.50</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Sex [males, females]</td>
<td>18 males, 63 females</td>
<td>5 males, 35 females</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Weight [Kg] ± SD</td>
<td>92.50 ± 16.40</td>
<td>105.40 ± 18.20</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>BMI [kg/m²] ± SD</td>
<td>72.20 ± 3.35</td>
<td>35.35 ± 5.50</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>AHI</td>
<td>3.5 ± 2.1</td>
<td>14 ± 4.5</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Mean O₂ saturation during sleep %</td>
<td>96.5 ± 2.2</td>
<td>93.4 ± 2.5</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Low O₂ saturation during sleep%</td>
<td>90.15 ± 5.7</td>
<td>84.6 ± 4.6</td>
<td>&lt; 0.05</td>
</tr>
<tr>
<td>Patient need for CPAP n [%]</td>
<td>0</td>
<td>4.5 ± 3.5</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>

**P** value < 0.05 indicates significant difference
DISCUSSION

Main findings of this study are that obese patients with obstructive sleep apnea who underwent bariatric surgery had marked improvement of sleep apnea indices, BMI and many had discontinuation of their CPAP therapy within 19+3.5 months of surgery, we have only 21 patients out of 121 patients who did not show significant improvement of AHI, and this may be due high initial BMI.

Obstructive sleep apnea results from upper airway collapse that which leads to ineffective respiratory efforts during sleep. The occlusion of the upper airway structures is secondary to the excessive fatty tissue and its laxity, a condition that is characteristic in the morbidly obese. Resolution of sleep apnea is linked to improvement in the upper airway passage associated with weight reduction and loss of the upper airway fatty tissue[10].

Compliance with CPAP can be problem, thus the reduction or resolution of the need for CPAP has positive personal implication for patients requiring CPAP for OSA[3,9].

In the present study, we found that AHI reduced postoperatively by 72%, and these confirm the study of Gionmattia et al.[11] who evaluated the impact of sleeve gastrectomy on upper respiratory physiology in the long term [5 years] and they showed that AHI improved in 80.6% of patients after surgery and the other 19.4% of patients without improvement in AHI all had a respiratory resistance due to nasal obstruction. Also, our study correlate with study done by Myura et al.[12] who study self-report remission of OSA following bariatric surgery and they found that self-reported OSA remission rate was 60%, one year after surgery.

As current study, Lankford and colleagues reported a significant reduction in overall CPAP pressure after Roux en-Y gastric bypass[9]. Similarly, Haines et al. reported that in a group of patients with sleep apnea and on CPAP, at a median of 11 months after bariatric surgery, only [37%] patients were still on CPAP therapy[13].

Because sleep apnea is known to be associated with intermittent hypoxia and increased risk for heart failure and pulmonary hypertension, improvement of sleep apnea symptoms after gastric bypass may reduce the risk for cardiopulmonary dysfunction in high-risk, morbidly obese subjects[14].

Obesity can impair pulmonary functions and decrease exercise capacity due to its adverse effects on respiratory mechanics, respiratory muscle strength, lung volumes, work of breathing and gas exchange[15].

In the present study we found a significant improvement of respiratory functions after surgery in obese patients. These results are correlated with Wei et al.[16] who studied anthropometric parameters and pulmonary function tests in 94 patients after bariatric surgery and show significant decrease of anthropometric parameters and improvement of pulmonary function tests three months after surgery, and found that reduction in waist circumference [WC] correlate significantly with increase in FEV1 and FVC.

Also our study agree with Aguiar et al.[17] who studied 16 patient underwent bariatric surgery, 90 days after surgery and showed mean BMI reduced from 48.15+8.58 to 36.91+6.67kg/m^2, significant difference between preoperative and postoperative period regarding neck and waist circumference, maximum inspiratory and maximum expiratory pressure, significant improvement of FVC and FEV1 and significant reduction of AHI after surgery 15.65+15.51 to 6.26+7.57 event/hour. Also, Gabrielsen et al. [18] study pulmonary function tests and blood gases after gastric bypass in 76 patients after one year of surgery, they showed that improvement in pulmonary function tests and blood gases were significantly greater after surgery than after lifestyle intervention.

In the present study we divided the patients into responders [BMI <30 kg/m^2] 75 patients and non-responders [BMI >30 kg/m^2] 46 patients, and in comparison, between two groups we found more improvement in BMI, AHI and pulmonary functions in responder group, this may be due to younger age and lower initial BMI.

Despite our best efforts, many potential participants did not return for repeat polysomnography and PFTs, we considered possible reasons for subjects who did not return for repeat tests. This could be due to time factor [they want not to miss their work], the adequacy of insurance coverage and some show subjective improvement and did not believe re-evaluation was necessary.
The limitation of our study: majority of patients were females in whom lesser effects on lung functions are expected due fat distribution in the female body. In our clinical practice, we found that patients regain weight by time after surgery so we recommend long-term study of pulmonary functions and polysomnography after surgery.

**Financial and Non-Financial Relationships and Activities of Interest**

None

**REFERENCES**


