ORIGINAL ARTICLE

Does sleeve gastrectomy improve obstructive sleep apnea?

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KEYWORDS
Body mass index; Obstructive sleep apnea; Positive airway pressure; Sleeve gastrectomy

Abstract  Background: The prevalence of obstructive sleep apnea (OSA) increases with obesity. Bariatric surgery provides a significant weight loss for morbidly obese patients. The aim of this study was to evaluate the effect of sleeve gastrectomy on OSA symptoms, sleep parameter, continuous positive airway pressure (CPAP) use in OSA patients with morbid obesity.

Methods: Sixty consecutive patients for whom morbid obesity surgery was planned were enrolled. All patients underwent physical examination, anthropometric measurements, chest radiography, pulmonary function tests, electrocardiography, measurement of daytime sleepiness with the Epworth sleepiness scale (ESS), Berlin Questionnaire, STOP BANG Questionnaire, and full night polysomnography (PSG). Patients with apnea–hypopnea index (AHI) ≥15/h were instructed to use CPAP. A second PSG was conducted 6–12 months postoperatively.

Results: Twenty patients continued the study. The mean duration for follow up was 8.25 ± 0.96 months. There was statistically significant improvement in ESS, Berlin Questionnaire, and STOP BANG Questionnaire (p < 0.001). Also, there was statistically significant improvement in anthropometric measures (p < 0.001). There was statistically significant improvement in spirometric data (p < 0.01). There was statistically significant improvement in sustained sleep efficiency, basal oxygen saturation, minimal oxygen saturation, oxygen desaturation index, arousal index and AHI (p < 0.001). There was a significant reduction in the number of patients who need CPAP after surgery (p = 0.002) with decrease in the required CPAP pressure after surgery (p = 0.041).

Conclusion: Sleeve gastrectomy improves OSA symptoms, sleep parameter, and decreases the need and pressure of CPAP in OSA patients with morbid obesity.

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Abbreviations: AHI, apnea–hypopnea index; AI, arousal index; BiPAP, Bilevel Positive Airway Pressure; BMI, body mass index; BS, bariatric surgery; CPAP, continuous positive airway pressure; ECG, electrocardiography; EEG, electroencephalograms; EMG, electromyogram; EOG, electro-oculograms; ESS, Epworth sleepiness scale; FEV1, forced expiratory volume in first second; FVC, forced vital capacity; ODI, oxygen desaturation index; OSA, obstructive sleep apnea; PSG, polysomnography; RDI, respiratory disturbance index; REM, rapid eye movement; RYGBP, Roux-en-Y gastric bypass

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Introduction

Obstructive sleep apnea (OSA) is a disorder resulting from an obstruction of the upper airway during sleep, so the patient frequently stops breathing during his or her sleep. Diagnosis of OSA usually requires overnight polysomnography (PSG) to detect the frequency of apneic and hypopneic events [1]. OSA adversely affects multiple organs and systems. It has been implicated in the etiology of hypertension and in the progression of congestive heart failure, atrial fibrillation, pulmonary hypertension, and diabetes [2,3].

There is a proportionate relationship between obesity and OSA. It was reported that 60–90% of OSA patients have a body mass index (BMI) ≥30 kg/m² [4]. There is a parallel increase in the prevalence of OSA with increase in the prevalence of obesity. While the prevalence of OSA in the adult population is estimated to be about 25%, it rises up to 45% in obese persons [5].

There is a complex relationship between OSA and obesity. Obesity can worsen OSA as fat deposition in the tissues surrounding the upper airway can result in a smaller lumen and leads to increased collapsibility of the upper airway, predisposing to apnea [6]. Also, fat deposits around the thorax reduce chest compliance and functional residual capacity, and may increase oxygen demand [7]. OSA may itself cause weight gain [8]. Reduced activity levels and increased appetite may contribute to weight gain in OSA patients [9].

Unfortunately, diet therapy is relatively ineffective in treating obesity in the long term [10]. Bariatric surgery (BS) is currently the only modality that provides a significant, sustained weight loss for morbidly obese patients, with resultant improvement in obesity-related comorbidities [11]. According to the 1991 consensus guidelines from the National Institutes of Health, patients with BMI greater than 40 kg/m² or a BMI greater than 35 kg/m² with significant obesity-related disease are candidate for BS [12].

The aim of this study was to evaluate the effect of sleeve gastrectomy as a type of BS on OSA symptoms, sleep parameter, continuous positive airway pressure (CPAP) use and pressure in OSA patients with morbid obesity.

Patients and methods

Patients

The study was conducted in Sleep Respiratory Disorders Unit, Chest department, Mansoura university hospital in the period between June 2013 to June 2015. Ethical approval has been obtained from Medical Research Ethics Committee, Mansoura University. Sixty consecutive patients for whom morbid obesity surgery was planned were enrolled to participate in the study after an evaluation according to the following inclusion criteria: BMI ≥ 40 kg/m², age > 18 years, failure to lose weight for at least 1 year despite drug and dietary therapies, and capable of understanding the operation and postoperative requirements. Patients with BMI < 40 kg/m², decompensated heart and/or lung diseases, known malignancy, neurologic, psychiatric, or endocrinological diseases were excluded. Also; pregnancy, alcohol and/or drug abuse and patients who required surgery other than sleeve gastrectomy were excluded.

Methods

All patients underwent a mandatory preoperative screening for OSA in addition to routine preoperative work-up. Patients enrolled in this study were included in a protocol with a physical examination, anthropometric measurements, blood tests, chest radiography, arterial blood gases, spirometric pulmonary function tests, electrocardiography (ECG), echocardiography, and measurement of daytime sleepiness and snoring with the Epworth sleepiness scale (ESS), Berlin Questionnaire, STOP BANG Questionnaire, ENT outpatient clinic examination and full night PSG.

If the apnea–hypopnea index (AHI) was ≥ 15/h, CPAP was prescribed preoperatively and immediately in the post operative period. CPAP pressure was adjusted according to the following equation: Auto-CPAP setting: reference pressure (Pref) = 0.193 × BMI + 0.077 × neck circumference + 0.02 × apnea + hypopnea index – 0.611 and Pref -4 to Pref + 3 cmH2O pressure limits [13]. Some modification according to each patient comfort and limitation of side effects was done to the pressure adjustment. Patients were instructed to use CPAP while sleeping, to be compliant with CPAP therapy post operatively. Morphinimetic painkillers were not prescribed in patients with OSA.

All patients diagnosed with OSA preoperatively received an invitation for a PSG 6–12 months postoperatively.

Polysomnography

PSG data were recorded by a computerized polysomnographic system using (sonmo screen plus PSG, Germany). This included a standardized montage: two channel electroencephalograms (EEG; C4/A1, C3/A2), bilateral electro-oculograms (EOG), submental electromyogram (EMG), bilateral leg EMGs, and ECG. Airflow was measured using a thermistor (Healthdyne Technologies), respiratory effort was included a standardized montage: two channel electroencephalograms (EEG; C4/A1, C3/A2), bilateral electro-oculograms (EOG), submental electromyogram (EMG), bilateral leg EMGs, and ECG. Airflow was measured using a thermistor (Healthdyne Technologies), respiratory effort was assessed by respiratory inductance plethysmography, and oxygen saturation was recorded using a finger probe.

Statistical analysis

The statistical analysis of data was done using SPSS programs version 16.0. The normality of data was first tested with one-sample Kolmogorov–Smirnov test. Categorical data were presented as numbers (percentage). For data with normal distribution; descriptive statistics were used to calculate mean ± standard deviation (SD); paired sample t-test was used to compare the results before and after surgery in the same group. For data without normal distribution; descriptive statistics were used to calculate median; non-parametric two-related-samples test (Wilcoxon type) was used to compare the results before and after surgery in the same group. McNemar Test was used to compare paired proportions. Statistical significance was defined as p value less than 0.05.

Results

Sixty patients underwent baseline PSG of whom four cases only had no OSA (AHI < 5/h). For the remaining 56 patients; twenty patients underwent follow up PSG. Diagnostic PSG revealed 5 cases with AHI < 15 and did not use CPAP, and
15 cases had AHI $\geq 15$ and received initial CPAP therapy (Fig. 1). The mean duration between surgery and follow up visit was 8.25 $\pm$ 0.96 months. Table 1 illustrates the demographic data and patient characteristics of studied group.

Changes in clinical parameters, anthropometric measures and spirometry after sleeve gastrectomy are illustrated in Table 2. There was statistically significant improvement in ESS, Berlin Questionnaire, and STOP BANG Questionnaire after sleeve gastrectomy ($p < 0.001$). Also, there was statistically significant improvement in BMI, and neck circumference after sleeve gastrectomy ($p < 0.001$). For spirometry, there was statistically significant improvement in forced expiratory volume in first second, ($\text{FEV}_{1}$)% of predicted ($p = 0.010$), and forced vital capacity ($\text{FVC}$)% of predicted ($p = 0.007$) during follow up.

Table 3 shows changes in sleep parameters after sleeve gastrectomy. There was statistically significant improvement in sustained sleep efficiency, basal oxygen saturation, minimal oxygen saturation, oxygen desaturation index (ODI), arousal index (AI) after sleeve gastrectomy ($p < 0.001$). Also, there was statistically significant improvement in AHI ($p < 0.001$).

While 15 cases received initial CPAP therapy with median pressure of 11 cmH$_2$O (minimum 9–maximum 13) before surgery; only 5 cases used CPAP after surgery with median pressure of 9 cmH$_2$O (minimum 8–maximum 10). There was also statistically significant decrease in the required CPAP pressure after surgery ($p = 0.041$).

**Discussion**

Obstructive sleep apnea (OSA) is a common chronic disorder affecting about 2–4% of adult population [14]. OSA is associated with many complications including premature death, sudden death from cardiac causes, road traffic accidents, ischemic heart diseases hypertension, stroke, type II diabetes, increased neck circumference and visceral adiposity [15].

Continuous positive airway pressure (CPAP) was known to be the most effective treatment for patients with moderate to severe OSA [16]. However, non-adherence to the treatment is a significant problem as in one study, researchers found only 46% of the cases met criteria for “regular use” (defined as 4 h use on 70% of days) [17]. Also, CPAP does not cure sleep apnea [18].

Bariatric surgery (BS) is currently the only available option for a long-term and sustainable weight loss [19]. These bariatric surgical procedures also cause improvement or resolution of obesity-related comorbidities including OSA [20]. Candi-
dates for BS must have a BMI greater than 40 kg/m² or a BMI greater than 35 kg/m² with significant obesity-related disease, according to the 1991 consensus guidelines from the National Institutes of Health [12].

The aim of this study was to evaluate the effect of sleeve gastrectomy as a type of bariatric surgery on OSA symptoms, sleep parameter, CPAP use and pressure in OSA patients with morbid obesity.

This study was continued on 20 cases with OSA. The mean time for follow up visits after surgery was 8.25 ± 0.96 months. Many other researchers had performed follow up visits for the studied cases between 6 and 12 months after BS. For example; Rasheed and colleagues conducted the follow-up visit at a median of 6 months [21]. Also, Busetto et al. performed the second assessment after 6 months at time of balloon removal [22]. Karaköse and coworkers conducted the second visit after a mean of 8.35 (±2.31) months [23], and follow-up visits in the study conducted by Haines et al. was at a median of 11 months (6 to 42 months) [24]. On the other side, some researchers conducted this follow-up visits at longer duration [25–27], that reached in one study up to 60 months [28].

The effect of BS on weight is gradual. Weight loss occurs rapidly in the first few months. However, it may take one year or more to reach the final result [29]. So, physicians should bear in mind that sleep and clinical parameters will most probably have improved significantly 6 months after surgery, but a continuation of reduction in the severity of OSA and improvement of the success rate can be expected thereafter [30].

In our study, there was statistically significant improvement in ESS, Berlin Questionnaire, and STOP BANG Questionnaire after sleeve gastrectomy (p < 0.001). Most studies had assessed ESS and found significant improvement in ESS after BS [21–23,26,30]. To the best of our knowledge; no one had addressed the effect of BS on Berlin Questionnaire, and STOP BANG Questionnaire. We added those two Questionnaires as they are more validated, informative, and not only subjective [31].

In our study, there was also significant improvement in BMI and neck circumference (p < 0.001) after sleeve gastrectomy. This was in agreement with that of many authors who found significant improvement in BMI and neck circumference (p < 0.001) after different BS [22,26,32]. Other authors had evaluated the effect of BS on BMI only, and they also found significant improvement in BMI (p < 0.05) after BS [21,23,30].

In an earlier study conducted by Davies and Stradling, they found that variation in neck size can explain the relationship between obesity and OSA [33]. Also, Zammit and coworkers found that neck circumference was a better predictor of OSA than BMI [34]. However, Schäfer et al. found no correlation between the degree of sleep-related breathing disorder and parapharyngeal fat pads or subcutaneous fat of the neck region [35].

In this study, there was significant improvement in forced expiratory volume in first second (FEV1)% of predicted (p = 0.010), and forced vital capacity (FVC)% of predicted (p = 0.007) after sleeve gastrectomy. This was in agreement with that of Busetto and coworkers who studied OSA cases after 6 months of insertion of an intragastric balloon as both FEV1% of predicted and FVC% of predicted improved significantly (p < 0.05) [25]. Also, Martí-Valeri et al. who performed follow up one year after open Capella Roux-en-Y gastric bypass (RYGBP) found significant improvement in FEV1% of predicted, FVC% of predicted (p ≤ 0.001) [36].

Also, in our study, there was significant improvement in sleep parameters including AHI, sustained sleep efficiency (SSE), oxygen desaturation index (ODI), baseline O2 saturation, minimum O2 saturation, and arousal index (AI) after sleeve gastrectomy (p < 0.001). Most of these results were in agreement with those of many authors. For example, Rasheed et al. followed up the patients after gastric bypass surgery. They found significant improvement in minimum O2 saturation (SpO2 86 ± 2 versus 77 ± 5), sleep efficiency (85 ± 2% versus 65 ± 5%) (p < 0.001), postoperative versus preoperative; and significant reduction in respiratory disturbance index (RDI) (56 ± 13 versus 23 ± 7, p = 0.041) [21]. Busetto and coworkers studied their cases after 6 months at the time of intragastric balloon removal and found that weight loss induced a nearly complete resolution of OSA (AHI, 52.1 ± 14.9 versus 14.0 ± 12.4 events/h, respectively; p < 0.001) [22]. Also, Fritscher et al. studied patients after a minimum of 18 months post Roux-en-Y gastric bypass procedure and found significant reduction in AHI, from a median of 46.5 (range: 33–140) to 16 (range: 0.9–87) events per hour (p < 0.05), an improvement in mean oxygen saturation from 85.7 ± 5.1 to 94.5 ± 3.6% (p < 0.05) and in minimum oxygen saturation from 64.7 ± 13.4 to 78.7 ± 13.7% (p < 0.05) [29].

On the other side, Karaköse and coworkers found significant improvement in all sleep parameter values for RDI, rapid eye movement (REM) RDI, non-REM RDI, AI, and 3% oxygen hemoglobin desaturation (p < 0.05). However, total sleep time (p = 0.687) and sleep efficiency (p = 0.507) did not change [23]. Dixon and colleagues found significant fall in AHI from 61.67 ± 34 to 13.47 ± 13, and AI from 48.27 ± 34 to 18.47 ± 10 (p < 0.001) after different BS [22,26,32]. Other authors had evaluated the effect of BS on BMI only, and they also found significant improvement in BMI (p < 0.05) after BS [21,23,30].

### Table 3: Sleep parameters and CPAP use changes preoperatively and in postoperative follow up (n = 20).

<table>
<thead>
<tr>
<th>Item</th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSE (mean ± SD)</td>
<td>83.75 ± 7.18</td>
<td>90.35 ± 3.66</td>
<td>0.000</td>
</tr>
<tr>
<td>AHI [median (min-max)]</td>
<td>18 (8.2–42)</td>
<td>10 (3–22)</td>
<td>0.000</td>
</tr>
<tr>
<td>ODI [median (min-max)]</td>
<td>35.05 (3–80)</td>
<td>20 (3–42)</td>
<td>0.000</td>
</tr>
<tr>
<td>Basal oxygen saturation (mean ± SD)</td>
<td>92.86 ± 4.45</td>
<td>95.00 ± 2.62</td>
<td>0.000</td>
</tr>
<tr>
<td>Minimum oxygen saturation (mean ± SD)</td>
<td>82.35 ± 6.44</td>
<td>87.10 ± 4.78</td>
<td>0.000</td>
</tr>
<tr>
<td>AI [median (min-max)]</td>
<td>23.5 (11–70)</td>
<td>15 (7–43)</td>
<td>0.000</td>
</tr>
<tr>
<td>CPAP use (n (%))</td>
<td>15 (75%)</td>
<td>5 (25%)</td>
<td>0.002</td>
</tr>
<tr>
<td>CPAP pressure [median (min–max)] (n = 15)</td>
<td>11 (9–13)</td>
<td>9 (8–10)</td>
<td>0.041</td>
</tr>
</tbody>
</table>

SSE, sustained sleep efficiency; AHI, Apnea–Hypopnea Index; ODI, oxygen desaturation index; AI, arousal index; CPAP, continuous positive airway pressure.
± 13 (p < 0.001) one year following laparoscopic adjustable gastric banding, without significant improvement in sleep efficiency (71 ± 18 versus 79 ± 10, p = 0.12) [26]. Recently, Ravensloot et al. found significant improvement in sleep parameter values for AHI, mean SaO2, minimum SaO2, desaturation index, and sleep efficiency (p < 0.001). However, AI did not improve (p = 0.330) [30]. Also, Lettieri et al. found significant reduction in AHI from 47.9 ± 33.8 to 24.5 ± 18.1 events per hour (p < 0.001) without improvement in sleep efficiency (92.8 ± 27.5 versus 83.6 ± 10.8, p = 0.66) [37].

In our study, there was significant reduction in AHI after sleeve gastrectomy that lead to improvement in OSA symptoms with a significant reduction in CPAP use in most of patients (15 versus 5, p = 0.002) with also reduction of median CPAP pressure in patients who continued to use CPAP therapy from 11 (9–13) to 9 (8–10) (p = 0.041). This was in agreement with that of many authors. Haines et al. prescribed preoperative CPAP or Bi-level Positive Airway Pressure (BiPAP) to all patients diagnosed with moderate to severe OSA and to the majority of patients diagnosed with mild OSA. During follow-up, the number of patients who were using CPAP/BiPAP decreased from 83 patients to 31 patients postoperatively, and the CPAP pressure settings were decreased from 11 ± 1 cmH2O preoperatively to 7 ± 1 (p < 0.001). BiPAP was discontinued in all 13 patients who were using it preoperatively [24]. In another study conducted by Guidiano and colleagues, they prescribed CPAP for those subjects with an RDI > 20 during split-night PSG. However, during follow-up, five of the eight subjects no longer required nasal CPAP. So, there were statistically significant improvements in nasal CPAP requirements (p < 0.05) [25]. Also, Dixon and coworkers demonstrated that while a total of 14 patients were using nasal CPAP preoperatively; only four continued to use it at the last annual follow-up visit [26]. Marti-Valeri et al., found that at 1 year after RYGBP, CPAP- BiPAP treatment after weight loss was necessary in only 14% of patients (p = 0.001) [36]. CPAP pressure also reduced during follow-up in other two studies. Lettieri found that all patients with residual OSA required CPAP to ablate apneic events, but the required pressures decreased from 11.5 ± 3.6 cmH2O to 8.4 ± 2.1 cmH2O (p = 0.004) [37]. Also, the starting CPAP pressures in a study conducted by Lankford et al. was averaged 11 ± 3.0 cmH2O, with a range of 7–18 cmH2O while follow-up CPAP pressures averaged 9 ± 2.7 cmH2O, with a range of 4–12 cmH2O, representing an overall reduction of 18% [38]. Lastly, in a study conducted by Varela and coworkers, they found that 29 of 56 (52%) patients required CPAP therapy preoperatively. Of the 29 patients requiring preoperative CPAP, only 4 (14%) patients required CPAP at 3 months postoperatively and none required CPAP at 9 months [39].

Conclusion

Sleeve gastrectomy improves OSA symptoms, sleep parameter, and decreases use and pressure of CPAP in OSA patients with morbid obesity.

Conflict of interest

There is no conflict of interest.

References


