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ORIGINAL CONTRIBUTIONS

Short-Term Assessment of Obstructive Sleep Apnea Syndrome Remission Rate after Sleeve Gastrectomy: a Cohort Study

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Abstract

Background Severe obesity is associated with a high prevalence of moderate-to-severe obstructive sleep apnea syndrome (OSA). Bariatric surgery has been shown to effectively reduce excess weight and comorbidities.

Methods We evaluated the remission rate of moderate-to-severe OSA (apnea-hypopnea index (AHI) ≥ 15) following sleeve gastrectomy. We performed a single-center retrospective chart review of all patients who underwent preoperative polysomnography (PSG) or polygraphy before primary sleeve gastrectomy. Patients with moderate-to-severe OSA treated by continuous positive airway pressure (CPAP) also underwent postoperative PSG. Bivariate analysis was performed to evaluate the criteria associated with remission of moderate-to-severe OSA.

Results From 2013 to 2018, 39 of 162 patients (24.1%) scheduled for sleeve gastrectomy (SG) presented moderate-to-severe OSA requiring CPAP. Postoperative PSG was performed in 36 patients a mean of 9.9 ± 6.1 months after SG. Mean BMI decreased from 47.4 ± 8.4 to 36.3 ± 7.1 kg/m^2 ($p < 0.001$), and all patients reported clinical improvement of OSA symptoms. A remission of moderate-to-severe OSA was observed in 72.2% of patients with a mean decrease of AHI from 45.8 events/h to 11.3 events/h ($p < 0.001$). Postoperative neck circumference was the only factor associated with OSA remission.

Conclusion SG is associated with a rapid improvement of moderate-to-severe OSA partially as a result of a reduction of neck circumference. However, the absence of correlation with excess weight loss suggests that other weight-independent factors may also be involved.

Keywords Bariatric surgery · Sleeve gastrectomy · Polysomnography · Obstructive sleep apnea · Continuous positive airway pressure

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Introduction

Obstructive sleep apnea-hypopnea syndrome (OSA) is characterized by repetitive upper airway collapse during sleep associated with a decrease or cessation of respiratory airflow, resulting in sleep fragmentation associated with numerous clinical signs. The severity of OSA is assessed in terms of two parameters: apnea-hypopnea index (AHI) and daytime sleepiness [1]. The prevalence of OSA associated with excessive daytime sleepiness is estimated to be 3 to 7% in adult men and 2 to 5% in adult women in the general population. Many factors are known to increase vulnerability for this disorder, including age, male gender, menopause, or obesity [2]. Up to 70% of patients evaluated for bariatric surgery present OSA when an AHI cutoff of ≥ 5 events/h is used [3–5]. Severe obesity is also associated with an increased risk of multiple comorbidities, such as cardiovascular diseases, type 2 diabetes, osteoarthritis, and cancers. In view of the growing worldwide prevalence of obesity, interventions designed to reduce obesity have been widely proposed and several studies have demonstrated the beneficial effects of bariatric surgery with a reduction of cardiovascular risk and weight loss. Evidence concerning the effect of bariatric surgery on OSA is mostly limited to Roux-en-Y gastric bypass (RYGB) [5–8] and, to a lesser extent, laparoscopic adjustable gastric banding [6, 7, 9]. Only limited data are available concerning the impact of sleeve gastrectomy (SG) on OSA. Moreover, the results of repeated polysomnography (PSG) or polygraphy (PV) have rarely been used as an endpoint to assess OSA remission [10–13]. In previous studies, assessment of OSA remission was based on self-reported discontinuation of continuous positive airway pressure (CPAP) or questionnaires such as the Epworth Sleepiness Scale or the STOP-Bang score [6, 14, 15]. Considering the usually moderate reported compliance with CPAP therapy and the poor diagnostic accuracy of these questionnaires to detect moderate-to-severe OSA [16], a study based on objective sleep evaluation needed to be performed. The aim of the present study was therefore to assess the course of moderate-to-severe OSA after SG by means of an objective assessment tool (repeated PSG).

Materials and Methods

Study Design

This study was a single-center retrospective chart review of a consecutive series of patients who underwent primary SG after preoperative PSG or PV in our sleep disorder unit. These patients were subdivided into two subgroups according to preoperative AHI: "AHI < 15" and "AHI ≥ 15". In the "AHI ≥ 15" group, patients on CPAP therapy were followed by a pulmonologist and clinical symptoms of OSA were reported. PSG was repeated in these four to 33 months after SG depending on the pulmonologist evaluation. Operated patients were also subdivided according to postoperative AHI: "AHI < 15" (i.e., remission of moderate-to-severe OSA) or "AHI ≥ 15" (i.e., persistence of moderate-to-severe OSA).

Study Population

Consecutive patients were studied over the period 2013–2017. All bariatric patients were screened for OSA through PV or PSG which are a mandatory part of the preoperative assessment in our institution. Patients who underwent preoperative PSG or PV in another unit were not included in this study to limit missing data. Surgical procedures other than SG were excluded to ensure a more homogeneous population. All patients who underwent bariatric surgery for morbid obesity in our institution (French University Hospital) met the criteria for bariatric surgery of the French guidelines for surgery for adult obesity [17]. Preoperative and postoperative PV or PSG were covered by insurance regardless of patient adherence to CPAP treatment. The local Institutional Review Board approved this study (registration number: DRCI T184).

Objective OSA Evaluation

Obstructive apneas, mixed apneas, and hypopneas were characterized according to the 2014 American Academy of Sleep Medicine standard criteria [18]. Baseline AHI was obtained for each eligible patient and was used to define OSA severity: mild OSA (5 ≤ AHI < 15/h), moderate OSA (15 ≤ AHI < 30/h), and severe OSA (AHI ≥ 30/h). According to French guidelines, subjects were treated with CPAP when they presented at least three clinical symptoms (excessive daytime sleepiness, severe snoring, suffocating during sleep, diurnal asthenia, nocturia, or morning headaches) associated with either AHI ≥ 30 or 15 ≤ AHI < 30 with an arousal index > 10, or 15 ≤ AHI ≤ 30 with severe cardiovascular comorbidities [19]. Following surgery, patients underwent routinely a second PSG to assess remission or persistence of OSA, after which it was decided whether or not patients still required CPAP therapy. This second PSG was performed after a CPAP washout period of at least 3 weeks (i.e., after temporary interruption of 3 weeks of the CPAP treatment).

Endpoint and Collected Data

The endpoint of this study was the moderate-to-severe OSA remission rate following SG according to the results of postoperative PSG.

Baseline characteristics (at the time of the preoperative PSG or PV), including gender, body mass index (BMI), neck circumference, comorbidities, sedentary lifestyle, smoking status, Epworth Sleepiness Scale, Beck Depression Inventory-short form, and Pichot fatigue scale [20–22], were collected from the patients' medical records. Neck circumference was measured in the midway of the neck, between the mid-cervical spine and mid anterior neck, to within 1 mm, using non-stretchable plastic tape with the subjects standing upright. In men with a laryngeal prominence (Adam's apple), it was measured just below the prominence. While taking this reading, the subject was asked to look straight ahead, with shoulders down, but not hunched. Excess weight (preoperative weight – ideal weight) was computed with the calculation of ideal body weight as that equivalent to a BMI of 25 kg/m^2. Postoperative BMI, neck circumference, Epworth Sleepiness Scale, Beck Depression Inventory-short form, and Pichot fatigue scale were also recorded for each patient who underwent postoperative PSG and percent of excess weight loss (%EWL) was computed ([preoperative weight – follow-up weight]/[preoperative weight – ideal weight] × 100).

Statistical Analysis

We first tabulated the patients' baseline characteristics. Data are expressed as mean ± standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables. A bivariate analysis has been done to compare baseline characteristics between patients with and without moderate-to-severe OSA with an independent *t* test for continuous data and chi-square tests or Fisher's exact test for categorical variables. Differences between results obtained at baseline and at follow-up were compared using a Student's *t* test for dependent samples or a Wilcoxon paired rank test, depending on the data distribution. Patients who underwent postoperative PSG were analyzed as 2 study groups: postoperative AHI < 15/h and postoperative AHI ≥ 15/h. Logistic regression was performed to evaluate the criteria associated with remission of moderate-to-severe OSA. A two-tailed significance level of 0.05 was used for all tests. Statistical analysis was performed using SPSS for Windows (version 17; SPSS Inc., Chicago, IL. USA).

Results

From March 2013 to March 2018, 255 patients scheduled for bariatric surgery underwent preoperative PSG or PV in our institution and 162 of these patients subsequently underwent SG. Eighty-four patients (51.9%) presented OSA, considered to be moderate to severe in 44 patients (27.7%), 39 of whom were treated by CPAP. Postoperative PSG was performed in 36 patients. The flowchart describing the patients included and excluded from this study is presented in Fig. 1.

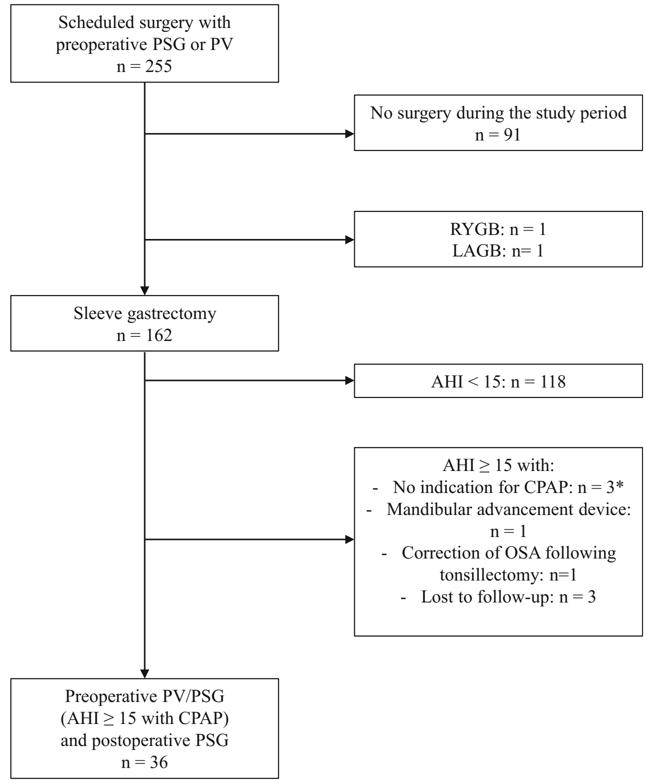

Fig. 1 Flowchart of eligible patients included in the study. PSG polysomnography, PV polygraphy, RYGB Roux-en-Y gastric bypass, OSA obstructive sleep apnea, AHI apnea-hypopnea index, CPAP continuous positive airway pressure. *Moderate OSA without sleepiness

Preoperative Patient Characteristics

Women represented 79.6% of the preoperative study population. Mean age was of 40.2 ± 11.1 years. Significant differences between moderate-to-severe OSA and non-OSA/mild OSA groups were observed for the following variables: gender, preoperative body weight, preoperative excess weight, preoperative BMI, and neck circumference. Baseline characteristics of the overall population and the two subgroups of patients (preoperative AHI < 15 or preoperative AHI ≥ 15) are shown in Table 1.

Postoperative Results

Postoperative PSG was routinely prescribed to all patients and was performed in 36 patients a mean of 9.9 ± 6.1 months after surgery. At the time of the postoperative PSG, 16 patients (44.4%) experienced poor tolerance and/or adherence to CPAP therapy. Mean BMI decreased from 47.4 ± 8.4 to 36.3 ± 7.1 kg/m^2 ($p < 0.001$), resulting in a mean BMI loss of 11.1 ± 5 kg/m^2 and mean EWL of 52.5 ± 21.0%. The AHI was dramatically reduced from 45.8 ± 25.6 to 11.3 ± 11.9 events/h ($p < 0.001$), and remission of moderate-to-severe OSA was observed in 26 patients (72.2%). Improvement of sleep architecture was observed after surgery, with a significantly increased proportion of non-rapid eye movement sleep stage 3 ($p = 0.035$) and a significantly decreased arousal index ($p = 0.019$). All 36 patients (100%) reported clinical improvement of their OSA symptoms. Subjective perceptions of sleepiness, depression, and tiredness were also improved. Baseline and follow-up characteristics are reported in Table 2.

No statistically significant correlation was observed between OSA remission (AHI < 15 versus AHI ≥ 15) and gender, age, preoperative BMI, preoperative excess weight, initial AHI, or comorbidities. All patients with persistent AHI ≥ 15 had a sedentary lifestyle compared with only 65.4% of patients with OSA remission. Postoperative neck circumference was the only factor significantly associated with remission of moderate-to-severe OSA after surgery (OR = 0.80 [0.64–0.99]; $p = 0.048$) while postoperative BMI, percent of total weight loss, %EWL, and poor tolerance/compliance to CPAP were not associated with OSA remission (Table 3).

Table 1 Baseline characteristics of the study population according to the presence of moderate or severe obstructive sleep apnea syndrome

	All patients ($n = 162$)	AHI < 15 ($n = 118$)	AHI ≥ 15 ($N = 44$)	p value
Gender				< 0.001
Female	129 (79.6)	103 (87.3)	26 (59.1)	
Male	33 (20.4)	15 (12.7)	18 (40.9)	
Age (years)	40.2 ± 11.1	39.4 ± 10.6	42.3 ± 12.3	0.133
Neck circumference (cm)	42.3 ± 4.1	41.8 ± 4.0	43.8 ± 4.0	0.014
Body weight (kg)	121.9 ± 21.5	118.1 ± 19.7	132.3 ± 22.8	< 0.001
Excess weight (kg)	52.8 ± 18.1	49.8 ± 15.6	61.0 ± 21.6	0.003
Preoperative BMI (kg/m^2)	44.1 ± 6.4	43.1 ± 5.0	46.7 ± 8.7	0.012
Obesity				
Class 1 (30 ≤ BMI < 35)	2 (1.2)	1 (0.8)	1 (2.3)	
Class 2 (35 ≤ BMI < 40)	39 (24.1)	30 (25.4)	9 (20.5)	
Class 3 (BMI ≥ 40)	121 (74.7)	87 (73.7)	34 (77.3)	
Hypertension	48 (29.6)	33 (28.0)	15 (34.1)	0.446
Sedentary lifestyle	110 (67.9)	79 (66.9)	31 (72.1)	0.572
Type 2 diabetes	27 (16.7)	16 (13.6)	11 (25.0)	0.099
Dyslipidemia	29 (17.9)	20 (16.9)	9 (20.5)	0.647
Smoking				0.433
Non-smoker	79 (48.8)	58 (49.6)	21 (48.8)	
Ex-smoker	31 (19.1)	20 (17.1)	11 (25.6)	
Active smoker	50 (30.9)	39 (33.3)	11 (25.6)	
AHI	14.2 ± 21.6	3.8 ± 3.5	42.1 ± 25.0	< 0.001
Epworth sleepiness scale	6.4 ± 4.5	6.3 ± 4.2	6.8 ± 5.2	0.597
Beck Depression Inventory-short form	6.3 ± 5.5	5.1 ± 5.3	6.8 ± 5.9	0.492
Pichot fatigue scale	9.8 ± 8.3	9.5 ± 8.0	10.9 ± 9.4	0.368

Data are expressed as mean ± standard deviation for continuous variables and as frequencies and percentages for categorical variables

BMI, body mass index; *AHI*, apnea-hypopnea index

Discussion

In this study, we observed an improvement of OSA after sleeve gastrectomy. With a mean interval of 9.9 months between surgery and postoperative PSG, total AHI decreased from 45.8 events/h to 11.3 events/h ($p < 0.001$), and remission of moderate-to-severe OSA was observed in 72.2% of patients, who were therefore able to discontinue their CPAP therapy. All patients of the cohort reported improvement of clinical symptoms of OSA. Subjective evaluations of sleepiness, depression, and tiredness were also improved independently of OSA remission. Moreover, preoperative results for the Epworth Sleepiness Scale, Beck Depression Inventory-short form, and Pichot fatigue scale which were collected prior to CPAP therapy were not associated with preoperative AHI ≥ 15. These results therefore suggest that these subjective improvements are not solely due to a decreased AHI but are probably more directly related to an improvement of general health induced by weight loss.

The OSA remission rates in our study are consistent with published results reported after RYGB, the most extensively studied bariatric surgery technique [5–8]. A higher remission rate after surgery can be expected with longer follow-up, as one-half of postoperative PSG assessments were performed during the first 9 months, and a previous study has shown that percent of total weight loss was maximal (25%) after 1 to 2 years following SG [23]. However, a slight weight increase has been described from the third postoperative year, but two studies have demonstrated the long-term benefit of SG on OSA: Del Genio et al. reported remission of moderate-to-severe OSA in up to 88.5% of patients at 5 years and Casella et al. reported OSA remission (AHI < 5) in 75.6% of patients at 6 years [10, 11, 23].

Morbid obesity is known to be associated with respiratory mechanical impairment leading to upper airway collapse during sleep. An interesting finding in terms of anthropometric changes was that postoperative neck circumference was the only variable associated with OSA remission in our study. Similar results have also been reported by Valencia-Flores et al., suggesting that the effects of obesity on sleep-disordered breathing are mainly mediated via fat deposition in the neck [24]. However, the absence of correlation with postoperative BMI or %EWL in our study suggests that other factors, independent of weight loss, could also be partly

Table 2 Baseline characteristics and at the time of postoperative polysomnography in the 36 patients assessed for the persistence of moderate-to-severe obstructive sleep apnea

	Baseline ($n = 36$)	Follow-up ($n = 36$)	p value
Neck circumference (cm)	43.9 ± 3.9	40.2 ± 3.7	< 0.001
Body weight (kg)	135.1 ± 22.8	103.2 ± 20.6	< 0.001
Excess weight (kg)	63.4 ± 21.7	31.5 ± 18.3	< 0.001
BMI (kg/m^2)	47.4 ± 8.4	36.3 ± 7.1	< 0.001
Obesity			< 0.001
Non-obese (BMI < 30)	0 (0.0)	2 (5.6)	
Class 1 (30 ≤ BMI < 35)	1 (2.8)	17 (47.2)	
Class 2 (35 ≤ BMI < 40)	6 (16.7)	9 (25.0)	
Class 3 (BMI ≥ 40)	29 (80.6)	8 (22.2)	
AHI (/h)	45.8 ± 25.6	11.3 ± 11.9	< 0.001
OSA			< 0.001
No OSA (AHI < 5)	0 (0.0)	13 (36.1)	
Mild OSA (5 ≤ AHI < 15)	0 (0.0)	13 (36.1)	
Moderate OSA (15 ≤ AHI < 30)	13 (36.1)	7 (19.4)	
Severe OSA (AHI ≥ 30)	23 (63.9)	3 (8.3)	
Epworth Sleepiness Scale	7.2 ± 5.0	3.3 ± 3.4	< 0.001
Beck Depression Inventory-short form	6.6 ± 6.4	2.3 ± 4.6	< 0.001
Pichot fatigue scale	10.9 ± 9.6	2.3 ± 4.6	< 0.001
NREM3 (%TST)	15.7 ± 9.7	19.7 ± 8.8	0.035
REM (%TST)	14.2 ± 6.4	16.3 ± 7.4	0.125
Arousal index (/h)	17.0 ± 12.4	10.5 ± 8.8	0.019

Data are expressed as mean ± standard deviation for continuous variables and frequencies and percentages for categorical variables

BMI, body mass index; *AHI*, apnea-hypopnea index; *OSA*, obstructive sleep apnea syndrome; *NREM3*, non-rapid eye movement stage 3; *REM*, rapid eye movement sleep stage; *TST*, total sleep time

responsible for the improvement of OSA. This hypothesis is supported by a recent study by Amin et al., who reported a postoperative decrease of the AHI by 9.2 events per hour only 3 weeks after bariatric surgery (6 SG and 1 RYGB) with no significant decrease in BMI [25]. They also observed that leptin levels decreased, and orexin levels significantly increased 3 weeks postoperatively. By means of this metabolic effect, bariatric surgery may therefore break the vicious circle linking obesity and OSA, as it has been shown that the sleep disorders displayed by leptin-deficient or leptin receptor-deficient mice can be reversed by leptin replacement. On the other hand, appetite and food intake are often increased as a result of sleep curtailment, possibly via a hyperactive orexin system or alteration of glucose tolerance and insulin sensitivity [26]. This bidirectional relationship between obstructive sleep apnea and metabolic diseases such as obesity and type 2 diabetes may explain why some types of surgery are more effective to control OSA. Comparative studies have reported almost twofold higher 1-year OSA remissions rates after RYGB or SG compared with laparoscopic adjustable gastric banding, a purely restrictive technique [27]. This type of weight-independent metabolic effect of surgery has been clearly elucidated for RYGB, which combines both restrictive and malabsorptive techniques, but it is also observed with SG, which is primarily a restrictive procedure. These metabolic effects are summarized by the acronym BRAVE: bile flow alteration, reduction of gastric size, anatomical rearrangement, vagal manipulation, and enteric gut hormone modulation [6, 27, 28]. However, SG presents several advantages compared with RYGB, as it is an easier and more rapid procedure without the need for digestive anastomosis and no risk of post-gastrectomy syndromes [14].

Although limited by its retrospective design, the results of this study can be generalized to the population of obese patients likely to benefit from SG. The baseline characteristics of our initial study population were similar to those of a French national cohort of patients who underwent bariatric surgery in 2009 with a high proportion of women (79.6%), mean age of 40.2 years and 24.1% of patients presenting moderate-to-severe OSA requiring CPAP therapy [29]. Unlike several other studies that selected patients on the basis of a questionnaire to detect symptoms of OSA and to propose preoperative PV or PSG, these objective tests are a mandatory part of the preoperative assessment in our institution. Follow-up of this study population was also almost complete, as postoperative PSG was missing for only 3 patients. We can therefore assume the

Table 3 Characteristics associated with remission of moderate-to-severe OSA after sleeve gastrectomy

	Success (AHI < 15; $n = 26$)	Failure (AHI ≥ 15; $n = 10$)	Odds ratio (IC95%)	p value
Preoperative characteristics				
Gender: female	17 (65.4)	5 (50)	1.89 (0.43–8.30)	0.400
Age (years)	44.9 ± 18.6	44.7 ± 13.6	1.00 (0.96–1.04)	0.977
Neck circumference (cm)	43.4 ± 3.9	45.1 ± 3.9	0.88 (0.71–1.12)	0.308
Body weight (kg)	132.7 ± 23.3	141.4 ± 21.5	0.98 (0.95–1.02)	0.303
Excess weight (kg)	61.7 ± 22.4	67.8 ± 20.1	0.99 (0.95–1.02)	0.443
Preoperative BMI (kg/m^2)	47.0 ± 8.8	48.3 ± 7.5	0.98 (0.90–1.07)	0.670
Obesity				
Class 1 (30 ≤ BMI < 35)	1 (3.8)	0 (0)		
Class 2 (35 ≤ BMI < 40)	5 (19.2)	1 (10.0)		
Class 3 (BMI ≥ 40)	20 (76.9)	9 (90.0)		
Hypertension	8 (30.8)	4 (40.0)	0.67 (0.15–3.03)	0.600
Sedentary lifestyle	17 (65.4)	9 (100.0)		
Type 2 diabetes	4 (15.4)	4 (40.0)	0.27 (0.05–1.43)	0.124
Dyslipidemia	5 (19.2)	4 (40%)	0.36 (0.07–1.76)	0.206
Smoking				
Non-smoker	14 (53.8)	3 (33.3)	Reference	
Ex-smoker	7 (26.9)	4 (44.4)	0.27 (0.04–1.641)	0.154
Active smoker	5 (19.2)	2 (22.2)	0.75 (0.10–5.58)	0.779
AHI	44.1 ± 27.4	50.1 ± 20.8	0.99 (0.96–1.02)	0.530
Postoperative characteristics				
Neck circumference (cm)	39.3 ± 3.6	42.2 ± 3.4	0.80 (0.64–0.99)	0.048
Body weight (kg)	100.8 ± 20.9	109.3 ± 19.5	0.98 (0.95–1.02)	0.273
Excess weight (kg)	29.8 ± 19.1	35.7 ± 16.2	0.98 (0.95–1.02)	0.391
%TWL (%)	23.7 ± 9.7	22.8 ± 7.0	0.99 (0.91–1.07)	0.779
%EWL (%)	52.5 ± 21.0	48.7 ± 14.5	1.01 (0.97–1.05)	0.600
Postoperative BMI (kg/m^2)	36.0 ± 7.6	37.1 ± 5.5	0.98 (0.88–1.08)	0.653
Obesity				
Non-obese (BMI < 30)	2 (7.7)	0 (0.0)		
Class 1 (30 ≤ BMI < 35)	12 (46.2)	5 (50.0)		
Class 2 (35 ≤ BMI < 40)	8 (30.8)	2 (20.0)		
Class 3 (BMI ≥ 40)	4 (15.4)	3 (30.0)		
Poor tolerance/adherence to CPAP therapy	12 (48)	4 (36.4)	2.25 (0.48–10.60)	0.305
Epworth Sleepiness Scale	3.1 ± 3.3	3.4 ± 3.9	0.97 (0.79–1.20)	0.795
Beck Depression Inventory-short form	3.3 ± 5.9	1.7 ± 2.1	1.09 (0.88–1.35)	0.435
Pichot fatigue scale	2.7 ± 5.3	2.1 ± 3.0	1.03 (0.87–1.22)	0.717

Data are expressed as mean ± standard deviation for continuous variables and frequencies and percentages for categorical variables

BMI, body mass index; *AHI*, apnea-hypopnea index; *OSA*, obstructive sleep apnea syndrome; *sBDI*, Beck Depression Inventory-short form; *%TWL*, percent of total weight loss; *%EWL*, percent of excess weight loss

absence of any selection bias. Another strength of this study is that OSA evaluation was based on objective criteria (baseline and postoperative AHI determined by PV or PSG), while many other studies on SG have only reported clinical improvements or cessation of CPAP therapy [6, 14]. We defined postoperative AHI ≥ 15 as the primary endpoint, as this cutoff is clinically relevant and plays a central role in the decision to continue or discontinue CPAP. OSA assessment after SG based on this cutoff has only been reported in the study by Del Genio et al. [10]. Finally, our results are strengthened by the CPAP washout period (> 3 weeks) that was applied prior to postoperative PSG. CPAP washout is an important parameter because CPAP is thought to play a role in reducing edema resulting from snoring-associated vibrations and apnea-induced suctions of the upper airway, which could theoretically lead to underestimation of AHI among chronic CPAP users [7].

We acknowledge that this study presents a number of limitations that must be taken into consideration. First, this study reports short-term outcomes with a mean follow-up of 9.9 ± 6.1 months after bariatric surgery. Since a weight increase is usually described from the third postoperative year [23], longer follow-up would be necessary to confirm the long-term OSA remission rates and sustainability. A second limitation of our study is related to its retrospective design, preventing the inclusion of patients assessed by preoperative PSG or PV outside of our sleep disorder unit. The results of preoperative evaluation would have been incomplete for these patients, and the results of systematic postoperative PSG evaluation were also rarely available. Lastly, due to its retrospective design, we were not able to evaluate the impact of other parameters like the Mallampati class, an anesthetic assessment of intubation risk based on the morphology of the oropharynx, which has been suggested as a possible simple assessment tool for OSA. The pharyngeal critical closing pressure which evaluates the upper airway collapsibility during sleep or dedicated imaging protocols of the upper airway have also been correlated to AHI but are not routinely used and were therefore not evaluated in our study.

Conclusion

Short-term follow-up revealed that SG is associated with weight reduction and a high moderate-to-severe OSA remission rate (72.2% of the patients). However, neither the improvement of clinical symptoms nor the poor tolerance of CPAP therapy was associated with OSA remission. Our study therefore suggests that these criteria require confirmation by an objective test before considering withdrawal of CPAP. Postoperative neck circumference was the only anthropometric parameter associated with OSA remission. The absence of correlation with excess weight loss or postoperative BMI suggests that other weight-independent factors may also be involved in the improvement of OSA after SG.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Statements Regarding Ethics and Consent Formal consent is not required for this type of study.

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