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ORIGINAL INVESTIGATION

The Role of Bariatric Surgery in Obstructive Sleep Apnea Syndrome

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Abstract

OBJECTIVES: Obesity is a chronic disease that impacts all age groups worldwide and leads to serious health problems, such as obstructive sleep apnea syndrome (OSAS). Bariatric surgery is a treatment option for patients with both OSAS and obesity who fail to lose weight. The efficacy of bariatric surgery in morbidly obese patients with OSAS was evaluated.

MATERIAL AND METHODS: Twenty-six patients for whom obesity surgery was planned were enrolled. All subjects underwent overnight polysomnography (PSG) preoperatively and postoperatively within 8.35 (±2.31) months. OSAS symptoms and sleep parameters were evaluated.

RESULTS: Symptoms were evaluated preoperatively and postoperatively in patients with (17, 65.4%) and without (9, 34.6%) OSAS. PSG results and sleep parameters were evaluated preoperatively and postoperatively in patients with OSAS (17/26) and those who completed the follow-up. All sleep parameter values for respiratory disturbance index (RDI), rapid eye movement (REM) RDI, non-REM RDI, apnea index (AI), and 3% oxyhemoglobin desaturation index were improved significantly ($p<0.05$).

CONCLUSION: Bariatric surgery may be another treatment option for morbidly obese patients with OSAS that is to be used together with other treatments, such as non-invasive mechanical ventilation.

KEY WORDS: Sleep apnea syndrome, bariatric surgery, morbid obesity

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INTRODUCTION

Obesity is a chronic disease with an impact on all age groups and an increasing incidence. The World Health Organization defines obesity as having a body mass index (BMI) >30 kg/m^2, and according to 2008 data, >500 million adults are obese worldwide [1]. A BMI ≥40 kg/m^2 defined as morbid obesity.

Obesity may lead to serious health problems. The association between obesity and obstructive sleep apnea syndrome (OSAS) is well known. Although OSAS affects 2%-4% of the adult population, the prevalence increases to 40%-70% in obese patients. This risk increases tremendously in morbidly obese cases [2,3].

Recurrent collapse of the upper airway results in OSAS signs and symptoms (sleep fragmentation, excessive daytime sleepiness (EDS), witnessed apnea) [3]. As BMI increases, the surrounding excess fat tissue increases airway collapsibility, and OSAS symptoms become more evident.

Non-invasive mechanical ventilation (NIMV), oral appliances, and upper respiratory tract surgery are treatment options for OSAS to maintain the airway open. In addition to these modalities, bariatric surgery is another effective treatment option (gastric band, tube, sleeve gastrectomy, gastric by-pass, and gastric balloon) in obese patients with a BMI >40 kg/m^2 whose diet program is unsuccessful or those with a BMI >35 kg/m^2 with co-morbid diseases. Gastric surgery may lead to significant weight loss and eventual improvement in OSAS severity or decrease NIMV pressure.

Gastric by-pass and sleeve gastrectomy are the most frequently used methods. The overall mortality rate is <1%, and that of morbidity is 5% [2,4-6].

The primary objective of the study was to evaluate the effect of bariatric surgery on weight loss, sleep parameters, and OSAS symptoms in morbidly obese patients with OSAS.

This study was presented as a poster at the 16th Annual Congress of Turkish Thoracic Society, April 3-7, 2013, Antalya, Turkey.

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Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
BMI, <40 kg/m^2	Decompensated heart and/or lung diseases
Age, 18-65 years	Malignancy
Presence of obesity for at least 3 years without hormonal problems	Neurologic, psychiatric, or endocrinological diseases
Failure to lose weight for at least 1 year despite drug and dietary therapies	Pregnancy
Capable of understanding the operation and postoperative requirements	Alcohol and/or drug abuse
	Patients require surgery other than sleeve gastrectomy or gastric by-pass

BMI: body mass index

MATERIAL AND METHODS

We conducted a prospective study between August 2011 and September 2012 in which 40 consecutive patients for whom morbid obesity surgery was planned were enrolled. This study design was approved by the institutional review board at Bezmialem Vakif University Medical School (18. AUG.2011:11/10), and informed consent was obtained from all subjects. The study was performed in the sleep laboratory of a university hospital. Patients were invited to participate in the study after an evaluation according to the inclusion and exclusion criteria (Table 1). Chest X-ray, biochemical tests, and arterial blood gas analyses were performed. Patients who met the inclusion criteria were assessed by a group of surgeons in terms of both the surgical technique and their clinical features. Patients who were accepted for sleeve gastrectomy or gastric by-pass surgery were enrolled. Patients who required a surgical technique other than sleeve gastrectomy or gastric by-pass were excluded. Eligible patients were invited to the sleep laboratory, and overnight polysomnography (PSG) was performed.

Electroencephalography, electro-oculogram, submental and leg electromyogram, nasal thermistor and nasal cannulae, piezoelectric thorax and abdominal bands, electrocardiogram, and pulse-oximetry were performed during PSG. All variables were recorded using a Compumedics E series PSG (E 3142, Compumedics Inc., Melbourne, Australia). All recordings, scoring, and interpretations were performed by two experienced sleep physicians according to the AASM 2007 guidelines [7]. All patients underwent surgery, regardless of the PSG results, and a control PSG session was performed 6-12 months after the operation in patients in whom OSAS was diagnosed at the first PSG. Changes in BMI, Epworth Sleepiness Scale (ESS), OSAS symptoms and severity, excess body mass index loss (EBMIL), and PSG parameters [total sleep time, sleep efficiency, respiratory disturbance index (RDI) during REM and non-REM periods, and oxygen desaturation index (ODI)] were recorded.

Obstructive sleep apnea syndrome was described as EDS with the presence of a minimum of five obstructive respiratory events (apnea, hypopnea or respiratory event-related arousal (RERA), snoring, witnessed apnea, or awakening with gasping) per hour during the course of sleep.

Obstructive apnea is the absence of airflow lasting ≥10 s despite continued respiratory effort, and central apnea was defined as complete cessation of airflow lasting ≥10 s in the absence of respiratory effort. Hypopnea was defined as a 50% reduction in airflow lasting ≥10 s that was associated with ≥3% oxygen desaturation. Respiratory event-related arousal was defined as a sequence of breaths lasting ≥10 s and characterized by increasing effort or by flattening of the inspiratory portion of nasal pressure. OSAS severity was classified as *'mild'* for RDI ≥5 and <15, as *'moderate'* for ≥15 and ≤30, and as *'severe'* for RDI >30/h. [3].

Bariatric surgery was performed according to the American Society for Metabolic and Bariatric Surgery guidelines [8]. The type of surgery was decided by the operating team. Only sleeve gastrectomy or gastric bypass surgery was performed. During the follow-up, NIMV treatment was suggested for patients who had moderate or severe OSAS at the first PSG. Seven patients refused to undergo the control PSG during the postoperative period, and these patients were excluded (Figure 1).

Statistical Analysis

Nonparametric chi-square, McNemar's, and Wilcoxon's tests were used for the statistical analysis with the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA) ver. 16 software package.

RESULTS

Forty patients were enrolled in the study, of whom were excluded based on the exclusion and inclusion criteria. The remaining 33 patients underwent PSG and bariatric surgery. Seven patients did not undergo the control PSG due to symptom resolution and were excluded. The data on the remaining 17 patients were analyzed. The demographic characteristics of the study group are shown in Table 2.

Diagnostic PSG revealed 8 mild, 3 moderate, and 6 severe OSAS cases; 9 patients had RDI <5/h. The 7 patients who did not undergo the control PSG had OSAS (1 mild and 6 severe).

Symptoms were evaluated preoperatively and postoperatively. Some changes in symptom frequency were observed postoperatively. While the improvement in witnessed apnea (p=0.016) and EDS (0=0.039) was significant, that in snoring was not (p>0.05). Mean preoperative and postoperative ESS scores were 8.35±5.57 and 3.35±3.04, respectively

(p<0.05). The changes in symptoms and ESS scores are shown in Table 3.

Eighteen patients (69.2%) had laparoscopic sleeve gastrectomy, and 8 (30.8%) underwent laparoscopic mini-gastric by-pass surgery.

During the first PSG, 24 subjects had a diagnosis of OSAS (9 mild, 3 moderate, and 12 severe). Unfortunately, 7 subjects (1 mild and 6 severe OSAS) did not undergo the control PSG because of symptom resolution and were excluded from the study. Seventeen patients underwent the control PSG at 8.35±2.31 months after surgery. Twelve patients had improved OSAS severity, and 5 did not. Mean RDI levels decreased significantly (p=0.005). Changes in OSAS severity and RDI values are shown in Table 4 and Figure 2. OSAS severity in 5 patients did not change. Only 1 patient exhibited an increase in RDI despite a decrease in BMI; the remaining 4 cases had only a minimal decrease in RDI. A blood gas analysis was performed preoperatively for a general evaluation, but no second analysis was performed on the following morning.

Body mass index, excess weight loss (EWL), and EBMIL measurements were also performed at the time of the control PSG. Significant weight loss was observed after surgery (BMI, 48.48±6.45 vs. 34.25±4.86, p<0.05). Additionally, the EWL and EBMIL values of the controls were 54.04±10.79 and 61.88±13.65, respectively. Some of the sleep parameters improved with decreasing BMI. RDI, REM RDI, non-REM RDI, ODI, and ESS scores decreased significantly (p<0.05), but the total sleep time and sleep efficiency did not change (p>0.005) (Table 5).

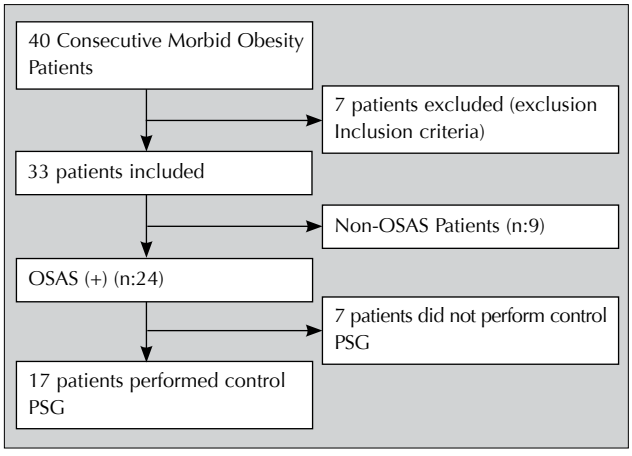

Figure 1. Study design

Table 2. Demographic data of the study group

Sex	
F	12 (70.6%)
M	5 (29.4%)
Age (years)	Median, 40 (range, 24-54 years)
Weight (kg)	135.52 (±22.55)
Height (cm)	166.8 (±9.32)
BMI	48.48 (±6.45)
Operation Type	Laparoscopic sleeve gastrectomy; 18 subjects (69.2%)
	Laparoscopic mini gastric bypass; 8 subjects (30.8%)

BMI: body mass index; F: female; M: male

Table 3. Symptom frequency and mean ESS of the patients

Symptom	Before surgery	After surgery	p value
Apnea –	8 (47.1%)	15 (88.2%)	0.016*
Apnea +	9 (52.9%)	2 (11.8%)	
EDS –	4 (23.5%)	11 (64.7%)	0.039*
EDS +	13 (76.5%)	9 (35.3%)	
Snoring –	1 (5.9%)	9 (52.9%)	0.08
Snoring +	16 (94.1%)	8 (47.1%)	
ESS	8.35	3.35	0.005*

EDS: excessive daytime sleepiness; ESS: Epworth Sleepiness Scale.
*p<0.05 denotes significance

Table 4. OSAS severity and RDIs before and after surgery

	OSAS severity before surgery	OSAS severity after surgery	RDI before surgery	RDI after surgery
Patient 1	Severe	Severe	69.7	86.5
Patient 2	Moderate	Moderate	22.2	15.2
Patient 3	Mild	No OSAS	13.0	1.1
Patient 4	Severe	Severe	33.9	33.7
Patient 5	Moderate	No OSAS	17.7	0.6
Patient 6	Severe	Moderate	47.3	25.2
Patient 7	Severe	Mild	50.4	12.9
Patient 8	Mild	No OSAS	9.6	1.6
Patient 9	Mild	Mild	12.9	6.1
Patient 10	Mild	No OSAS	6.3	0.6
Patient 11	Severe	Mild	35.8	10.9
Patient 12	Mild	No OSAS	9.5	0.8
Patient 13	Mild	Mild	8.7	8.5
Patient 14	Severe	Moderate	59.3	19.4
Patient 15	Mild	No OSAS	7.0	1.0
Patient 16	Moderate	No OSAS	15.6	0.2
Patient 17	Mild	No OSAS	14.0	0.2

RDI: respiratory disturbance index; OSAS: obstructive sleep apnea syndrome

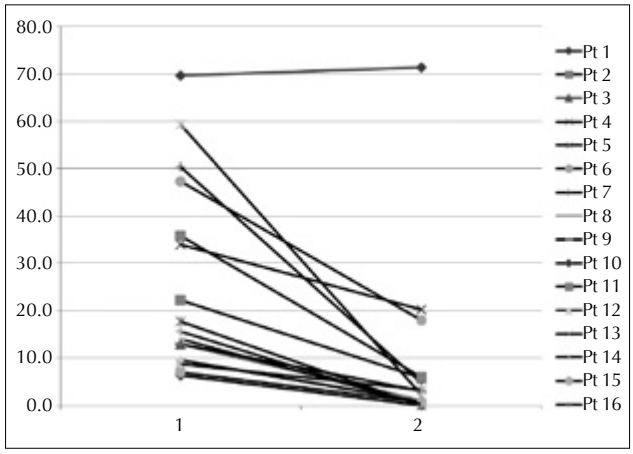

Figure 2. RDI levels of the patients before (1) and after (2) surgery
Pt: patients; RDI: respiratory disturbances index

Table 5. Sleep parameters in patients with OSAS during the preoperative and postoperative periods

	Mean±SD	p
Pre-TST	5.98±0.73	0.687
Post-TST	5.79±0.81	
Pre-sleep eff.	88.94±7.40	0.507
Post-sleep eff.	90.52±7.01	
Pre-REMRDI	39.01±24.95	0.001
Post-REMRDI	12.28±13.11	
Pre-non-REM RDI	26.66±29.28	0.005
Post-non-REM RDI	12.32±21.32	
Pre-RDI	28.41±27.64	0.005
Post-RDI	13.23±21.36	
Pre-AI	12.84±11.70	0.026
Post-AI	8.15±17.36	
Pre-3% ODI	23.84±22.01	0.002
Post-3% ODI	11.19±19.76	

BMI: body mass index; AI: apnea index; ESS: Eppworth Sleepiness Scale; RDI: respiratory disturbance index; REM: rapid eye movement; ODI: oxyhemoglobin desaturation index; TST: total sleep time; eff: efficiency; pre: preoperative; post: postoperative period; SD: standard deviation

DISCUSSION

We found that bariatric surgery provided significant weight loss and improved sleep parameters and OSAS severity in morbidly obese patients.

The improvements in sleep parameters, including RDI, REM RDI, non-REM, RDI, Apnea Index, and ODI, were significant ($p<0.05$). However, total sleep time and sleep efficiency did not change.

We performed a control PSG at 6-12 months postoperatively (8.35±2.31 months) and found significant effects of the surgery. Some authors reported data after 3 months, whereas others reported findings after 11 years [4,9-11].

Although the mean ESS score was not high (8.35±5.57) before surgery, it improved significantly (3.35±3.04) thereafter ($p<0.05$). Under normal circumstances, an ESS score >12 should alarm the clinician. Despite the ESS cut-off value used in some studies, the value of the ESS scale for PSG was not considered in our study because of the high prevalence of OSAS in morbidly obese patients. Only 3 of our patients had ESS scores >12. ESS may not highlight OSAS; however, a full overnight PSG was suggested for all morbidly obese patients before surgery [12,13].

The significance of the reduction in the number of patients with witnessed apnea and EDS suggested that these parameters are more highly correlated with weight loss. Snoring is probably due to upper airway problems and was not evaluated in this study.

The prevalence of OSAS in our study (65.3%) was similar to that in previous reports. The prevalence of OSAS in obese people is 40%-70% [12,14,15]. The incidence of sleep problems likely increases with increasing BMI.

Although both mean RDI and BMI decreased significantly, their reduction was not correlated. The mean RDI of the patients decreased to more than half of the original value. This reduction in RDI was more prominent during REM sleep ($p=0.001$) compared to non-REM sleep ($p=0.005$). Significant decreases in the Apnea Index ($p=0.026$) and ODI ($p=0.002$) were also observed. These findings suggest that the increase in oxygen levels is more important than the decrease in the Apnea Index following surgery. No significant changes in the arousal index, total sleep time, or sleep efficiency were observed in this study. Total sleep time was sufficient, and sleep efficiency was high enough to diagnose sleep problems in both PSG studies.

Obstructive sleep apnea syndrome severity changed in 12 subjects. The remaining 5 exhibited unchanged OSAS severity with a minimal or moderate reduction in RDI level, with the exception of 1 patient who showed an increased RDI level. All patients with moderate or severe OSAS were proposed to undergo positive airway pressure titration; however, only 1 patient agreed to receive NIMV treatment. These patients focused on the benefit of operation, and they preferred to see the final result after the operation.

A 10% increase in weight is associated with a 32% increase in the RDI, and a 10% decrease in weight is associated with a 26% decrease in RDI [15]. A 50% (±15) decrease in overweight, a 61.6% (±34) to 13.4% (±13) decrease in AHI, and improvement in sleep quality and diurnal somnolence were reported by Dixon et al. [16] at 17 months after obesity surgery [14,15]. Our subjects also experienced significant weight loss. The EWL and EBMIL values of the controls were 54.04±10.79 and 61.88±13.65, respectively. Given that only 5%-10% of patients who lose weight through a diet program maintain their reduced body weight for several years, obesity surgery is an effective method in the long term. Bariatric surgery is recommended for morbidly obese patients with OSAS who fail to lose weight and should be used in conjunction with treatments, such as NIMV [14,15,17,18].

Patients who did not undergo the control PSG had similar baseline sleep parameters and BMI as the study group. However, they refused to undergo the control PSG due to improvements in their sleep symptoms. These improvements in symptoms might have been due to the surgical intervention or a placebo effect; neither possibility can be ruled out.

This study had several limitations. The most important limitation was the number of patients. Several previous studies included higher numbers of patients, but our results express the experience of our center. The second limitation was the follow-up interval. Although some studies have reported longer follow-up times, an average of 8 months is sufficient to determine improvements in functional parameters. Third, we did not measure neck and waist circumferences before and after surgery, which are important prognostic parameters for sleep problems. However, the correlation between neck circumference and BMI in other studies shows BMI to be a useful prognostic factor. Fourth, we evaluated the effects of sleeve gastrectomy and mini by-pass surgery, because our surgeons were experienced with these techniques, and they are the most frequently performed bariatric surgery techniques. Finally, a significant number of patients (7) were lost to follow-up. These losses were unpredictable and might have been due to marked improvements in symptoms in these patients.

Bariatric surgery may be a treatment option for morbidly obese patients with OSAS to be used in conjunction with other modalities, such as NIMV.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Bezmialem Vakif University Faculty of Medicine.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Per-review: Externally peer-reviewed.

Author Contributions: Concept - L.K., F.K., H.C.; Design - F.K.; Supervision - M.S., M.B.; Materials - S.B.; Data Collection and/or Processing - F.K., S.B., M.E.A., H.C., F.Y., M.B., M.S., H.K.Ö.; Analysis and/or Interpretation - F.Y.; Literature Review - H.K.Ö.; Writer - F.K., S.B., M.E.A., H.C., F.Y., M.B., M.S., H.K.Ö.; Critical Review - M.E.A., M.S.

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Conflict of Interest: No conflict of interest was declared by the authors.

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