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REVIEW

METABOLIC BARIATRIC SURGERY AND COMBINED MULTILEVEL SURGERY AS A TREATMENT FOR OBSTRUCTIVE SLEEP APNEA PATIENT WITH OBESITY

Grzegorz Bienia[1a] • Jakub Świętochowski[1b] • Maja Żołnierek[1c] • Nikola Siekierko[1d] • Zuzanna Lubczyńska[1e] • Mateusz Lewandowski[1f] • Wiktoria Kotusiewicz[1g] • Yevheniia Popravko[1h] • Aleksander Kostrzewa[1i]

Grzegorz Bienia
Military Institute of Medicine-National Research Institute
https://orcid.org/0000-0001-9036-5510
Jakub Świętochowski
Uniwersyteckie Centrum Kliniczne w Gdańsku, ul. Dębinki 7, 80-952 Gdansk
https://orcid.org/0000-0003-3848-6520
Maja Żołnierek
Samodzielny Publiczny Specjalistyczny Szpital Zachodni im. św. Jana Pawła II
https://orcid.org/0000-0001-9030-7505
Nikola Siekierko
Szpital Praski p.w. Przemienienia Pańskiego, Aleja Solidarności 67, 03-401 Warsaw
https://orcid.org/0000-0002-1113-7112
Zuzanna Lubczyńska
Szpital Grochowski im. dr med. Rafała Masztaka, ul. Grenadierów 51/59, 04-073 Warsaw
https://orcid.org/0000-0002-4860-2508
Mateusz Lewandowski
University Clinical Center Of Warsaw Medical University
https://orcid.org/0000-0002-4968-1770
Wiktoria Kotusiewicz
Wojskowy Instytut Medyczny- Państwowy Instytut Badawczy, ul. Szaserów 128, 04-141 Warsaw

https://orcid.org/0000-0003-4033-0648
Yevheniia Popravko
Szpital Praski p.w. Przemienienia Pańskiego, Aleja Solidarności 67, 03-401 Warsaw
https://orcid.org/0000-0002-1164-1802
Aleksander Kostrzewa
Szpital Praski p.w. Przemienienia Pańskiego, Aleja Solidarności 67, 03-401 Warsaw
https://orcid.org/0009-0004-8157-9671

[a] grzegorzbienia@gmail.com, https://orcid.org/0000-0001-9036-5510
[b] jakub.swiet@gmail.com, https://orcid.org/0000-0003-3848-6520
[c] maja.zolnierek@gmail.com, https://orcid.org/0000-0001-9030-7505
[d] n.siekierko@gmail.com, https://orcid.org/0000-0002-1113-7112
[e] zuzanna.smiech@gmail.com, https://orcid.org/0000-0002-4860-2508
[f] xm.lewandowski@gmail.com, https://orcid.org/0000-0002-4968-1770
[g] ww.kotusiewicz@gmail.com, https://orcid.org/0000-0003-4033-0648
[h] epopravko1997@gmail.com, https://orcid.org/0000-0002-1164-1802
[i] alex.kostrzewa@gmail.com, https://orcid.org/0009-0004-8157-9671

Abstract

Body mass index (BMI) and the degree of obstructive sleep apnea (OSA) are strongly correlated. Managing obesity is an important strategy for preventing and treating OSA. Bariatric surgery can lead to significant weight loss and improvements in metabolic function, which can have beneficial effects on OSA symptoms within obese population. There is a relative lack of data directly comparing the different types of bariatric surgery and multilevel upper airway surgery for the treatment of obstructive sleep apnea (OSA). While there is some evidence to suggest that bariatric surgery can improve OSA symptoms in obese individuals, and multilevel upper airway surgery can improve OSA symptoms in some cases of anatomical obstruction, there is limited research directly comparing these treatment options. Therefore, this review provides an update on the relationship between OSA, MBS and MLS for demonstrating the significance of multidisciplinary surgery approach for obese patients with OSA.

Key words: Obesity; Bariatric surgery; Weight loss surgery; Combined multilevel surgery; Obstructive sleep apnea; Review

Introduction

According to a recent World Health Organization report [1], which claims that over 600 million individuals have a body mass index (BMI) over 30 kg/m2, this means that obesity is a significant global issue. The high prevalence of obstructive sleep apnea (OSA) is one of the main effects of obesity [2], and the chance of developing OSA rises 1.14 (95% confidence interval [CI] 1.10, 1.19) times with each unit increase in BMI [3]. Recurrent episodes of partial or total upper airway obstruction during sleeping are a typical OSA symptom. Patients with at least five episodes of apnea or hypopnea per hour are diagnosed with OSA (AHI >=5/h). Based on the severity of the apnea-hypopnea index (AHI), OSA can be divided into three different categories. Patients are classified as having mild, moderate, or serious OSA, depending on their AHI (5–14, 15–29, or >30 events per hour) [4]. Obesity-related OSA can lead to a variety of health problems, including hypertension, cardiovascular disease, stroke, and type 2 diabetes. It can also cause daytime sleepiness, fatigue, and cognitive impairment, which can affect daily functioning and quality of life [5]. The two main therapeutic approaches for obese individuals with OSA are continuous positive airway pressure (CPAP) and weight loss. Continues positive air pressure is considered as a gold standard in OSA therapy and operates by insufflating air under pressure to airways to keep them open. In contrast, data from randomized controlled trials (RCTs) demonstrates that CPAP adherence to CPAP therapy is consistently low (3.5 hours use per night) [6] and that up to 50% of patients stop using this therapy after three months [7]. Weight loss is one of the most frequently suggested adjunctive therapies. The only option presently accessible for a long-term and sustainable weight loss is bariatric surgery [3]. Comorbidities linked to obesity such as OSA are also improved or eliminated by these bariatric surgical procedures. In a recent meta-analysis, Greenburg et al. found that patients who underwent bariatric surgery experienced a marked decline in AHI. These researchers discovered that patients' BMI and AHI decreased after bariatric surgery by an average of 17.9 kg/m2 and 38.2 events/hour, respectively [8].

Despite the vast evidence suggestive of importance of bariatric surgery in improvement or resolution of obesity disease comorbidities. There is still no particular metabolic bariatric surgical recommendation for obese patient with OSA. Therefore, in order to emphasize the significance of weight reduction techniques, this study offers an update on how OSA and MBS are related and gives a quick overview of combined surgery techniques used to treat OSA.

Who is a candidate for MBS

Body Mass Index (BMI) of 40 or higher, regardless of the presence, lack, or severity of comorbidities states indication for bariatric surgery. MBS also is recommended for individuals with BMI of 35 kg/m2 or higher with obesity-related medical conditions like OSA, DM2, blood hypertension and others [9]. A background of controlled diets, exercise program used for weight management, weight loss efforts and attitude evaluation are also needed before qualification for MBS. It's crucial that candidates undergo a psychological assessment as part of the pre- operative assessment procedure [10]. The mental health experts carry out this assessment to decide whether surgery is the best course of treatment.

Impacts of different MBS procedures on OSA Fortunately, weight loss can be an effective treatment for OSA in obese individuals. Losing weight can reduce the amount of fat in the neck and throat area, which can help to open up the airway and reduce the severity of OSA symptoms [11]. Bariatric surgery can have a significant impact on obstructive sleep apnea and has been postulated to cause OSA resolution. A significant decrease in postoperative AHI was seen in surgical patients compared to non-surgical ones in systematic analysis comparing bariatric surgery and non- surgical weight loss [12]. Furthermore, over 75% of patients reported improvement or resolution in OSA following bariatric surgery, according to a systematic analysis by Sarkhosh et al. [13] who analyzed data from studies involving 13,900 patients. This trial also stated that BPD (biliopancreatic diversion) was the

most efficient way to cure or improve OSA resulted in resolution of sleep apnea in 82,3% of patients who undergo this procedure. It also indicates that laparoscopic adjustable gastric banding (LABG) the least efficient method where on average only 70,5% of patients experienced resolution of their sleep apnea.
In the Buchwald et al. study, the authors came to different conclusions that gastric bypass (RYGB) was the most efficient in treating or resolving OSA leading to 94,8% improvement. The comparatively small number of patients examined within each subgroup in the Buchwald review [14] may have contributed to this difference. The trend between these two systematic reviews, however, is that interventions with a malabsorptive mechanism, such as RYGB and BPD, which change the gut anatomy and transit time through intestine, are more effective at treating or improving sleep apnea than strictly restrictive interventions, such as LAGB, which only decrease gastric capacity and merely reduce oral intake. Further evidence suggests that the improvement in OSA following bariatric surgery may not have been solely due to Buchwald et al.'s theory of reduced mechanical force on the neck, upper airway, and diaphragm as a weight-dependent effect, but also that weight-independent, metabolic effects may have played a role. [14,15]

Metabolic and inflammatory effect of MBS

Following metabolic surgery, changes in food preferences, metabolic rate, metabolic modulation, the gut microbiome, and improved exercise capacity are among the weight-independent mechanisms for weight loss [16,17]. Although certain metabolic effects leading to reduction in severity of OSA and other obesity related comorbidities are still unknow. Additionally, it is now known that sleep apnea and obesity are linked to low-grade system inflammation [18], and that this inflammatory reaction may be significantly influenced by highly sensitive interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-alpha). Following previous research on the relationship between sleep apnea and proinflammatory cytokines have found either positive correlations or lack thereof between sleep apnea and TNF-alfa [19-22] or IL-6 [22]. Other current research shows that baseline serum CRP and sTNF-R2 levels are two- to threefold above reference levels in people with morbid obesity who have sleep apnea [23]. Furthermore, numerous studies have also demonstrated that bariatric surgery resulted in significant weight loss and improvements in sleep apnea, which are associated with a reduction in inflammation [8, 19] and lower levels of various inflammatory biomarkers. [23].

Weight dependent mechanism

Following bariatric surgery, weight loss is one of the primary mechanisms by which obstructive sleep apnea (OSA) may improve [24]. The upper airway stenosis and chest wall compliance improved as the overall weight and adiposity declined, particularly the amount of adipose tissue deposited around the upper respiratory tract [11] and abdomen, demonstrating that postoperative respiratory function was significantly better than preoperative lead to a reduction or resolution of OSA symptoms.

Impact of MBS on OSA symptoms

Sleep-disordered breathing (SDB) can have a significant impact on an individual's quality of life [25] and OSA is an example of probably the most common type of disordered breathing during the sleep among obese population. One of the primary effects of OSA is disrupted sleep, which can lead to daytime sleepiness, fatigue, and difficulty concentrating. This can impact daily activities such as work and social interactions, and increase the risk of accidents and injuries. SDB can also cause morning headaches, irritability, and mood disturbances [26]. There are several methods that can be used to assess the quality of life in people with obstructive sleep apnea (OSA). The scales listed below are used to assess the evolution of a patient's subjective complaints. The choice of method will depend on the specific research or clinical context, as well as the population being studied.

1. Epworth Sleepiness Scale (ESS): The ESS is a self-administered questionnaire that measures daytime sleepiness [11, 27, 28]. 2. Short-Form 36 (SF-36): The SF-36 is a self-administered questionnaire that assesses quality of life [27]. 3. Functional Outcomes of Sleep Questionnaire (FOSQ): The FOSQ is a self-administered survey that evaluates how sleep disorders affect day-to-day performance [30]. 4. The STOP-Bang questionnaire is a screening tool used to identify individuals who may be at risk for obstructive sleep apnea (OSA) [11]. Priyadarshini's study recorded after LSG or RYGB decline mean ESS score from 8.9 ± 3.2 to 4.03 ± 2.15 ($P < 0.001$) in the group of 27 patients where the mean pre-operative weight and body mass index (BMI) were 126.4 ± 24.9 kg and 48.4 ± 8.2 kg/m^2, respectively. And with mean follow-up of 5.2 ± 2.5 months after surgery, average weight and BMI dropped to 107.4 ± 24.5 kg and 41.2 ± 8.2 kg/m^2, respectively [28]. The similar result was obtained in following study - in 25 severely obese patients (mean BMI 52.7 kg/ m2) with OSA (AHI 25/h), JB Dixon et al. documented changes in ESS scores and SF-36 domain scores before and after LAGB. The ESS score dropped from 13.067 to 3.863.0, and SF-36 domain scores increased from 38 to 90 points [27]. The analogous outcomes were reported in Polish Study by Nastałek and Polok who detected significant improvement in STOP-BANG (6.0 vs. 3.0, p< 0.001) and ESS (12.0 vs. 5.0, p < 0.001) scores among 44 patient who underwent LSG or RYGB and were observed for 12 months after surgery [11]. Daily functional improvement within obese people with OSA after MBS was also noted by H Xie [29]. All above-mentioned studies have shown that bariatric surgery can lead to significant improvements in OSA symptoms and overall quality of life. The degree of weight loss achieved after metabolic bariatric surgery has a directly proportional impact on OSA symptoms improvement – the patients who achieved greater weight loss after surgery had a greater reduction in the severity of OSA.

Impact of MBS on AHI, PSG parameter

Overnight polysomnography (PSG) is considered the gold standard for diagnosing obstructive sleep apnea (OSA) [30] and is also commonly used to evaluate the efficacy of OSA treatment, including post-MBS. PSG involves monitoring various physiological parameters during sleep, such as airflow, oxygen saturation, heart rate, and brain waves, to diagnose sleep disorders and assess their severity.

In the case of OSA, PSG can measure the frequency and severity of apneas and hypopneas, which are characteristic of the condition. The AHI (Apnea-Hypopnea Index) parameter is a parameter measured during polysomnography (PSG) and it is used to assess the severity of OSA [30]. AHI is calculated by dividing the number of apneas (complete cessation of breathing for 10 seconds or longer) and hypopneas (partial obstruction of the airway resulting in decreased airflow by at least 30%) by the number of hours of sleep. The resulting value indicates the average number of apneas and hypopneas per hour of sleep.

Metabolic bariatric surgery has been found to have a positive impact on sleep apnea, as measured by the Apnea-Hypopnea Index (AHI) on polysomnography and there have been several studies to confirm that. Whatever the weight reduction intervention method, patients who lose the most weight and/or have more severe OSA experience the highest benefits [31].

One study by JB Dixon analyzed the outcomes of 25 obese patients who underwent laparoscopic adjustable gastric banding (LAGB) and had baseline AHI measurements during pre and post-operative PSG. The study found that AHI decreased significantly after surgery, from 61.6 ± 34 to 13.4 ± 13 within average 17 (± 10) months of follow-up [32]. Another clinical study showed close improvement of PSG parameters after even shorter period after surgery. There was analyzed group of 110 patients who underwent postoperative PSG 7,7 months after various types of MBS. They noticed significantly drop of AHI from 39,5 to 15,6 per hour [11].

It is important to notice that in numerous of cases of morbid obese with severe OSA there is low chance to achieve AHI normalizing (<5/h), especially within such short period of follow up when the postoperative sleep assessment is conducted (like above). Even though such a reduction of AHI following MBS enables discontinuation of CPAP treatment
[11] and improves quality of life.

Combined multilevel surgery for OSA

Combined multilevelsurgery (MLS) and metabolic bariatric surgery is a surgical approach for patients with obesity accompanying by obstructive sleep apnea. MLS is a surgical technique that involves addressing multiple levels of the upper airway to optimize the airway space and improve airflow. MLS can include procedures such as uvulopalatopharyngoplasty (UPPP) or genioglossus advancement (GA). Combining MLS and metabolic bariatric surgery can result in significant weight loss, which can improve OSA by reducing the pressure in the upper airway [33]. The MLS procedures can optimize the airway space and improve airflow, which can further reduce OSA severity [34, 35]. An example of such surgical approach of multilevel upper airway surgery within nonobese population is presented by MacKay and his team [34]. This is a randomized clinical trial of 102 adults where researchers compared influence of modified UPPP and radiofrequency in saline tongue reduction with conventional management of OSA. They noticed a significant reduction the number of apnea and hypopnea events and patient-reported sleepiness (reduction of AHI and ESS value) within 6 months follow-up after MLS comparing to morbid improvement of symptoms within convectional treatment group [34]. The mean AHI for the surgery group was 47.9 at baseline and 20.8 at six months, while for the medical treatment group it was 45.3 at baseline and 34.5 at six months [34]. According to ESS the mean value was 12.4 at baseline, 5.3 at six months for the surgery group, and 11.1 at baseline, 10.5 at six months for the medical treatment group [34]. On one step further went Mahmoud A. K. Ebrahim with other two authors who presented the 5-year follow-up statistics of a patient who underwent laparoscopic Roux-en- Y gastric bypass and combined multilevel surgery (MLS) [33]. A morbidly obese male patient whose BMI was 39 kg/m^2 underwent MLS, which involved the insertion of five pillar palatal implants in the soft palate, followed by cold dissection tonsillectomy and reduction of nasal turbinate. After MLS laparoscopic Roux- en-Y gastric bypass was immediately conducted. Preoperative presented AHI was 53 episodes/h, indicating severe OSA and his ESS score was 18. Repeat polysomnography (PSG) at 18 months after surgery revealed that the patient was asymptomatic and that the AHI had dropped from 53 to 5.2 episodes/h without the use of CPAP. After five years of follow-up AHI remains low (6,8 episodes/h) and patient was still asymptomatic. His latest BMI was 27 kg/m^2 and ESS score after all decreased from 18 (preoperatively) to 8 [33].

Conclusion

Obesity is a major risk factor for obstructive sleep apnea (OSA), and there is a strong correlation between the two, furthermore studies have shown that over 70% of people with OSA are obese [35]. Patients who are morbidly obese and have obstructive sleep apnea may benefit greatly from weight reduction programs. Even a modest weight loss of 10-15% can significantly improve OSA symptoms [36, 37]. That’s why metabolic bariatric surgery can become an important therapeutic option in the management of obstructive sleep apnea (OSA), particularly in patients who are morbidly obese. MBS can lead not only to decreasing of body weight but also have important influence on obesity-associated metabolic disorder. One of the primary metabolic effects of MBS is improvements in insulin resistance and glucose metabolism. Also, a beneficial effect on lipid metabolism, reduction of blood pressure and markers of inflammation. Current literature shows a clear benefit of metabolic bariatric surgery as an option in management of concomitant OSA, obesity and metabolic disturbance. To support bariatric effect, multiple levels surgery (MLS) of the upper airway can be considered. The combination surgery can have two results. Firstly, in significant weight loss, which can improve OSA by reducing the pressure in the upper airway. Secondly, the MLS procedures can optimize the airway space and improve airflow, which can further reduce OSA severity. Several small studies have suggested that a combination of MBS and MLS can be beneficial in the management of obstructive sleep apnea (OSA) in obese populations, however, these studies have been limited by small sample sizes and short follow-up periods that's why the evidence is not strong enough and further research is needed to confirm these findings. Additionally, it is important to note that not all patients with OSA and obesity may be candidates for MBS and/or MLS, and individualized treatment plans should be developed based on each patient's specific needs and medical history. Consultation with a qualified healthcare provider who specializes in the management of OSA and obesity is recommended to determine the most appropriate treatment approach.

Abbreviations

BMI – Body mass index

OSA – Obstructive sleep apnea

MBS – Metabolic bariatric surgery

MLS – Multilevel surgery

PSG – Polysomnography

AHI – Apnea-hypopnea index

CPAP - Continuous positive airway pressure

LAGB - Laparoscopic gastric banding

RYGB - Roux-en-Y gastric bypass

BPD - Biliopancreatic diversion

ESS - Epworth Sleepiness Scale

SF-36 - The Short Form (36) Health Survey

FOSQ - Functional Outcomes of Sleep Questionnaire

UPPP – Uvulopalatopharyngoplasty

GA - Genioglossus advancement

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