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THE ROLE OF OBESITY IN THE SURGICAL TREATMENT OF OBSTRUCTIVE SLEEP APNEA SYNDROME

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Obesity, represented by a Body Mass Index (BMI) above 30 kg/m^2, is a major risk factor for Obstructive Sleep Apnea Syndrome (OSAS). Its effect depends of the distribution of adiposity, men beeing more susceptible than women. The treatment applied may vary from non-surgical procedures to multilevel surgery. The aim of these study was to determine the implication of obesity in the development and progression of OSAS and to establish its role in the surgical treatment planning and outcome. The effect of bariatric surgery on OSAS has been studied by several trials which revealed a decrease in Apnea-Hypopnea Index (AHI) at follow-up. Surgery for hypopharyngeal obstruction in morbidly obese patients reduced the mean AHI. Even though some authors claim that Continuous Positive Airway Pressure (CPAP) does not change the BMI, this therapy is associated with the decrease of blood pressure, gycemia and daytime sleepiness. Guidelines recommend for bariatric surgery patients with a BMI≥35kg/m^2 and OSAS or patients with a BMI≥40kg/m^2.Weight loss increases upper airway diameter and reduces the metabolic effect of the adipose tissue resulting in increased compliance to CPAP, better surgical outcome, higher quality of life and reduced comorbidity.

Key words: OSAS, obesity, surgical treatment.

INTRODUCTION

Obesity is a widespread health problem represented by a BMI above 30kg/m^2 and associated with several comorbidities like obstructive sleep apnea syndrome (OSAS), type 2 diabetes, hypertension, heart disease, stroke, cancer and degenerative problems. Obesity, along with its metabolic and anatomical changes, is a major risk factor in the etiology of OSAS determining the collapse of the upper airway. Its effect depends of the distribution of adiposity whether it is central or peripheral, in this aspect men beeing more susceptible than women. The treatment applied in obese patients with OSAS may vary from non-surgical procedures as weight loss, CPAP, oral appliances and positional therapy to multilevel surgery[1].

The aim of this study was to determine the implication of obesity in the development and progression of OSAS and, in the same time, to establish its role in the surgical treatment planning and outcome.

Clinical evidence of the role of obesity on OSAS

The fat depositions may surround the upper airway resulting in smaller lumen and increased collapsibility of the upper airway and may generate the truncal obesity reducing chest compliance and functional residual capacity. However, OSAS may cause weight gain by increased appetite and lack of activity[2]. It has been described a genetic polymorphism that may affect in the same time sleep apnea and obesity. Patel et al. reported that obesity explains 40% of OSAS[3] and Popko et al. showed that leptin receptor is correlated with OSAS and obesity[4].

The metabolic dysregulation has been associated with OSAS independent of obesity: glucose intolerance, insulin resistance, diabetes, cardiovascular diseases and lipid abnormalities. This may be an explanation of the metabolic improvement of patients who underwent Continuous Positive Airway Pressure (CPAP) therapy. Even though some authors claim that CPAP does not change the BMI[5], this kind of therapy is associated, among others, with the decrease of blood pressure, better glycemic control and reduction of daytime sleepiness[6].

The interaction between OSAS, obesity and sleep deprivation may trigger the pathophysiologic feature of metabolic dysregulation. *Leptin*, produced by adipose tissue, is a hormone responsible for the sensation of satiety; paradoxically hyperleptinemia does not increase this sensation because it desensitizes the cellular response. Because it has been demonstated that leptin level is reduced after 4 days of CPAP use[7], we may conclude that OSAS has its own implication in metabolic disorders besides obesity. *Ghrelin*, a counter-regulator to leptin, increases its production while

reduced sleep, which stimulates appetite leading to obesity and OSAS[8,9]. Several adipokines have been proved to interfere in OSA and obesity pathophysiology, like *tumor necrosis factor* α and *interleukin-6*, which produce depression of central nervous system activity and airway neuromuscular control and may also trigger proinflammatory substances[10] creating a vicious circle in which OSA increases its severity. *Adiponectin* prevents inflammation and atherosclerosis by involving in glucose and lipid metabolism; unfortunately, its levels are low in obesity and OSAS, but CPAP treatment is proved to increase its level[11]. *Nesfatin-1* regulates the brain functions linked to stress, food ingestion, mental state and paradoxical sleep. Aksu et al. studied the connection between OSAS, metabolic syndrome and Nesfatin-1 levels by admitting 59 patients diagnosed with OSAS with or without metabolic syndrome and dividing them into three groups - mild, moderate and severe apnea. He discovered that there was a significant lower level of Nesfatin-1 in the metabolic syndrome group compared to non- metabolic syndrome group[12]. *Aldosterone*, as a part of the hypothalamic–pituitary–adrenal axis, increases along with the activity of the sympathetic nervous system resulting in high blood pressure and greater heart rate; sleep fragmentation, frequent arousals and hypoxemia produce pulsatile cortisol release with a rise of its concentration in the evening[13,14]. Caneiro et al. showed a reduction in heart rate after 3 month of CPAP use, but no difference in arterial blood pressure[15].

Metabolic Syndrome Z represents a risk factor for cardiovascular diseases beeing characterized by central obesity, hypertension, insuline resistance and hyperlipidaemia. When, in the clinical pannel, OSAS is also present, it is considered as "syndrome Z"[16]. The relationship between sleep apnea and blood pressure has a circadian pattern (dipping and non-dipping) and represents an important prognostic factor in terms of risk for cardiovascular events[17-19]. Grunstein et al. showed that morning diastolic blood pressure is increased in patients with OSAS compared with those without OSAS, independently of obesity and age, but with a stronger correlation in the women cohort[20,21].

As the central control of blood pressure is affected by OSAS, the daytime blood pressure response to hypoxia and the physiological decrease of blood pressure at night may become abnormal[22]. Furthermore, there is a cyclic variation in heart rate and blood pressure that occur during sleep compared to normal subjects. That may explain why the acute coronary events take place more frequently during sleep in the case of OSAS patients, especially in the early hours after awakening, due to the increased sympathetic nerve activity that persists during wakefulness[23,24].

Surendra et al. performed a 2 year cross-sectional study showing that, in subjects with normal BMI, the metabolic syndrome appears first followed by OSA with the developing of syndrome Z[25].

Bariatric surgery for treatment of OSAS

The bariatric surgery reduces the amount of caloric intake by changing the anatomical features of the gastrointestinal tract. It is indicated, as the National Institutes of Health guidelines recommends, for patients with BMI > 35 kg/m^2 and OSAS or for patients with a BMI $\geq$ 40 kg/m^2 [26]. The weight loss effect is seen in about 2 years, when reaches a plateau and continues to decrease for about 10 years until reaches 25% of initial weight[27]. Moreover, bariatric surgery may provide great outcome in terms of improvement in oxygen saturation, sleep efficiency and rapid eye movement latency by reducing the intra-abdominal pressure and increasing the diaphragmatic excursion[28]. The principle of bariatric procedures is represented by the reduction of gastric reservoir and the narrowing of outlet region, in order to reduce the gastric volume to 20-25ml and delay emptying. These procedures may be restrictive, mal absorptive or combined and the most commonly performed are adjustable gastric banding (AGB), Roux-en-Y gastric bypass (RYGB), sleeve gastrectomy (SG) and bilio-pancreatic diversion (BPD)[1,29]. The final effect of this surgery is the reduction of both visceral and subcutaneous adipose tissue resulting in anatomical and hormonal changes that are more common after performing mal absorptive procedures[30]. That explains why AGB is not superior to weight loss therapy and BPD is considered to be the most effective in improving OSA, followed by SG and RYGB[31].

The effect of bariatric surgery on the severity of OSAS has been studied, using polysomnographic parameters, by several trials[32-44] which revealed a significant decrease in Apnea-Hypopnea Index (AHI) at follow-up (Table 1).

BMI pre	BMI post	AHI pre	AHI post	p-Value	EBM	Author
48.3	33.1	82.0	15.3	No data	4	Peiser et al.[32]
70.8	55.0	88.8	8.0	<0.05	4	Charuzi et al.[33]
47.5	32.1	58.8	7.8	<0.001	4	Charuzi et al.[34]
54.0	37.0	40.0	5.0	No data	Case report	Summers et al.[35]
56.0	40.0	64.0	26.0	<0.001	4	Sugerman et al.[36]
45.0	35.0	40.0	24.0	<0.05	4	Pillar et al.[37]
160 kg	105 kg	96.9	11.3	<0.0001	4	Scheuller and Weider[38]
62.0	40.0	56.0	23.0	<0.05	4	Rasheid et al.
49.0	34.0	55.0	14.0	<0.01	4	Guardiano et al.[39]
56.5	39.2	53.7	8.6	<0.01	4	Valencia-Flores[40]
55.8	48.6	52.1	14.0	<0.01	4	Busetto et al.[41]
52,7	37.2	61.6	13.4	<0.01	4	Dixonet et al.[42]
51.5	34.1	46.5	16.0	<0.05	4	Frischer et al[43].
56.0	38.0	51.0	15.0	<0.001	4	Haines et al.[44]
54.51	**38.39**	**57.91**	**14.80**		**C**	**All**

Table 1. Effect of gastric surgery on the severity of obstructive sleep apnea[1]

There are several authors who have studied the effect of bariatric surgery on OSAS severity using polysomnographic data and CPAP pressure requirement before and after surgery[46,47].

Buchwald et al. performed a meta-analysis revealing that OSAS was resolved or improved after surgery and that RYGB was the most successful procedure, followed by SG, BPD and gastric banding. However, the patients cured were younger and lighter. Another finding was that of a mean residual AHI > 15 events/hour, despite the considerable improvement. The limitation of the study was the short term follow-up (3 months) as most of the patients had not been achieving the final weight loss[46].

Dixon et al. conducted a randomised trial that revealed no significant weight loss after bariatric surgery compared to conventional weight loss measures. However, the patients received only AGB, which is known to have the least improvement on OSAS[47].

Multilevel surgery

The aim of surgical therapy in OSAS is to eliminate airway collapse, improve sleep, raise compliance to CPAP and, overall, increase quality of life[48]. In 1996, Sher et al. defined the surgical success as the improvement of the Respiratory Distress Index (RDI) with 50% with decrease to below 20, or the Apnea Index (AI) to below 10; an AHI under 5 define a curative surgical treatment[49-52]. In Table 2, there are highlighted the surgical options according to each anatomical region that may be involved in the obstructive process.

Anatomic location	Surgical procedure
Nasal cavity	Polypectomy Ablation of turbinate Septoplasty
Nasopharynx	Adenoidectomy
Oropharynx	Tonsillectomy UPPP LAUP Rapid maxillary expansion
Hypopharynx	Midline glossectomy, Tongue base reduction Mandibular advancement Genioglossal advancement Hyoid myotomy suspension
Oro and hypophanrynx	Maxillomandibular advancement
Bypass of the airway	Tracheotomy

UPPP – *Uvulopalatopharyngoplasty*;
LAUP - *Laser-Assisted Uvulopalatoplasty*

Table 2. Surgical options according to each anatomical site[49]

Surgical therapy aims the obstruction, usually at multiple levels, of the upper airway and it is indicated for patients unresponsive or unwilling to wear CPAP. Because the surgical interventions may take place at more than one level, the procedures were divided into two groups (Table 3). The Phase 1 surgery encompasses the most conservative procedures and is recommended to be attempted first. The benefits and risks of different surgical interventions are also an important factor in choosing the right technique[53].

	Procedures
Phase 1	Nasal reconstruction Uvulopalatopharyngoplasty Geniohioid advancement
Phase 2	Maxillary advancement Mandibular osteotomy Tongue base resection

Table 3. Surgical procedures divided into two phases according to the anatomical level of obstruction[53]

Friedman et al. (2007), in a retrospective review of a prospective dataset of 145 patients, studied the effect of a three-level treatment (nasal surgery, palatal implant technique, radiofrequency reduction of the tongue base) by assessing polysomnographic parameters, Epworth Sleepiness Scale and visual analogue scale of the bed partner; he revealed that multilevel minimally invasive single-stage surgery improved the targeted parameters in patients with mild to moderate OSAS[54]. A year later, along with Lin et al. in a meta-analysis, he assessed the multilevel surgery outcome for the treatment of OSAS discovering that surgical succes may be represented by the improved condition of the patient[55].

CONCLUSIONS

Obese patients are associated with obstructive apnoea, therefore screening these patients by using polysomnography it is advisable. Reduction of adipose tissue around the neck and waist improves the metabolic and inflammatory status. Weight loss increases upper airway diameter which results in improvement of polysomnographic parameters and reduces the metabolic effect of the adipose tissue resulting in increased compliance to CPAP, better surgical outcome, higher quality of life and low comorbidity. Guidelines recommend for bariatric surgery patients with a BMI $\geq$ 35 kg/m^2 and OSAS or patients with a BMI $\geq$ 40 kg/m^2. Roux-en-Y gastric bypass is the most efficient of bariatric procedures. A life-long follow-up is mandatory for long-term weight control and therapeutic success.

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