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CURRENT CHALLENGES IN THE DIAGNOSIS AND TREATMENT OF OBSTRUCTIVE SLEEP APNEA SYNDROME IN THE ELDERLY

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ABSTRACT

Obstructive sleep apnea syndrome (OSAS) is a respiratory sleep disorder characterized by repeated episodes of partial or complete obstruction of the upper airway that occur during the night. OSAS is a common disease in the elderly population with an estimated incidence of between 20% and 60% in people over the age of 65. Due to the high prevalence of OSAS in older people and considering the increase in the average age of the world population, it is essential to know how to diagnose and treat this disease in elderly patients.

Keywords: OSAS, the elderly, respiratory sleep disorders, apnea

INTRODUCTION

The number of adults aged 65 and over has been growing in recent decades, and the number of people over 65 is expected to double by 2030 in the United States [1,2].

Obstructive Sleep Apnea Syndrome (OSAS) is a respiratory sleep disorder characterized by repeated episodes of partial or complete obstruction of the upper airway that occurs during the night. This obstruction usually occurs with a reduction (hypopnea) or complete cessation (apnea) of the airflow in the upper airways with the persistence of thoracic-diaphragmatic respiratory movements [1-3].

During the hypopnea/apnea events, poor alveolar ventilation leads to a reduction of the oxygen saturation in the arterial blood (SaO2) and a gradual increase in the partial arterial pressure of carbon dioxide (PaCO2). At the end of the apneic events, due to activation of the sympathetic systems, a subclinical awakening defined as "arousal" occurs. The electroencephalographic appearance of ‘’arousal’’ consists of an alteration of the micro- and macrostructure of sleep that is the cause of daytime sleepiness of OSAS patients [1-3].

OSAS is a frequent and often underestimated disease, affecting between 2% and 4% of middle-aged women and men; however, various clinical studies have reported a much higher incidence in elderly people. The OSAS incidence in the elderly has been estimated between 20% and 60% in people over 65 years [1-5]. To this regard, Ancoli et al., analyzing 427 elderly patients, showed that 24% of 65 patients showed a higher apnea/hypopnea index (AHI) ≥ 5 and that 62% had a respiratory disturbance index RDI ≥ 10[5]. In another study reported by Young et al., comprising 5615 men and women between 40 and 98 years of age, sleep apnea was found to be most frequent in subjects aged 60 years or older (approximately 50% had an AHI of 5–14, and nearly 20% had an AHI ≥ 15) [6].

Additional data were provided by Senaratna et al., who analyzed the increase in the incidence of OSA with age. In the elderly population 88% of men aged 65 to 69 have ≥ 5 events / h while this incidence goes up to 90% in men aged 70 to 85 % [7].

Due to the high incidence of OSAS in older people and considering the increase in the average age of the world population, it is essential to be aware of the diagnosis, classification and treatment of this disease in elderly patients [8-10]. In this manuscript, we report a review of the main diagnostic-therapeutic approaches and current challenges in the diagnosis and treatment of obstructive sleep apnea syndrome in the elderly.

OSAS DIAGNOSIS IN ELDERLY PATIENTS

Symptoms of OSAS in elderly patients

Even in the elderly, a clinical suspicion of OSAS must be considered in the presence of some typical nocturnal symptoms (persistent snoring, awakenings with dyspnea sensation, polyuria) and diurnal (sleepiness, headache; dry mouth and feeling of restless sleep; asthenia; neurological disorders, mood disorders, changes in lifestyle habits with impaired personal relationships) [5,11-15].

The main symptom of OSAS is daytime sleepiness. However, daytime sleepiness in elderly patients is usually less pronounced than in patients under 65 years old. This data has been confirmed by several clinical studies that compare the results of the Epworth (ESS) questionnaire on sleepiness in patients over 65 and under 65 years of age, showing that the mean ESS values of the elderly groups were lower than those of younger patients [3-5]. To this regard, Gottlieb et al. conducted a cross-sectional cohort study to analyze OSAS characteristics[16]. In univariate analyses, subjects <65 years of age had higher average scores of ESS than those aged >65 (8 versus 7.5, p = 0.012).

Recently, Iannella et al., by means of a regression analysis comparing the age of the patients and the ESS, confirmed a reverse correlation between ageing and daytime sleepiness (p = 0.05) [8].

Anatomical features associated with OSAS diagnosis in the elderly

The ENT evaluation is an essential step in the assessment of elderly patients with OSAS. At clinical examination, different predictive anatomical characteristics of OSAS might be identified. A body mass index> 29 kg / m2, neck circumference> 43 cm in males and> 41 cm in females is related to a 70% probability of being affected by OSAS [3]. Any possible craniofacial dysmorphism should be investigated even though these represent the most frequent cause of OSAS in young patients or children [5,10,11].

At oropharyngoscopy, dental occlusion, Mallampati grade and palatine tonsil Friedman classification should be evaluated and collected. The degree of palatine tonsil and Mallampati score is directly related to the severity of OSA [17]. Moreover, elderly patients have a higher incidence of macroglossia and a thinner and soft velopharyngeal region compared with younger patients [5,11-16,25].

Fibrolaringoscopy is an essential diagnostic procedure in the diagnosis of OSA. It allows assessment of the anatomical features of the soft palate, the hypopharyngeal region, the base of the tongue and epiglottis. In elderly patients, lymphatic hypertrophy of the tongue base may be the cause of hypopharyngeal obstruction during the night [11-16,25]. Finally, Muller's endoscopic manoeuvre provides essential indications about the degree of muscle laxity of the oropharyngeal walls that is usually higher in older patients [11,12].

Polysomnographic diagnosis

According to the AASM Manual for the Scoring of Sleep and Associated Events, the polysomnography (PSG) represents the first test for confirming diagnosis in adult patients with a clinical suspicion of OSA (clinical symptoms and anatomical objectivity) [24]. PSG records different sleep parameters: electroencephalogram, eye movements, cardiac activity (ECG monoderivation), thoraco-abdominal movements, snoring, oxygen saturation and nocturnal respiratory activity through the analysis of nasal and buccal airflow [11-13]. Moreover, in elderly patients, the PSG test can be performed at home, following specific recommendations from national and international scientific societies [13].

The respiratory pattern emerging from the night study is then assessed according to standard criteria for evaluating the type, frequency, and duration of apneas and hypopneas [10-13]. The OSA is classified according to the apnea-hypopnea index (AHI), which is obtained by adding the number of apneas-hypopneas during sleep and dividing it by the hours of sleep: an AHI <5 per hour is considered normal, between 5 and 15 indicates mild OSA, between 15 and 30 moderate OSA, > 30severe [11-13].

In the analysis of the polysomnogram, the parameters relating to SpO2 should not be underestimated. Usually, the average SpO2 and Nadir (lowest recorded SpO2 value) of patients over 65 years are lower than in younger patients, explained by the higher incidence of Chronic obstructive pulmonary disease **(**COPD) and the reduced lung exchange capacity of these patients [11-13].

Although different authors have evaluated the effect of age on the AHI value and the severity of OSA, there is currently no consistent opinion on this topic [8,18,26-29].
Chun et al. reported a higher value of AHI and a longer duration of apnea-hypopnea in the elderly group compared to young patients ($p = 0.02$). However, no significant difference in the polysomnographic results related to night oxygen desaturation was reported [18]. Iannella et al. through a meta-analysis study that compared the age of the patients and the AHI scores, found no significant differences in the basal AHI between young (<65 years) and elderly (> 65 years) patients [8]. Via random-effects modelling, they did not demonstrate an aging effect on AHI (k = 6 studies; 95% CI - 0.01 to 0.12; $p <0.01$, $I^2 = 75.5\%$).

Current challenges in diagnosis

Nowadays, a new diagnostic tool in the OSA syndrome is represented by the Drug-Induced Sleep Endoscopy" (DISE). By means of some drugs (propofol, midazolam, etc.) sleep, similar to the real one, is induced and a fibre optic evaluation of the upper respiratory airways is performed. These studies make it possible to evaluate the location, exact type and degree of collapse of the anatomical structures of the upper airways implicated in each single case.
In the past, this procedure was reserved exclusively for young patients in order to define appropriate operative planning [23]. However, it has been increasing used more recently in elderly patients both in those with poor compliance or ineffectiveness of ventilatory therapy or to better understand the sites and the collapse pattern of the upper respiratory airways.
Interesting data regarding different sites of obstruction and patterns of collapse during the DISE procedure have emerged between elderly and young patients [8]. Vicini et al. found a higher incidence of total collapse in the Velum region in elderly patients compared to younger ones (90.9% vs 70%) ($p = 0.01$) but a lower rate of the whole oropharyngeal lateral wall (20 % versus 50%). Furthermore, a partial collapse of the epiglottis has been demonstrated in adults aged 65 and over compared to young patients ($p = 0.0006$) [8]. Zhao et al. in another study regarding DISE in elderly

patients confirmed a significant correlation with combined upper (palatopharyngeal) + lower (hypopharyngeal) level obstructions. At the same time, lateral oropharyngeal wall collapse was significantly lower in the older group [27].

In some patients with OSA there was a reduction of the number of apneas during sleep in the lateral position recoded by PSG. These are classified as Positional Obstructive Sleep Apnea (POSA) patients.

Heinzer et al. reported exciting findings regarding positional sleep apnea in the middle to older age general population [30]. In this study, the prevalence of POSA in elderly patients was higher than expected, with 53% of the analyzed patients presenting a POSA diagnosis. In another recent study, evaluating POSA in the elderly, similar data emerged showing that 49.3% of patients aged >65 years were defined as POSA using the Cartwright classification system [31]. Identifying elderly patients with POSA would mean using this characteristic as a possible customized treatment.

TREATMENTS FOR OSA IN ELDERLY PATIENTS

CPAP continuous positive airway ventilation

There are several treatment options available for elderly patients with OSAS. As reported by many authors, the first-choice therapy remains the use of continuous positive airway pressure (CPAP) [1-5].

CPAP keeps the airways open by creating positive pressure during sleep. Available CPAP machines are also able to document the primary night outcomes (the AHI, the air leaks, and the daily use of the device). These data can be used by the physician to assess device efficacy and patient compliance [5,10,11]. CPAP should be used for ≥ 4 hours and for 70% of nights to increase the OSAS clinical symptoms and decrease the likelihood of associated cerebrovascular events [5,10-13].

Numerous studies in the literature have evaluated the effectiveness of ventilatory therapy in elderly patients with OSA. Martínez-García et al. reported CPAP use in a randomised, multicentre clinical trial in a clinical cohort of 224 elderly subjects (mean±SD age 75.5±3.9 years) with severe OSA [33]. Residual AHI following the application of CPAP device was 3.9±7.4 events/h. The everyday use of CPAP treatment was 4.9±2.5 h/night, with 35 (30.4%) patients presenting <4 h per night (69.6% with good adherence).

The efficacy of CPAP treatment in elderly patients was also confirmed in a study of 404 patients with a mean age of 61.59±13.82 years performed by Philip et al [34]. In particular, while the mean initial ESS score was 9.55±6.07 and the AHI score was 34.61±20.71/h., following CPAP treatment there was a significant improvement in the post-treatment ESS score of 4.82±4.01 and the mean residual AHI of 1.93±2.61/h.

The main problem related to CPAP therapy is that between 30 and 50% of OSAS patients do not tolerate the device. This percentage is now also increasing in patients over 65 years of age who tend to accept less and less this device for quality improvement.

Sawyer et al. through a systematic review of CPAP adherence across age groups, examinated factors that influenced adherence to CPAP [35]. In particular, they found that in older patients functional deterioration (movement disability), hearing loss, and psychiatric illness were not associated with lower adherence to CPAP, but with slightly higher utilization rates. Besides, reduced alcohol consumption and the degree of severity of OSAS are related to an increased use of CPAP. Cognitive-behavioural disorders and insomnia, on the other hand, were related to poorer adherence to CPAP treatment in the elderly patients [35].

Therefore, alternative therapies to CPAP, which in the past was considered the only valid treatment for these people, should be regarded in the same way as in the population over the age of 65 years [1-5].

Mandibular Advancement Devices MAD

A CPAP therapeutic alternative in elderly patients could consist of the use of an oral appliance (Mandibular Advancement Devices, MAD). These devices are applied overnight and anchored to the upper and lower dental arches. The treatment determines a mandibular advancement with the forward movement of the tongue and enlargement of the hypopharyngeal diameter in the anteroposterior direction. These devices also exert a stabilization of the hypopharyngeal lateral walls. Though, not data are available regarding the stabilizing effect of the soft palate. For this reason, MAD are indicated in patients with mainly hypopharyngeal obstructions [10,36].

Jaiswal et al. comparing the AHI values before and after using MAD, showed an average reduction of the AHI from 26.2 +/- 6.53 to 13.7 +/- 6.2 with a statistically significant difference. However, the main problem related to the use of the oral appliance consists of the patient's dental situation and to the temporomandibular joint. A precarious situation of dental stability, an edentulism or dysfunction of the temporomandibular joint could be absolute contraindications to use this device [10,36]. Since patients over 65 are more likely to present these clinical situations, this reduces the possibility of using this device in this population of OSA patients. In the literature, there is little data available on the use of MAD in a patient population over 65 years of age. In 2015 Marklund et al. evaluated MAD use for treating patients with snoring and obstructive sleep apnea (OSA) and included 56 patients over 65 years; only 45 of these initially enrolled (80 %) patients continued treatment at a 1-year follow-up [36]. Although in elderly patients MAD reduced AHI to similar values of younger age groups ($p<0.001$) with the same success rate, in an older population more severe bite changes occurred due to the presence of fewer teeth and impaired bone support. Indeed, after the treatment, the horizontal distance between the upper and the lower frontal teeth, the overjet, decreased by 1.0 mm in the older group and by 0.7 mm in the younger group ($p=0.24$).

Therefore, further studies are necessary to evaluate the cost/benefit ratio and applicability of this device in elderly patients.

Surgery for OSA

Different surgical options are available for OSA treatment [10]. Over the years, classic uvulopalatopharyngoplasty (UPPP) palatal surgical techniques have been replaced by more modern lateral pharyngoplasty techniques [38,39].

In 2015 Vicini et al. proposed a new palatal procedure for snoring / obstructive sleep apnea (OSA) called barbed repositioning pharyngoplasty (BRP) [40]. Through the use of a " barbed" suture, the palatopharyngeal muscle is relocated into a more lateral and anterior position in order to enlarge and stabilize the area of the velopharyngeal region. Good results in terms of AHI reduction and lower postoperative complicationa after BRP surgery for OSA was reported in a recent study reported by Iannella et al [41]. However, surgery should be carefully evaluated in elderly OSA patients; anaesthesiological risks, possible surgical complications and the risk of surgical failure should be considered before choosing surgery [1-5].

In this context, in their recent observational study Gouveia et al. analysed the complications of surgery in 107 OSAS patients aged> 65 years, showing that elderly patients undergoing sleep surgery have an increased risk of postoperative complications compared to younger people treated with the same procedures [10]. In particular, the elderly group had higher rates of wound dehiscence, postoperative bleeding and postoperative urinary tract infections. The specific complication rate for the elderly patients reported was 7.5%, and multivariate analysis identified age>65 was as an independent risk factor for peri-operative complications [10].

Furthermore, in elderly patients, it should be borne in mind that the degree of collapsibility of the retropalatal structures is certainly greater than in younger patients. This anatomical-functional characteristic could lead to a higher degree of failure in terms of functional outcome of the various surgical pharyngoplasty techniques [1-5].

Major surgery interventions such as tongue base resection using trans-oral robotic surgery and bi-maxillary advancements must be considered with extreme caution in elderly OSA patients due to the high peri- and post-operative risk of complications (bleeding, dyspnoea, etc.) [10].

Vibrational Alarm Devices

OSAS treatment devices can be used in elderly POSA patients. The purpose of these devices is to decrease the amount of sleeping time in the supine position and promote sleep in a lateral position in patients who show a reduction of the AHI during sleep in lateral position at the PSG evaluation. The most commonly used device for POSA treatment, called 'Night Shift', is a small, neck-worn vibrating device, which prevents patients from assuming a supine sleeping position. When wearing the device, adopting a supine position triggers a vibration that increases in intensity until a new position is adopted, without significantly reducing total sleep time or disrupting sleep.

Thirty patients with positional sleep apnea were included in a pilot study to evaluate this device performed by Van Maanen et al. [42]. No side- effects were reported. The mean AHI dropped from 27.7 ± 2.4 to 12.8 ± 2.2. Seven patients developed an overall AHI below 5 when using the device.

Although vibrational alarm devices can be equally used in the elderly as in young patients, no study in the literature has confirmed the efficacy in AHI reduction in elderly patients. Besides the long-term effect of these devices remains to be studied.

Weight loss

The fundamental role of lifestyle intervention, intensive physical exercise with the aim of weight loss, and the acquisition of correct behavioural rules is proven to be effective in AHI reduction [43,44].

In elderly patients, weight loss can have a significant impact. It has been estimated that in these patients, a 10% loss of body weight is equivalent to a 27% decrease in AHI.

To examine the change in OSA severity following exercise training and dietary-induced weight loss in older adults, Dobrosielski et al. enrolled n=25 obese adults with OSA, aged 60 years or older [45]. All the participants performed cardiorespiratory training and resistance exercise, according to the American College of Sports Medicine guidelines. Weight loss after activity was 9% ($p<0.01$) and resulted in decreased AHI by 10 events per hour of sleep ($p=0.03$). Furthermore, there was an increase in total sleep time ($p<0.01$), and nocturnal mean SaO_2 changed from 94.9% to 95.2% post-intervention ($p=0.02$).

Moreover, in a study performed on obese patients with Type 2 diabetes, Kuna et al. demonstrated the relationship between changes in the apnea-hypopnea index related to the amount of weight loss ($P < 0.0001$) and intervention, independent of weight loss ($P = 0.001$) [43]. In particular, they stated that the AHI reduction was 5 times more frequent with intensive lifestyle intervention (20.7%) than diabetes therapy (3.6%).

CONCLUSIONS

OSAS must always be suspected in elderly patients who show typical night and daytime symptoms of sleep apnea. For OSA diagnosis in elderly patients, polysomnographic examination is mandatory. Today, DISE could play an increasing role in the diagnosis of OSA in elderly patients to analyze patterns and sites of collapse.

The first choice of treatment remains CPAP. Alternative therapies such as surgery and MAD should not be excluded even if the evidence of the literature regarding these therapeutic modalities is still limited and no validated risk-benefit ratio exists.

REFERENCES

1. Gulia KK, Kumar VM. Sleep disorders in the elderly: a growing challenge. Psychogeriatrics. 2018; 18:155-165.
2. Bosi M, De Vito A, Kotecha B et al. Phenotyping the pathophysiology of obstructive sleep apnea using polygraphy/polysomnography: a review of the literature. Sleep Breath. 2018; 22(3):579-592.
3. Rodriguez JC, Dzierzewski JM, Alessi CA. Sleep problems in the elderly. Med Clin North Am. 2015; 99:431-9.

4. Wang S, Niu X, Zhang P, et al. Analysis of OSAS incidence and influential factors in middle-aged and elderly patients with hypertension. Minerva Med. 2019;110(2):115-120.
5. Ancoli-Israel S, Kripke DF, Klauber MR et al. Sleep-disordered breathing in community-dwelling elderly. Sleep. 1991; 14:486-95.
6. Young T, Shahar E, Nieto FJ et al. Predictors of sleep-disordered breathing in community-dwelling adults: the sleep heart health study. Arch Intern Med. 2002; 162:893–900
7. Senaratna CV, Perreta JL, Lodge CJ et al. Prevalence of obstructive sleep apnea in the general population: A systematic review, Sleep Medicine Reviews. 2017; 34:70-81.
8. Iannella G, Vicini C, Colizza A et al. Aging effect on sleepiness and apneas severity in patients with obstructive sleep apnea syndrome: a meta-analysis study. Eur Arch Otorhinolaryngol. 2019; 276, 3549–3556.
9. Vicini C, De Vito A, Iannella G et al. The aging effect on upper airways collapse of patients with obstructive sleep apnea syndrome. Eur Arch Otorhinolaryngol. 2018; 275, 2983–2990.
10. Gouveia CJ, Cramer JD, Liu SY, Capasso R. Sleep Surgery in the Elderly: Lessons from the National Surgical Quality Improvement Program. Otolaryngol Head Neck Surg. 2017; 156:757-764.
11. Lin J, Suurna M. Sleep Apnea and Sleep-Disordered Breathing. Otolaryngol Clin North Am. 2018; 51(4):827-833.
12. Bosi M, De Vito A, Bellini C et al. The interpretation of compact polysomnography/polygraphy in sleep breathing disorders patients: a validation's study. Eur Arch Otorhinolaryngol. 2017; 274:3251-325
13. Bosi M, De Vito A, Gobbi R et al. The importance of obstructive sleep apnoea and hypopnea pathophysiology for customized therapy. Eur Arch Otorhinolaryngol. 2017; 274:1251-1261.
14. Magliulo G, Iannella G, Ciofalo A et al. Nasal pathologies in patients with obstructive sleep apnoea. Acta Otorhinolaryngol Ital. 2019; 39(4):250–256.

15. Iannella G, Vicini C, Polimeni A et al. Laryngopharyngeal reflux diagnosis in obstructive sleep apnea patients using the pepsin salivary test. Int J Environ Res Public Health. 2019; 16(11):2056.
16. Gottlieb DJ, Whitney CW, Bonekat WH et al. Relation of sleepiness to respiratory disturbance index: the Sleep Heart Health Study. Am J Respir Crit Care Med. 1999; 159:502–507
17. Nuckton TJ, Glidden DV, Browner WS, Claman DM. Physical examination: Mallampati score as an independent predictor of obstructive sleep apnea. Sleep. 2006; 29(7):903-8.
18. Chung S, Yoon IY, Lee CH et al. Effects of age on the clinical features of men with obstructive sleep apnea syndrome. Respiration 2009; 78(1):23–29.
19. Somers VK, White DP, Amin R et al. Sleep apnea and cardiovascular disease: an American Heart Association/American College of Cardiology Foundation Scientific Statement from the American Heart Association Council for High Blood Pressure Research Professional Education Committee, Council on Clinical Cardiology, Stroke Council, and Council on Cardiovascular Nursing. Journal of the American College of Cardiology. 2008; 52 (8):686-717.
20. Peppard PE, Young T, Palta M et al. Prospective study of the association between sleep-disordered breathing and hypertension. N Engl J Med. 2000; 342:1378–1384
21. Marshall NS, Wong KK, Liu PY et al. Sleep apnea as an independent risk factor for all-cause mortality: the Busselton Health Study. Sleep. 2008;31(8):1079-85.
22. Yaffe K, Laffan AM, Harrison SL et al. Sleep-disordered breathing, hypoxia, and risk of mild cognitive impairment and dementia in older women. JAMA. 2011, 306:613–619
23. Tsai MS, Li HY, Huang CG et al. Risk of alzheimer's disease in obstructive sleep apnea patients with or without treatment: Real-world evidence. Laryngoscope. 2020; doi:10.1002/lary.28558

24. Kezirian EJ, Hohenhorst W, de Vries N. Drug-induced sleep endoscopy: the VOTE classification. Eur Arch Otorhinolaryngol. 2011; 268:1233-1236.

25. Hora F, Napolis LM, Daltro C et al. Clinical, anthropometric and upper airway anatomic characteristics of obese patients with obstructive sleep apnea syndrome. Respiration. 2007; 74 (5):517-524.

26. Berry RB, Brooks R, Gamaldo CE et al. AASM Scoring Manual Updates for (Version 2.4). J Clin Sleep Med. 2017; 15;13(5):665-666.

27. Zhao C, Viana A Jr, Ma Y, Capasso R. The effect of aging on drug-induced sleep endoscopy findings. Laryngoscope. 2018; 128(11): 2644–2650.

28. Morrell MJ, Finn L, McMillan A, Peppard PE. The impact of ageing and sex on the association between sleepiness and sleep disordered breathing. Eur Respir J. 2012; 40:386–393 9.

29. Peppard PE, Young T, Barnet JH et al. Increased prevalence of sleep-disordered breathing in adults. Am J Epidemiol. 2013; 177:1006–1014

30. Edwards BA, Wellman A, Sands SA et al. Obstructive sleep apnea in older adults is a distinctly different physiological phenotype. SLEEP. 2014; 37(7):1227-1236.

31. Heinzer R, Petitpierre NJ, Marti-Soler H, Haba-Rubio J. Incidence and characteristics of positional sleep apnea in the HypnoLaus population-based cohort. Sleep Med. 2018; 48, 157–162.

32. Iannella G. Magliulo G, Lo Iacono CAM et al. Positional Obstructive Sleep Apnea Syndrome in Elderly Patients. Int. J. Environ. Res. Public Health. 2020; 10;17(3). pii: E1120.

33. Martínez-García MÁ, Chiner E, Hernández L et al. Obstructive sleep apnoea in the elderly: role of continuous positive airway pressure treatment. Eur Respir J. 2015; 46(1):142-51.

34. Philip P, Bioulac S, Altena E et al. Specific insomnia symptoms and self-efficacy explain CPAP compliance in a sample of OSAS patients. PLoS One. 2018; 13(4):e0195343.

35. Sawyer AM, Gooneratne NS, Marcus CL et al. A systematic review of CPAP adherence across age groups: clinical and empiric insights for developing CPAP adherence interventions. Sleep Med Rev. 2011; 15(6):343–356.

36. Jaiswal M, Srivastava GN, Pratap CB et al. Effect of Oral Appliance for Snoring and Obstructive Sleep Apnea. Int J Orthod Milwaukee. 2015; 26(3):67-71.

37. Marklund, M., Franklin, K.A. Treatment of elderly patients with snoring and obstructive sleep apnea using a mandibular advancement device. Sleep Breath. 2015;19(1):403-5.

38. Vicini C, Meccariello G, Montevecchi F et al. Effectiveness of barbed repositioning pharyngoplasty for the treatment of obstructive sleep apnea (OSA): A prospective randomized trial. Sleep Breath. 2019; doi: 10.1007/s11325-019-01956-7.

39. Dizdar D, Civelek Ş, Çaliş ZA et al. Comparative Analysis of Lateral Pharyngoplasty and Uvulopalatopharyngoplasty Techniques with Polisomnography and Epworth Sleepiness Scales. J Craniofac Surg. 2015;26(7):e647-51.

40. Vicini C, Hendawy E, Campanini A et al. Barbed Reposition Pharyngoplasty (BRP) for OSAHS: A feasibility, safety, efficacy and teachability pilot study. “We are on the giant’s shoulders”. Eur Arch Otorhinolaryngol. 2015; 272(10):3065-70.

41. Iannella G, Vallicelli B, Magliulo G et al. Long-Term Subjective Outcomes of Barbed Reposition Pharyngoplasty for Obstructive Sleep Apnea Syndrome Treatment. Int J Environ Res Public Health. 2020;17(5). pii: E1542.

42. Van Maanen JP, Richard W, Van Kesteren ER et al. Evaluation of a new simple treatment for positional sleep apnoea patients. J Sleep Res. 2012; 21(3):322-9.

43. Kuna ST, Reboussin DM, Borradaile KE et al. Long-term effect of weight loss on obstructive sleep apnea severity in obese patients with type 2 diabetes. Sleep. 2013; 36(5):641-649A.

44. Shechter A, St-Onge MP, Kuna ST, et al. Sleep architecture following a weight loss intervention in overweight and obese patients with obstructive sleep apnea and type 2 diabetes: relationship to apnea-hypopnea index. J Clin Sleep Med. 2014;10(11):1205–1211.

45. Dobrosielski DA, Patil S, Schwartz AR et al. Effects of exercise and weight loss in older adults with obstructive sleep apnea. Med Sci Sports Exerc. 2015; 47(1):20–26.