REVIEW ARTICLE

Current challenges in the diagnosis and treatment of obstructive sleep apnea syndrome in the elderly

Giannicola Iannella[1,2], Antonino Maniaci[3], Giuseppe Magliulo[4], Salvatore Cocuzza[3], Ignazio La Mantia[3], Giovanni Cammaroto[2], Antonio Greco[1], Claudio Vicini[2,4]

1 Department of Organs of Sense, "La Sapienza" University, Rome, Italy
2 Department of Head-Neck Surgery, Morgagni Pierantoni Hospital, Forlì, Italy
3 Department of Medical and Surgical Sciences and Advanced Technologies "GF Ingrassia," Ear, Nose, Throat Section, University of Catania, Catania, Italy
4 Ear, Nose, Throat and Audiology Department, University of Ferrara, Ferrara, Italy

KEY WORDS

apnea, obstructive sleep apnea syndrome, respiratory sleep disorders, the elderly

ABSTRACT

Obstructive sleep apnea syndrome is a respiratory sleep disorder characterized by repeated episodes of partial or complete obstruction of the upper airways that occurs during the night. It is a common disease in the elderly population, with an estimated incidence ranging from 20% to 60% in those over the age of 65 years. Due to the high prevalence of obstructive sleep apnea syndrome 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.

Correspondence to:
Giannicola Iannella, MD, Department of Organs of Sense, "La Sapienza" University, Viale dell'Università 33, 00183 Roma, Italy,
phone: +393287893753,
email: giannicola.iannella@uniroma1.it
Received: March 26, 2020.
Accepted: March 27, 2020.
Published online: April 6, 2020.
Pol Arch Intern Med. 2020; 130 (7-8): 649-654
doi:10.20452/pamw.15283
Copyright by the Author(s), 2020

Introduction The number of adults aged 65 years and older has been growing in recent decades, and the number of people over 65 years 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 airways that occurs during the night. This obstruction is usually accompanied by reduction (hypopnea) or complete cessation (apnea) of the airflow in the upper airways and maintained thoracic-diaphragmatic respiratory movements.[1-3]

During hypopnea / apnea, poor alveolar ventilation leads to reduced oxygen saturation in the arterial blood (SaO_2) and a gradual increase in the partial arterial pressure of carbon dioxide ($PaCO_2$). Due to activation of the sympathetic system, a subclinical awakening defined as "arousal" occurs at the end of apneic events. The electroencephalographic appearance of "arousal" includes alteration of the micro- and macrostructure of sleep, which is the cause of daytime sleepiness in patients with OSAS.[1-3]

Obstructive sleep apnea syndrome is a frequent and commonly 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 incidence of OSAS in the elderly has been estimated to range between 20% and 60% in those over 65 years.[1-5] To this regard, Ancoli et al[5] analyzed 427 elderly patients and demonstrated that 24% of 65 patients showed a higher apnea-hypopnea index (AHI), that is, higher than or equal to 5, and that 62% had a respiratory disturbance index higher than or equal to 10.[5] In another study by Young et al,[6] which included 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 to 14, and nearly 20% had an AHI ≥15).[6]

Further data were provided by Senaratna et al,[7] who analyzed the increase in the incidence of OSA with age. In the elderly population, 88% of men aged 65 to 69 years had 5 or more events per hour, while that incidence increased to 90% in men aged 70 to 85 years.[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] Here,

we review the main diagnostic and therapeutic approaches and current challenges in the diagnosis and treatment of OSAS in the elderly.

Diagnosing obstructive sleep apnea syndrome in elderly patients

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

Daytime sleepiness is the main symptom of OSAS. However, in elderly patients, it is usually less pronounced than in those younger than 65 years. These data have been confirmed by several clinical studies that compared the results of the Epworth Sleepiness Scale (ESS)—a 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] In this regard, Gottlieb et al[16] conducted a cross-sectional cohort study to analyze OSAS characteristics.[16] In univariate analyses, subjects under 65 years of age had higher mean ESS scores than those older than 65 years (8 and 7.5, respectively; $P = 0.012$).

Recently, Iannella et al[8] used a regression analysis to compare the age of the study patients and the ESS score and confirmed an inverse correlation between aging and daytime sleepiness ($P = 0.05$).

Anatomical features associated with the diagnosis of obstructive sleep apnea syndrome in the elderly The ear, nose, and throat 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 greater than 29 kg/m^2 and a neck circumference longer than 43 cm in men and 41 cm in women are related to a 70% probability of being affected by OSAS.[3] Any possible craniofacial dysmorphism should be investigated, even though it represents the most frequent cause of OSAS in young patients or children.[5,10,11]

At oropharyngoscopy, dental occlusion, the Mallampati score, and the palatine tonsil Friedman classification should be evaluated. The degree of the palatine tonsil and Mallampati scores 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.[5,11-16-32]

Fiberoptic laryngoscopy is an essential diagnostic procedure in the diagnosis of OSA. It allows clinicians to assess anatomical features of the soft palate, the hypopharyngeal region, the base of the tongue, and the epiglottis. In elderly patients, lymphatic hypertrophy of the tongue base may be the cause of hypopharyngeal obstruction during the night.[11-16,25] Finally, the Müller endoscopic maneuver provides essential information about muscle laxity of the oropharyngeal walls, which is usually more pronounced in older patients.[11,12]

Polysomnographic diagnosis According to the American Academy of Sleep Medicine Manual for the Scoring of Sleep and Associated Events, polysomnography (PSG) represents the first test to confirm diagnosis in adult patients with clinically suspected OSA (clinical symptoms and anatomical objectivity).[24] Polysomnography records various sleep parameters: electroencephalography, eye movements, cardiac activity (electrocardiogram), thoracoabdominal movements, snoring, oxygen saturation, and nocturnal respiratory activity through the analysis of nasal and buccal airflow.[11-13] Moreover, in elderly patients, PSG can be performed at home, following specific recommendations of 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 apnea and hypopnea.[10-13] Obstructive sleep apnea is classified according to AHI, which is obtained by adding the number of apnea and hypopnea events during sleep and dividing it by the hours of sleep: an AHI lower than 5 per hour is considered normal, between 5 and 15 indicates mild OSA, between 15 and 30—moderate OSA, and above 30—severe OSA.[11-13]

In the PSG analysis, the parameters relating to SpO_2 should not be underestimated. Usually, the mean SpO_2 and nadir (the lowest SpO_2 value recorded) of patients over 65 years of age are lower than in younger patients, which is explained by the higher incidence of chronic obstructive pulmonary disease and reduced lung exchange capacity of these patients.[11-13]

Although several authors have evaluated the effect of age on AHI and severity of OSA, there is currently no consensus regarding this issue.[8,18,26-29]

Chun et al[18] reported a higher AHI and longer duration of apnea-hypopnea in the elderly group compared with young patients ($P = 0.02$). However, no significant difference in the polysomnographic results related to night oxygen desaturation was reported.[18] Iannella et al,[8] through a meta-analysis study that compared the age of the patients and AHI, found no significant differences in the basal AHI between younger (age <65 years) and elderly (age >65 years) patients. Using random-effects modelling, they did not demonstrate an aging effect on AHI ($k = 6$ studies; 95% CI, 0.01–0.12; $P < 0.01$; $I^2 = 75.5\%$).

Current diagnostic challenges Nowadays, drug-induced sleep endoscopy (DISE) is used as a new tool for the diagnosis of OSAS. In this method, some drugs (eg. propofol or midazolam) are

administered to induce sleep, similar to the real one, and fiberoptic evaluation of the upper respiratory airways is performed. This study makes 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 and aimed to define appropriate operative planning.[23] However, recently, it has been increasingly used in elderly patients, both in those with poor compliance or ineffectiveness of ventilation therapy, or to better understand the involved sites that collapse and the pattern of collapse of the upper respiratory airways.

Interesting data regarding different sites of obstruction and patterns of collapse during the DISE procedure have emerged, differing between the elderly and young patients.[8] Vicini et al[9] found a higher incidence of total collapse in the region of the velum in elderly patients compared with the younger ones (90.9% vs 70%; $P = 0.01$). Differently, a lower rate of oropharyngeal lateral wall collapse emerged in elderly patients (20% vs 50%). Furthermore, a partial collapse of the epiglottis has been demonstrated in adults aged 65 years and older compared with young patients ($P = 0.0006$).[8] In another study on DISE in elderly patients, Zhao et al[27] confirmed a significant correlation with combined upper (palatopharyngeal) and 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, a reduced number of apneas during sleep in the lateral position was recorded by PSG. These are classified as patients with positional obstructive sleep apnea (POSA).

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

Treatment of obstructive sleep apnea in elderly patients

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

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

Numerous studies have evaluated the effectiveness of ventilation therapy in elderly patients with OSA. Martínez-García et al[33] reported on CPAP use in a randomized, multicenter clinical trial in a cohort of 224 elderly subjects (mean [SD] age, 75.5 [3.9] years) with severe OSA.[33] A residual mean (SD) AHI following the application of the CPAP device was 3.9 (7.4) events per hour. The mean (SD) time of everyday use of CPAP treatment was 4.9 (2.5) hours per night, with 35 patients (30.4%) using it shorter than 4 hours per night (69.6% with good adherence).

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

The main issue related to CPAP therapy is that between 30% and 50% of patients with OSAS do not tolerate the device. This percentage is now also increasing in those over 65 years of age who tend to show a decreasing level of acceptance for this device to achieve improvement.

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

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

Mandibular advancement devices A CPAP therapeutic alternative in elderly patients could involve using an oral appliance (mandibular advancement device [MAD]). These devices are applied overnight, anchored to the upper and lower dental arches. The device determines mandibular advancement with the forward movement of the tongue and enlargement of the hypopharyngeal diameter in the anteroposterior direction. These devices also exert stabilization of the hypopharyngeal lateral walls. Though, no data are available regarding the stabilizing effect of the soft palate. For this reason, MADs are

indicated in patients with mainly hypopharyngeal obstructions.[10,36]

Jaiswal et al,[36] comparing AHI before and after using MADs, showed a significant mean (SD) reduction of AHI ranging from 26.2 (6.53) to 13.7 (6.2). However, the main problem related to the use of oral appliances is the patient's dental condition and the temporomandibular joint. Precarious dental stability, edentulism, or dysfunction of the temporomandibular joint could be absolute contraindications to using this device.[10,36] Since patients over 65 years are more likely to present such clinical status, this reduces the possibility of using the device in this group of patients with OSA. There are scarce data on the use of MADs in a population over 65 years of age. In 2015, Marklund et al[37] evaluated MAD use for treating patients with snoring and OSA and included 56 patients over 65 years of age; only 45 of these initially enrolled patients (80%) continued treatment at 1-year follow-up. Although, in elderly patients, MAD reduced AHI to values similar to those of younger age groups (P <0.001) with the same success rate, in an older population, more severe bite changes occurred because of the presence of fewer teeth and impaired bone support. Indeed, after treatment, the horizontal distance between the upper and the lower frontal teeth, the overjet, decreased by 1 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-to-benefit ratio and applicability of this device in elderly patients.

Surgery for obstructive sleep apnea Different surgical options are available for OSA treatment.[10] Over the years, classic uvulopalatopharyngoplasty palatal surgical techniques have been replaced by more modern lateral pharyngoplasty procedures.[38,39]

In 2015, Vicini et al[40] proposed a new palatal procedure for snoring / OSA, called barbed repositioning pharyngoplasty. Using a "barbed" suture, the palatopharyngeal muscle is relocated into a more lateral and anterior position in order to enlarge and stabilize the velopharyngeal region. Good outcomes in terms of AHI reduction and less frequent postoperative complications after barbed repositioning pharyngoplasty for OSA was reported in a recent study by Iannella et al.[41] However, surgery should be carefully evaluated in elderly patients with OSA; anesthesiological risks, possible surgical complications, and the risk of surgical failure should be considered before choosing this treatment option.[1-5]

In this context, in a recent observational study, Gouveia et al[10] analyzed surgical complications in 107 patients with OSAS older than 65 years of age and showed that elderly patients undergoing sleep surgery had an increased risk of postoperative complications compared with younger people treated with the same procedures.[10] In particular, higher rates of wound dehiscence, postoperative bleeding, and postoperative urinary tract infections were noted in the elderly. The specific complication rate in the elderly patients was 7.5%, and multivariate analysis showed that the age over 65 years was an independent risk factor for perioperative complications.[10]

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

Major surgical interventions such as tongue base resection using transoral robotic surgery and bimaxillary advancements must be considered with extreme caution in elderly patients with OSA owing to the high peri- and postoperative risk of complications (eg, bleeding and dyspnea).[10]

Vibration alarm devices Devices for the treatment of OSAS can be used in elderly patients with POSA. The purpose of these devices is to decrease the amount of sleeping time in the supine position and promote sleep in the lateral position in those who show a reduced AHI when sleeping in the lateral position during PSG. The device most commonly used for POSA treatment, called "Night Shift," is a small, vibrating device worn around the neck, which prevents patients from assuming the supine sleeping position. When wearing the device, adopting the supine position triggers 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 by Van Maanen et al[42] to evaluate this device. No adverse effects were reported. The mean (SD) 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 vibration alarm devices can be used both in the elderly and in young patients, no study has confirmed the efficacy in AHI reduction in elderly patients so far. Besides, the long-term effect of these devices remains to be examined.

Weight loss The fundamental role of lifestyle intervention, intensive physical exercise aimed at weight loss, and the acquisition of appropriate behavioral rules is proven to be effective in AHI reduction.[43,44]

In elderly patients, weight loss can have a significant impact on AHI. 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 and dietary-induced weight loss in older adults, Dobrosielski et al[45] enrolled 25 obese adults with OSA, aged 60 years or older. All 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 AHI decreased 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% after the intervention (P = 0.02).

Moreover, in a study of obese patients with type 2 diabetes, Kuna et al[43] demonstrated the relationship between changes in AHI related to the amount of weight loss (P <0.0001) and intervention, independently of weight loss (P = 0.001). In particular, they stated that the AHI reduction was 5-fold more frequent with intensive lifestyle intervention (20.7%) than with antidiabetic treatment (3.6%).

Conclusions Obstructive sleep apnea syndrome should be always suspected in elderly patients who show typical night and daytime symptoms of sleep apnea. Polysomnographic examination is necessary for the diagnosis of OSA in elderly patients. Today, DISE could play an increasing role in the diagnosis of OSA in elderly patients when analyzing patterns and sites of collapse.

Continuous positive airway pressure remains the first-choice treatment. Alternative therapies such as surgery and MADs should not be excluded even if the scientific evidence regarding these therapeutic modalities is still limited and no validated risk-to-benefit ratio exists.

ARTICLE INFORMATION

CONFLICT OF INTEREST None declared.

OPEN ACCESS This is an Open Access article distributed under the terms of the Creative Commons AttributionNonCommercialShareAlike 4.0 International License (CC BY-NC-SA 4.0), allowing third parties to copy and redistribute the material in any medium or format and to remix, transform, and build upon the material, provided the original work is properly cited, distributed under the same license, and used for noncommercial purposes only. For commercial use, please contact the journal office at pamw@mp.pl.

HOW TO CITE Iannella G, Maniaci A, Magliulo G, et al. Current challenges in the diagnosis and treatment of obstructive sleep apnea syndrome in the elderly. Pol Arch Intern Med. 2020; 78: 649-654. doi:10.20452/pamw.15283

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: 579-592.

3 Rodriguez JC, Dzierzewski JM, Alessi CA. Sleep problems in the elderly. Med Clin North Am. 2015; 99: 431-439.

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: 115-120.

5 Ancoli-Israel S, Kripke DF, Klauber MR, et al. Sleep-disordered breathing in community-dwelling elderly. Sleep. 1991; 14: 486-495.

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: 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: 3251-3257.

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: 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: 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: 903-908.

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: 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: 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: 1079-1085.

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 Feb 11. [Epub ahead of print].

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: 517-524.

26 Berry RB, Brooks R, Gamaldo CE, et al. AASM scoring manual updates for 2017 (version 2.4). J Clin Sleep Med. 2017; 13: 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: 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.

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: 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: 1120.

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: 142-151.

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: 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: 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: 67-71.

37 Marklund M, Franklin KA, Treatment of elderly patients with snoring and obstructive sleep apnea using a mandibular advancement device. Sleep Breath. 2015; 19: 403-405.

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. 2020; 24: 687-694.

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: e647-e651.

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: 3065-3070.

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: 1542.

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: 322-329.

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: 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: 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: 20-26.