REVIEW ARTICLE

Obstructive sleep apnea: Awakening the hidden truth

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ABSTRACT

Obstructive sleep apnea (OSA) is a common type of sleep apnea and is caused by obstruction of upper airway. Sleep apnea is clinically defined as frequent episodes of apnea, hypopnea and symptoms of functional impairment, which could be life-threatening and associated with extreme daytime hyper somnolence, dysfunction, discrements in health-related quality of life, automobile accidents, and cardiovascular morbidity and mortality. Etiopathogenic factors that contribute to OSA include reduced upper-airway dilator muscle activity during sleep, upper-airway anatomical features, ventilatory control insufficiency, lung volume, and rostral fluid shifts. The presence of risk factors such as age, gender and obesity increases the incidence of OSA. The repetitive nocturnal hypoxemia experienced by patients with OSA is associated with activation of a number of neural, humoral, thrombotic, metabolic, and inflammatory disease mechanisms, all of which have also been implicated in the pathophysiology of various systemic diseases. This article summarizes the etiopathogenesis, epidemiology, associated systemic diseases such as cardiovascular diseases, diabetes, and dental diseases with OSA and the influence of tongue on oropharyngeal airway in OSA patients.

Key words: Apnea, breathlessness, snoring

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Introduction

"Sleep disorder breathing" (SDB) is a term, which includes simple snoring, upper-airway resistance syndrome, and sleep apnea.[1] Sleep apnea is clinically defined as frequent episodes of apnea (cessations) and hypopnea (discrete reductions) and symptoms of functional impairment, which could be life threatening and associated with extreme daytime hyper somnolence, dysfunction, discrements in health related quality of life, automobile accidents, and cardiovascular morbidity and mortality.[2] Sleep apnea is the most prevalent of all the upper-airway disorders and is classified as central, obstructive and mixed or mild, moderate and severe.[3] Obstructive sleep apnea (OSA) is a disorder characterized by repetitive collapse and reopening of the upper airway during sleep, which impairs ventilation and can result in intermittent hypoxemia and hypercapnia.[4]

Obstructive sleep apnea is insidious and patients are often unaware of the associated symptoms. Cardinal manifestations include loud snoring, witnessed breathing pauses during sleep, fitful sleep quality, fatigue, dry mouth, morning headache, and excessive daytime sleepiness (EDS). Early recognition and appropriate therapy can ameliorate the neurobehavioral consequences.[5]

Etiopathogenic factors that contribute to OSA includes reduced upper-airway dilator muscle activity during sleep,[6] upper-airway anatomical features,[7] ventilatory control insufficiency,[8] lung volume,[9] and rostral fluid shifts.[10,11]

Age,[12] gender,[13] and obesity[14] are interrelated in a complex manner and considered to be a risk factor for incidence of OSA. The cutoff value of body mass index (BMI) for obesity in the Caucasian populations is at 30 kg/m^2, but some Asian-Indian populations have redefined obesity at a lower BMI of 23 kg/m^2 for both the sexes.[15] The World

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Health Organization (WHO) task force on obesity suggested that Asian-Indian populations have different associations between BMI, percentage of body fat, and health risks than do Caucasians (WHO, 2000). Clinically, neck circumference has been reported to be a useful predictor of OSA.[16]

Several anatomic factors predisposes to the development of OSA, which includes size of the tongue and craniofacial morphology.[17] In adult snorers and OSA patients, there is a good correlation between clinical tonsil grade and objective tonsil volume.[18] According to Nuckton *et al*. (2006), the Mallampati score is an independent predictor of OSA and its severity.[19]

There is a robust association between OSA and systemic conditions such as cardiovascular diseases such as hypertension (HT) and diabetes mellitus (DM), which are the main health problems in both developed and developing countries. Patients with HT are nearly 2.5 times more likely to develop OSA.[20] In patients with drug resistant HT an even higher OSA prevalence of 83%[21] is seen. HT is defined as blood pressure at least 140/90 mmHg.[20]

Until date, four studies including a total number of nearly 900 type 2 diabetic patients have reported a striking overall prevalence of 73%.[22-25]

Literature Review

Definitions and classification

According to the American Academy of Sleep Medicine recommendations, OSA is defined with apnea-hypopnea index (AHI) >5 or AHI ≥ 5 and associated with symptoms such as EDS, impaired cognition, mood disorders, insomnia, HT, ischemic heart disease, or history of stroke.[26,27] OSA is a disturbance in normal sleep patterns; when combined with daytime symptoms, this condition is termed "OSA syndrome".[28-30]

Prevalence estimates of disturbed sleep range from 35% to 41% among adults, out of which the most common sleep disturbances is OSA, followed by the frequent snoring, difficulty initiating or maintaining sleep (insomnia symptoms), and EDS.[31]

Etiopathogenesis of obstructive sleep apnea

The most common factors that are known to contribute to the etiopathogenesis of OSA, are upper-airway dilator muscle activity during sleep, upper-airway anatomy, lung volume, ventilatory control instability, sleep state stability, and rostral fluid shifts.[11]

Upper-airway dilator muscle activity

The largest of the pharyngeal dilator muscles is the genioglossus, the muscle that forms the majority of the body of the tongue[32] and its function can be augmented in response to heightened airway resistance and hypercapnia through inputs from[6,33] the sleep/awake centers of the brain, respiratory pattern generating neurons, chromoreceptors, and negative pressure receptors in the airway that can modify its activity.[6,34]

Upper-airway anatomy

Anatomical factors, including increased airway length, lateral wall thickness, and tongue volume, are associated with the presence of OSA.[35] A small maxilla or mandible can result in a reduced airway size.[7]

Lung volume

Lower end-expiratory lung volume, increases the tendency of the upper-airway collapse.[36] A continuous positive airway pressure (CPAP) level is necessary to maintain airway patency, and to reduce the severity of OSA.[9,37]

Ventilatory control instability

Persons with OSA generally have greater instability of ventilatory control and higher loop gain than healthy individuals.[38] Since upper-airway muscles receive input from respiratory control centers, unstable ventilatory control will cause greater fluctuation in the activity of the upper-airway muscles and promote upper-airway collapse.[8,33]

Fluid shifts

Fluid shifts from the legs to the neck appear to play a role in pathogenesis of OSA. Overnight rostral fluid displacement from the legs correlates strongly with AHI, change in neck circumference.[10] Furthermore, time spent in sitting was a significant risk factor even in non-obese, healthy men suspected of having OSA.[10,39,40]

Genetics

Evidence from racial, familial, and twin studies indicates that OSA has a strong genetic basis.[41] There is an evidence that the genetic determinants present for upper-airway muscles activity, skeletal structures, obesity, epidemiology of fat distribution and respiratory control may interact to cause OSA. The role of specific genes in the pathogenesis remains to be elucidated.[42]

Epidemiology of obstructive sleep apnea

Gender and age on obstructive sleep apnea

Several investigators have reported gender differences in the abnormalities of nocturnal respiration. In the widely quoted Wisconsin Sleep Cohort Study, the prevalence of sleep disordered breathing in men (24%) is almost three times higher than in the women (9%).[13,43] The reason for the gender differences in the prevalence and severity of sleep apnea are multifactorial, and is primarily attributed to

difference in fat distribution,[44] and structural differences in upper-airway dimensions.[34] Percentage of neck fat in Women and percentage abdominal fat in men, were significant predictors of AHI severity in the sexes.[44] The prevalence of snoring is correlated with BMI independent of menstrual status, and lower BMI is a protective factor against snoring in premenopausal women.[45] Therefore, BMI is an independent risk factor for OSA in women.

OSA remains highly prevalent among the elderly;[46,47] the prevalence of at least moderate OSA varies widely from as low as 7% to as high as 44%.[48] It has been shown that the BMI had a smaller influence on the AHI in the elderly when compared with the middle aged individuals[12,48,49]

Obstructive sleep apnea and obesity

Obesity develops from an imbalance of energy over time, when energy intake exceeds energy expenditure, leading to accumulation of adipose tissue with a corresponding increase in lean body mass.[50] Patients with mild OSA who gain 10% of their baseline weight are at a six-fold increased risk of progression of OSA, and an equivalent weight loss can result in a more than 20% improvement in severity of OSA.[51] Fat deposition in the tissues surrounding the upper airway appears to result in a smaller lumen and increased collapsibility, predisposing to apnea.[14] Moreover, fat deposits around the thorax (truncal obesity) reduce chest compliance and functional residual capacity, and may increase oxygen demand.[52-54] Factors such as reduced activity levels and increased appetite, particularly for refined carbohydrates, may conceivably contribute to weight gain in OSA patients. Current evidence based studies suggest that OSA may itself cause weight gain.[14,55]

The cutoff value of BMI for obesity in the Caucasian populations is at 30 kg/m^2, but some Asian-Indian populations have redefined obesity at a lower BMI of 23 kg/m^2 for both the sexes.[15] The WHO task force on obesity suggested that Asian-Indian populations have different associations between BMI, percentage of body fat, and health risks than do Caucasians (WHO, 2000). Clinically, neck circumference has been reported to be a useful predictor of OSA,[16] however the exact role of neck circumference in the development of OSA has not been fully clarified.[56]

Obesity is a major modifiable risk factor for OSA,[57,58] weight loss is recommended for all overweight or obese patients with sleep apnea, as its beneficial effects embrace other obesity related health problems, notably cardiometabolic diseases.[50,59]

Obstructive sleep apnea and craniofacial morphology

Craniofacial characteristics associated with OSA include aspects of skeletal morphology pertaining to the mandible, maxilla, cranial base, hyoid, and head position,[7] as well as soft tissue morphology relating to size of upper-airway soft tissues.[54] Aspects of skeletal craniofacial morphology relating to OSA have been explored primarily using cephalometric analysis.[7] Most common predictors include differences in maxillary mandibular morphology and its relationship. In terms of the maxilla, a shorter length and also narrower[60] and more tapered maxillary arch[50,61] and mandibular deficiency has also been associated with OSA patients. Three-dimensional imaging techniques have also confirmed, a smaller mandibular enclosure areas seen in OSA subjects.[50]

The lowered hyoid position is also been considered as confounding factors for OSA patients.[62]

Obstructive sleep apnea and cardiovascular diseases

The strong association between OSA and HT[63] has attracted considerable attention in recent years. HT is defined as taking antihypertensive without regard to the actual measurement of blood pressure, or having a systolic blood pressure reading greater than 140 mm Hg or a diastolic blood pressure reading greater than 90 mm Hg.[64]

Pathophysiology

Three key pathophyiological features of OSA that give rise to these abnormal cardiovascular oscillations are:

a. Generation of exaggerated negative intrathoracic pressure against the occluded pharynx
b. hypoxia and
c. arousals from sleep.

a. Negative intrathoracic pressure against the occluded pharynx: Ineffective inspiratory efforts are a hallmark of obstructive apneas. The resulting exaggerated negative intrathoracic pressure swings increase left ventricular (LV) transmural pressure by increasing the difference between extra cardiac and intracardiac pressures, and hence after load, but without increasing Blood Pressure (BP). It also increases venous return to the right ventricle, leading to its distention. The resulting leftward shift of the interventricular septum can impede LV diastolic filling. There is also evidence that exaggerated negative intrathoracic pressure during apnea can impair LV relaxation, which could further impede LV filling.[65] The combination of increased LV after load and reduced LV preload leads to a reduction in stroke volume during obstructive apneas that is proportional to the negative intrathoracic pressure generated.[66]
b. Hypoxia: During obstructive apneas, the sympatho excitatory effect of hypoxia is amplified by apnea and CO_2 retention.[67] This result in increased sympathetic vasoconstrictor tones however; these sympatho excitatory effects are not engaged until several seconds into the apnea. Intermittent hypoxia during obstructive apneas may directly depress cardiac contractility, or

reduce cardiac performance indirectly by causing pulmonary vasoconstriction and increasing pulmonary arterial pressure.[63] The degree of desaturation during each obstructive apnea has been directly related to the magnitude of the increase in BP following the apnea.[9]

c. Arousals: Arousal is a critical defense mechanism that makes active upper-airway dilator muscles and prevents asphyxiation in OSA. Arousals causes only a small further increment in heart rate (HR) and blood pressure (BP).[68] One confounding factor is that arousals are accompanied by an abrupt increase in ventilation that precedes increases in HR and BP. This suggests that the increased ventilatory drive at termination of apnea coactivates cardiovascular sympathetic neurons that are closely linked with respiratory neurons in the brainstem.[66,69]
d. Correlation of HT and OSA: Patients with HT are nearly 2.5 times more likely to develop OSA.[20] In patients with drug resistant HT an even higher OSA prevalence of 83%[21] is seen and has been reported that SDB and HT is seen in both sexes and all ethnic groups and are slightly stronger among those who are overweight or obese.[44,70] The hypothesis of a causal association between sleep apnea and HT is supported by evidence from intervention trials, showing that successful treatment of sleep apnea by means of weight loss; CPAP is accompanied by significant decreases in both daytime and nighttime blood pressure.[71] SDB is more prevalent in men with HT than in normal individuals without HT.[72] Several studies have proposed hemodynamic disturbances due to OSA resulting in abnormal activation of arterial chemoreceptors and increased sympathetic activity, followed by arousals during sleep.[57,73]

Metabolic syndrome and obstructive sleep apnea

Metabolic syndrome (MS) is strongly linked to obesity and comprises of multiple metabolic abnormalities, such as HT, insulin resistance, central obesity, and dyslipidemia. Current data suggest that there is an increased prevalence of MS in subjects with OSA.[24,53]

The MS is also known as insulin resistance syndrome. The constellation of metabolic derangement includes insulin resistance/glucose intolerance, central obesity, HT, and dyslipidemia, which are well-known risk factors for cardiometabolic diseases.[74] Several studies has been indicated that MS predicts future diabetes as well as an increased risk of cardiovascular disease and all causes of mortality.[53,75,76]

Pathophysiology of MS is still a subject of debate, and both visceral obesity and insulin resistance appear to be the predominant drivers of this syndrome. It has been proposed that visceral fat probably plays a role in the hepatic manifestations of central obesity[55] and systemic free fatty acid concentrations are found to affect muscle, pancreatic β cells, and vascular functions at molecular level. The current status stated that visceral fat is particularly damaging and is of greater risk for DM, cardiovascular disease and certain cancers.[53,77]

Prevalence of obstructive sleep apnea in type 2 diabetics

The prevalence of OSA in patients with type 2 diabetes was assessed by methods other than the gold standard full polysomnography (PSG) (e.g, limited PSG or overnight oximetry), should variable estimate ranging from 2 to 70%.

Until date, four studies including a total number of nearly 900 type 2 diabetic patients have reported a striking overall prevalence of 73%,[22,23,25] reported an OSA prevalence of 77% in 60 type 2 diabetics (Mean Age: 57 years) using a less stringent cutoff of 3% for oxygen desaturations, and when the dataset was reanalyzed using a stricter 4% criteria, this estimate decreased to 58%. Considering that the prevalence of OSA by full-night PSG in patients with type 2 diabetes averages 73%, this would then suggest that nearly 17 million diabetics currently suffer from this unrecognized comorbidity.[5]

Prevalence of type 2 diabetes in obstructive sleep apnea

In cross-sectional analyses, it has been demonstrated that there is a significantly higher prevalence of DM in patients with OSA as compared to those without OSA.[24] The Busselton health study found a significant independent association between moderate to severe OSA and incident DM over a 4-year follow-up period, but the sample size was small and there were only few incident cases of diabetes, which resulted in a wide confidence interval.[77] The prevalence of undiagnosed obstructive OSA is high among patients with poorly controlled type 2 diabetes[78] and that it is mainly related to visceral obesity. Furthermore, we have found that the presence of obstructive OSA cannot be predicted by clinical data, which suggests that OSA should be systematically screened for in such a patient population.[79]

In summary, future studies from large longitudinal cohorts are clearly needed to assess the role of OSA as a potential risk factor for diabetes.[77]

Dental predisposing factors and obstructive sleep apnea

Influence of tongue on oropharyngeal airway in obstructive sleep apnea patients

Cephalometric analysis in patients with OSA and healthy controls, reported that the non-obese patients with OSA showed enlarged tongue[55] and inferior shift of the tongue volume,[18] in comparison with their BMI matched healthy controls.

The upper-airway soft tissue structures were three-dimensionally analyzed with an advanced analysis technique through magnetic resonance imaging and Shigeta *et al*. stated that the volume of the tongue and lateral walls independently increases the risk of sleep apnea. There is a significant positive correlation between BMI and tongue volume,[7] and a significant negative correlation between BMI and airway volume[80] and also there is a negative correlation between airway volume and tongue and mandible (T/M) ratio. As tongue volume increases with BMI, the T/M ratio is affected, and thus is likely to be involved in the development of OSA.[80]

Influence of tonsil volume and uvula size on obstructive sleep apnea patients

The role of thickened and exceedingly collapsible lateral pharyngeal walls in the pathophysiology of OSA is well recognized in adults.[18,35]

According to Force *et al*. (2009); tonsils are subjectively measured using a grading system in which grade I represents; tonsils are hidden in the tonsillar fossa and barely visible behind the anterior pillars. In grade II, the tonsils are visible behind the anterior pillars and occupied up to 50% of the pharyngeal space (the distance between the medial borders of the anterior pillars). In grade III, the tonsils occupied between 50 and 75% of the pharyngeal space. In grade IV, the tonsils occupied more than 75% of the pharyngeal space.[4]

In Mallampati's technique,[19] with the tongue kept in place without the use of a tongue depressor, grade 1, represents the tonsils, pillars, pharynx, and soft palate are clearly visible; grade 2, the uvula and only the upper part of the pillars and tonsils are visible between the palate and the tongue; grade 3, only the soft and hard palate are visible, whereas the tonsils, pillars, pharynx and base of the uvula are hidden behind the tongue. In grade 4, only the hard palate is visible.[30] The Mallampati score is an independent predictor of OSA and its severity.[19]

In adult snorers and OSA patients, there is a good correlation between clinical tonsil grade and objective tonsil volume.[18] The clinical ability to infer tonsil volume is not impaired by possible changes in pharyngeal geometry that are related to OSA.[4] Although tonsil volume correlates with AHI, from a clinical perspective, only tonsil grade IV predicts severe OSA. Pharyngeal tissue volume likely reflects BMI rather than OSA.[18]

Conclusion

Obstructive sleep apnea is gaining lots of importance in the recent years due to its impact on various systems of our body. It has been considered as a Pandemic disease. We conclude that snoring and sleep apnea are common among Indian adults. Recognition of the importance of OSA among general public would be a valuable step toward implementing population-based strategies to reduce OSA prevalence. Various studies have showed sex, higher BMI, and presence of HT is considered as risk factors for OSA. Therefore, early detection and treatment of OSA may be essential with intervention to reduce risk of associated medical problems.

References

1. Padma A, Ramakrishnan N, Narayanan V. Management of obstructive sleep apnea: A dental perspective. Indian J Dent Res 2007;18:201-9.
2. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea: A population health perspective. Am J Respir Crit Care Med 2002;165:1217-39.
3. Brown LK. Sleep apnea syndromes: Overview and diagnostic approach. Mt Sinai J Med 1994;61:99-112.
4. Epstein LJ, Kristo D, Strollo PJ Jr, Friedman N, Malhotra A, Patil SP, *et al*. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. J Clin Sleep Med 2009;5:263-76.
5. Pamidi S, Knutson KL, Ghods F, Mokhlesi B. Depressive symptoms and obesity as predictors of sleepiness and quality of life in patients with REM-related obstructive sleep apnea: Cross-sectional analysis of a large clinical population. Sleep Med 2011;12:827-31.
6. Younes M, Loewen AH, Ostrowski M, Laprairie J, Maturino F, Hanly PJ. Genioglossus activity available via non-arousal mechanisms vs. that required for opening the airway in obstructive apnea patients. J Appl Physiol (1985) 2012;112:249-58.
7. Watanabe T, Isono S, Tanaka A, Tanzawa H, Nishino T. Contribution of body habitus and craniofacial characteristics to segmental closing pressures of the passive pharynx in patients with sleep-disordered breathing. Am J Respir Crit Care Med 2002;165:260-5.
8. Lattimore JD, Celermajer DS, Wilcox I. Obstructive sleep apnea and cardiovascular disease. J Am Coll Cardiol 2003;41:1429-37.
9. Eastwood PR, Malhotra A, Palmer LJ, Kezirian EJ, Horner RL, Ip MS, *et al*. Obstructive sleep apnoea: From pathogenesis to treatment: Current controversies and future directions. Respirology 2010;15:587-95.
10. Redolfi S, Yumino D, Ruttanaumpawan P, Yau B, Su MC, Lam J, *et al*. Relationship between overnight rostral fluid shift and obstructive sleep apnea in nonobese men. Am J Respir Crit Care Med 2009;179:241-6.
11. Kapur VK. Obstructive sleep apnea: Diagnosis, epidemiology, and economics. Respir Care 2010;55:1155-67.
12. Bixler EO, Vgontzas AN, Ten Have T, Tyson K, Kales A. Effects of age on sleep apnea in men: I. Prevalence and severity. Am J Respir Crit Care Med 1998;157:144-8.
13. Dancey DR, Hanly PJ, Soong C, Lee B, Shepard J Jr, Hoffstein V. Gender differences in sleep apnea: The role of neck circumference. Chest 2003;123:1544-50.
14. Romero-Corral A, Caples SM, Lopez-Jimenez F, Somers VK. Interactions between obesity and obstructive sleep apnea: Implications for treatment. Chest 2010;137:711-9.
15. Snehalatha C, Viswanathan V, Ramachandran A. Cutoff values for normal anthropometric variables in asian Indian adults. Diabetes Care 2003;26:1380-4.
16. Stradling JR, Crosby JH. Predictors and prevalence of obstructive sleep apnoea and snoring in 1001 middle aged men. Thora×1991;46:85-90.
17. Ivanhoe JR, Cibirka RM, Lefebvre CA, Parr GR. Dental considerations in upper airway sleep disorders: A review of the literature. J Prosthet Dent 1999;82:685-98.
18. Cahali MB, Soares CF, Dantas DA, Formigoni GG. Tonsil volume, tonsil grade and obstructive sleep apnea: Is there any meaningful correlation? Clinics (Sao Paulo) 2011;66:1347-52.
19. Nuckton TJ, Glidden DV, Browner WS, Claman DM. Physical examination: Mallampati score as an independent predictor of obstructive sleep apnea. Sleep 2006;29:903-8.
20. Demede M, Pandey A, Zizi F, Bachmann R, Donat M, McFarlane SI, *et al*. Resistant hypertension and obstructive sleep apnea in the primary-care setting. Int J Hypertens 2011;2011:340929.

21. Lüthje L, Andreas S. Obstructive sleep apnea and coronary artery disease. Sleep Med Rev 2008;12:19-31.
22. Resnick HE, Redline S, Shahar E, Gilpin A, Newman A, Walter R, *et al.* Diabetes and sleep disturbances: Findings from the Sleep Heart Health Study. Diabetes Care 2003;26:702-9.
23. Einhorn D, Stewart DA, Erman MK, Gordon N, Philis-Tsimikas A, Casal E. Prevalence of sleep apnea in a population of adults with type 2 diabetes mellitus. Endocr Pract 2007;13:355-62.
24. Aronsohn RS, Whitmore H, Van Cauter E, Tasali E. Impact of untreated obstructive sleep apnea on glucose control in type 2 diabetes. Am J Respir Crit Care Med 2010;181:507-13.
25. Foster GD, Sanders MH, Millman R, Zammit G, Borradaile KE, Newman AB, *et al.* Obstructive sleep apnea among obese patients with type 2 diabetes. Diabetes Care 2009;32:1017-9.
26. Park JG, Ramar K, Olson EJ. Updates on definition, consequences, and management of obstructive sleep apnea. Mayo Clin Proc 2011;86:549-54.
27. Lam JC, Sharma SK, Lam B. Obstructive sleep apnoea: Definitions, epidemiology and natural history. Indian J Med Res 2010;131:165-70.
28. Magliocca KR, Helman JI. Obstructive sleep apnea: Diagnosis, medical management and dental implications. J Am Dent Assoc 2005;136:1121-9.
29. Sharma SK, Kumpawat S, Banga A, Goel A. Prevalence and risk factors of obstructive sleep apnea syndrome in a population of Delhi, India. Chest 2006;130:149-56.
30. Friedman M, Ibrahim H, Joseph NJ. Staging of obstructive sleep apnea/hypopnea syndrome: A guide to appropriate treatment. Laryngoscope 2004;114:454-9.
31. Baldwin CM, Ervin AM, Mays MZ, Robbins J, Shafazand S, Walsleben J, *et al.* Sleep disturbances, quality of life, and ethnicity: The Sleep Heart Health Study. J Clin Sleep Med 2010;6:176-83.
32. Carrera M, Barbé F, Sauleda J, Tomás M, Gómez C, Agustí AG. Patients with obstructive sleep apnea exhibit genioglossus dysfunction that is normalized after treatment with continuous positive airway pressure. Am J Respir Crit Care Med 1999;159:1960-6.
33. Eckert D, Malhotra A. Journals consult-powered by ScienceDirect-Progress in cardiovascular diseases: Mechanisms of apnea. Prog Cardiovasc Dis 2009;51:313-323.
34. Jordan AS, McEvoy RD. Gender differences in sleep apnea: Epidemiology, clinical presentation and pathogenic mechanisms. Sleep Med Rev 2003;7:377-89.
35. Schwab RJ, Pasirstein M, Pierson R, Mackley A, Hachadoorian R, Arens R, *et al.* Identification of upper airway anatomic risk factors for obstructive sleep apnea with volumetric magnetic resonance imaging. Am J Respir Crit Care Med 2003;168:522-30.
36. Stanchina ML, Malhotra A, Fogel RB, Trinder J, Edwards JK, Schory K, *et al.* The influence of lung volume on pharyngeal mechanics, collapsibility, and genioglossus muscle activation during sleep. Sleep 2003;26:851-6.
37. Owens RL, Malhotra A, Eckert DJ, White DP, Jordan AS. The influence of end-expiratory lung volume on measurements of pharyngeal collapsibility. J Appl Physiol (1985) 2010;108:445-51.
38. Wellman A, Jordan AS, Malhotra A, Fogel RB, Katz ES, Schory K, *et al.* Ventilatory control and airway anatomy in obstructive sleep apnea. Am J Respir Crit Care Med 2004;170:1225-32.
39. Jafari B, Mohsenin V. Overnight rostral fluid shift in obstructive sleep apnea: Does it affect the severity of sleep-disordered breathing? Chest 2011;140:991-7.
40. Mohsenin V. Effects of gender on upper airway collapsibility and severity of obstructive sleep apnea. Sleep Med 2003;4:523-9.
41. Redline S, Tosteson T, Tishler PV, Carskadon MA, Millman RP. Studies in the genetics of obstructive sleep apnea. Familial aggregation of symptoms associated with sleep-related breathing disturbances. Am Rev Respir Dis 1992;145:440-4.
42. Casale M, Pappacena M, Rinaldi V, Bressi F, Baptista P, Salvinelli F. Obstructive sleep apnea syndrome: From phenotype to genetic basis. Curr Genomics 2009;10:119-26.
43. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. N Engl J Med 1993;328:1230-5.
44. Riha RL. Regional fat distribution and sleep apnea: Sex makes a difference. Sleep 2010;33:419-20.
45. Morselli L, Leproult R, Balbo M, Spiegel K. Role of sleep duration in the regulation of glucose metabolism and appetite. Best Pract Res Clin Endocrinol Metab 2010;24:687-702.
46. Kripke DF, Ancoli-Israel S, Klauber MR, Wingard DL, Mason WJ, Mullaney DJ. Prevalence of sleep-disordered breathing in ages 40-64 years: A population-based survey. Sleep 1997;20:65-76.
47. Zamarrón C, Gude F, Otero Y, Alvarez JM, Golpe A, Rodriguez JR. Prevalence of sleep disordered breathing and sleep apnea in 50- to 70-year-old individuals. A survey. Respiration 1999;66:317-22.
48. Durán J, Esnaola S, Rubio R, Iztueta A. Obstructive sleep apnea-hypopnea and related clinical features in a population-based sample of subjects aged 30 to 70 yr. Am J Respir Crit Care Med 2001;163:685-9.
49. Al Lawati NM, Patel SR, Ayas NT. Epidemiology, risk factors, and consequences of obstructive sleep apnea and short sleep duration. Prog Cardiovasc Dis 2009;51:285-93.
50. Sutherland K, Lee RW, Cistulli PA. Obesity and craniofacial structure as risk factors for obstructive sleep apnoea: Impact of ethnicity. Respirology 2012;17:213-22.
51. Peppard PE, Young T, Palta M, Skatrud J. Prospective study of the association between sleep-disordered breathing and hypertension. N Engl J Med 2000;342:1378-84.
52. Naimark A, Cherniack RM. Compliance of the respiratory system and its components in health and obesity. J Appl Physiol 1960;15:377-82.
53. Lam JC, Mak JC, Ip MS. Obesity, obstructive sleep apnea and metabolic syndrome. Respirology 2012;17:223-236.
54. Ferguson KA, Ono T, Lowe AA, Ryan CF, Fleetham JA. The relationship between obesity and craniofacial structure in obstructive sleep apnea. Chest 1995;108:375-81.
55. Isono S. Obstructive sleep apnea of obese adults: Pathophysiology and perioperative airway management. Anesthesiology 2009;110:908-21.
56. Onat A, Hergenç G, Yüksel H, Can G, Ayhan E, Kaya Z, *et al.* Neck circumference as a measure of central obesity: Associations with metabolic syndrome and obstructive sleep apnea syndrome beyond waist circumference. Clin Nutr 2009;28:46-51.
57. Levinson PD, McGarvey ST, Carlisle CC, Eveloff SE, Herbert PN, Millman RP. Adiposity and cardiovascular risk factors in men with obstructive sleep apnea. Chest 1993;103:1336-42.
58. Daltro C, Gregorio PB, Alves E, Abreu M, Bomfim D, Chicourel MH, *et al.* Prevalence and severity of sleep apnea in a group of morbidly obese patients. Obes Surg 2007;17:809-14.
59. Tasali E, Van Cauter E. Sleep-disordered breathing and the current epidemic of obesity: Consequence or contributing factor? Am J Respir Crit Care Med 2002;165:562-3.
60. Dempsey JA, Skatrud JB, Jacques AJ, Ewanowski SJ, Woodson BT, Hanson PR, *et al.* Anatomic determinants of sleep-disordered breathing across the spectrum of clinical and nonclinical male subjects. Chest 2002;122:840-51.
61. Lam B, Lam DC, Ip MS. Obstructive sleep apnoea in Asia. Int J Tuberc Lung Dis 2007;11:932-933.
62. Ferguson KA, Cartwright R, Rogers R, Schmidt-Nowara W. Oral appliances for snoring and obstructive sleep apnea: A review. Sleep 2006;29:244-62.
63. Stoohs R, Guilleminault C. Cardiovascular changes associated with obstructive sleep apnea syndrome. J Appl Physiol (1985) 1992;72:583-9.
64. Lavie P, Herer P, Hoffstein V. Obstructive sleep apnoea syndrome as a risk factor for hypertension: Population study. BMJ 2000;320:479-82.
65. Virolainen J, Ventilä M, Turto H, Kupari M. Effect of negative intrathoracic pressure on left ventricular pressure dynamics and relaxation. J Appl Physiol (1985) 1995;79:455-60.
66. Leung RS, Bradley TD. Sleep apnea and cardiovascular disease. Am J Respir Crit Care Med 2001 15;164:2147-65.
67. Guyenet PG. Neural structures that mediate sympathoexcitation during hypoxia. Respir Physiol 2000;121:147-62.
68. Yoon IY, Jeong DU. Degree of arousal is most correlated with blood pressure reactivity during sleep in obstructive sleep apnea. J Korean Med Sci 2001;16:707-11.
69. Lam J, Lam B, Lam CL, Wang JK, Tse HF, Lam KS, *et al.* A community-based study of the relationship between metabolic syndrome and sleep-disordered breathing in Chinese subjects. Chest Meet Abstr 2004;126:905S.
70. Shamsuzzaman AS, Gersh BJ, Somers VK. Obstructive sleep apnea: Implications for cardiac and vascular disease. JAMA 2003 8;290:1906-14.
71. Campos-Rodriguez F, Grilo-Reina A, Perez-Ronchel J, Merino-Sanchez M, Gonzalez-Benitez MA, Beltran-Robles M, *et al.* Effect of continuous positive airway pressure on ambulatory BP in patients with sleep apnea and hypertension: A placebo-controlled trial. Chest 2006;129:1459-67.

72. Sjöström C, Lindberg E, Elmasry A, Hägg A, Svärdsudd K, Janson C. Prevalence of sleep apnoea and snoring in hypertensive men: A population based study. Thora×2002;57:602-7.
73. Nieto FJ, Young TB, Lind BK, Shahar E, Samet JM, Redline S, *et al.* Association of sleep-disordered breathing, sleep apnea, and hypertension in a large community-based study. Sleep Heart Health Study. JAMA 2000;283:1829-36.
74. Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. JAMA 2004;291:2013-6.
75. Lakka HM, Laaksonen DE, Lakka TA, Niskanen LK, Kumpusalo E, Tuomilehto J, *et al.* The metabolic syndrome and total and cardiovascular disease mortality in middle-aged men. JAMA 2002;288:2709-16.
76. Vgontzas AN, Bixler EO, Chrousos GP. Sleep apnea is a manifestation of the metabolic syndrome. Sleep Med Rev 2005;9:211-24.
77. Botros N, Concato J, Mohsenin V, Selim B, Doctor K, Yaggi HK. Obstructive sleep apnea as a risk factor for type 2 diabetes. Am J Med 2009;122:1122-7.
78. Tamura A, Kawano Y, Watanabe T, Kadota J. Relationship between the severity of obstructive sleep apnea and impaired glucose metabolism in patients with obstructive sleep apnea. Respir Med 2008;102:1412-6.
79. Laaban JP, Daenen S, Léger D, Pascal S, Bayon V, Slama G, *et al.* Prevalence and predictive factors of sleep apnoea syndrome in type 2 diabetic patients. Diabetes Metab 2009;35:372-7.
80. Shigeta Y, Ogawa T, Ando E, Clark GT, Enciso R. Influence of tongue/mandible volume ratio on oropharyngeal airway in Japanese male patients with obstructive sleep apnea. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:239-43.

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