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Local Anatomical Factors Predisposing to Obstructive Sleep Apnea: A Review

Review Article

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Abstract

Obstructive sleep apnea (OSA) is a condition that is characterized by collapse of the pharyngeal airway resulting in repeated episodes of airflow cessation, oxygen desaturation, and sleep disruption during the course of night. Obstructive sleep apnea-hypopnea syndrome (OSAHS) is characterized by repetitive episodes of airflow reduction (hypopnea) or cessation (apnea) due to upper airway collapse during sleep. OSA is classified as mild, moderate or severe. Patients with OSA have excessive daytime sleepiness, and may develop systemic hypertension, right heart failure, and cardiac arrhythmias. The interaction between local or general anatomic factors are important in mediating airway size and may have a strong impact on the development of OSA. Various local anatomical factors that can have an impact on the upper airway and predisposing to OSA are the craniofacial bony factors and soft tissue factors. Craniofacial bony anatomical factors include the mandible and the hyoid bone. Soft tissue factors include tongue, uvula, soft palate, tonsils and lateral pharyngeal wall. This article discusses in detail the various local anatomic factors predisposing to OSA. It is very evident from this review that various local anatomic factors play a role in the development of Obstructive Sleep Apnea.

Keywords: Obstructive Sleep Apnea; Obesity; Mandible; Upper Airway; Tongue; Hyoid Bone; Pharynx; Uvula; Risk Factors; Sleep Disorders; Apnea.

Introduction

Obstructive sleep apnea (OSA) is a condition that is ideally characterized by collapse of the pharyngeal airway resulting in repeated episodes of airflow cessation, oxygen desaturation, and sleep disruption during the course of night. Patients complain of a range of symptoms, particularly excessive daytime sleepiness, and may develop physical complications that include systemic hypertension, right heart failure, and cardiac arrhythmias [1]. Obstructive sleep apnea-hypopnea syndrome (OSAHS) is characterized by repetitive episodes of airflow reduction (hypopnea) or cessation (apnea) due to upper airway collapse during sleep. There are various scales which can be used to measure the severity as mild, moderate and severe.

Upper airway anatomic factors are thought to play an important role in the pathogenesis of airway closure in Obstructive Sleep Apnea [2-4]. Patients with apnea may have blockage at different points along the upper airway,the most commonly implicated regions for obstruction are the retropalatal region and retroglossal regions [5-7]. Airway narrowing in these different anatomic regions is dependent on the surrounding structures which maybe craniofacial or soft tissue structures [3, 8].

There are various important anatomic risk factors for sleep-disordered breathing, and these factors directly relate to changes in the

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upper airway craniofacial and soft tissue structures. Morphologic changes in upper airway structure, neck circumference (NC), and obesity contribute to such factors although these factors may not be local and can be attributed on a broader scale or as general factors. The soft tissues of the pharynx that are important in mediating airway size include the tonsils, soft palate, uvula, tongue, and the lateral pharyngeal walls [8]. The major craniofacial bony structures that determine airway size and are implicated in obstructive sleep apnea, if altered are the mandible [9] and position of the hyoid bone [10]. Abnormalities in any of these upper airway structures may affect airway size aggressively, leading to development of obstructive apneas which will lead to a cascade of events.

Of the general predisposing factors, Obesity is assumed to affect airway size through deposition of fat within the soft tissue regions of the neck [11, 12] and maybe by changing resistive loading on the upper airway to promote airway collapsibility [13]. Neck circumference (NC) may be a well-known risk factor for OSA [14] and should be a surrogate marker of regional fat distribution within the neck [15]. We believe the interaction between anatomic factors be it local or general are important in mediating airway size and may have a strong impact on the development of OSA and hence in this review the various local anatomical factors are discussed in detail.

Craniofacial Bony Anatomical Factors

Mandible

Through the years there have been various methods of analysis of these anatomical factors that are predisposing the development of Obstructive sleep Apnea such as the use of cephalograms and Magnetic Resonance Imaging. The first craniofacial bone anatomical factor that is implicated in OSA is mandible. In a study conducted by Alan A Lowe et al [16], 25 patients with moderate Obstructive Sleep Apnea were assessed and it was observed that patients with OSA had a more posteriorly placed mandible as well as maxilla.It has also been shown in literature that Mandibular advancement surgeries relieve this condition [17]. In a study conducted by Joseph B et al [18], 420 patients who had a suspected sleep disorder were evaluated at a regional sleep Center.It was observed that retrognathia was absent in 61.66% of the patients and only observed in 38.33% of the population and they concluded that this bony structure does not play a role in the development of sleep apnea. However, the position of the mandible plays a role in the development of Obstructive Sleep Apnea as reported in the study by Alan et al.

In a study conducted by Mau Okubo et al [19], the morphological parameters of the mandible were assessed with the help of MRI, which revealed that there was no difference in the thickness of the mandible between the groups with and without Obstructive Sleep Apnea. They found a smaller mandibular internal length which was measured as the perpendicular distance from the spina mentalis to the line joining the right gonion and the left gonion, as well as a wider mandibular divergence which was measured as the angle between the spina mentalis-Internal Right Gonion line and Spina Mentalis- Internal Left Gonion line. However, Mohamad Bayat et al [20] did cephalometric analysis and observed that patients with Obstructive Sleep Apnea had longer mandibles. Patricia H et [21] studied 48 children in which 24 children had OSA and observed that patients with OSA had a longer and wider mandible when compared with the control group without OSA. Thus, there is no unison on the agreement on length of the mandible as a predisposing factor for the development of OSA. Also, the hypothesis exists that a wider mandible plays an effect and constricts the airway.

Among the anatomical features that are pertaining to the mandible, it has been accepted by various authors [22] that the predisposing factors include a longer wider retrognathic mandible. Chi et al [23] reported that a longer mandible acts as a predisposing factor only in females and not in males. Retrognathic mandible might lead to the development of OSA as the tongue will fall back in such patients leading to blockage of airway thereby resulting in OSA [24].

Hyoid Bone

The next bony craniofacial structure that has been reported as a predisposing factor for Obstructive Sleep Apnea is the Hyoid bone. Chi et al [23] performed magnetic resonance imaging and observed that there was an increased length between hyoid to sella, hyoid to nasion and hyoid to supramentale in the group with OSA than in the group without Obstructive Sleep Apnea. This would ultimately mean that the patients would have a more posteriorly placed hyoid bone and thus would impinge on the airway. It was also been reported that hyoid advancement as well as a suspension of the bone would aid OSA [25].

Yu et al [22] analyzed cephalometric features of patients with OSA and observed that the hyoid bone was inferiorly placed. They concluded that one of the important determinants is anterior displacement of the hyoid bone to prevent the development of OSA. Nonglak et al [26] in their study observeda significant difference between groups in hyoid bone position relative to the mandibular plane. Subjects with OSA also had more obtuse craniocervical angles. This was in contrast to many previous studies, each identifying few cephalometric parameters to be associated with OSA with a lot of controversies except in the case of the position of the hyoid bone,which was one of the very few factors on which most studies agreed [27-32]. For instance, Riha et al. [33] suggested that there was a link between the hyoid position (distance between the mandibular plane to the hyoid bone in particular) and the occurrence of OSA.

Partinen et al. [34] identified the parameter "distance from the mandibular plane to the hyoid bone" (MP-H) as a factor contributing to sleep apnea. This would be a more concrete quantitative parameter. They also reported the posterior airway space (PAS) as another parameter which could be potentially associated with sleep apnea. Silva et al. [35] found only the distance between the hyoid and mandibular plane as the only factorpredisposing to sleep apnea. In their study, the parameters PNS-U, PAS, SNA, or SNB were not associated with OSA. Sforza et al. [36] found the distance between hyoid and mandibular plane as well as the length of the soft tissue palate (PNS-P) as the only parameters potentially relevant to OSA. Thus, it is evident that cephalometric values can be used to assess the status of a patient.

Miles et al. [37] conducted an extensive literature review and concluded that due to the controversies, it is difficult to identify clear cephalometric risk factors for OSA. According to them, although

the conclusions were not clear, some variables could still be highlighted as potential etiologies or predisposing factors of sleep apnea. They identified the distance between the mandibular plane and the hyoid (MP-H), the angle indicating the sagittal position of the maxilla (SNA), the angle relevant to the sagittal position of the mandible (SNB), the soft palate length (PNS-P), and the PAS as potential associated factors.

Soft Tissue Factors

Tongue

Among soft tissue factors, tongue is considered as the first predisposing factor for OSA. RJ Schwab et al [38] assessed the soft tissue factors with the help of magnetic resonance imaging between OSA patients and normal patients. They observed an increased volume of tongue among the patients with OSA. This could be explained by the fact that when there is a larger tongue it would fall back during sleep and the same would impinge on the airway.Schellenberg et al [18] in their study observed an enlarged tongue in the group with Obstructive Sleep Apnea than the normal group. Yuko Shigeta et al [39] also observed an increased volume of tongue involved in patients with Obstructive Sleep Apnea. Thus, it can be concluded from various studies that an enlarged tongue is a predisposing soft tissue anatomical factor for the development of OSA.

In 2006, Iida et al [40] compared the tongue volume/oral cavity volume (TV/OCV) ratio between 20 male patients with OSA and 20 normal male adults. They described that BMI was significantly correlated with tongue volume in the OSA patient group. This was an innovative finding that would link all the aspects. They also observed that patients with OSA had a larger TV/OCV ratio than controls, and AHI (Apnea–hypopnea index) did not correlate with tongue volume or TV/OCV ratio. In addition, they concluded that the TV/OCV ratio was likely to be involved in the development of OSA and can be used as a diagnostic tool, even if AHI was not correlated with TV/OCV. Eung Kwon Pae et al [41] in a study reported that the shape of the tongue also contributes as a factor for OSA, however there aren't many studies pertaining to the same and further investigation is to be done to improve the knowledge in the field and to aid in the process of diagnosis as well.

Uvula

The next soft tissue anatomical feature to be considered as a risk factor for OSA is uvula. John L Stauffer et al [42] concluded that the uvula in patients with OSA contains more muscle and fat than the uvula in control subjects, possibly contributing to pharyngeal narrowing in OSA.Schellenberg et al [18] reported that an enlarged uvula was not present in most patients that had obstructive sleep apnea when 420 patients with a sleep disorder were assessed. This can also be attributed to the fact that uvuloplasty can be used as a treatment measure for the same.

Marin Sekosan et al [43] in their study assessed uvulas after uvulo-palatopharyngoplasty procedure in 21 patients and concluded that there was evidence of inflammation of the mucosa of the uvula. In a study conducted by Gilead Berger et al [44] it was observed that there was an increase in the amount of connective tissue surrounding the uvula between moderate and severe cases with obstructive sleep apnea.Thus, most researchers are in agreement that an enlarged uvula is a predisposing factor for the development of Obstructive Sleep Apnea.

Soft Palate and Tonsils

The other two soft tissue anatomical factors that has been considered as predisposing factors for OSA in the literature are the soft palate and the tonsils. Schwab et al [8] conducted a study on 48 patients with OSA and 48 normal patients,and observed an increase in the volume of soft palate in patients with OSA when compared to the normal patients. In their study tonsils were not assessed. Schellenberg JB et al [18] assessed the tonsils and adenoids and observed that the enlargement of tonsils was only present in few patients in the study population. Thus, although the role of tonsils and soft palate in OSA is inconclusive, it can definitely be considered as one of the predisposing factors towards OSA development.

Conclusion

It is very evident from the review that various local anatomic factors play a role in the development of Obstructive Sleep Apnea. Further studies are to be done to determine definitive predisposing factors and prevent the development of OSA, which would inturn benefit the entire human community.

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