REVIEW ARTICLE

Obstructive Sleep Apnea: A Review

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ABSTRACT

Obstructive Sleep apnoea is a medical disorder that occurs irrespective of age. It is seen more in overweight middle- age males. Strained respiration, decreased blood oxygen levels, and arousals that interrupt a normal sleep pattern are features of this syndrome. Obstructions in OSA occur at the oropharynx, and sometime in nasopharynx. Hypertrophied adenoids are a commonly cause obstruction of the upper airway. Many cases present a significant health risk and can result in excessive daytime sleepiness, early morning headaches, impaired concentration, social impairments, systemic and pulmonary hypertension, traffic and work-related accidents, ischemic heart disease, and cerebrovascular disease. This article reviews gives a brief idea about OSA, its pathophysiology, treatment modalities and its paediatric aspects.

KEYWORDS: Apnea, Obstruction, Nasopharynx

INTRODUCTION

Sleep apnea is a medical disorder that can be present in any age group.[1,2] It is estimated to affect approximately 2% to 4% of the adult population and is most commonly observed in the middle- age overweight males. The typical characteristics of this syndrome are strained respiration, decreased blood oxygen levels, and arousals that interrupt a normal sleep pattern.

Such type of cases can also result in daytime sleepiness, morning headaches, impaired concentration, social impairments, systemic and pulmonary hypertension, traffic and work-related accidents, ischemic heart disease, and cerebrovascular disease.[3,4]

Also referred to as obstructive sleep apnea/hypopnea syndrome (OSAHS), this condition occurs when the base of the tongue periodically contacts the posterior pharyngeal wall or partially occludes the upper airway during sleep. Relaxation of the genioglossal muscles and reduction of the tone of surrounding musculature are contributing factors.

This article aims to review the sleep medicine literature with special focus to the articles about randomized, controlled studies. It discusses terminology, clinical procedures, patient communication, and contraindications and complications of therapy.

TERMINOLOGY

The following terminology is quite helpful in understanding Obstructive Sleep Apnea(OSA)[5]:-

- *Apnea* is the cessation of airflow for at least 10 seconds.
- *Apnea index* (AI) is the number of apneas per hour of sleep, with 5 or less considered normal.
- *Apnea-hypopnea index* (AHI) is the number of apneas and hypopneas per hour of sleep. Ten or less is usually considered to be normal.
- *Central sleep apnea* is the cessation of airflow from lack of respiratory effort.
- *Epworth sleepiness scale* (ESS) is a reliable and validated subjective assessment of daytime sleepiness. A score greater than 10 on this self-administered questionnaire indicates excessive sleepiness.
- *FDA 510k* is a premarket notification that a medical device manufacturer must submit to the Food and Drug Administration. It helps the FDA by determining whether the device is similar to one in commercial distribution before May 28, 1976. New or modified devices must be equipped with safety and effectiveness data that may include material composition, biocompatibility, and clinical testing.
- *Hypopnea* is an abnormal reduction of airflow for at least 10 seconds.
- *Mixed sleep apnea* is the cessation of airflow starting as central followed by obstructive.
- Daytime Sleepiness can be objectively measured by *Multiple sleep latency test* (MSLT). A time greater than 10 minutes is oftentimes defined as normal.
- *Obstructive sleep apnea* (OSA) is the cessation of airflow despite adequate effort to breath.
- *Polysomnography* is the science dealing with the physiology of sleep and the definitive objec-tive means of diagnosis of sleep apnea and related

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disorders. Activities monitored during a sleep study are brain waves (EEG), eye movements (EOG), muscle activity (EMG), heartbeat (EKG), blood oxygen levels (SaO2), and respiration. Polysomnographic markers include total sleep time, sleep efficiency, sleep stage distribution, the arousal index (sleep fragmentation), and snoring frequency and intensity.

- *Respiratory disturbance index* (RDI) is another term for AHI. The usual definition of slight OSA is an RDI of 5 to 14, moderate OSA is an RDI of 15 to 30, and severe OSA is an RDI of >30.
- *Sleep stages* are the intervals of non-REM and REM sleep. Non-REM sleep is divided into stages 1 to 4 with stage 1 being the lightest level and stage 4 very deep sleep. After progression through all 4 stages in about 90 minutes, stage REM begins. Dreams most often occur and muscle tone decreases in this stage.
- *Snoring* is breathing through a narrowed upper airway space during sleep with harsh noises, as caused by the vibrating of the soft palate.
- *Treatment outcomes* are the subjective and objective measures of patient responses to a particular mode of therapy. Definitions of complete response, partial response, and failure vary among investigators.
- *Upper airway resistance syndrome* is an incomplete upper airway obstruction without apneas or hypopneas. Snoring, inadequate sleep, and daytime sleepiness characterize this condition.

PATHOPHYSIOLOGY

Negative airway pressure is generated by the activity of the diaphragm and intercostal muscles during inhalation. To a large extent, the patency of the upper airway is dependent on the action of oropharyngeal muscles. These dilator and abductor muscles are normally activated in a rhythmic mode in coordination with each inspiration.

When the negative pressure exceeds the force produced by these muscles, the pharynx will collapse, occluding the airway.[6] Frequently, sleep apnea patients have constricted upper airways that increase the pharyngeal resistance during inspiration. This, in turn, necessitates an increase in pharyngeal dilator muscle contraction to maintain airway patency.

Such an increase has been shown in OSAHS patients during wakefulness,[7] but was also shown to decrease in contraction during sleep, thus contributing to the development of obstructive apnea.[8] Interestingly, when compared with normals, OSAHS patients show greater pharyngeal dilator muscle contraction during sleep, suggesting that an imbalance between negative airway pressure and dilator muscle contraction is responsible for the obstruction, rather than a primary deficiency in muscle contraction.[9] A sustained increase in dilator muscle contraction in OSAHS could predispose these muscles to fatigue,[10] possibly aggravating the tendency to pharyngeal occlusion.[9]

Although this model explaining OSAHS pathophysiology needs to be studied much further, the role of negative intrapharyngeal pressure as a stimulus to dilator muscle contraction is reinforced by studies of the impact of nasal continuous positive air pressure (CPAP) on pharyngeal muscle function.[9] Nasal CPAP results in a marked decrease in both tonic and phasic contraction of the genioglossus muscle.[11]

CPAP therapy is based on counteracting the negative airway pressure during inspiration, and hypoglossal nerve stimulation was suggested to enhance pharyngeal dilator muscle contraction.[12]

Other procedures such as uvulopalatopharyngoplasty (UPPP) and mandibular advancement (either surgical or with a mandibular advancement oral appliance) are based on the principle of pharyngeal enlargement to reduce the degree of negative intrapharyngeal pressure during inspiration.[13,14] The translation of these basic concepts into realized therapeutic benefits does not occur consistently, especially in the arena of surgical management.[15]

CONSEQUENCES OF OSA

Cardiovascular disorders are one of the most serious consequences of OSA. These include tachycardia, daytime hypercapnia, hypertension, increased risk of cerebrovascular accidents, atrial fibrillation and even coronary artery disease. Hypertension is more prevalent in younger or middle- aged OSA sufferers than those aged 60 years or older.[16] The pathogenesis of these effects of OSA is still being researched, but it is well known that apneic episodes cause intermittent hypoxia and hypercapnia which in turn cause homeostatic compensation events overall that result in cardiovascular disease gradually.

The cardiovascular consequences of OSA have been investigated by various authors. The occurrence of Hypertension is around 50-90%.[17] It has been shown that nocturnal blood pressures of patients with severe OSA can reach up to 240/120 mm Hg.[17] Another feature of OSA-related hypertension is that the organs affected are mostly the brain and the heart, kidneys are usually spared, which differentiates it from other of hypertension.[18]

Kawata et al[19] found that the incidence of daytime hypercapnia, is around 14%. A statistical relationship exists between the severities of OSA and hypertension was shown by the Wisconsin sleep cohort study and Kawata et al[18] showed that AHI and body mass index (BMI) can predict daytime hypercapnia severity.

In addition to hypertension, atherosclerosis is also a sequel of OSA. OSA patients have an increased oxidative stress and decreased antioxidant capabilities.[19,20,21] Oxidative stress is associated with the increased levels of cytokines and interleukins, which can lead to an acclerated rate of vascular damage, atherosclerosis and coronary artery disease.[16]

Airway obstruction can be caused by numerous types of blockages on any of the different levels of the upper/lower airway. This article sheds light mainly on the anatomy of the oro and velopharyngeal areas.[21]

DIAGNOSIS

Originally, sleep medicine began in academic research environments to investigate the physiology and psychophysiology of sleep and dreaming. Sleep research was largely the domain of psychiatry and psychology. During the past 2 decades, the mounting evidence of the significance of sleep disorders to health, and thus the clinical relevance of sleep, spurred growth in the field of sleep medicine aimed at diagnosis and treatment of sleep disorders.[22]

The laboratory recording technique is called polysomnography (PSG). It was proposed by Holland and colleagues[23] in 1974. It intended to describe the recording, analysis, and interpretation of multiple physiologic findings. As a tool, PSG has been essential in the diagnosis for sleep-disordered patients and in the enhancement of our understanding of both normal sleep and its disorders.[24]

Polysomnography is a complex procedure that should be performed by a trained technologist. Using electrodes and other sensors, a routine clinical polysomnogram includes the monitoring of brain electrical activity, electro-oculography, electromyography, effort to breath, nasal and oral airflow, oxygen saturation, electrocardiography, and body position.

Other more specialized studies may include additional measures, such as endoesophageal pressure.[25]

The number of times a patient experiences the respiratory events has been the primary instrument in diagnosis of sleep disordered breathing. The apnea-hypopnea index (AHI) and the respiratory disturbance index (RDI) are a reliable predictor of associated cardiovascular disease as well.[26] Clinical symptoms plus the severity of the oxygen desaturation and sleep fragmentation during polysomnography are used to assess the severity & acute consequences of OSA[26]

A time period of at least 10 seconds in adults was the common consensus for both apnea and hypopnea. However, the inconsistency in the definition of hypopnea has been due to the inclusion or exclusion of different parameters, and the different methods used to measure them, eg, the degree of airflow or respiratory effort reduction, degree of oxyhemoglobin desaturation, and arousal from sleep.[22,27,28] The clinical criteria for the diagnosis of clinically significant OSAHS & its related grading of severity has been proposed by American Academy of Sleep Medicine. [29]

It is now accepted that a diagnosis of clinically significant OSAHS should be accompanied by compatible signs and symptoms, and not based simply on an arbitrary AHI/RDI threshold.[30,31,32] The syndrome should be said present when there are abnormal obstructed breathing events and mid-sleep arousals that exceed the normal threshold in a patient with clinical features related to the abnormal respiratory pattern during sleep.[22] A recent suggestion by Kryger[22] stated that patients with daytime sleepiness who have more than 5 abnormal respiratory events per hour of sleep should be treated, or at the very least receive a clinical trial of nasal CPAP, is in agreement with the previously published consensus statement in 1999.[33]

The formulation of clear-cut guidelines for the assessment, management, and follow-up of OSAHS patients is essential.[34] The high prevalence of OSAHS, and the increasing availability of new simplified limited diagnostic systems, suggest this likelihood.[29] The efficacy of home-based sleep studies has been recently reviewed. While offering improved sleep quality and cost savings, the risk of technically unsatisfactory results is still high due to the lack of technician supervision.[35]

DIAGNOSTIC PROBLEMS IN OSA

Polysomnography is nothing but a sleep study that intends to measure many physiological sleep variables and helps to diagnose OSA. The measurements include oxygen saturation, electrocardiography, air flow, respiratory effort, limb movement, eye and jaw muscle movement, and brain electrical activity. Polysomnography is the gold standard for OSA diagnosis. Around 80% and 90% of the patients go undiagnosed. Rahaghi and Basner[36] investigated the cause of this great deficiency by interviewing known OSA patients.

They found that there was an average of 87 months that elapsed between the patient first noticing a symptom of OSA, and being diagnosed with this condition.

Because of the large percentage of undiagnosed sufferers, preliminary examinations of patients should include screening for sleep apnea to help reduce the number of OSA patients going untreated. Faber and Grymer[37] reviewed several techniques for diagnosis of OSA and rated them for ease, accuracy, ability to be standardized, and cost-effectiveness.

Obesity is one of the most important risk factors of OSAS. National Institute of Health defines Obesity as a BMI of 30 or greater. BMI is calculated by dividing weight in kilograms by the square of height in meters. Although obesity is a very important risk factor, the direct relationship between BMI and severity of OSA is poorly understood. The correlation between BMI and AHI was found out to be very low in one study(r _ 0.23).[38]

Fogel et al.[38] set out to determine more specific predicting factors than BMI within the obese population. The later results are likely related to the resultant mechanical limitation of the genioglossus muscle. Its function is to pull the tongue anteriorly and helps to improve patency of the airway. If the length of the muscle is shortened, it resuts in its disfunction, thus, allowing the

tongue to stay in a retruded position. At the level of the oropharynx, it results in obstruction in OSA.

MOST COMMON TYPES OF OBSTRUCTION

Although most obstructions in OSA occur at the oropharynx, another site of airway blockage is the nasopharynx. In the upper airway, common source of obstruction are hypertrophied adenoids. This type of obstruction may results in OSA if the individual is not able to breathe through the mouth during sleep.[39]

As a screening tool for airway obstruction, the cephalogram can be used. The mechanism that decreases oropharyngeal patency in cases with those skeletal anomalies related with OSA has been studied. In cases, where maxilla being protruded anterior relative to the mandible causes skeletal Class II configuration or due to retruded mandible or simply not developed.[40]

Johal et al.[41] examined the specific anatomical anomalies providing to OSA. As one of the contributing factor in OSA retrognathia was found, patients having a shorter mandibular body length and with shorter distance from the lingual surface of the lower incisors to the posterior pharyngeal wall. As treatment for OSA, bimaxillary surgical advancement is supported by their findings. Many investigators also agree that a lower-positioned hyoid is also a contributing factor.[42,43,44]

Sher et al, examined causative factors by regions of the pharynx, the retrolingual region and the retropalatal region.[45] There may be an obstruction in either or both of these regions of the pharynx. (Haskell)

TREATMENT

Clinical Approach to Obstructive Sleep Apnea

The following treatment guidelines are based on recommendations from the American Sleep Disorders Association.[46]

1. The physician has the responsibility to diagnose OSA and recommend an appropriate course of treatment.
2. The patient is referred to a dentist or dental specialist who practices in this field.
3. At the initial dental evaluation, medical and dental histories should be taken. The clinician should explain the rationale, advantages, and disadvantages of treatment, together with a review of informed consent.
4. During the initial appointment, a clinical examination notes:
    - Soft tissue facial features and facial type.
    - Physiologic activity including abnormal habits.
    - Temporomandibular joint health, occlusion, a range of mandibular movement, and abnormal attrition.
    - Teeth present and restorations with special attention to full coverage crowns.
5. A records appointment is scheduled to take impressions for study, and work models, photographs, a mandibular advancement registration, and an optional cephalometric radiograph.
6. The clinician selects an appliance for laboratory fabrication and delivers the completed appliance with home care instructions according to the manufacturer's specifications.

Various Treatment Modalities

Continuous Positive Airway Pressure (CPAP)

The principal of all treatment modalities in OSA is to enhance breathing and minimize the propect of increased morbidity. Their aim is to prevent the collapse of the lumen of the pharynx during sleep. CPAP18 seems to cure all OSA and considered as an initial treatment according to the gold standard. This keeps the pharynx patent due solely to increased air pressure as if it is being blown up like a balloon. This method is highly effective, although there are several negative aspects also.[47]

Surgical Treatments

It is very effective in many cases of OSA, but all the patients are not able to indulge, CPAP will respond to the treatment. These are severe cases of OSA. For these patients, surgery is another treatment option. The guidelines for OSA surgery state that a prerequisite for surgery candidates is that they must be nonresponsive to CPAP or other nonsurgical OSA treatments.[48]

To treat OSA, there are many different types of surgery that have been used. These includes soft tissue to osteotomy surgeries. The uvulopalatopharyngoplasty (UPPP) was introduced in 1981 and has been the most popular form of soft tissue surgical treatment of OSA. In this type of treatment, part of the soft palate and surrounding oropharyngeal tissues are surgically resected. This treatment has shown 50% success rate.[49,50]

Orthognathic treatments have been used because of the disadvantages of soft-tissue surgery. Moving the mandible anteriorly helps in pulling the tongue forward and away from the posterior wall of the oropharynx, thus, enhance the airway. These procedures include inferior sagittal mandibular osteotomy and maxillomandibular osteotomy and advancement.[48, 51]

The dental occlusion can be controlled in the surgically bimaxillary advancement as both jaws are being moved with all soft tissue attached to them and the hyoid bone. In this skeletal malocclusion can be corrected and the original occlusion can be maintained. Moreover, it can correct OSA at different levels of the oropharynx. [48]

When used in combination with bimaxillary advancement, this treatment can result in a significant increase effect on the dimensions of the oropharynx,[51] as a decreased lateral dimension of the airway is a very common etiology of OSA in obese patients.

Mandibular Repositioning: For patients with mild-to-moderate OSA, who cannot tolerate CPAP treatment, orthognathic surgery may be too aggressive a form of

treatment. An option for these patients is a removable oral appliance that repositions the mandible forward. By placing the mandible forward, it shows these structures that make up the lumen of the oropharynx forward as well, thereby increasing the airway space. Many authors now agree that mandibular repositioning treatment with an oral appliance has many advantages and should be the first line of treatment, including patients with severe OSA, if an optimal amount of advancement is possible.[53,55-57]

The removable Herbst appliance is one type used for mandibular advancement in patients with OSA. This appliance is composed of 2 acrylic splints, one that fits over the teeth in each arch, with a piston like connector in between. This piston helps to push the mandible forward relative to the maxilla, allow the patient to open and close when a rod slides inside a tube. This device can be altered by the patient to more or less forward extension, which is called titrating to effectiveness.

OSA patients treated with removable Herbst appliance shown significant increase in AHI values by up to 34 apneic events. The cephalometric analysis of these patients revealed that those who responded the most had a shorter mandible-tohyoid distance.[52,53,54,56,57,58,59]

PEDIATRIC ASPECTS

Children can develop a sleep apnea syndrome similar to that seen in adults. Epidemiological reports suggest a relatively high prevalence of upto 2% of all children.[60,61] The frequency of snoring in the general pediatric population ranges from 8% to 27%.[62-65] Snoring is considered the hallmark of OSAHS in children.[66] In the pediatric patient, 3 major categories of morbidity can be defined: neurobehavioral, cardiovascular, and somatic growth.[67]

Neurobehavioral Aspects: In OSAHS pediatric patients, sleep fragmentation is rare.[68] Parental observations and objective sleep latency testing do not report excessive daytime sleepiness as a major symptom; thus it cannot be considered a predominant feature, in contrast with adult patients.[69,70] The major concern is the association of the OSAHS, and even snoring, with significant and at least partially reversible behavioural and learning deficits.[71-80]

Cardiovascular Aspects: Despite the paucity of studies addressing this area in children, the current evidence suggests children with OSAHS have elevated diastolic blood pressure that persists during wakefulness, [81] in addition to changes in left ventricular wall thickness, indicating elevated afterload and systemic blood pressure elevations.[82]

Somatic Growth: Children with OSAHS have a higher risk for failure to thrive. The incidence of this consequence has not been systematically assessed; however, increased awareness and early diagnosis have reduced this problem in recent years.[71] Marcus and coworkers[83] postulated that the increased respiratory effort during sleep leads to increased metabolic expenditure and slower weight gain in these children. OSAHS treatment has been associated with decreases in energy expenditure and weight gain. Decreased insulin growth factor-1 may account for the slower growth in some OSAHS children.[84] Weight gain has been reported after treatment, even in obese subjects.[85]

Intervention: It is widely accepted that once the diagnosis of OSAHS has been established, the first line of treatment is the surgical removal of the enlarged tonsils and/or adenoids. However, the effectiveness of this treatment needs to be further established.[67] One study suggested that children from certain ethnic minorities, obese children, and those with a family history of sleep disordered breathing were at a higher risk for having residual OSAHS after tonsillectomy and adenoidectomy.[86]

CPAP intervention in children examined to be safe but essential expansive behavioral training to achieve reasonable compliance. It is usually reserved for children with OSAHS in association with other medical conditions, and also for a few otherwise normal children, in whom a failed tonsillectomy and adenoidectomy procedure had culminated in residual postoperative severe OSAHS.[71]

A variety of conditions involving children have been associated with OSAHS: Down syndrome, Crouzon and Apert syndromes, cerebral palsy, Treacher-Collins syndrome, Pierre-Robin syndrome and multiple other rare craniofacial disorders are involved. The degree of obstruction in many of these conditions could be so severe as to warrant tracheotomy.

A change of surgical techniques have been implemented to achieve these goals; they include maxillomandibular advancement, distraction osteogenesis, septoplasty, and turbinectomy. An introduction to tonsillectomy and adenoidectomy, soft tissue methods could include uvulopalatopharyngoplasty, uvulectomy, epiglottoplasty, and tongue reduction. There seems to be an agreement that sleep studies need to be an integral part of the pre/ postoperative workup to measure the success of the OSAHS treatment. Although the literature has a plethora of case-series studies of various conditions,[87-102] only few offered critical postoperative outcome assessment with polysomnography. In a prospective study of 18 cerebral palsy and OSAHS patients, surgery decreased the RDI from 7 to1.4, increased the lowest recorded oxygen saturation from 73.7% to 88.2%, and required tracheotomies in only 17% of the cases.[90] More recently, Cohen and colleagues[88] also reported outcomes of a variety of individualized procedures in 70 children. The average RDI was decreased from 25.9 to 4.4 postoperatively. The lowest recorded oxygen saturation increased from an average of 61% to 92% after surgery, while the tracheotomy rate was lowered to 9.6%. A prospective analysis of a subgroup from this study has suggested that surgery is most effective at ages greater than 12 months.[89]

CONCLUSION

Obstructive sleep apnea is a disorder that has significant medical and psychosocial consequences. As discussed in this review, this is a common, underdiagnosed disorder that affects both adults and children. However, recognized for centuries, its significance for individuals and society has been valued. Because individuals with narrow airways and/or craniofacial anomalies may have raised chance for obstructive sleep apnea/hypopnea syndrome, dentistry can play a pivotal role in the identification and possible treatment of patients with this syndrome.[103]

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