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An Overview of Obstructive Sleep Apnea/Hypopnea with a Comparison of Existing Treatments

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Abstract

Obstructive Sleep Apnea (OSA) and Hypopnea is a disorder that is quite prevalent across the globe. It is defined as recurring temporary cessation of breathing. OSA/Hypopnea is diagnosed through the Epworth Sleepiness scale and STOP-Bang questionnaire and is followed by a sleep study involving a polysomnograph and electroencephalogram to utilize the apnea-hypopnea index (AHI) for the severity of a patient's OSA/Hypopnea. The long-term consequences of untreated OSA/Hypopnea includes altered mental status, sleep deprivation, mood changes, cardiovascular disease to mention a few. The common treatments to address this problem are CPAP, orthodontic devices (MAD, TRD), and surgical intervention (orthognathic surgery with maxillomandibular advancement). The etiologies of the disorder had to be reviewed to be able to correctly identify the best route of treatment. It was identified that CPAP and OMFS surgery are the golden standards of treatment depending if the patient had modified or unmodified factors.

Keywords: Obstructive sleep apnea; Hypoapnea; cessation of breathing; mental status; sleep deprivation; surgical interventions; orthodontic devices

Introduction

OSA/Hypopnea and current treatments

Obstructive Sleep Apnea is a common, chronic condition. It is explicitly defined as a temporary cessation of breathing of approximately 10 seconds, whereas hypopnea is a reduction in airway flow of greater than 10 seconds; both resulting from either an absence or reduction in brainstem communication to the upper airway muscles and the diaphragm & intercostal muscles (Chang, Hong-Po et al., 2020). The obstruction of the airway to be more specific, can be caused by the tongue (genioglossus m.) to fall backwards because of a lack of neural activity from the brainstem (Shahrokh et al., 2017). A diagnosis of OSA/hypopnea if left untreated is causally linked with long-term health issues; cardiovascular disease, cognitive impairment, and changes in mental health (Amal M et al., 2018).

Occurrence of OSA/Hypopnea

It is assumed that over 30% of men and over 15% of women in their 50s fit the criteria for OSA/hypopnea, but over 40% of individuals with pre-existing health conditions such as cardiovascular disease, have OSA/hypopnea (Yerem et al, 2021). The effects of untreated OSA/hypopnea on a patient is detrimental and may translate into a decrease in productivity levels both at home and in the work place along with an increase in risk of a motor-vehicle accident (Gaia et al., 2021). There are several well-known treatment

modalities to address the issue such as CPAP (continuous positive airway pressure), orthodontic devices, and OMFS surgery to prevent any short-term and long-term consequence from manifesting (Hsueh-Yu et al, 2019; Julia A M et al., 2021; Susheel P et al., 2019). There have also been recent advancements in research regarding this arena with the aim of further improving the patient's quality of life.

Sleep medicines and OSA/Hypopnea

Sleep medicine has long approached OSA/Hypopnea mainly by prescribing either CPAP or an orthodontic device. Over the last decade, several new novel therapies have been developed to solve some of the limitations that current treatment options face. While orthodontic devices do not have any glaring limitations, CPAP does. It is estimated that between 20% to 80% of patients are unable to comply with CPAP for a number of reasons ranging from facial anatomical abnormalities to lifestyle choices (Saif et al., 2021). The hypoglossal nerve stimulator (hgns) is the answer for patients unable to comply with CPAP. This novel therapy is a device that is surgically implanted in the upper chest (5th, 6th rib) and wrapped around the hypoglossal nerve in the upper neck. It functions to ensure the tongue is stiffened and kept in a protruded manner to achieve a healthy cross-sectional area of the pharynx for normal respiration (Olson and Junna, 2021). The HGNS device has so far shown better outcomes than CPAP in terms of compliance and improvement in quality of life in the long-term (Peter M et al., 2020). On another note, a number of published literature has strongly demonstrated that pharmacotherapy is proving to be difficult in reducing the severity of an individual's OSA/Hypopnea experience. However, a very recent study is showing promise in administering a combination of atomoxetine with antimuscarinic aroxybutynin in reducing the patient's severity of OSA/Hypopnea (Russell et al., 2022). More literature is needed on this recent study to demonstrate whether or not the promise holds up. Extensive research is warranted in developing more novel therapies to minimize the severity and prevalence of this disorder. Due to the steady increase in number of cases of OSA/hypopnea a review of the pertinent literature of the disorder is warranted.

Obstructive Sleep Apnea/Hypopnea

Obstructive Sleep Apnea/Hypopnea is a disorder that has genetic and environmental etiologies that severely disrupts one's day to day quality of life (Alvina R et al., 2021). Sleep has been ingrained into every person's subconscious as the singular most important part of a successful and productive day. But, with this disorder especially when untreated, the utility that is produced on a day to day basis begins to decline. This can lead to serious long-term effects on a patient's mental and physical health, and to treat it is of utmost importance (Carl et al., 2019). A number of different treatment options to improve and minimize the severity of sleep apnea/hypopnea are available. But, those that deserve a closer look are CPAP, orthodontics, and oral & maxillofacial surgery. More specifically, the hypothesis of this review article is to review literature pertaining to OSA/Hypopnea and to compare the current treatments to identify the best route to pursue.

Epidemiology of OSA/Hypopnea

When it comes to the sex, according to Dr. Rundo, men are at a greater risk than women are until menopause is reached, in which case the risk becomes similar with the exception of women undergoing hormone replacement therapy post-menopause (2019). An interesting piece of information lies in the sleeping position. When women are sleeping supine OSA does not take place, but for men sleeping supine OSA is present despite having a similar body mass index (BMI) as women. The symptoms were more apparent in men, which made it more difficult to diagnose women allowing for a higher mortality rate compared to men. As for age, the risk of OSA increases as one ages. More specifically, the prevalence for men under 72 years was 23% and 30% for those aged 80, whereas those under the age of 40 it was only 10%. The craniofacial anatomy was taken into consideration when comparing OSA rates in different races. American Indians were identified at greater risk of having moderate to severe OSA compared to blacks at 20%, and the white population at 17%. But, it was identified that Chinese individuals are at greater risk with a prevalence of 39% with hispanics at 38% compared to blacks at 32% and whites at 30%. It is acknowledged the differences in craniofacial anatomy and body fat distribution may play a key role in the differences of prevalence. With the facial anatomy having a genetic predisposition to OSA/Hypopnea being one-half the narrative, comes the other half of the OSA/Hypopnea narrative.

Lifestyle choices can also play a role in picking up OSA/Hypopnea. A substantial number of literature exists to demonstrate the relationship between obesity and OSA/Hypopnea being evident like the study done on the reversal of obesity-induced OSA (Devon A et al., 2017). Cardiovascular disease is a very common comorbidity in patients with OSA/hypopnea (Jordan et al., 2021). It is well-demonstrated that adult OSA has been throughly researched, but the focus on children has only increased as of late. Pediatric patients are still developing physically and so it is intuitive they are at a high risk of OSA/Hypopnea. Obesity is a risk factor in the pediatric population because their physical development is not complete. To elaborate, the fat distribution to the abdomen and thorax complicates the breathing process (Giampiero et al., 2019). The risk for OSA among pediatric patients with obesity is as high as 60% (Rasintra et al., 2020) The data for the pediatric population remains limited at this time and further investigation is warranted. Nonetheless, properly diagnosing a patient with the disorder is done through extensive testing.

Diagnostic criteria for OSA/Hypopnea

Patients are screened before undergoing further testing through identifying their sleep history, present symptoms, and two questionnaires; the Epworth Sleepiness scale and STOP-Bang questionnaire (Paulo-Henrique et al., 2022). The Epworth Sleepiness scale consists of 8 scenarios that the patient must score 0 (never) to 3 (high) in regards to their sleepiness, and if the score exceeds 10 then the patient is in a constant state of sleepiness (Rundo, 2019). The STOP-Bang scale also consists of eight items that require either a yes or no answer, and a score of equal to or greater than 3 indicates a mild to severe case of OSA/hypopnea (Babak et al., 2018). In addition to the questionnaires is a sleep study for a more definitive diagnosis. The questionnaires are used before undergoing physical testing to confirm an OSA/Hypopnea diagnosis.

The classic method of diagnosing a patient with OSA/hypopnea, according to Hong-Po et al., is through a sleep study (2020). Determining whether the patient has it and how severe the case is determined through a polysomnograph (PSG), gold-standard test, via measuring the cardio-respiratory activity. An electroencephalograph (EEG) that measures neurologic activity is used alongside a PSG. If the sensors responsible for changes in respiration illustrate either a complete cessation or a partial cessation of 10 seconds the apnea-hypopnea index (AHI) is utilized to calculate the number of cessations per hour divided by the hours of sleep obtained. Approximately 5 to 15 events per hour is considered a mild case, whereas 15 to 30 events per hour is a severe case of OSA/hypopnea. An invasive method of diagnosis is a drug-induced sleep endoscopy (DISE) where the upper airway tract is examined via an endoscope. This method allows for a better approach to treating the cause of OSA/hypopnea. Diagnosing the disorder is important, but the etiology must be identified for the best treatment approach.

Pathophysiology of OSA/Hypopnea

OSA/Hypopnea has structural and non-structural causes. Three ways the disorder manifests is through maximal inspiration generated by the diaphragm, abnormal upper airway development, and weaker pharyngeal dilation (Joseph et al., 2017). The facial elongation or compression, retrognathia, micrognathia, mandibular hypoplasia, an inferior placement of the hyoid bone, and a finding more common in children is adenotonsillar hypertrophy are key in OSA/Hypopnea (Wickramasinghe et al., 2020). Shorter craniofacial anatomy (mandible and maxilla) severely limits the upper airway area as well an enlarged tongue and soft palate would also reduce the space of the airway (Yamini et al., 2017). The relationship between the maxilla and the upper airway anatomy and the severity of OSA/Hypopnea was evident when performing a DISE (Eric et al., 2021). The role craniofacial anatomical abnormalities play in developing OSA/Hypopnea is significant that understanding it better is required.

According to Wickramasinghe et al., the craniofacial anatomical abnormalities results in a decreased cross-sectional area of the upper airway creating an instability in the pressure of the pharynx an upper airway collapse, is due to a difference between the pressure of the upper airway tract and the pressure of the surrounding tissue. The relationship between the anatomical differences and neuromuscular function in sleep is that when sleeping in a supine position, for instance, a reduction in ventilator motor output to the upper airway muscles is the cause of an obstruction in the patient's breathing. The pressure of the surrounding upper airway muscles can be better understood through the Bernoulli effect; as airflow velocity increases pressure on the surrounding wall decreases and in

the scenario the pressure is attained the result is a collapse of the airway. The literature covering pathophysiology of OSA/Hypopnea warrants more research to better understand it. Moving forward from identifying and understanding the causes of OSA/Hypopnea requires treatment to mitigate the severity.

Treatment of OSA/Hypopnea with Orthodontic devices

There are two primary orthodontic devices warranting further analysis; mandibular advancement device (MAD) and a tongue-retaining device (TRD). According to Hao and Yow, the mechanism of a MAD is to shift the mandible and tongue forward so a reduction in the constriction of the upper airway takes place (2019). On the other hand, a TRD holds the tongue in a forward position via suction and salivary adhesion to open up the airway and prevent obstruction. But, approximately 90% of users prefer using a MAD over a TRD because of the ease of its use and compliance. The use of a cone-beam computed tomography and an MRI in showed the MAD to significantly bring forward the mandible as well the tongue muscles anteroposteriorly. This translates into an increase of the cross-sectional area of the upper airway from the posterior palate by expanding the lateral walls and pushing away the adipose tissue within the pharynx. Despite a heavy preference for the MAD the TRD demonstrated a significant increase in the cross-sectional area of the upper airway by shifting the genioglossus muscle more forward causing an expansion of the upper airway. It should be noted that an electromyography was utilized to demonstrate the efficacy of the MAD; masseter, lateral pterygoid, genioglossus, and geniohyoid muscles were activated allowing the observation of an increase in neuromuscular communication, which in return ensured the upper airway remained expanded and unobstructed. The mandibular advancement device proves to be as useful in alleviating acute symptoms and is far more preferred over the tongue retaining device despite being more efficacious. It does stand as a good solution in alleviating the etiologies of OSA/hypopnea, whether it is modifiable or unmodifiable despite not fixing the anatomical cause of OSA/hypopnea.

The effects of oral appliances is still not as efficacious as the use of a CPAP machine. The use of a CPAP machine is significantly more efficacious in correcting the breathing patterns of a sleeping patient as opposed to the use of a MAD or TRD. Continuing with the same data from Hao and Yow, it is shown that using a CPAP machine compared to a MAD reduced the number of events experienced by approximately 8 per hour (2019). MADs have demonstrated efficacy in improving arterial oxygen saturation although the CPAP machine has a slight edge, but when it came to reducing cardiovascular effects both MADs and CPAP share no difference in efficacy, more particularly the mean arterial blood pressure reduced approximately 2 mm Hg. But, in a prospective cohort study made up of over 20 participants the data showed a long-term improvement with the use of MADs in reducing the risk of a cardiovascular event in patients with severe OSA/hypopnea. CPAP does share the same result as MADs when reducing the risk of a fatal cardiovascular event, but further studies are needed to further validate the findings. The use of MADs is recommended for patients with a mild case of OSA/Hypopnea rather than a severe case. If the patient is not able to comply with either CPAP or an orthodontic device it may be due to an anatomical abnormality, which calls for surgical intervention.

Comparison of CPAP and Oral & Maxillofacial surgery

Continuous positive airway pressure (CPAP) is a device that functions with a mask that is placed over the mouth that enables inspiration and expiration while asleep. There is a flow sensor that detects the user's breathing behavior and continually delivers inspiratory and expiratory pressure during each breathing cycle (Selim, Bernardo, and Ramar, 2021). CPAP would best suit individuals that suffer from neurologic disease such as a stroke or Alzheimer's to mention a few granted some of the conditions are progressive (Janna R., et al., 2021). For obese patients, the adipose tissue around the neck and waist as well the abdomen and thorax places stress on the airway as well the diaphragm, therefore qualifying for CPAP due to an upper airway collapse (Anna et al., 2021). This particular treatment is a very common route of pursuit because of its efficacy being considerably high.

The efficacy of CPAP on a patient's metabolic profile was studied through a comparison to Mandibular advancement device (MAD) using patients with mild OSA of both genders ranging in age from 18 to 65 with a BMI of less than 35 that were broken up into 3 randomized groups; CPAP, MAD, and control. The results showed that CPAP had the greatest influence in reducing a patient's cholesterol level (LDL) over a 1 year period (Luciana Oliveira et al., 2021). The same exact set up was made for a comparison of CPAP to MAD in

its effect on blood pressure and endothelial function over a 1 year period. The results showed that there was not an improvement in either randomized controlled group in comparison to the control group after active observation over 12 months (Thais Moura et al., 2021). In another randomized trial for over 80 participants data was collected for 54 days to investigate the efficacy of CPAP and MAD in treating cardiovascular disease. However, it did not demonstrate significant enough of an effect thus showing that the treatment modalities mentioned are more effective in minimizing the symptoms caused by OSA/hypopnea, but not the associated comorbidities (Julia A M et al., 2022). Limited data persists when demonstrating the efficacy of said treatment modalities for the pediatric population. However, from the findings above it can be inferred that CPAP has demonstrable evidence of why it is touted the gold standard of treatment in sleep medicine. It does improve considerably, the quality of life of a user but to a limited extent health-wise. It needs to be taken into consideration CPAP is limited to being effective in treating patients with obesity and persons affected with different neurologic conditions ranging from ALS to Alzheimer's to experiencing a stroke and so on. Additionally, patients with CPAP with modifiable, reversible factors are generally expected to use CPAP as a short-term solution to alleviate the acute symptoms, such as excessive daytime sleepiness affecting cognitive function, while resolving the crux of OSA/hypopnea. However, for those unable to use CPAP surgical intervention is another option if the factors causing OSA/Hypopnea are unmodified.

Treating OSA/hypopnea surgically is another option that can be considered in patients with unmodified factors such as craniofacial anatomical differences leading to an obstruction of the upper airway. Orthognathic surgery with maxillomandibular advancement (MMA) is a surgical procedure performed by realigning the maxillary and mandibular bones as well the corresponding muscles to prevent airway obstruction (Christiane Cavalcante et al., 2017). The AHI shows a reduction rate of over 90% for primary MMA with an extra pharyngeal procedure and over 85% for primary MMA (Hyung Joon and Choi, 2021). This is due to a successful surgical reversal of the unmodified factors causing OSA/Hypopnea. It is demonstrated through numerous literature CPAP is the gold-standard treatment option for OSA/Hypopnea. But, as previously stated that the biggest limitation CPAP faces is the compliance factor. It is shown that well over 20% of CPAP users are unable to comply with CPAP for a number of reasons (Saif et al., 2021). But, the number of patients that are noncompliant in the long-term surpasses 50% (Maria et al., 2019). With CPAP being more efficacious than the use of orthodontic devices it is still a very limited treatment option in the long-term regarding its efficacy. For the pediatric population dealing with cleft lip/palate the AHI showed a favorable improvement following surgical intervention (Sahand et al., 2020). The reality of OMFS surgery is the complete reversal of OSA/Hypopnea is a preventative measure that allows associated comorbidities to not take shape.

Conclusion

A number of existing treatment options exist to minimize the severity of OSA/Hypopnea and even cure it altogether. Numerous are briefly introduced in this section, but a few will be discussed in more detail in later sections. CPAP (continuous positive airway pressure), improving one's lifestyle choices and participating in weight loss, and positional therapy where the patient avoids sleeping in a supine position all are immediate solutions to minimizing the degree of severity of OSA/Hypopnea (Francesco et al., 2022). The aforementioned treatment modalities are more ideal for patients with modifiable factors granted their anatomical structure and neuromuscular physiology is intact and can be remediated with a reversal of the OSA triggers. On the other hand, for unmodifiable factors require more advanced treatment. For children, it has been noted an adenotonsillectomy is more effective in children than it would be in adults, followed by observation over a period of 6 months. But, for mild cases following an AT, intranasal corticosteroids is the recommended route and on the other hand for severe cases, in addition to weight loss/management a tracheostomy would suffice if positive airway pressure (PAP) therapy did not work (Bitners, Anna C, and Raanan Arens, 2020). Another treatment that is somewhat novel is hypoglossal nerve stimulation. The mechanism of this treatment is to send electrical impulses to the hypoglossal nerve while the patient is asleep and breathing with the goal of keeping the tongue from obstructing the upper airway (Ladan et al., 2021). Repositioning of either the maxillary or mandibular jaw through orthodontic or oral & maxillofacial surgical treatment are also highlighted in improving previously unmodifiable etiologies of OSA/hypopnea (Joseph et al., 2017). Adult OSA/hypopnea is far more prevalent and receives a lot more attention in identifying sound treatment options while the pediatric population is quite limited in management of the condition, but warrants further investigation because early prevention is key to preventing further health complications from arising later on in life.

Numerous research literature highlight CPAP, orthodontic treatment, and oral & maxillofacial surgical treatment as the gold standard of improving OSA/hypopnea among both the adult and pediatric populations. Hypoglossal nerve stimulation appears somewhat of a novel treatment comparatively speaking that is showing a lot of promise and warrants further investigation (Peter M et al., 2020). It would make sense for patients with modifiable factors causing OSA/hypopnea to pursue lifestyle changes and weight loss/management to attempt and alleviate the degree of OSA/hypopnea present. Especially, in male obesity where the fat distribution may likely appear within the abdominal and thoracic region where sleeping in a supine position would increase the likelihood of experiencing OSA/hypopnea (Rundo, 2019). Furthermore, it needs to be taken into consideration that some of the aforementioned treatments may only be a temporary fix. Take for example, a male suffering from OSA/hypopnea, at first glance, due to obesity and needs to manage their weight and does so, but craniofacial anatomical abnormalities surface. Obstructive sleep apnea is a significant issue that remains highly prevalent despite it being actively researched. There is promise moving forward in the field of sleep medicine when identifying new novel therapies to improve the overall quality of life for persons with OSA/Hypopnea.

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