ACTA SCIENTIFIC DENTAL SCIENCES

Volume 9 Issue 4 April 2025

Review Article

Obstructive Sleep Apnea-A Review

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DOI: 10.31080/ASDS.2025.09.1998

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Received: February 24, 2025

Published: March 05, 2025

Abstract

Obstructive sleep apnea has a high prevalence, amongst the adult world population especially in the middle and old aged individuals. It has become a major public health concern because it makes the society morbid and affects the working potential of the adults. It has attracted the attention of the research workers and identified the associate risk factors that spans from snoring to obesity. The treatment involves life style modifications, wearing of oral appliances, surgeries and in select cases pharmacologic agents. Early detection of the disease avoids complications mainly related to obesity, diabetes and cardiac problems.

Keywords: Sleep Apnea; Obstructive Sleep Apnea; Sleep Apnea Syndrome; Lifestyle Changes; Obesity; Snoring; Polysomnography; Day Time Sleepiness; Burden of Disease

Introduction

The current world-wide statistics has estimated that one billion people suffer from Obstructive Sleep Apnea (OSA); this will come up to one seventh of the adult population. Individuals who suffer from OSA are mainly spread into China, USA, Brazil and India. OSA affects one seventh of the adult population viz. of 30-69 years. 104 million Indians of the working age suffer from moderate to severe form of OSA. Obesity, excessive day time sleepiness and cognitive impairment associated with OSA are considered as major risk factors and creates public health problems. The working individuals are mainly affected by morbidity -diabetes and cardiac problems. The life style of a large section of the society is going to increase the prevalence of OSA. OSA is a major economic burden to many of the countries of the world [1,2].

History

Periodic breathing obstructions during sleep were reported during the 1850s and in 1870s British physicians have reported many cases, which they thought was caused by contractions of inspiratory and expiratory muscles against glottis. Cyanosis during sleep that accompanied the respiratory obstruction was also observed by the physicians. Charles Dickens has portrayed a character 'Fat Boy Joe' in his famous book 'Pickwick Papers'. Obese persons with daytime sleepiness were branded as having 'Pickwickian Syndrome'. Obesity, breathing difficulties and daytime sleepiness were linked during mid 1950s and it was described as 'CO_2 poisoning'. In 1960s, a comprehensive link between obesity, sleep induced airway obstruction, sleep fragmentation and sleepiness at day time

was obtained. In the 1970s and 1980s many research works were conducted on physiology using animal models. In the 1990s, sleep apnea related population studies were conducted and the prevalence, causes and consequences were recorded. Many commercial ventures started because of the newly found interest in OSA and sleep clinics got popularized [3].

Signs and symptoms of OSA

OSA is characterised by the following signs and symptoms:

- Loud snoring is a classic symptom of OSA that would wake up others who are sleeping in the room.
- Snoring is interrupted by quiet periods known as apnea episodes.
- After apnea, the individual wakes up by choking and they would gasp for breath (frequent arousal).
- OSA patients would suffer from Hypersomnolence – a condition that would induce sleepiness during day time even if the individual had adequate sleep during the night.
- Morning head ache and nausea possibly due to nocturnal carbon di oxide retention.
- OSA patients will experience intellectual deterioration, trouble in remembering things, temperamental behaviour, mood changes, anxiety and depression.
- Deterioration in performing the job might lead to accidents.
- Dry mouth, sore throat and frequent urination may also be experienced by OSA patients.

It is interesting to note that some individuals may not have any symptoms. Some individuals may suffer from apnea but they are not aware of it [4].

Pathophysiology of OSA

Human upper airway consists of nose, nasal cavity, pharynx and larynx. It serves multiple functions like speech, swallowing and passage of air for breathing. The upper airway is composed of numerous muscles and soft tissues and has no bony support. Upper airway can change its shape and can collapse for a moment during swallowing and speech when an individual is awake and when it collapses during sleep it can cause apnea. If the upper airway is anatomically narrow, the chances of collapse leading to OSA is more.

When an individual lies down, during inspiration a suctional force is generated. Along with this the gravitational forces will also act on the tongue and the mandible and the airway gets collapsed. Generally, the collapse is resisted by the muscle tone of the airway and the genioglossus muscle. During sleep, the muscle tone decreases and the tongue and soft palate are sucked towards the posterior pharyngeal wall, eventually causing obstruction of air passage. Investigators have observed through EMG that genioglossus muscle exhibit low activity during sleep [5,6].

Obesity has a strong association with OSA. In obese people, the airway is obstructed due to accumulation of fat in the peri-oropharyngeal tissues. In men neck circumference more than 17 inches and in women more than 16 inches are considered as a risk factor for OSA [7].

Pathophysiologic changes that happen in OSA are hypercapnia (increased CO_2), hypoxemia (decreased O_2) and pulmonary and systemic hypertension. Hypoxemia causes an increase in the motor activity of the pharyngeal muscles and the airway gets dilated. Individuals get awakened and resumes ventilation. Patients do not remember the episodes of apneas and arousals and it can occur in every 90 seconds. Cardiac problems get precipitated at a future date. Body mass index if it increases, there is every possibility of having OSA [8] (Figure 1).

Diagnosis of OSA

American academy of sleep medicine and US preventive services recommend the following criteria for diagnosing OSA and they are categorised under three groups: A, B and C.

A Presence of one or more of the following

- Patient reports sleepiness (during day time), non restorative sleep (after sleep body and mind are not adequately restored or not feeling refreshed), fatigue and insomnia symptoms (difficulty to fall asleep, frequent waking up and feeling sleepy during day time).
- Patient wakes up from sleep holding the breath, gasps or chokes.
- Bed partner or others report habitual snoring, interruptions in breathing during sleep.
- Diagnosed hypertension, type-2 diabetes mellitus, cognitive disfunction, mood disorders, stroke or congestive cardiac failure in these patients.

B. Polysomnography or home sleep apnea testing shows, five or more obstructive respiratory events per hour.

C. Polysomnography or home sleep apnea testing shows, fifteen or more obstructive respiratory events per hour [9] (Figure 2).

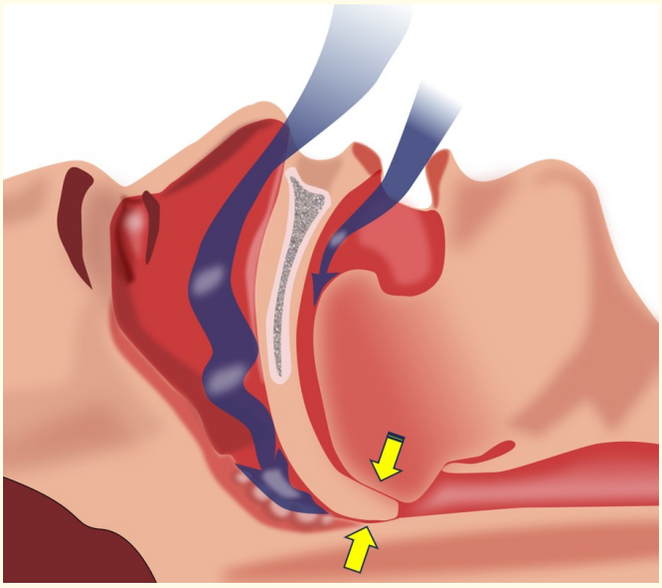

Figure 1: Upper airway obstruction by soft palate and tongue.

Figure 2: Polysomnography - schematic diagram.

Severity of OSA

Severity of OSA is determined by the Apnea-Hypopnea index (AHI) which is calculated by the number of occurrences of apnea (stoppage of breathing completely) and hypopnea (breathing decreases significantly) episodes per hour.

- **Mild OSA:** AHI ≥ five episodes per hour
- **Moderate OSA:** AHI ≥ fifteen episodes per hour
- **Severe OSA:** AHI ≥ thirty episodes per hour

Diagnostic tools

Epworth sleepiness scale (ESS): ESS is a questionnaire that can measure sleepiness of an individual during day time. This self-administered questionnaire consists of eight questions. The questions are related to eight situations when day time sleeping can happen viz. 1. sitting and reading 2. watching television 3. sitting inactive in a public place 4.sitting for an hour as a passenger in a car 5.lying down in the afternoon to rest 6.sitting and talking to another person 7.sitting quietly after lunch 8.sitting in a car, stopped for a few minutes due to traffic.

Respondents are asked to rate on a four-point scale (0-3).

- No chance of dozing (0 point)
- Slight chance of dozing (1 point)
- Moderate chance of dozing (2 points)
- High chance of dozing (3points)

The total score can range from 0 to 24. The interpretation is as follows

- 0-5 lower normal day time sleepiness
- 6-10 higher normal day time sleepiness
- 11-12 mild excessive day time sleepiness
- 13-15 moderate excessive day time sleepiness
- 16-24 severe excessive day time sleepiness

Beyond 11, the individual has to change the sleeping habits during night and seek help from concerned health professionals. ESS helps to distinguish between normal snorers and who suffer from OSA [10].

- **Pulse oximetry**: Pulse oximeter is a non-invasive electronic device that estimates blood oxygen level or oxygen saturation. This instrument is usually attached to the index finger. In OSA, pulse oximeter monitors the oxygen saturation during sleep. In the household, Oximeter is attached to the index finger when the patient is in a sitting position with hand below the heart level. This is the simplest testing device.
- **Polysomnography**: This is considered as the gold standard of OSA diagnosis. This collects data from seven or more channels viz. electro encephalogram, electro oculogram, electro myogram, electro cardiogram and respiratory channels. Polysomnography measures airflow in and out of the lungs, blood oxygen level, body position, brain waves, breathing effort and rate, electrical activity of muscles, eye movement and heart rate. Polysomnography can be done in a sleep centre or in the house of the patient [11] (Figure 2).

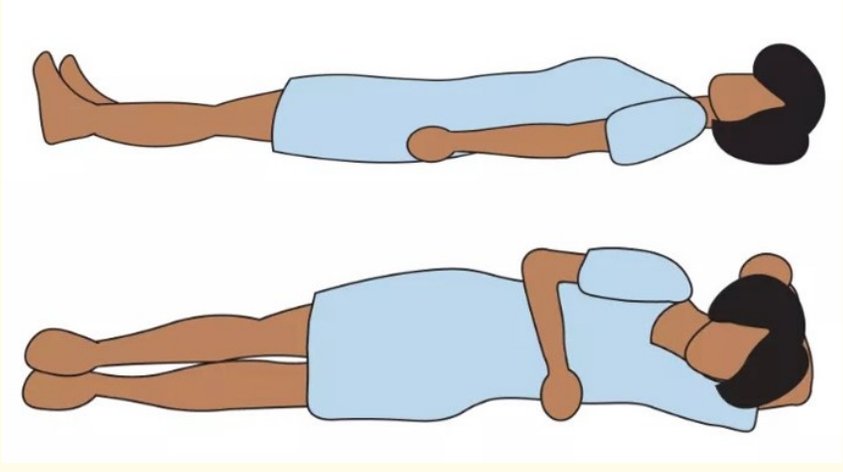

Figure 3: Supine and decubitus sleep position.

Additional investigations

Once OSA is confirmed, thorough blood investigation should be done to find out the presence of secondary polycythaemia. Individuals with OSA may develop an elevated RBC count due to the episodes of low oxygen levels which may trigger production of RBC in an attempt to compensate hypoxia. Thyroid function test is also done to rule out possibilities of hypothyroidism. Examination of the nose, pharynx and larynx should be carried out by an ENT specialist to find out anatomic abnormalities that can cause respiratory obstruction. Retrognathic mandible, micrognathia and partial resections of mandible can cause OSA in many patients.

Treatment of OSA

Control of body weight

Calculating the body mass index (BMI) serves as a predictor of OSA. Considerable loss of body weight can result in the reduction of apneic episodes in obese people who suffer from OSA. Studies have suggested that 26% reduction in AHI can be obtained by 10% loss of body weight [12].

Conventional weight loss programmes are time consuming and very often these individuals regain their weight after some time. Bariatric surgery has been associated with improvement in OSA with positive results ranging from 45% to 86%. Patient cannot be given assurance that gastric banding will definitely control OSA. Patients who have undergone bariatric surgery had less dependence on CPAP [13-16].

Sleep position

Individuals who sleep in the supine position showed higher apneic index when compared to those who sleep on the decubitus (side) position. Sleeping on one's back causes more apneic episodes because of the restriction in the airway. In the supine position, gravity and the reduced tone of the genioglossus muscle cause obstruction to the airway. In mild to moderate OSA, adopting a side sleeping position can be a primary treatment strategy. Individuals who cannot sleep on their side can use positional therapy pillows, belts, warning devices or soft balls stitched to the back of the dress. In non-obese people, marked improvements in OSA is observed when sleeping position is changed to the side; this type of OSA is known as 'positional OSA'. Sleeping on the left side has benefits for digestion, avoids heart burn, improves brain health and improves blood circulation. An interesting association of OSA with bruxism has been observed by investigators. Morning headaches reported in the OSA patients might be due to the clenching and bruxism [17,18] (Figure 3).

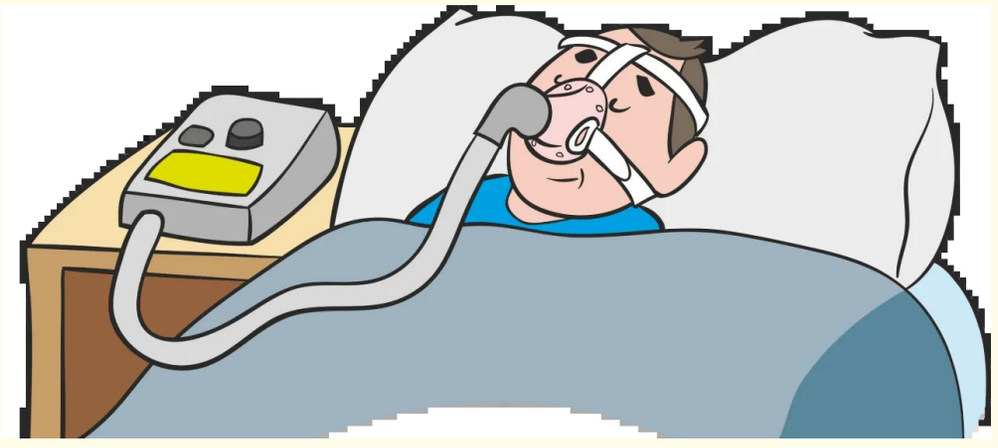

Figure 4: CPAP in use - shematic diagram.

Control of alcohol consumption

In individuals who are habituated with alcohol consumption, the prevalence of OSA was comparatively higher (25%) and duration of apnea was longer. The nadir oxygen saturation (lowest level of recorded SpO2) was also low in them. Alcohol may have an adverse effect on the dilator muscles of the airway and can cause depression on genioglossus muscle and the hypoglossal nerve. Alcohol consumption may not initiate snoring but in individuals with sleep apnea, snoring will definitely get aggravated [19-21].

Exercise

A direct link between improvement in sleep apnea and exercise cannot be established through definite evidences. However, when exercise is advised in individuals with diabetes and obesity, AHI was observed to be decreasing. Weight change may not happen with exercise but AHI decreased. It is better to follow an exercise regimen and it may have and overall beneficial effect on the health profile and thereby on the reduction of OSA [22,23].

Continuous positive airway pressure (CPAP)

CPAP is considered as a first line therapy for moderate and severe OSA. It is also advised in mild OSA cases if they prove to have comorbidities or cardiovascular risk factors. CPAP machine takes in air from the room atmosphere, filters it and pressurises it before delivering it through a mask which is worn by the patient over the nose or mouth during sleep. The machine consists of a motor that delivers positive air pressure and is connected to mask through a tubing. The airflow acts like a pneumatic splint and prevents the airway from collapsing by avoiding tongue and soft palate from shifting back to the pharyngeal wall. The mask and the tubing restrict patient movement during sleep. Some of the patients complain about suffocation caused by the mask. Obstruction in the tubing and interrupted power supply can fail the functioning of CPAP [13,24]. (Figure 4).

Figure 5: Mandibular advancement appliance.

CPAP improves the quality of life related to sleep by reducing the AHI during sleep and daytime sleepiness. Effectiveness of CPAP in controlling blood pressure, cardiovascular risks and blood sugar levels but needs more concrete evidence. Mild, transient improvement in the frontal lobe cognitive functions like reasoning, problem solving, creativity and emotional regulation has been noticed by some workers, but it is evident markedly in severe OSA. Ideally the CPAP usage is indicated for the entire sleep period, but medical insurance companies have suggested a regulatory norm of at least 4 hours during 70% of nights. CPAP and body weight control has received controversial responses [25-27].

Improvements in CPAP has been made in the recent times like quietly operating machines, comfortable masks, sleep data monitoring and transmitting the data to the doctor. Micro CPAP machines which can be secured to the nostrils have been designed but pending the approval. Tiny fans are attached to the instrument and which can create stream of pressurised air. The instruments work under the principle of Nasal expiratory airway pressure (EPAP). While CPAP provides pressure both in inspiration and expiration, EPAP provides back pressure only during expiration [28].

Drug therapy in OSA

Treatment of OSA with pharmacologic agents is not popularly recommended. However, the following medications have been tried like nasal decongestants, CNS stimulants, antidepressants, carbonic anhydrase inhibitors and potassium channel blockers. Fluoxetine an antidepressant is found to reduce the apnea-hypopnea events. Response to the drug is variable in different individuals. Carbonic anhydrase inhibitors like Azetazoleamide and Zonisamide have reduced AHI by 42%. These drugs can improve sleep efficiency and oxygen saturation. These are usually combined with CPAP. Drug therapy should be undertaken with great care [29,30].

Oral appliances (Figure 4)

Oral appliances belong to three different categories viz. Soft Palate Lifter (SPL), Tongue Retaining Device (TRD) and Mandibular Advancement Appliance (MAA). Soft palate lifters are no longer in use. Tongue restrainers are used only when MAA cannot be used for dental reasons. MAA is the most popular appliance in use today. MAA can keep the mandible in a protruded position and are worn during sleep. MAA prevents or minimises the airway collapse.

Snoring is the hoarse or harsh sound that occurs when air flows past relaxed tissues in the throat, causing the tissues to vibrate during breathing. Vibration happens due to the partial blockage of the airway. While sleeping on the back, the tongue drops back into the pharynx. Soft palate, elongated uvula and overgrown tissues of the throat can also narrow down the air passage. Upper airway obstruction can occur between nasopharynx and the larynx. Usually, it happens behind the base of the tongue (retroglossal) and the behind the soft palate (retro palatal).

Determination of the required mandibular protrusion to ensure adequate airway is not easily done without the support of advanced technology. A trial and error method of advancing the mandibular positioning by noticing the tolerance limit of the patient and later adjusting it in protrusion and the occlusal distance is commonly practised. On comparing the efficiency, CPAP is more efficient than oral appliances. However, patients prefer the oral appliances because of the simplicity in design and ease of wearing.

When mandible is advanced, tongue also is brought anteriorly along with it because of the muscular attachments. As a consequence, the airway is opened up and the obstruction to ventilation is reduced. Vertical opening should be made optimum, to the minimum possible distance. When the opening is increased, the mandible gets rotated and the results may be counterproductive [31,32].

Monobloc MAA

Casts are made and related using orthodontic bite fork. It is first engaged with the maxillary teeth and the mandible is advanced to either 5mm or 10mm. The bite fork has a provision to engage the maxillary incisors and the mandibular anterior teeth. This relation is registered with bite registration paste. The casts are then mounted in a plaster less articulator. Splints are made on both the jaws using thermo- softening poly vinyl acetate polythene. Undercuts are blocked and the extension is limited to cover 2mm of the gingival tissue. The upper and the lower splints are then united in the articulator with a glue gun. Anterior airway is kept patent. The appliance should be worn in the night after brushing and cleaning of the teeth. The appliance should be disinfected daily and washing the MAA with hot water should be avoided. Patient should be reviewed after eight weeks using ESS and API scores [33].

Surgical treatment for OSA

When conventional treatments like life style changes and CPAP do not give adequate relief, surgical options are planned. Four different surgical methods are presently followed: 1. uvulo-palato-pharyngoplasty, 2. tongue reduction, 3. hypoglossal nerve stimulation and 4. maxillo-mandibular advancement.

Uvulo-palato-pharyngoplasty

This surgical procedure was considered as the lone surgical option to treat OSA during 1980s. It was mainly indicated in patients with excessive sleepiness during day time and associated snoring. Surgical removal of soft palate gave 33% reduction in AHI and when laser assisted uvuloplasty was done, the reduction of AHI was only 18%. Velopharyngeal insufficiency and nasal regurgitation can occur as postsurgical complications. In the recent times it is not performed.

Reduction of tongue

When macroglossia is noticed in cases of OSA, tongue reduction was attempted. Surgeons employ different methods but radio frequency ablation to create channelling within the tongue provided 34% of AHI. Post surgical bleeding and oedema are possible complications and as a sequel airway obstruction can also happen.

Hypoglossal nerve stimulation

Hypoglossal nerve stimulation is the most recent surgical treatment for OSA. A pulse generator is implanted below the skin in the chest. It has a stimulation lead and a respiratory sensor lead. The device stimulates the hypoglossal nerve that supplies the genioglossus and geniohyoid muscles, resulting in the protrusion of the tongue. The muscle activity happens when the device senses the respiration. AHI value reduces by 68%. Weakness of the tongue, hematoma and infection may be the possible complications that can occur [13,34-36]. (Figure 6).

Maxillomandibular advancement

Maxillomandibular advancement (MMA) is also known as double jaw surgery or bimaxillary advancement surgery. It is a combination of LeFort 1 osteotomy (maxilla) and a bilateral sagittal split of mandibular ramii. MMA is done in adult patients who cannot tolerate CPAP. The surgery opens up the obstructions of the airway that happen behind the soft palate and the tongue, during sleep at night. 87% reduction in AHI happens because of the surgery and the effects are long lasting. Change in appearance and dental and facial numbness are possible post operative complications. Though the results are better, the acceptability amongst patients is far less than that of uvulo-palato-pharyngoplasty [37].

Role of dentists in OSA

OSA is a multifactorial disorder, the treatment of which requires a comprehensive multidisciplinary approach. In the management of OSA, oral appliance therapy has a significant role and hence the dentist has to play an important part. OSA care team responsible for OSA assessment and management consists of physicians, den-

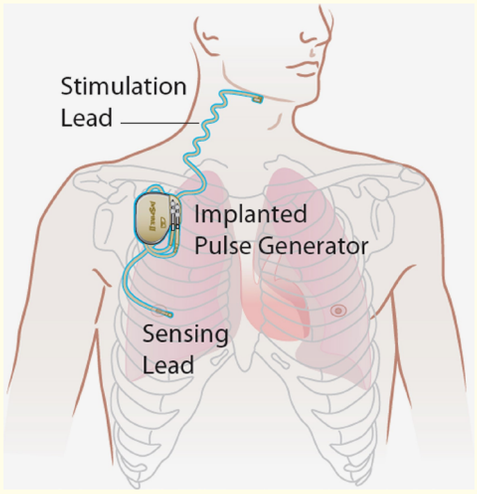

Figure 6: Hypoglossal nerve stimulation.

tists and allied health professionals. The physician team includes ENT specialist, pulmonologist, neurologist, cardiologists, psychiatrist, paediatrician and primary care physician. The dentists team consists of orofacial pain specialist, orthodontist, maxillofacial surgeon, prosthodontist, pedodontist and general dentist. Services of allied health professionals are also included: viz. Respiratory therapist, sleep lab technologist, psychologist and nurse.

Dentists can do screening and assessment of OSA patients; to be specific in identifying the risk factors like enlarged tongue and tonsils, retrognathism, narrow and high arched palate, long soft palate, enlarged uvula, inferiorly positioned hyoid bone and nasal abnormalities. Assessment using Epworth sleepiness scale (EPSS), referral to the sleep physician and arranging interdisciplinary planning are also done by the dentist. Planning and executing oral appliance therapy (OAT) independently or in combination with CPAP is planned by the dentist along with the assessment of TMJ and dental health status to determine the fitness of the patient to receive OAT. In extreme cases, planning of maxillary expansion, maxillary protraction and maxillomandibular advancement are also planned with the assistance of the concerned specialists are also included in the function of the dentist working in the team. It is crucial to entrust the diagnosis and management of OSA to a multidisciplinary team to achieve successful treatment outcome. Dentists should receive appropriate training before getting included in the OSA management team [38,39].

Discussion

Snoring, repetitive apneas, sleep fragmentation and excessive day time sleepiness indicate the presence of OSA. It has gained importance because of the association with road traffic accidents and cardiovascular morbidity which are crucial public health problems. Apnea is characterised by cessation of airflow (breathing) for ten seconds whereas hypopnea is reduction in airflow. The number of these two events per hour is used to calculate apnea/hypopnea index (AHI) which provides diagnostic evidence for OSA. AHI >5 is considered as the lower cut off value to diagnose OSA, along with morning sleepiness and oxygen desaturation (4%). During sleep the upper airway gets narrowed because of the loss of tone of the related muscles. This is overcome by the autonomic activation of the body and apnea gets terminated. The activation causes a neurophysiological arousal and the sleep gets disturbed. Confirmatory diagnosis is done by polysomnography which has a multichannel recording system and can measure snoring, nasal airflow, body position, oximetry, pulse rate and electroencephalography [40-42].

The first level of treatment of OSA is modifying the lifestyle. There is a close association of OSA with obesity, consumption of alcohol and sleeping in supine position. Corrections are possible in these situations and OSA gets controlled along with it. Evaluation of body weight, body mass index and AHI will serve as good monitoring systems. Patients should cooperate with dietary advices on a regular basis [43].

If life style modification does not work, possibly with poor compliance on the part of the patients, the next step is the usage of CPAP. Usage of CPAP brings in dramatic improvements in the symptoms and in the monitoring parameters like Epworth sleepiness score and AHI. The minimum required duration of usage is not specifically determined but a minimum of 4 hours usage in the night is the generally accepted norm [44].

Oral appliance therapy intended to advance the mandible and enlarge the upper airway is effective in mild to moderate OSA. But oral appliances are not recommended in severe OSA characterised by high sleepiness and nocturnal desaturation. In cases of intolerance to CPAP, oral appliance therapy is suggested. Oral appliances generally receive high compliance rate [45].

When CPAP and oral appliances fail, surgical treatments ranging from tonsillectomy to maxillomandibular advancement are indicated. Variable range of effectiveness are reported for the surgical procedures. However patient acceptance to undergo the surgical treatment is very less [46].

Conclusion

A considerable percentage of people in the working age group do suffer from OSA. Snoring obese individual with complaints of excessive day time sleepiness should suggest the presence of OSA. Seen more in men than in women. The prevalence of OSA shows an increasing trend.

The first level of treatment is to alter the lifestyle especially to control the body weight. Association of OSA with diabetes and hypertension should be closely monitored.

Treating OSA with drugs do not give strong positive evidence of getting good results.

Surgical treatments give positive results but patient acceptance is very low.

CPAP is presently the most widely accepted treatment. If the gadgets used for CPAP are miniaturised, its acceptance will be improved.

Hypoglossal nerve stimulation is a recently introduced treatment regimen.

Oral appliances meant to advance the mandibular position are considered as efficient next to CPAP. They are highly patient compliant.

Dentists have an important role to play in the OSA treatment team.

Author Contributions

Conceptualization-K. Chandrasekharan Nair, Viswanath Gurumurthy, Review of articles- Pradeep Dathan, Vishak, Janaki; Initial draft preparation: Pradeep Dathan, Viswanath Gurumurthy, Review and editing- K. Chandrasekharan Nair; Supervision– K. Chandrasekharan Nair.

All the authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors do not declare any conflict of interest.

Figure credits

Fig 1. https://en.wikipedia.org/wiki/Obstructive_sleep_apnea
Fig 2. https://sleep-disorders.net/polysomnography-sleep-study
Fig 3 https://www.thoughtco.com/anatomical-position-definitions-illustrations-4175376
Fig 4. https://www.oxigensalud.com/en/cpap-for-sleep-apnoea/ wikipedia
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