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Review Article

Obstructive sleep apnea - a review

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Abstract

Sleep related problems affect large group of people of all ages around world. One of the most common disorders is Obstructive Sleep Apnea (OSA) characterized by repetitive, complete or partial collapse of upper airway during sleep. Due to complexity of disease and associated medical conditions, a broad spectrum of clinicians play important roles in treatment of OSA. Evaluation of OSA is best performed using a multidisciplinary team approach.

This article aims to reviewthe exhaustive current literature for relevant information regarding terminology, pathophysiology, prevalenceand treatment including conservative and surgical.

Keywords : Obstructive sleep apnea, Epworth sleepiness scale, Continuous Positive Airway Pressure (CPAP) Therapy, Polysomnography, Osteotomy, Palatal implants

Introduction

Obstructive Sleep Apnea (OSA) was first reported in the medical literature in 1965, although William Osler recognized the stigmata in the early 1900s and named the trait “Pickwickian Syndrome” after a character in a Charles Dickens novel.(1) It is defined as a presence of five or more apneas/hypopneas per hour of sleep with daytime symptoms. It is a common sleep-related breathing disorder of major public health importance(2)

In adults, apnea is defined as cessation of airflow for greater than 10 seconds. Hypopnea is defined as 50% or greater decrease in airflow, often accompanied by hypoxemia or arousal. OSA is also characterized by cessation of respiration during sleep, secondary to obstruction of upper airway(3).

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OSA is characterized by recurrent episodes of partial or complete upper airway collapse at the end of expiratory phase during sleep. The collapse is due to reduction in or complete cessation of airflow despite ongoing inspiratory efforts. The events are caused by multiple factors like high intra-luminal pressure, obesity, decreased dilator and increased constrictor activity, low tracheal traction, etc (4).

Review of Literature

Prevalence

It is estimated that the prevalence of OSA in general is 1-6% (5). Community based studies has shown the male to female ratio for OSA is in the range of 2:1 or 3:1 (6). In an epidemiological study by Young et. al., it was estimated that 2% of adult women and 4% of adult men fulfilled diagnostic criteria of OSA i.e. apnea-hypopnea index (AHI) $\geqslant$5 and daytime hypersomnolence (7).

Differences in gender specific OSA prevalence is not uniformly the same across all ages. These differences were not observed in the pediatric and adolescent age groups. Difference in the middle age is attributed to sex hormones which play an important role in the natural history of OSA. (8)Menopause is a risk factor for sleep-disordered breathing while prevalence of OSA in elderly is similar in men and women (9). Finally the influence of other risk factors like alcohol consumption and smoking has been associated with higher prevalence of OSA in men (10).

However, the male predominance reported for OSA in epidemiological studies is more marked in the clinical setting, with estimates male/female ratio as high as 8-10:1 (11).

Pathophysiology

The upper airway is composed of bony structures and soft tissues and it can be divided into 4 sections – nasopharynx (from nasal turbinates to hard palate), velopharynx (from hard palate to tip of uvula), oropharynx (from tip of uvula to tip of epiglottis) and hypopharynx (from tip of epiglottis to level of vocal cords) (12). The most common site of upper airway collapse in OSA is velopharynx. The collapse usually extends to other sites; however, it can also begin at other locations within the upper airway (13).

Upper airway anatomy is an important consideration in understanding the pathophysiology of OSA given the relationship between its structure and function. (12)

Table 1 : Factors predisposing to collapse of the upper airway and the development of OSA

- Restriction in size of bony compartment
  - Mandibular hypoplasia
  - Maxillary hypoplasia
- Increase in soft tissue volume
  - Deposition of fat around upper airway (e.g., in obesity)
  - Macroglossia
  - Enlargement of soft palate -Thickening of lateral pharyngeal walls
  - Adenotonsillar enlargement
  - Pharyngeal inflammation and edema
- Increase in pharyngeal compliance
- Decrease in pharyngeal dilator muscle activity
  - Impairment of mechanoreceptor sensitivity
  - Impairment of upper airway neuromuscular reflexes
  - Impairment of strength & endurance of pharyngeal dilator muscles
- Decrease in lung volume
- Instability of ventilatory control » Increase in surface tension
  - Hormonal factors
  - Presence of testosterone (e.g., male gender or testosterone replacement)
  - Absence of progesterone (e.g., menopause)
- Endocrine disorders (eg, hypothyroidism or acromegaly)

Table 2 : Risk Factors

Unmodifiable	Potentially modifiable	Associated conditions (examples)
Increasing age	Obesity	Marfan's syndrome
Male gender	Neck or visceral fat distribution	Hypothyroidism
Ethnicity	Upper airway soft tissue abnormalities	Down's syndrome
Menopause	Craniofacial abnormalities	Acromegaly
Genetics	Alcohol consumption	

Symptoms and Signs

SYMPTOMS	SIGNS	SYMPTOMS	SIGNS
Snoring	Obesity	Morning headaches	Tonsillar hypertrophy
Witnessed Apneas	Increased neck circumference	Impaired concentration	Macroglossia
Excessive daytime sleepiness	Increased waist circumference	Impaired memory	Oropharyngeal narrowing
Nocturnal choking	Retrognathia	Nocturia	Soft palate edema and erythema
Unrefreshed sleep	Maxillary constriction	Impotence	Nasal obstruction
Poor sleep quality	Increased overjet	Anxiety and depression	Hypertension
Insomnia	Increased overbite	Esophageal reflux	

Evaluaution and Diagnosis

Epworth Sleepiness Scale (ESS)

The ESS developed by Murray Johns at the Epworth Sleep Center, Richmond, Victoria, Australia is an excellent measure of the patient's general level of daytime sleepiness. Patients simply score their likelihood of falling asleep in 8 different situations. (14)

Name: _____ Date : _____

Your age (Yrs): _____ _____ Your Sex (Male=M, Female=F): _____

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently, try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation:

0 = would never doze
1 = slight chance of dozing
2 = moderate chance of dozing
3 = high chance of dozing

Situation	Chance of dozing (0-3)
Sitting and reading	_____
Watching TV	_____
Sitting inactive in a public place (e.g., a theatre or a meeting)	_____
As a passenger in a car for an hour without a break	_____
Lying down to rest in the afternoon when circumstances permit	_____
Sitting and talking to someone	_____
Sitting quietly after a lunch without alcohol	_____
In a car, while stopped for a few minutes in traffic	_____

Fig. 1 : Questionnaire for Epworth Sleepiness Scale (14).

ESS - A score of greater than 10 is consistent with excessive daytime sleepiness and a score of greater than 16 is indicative of a high level of daytime sleepiness (14).

There is evidence that a questionnaire based scale as simple and brief as ESS can give valid measurements of sleep propensity in adults. That it can distinguish patients who simply snore from those with even mild OSA is evidence for the sensitivity of the ESS. (15)

Apnea-Hypopnea Index (AHI)

The primary measure of sleep-disordered breathing is the AHI, which is the number of apneas and hypopneas per hour of sleep. OSA is classified as mild (AHI 5-15), moderate (AHI 15-30) severe (AHI $\geq$ 30) (16).

Polysomnography (PSG)

The nocturnal polysomnography has been the objective gold standard for modern diagnosis of OSA (17).

PSG evaluates sleep-disordered breathing, sleep architecture, and oxygen desaturation. A typical 8-hour nocturnal laboratory PSG involves measurement of physiologic parameters including electroencephalogram, electrooculography, chin movements and leg movements via electromyography. Electrocardiography, heart rate, respiratory effort, chest wall movement, abdominal wall movement, airflow, and oxygen saturations are also monitored. As these physiologic parameters are scored, a sleep technologist documents body position. The recordings and scoring data are interpreted by a physician to diagnose OSA (17).

Treatment Protocol

Conservative

Conservative approaches involving weight loss, smoking cessation and alcohol moderation are encouraged and useful in selected patients with OSA. Weight loss has shown to be beneficial in reducing the severity of OSA (18). Major weight loss such as may occur following bariatric surgery can result in resolution of OSA. Positional therapy (e.g. using a backpack that prevents the subject from sleeping in the supine position) is most beneficial when OSA predominantly occurs supine in position. However, studies suggest only a partial response to such therapy (19).

A large range of pharmacologic approaches to treating OSA have been explored over many years, but these have been shown to be minimally or not at all effective (20).

Non-Surgical

1. Continuous Positive Airway Pressure (CPAP) –

CPAP therapy for OSA was developed in the early 1980s and subsequently became the initial line of treatment for symptomatic OSA. It still continues to be used as a conservative therapy. (21)

Sleep induces collapse and reduces the diameter of the floppy-toned pharyngeal musculature, as a result of negative transmural pressure. CPAP counteracts this change by pneumatically splinting the upper airway via the application of a positive pressure across the airway walls. This prevents the narrowing (hypopnea) or complete collapse (apnea) of the breathing conduit during sleep. (22)

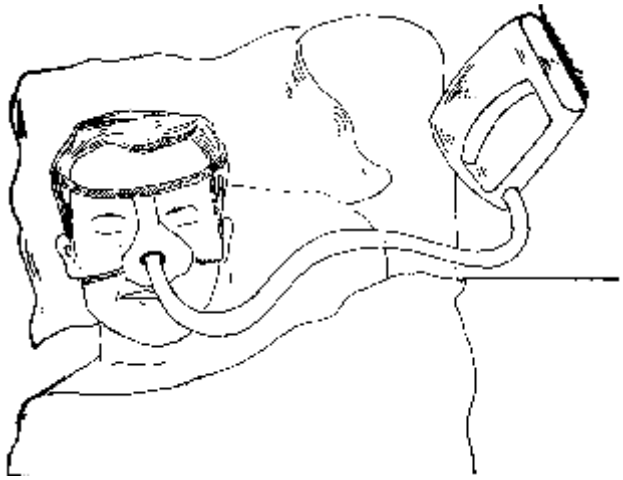

Fig. 2: A diagrammatic representation of a patient receiving CPAP therapy.

Table 3: Relative and absolute contraindications to the use of continuous positive airway pressure (CPAP) (23)

Clinical situation	Rationale for avoiding CPAP
Tracheo-oesophageal fistula	Ineffective because of loss of pressure to the gut
Upper airway abnormalities (cleft palate, choanal atresia)	Technically difficult/ impossible, often traumatic
Congenital diaphragmatic hernia	Leads to intestinal distension and clinical deterioration
Absent/poor respiratory effort	Ineffective carbon dioxide removal
Extreme prematurity	Lack of reliable evidence in the most preterm infants

1. Oral Appliances

Oral Appliance (OA) therapy for snoring, obstructive sleep apnea or for both is simple and cost-effective. It may be indicated in patients who are unable to tolerate CPAP or poor surgical risks.

Their efficacy is variable and act by a) increase in airway space by stabilizing the mandible in an anterior position, b) advancement of the tongue or soft palate and c) possibly a change in genioglossus muscle activity. The appliances should be used during sleep for life and must be comfortable for the patient (24).

Oral Appliances therapy falls into two main categories: those which hold the tongue forward (24) (Tongue retaining device - TRD) (12) and the ones which reposition the mandible forward (Mandible repositioning appliances - MRA) during sleep (24). MRA's are the most evaluated type of oral appliances (12).

Table 4: Food and Drug Administration (FDA) Approved Oral Appliances for the Treatment of Obstructive Sleep Apnea (25)

Appliances	Manufacturer
Adjustable PM Positioner	Jonathan Parker, DDS
Triation (EMA-T)	
Elastic Mandibular Advancement	Frantz Design, Inc.
Elastomeric Sleep Appliance	Village Park Orthodontics
Herbst	Orthodontics, SUNY at Buffalo
Equalizer Airway Device	Sleep Renewal Inc.
NAPA	Great Lakes Orthodontics Ltd.
Klearway	Great Lakes Orthodontics Ltd.
OSAP	Snorefree, Inc.
PM Positioner	Jonathan A Parker, DDS
Sleep-In Bone Screw System	.Influence Inc.
Silencer	Silent Knights Ventures, Inc
SNOAR Open Airway Appliance	Kent J Toone, DDS
Thornton Airway Appliance	W. Keith Thornton, DDS

Surgical

A. Non Invasive

1. Injection Snoreplasty -

Soft Palate sclerotherapy (Injection Snoreplasty) is a popular technique as a primary treatment of palatal snoring because of its comparative advantages over other anti-snoring procedures. It is very simple during a routine office visit, minimally painful, is highly effective and is very inexpensive. After topical anesthesia, midline soft palate is

injected submucosally with a small amount of sodium tetradecyl sulfate-a well described, safe sclerotherapy agent. Controlled fibrosis eliminates or significantly diminishes palatal flutter snoring (26).

2. Palatal Implants -

Relatively new procedure, the Pillar palatal implant system, consisting of a delivery system and an implant, is designed to reduce airway collapse and obstruction at the level of the soft palate by placement of 3 woven implants. The implants are flexible enough to allow full soft palate function but stiff enough to provide structural support. In addition, the porosity of the implant surface allows tissue ingrowth to anchor the implant, and the surface texture encourages formation of a fibrotic capsule that extends and connects the 3 implants, thereby further stiffening the soft palate. The implant is a segment of braided polyethylene terephthalate 18 mm long and 2 mm in diameter. Polyethylene terephthalate has been widely used in human implants and stimulates a fibrotic response (27).

A.More Invasive

Table 5: Range of surgical techniques for OSA in adults (28)

Surgical site	E.g. of surgical techniques available	Advantages	Potential difficulties
Nasal	Septoplasty	Adjunct for better tolerance of CPAP and lower pressures	Septal perforation can adversely affect future CPAP use.
	Septorhinoplasty		
	Turbinate reduction		
	Endoscopic sinus surgery	Improve nasal airway	Requires expert assessment of nasal symptoms/examination to identify pathology
Oropharyngeal surgery	Tonsillectomy	Prevent retropalatal restriction	Pain
	Uvulo-Palatopharyngoplasty	Combined with other procedures in multi-level approach	May affect future CPAP tolerance
	Laser assisted Uvulo-palatoplasty		
	Radiofrequency thermo-therapy (Soft palate)		Absence of long-term data in OSA.
Hypopharyng-eal surgery	Radiofrequency thermotherapy (Tongue base)	Combined with other procedures in multilevel approach	Absence of long-term data in OSA.
	Hyoid suspension		
	Midline glossectomy	Directly deals with anatomical abnormality	
	Epiglottic wedge resection		Morbidity associated includes dysphagia, odynophagia, dysphonia and aspiration. Robotic approach is resource intensive and restricted to specialised centres. May require 'covering' tracheostomy in post-op period
Maxillofacial	Maxillo-mandibular advancement	Highly effective	Highly Invasive Need for prolonged fluid diet. Velopharyngeal incompetence.
Tracheal	Tracheostomy	Bypasses obstructive segment Highly efficient	Invasive Technically difficult to perform in obese individuals
Bariatric surgery	Roux-en-Y gastric bypass	Objective improvement demonstrated-decrease CPAP requirements	Maintenance in weight loss required for benefits
	Vertical banded gastroplasty	Further health benefits	May not be deemed curative

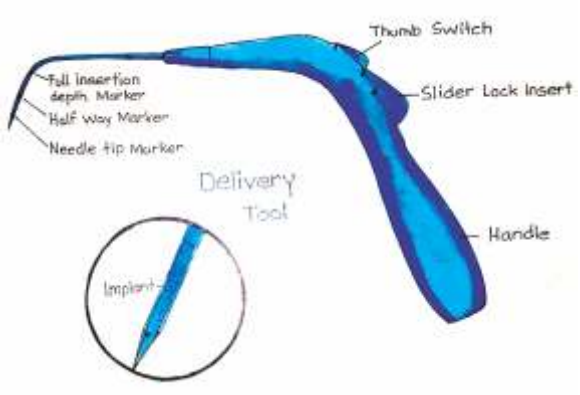

Fig. 3 : Delivery Tool for the placement of palatal implants.

Colin Sullivan, in 1981 showed CPAP as the gold standard in the treatment of OSA. There are only minimal side effects with this mode of treatment.However, despite its high efficacy, patients frequently cannot tolerate its usage every night for life and thus long-term acceptance has been found to be low. (29)

MRDs for OSA patients is considered as another form of noninvasive therapy. A review of the literature showed that these MRDs are more acceptable than CPAP and have reasonable success rates when used in mild-to-moderate OSA.However, the long compliance rates are still not good and there are complications associated with long term usage of the MRDs, such as temporo-mandibular joint problems and changes in the occlusion. (30)

When the non-surgical therapies for OSA fail or are unacceptable to the patients, surgical options are considered. The first surgical treatment for OSA was tracheotomy in 1969 by Kuhol.Previously, in 1964, Ikematsu started treating snoring with a soft palate procedure known as uvulopalatopharyngoplasty (UPPP). Following that, Fujita published results on UPPP in OSA.However, Sher's review in 1996 showed the successrate to be close to 40%.Since then, anumber of procedures were developed totreat OSA. They are all designed to improve the

posterior airway from the nasal aperture to the larynx. These procedures are shown in Table 5.(31)

Most of the soft-tissue procedures only augment one part of the posterior airway and thus were limited in their success rate when used individually. Derived from Moore's concept,two principles of therapy were developed.The first principle states that the entire upper airway is affected, especially in moderate and severe OSA. The second principle states that the more severe the disorder, the more aggressive the surgical therapy has to be to achieve success. Modern surgical reasoning suggests that severe OSA affects the entire airway and that multilevel procedures are necessary to achieve good results. Riley et alfound the success rate for UPPP, genioglossusadvancement (GGA), and hyoid suspension(HS) to be 61% and Friedman, et alachieved a 41% success for UPPP. (31)

Hard tissue surgical procedures have shown better success rates but are more tedious and may have higher morbidity. Maxillomandibular advancement

(MMA) which is modeled after conventional orthognathic surgery has achieved remarkable success rates of 97-100%.Therefore, it is important to examine the patients carefully before deciding on the most appropriate surgical procedures. (32)

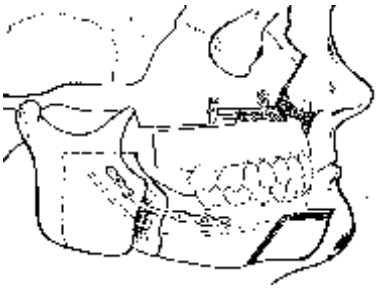

Fig. 4 : A diagrammatic representation showing typical osteotomy cuts with fixation by mini plates after Maxillo-mandibular advancement.

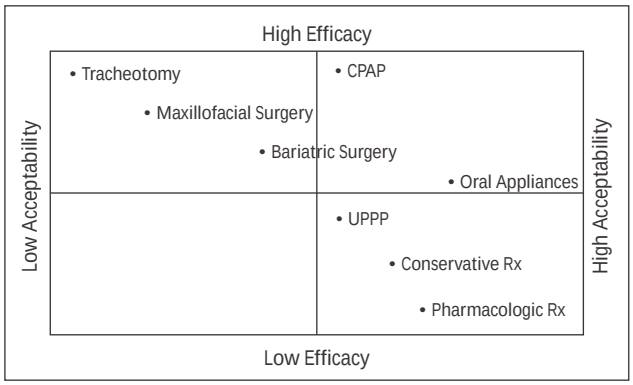

Fig. 4 Positioning of various OSA treatment classes in a matrix comparing efficacyand acceptability of treatments. (33)

Conclusion

Obstructive Sleep Apnea is a relatively common condition that predisposes the patient to physical harm, significant social discord and poor quality of life. Conservative and surgical techniques are components of multimodal algorithm of OSA which focuses on modifying skeletal or soft tissue anomaly. It is important to understand intended goal of procedure, some procedures have been shown to independently improve the quality of life as well as acceptance of therapy. Emphasis on modifying the treatment procedure is key factor to achieve best and long term effects .Team effort and collaborated approach gives the optimal result for patient.

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