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Diagnosis and determination of severity of Obstructive Sleep Apnea and Management Lines

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Abstract: Background: Obstructive sleep apnea (OSA) is a condition characterized by repeated episodes of partial or complete obstruction of the respiratory passages during sleep. The body's response to obstructed breathing leads to arousal of the brain, sympathetic activation, and disturbances in gas exchange leading to oxygen desaturation, hypercapnia, and sleep fragmentation. Abnormal upper airway anatomy, resulting in smaller cross-sectional area, is an important factor contributing to OSA (Chen et al., 2016). In addition to decreased cross-sectional area, differences in the shape and length of the upper airway are evident. An increased antero-posterior dimension decreases the efficiency of upper airway dilator muscles. Increased upper airway length contributes to its collapsibility. Increased fat deposit around the pharynx is regarded as a key mechanism through which obesity results in OSA. Peri-pharyngeal fat deposition can produce an extra-mechanical load that can prevent dilator muscles from keeping the airway patency. Through weight loss, nasopharyngeal collapsibility can be reduced, thereby increasing the capability of the upper airway. The pharyngeal fat pad area may play a crucial role in the early stage in overweight patients with OSA. Weight reduction through behavior intervention brings an improvement in obese OSA patients. Treatment for OSA in patients with overweight or obesity includes reduction of fat mass via healthful nutrition, physical activity, antiobesity medications, bariatric surgery, as well as behavior therapy to improve sleep patterns and positional therapy

Keywords: *Obstructive sleep apnea*

Introduction

Although the gold standard for the diagnosis and determination of severity of OSAS, polysomnography does not provide information on the physiopathology of apnea. Detection of areas of collapse in these patients is extremely important for the prognosis and planning of appropriate treatment. Unfortunately, from a surgical point of view, PSG cannot provide information regarding the site of obstruction and the pattern of airway collapse. Thus, several diagnostic tests and procedures have been developed. Traditional nasopharyngoscopy examination is generally performed to evaluate the topography of the upper airway in OSA patients [1].

Clinical evaluation of the entire upper airway to detect obstruction sites accurately is the most important part of OSAS assessment. Numerous treatment approaches have been developed to enlarge the upper airway or keep the airway from collapsing during sleep, most of which are site-specific treatments. Therefore, inaccurate identification of the obstruction sites can lead to suboptimal outcomes. Various techniques, including nasopharyngoscopy, video fluoroscopy (VF), pressure measurements, computed tomographic scanning, or magnetic resonance imaging (MRI), have been used in an attempt to localize the obstruction site accurately. However, each technique has limitations, and no gold standard method has been established until now. A validated investigation capable of identifying the obstruction site during sleep accurately would enable patient selection for surgery and other treatment modalities and improve treatment outcomes [2].

In 1978, fiber-optic nasal endoscopy with Müller's maneuver (MM) was first used by Borowiechi et al. to determine sites of upper airway collapse in patients with OSAS collapse during the awake state. In 1991, Croft and Pringle introduced drug-induced sleep endoscopy (DISE), which is an endoscopic examination performed to evaluate the upper airway while the patient is asleep [1].

[3] compared Muller’s Maneuver to DISE:

Muller's maneuver (MM) involves easing a flexible endoscope through the nasal cavity to identify the levels of collapse in the upper airway. This method is convenient, low cost, non-invasive, and can be performed while the patient is awake. However, MM is limited in that it cannot evaluate anatomical structures while patients are asleep, and MM results are dependent on many subjective variables, such as examiners consensus, patient position, and endoscope location.

Drug-induced sleep endoscopy (DISE) is used to observe the upper airway under similar conditions as in normal sleep. This method enhances operation efficiency by determining a suitable surgical treatment based on the observed obstruction level and reduces unnecessary operational procedures. However, DISE still has limitations. Primarily, drug-induced sleep is not representative of normal sleep conditions. DISE does not allow for simultaneous observation of multiple airway levels, and it cannot identify variable obstruction areas during the whole sleep cycle, as it is performed during a short time.

The most frequently used and easiest evaluation method is Muller’s maneuver, which aims to identify the areas of obstruction in the upper respiratory tract (URT) of patients when they are awake and in a sitting / supine position [4].

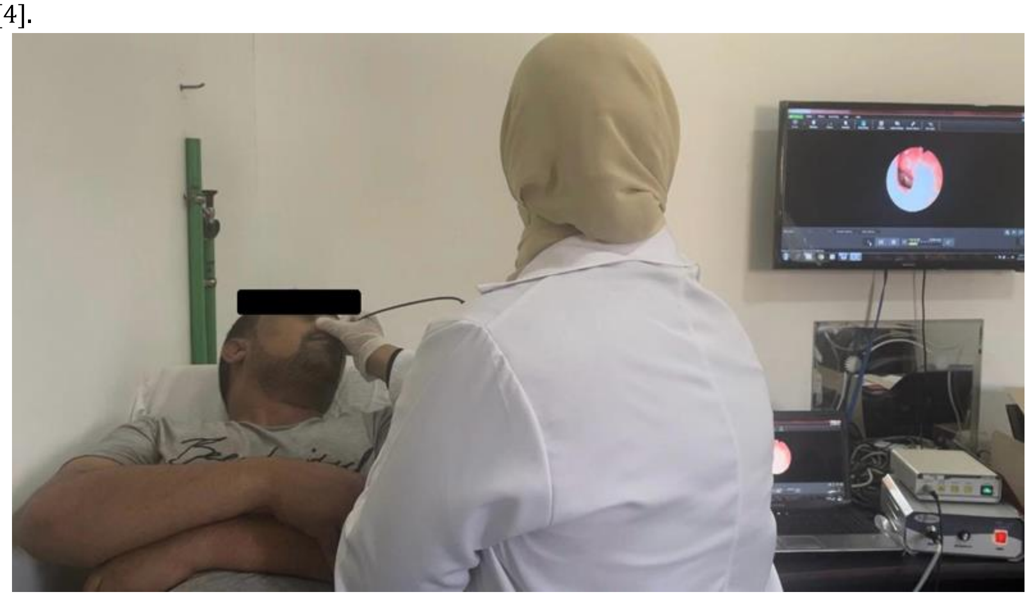

Figure.1: Nasopharyngoscopy during Muller Maneuver.

The Muller maneuver is produced by a forced inspiration against a closed mouth and nose opposite to Valsalva, it is used to determine the level of obstruction on OSA while doing the nasopharyngoscopy, according to the VOTE classification or NOHL classification [5].

Various classifications have been reported such as Bachar, Boudewns, Chan, Fishman, Sleep Endoscopy Rating Scale (SERS), (VOTE) and (NOHL) to describe the findings of DISE. Although there is no consensus, the VOTE classification and NOHL classification are the most widely used. The VOTE classification combines the four main structures that contribute to upper airway obstruction in most patients namely the velum, lateral oropharyngeal wall, tongue base, and epiglottis. The NOHL classification provides an overview that includes the nose, oropharynx, hypopharynx, and larynx. These two classifications shared most of the parameters for identifying the location, degree of collapse, and pattern of upper airway obstruction. The NOHL classification has the advantage of providing additional coverage of information on nasal obstruction. In contrast, other studies have shown that the VOTE classification provides a more comprehensive picture in the assessment of the pharynx and epiglottis. The relationship between the severity of OSA and the number of sites affected is significant according to the VOTE classification [6].

Table.1: Assessment of the VOTE and NOHL classification systems [6].

	Structure	**Degree**	**Configuration**		
VOTE	• Velum • Lateral wall of oropharynx • Base of tongue • Epiglottis	0: absent 1: partial 2: complete	Antroposterior Not visible Antroposterior Antroposterior	Lateral Lateral Not visible Lateral	Concentric Not visible Not visible Not visible
	Obstruction	**Level**	**Configuration**		
NOHL	• Nose • Oropharynx • Hypopharynx • Larynx	1: 0-25% 2: 25-50% 3: 50-75% 4: 75-100% +/-	- Antroposterior Antroposterior -	- Lateral Lateral -	- Concentric Concentric -

According to the NOHL classification, grading and pattern of obstruction can be evaluated at four different anatomic levels: N (Nasopharynx cavity and walls), O (Oropharynx – retro-palatal space), H (Hypopharynx - tongue base) and L (Larynx - epiglottis). Grading of obstruction for nasopharynx cavities and pharyngeal walls can be classified as follows:

Grade 1: 0-25% collapse.

Grade 2: 25-50% collapse.

Grade 3: 50-75% collapse.

Grade 4: total collapse during Muller manoeuver (100%).

The grading system described can be applied for both awake and sleep endoscopy; furthermore, it is possible to define the pattern of pharyngeal collapse for oropharynx and hypopharynx, as transversal (lateral), antero-posterior or concentric. The presence of any laryngeal obstruction could be reported as positive or negative [7].

Airway obstruction in OSA patients is commonly multilevel and includes the velopharynx, oropharyngeal lateral wall, tongue, and epiglottis, whereby velopharyngeal obstruction is the most common obstruction type. On the other hand, epiglottic collapse (EC) is the least common obstruction type and is usually ignored in the OSA surgical plan. Although epiglottic collapse is usually ignored, the incidence of epiglottic collapse may be much higher and may result in failure of treatment if neglected. Clinically, EC may not be detected by awake examination [8].

Other radiological techniques used in investigations of OSAS include:

Cephalometry:

Cephalometry is a diagnostic instrument that uses X-rays to provide data on the dimension and location of upper airway structures, which can aid in the diagnosis and classification of the severity of OSA. Cephalometry can direct treatment planning by focusing on the areas of the upper airway that may benefit from corrective surgery or other therapies by recognizing anomalies or obstructions that contribute to OSA. Despite being a static imaging technique that cannot capture dynamic changes in airway structure, cephalometry is an economical, non-invasive diagnostic tool that could offer useful data in the assessment of the presence of OSA [9].

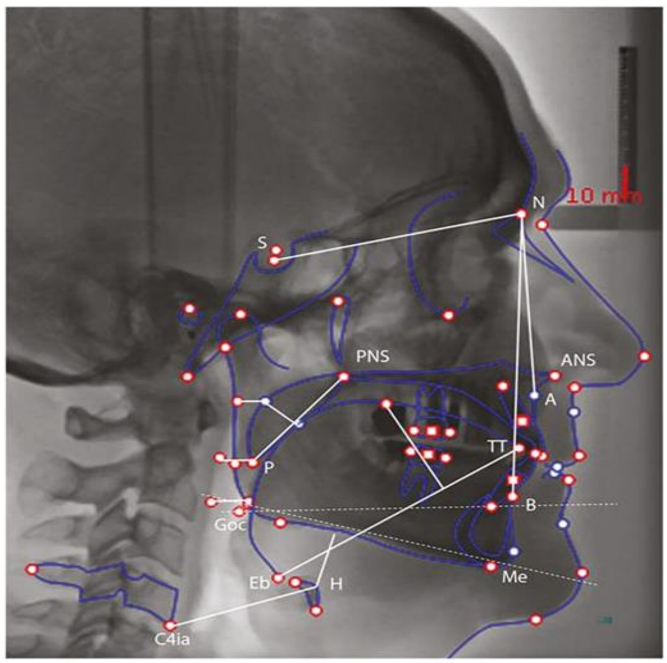

Figure. 2: Graphical representation of landmarks, reference lines, and cephalometric parameters [10].

The pharyngeal airway space, hyoid bone position, mandibular plane angle, and craniofacial dimensions are all cephalometric landmarks commonly used to assess OSA. The distance between the posterior pharyngeal wall and the base of the tongue is measured as the pharyngeal airway space (PAS). A narrow pharyngeal airway space increases the risk of airway collapse during sleep. The location of the hyoid bone can influence the position and support of the upper airway structures, whereas the mandibular plane angle can suggest the inclination of the mandible and the upper airway's stability. Further, craniofacial parameters offer useful data regarding the dimension and form of the upper airway and can be employed to recognize abnormal development that contributes to OSA. Healthcare professionals can better identify and manage OSA by using cephalometric landmarks to evaluate the upper airway, ultimately improving patient outcomes [9].

Video-fluoroscopy

Multi-view video-fluoroscopy is a radiological method of investigation that was used to evaluate the dynamics of the upper airway during speech and more recently to study OSA subjects. Video fluoroscopy can detect the upper airway mobility and its dynamic changes during sleep; it is a non-invasive method of investigation that can get the collapse happening in different parts and able to image the whole pharyngeal airway in a single plane besides its ability for direct observation the sites of obstruction during episodes of apnea and accessibility of fluoroscopy in most hospitals with a low financial burden. Video fluoroscopy is less invasive and needs less cooperation from the patient than nasopharyngoscopy and magnetic resonance imaging; this will help in understanding the airway obstruction mechanism and deciding the plans of treatment [11].

Computed Topography

There is a major benefit of cone-beam CT imaging. It provides an anatomical evaluation of the airway at a lower radiation dose and cost than traditional multidetector CT to detect possible obstructions. It allows the clinician to evaluate the airway and correlate those findings with clinical examination and history; Cone beam computed tomography (CBCT) provides a detailed depiction of the airway and craniofacial anatomy that allows identification of normal anatomy, variant anatomy, or pathological conditions that may cause obstruction of the airway. This invaluable information, combined with clinical screening, can help identify individuals that may suffer from sleep apnea [12].

Magnetic Resonance Imaging

MRI of the airway with cine sequence is considered a good alternative method to examine dynamic upper airway conditions during sleep. MRI sleep studies are rapid, noninvasive and allow dynamic abnormalities of the entire airway to be assessed at once. Compared with PSG, MRI is similar in accuracy in diagnostic evaluation of upper airway pathology and superior in delineating upper airway anatomy in OSAS. Dynamic MRI identify obstruction sites of the upper airway during sleep in patients with OSAS, which better characterize the airway obstruction under dynamic conditions, identify its location, and improve knowledge to guide surgical treatment and advancements. MRI evaluation is helpful in determining the level of obstruction, i.e., whether the collapse of the airway is retropalatal or retroglossal or at both levels. Multiple levels of obstruction may require multilevel surgery [2].

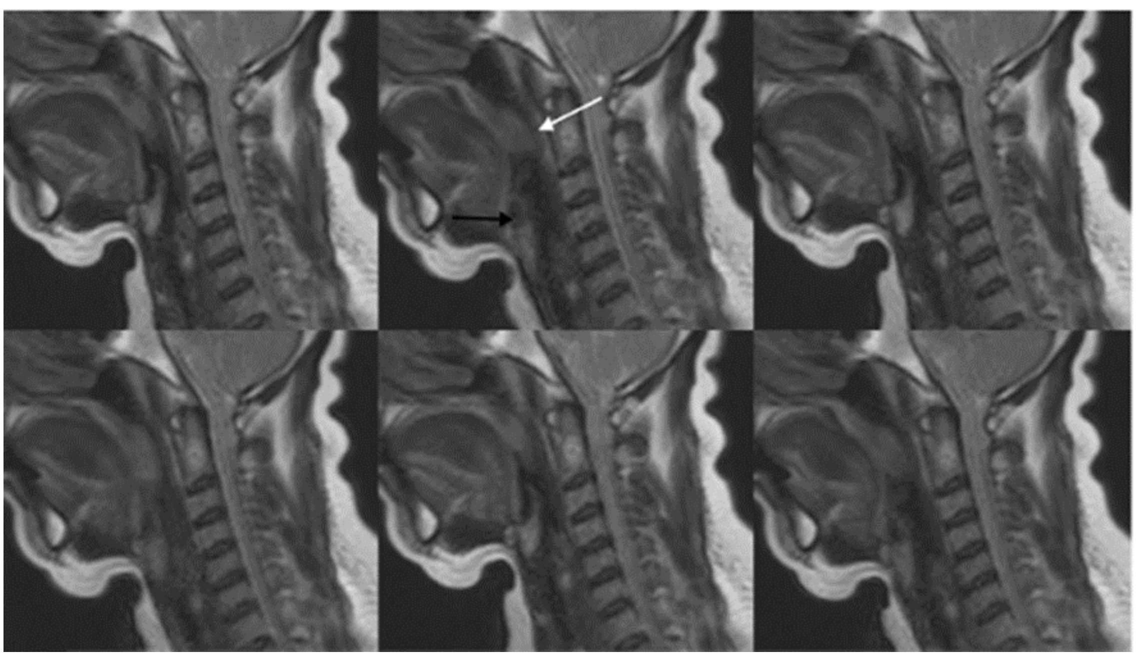

Figure.3: Dynamic sagittal sleep MRI showing patent retroglossal airway (black arrow) and retropalatal airway collapse (white arrow) [2].

Chapter: 4 Treatment of OSA

Increased fat deposit around the pharynx is regarded as a key mechanism through which obesity results in OSA. Peri-pharyngeal fat deposition can produce an extra-mechanical load that can prevent dilator muscles from keeping the airway patency. Through weight loss, nasopharyngeal collapsibility can be reduced, thereby increasing the capability of the upper airway. The pharyngeal fat pad area may play a crucial role in the early stage in overweight patients with OSA. Weight reduction through behavior intervention brings an improvement in obese OSA patients [14].

Treatment for OSA in patients with overweight or obesity includes reduction of fat mass via healthful nutrition, physical activity, antiobesity medications, bariatric surgery, as well as behavior therapy to improve sleep patterns and positional therapy [15].

[16] classified the treatment plan to:

Nonsurgical treatments for adult OSA

Continuous positive airway pressure

Oral appliances

Surgical treatments for adult OSA

Uvulopalatopharyngoplasty

Maxillomandibular advancement surgery

Hypoglossal nerve stimulation

Nonsurgical treatments for adult OSA

Continuous positive airway pressure (CPAP)

The most widely used method for treating OSA is CPAP. A CPAP system provides constant pressure to the airway through a tube connected to a face mask or nasal mask. It provides a continuous flow of inspired gases to keep airways firm and open and prevent collapse of the airway during inspiration. The therapeutic effect is related to the duration of CPAP treatment as well as the adherence of the OSA patients. The minimal use of CPAP is recommended as 4 hours per day and 5 days per week according to acceptable adherence of clinical definition. The use of CPAP could reduce the comorbidities of cardiovascular disease, hypertension, and diabetes while improving the quality of life. It also reduces blood pressure for patients with cardiovascular diseases and multiple cardiovascular risks in the middle-aged population [14].

Initiation and prescription of CPAP may be accomplished by in-laboratory PSG with CPAP titration, which determines CPAP pressure requirements for all stages of sleep in all sleep positions. Alternatively, autotitrating positive airway pressure (APAP) devices may be used to initiate therapy [17].

Oral Appliances

Mandibular advancement oral appliances can be considered either as first-line therapy for mild to moderate OSA or as an alternative for patients intolerant of CPAP. Mandibular protrusion increases the retropalatal airway by lateral expansion and augments the oropharyngeal and retroglossal airway by anterior movement of the tongue base. Although not as effective as CPAP in eliminating disordered breathing events, improvement in functional outcomes and systemic hypertension achieved with oral appliances is similar in magnitude to that seen with CPAP, which may reflect better adherence to therapy. However, because of the variable response to oral appliances, it is important to perform follow-up PSG or OCST to assess the efficacy of the appliance because subjective reports may not reliably predict improvement in the AHI [17].

Surgical Therapy

From a surgical viewpoint, upper airway obstructions can be single- or multi-level. Common levels of obstruction include nasal, retropalatal, retro-lingual, and laryngeal obstruction. The management and responses to treatment for these different levels of obstruction can differ [20].

Uvulopalatopharyngoplasty

Uvulopalatopharyngoplasty (UPPP) remains the most commonly performed sleep surgical procedure worldwide. In clinical practice, various forms of UPPP are often performed as part of multi-level surgery to maximize surgical success. Most forms of contemporary UPPP focus on palatal muscle expansion and stabilization with targeted vectors during suturing. Various techniques of palatopharyngoplasty such as lateral pharyngoplasty, expansion sphincter pharyngoplasty, and trans-palatal advancement pharyngoplasty have been introduced to resolve the limitations of classic UPPP. Collectively, they have shown more successful outcomes than the classic UPPP. Sleep surgeons can individualize the options according to the pattern of collapse. For example, lateral pharyngoplasty, expansion sphincter pharyngoplasty, or similar procedures can be applied to lateral pharyngeal collapse, while trans palatal advancement pharyngoplasty can be utilized in anteroposterior narrowing [21].

Maxillomandibular advancement surgery

Maxillomandibular advancement (MMA, sometimes called bimaxillary advancement) effectively enlarges the airway in both the palate and tongue regions, by moving the maxilla and the mandible forward. Compared to other procedures, it provides the greatest improvement and serves as one of the most effective surgical treatments for obstructive sleep apnea. It can be performed on patients with moderate to severe obstructive sleep apnea as monotherapy, or considered when other procedures fail. In some patients with jaw deformity, it can be the first-line surgical treatment since significant jaw deformity can contribute to OSA [22].

Hypoglossal nerve stimulation (HSN)

HSN was introduced in 2014 for the treatment of OSA. The hypoglossal nerve contains only motor fibers innervating several muscles including the genioglossus (GG), the main pharyngeal dilator muscle. There are monolateral devices approved for clinical use, and one device producing bilateral stimulation of the GG; the reader is referred to an extensive review for technical details. HSN is indicated in adult patients intolerant of CPAP, with moderate-severe OSA. Implantation of the device requires surgical intervention by an ENT specialist. Results have been promising and stable over time, and patients' adherence and satisfaction are high. However, efforts are being made to identify predictors of a positive response, and HSN is far from being completely clarified as pathophysiological effects and outcomes are concerned [23].

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