

TITLE: Adult and Pediatric Obstructive Sleep Apnea

SOURCE: Grand Rounds Presentation, UTMB, Dept. of Otolaryngology

DATE: June 5, 2002

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Sleep apnea syndrome is now recognized to be a very common condition with prevalence figures ranging from one to four percent depending of the diagnostic criteria used. This establishes obstructive sleep apnea syndrome (OSAS) as second to only asthma in the prevalence of chronic respiratory disorders. Although Charles Dickens is credited with the classic description of a typical OSAS patient in his *Pickwick Papers* (1837), much was not known about the disorder until Guilleminault and colleagues described the syndrome more accurately in the 1970s. This led to further understanding of the serious health problems associated with the disorder.

Background

It has been reported that 85% of adult OSAS patients are men. The prevalence is 4% in men and 2% in women, which is higher than expected. Approximately two-thirds of the adult patients are obese. Mortality appears to be related in a graded fashion to the intensity of the disorder and is highly related to co-morbidity. OSAS plays a causal or contributing role in hypertension and cardiovascular events. Untreated OSAS is also associated with an increased risk for motor vehicle accidents.

Pathophysiology

It is known that airflow obstruction in OSAS is caused by collapse of the pharynx. Obstructive sleep apnea is manifested by repeated episodes of decreased breathing of upper airway origin occurring during sleep. In obstructive sleep apnea, there is a decreased airway as a result of anatomic, neuromuscular, or other factors. To maintain adequate airflow through a diminished lumen, the patient must increase respiratory effort. This attempt to increase airflow requires increasing airway pressure. Because of the Bernoulli effect, increased intraluminal negative pressure, and a compliant airway structure, collapse of the airway and cessation of airflow result. Increasing negative airway pressures paradoxically cause further airway collapse and increased resistance to airflow.

Anatomic narrowing and neuromuscular control of the pharynx contribute to this process. Anatomic narrowing at any level can be responsible because greater inspiratory pressures are needed to generate airflow to bypass the smaller diameter of the airway. More common abnormalities include: soft palate elongation, adenotonsillar hypertrophy, macroglossia, retrognathia, and micrognathia. Abnormal neuromuscular control also contributes as reflex activation of the pharyngeal dilators in response to airway obstruction often fails in these patients.

Diagnosis

History

The most common and important symptoms suggesting OSAS are snoring and daytime sleepiness. Input from the bed partner should be included as these patients are often unaware of their symptoms. Observed apneas, restless sleep, morning headaches, and sexual dysfunction are often seen. The sleep history should be explored determining bedtimes, arousal times, and awakening times. The use of caffeine and alcohol should be elicited. Since daytime sleepiness is a subjective measure the Epworth Sleepiness Scale can be used to evaluate their complaints more reliably.

Physical Exam

The physical examination begins with a full set of vital signs including evaluation of height, weight, and collar size. The patient's weight one and five years previously is important as the onset of symptoms will often parallel an increase in weight. For adult males, collar size over 17 inches (measured at the cricothyroid membrane) is a significant predictor of OSA. Collar size over 17 inches and snoring predisposes to OSA in 30% of patients. For females, collar size over 15 inches is significant. The body mass index (BMI) can be calculated. $BMI = \text{weight in kgs.} / \text{height in meters squared}$ (or $BMI = 705 \times \text{wt. in lbs.} / \text{ht. in inches squared}$). $BMI > 27.8$ in men and 27.3 in women is defined as obesity which predisposes to OSAS.

A complete examination of the head and neck commences including flexible endoscopic evaluation. Examination of the oral cavity and oropharynx is vital since retropalatal and/or retrolingual collapse leads to the obstruction. Exam begins with evaluation of the tongue and palate. The size of the tongue can be subjectively evaluated by noting its position relative to the mandibular occlusal plane. Normally, it should sit below this plane. Elevation above this plane is subjectively staged as mild, moderate, or severe enlargement. A high arched palate may be present in patients with OSA. The soft palatal anatomy is varied. The uvula can be long or wide. The width of the oropharynx is noted. The size of the tonsils is evaluated. Nasal evaluation can reveal sites of increased nasal resistance, which can worsen the condition and decrease potential benefit from CPAP therapy. The position of the hyoid and its relationship to the mandible should be noted. Fiberoptic endoscopy can be performed in the sitting and supine positions. Collapse of the retropalatal and retrolingual segments can be seen when the patient performs the Muller maneuver, which generates negative pressure in the oro- and hypopharynx and roughly simulates the negative pressure seen during sleep. Lastly, the relationship of the

mandible and maxilla should be noted as hypoplasia of either or both can contribute to airway narrowing.

Radiography

A variety of imaging techniques have been suggested to evaluate the upper airway and surrounding bony and soft tissue structure including acoustic reflection, fluoroscopy, nasopharyngoscopy, cephalometry, computed tomography (CT), and magnetic resonance (MR) imaging. The ideal upper airway imaging modality should be inexpensive, noninvasive, and allow for supine imaging in the absence of radiation. Although this technology doesn't exist as of yet, MRI probably comes the closest to meeting these criteria. At the present time, upper airway imaging should be considered primarily a research tool but it has provided more understanding of the pathology and treatment of the disorder. These imaging techniques are rarely used at our institution in routine evaluation.

Cephalometrics are standardized lateral radiographs of the head and neck examining bony and soft tissue structure. The technique is widely available, easily performed, and less expensive than CT or MR imaging. It has been found useful in quantifying abnormalities in patients with craniofacial deficiencies leading to their OSAS. Limitations include its two-dimensional evaluation of a three-dimensional structure, lack of volumetric data, poor representation of soft tissue structures leading to collapse, and its inability to be performed during sleep. Despite these limitations it should be performed in patients being considered for maxillomandibular surgery and considered in patients to be treated with oral appliances.

CT provides excellent imaging of the airway, soft tissue, and bony structures from the nasopharynx to larynx. It is performed in the supine position and volumetric reconstructions can be performed. Disadvantages include the cost, weight limitations of the table, and ionizing radiation especially if repeat studies are planned postoperatively.

MR imaging also provides excellent views of the upper airway and its soft tissue. It can be performed in a variety of planes and used for volumetric reconstruction. It can be performed during sleep and wakefulness without ionizing radiation. Disadvantages again include cost, weight limitations, the scanner's associated noise when trying to achieve sleep, and claustrophobia.

Polysomnogram

A polysomnogram (PSG), or sleep study, is a comprehensive study used to diagnose a wide spectrum of sleep disorders. It is the "gold standard" in the evaluation and diagnosis of OSAS. Terminology important to understand includes: a) obstructive apnea – cessation or obstruction of airflow for at least 10 seconds with respiratory effort, b) central apnea – cessation of airflow for at least 10 seconds without respiratory effort, c) mixed apnea – characteristics of both for 10 seconds generally beginning with a central event, and d) hypopnea – hypoventilation secondary to partial obstruction of the airway. Indices to evaluate include the apnea index (AI), apnea-hypopnea index (AHI) or respiratory disturbance index (RDI), and arousal index, all based on the number of events occurring per hour. A level I PSG will have measurements including EEG, electrooculogram (EOG), submental and anterior tibialis EMG, EKG, nasal or

oral airflow, pulse oximetry, respiratory movement or effort, and sleeping position. Esophageal manometry will allow more sensitive determination of increased respiratory effort.

A full-night PSG in a sleep lab is considered the best study available for diagnosis but split-night studies are used if OSAS is definitively diagnosed during the first half of the night. During the second half of the study, CPAP titration is performed so that the patient does not have to return for another study. There is also an effort to standardize “in-home” studies, which would be more convenient for the patient and potentially less costly. The “first night effect” may also be avoided with an in-home study.

Treatment

Nonsurgical Modalities

Since obesity is one of the major risk factors for OSAS, weight loss should be encouraged in all obese patients with OSAS. It is widely accepted that most patients have a “trigger weight” above which apnea occurs or becomes symptomatic. Many studies have reported resolution of obstructive events with loss of excessive weight. Weight-loss methods include diet, exercise, medications, and even bariatric surgery. A complete life-style change is needed as it is often difficult for patients to maintain the weight loss over time. Sleep hygiene should be reviewed as alcohol and sedating medications can exacerbate OSAS. Patients with insomnia should be instructed to avoid nighttime caffeine and avoid activities such as reading in bed. Positional changes can also exacerbate OSAS. Some patients can obtain benefit by sleeping on their sides or in the prone position.

Pharmacotherapy has also been suggested as a nonsurgical modality. Protriptyline is a tricyclic antidepressant that functions by decreasing the amount of time spent in REM sleep- the time in which pharyngeal tone is least, which predisposes to obstruction. Xanthine based drugs such as theophylline have been used but chiefly for central apneas. Intravenous or oral steroids can diminish adenotonsillar hypertrophy in the acute setting such as with mononucleosis. Antibiotics can also temporarily decrease the size of obstructing tonsils but don't offer significant long-term benefit. Nasal steroid and topical decongestants can also improve nasal obstruction with corresponding improvement in OSAS symptoms.

Since its introduction in 1981, nasal continuous positive airway pressure (CPAP) has become the widely accepted treatment of choice for OSAS. CPAP equipment acts as a pneumatic splint, creating positive pressure inside the airway throughout the respiratory cycle. One reason that CPAP is so effective is that the pressure acts along the entire upper airway so that all potentially occluding segments are stabilized. Initially, CPAP therapy was recommended for patients who have moderate to severe OSAS but has been extended to patients with mild disease. CPAP treatment can be given to a patient on a trial basis and easily modified or withdrawn if it is not tolerated or if the expected clinical response is not achieved. During the titration process, the pressure is increased until apneas, hypopneas, snoring, and desaturations are stopped. Minor side effects are seen in 40-50% of patients and can usually be lessened by a variety of technologies, this is important as CPAP use is only about 60% in patients who reports side effects. Acceptance of CPAP ranges from 50 to 90% and is much higher if a patient's daytime symptoms are improved.

Oral appliances are also effective in relieving OSAS. These devices work by either advancing the mandible forward or retaining the tongue anteriorly. These devices are particularly effective in nonobese patients with retrognathia and micrognathia. They are most effective in mild to moderate cases or as part of a combined approach in severe cases. In one review, 51% of OSAS patients achieved normal parameters as defined by a post-treatment AHI of <10, and 61% of patients with a pre-treatment AHI of 20 were improved to below this level. Since TMJ dysfunction and occlusal changes can occur, these devices should be fitted and followed by an experienced dentist or orthodontist. Importantly, patients tolerate these devices better than CPAP.

Surgical Modalities

Uvulopalatopharyngoplasty (UPPP) is the most commonly performed surgical procedure for OSAS. Introduced by Fujita in 1981, the uvula, tonsils, and portions of the anterior pillars and soft palate are resected. It is most effective in younger, less-obese patients with mild to moderate OSA and isolated retropalatal collapse. Success rates range from 10-50% based on preoperative evaluation of the collapse site. UPPP is the first-line procedure for identified retropalatal collapse.

A variety of procedures exist to decrease bulk of the tongue base including lingual tonsillectomy, laser midline glossectomy, lingualplasty, and radiofrequency volumetric tissue reduction. The latter technique appears most promising as it is well tolerated in comparison to the former techniques.

A number of techniques are used to advance the mandible. The goal is to enlarge the retrolingual airway without moving the entire mandible or teeth. Mandibular osteotomy with genioglossus advancement has become the procedure of choice. The rationale is that it will prevent the tongue base from falling posteriorly during sleep. A variety of techniques exist but all essentially involve an osteotomy along the inferior border of the mandible with subsequent fixation of this segment (which has the geniotubercle attached) into a more anterior position.

Hyoid myotomy and suspension enlarges the retrolingual airway space by advancing the epiglottis and tongue base anteriorly. The hyoid bone is freed of its attachments and then secured to thyroid cartilage by permanent sutures.

Maxillomandibular osteotomy and advancement is reserved for patients with severe disease or those who fail treatment by more conservative measures. The midface, palate, and mandible are moved forward increasing the posterior airway space. The procedure is limited by the ability to stabilize the segments and the aesthetic facial changes associated with this procedure. Generally, the advancement will be between 10 to 14 mm and bone grafting between the segments is recommended.

Tracheostomy is still the gold standard in the treatment of OSAS and it completely eliminates airway obstruction by bypassing the sites of obstruction. It is effective virtually 100% of the time and has been used since the 1970s. Tracheotomy is done for two reasons: 1) as a temporary procedure to stabilize the airway while undergoing airway reconstruction, or 2) as a

permanent procedure in severe OSAS when CPAP is refused, unsuccessful, or poorly tolerated or if significant cardiac, pulmonary, or neurologic diseases are exacerbated by the apneas. When done on a permanent basis it is suggested that skin flaps are designed to line the stoma in order to minimize complications. Lack of social acceptance limits its usefulness.

Nasal obstruction may be a contributing factor in OSAS although it does not cause the apneic events itself. Procedures such as septoplasty, turbinate reduction, and functional nasal reconstruction can be adjunctive procedures and make CPAP more tolerable.

Treatment Algorithm

Although very subjective, most authorities recommend starting nasal CPAP for newly diagnosed OSAS patients in all classes. Patients with mild OSAS have more treatment options, as these cases are the most amenable to surgical correction and use of oral appliances. In addition, weight loss is often an option for patients with mild OSAS. CPAP failures or patients who are unable to tolerate CPAP move into the surgical arm of therapy.

The Riley-Powell-Stanford surgical protocol is a surgical treatment strategy based on their extensive experience since 1988. It is divided into two phases of upper airway obstruction. Phase I treatment targets the specific site of obstruction. Retropalatal collapse warrants a UPPP, retrolingual collapse warrants mandibular osteotomy with genioglossus advancement (occasionally a hyoid myotomy and suspension), and collapse at both sites will garner procedures at both levels. If nasal surgery is needed, it is done 6-8 weeks later to allow adequate healing and to limit complications. Six months postoperatively a repeat PSG is performed to evaluate surgical outcome. Success is defined as postoperative PSG equivalent to the nasal CPAP study, or RDI less than 20 with at least a 50% reduction over the preoperative study. Patients must also have improved daytime symptoms. Using this method, 61% of patients achieve success. If the preoperative RDI was <60 there has been a 75% success rate where a preoperative RDI >60 only has a 42% success rate. Phase I failures move to Phase II which consists of maxillomandibular osteotomy and advancement. They are able to obtain 95-100% success rates during the second phase.

Pediatric Obstructive Sleep Apnea

Many features of childhood OSAS are different than adult OSAS. The prevalence of pediatric OSAS is estimated to be around 2% with the peak age being between 2 and 5. This coincides with the peak of adenotonsillar hypertrophy (ATH). Gender distribution is equal in prepubertal groups.

Almost all children with OSAS snore but this alone is not indicative of OSAS. The severity of snoring does not correlate with severity of the disorder. The majority of children with OSAS referred to otolaryngologists have ATH with mouth breathing (MB). Unfortunately, it has not been shown to be a good predictor of OSAS. MB has been shown to be a contributor in the development of adenoid facies but not OSAS. In fact, only 15% of patients with adenoid facies are reported to have OSAS. Excessive daytime sleepiness is not a common complaint in children with OSAS, it is a subjective complaint and is difficult to evaluate in children. Although obesity predisposes to OSAS in children, most patients are not obese. Many patients in fact have failure

to thrive. Almost all children with OSAS demonstrate increased respiratory effort during breathing and parents often describe this as frightening. Hypoxia associated with apnea, or sleep fragmentation resulting in sleep deprivation, are thought to be responsible for the increased incidence of parasomnias in childhood OSAS. Restless sleep and bed-thrashing are common. Aggressive and rebellious behavior has been reported. Some children may also have behavioral and learning disabilities secondary to their OSAS. Secondary enuresis and asphyxic encephalopathy have been reported as manifestations and can be reversed with treatment. Impaired growth is one of the main features of advanced pediatric OSAS. It has been suggested that disruption of sleep architecture may impair release or end-organ response to growth hormone. Increased respiratory effort during sleep may drain the child's caloric resources and obstructing tonsils can interfere with caloric intake. An association with gastroesophageal reflux disease has been found. It is likely that the increase in negative intrathoracic pressure predisposes to reflux. A variety of syndromes and diseases will also predispose to pediatric OSAS.

Complete history and physical exam must be undertaken. Unlike in adults though, in most children the diagnosis can be made with this modality alone. Brouillette found that if a child always snores, has restless sleep resulting from obstruction, and has apneic episodes as reported by the parents, the child virtually always has apnea confirmed by PSG. It is probably not cost-effective to evaluate each child with these symptoms with formal sleep studies. PSG is still the gold standard in diagnosis in children. PSG should be considered in children with severe CNS disease, age less than 2, medical conditions that increase the risk of surgical management, and when nonsurgical therapy is more likely to be indicated by specific pathology or patient and family desires. Additionally, if the history is discordant with physical exam it should be considered. In young children, an apnea index of one or an AHI greater than five is considered abnormal. An AHI of more than 20 is very abnormal. Lateral neck radiographs evaluating the adenoids are commonly employed to diagnose obstructing adenoids when tonsil size is relatively normal.

Since ATH is the most common cause of pediatric OSAS, tonsillectomy and adenoidectomy is the most common procedure in the treatment of pediatric OSAS. Most children are cured, but there are nonresponders. Children with Down syndrome, neurologic deficits, or craniofacial anomalies may not have resolution of OSAS with T&A alone. We routinely admit our tonsillectomy patients who are younger than age 4, those being done for upper airway obstruction, and those with medical comorbidities, craniofacial anomalies, and adverse social factors (distance from hospital). UPPP can be done in patients who have identified obstruction by long or thick uvulas and soft palates. The procedures described for adult treatment such as genioglossus advancement and maxillomandibular osteotomies can all be done in children but decision to proceed with these procedures is difficult due to long-term growth considerations. Tracheotomy is a reliable procedure for young children with OSAS. It is warranted for severe symptoms and those with complicating neurologic or pulmonary conditions.

Special mention should be made of two classes of patients. Children with Down syndrome have a very high probability of developing OSAS because of their relatively small midface and cranium, narrow nasopharynx, large tongue, muscular hypotonia, obesity, increased susceptibility to upper respiratory tract infections, and small larynx. Up to 50% of these patients

may have heart disease, which can predispose to cor pulmonale. The incidence of OSAS is 54-100% in these patients. More liberal use of UPPP is indicated in these patients. Children with craniofacial anomalies are predisposed to OSAS. Those with Pierre-Robin sequence are predisposed due to their small recessed mandibles. Children with midface hypoplasia as seen in Crouzon and Treacher Collins syndromes are also at high risk for OSAS. Many of these patients require tracheotomy until growth or further surgery alleviates their condition.

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