Introduction

Obstructive sleep apnea affects millions of people across the United States. This affects not only the patient, but also their bed partner. Affects of OSA include daytime hypersomnia, decreased productivity at work, and with long-term untreated OSA, cor pulmonale and heart failure. The treatment of OSA can be purely medical, surgical, or a combination of both. Continuous positive airway pressure (CPAP) is the current therapy of choice and can relieve most causes of OSA. The surgical management has been a bit more disappointing. The reason for this is that OSA is not a single entity that has a single surgical management. There are many sites that may cause the obstruction of OSA. As clinicians, we use physical examination to attempt to diagnose the sites of obstruction, which is poor at distinguishing this. We use objective data in the form of sleep questionnaires as well as polysomnography to diagnose OSA. Most of these patients go on to trial of CPAP. For effective CPAP, the patient must wear the mask for 5 out of 7 nights for over 80% of the night. Many people cannot tolerate the CPAP mask and seek a surgical solution. That is where the Otolaryngologist enters the management.

Diagnosis of Obstructive Sleep Apnea

History

Patients with sleep apnea often present when their bed partner can no longer stand loud snoring. These patients complain of excessive daytime sleepiness, and feeling like they did not sleep the night before. They may complain of awakening multiple times during the night because of apneas or because of the loudness of their own snoring. In the morning, they may have headache or dry mouth. Sometimes these patients are prone to accidents at work or while driving because they fall asleep at inappropriate times. It is important to illicit co-morbidities, use of alcohol or tobacco, and any previous trauma to the face. Other medical problems that can contribute or exacerbate obstructive sleep apnea are allergic rhinitis, acute rhinosinusitis, nasal polyposis, nasal tumors, and acquired nasal deformities. The Epworth sleepiness scale is an invaluable tool for initial the assessment of obstructive sleep apnea. This survey asks the likelihood of falling asleep in 8 common situations, scaled from 0 (never) to 5 (always), and a score greater than 11 is correlated with OSA.
Physical

A complete head and neck exam is warranted in these individuals because there are multiple sites that can be obstructed. The nose can be obstructed by nasal valve collapse, septal deviation, turbinate hypertrophy or nasal masses. Evaluation of the oral cavity should be done with the tongue inside of the mouth in a relaxed position. The tonsils should be graded from 0 to 4, with zero being absent and four being kissing. Examination of the palate and uvula should also be noted. Many patients with OSA will have a long, thick uvula, or redundant soft palate tissue. They may also have macroglossia, which obscures the view of the palatal structures. Friedman et al developed a classification system based on modifying the Mallampati system. Friedman palate position I, you can see the entire soft palate and uvula. Position II allows visualization of the uvula but not the tonsils. Position III allows visualization of the soft palate, but not the uvula, and position VI only the hard palate is visualized. When combined with tonsil size, these form the Friedman stages I-III. In stage one, the patient has large tonsils (3 or 4), with visualization of the soft palate and uvula. Stage II has large tonsils (3 or 4), and visualization of only the soft or hard palate. Stage III has small tonsils (0 – 2), and visualization of only the soft or hard palate. Examination of the complete pharynx requires either indirect mirror laryngoscopy or fiberoptic nasopharyngoscopy.

Examination of the nasopharynx may reveal adenoid hypertrophy, or other occluding mass. The oropharynx may reveal lingual tonsil hypertrophy or retroflexed epiglottis. With inspiration, there may be collapse of the supraglottic structures. The Mullers maneuver can be performed while occluding the nose and mouth and having the patient take an inspiration. This will allow the examiner to visualize pharyngeal collapse and objectively identify anterior-posterior collapse or lateral wall collapse.

Polysomnography

This is the gold standard for diagnosis obstructive sleep apnea. This is generally and overnight, attended study performed in a sleep laboratory. EEG, pulse oximetry, EKG, nasal and oral airflow, respiratory effort, and leg movements are all measured during testing. Apneas are recorded when there is cessation of nasal or oral airflow for at least 10 seconds. Hypopneas are recorded when airflow decreases by 30% and there is an associated 4% drop in oxygen saturation. Respiratory related arousals have a 30% decrease in airflow not associated with a 4% drop in oxygen saturation. The apnea/hypopnea index and respiratory disturbance index as well as the minimum oxygen saturation are the important numbers to review in the summary. An AHI or RDI greater than five is considered mild obstructive sleep apnea. When this number is greater than twenty, it is moderate, and when it is greater than forty it is severe. Minimum oxygen saturation less than 90% is considered abnormal, and total time under 85% should be assessed to help determine the severity of sleep apnea. After a positive PSG, the patient should be fitted with a CPAP mask and a titration study is performed.

Standard Treatment for Adult Obstructive Sleep Apnea

One of the first steps is behavioral modification. This involves smoking cessation, avoidance of alcohol and sedatives, weight loss and modifying sleep position. Continuous positive airway pressure bypasses all of the levels of obstructive sleep apnea and is first-line therapy. The optimal pressure must be achieved and the patient must wear the mask for 5 hours/night and 5 nights/week to be considered compliant. Despite all of the benefits of CPAP, some patients cannot tolerate it. The reasons for non-compliance include excessive pressures, noise, air leakage, discomfort and claustrophobia. Robinson et al (2009) performed a cohort study of patients with OSA comparing health related quality of life if patients that opted for upper airway surgery to patients that tried CPAP. Found that for the patients that could tolerate CPAP, their quality of life was improved and their Epworth sleepiness score improved. They also found that 45% of the people that tried CPAP were non-compliant or complained of side effects. They
concluded that patients with side effects or non compliant with CPAP therapy, will benefit from evaluation by an Otolaryngologist for possible surgical intervention.

In the past, surgical therapies focused on treatment of the soft palate. This included snare uvulectomy, uvulopalatoplasty, uvulopalatopharyngoplasty, laser-assisted uvuloplasty, and more recently radiofrequency ablation of the soft palate, and tonsillar pillar implantation. The most well-known and popular of these treatments is the uvulopalatopharyngoplasty. This procedure was developed to address the most probable site of obstruction and redundant tissue. It involves tonsillectomy, followed by trimming and repositioning of the anterior and posterior tonsillar pillar, and excision of the uvula with creation of a smaller neo-uvula. Kahn et al (2009) performed a retrospective chart review of patients diagnosed with OSA undergoing UPPP over an eighteen year period. They found 63 patients that underwent preoperative and postoperative polysomnography. Unlike many other studies that use a 50% reduction in AHI or AHI less than 20, they used an AHI of less than 5, which is considered normal. All patients underwent UPPP, and a smaller percentage underwent nasal procedures (septoplasty or turbinate reduction) or tongue somnoplasty (5%). There cure rate (AHI<5) was 23.8%, these patients had a lower BMI, less severe OSA, and a higher preoperative minimum oxygen saturation. Using the standard criteria for success, they had cure rates of 50%, which correlates with other studies performed. This study and many other studies like this one can be interpreted in many ways. One may say that UPPP is not effective for obstructive sleep apnea, but this statement is not an absolute truth. Obstructive sleep apnea is caused by obstruction at multiple sites within the upper airway, thus addressing the site or sites of obstruction should be the goal of any therapy. While CPAP addresses all sites of obstruction, many patients require excessive pressures, or have leaks around the apparatus that preclude its use. These are the patients that may not obtain a cure with upper airway surgery, but there tolerance and compliance may be improved by undergoing surgery. This has lead pioneers of upper airway surgery to develop surgeries that address all of the sites of upper airway obstruction.

Tongue base procedures for Adult Obstructive Sleep Apnea

Riley and Powell outlined phases of surgery, with soft tissue work being phase I and bony work being phase II. They understood that often times, multiple procedures had to be performed to address the palatal obstruction, tongue base/retrorhinal obstruction, and nasal obstruction. Phase I focuses on soft tissue work, while phase II surgery is performed when soft tissue work fails. Tongue base procedures are playing a larger role in upper airway surgery for obstructive sleep apnea because in combination with palatal procedures, they can improve outcomes from surgery. In the past, these procedures have been associated with high morbidity. Many studies have been performed to increase our knowledge of tongue base anatomy, and these procedures have become safer in the process.

Pertinent Tongue Base Anatomy

The base of tongue is an important structure for swallowing and speech. The tongue base provides the primary force for movement of food from the oropharynx, around the epiglottis, and into the hypopharynx. The sulcus terminalis (a V-shaped furrow on the dorsal surface) divides the tongue into its oral and pharyngeal components. Its apex is marked by the foramen cecum. The tongue is a muscular organ covered by a thin layer of mucosa. There are two types of muscle which comprise the tongue—intrinsic and extrinsic. Intrinsic muscles have no outside attachments whereas extrinsic muscles have attachments to structures outside the tongue. Extrinsic tongue muscles include the genioglossus, styloglossus, chondroglossus and hyoglossus. Embryologically, the muscles on each side of the oral tongue develop separately and then fuse in the midline. This near-bloodless plane can be used for surgical access to the
base of tongue. Taste papillae, serous and mucus glands dot the tongue’s dorsal surface. Irregular lymphoid tissue lies at the tongue base and is referred to as the lingual tonsils.

The vallecula is the area between the tongue base and the epiglottis. Irregular lymphoid tissue lies at the base of the tongue in this trough-shaped area. These “lingual tonsils” are part of the ring of lymphoid tissues that surrounds the oropharynx. The epiglottis is composed of a long spoon-like cartilage skeleton covered with mucosa. It serves as the posterior border of the vallecula and helps to direct food bolus around the larynx and into the piriform sinuses. Its cartilaginous makeup allows it to bend with elevation of the larynx and retraction of the tongue base. As it bends posteriorly it covers the larynx and serves to direct food around it. After the tongue relaxes it quickly springs back into its upright position.

A fibrous connective tissue structure runs between the hyoid bone anteriorly and the epiglottis posteriorly. This structure is called the hyoepiglottic ligament. It is an important barrier to the spread of cancer from the tongue base into the deep compartments of the larynx, preepiglottic and paraglottic spaces. It also serves as an important surgical plane for precise entry into the vallecula. It condenses medially to form the median glossoepiglottic fold.

Surgery on the tongue base requires knowledge of the anatomical structures that reside within the tongue base and their position. In 1997 Dr. Arthur M. Lauretauno et al performed cadaver studies to determine the relationship of the hypoglossal/lingual artery neurovascular bundle to the soft tissue and bony landmarks at the tongue base. These landmarks are the foramen cecum, the lateral tongue margin at the level of the foramen cecum, the hyoid bone, and the retromolar trigone. They found that the neurovascular bundle was 2.7 cm inferior and 1.66 cm lateral to the foramen cecum, 2.77 cm inferior and 1.1 cm medial to the lateral tongue margin at the level of the foramen cecum, 0.9 cm superior to the hyoid bone, and 2.18 cm medial to the mandible at the level of the retromolar trigone. They concluded that the neurovascular bundle in the transverse dimension lies midway between the retromolar trigone/lateral tongue border and the midline of the tongue, and that it lies fairly inferiorly, within 1.5 cm of the hyoid bone.

**Perioperative Management**

There are many sequelae from untreated or inadequately treated obstructive sleep apnea. There is cognitive dysfunction, higher incidence of hypertension and cardiovascular disease, risk of pulmonary hypertension, and increased incidence of stroke. Many of these patients will have co-morbidities that will need to be addressed prior to surgery. While most patients undergo surgery because of CPAP intolerance, it is imperative that they use their CPAP for at least two weeks prior to and after surgery. This is so they do not accumulate a sleep debt. Hypertension should be treated aggressively in the perioperative period. After surgery, admission with pulse oximetry and pain management with narcotics is required. Patients need to demonstrate the ability to tolerate a liquid diet, have adequate pain control, and have a safe airway prior to discharge.

**Overview of Soft Tissue Tongue Base Procedures**

**Radiofrequency tongue base ablation** – a two-pronged insulated probe is inserted into the tongue base around the level of the foramen cecum. Radiofrequency is delivered at a frequency of 465 KHz to ablate the tongue tissue, and cause scar contracture, thus reducing the tongue volume. This can be done in the office under local anesthesia, or can be performed in the operating room under general anesthesia. The best results have been seen when delivering a total of 12kJ in 8-12 locations, over a four week period. This may also be done as a onetime procedure, but there is more risk of mucosal ulceration.
**Lingual tonsillectomy** – this can be performed with either microdebrider or coblation. This should be done under visualization with telescope, and care should be taken to avoid damage to the hypoglossal nerve, lingual artery neurovascular bundle.

**Midline Glossectomy** – Enlarges the retrolingual airway by reducing the base of tongue by approximately 2.5 x 5 cm through an intraoral approach. Lingual tonsillectomy, epiglottectomy, and aryepiglottic fold reduction may be performed at the same setting. There usually is significant airway edema, necessitating tracheotomy.

**Submucosal minimally invasive lingual excision** – This procedure is performed under general anesthesia. The tongue base is infiltrated with 25 ml of saline, and the course of the lingual arteries is marked using a Doppler for guidance. An incision is made in the midline of the tongue, and the coblator is used to ablate tissue at the tongue base. Ablation is performed medially to the marked lingual arteries. The incision is left open, and heals by secondary intention. This allows for a greater degree of tongue base reduction than radiofrequency tongue base ablation, with less morbidity than the midline glossectomy.

**Mandibular Tongue Base Procedures**

**Geniotubercle advancement** – This opens the retrolingual space by pulling the tongue base forward. This is performed through a gingivobuccal incision. The midline of the mandible in the lingual cortex is the site of insertion of the genioglossus muscle. Osteotomies are made to mobilize the genial tubercle, with care not to cut the tooth roots. The gingival cortex is then drilled away, and the segment is advanced and rotated. It is secured in place with 1 or 2 screws, and the wound is closed.

**Repose system** – An intraoral incision is made at the mandibular frenulum, a titanium screw is placed at the lingual cortex of the geniotubercle. A permanent suture is then passed through the paramedian tongue bilaterally to the base of tongue, and back to the titanium screw in the lingual cortex. Tightening the screw pulls the tongue base anteriorly.

**Hyoid suspension** - horizontal cervical incision is made over the hyoid bone, and dissection is carried down to the suprathyroid musculature. The hyoid bone is then advanced over the thyroid ala, and secured with permanent suture.

**Maxillomandibular Advancement**

This procedure requires extensive preoperative measurements and planning in order to achieve surgical success. It is usually performed after the above surgeries have failed to improve obstructive sleep apnea. Cephalometrics can assist in evaluating the hypopharyngeal airway. This is an x-ray taken with the patient in profile, sagittal orientation. The important landmarks are the sella (S), nasion (N), anterior nasal spine (ANS), gnathion (Gn), gonion (Go), A point (A), B point (B), posterior airway space (PAS), and the hyoid (H). The normal angle for SNA is 82, and the normal for SNB is 80. Splints need to be made with preoperative occlusion, and intermediate occlusion. Advancement is performed by at least 10 mm for optimal results. A Lefort I osteotomy is performed with plating of the fractured segment after appropriate advancement. Bone grafts may need to be placed. The bilateral sagittal split osteotomy is then performed. The patient is then kept in maxillomandibular fixation.
Complications

Radiofrequency ablation is the safest method of addressing the base of tongue with a low rate of complications (3.4%). These range from mucosal ulceration, to superficial infection, and transient parasthesia of the hypoglossal nerve. The midline glossectomy and smile procedures allow for more resection, but also pose a greater risk to the hypoglossal nerve/lingual artery neurovascular bundle. There can be significant bleeding requiring neck exploration with ligation of vessels. There is also risk for airway edema, hematoma, abscess formation, and permanent hypoglossal injury. The Repose system and geniotubercle advancement, can cause patient discomfort if there is excess tension, and can cause mild aspiration that is temporary. MMA may cause permanent parasthesias of the mental, infraorbital, or inferior alveolar nerve because of stretching during advancement. This has been shown to occur in up to 89% of patients, in addition, many patients have TMJ complaints. MMA also may drastically alter the person’s facial appearance (89%). These are all things that must be discussed at the time of preoperative evaluation.

Future Directions

Sleep endoscopy – drug induced sleep endoscopy has been performed by infusing propofol until the patient was deeply sedated, but arousable to loud stimuli. An assessment of the patient’s airway is then performed to determine the sites of obstruction. This is relatively new, and has not been performed in the US at many centers, thus more studies are needed for a standardized protocol.

Sleep MRI – real time MRI image while the patient is asleep. This also is in early stages of research, but may help with determining the site of obstruction in the future.

Bariatric surgery - may play a role in patients with morbid obesity and severe obstructive sleep apnea. More studies

Conclusions

Obstructive sleep apnea affects millions of Americans. First line treatment includes behavioral modifications such as avoidance of alcohol and sedatives, discontinuing smoking, and weight loss, but the mainstay of therapy is continuous positive airway pressure. Compliance is defined as wearing the CPAP apparatus for five nights per week, and at least four to five hours per night. Because of excessive pressure, or many other side effects, there are patients that cannot tolerate CPAP. Titration studies can be performed to decrease the amount of pressure given, but some patients ultimately want a surgical solution for their sleep apnea. This disease is generally characterized by obstruction at multiple sites, and one surgery is not effective for all patients with sleep apnea. Because of this, many patients require multilevel upper airway surgery. Tongue base procedures are relatively novel, and knowledge of the anatomy is crucial to avoid injury to the hypoglossal nerve/lingual artery neurovascular bundle. These procedures should be offered to appropriately selected patients.
Discussion by Dr. Vicente Resto: Dr. Briscoe’s Grand Rounds presentation on OSA 11/20/2009

That was a great comprehensive review, Dr. Briscoe, about not only the definitions and diagnosis of sleep apnea but also the surgical interventions.

I think your talk highlights what I think is the greatest obstacle to understanding the effectiveness of the procedures in the management of this disease. And that is that the definition is so varied in terms of describing success or failure.

As reported in the first study that you reviewed where the group looked at improvement by using the Epworth score and as well as polysomnography and also demonstrated that although both of those measures improved greatly the Glasgow index failed to improve and that has the important component of a quality of live for the patient.

So it remains to be seen how many of these interventions really drive patient improvement. I think it’s fair to say that unless we achieve an RDI of less than 5 it’s really up for debate whether the things we do are really worthwhile or not or are we just simply impacting the patient by allowing them to better tolerate CPAP.

Alternatively, we know that there are physiological consequences to sleep apnea but none of these studies have looked that as an endpoint. Is there benefit from reducing the RDI by 50% yet still remain within the abnormal range as pertains to these comorbid scores? Does that translate into a physiologic improvement by way of preventing hypertension and perhaps some of the other cardiopulmonary issues?

As it stands today, one has to be cautious about the level of morbidity that one is willing to engage in with our patients, especially in a setting where we know that CPAP is truly curative.

Bibliography


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