A Cost-Effectiv and Rational Surgical Approach to Patients With Snoring, Upper Airway Resistance Syndrome, or Obstructive Sleep Apnea Syndrome

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The past decade has seen several innovations in the surgical techniques available for treatment of patients with sleep-disordered breathing. Outpatient techniques such as laser-assisted uvulopalatoplasty (LAUP) and more aggressive procedures designed to address hypopharyngeal and base of tongue obstruction (genioglossus advancement and hyoid myotomy) have been developed and proven successful. We describe the efficacy of LAUP for snoring (72.7%), upper airway resistance syndrome (81.8%), and mild (mean \[SD\] respiratory disturbance index \[RDI\] = 12 \(\pm\) 8.1) obstructive sleep apnea (41.7%) in 56 patients who underwent 132 LAUP procedures in a 26-month period. Thirty-two patients with more significant obstructive sleep apnea (mean \(RIM\) = 41.8 \(\pm\) 23.1) underwent multilevel pharyngeal surgery consisting of genioglossus advancement and hyoid myotomy combined with uvulopalatopharyngoplasty. The surgical success rate in this group of patients was 85.7% when commonly accepted criteria were applied. We recommend a stratified surgical approach to patients with sleep-disordered breathing. Progressively worse airway obstruction marked by multilevel pharyngeal collapse and more severe sleep-disordered breathing is treated with incrementally more aggressive surgery addressing multiple areas of the upper airway.

INTRODUCTION

Sleep-disordered breathing (SDB) encompasses a wide spectrum of disease severity. At one end of the spectrum is primary snoring without arousals, oxygen desaturations, or significant changes in intrathoracic pressure. At the other end of the spectrum is severe obstructive sleep apnea syndrome (OSAS) with frequent arousals, severely disrupted sleep architecture, frequent apnea-hypopnea events, abnormally negative intrathoracic pressures, and excessive daytime somnolence (EDS). Intermediate between these two extremes are milder forms of OSAS, as well as the recently described upper airway resistance syndrome (UARS). Patients with UARS have arousals during sleep related to an abnormally increased work of breathing and increased upper airway resistance, yet the respiratory disturbance index (RDI) may remain normal. These arousals commonly result in symptoms of EDS.1,2

Although surgical intervention is one of the well-recognized treatments of SDB, there is controversy as to which of the surgical approaches is most appropriate. Uvulopalatopharyngoplasty (UPPP), first described in 1964 by Ikematsu3 for treatment of snoring, was later found to be an effective, acceptable alternative to tracheostomy in patients with OSAS.4 In unselected patients with OSAS, however, reported success rates vary from 0% to 90%.5 In their extensive meta-analysis of 37 published reports on UPPP, Sher et al.5 reported the overall success of UPPP for OSAS to be 40.7% when success was defined as a greater than 50% drop in apnea index (AI) or RDI and a postoperative AI of less than 10 or a postoperative RDI of less than 20. The high failure rate that this implies may be explained by the likelihood of upper airway collapse at sites other than the palate.

A multilevel, pharyngeal surgical approach consisting of UPPP, mandibular osteotomy with genioglossus advancement (GA), and hyoid myotomy with advancement (HM) has been proposed by Riley et al.6,7 They reported a 60% success rate (RDI decreased
by more than 50% and a postoperative RDI of less than 20, or a result equivalent to the continuous positive airway pressure (CPAP) polysomnogram for this combined procedure.

The role of laser-assisted uvulopalatoplasty (LAUP) in the management of OSAS or UARS is less clear. LAUP has some degree of efficacy in treating OSAS, as documented by several recently reported success rates of 38.5% to 86.9%. The patients in one of these studies were selected for having predominantly velopharyngeal collapse. In each report, some patients had worsening of their OSAS after LAUP 8–10

Most prior investigations of the surgical management of patients with SDB have concentrated on the evaluation of a single intervention, for example, LAUP, UPPP, GA, HM, or nasal surgery. Because cause SDB is composed of patients with a wide spectrum of disease severity, we propose a surgical approach for the management of SDB that involves increasingly aggressive surgery for incrementally more severe SDB and multiple levels of pharyngeal collapse. This approach acknowledges the varied costs of the surgical procedures, the incremental surgical risk, and the likelihood of success of each technique in ameliorating SDB.

MATERIALS AND METHODS

A retrospective review of the patients referred to the Stanford University Medical Center Division of Otolaryngology-Head and Neck Surgery between November 1, 1993, and December 31, 1995, for evaluation of SDB was performed. The preoperative evaluation included a thorough history (focusing on the symptoms of OSAS, including EDS), complete head and neck examination, flexible fiberoptic nasopharyngoscopy with a modified Muller maneuver, the Epworth Sleepiness Scale (ESS) questionnaire, and polysomnography. A lateral cephalometric radiograph and panoramic radiograph of the mandible were also obtained for patients who were considered candidates for multilevel pharyngeal surgery.

Modified Muller Maneuver

The modified Muller maneuver was performed with the patient in a sitting position as described by Sher et al.16 The degree of collapse was graded separately at the retropalatal area, the lateral pharyngeal walls, and the base of tongue as follows: 0 for no collapse, 1+ for a 25% reduction in cross-sectional area, 2+ for a 50% reduction in area, 3+ for a 75% reduction in area, and 4+ for complete obstruction. A single examiner (D.J.T.) was responsible for all preoperative and postoperative evaluations. The examiner was blinded to the polysomnography data at the time of both preoperative and postoperative modified Muller maneuver. Differences between preoperative and postoperative modified Muller maneuver data were assessed using the paired Student’s t-test for means.

Epworth Sleepiness Scale

The ESS questionnaire determines the likelihood of dozing in each of eight situations, from highly soporific situations (lying down in the afternoon) to much less soporific ones (talking to someone). The patient rates each situation from 0 to 3, with 3 being the highest likelihood, giving a total range of scores from 0 to 24. A score of less than 7 is considered within normal limits, and a score greater than 9 is suggestive of SDB.17 Differences between preoperative and postoperative ESS data were assessed using the paired Student’s t-test for means.

Polysomnography

The patients were evaluated preoperatively and then at least 4 months postoperatively by polysomnography. Patients had either an attended in-hospital study or ambulatory polysomnography. The attended study consisted of nocturnal polygraphic monitoring, including electroencephalogram (C3/A2 and 02/A1 electrodes of the internation electrode placement system), electrooculogram, chin and leg electromyogram, and electrocardiogram (modified V2 lead), and intraesophageal pressure monitoring. Respiratory events were scored using similar criteria as used for in-hospital polysomnography.22 Differences between preoperative and postoperative polysomnography data were assessed using the paired Student’s t-test for means.

Surgery

Patients with primary snoring or UARS were encouraged to undergo LAUP. Those with mild OSAS (a RDI of more than 5 but less 20, without significant oxygen desaturation) were encouraged to undergo LAUP or UPPP depending on their preference. If these patients demonstrated significant preoperative lateral pharyngeal or base of tongue collapse on the modified Muller maneuver, they were offered multilevel pharyngeal surgery as a more aggressive alternative to LAUP or UPPP alone. Patients with moderate (RDI >20 and <40) or severe (RDI >40) OSAS usually had multiple sites of obstruction and were offered multilevel pharyngeal surgery. The patients with more severe OSAS were referred for continuous positive airway pressure (CPAP), to expeditiously treat their OSAS and so that CPAP was available for the perioperative period. A small number of patients with moderate or severe OSAS who already had CPAP requested treatment with LAUP alone. In all cases, patients with significant nasal obstruction were treated with topical nasal corticosteroids and, in the event of treatment failure, were offered a septoplasty with turbinate reduction. The "nasal spray..."
test” as described by Fairbanks23 (patients use intranasal decongestant spray on alternate nights for 1 week and then compare snoring on spray and nonspray nights) was useful in choosing appropriate surgical candidates.

A standard technique for UPPP was used as described originally by Fujita et al.4 and Simmons et al. Standard septoplasty was performed in a subset of patients and was combined with resection of approximately 50% of each inferior turbinate as described by Goode24.

The LAUP procedures were performed with a Luxar LX-20 CO2 laser (Bothell, WA) at a setting of 20 W, continuous mode. Uvular and palatal reduction was performed, as were bilateral vertical trenches through the palate (Fig. 1) and ablation of tonsils, when present. The patients received perioperative antibiotics (amoxicillin, 250 mg three times daily for 7 days) and perioperative corticosteroids (methylprednisolone, dispensed as a 6-day Medrol Dosepak). The number of stages ranged from 1 to 5, with each stage separated by a minimum of 4 weeks.

Multilevel pharyngeal surgery comprised three procedures (UPPP, GA, and HM) performed during a single operation as described by Riley et al.,7 using the modification in which a window is created in the mandibular symphysis to incorporate the genial tubercle, instead of an inferior sagittal osteotomy, and a second modification in which the hyoid is advanced over the thyroid laminae, instead of being suspended from the inferior mandibles (Fig. 2).

RESULTS

Of 229 patients who were evaluated in the Stanford University Medical Center Division of Otolaryngology-Head and Neck Surgery between November 1, 1993, and December 31, 1995, for treatment of snoring, OSAS, and/or EDS, 95 were determined to be candidates for surgical treatment. The remaining 134 patients either chose nonsurgical interventions (including CPAP, dental appliances, or behavioral modification) or refused conventional treatment. Twenty-one of these patients also underwent septoplasty and bilateral inferior turbinate resection of less than 20). Results were available for 12 of these patients. Preoperatively, 81.8% reported an improvement in the volume and frequency of snoring. This was a subjective determination based on interviews of the patient and sleep partner that were conducted at least 4 weeks after surgery. Patients were asked whether the snoring volume had changed and to what degree, and if the snoring occurred less frequently each night or on fewer nights per week. Snoring was completely cured in 23 patients (41.8%), 50% to 99% improved in 28 (50.9%), and less than 50% improved in 4 (7.3%). Overall, 72.7% of patients had greater than 70% improvement in their snoring.

Preoperative and postoperative modified Muller maneuver data were available for 18 patients, with palatal collapse decreasing from 2.5 ± 1.3 to 0.9 ± 1.3 (P < 0.001). No significant change was seen in collapse of the lateral pharyngeal walls or the base of tongue (Table I). One vasovagal episode occurred during LAUP and was successfully treated with conventional measures. One patient had postoperative palatal bleeding requiring electrocautery in the office. There were no major complications.

Of the 56 patients who underwent LAUP, 11 were diagnosed with UARS (minimal esophageal pressure [Peg] <20 mm Hg; RDI <10; and ESS >7).1,2 Of these patients, 81.8% reported improvement in EDS symptoms as evidenced by improved ESS scores from 13.5 ± 4.4 to 8 ± 2.5 (P = 0.002).

Multilevel Pharyngeal Surgery

Thirty-two patients underwent multilevel pharyngeal surgery consisting of UPPP, GA, and HM (30 men, 2 women; mean age, 46.1 ± 11 years; mean body mass index [BMI] = 31.1 ± 4.8). Nine of these patients also underwent septoplasty and bilateral inferior turbinate resection 1 month after UPPP/ GA/HM. The demographic, polysomnography, and anatomic data for the entire group are indicated in Table II. All patients snored. Of the patients in whom preoperative and postoperative ESS scores were available (29 of 32), the mean score fell from 12.1 ± 4.9 to 4.5 ± 4.1 (P < 0.001). Preoperative and postoperative polysomnography data were available for 14 of these patients. Preoperatively, 13 had
Fig. 1. a: Uvula and palate before laser-assisted uvulopalatoplasty. Dashed lines represent incisions to be made with the CO₂ laser. b: Vertical, through-and-through trenches created in the soft palate with the Luxar CO₂ laser handpiece with a backstop. c: The uvula is retracted anteriorly with a specially designed tongue blade, which also acts as a laser backstop and smoke evacuator. The uvula is resected at the first procedure to approximately 75% of its original length. d: Uvula and palate appearance after LAUP.
Fig. 2. Diagram of mandibular osteotomy, genioglossus advancement, and hyoid myotomy and suspension. The osteotomized mandibular segment is advanced and turned 90°, the outer cortex and marrow are removed, and the segment is secured with a titanium screw. The infrahyoid musculature is divided, as is the stylohyoid ligament. The hyoid bone is advanced over the thyroid laminae and secured with four nonabsorbable sutures.

patients (79.2%) had greater than 70% improvement in snoring.

Preoperative and postoperative modified Muller maneuver data were available for 21 of the 32 patients. The mean palatal collapse decreased from 3.3 ± 1 to 0.8 ± 0.9 (P < 0.001), the mean lateral pharyngeal wall collapse decreased from 2.5 ± 1.1 to 1.5 ± 1.1 (P < 0.05), and the mean base of tongue collapse decreased from 1.9 ± 1.4 to 0.7 ± 1.2 (P < 0.05).

Complications included five gingivolabial sulcus incision dehiscences (all healed spontaneously), two extruded screws and mandibular bony segments (one required operative management), one case of moderate ecchymosis and edema of the neck and face skin without airway compromise, and one gingivolabial sulcus wound infection that resolved with local wound care and antibiotics. All patients reported transient paresthesia of the mandibular incisors that resolved after 3 months.

Septoplasty and Inferior Turbinate Resection

Six patients underwent septoplasty and bilateral inferior turbinate resection (five men, one woman; mean age, 48.8 ± 11.1 years; mean BMI, 29.8 ± 6.2). ESS scores for four of the six patients worsened or remained unchanged, but the overall mean score decreased from 7.8 ± 5.2 to 6.8 ± 5.4 (P = 0.56). There was one case of surgical success for OSAS (50% reduction in RDI and RDI <20), but the overall mean RDI increased from 11.4 ± 4.9 to 20.7 ± 16 (P = 0.24) (Table III). Two of the six patients reported an improvement in the volume and frequency of snoring; it was completely cured in one patient (16.7%) and 50% to 99% improved in the other (16.7%). No complications were experienced.

The remaining seven patients had various procedures consisting of UPPP alone or in combinations with septoplasty, turbinate resection, or adenoidectomy. The heterogeneity of this group prevented meaningful analysis of the results.

Costs

Costs for various surgical procedures directed at treating SDI vary widely between institutions. The estimated charge, however, for complete treatment of snoring with LAPP is $2500. A UPPP with a single-night, inpatient hospitalization would incur a charge of approximately $10,600. Because of the need for one night in the intensive care unit and one night on the ward, the charge for UPPP/GA/HM is estimated to be $28,000. The approximate charge for outpatient septoplasty and bilateral turbinate trim is $9600. The above estimates include anesthesia fees, surgeon fees, and operating room and hospital charges where applicable. Reimbursement is considerably lower than the charges.

attended studies and 1 had an ambulatory study. Postoperatively, 12 had attended studies and 2 had ambulatory studies. The RDI decreased in 92.9% of these patients (13 of 14), and 57.1% (8 of 14) were considered a success by having a reduction in RDI of more than 50% and a postoperative RDI of less than 20. Application of the response criteria defined by Sher et al.5 (>50% drop in AI or RDI, with a postoperative AI <10 or a postoperative RDI <20) yielded a success rate of 85.7% (12 of 14 patients). The mean preoperative and postoperative data for this subgroup are detailed in Table II. The improvement in RDI (P = 0.011) and AI (P = 0.006) was statistically significant. All patients in the UPPP/GA/HM group for whom snoring data were available (24 of 32) reported an improvement in the volume and frequency of snoring; it was completely cured in 12 patients (50%), 50% to 99% improved in 10 (41.7%), and 25% or less improved in 2 (8.3%). Nineteen of 24
DISCUSSION

Since its description more than 25 years ago, SDB has been the focus of increasingly intense clinical and basic research. The protean manifestations of OSAS include snoring, hypertension, coronary artery disease, cerebrovascular disease, cerebral ischémia, cardiac arrhythmias, and sudden death.25-28 The consequences of significant daytime somnolence (usually the index symptom of UARS and mild OSAS) may include diminished cognitive function, decreased work productivity, impotence, and significantly increased risk of accident-related injuries and fatalities in drivers and heavy machinery operators.29

Because SDB comprises a spectrum of syndromes with incremental severity, it seems appropriate to devise a treatment algorithm that incorporates interventions that have an incremental degree of aggressiveness and associated morbidity and risk. The costs and risks associated with nonsurgical treatments for SDB such as weight loss, avoidance of sedatives and alcohol, and body positioning are negligible; therefore these measures should always be discussed with patients with SDB. Dental appliances, while sometimes costly, have low risk and may be considered. The best nonsurgical treatment, however, is nasal CPAP Patients who refuse CPAP or who are unable to tolerate it should be presented with surgical options that are commensurate with the disease severity.

In evaluating patients who have had surgical management of SDB, we have relied heavily on polysomnography for determining success. Indeed, many authors report postoperative success as an improvement in RDI or AI of greater than 50% and a postoperative RDI of less than 20 (or AI <10), or a polysomnography result equal to that when the patient is on a regimen of CPAP.5,7,9,30 However, the value of a lowered RDI in a patient with mild SDB and "success" based on these criteria may not be as significant as a reduction in daytime somnolence to a level that will prevent a fatigue-related motor vehicle accident. While the longitudinal study by He et al.21 established that untreated moderate SDB (AI >20) represents an important independent risk factor for morbidity and mortality, the significance of mild SDB (e.g., RDI between 5 and 20) is less clear. Therefore we emphasized the importance of improvement of EDS after each surgical approach, as represented by a reduction in the ESS score. The ESS is a reliable, economical alternative to the multiple sleep latency test for evaluating EDS, has high test-retest reliability, can help to differentiate snoring from more severe SDB, and may help to diagnose UARS in patients who may otherwise go undiagnosed with some types of sleep testing.31 For patients who demonstrate substantially improved ESS scores,
increased upper airway dimensions, and improved snoring, despite minimal improvement on sleep testing or insufficient improvement to be considered a surgical success, consideration should be given to the potential night-to-night variability of polysomnography results. This degree of variability may be derived from interobserver differences in scoring,32 the "first-night" effect,33 or variability in sleep position, alcohol use, or nasal congestion.22

Although there is bias built into any retrospective study, especially when subjective assessments are employed, we believed that the preoperative and postoperative modified Muller maneuver evaluation of the upper airway anatomy provided an important adjunct to the ESS and polysomnography. The examiner in the present study knew whether patients were in the presurgical or postsurgical period but was not aware of polysomnography data while grading collapse preoperatively or postoperatively, thereby minimizing bias. The modified Muller maneuver was particularly valuable when the multi-level pharyngeal surgical approach was assessed; those patients who were cured had more severe pre-operative collapse of the upper airway and a greater improvement in modified Muller maneuver scores postoperatively.

Our analysis confirmed that LAUP is an effective tool for the treatment of primary snoring, with 72.7% of patients reporting significant improvement (70%) of snoring. These results compare favorably with the greater than 70% resolution of snoring in 60% to 71% of patients reported by others.10,15 LAUP has not completely replaced UPPP for treatment in patients with this mildest form of SDB, but it remains an excellent alternative, since it can be performed in a cost-effective manner (approximately one fourth the cost of UPPP) in an office-based setting using local anesthesia, without the need for hospital admission.

The effectiveness of LAUP in the treatment of UARS was confirmed by improvement in EDS symptoms as evidenced by significantly reduced postoperative ESS scores. Guilleminault et al.1 recommended against the use of CPAP for the treatment of UARS and indicated that surgical management was desirable. Although our number of patients is too small to draw firm conclusions, it appears that LAUP is an appropriate surgical approach for patients with UARS.

Our experience with LAUP for OSAS, however, confirmed the limitations of single-level pharyngeal surgery for a disease that is often manifested by multilevel pharyngeal obstruction. Despite improvement in snoring and ESS scores for this group as a whole.
our polysomnography success rate (41.7%) is similar to that reported for UPPP, and since we failed to reproduce the remarkable results achieved by other authors,8 we continue to advocate LAUP primarily for patients with mild OSAS (RDI <20, LSAT > 85%) or for patients who refuse any other type of therapy. Therefore patients should understand the limitations of this procedure, and physicians should recognize the potential surgical risks, which include immediate postoperative worsening of the SDB34 and the potential for long-term worsening of OSAS in some patients.9,10 For this reason and for the purpose of evaluating treatment outcome,5 all patients should have preoperative and postoperative polysomnography.

Multilevel pharyngeal surgery (as described originally by Riley et al 5.7) was the most effective surgical approach for patients with OSAS in our review, as assessed by improvements in polysomnography, ESS, and upper airway dimensions. A success rate of 85.7%, using the criteria set forth by Sher et al.5, fell to 57.1% when improvement in only RDI was considered, and this compares favorably with previous reports.9 Our group of patients reported dramatic improvements in daytime somnolence as demonstrated by a decrease in mean ESS scores from 12.1 to 4.5. There was also marked improvement in the upper airway dimensions as measured by the modified Muller maneuver, especially at the level of the palate and the base of tongue. The patients who underwent this more aggressive surgery manifested the most severe degree of preoperative sleep disturbance and EDS; therefore we believe that the increased cost and potential operative morbidity were justified. Because the anatomic obstruction associated with SDB may occur at multiple sites and in severe cases usually does, it is logical to focus the surgical “attack” to address each of these sites.

There appears to be little role for septoplasty with bilateral inferior turbinate resection as the primary surgical modality in the management of SDB. In our small series the ESS scores worsened in two thirds of the patients, snoring improved in only one third, and only one of three patients (33.3%) achieved a significant reduction in RDI. However, because increased nasal resistance may contribute to the various degrees of SDB and because decreased nasal resistance reduces the arousal index,35 it seems appropriate to continue use of this modality in selected patients, usually as an adjunct to pharyngeal surgery or to improve the tolerance of CPAP.

The authors acknowledge that the total number of patients with preoperative and postoperative PSG data in this study is limited, preventing definitive conclusions regarding management of OSAS. An additional limitation is the fact that six patients had preoperative attended polysomnography followed by a postoperative Edentec study, which adds a potentially confounding variable. However, the Edentec system has been validated against level I polysomnography,22; furthermore, to minimize test-based differences, the ambulatory studies were restored manually by a sleep technician.

CONCLUSION

Laser-assisted uvulopalatoplasty is an effective surgical procedure for primary snoring and UARS, with success rates for snoring that are comparable to UPPP for one fourth the cost. It is appropriate to
offer LAUP to patients with mild OSAS, as long as the patient is aware of the surgical success rate and the possible need for additional surgery or CPAP.

Multilevel pharyngeal surgery is the most efficacious procedure for OSAS evaluated in this review and is particularly appropriate for patients with severe OSAS. Patients with more severe preoperative airway collapse during the modified Muller maneuver had a higher rate of surgical success. Septoplasty with bilateral inferior turbinate resection should be reserved as an adjunct to pharyngeal surgery or to improve the tolerance of CPAP.

We recommend an incremental approach to the management of SDB in which patients with more severe disease and greater, multilevel pharyngeal collapse are given treatment with incrementally more aggressive surgery that may involve higher costs and higher potential morbidity. The assessment of surgical success in the treatment of SDB should consider anatomic dimensions and improvement in daytime somnolence, in addition to polysomnography data.

**BIBLIOGRAPHY**