The Laryngoscope

The Effect of Multilevel Upper Airway Surgery on Continuous Positive Airway Pressure Therapy in Obstructive Sleep Apnea/Hypopnea Syndrome

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Objective: To investigate the effect of multilevel upper airway surgery (USA) on subsequent continuous positive airway pressure (CPAP) therapy in patients with obstructive sleep apnea/hypopnea syndrome (OSAHS).

Study Design: Fifty-two patients who underwent multilevel UAS with persistent symptoms of OSAHS represent the cohort for this study. All patients had undergone manual CPAP titrations both pre- and postoperatively. Patients were used as their own controls and were compared pre- and postoperatively with regard to body mass index, full night polysomnography (PSG), optimal CPAP pressure settings, presence of rapid eye-movement (REM) sleep, identification of mouth leakage, and CPAP compliance.

Results: Postoperative values for apnea index (AI), apnea hypopnea index (AHI), and minimum oxygen saturation (min SaO_2) were all significantly decreased from their preoperative levels. Compliance with CPAP therapy significantly increased from a mean 0.02 ± 0.14 hours per night prior to surgery to a 3.2 ± 2.6 hours per night following surgery ($P < .001$). In addition, the optimal CPAP pressure setting decreased significantly for a preoperative value of 10.6 ± 2.1 cm H_2O to 9.8 ± 2.1 cm H_2O following surgery. Fifty of the 52 patients (96.2%) studied were able to maintain optimal pressure settings without mouth leak, postoperatively.

Conclusions: In this study, most patients who had persistent symptoms of OSAHS after multilevel UAS did not have significant mouth leak that would preclude CPAP therapy. In this cohort of patients, CPAP pressure setting as well as compliance was significantly improved postoperatively.

Key Words: Post UPPP treatment, postoperative CPAP treatment, UPPP/CPAP.

***Laryngoscope*, 119:193–196, 2009**

INTRODUCTION

Since it was first described 1981, continuous positive airway pressure (CPAP) therapy has been the gold standard treatment for obstructive sleep apnea/hypopnea syndrome (OSAHS).[1] The most accepted mechanism of action of CPAP is that positive airway pressure acts as a pneumatic splint that anteriorly displaces collapsible tissue, preventing occlusion of the airway.[2] This mechanism can be highly effective because it can stabilize all levels of the upper airway concurrently. However, the formation of this pneumatic splint is dependent on having an airtight passage originating from the machine all the way to the lung. Any leak or escape of pressure may compromise the formation of the splint and adversely affect the efficacy of the treatment.

Although CPAP is a highly effective treatment, CPAP therapy has historically suffered from poor patient compliance.[3] Many patients, even those with severe disease, refuse to use CPAP. For those who cannot tolerate CPAP therapy, upper airway surgery (UAS) has offered an alternative mode of treatment. There has been significant debate about the role of UAS is the treatment algorithm of OSAHS, but one concern raised by a small number of studies is that UAS may adversely affect a significant number of patients who need postoperative CPAP therapy.[4,5] These studies observed that some patients were unable to tolerate subsequent CPAP therapy, and air leak in the mouth compromised the ability of forming an airtight tube. This concern is rather

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Editor's Note: This Manuscript was received on April 28, 2008 and accepted for publication on July 10, 2008.

Presented at the Combined Otolaryngological Spring Meetings (COSM), Orlando, FL, U.S.A., May 1–4, 2008.

This study was sponsored in its entirety by the principal investigator (Michael Friedman, MD, FACS). There are no financial relationships to disclose.

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DOI: 10.1002/lary.20021

serious, as many patients who do not respond to UAS may need to reattempt CPAP therapy.

There has also been also has been some debate in the literature concerning the effect of UAS on CPAP pressures. Series et al.[6] and Friedman et al.[7] both reported decreased CPAP pressures after nasal surgery. A follow-up study by Masdon et al.[8] found that there was no change in pressure settings after UAS. The effect of UAS on pressure settings is important to evaluate, as it has been hypothesized that higher pressures decrease patient tolerance of CPAP. If UAS increases pressure settings in a population already resistant to CPAP therapy, compliance with subsequent use may be severely compromised. However, if pressures are reduced, patient compliance may improve.

Over the past decade, the standard in UAS for OSAHS has been multilevel surgery. Multilevel surgery commonly addresses obstruction at the levels of the nose, palate, and hypopharynx. A systematic review of multilevel surgery demonstrates a success rate of 64%.[9] Although this result is significantly better than for uvulopalatopharyngoplasty (UPPP) alone, some patients who fail may want to reattempt CPAP therapy. The two small studies that evaluated the use of postoperative CPAP therapy examined only patients that had UPPP as their surgical procedure. No study has yet examined the effect of multilevel surgery on postoperative CPAP. This study is limited to patients who underwent only minimally invasive tongue base reduction in addition to UPPP and not true multilevel surgery.

This study was designed to assess the impact of multilevel UAS on subsequent CPAP therapy. First, we determined if postsurgical patients can maintain optimal, leak-free CPAP pressures that can effectively treat any residual OSAHS. Second, we compared CPAP pressure settings and compliance before and after UAS. This is the first study to assess CPAP tolerance and compliance after multilevel surgery.

METHODS

After institutional review board approval, the charts of 300 patients who underwent surgical intervention for OSAHS at a tertiary care institution were reviewed. All patients had received multilevel surgery consisting of UPPP and radiofrequency base of tongue reduction (RFBOT) and a variety of nasal procedures. Fifty-two of these patients underwent both pre- and postoperative CPAP titration studies and were the cohort for the present study. Patients were excluded from the study if they did not have persistent disease requiring CPAP therapy or felt enough symptom relief that they did not want to pursue further evaluation on therapy. Pre- and postoperative body mass index (BMI), Epworth Sleepiness Scale (ESS), full-night polysomnography (PSG) data, optimal CPAP pressure settings, presence of rapid eye-movement (REM) sleep, identification of mouth leak, and CPAP usage data was collected from the charts. Optimal CPAP setting was defined as the lowest pressure needed to achieve an apnea hypopnea index (AHI) of less than 5. CPAP usage was obtained from patient interviews and from smart cards on CPAP units when available.

Polysomnography and CPAP Titration

An all-night, attended, comprehensive sleep study was performed with a computerized polygraph to monitor electroencephalogram (C3-A2, C4-A1), left and right electrooculogram, electrocardiogram, chin and anterior tibialis electromyogram, abdominal, and thoracic movement by inductive plethysmography, nasal buccal airflow, oxygen saturation (SaO_2) by pulse oximetry, and throat sonogram. Apnea was defined as cessation of breathing for at least 10 seconds. Hypopnea was a decreased effort to breathe at least 50% less than baseline and with at least a 4% decrease in oxygen saturation. Apnea hypopnea index was calculated as the sum of total events (apneas and hypopneas) per hour. The minimum oxygen saturation levels (min SaO_2) were recorded.

CPAP titration studies were also performed under the same conditions as described above with the level of nasal CPAP (in centimeters of water) adjusted to reach the optimal pressure setting. Prior to all titration studies, patients were required to attend a short educational program to familiarize them with the CPAP machine. An experienced PSG technician discussed with the patients the mechanism CPAP and the advantages and disadvantages of the treatment. A careful review of all the equipment involved, including the different options for masks, as well as any questions the patients had were discussed in detail. An initial 15-minute trial was also conducted while the patient was awake to acclimate the patient to the mask and equipment.

The titration procedure was started after the patient was asleep. Nasal CPAP at an initial pressure of 4 cm of H_2O was applied. This pressure was slowly increased 1 cm of H_2O at a time until the lowest pressure setting needed to achieve an AHI of zero. This pressure is considered the optimal pressure setting for the patient. Tolerance of CPAP pressure was monitored by two primary modes. First, if an increase in pressure caused arousal from sleep, the pressure was considered nontolerable. Second, significant mouth leak that could compromise therapy was remotely monitored via an oral pressure sensor. Any pressure that achieved an AHI of less than 5, even if it was not zero, was considered acceptable.

Patient compliance with CPAP therapy was determined by telephone interview 3–4 months following the CPAP titrations. Patients were asked if they consistently use CPAP, and if so, for how long every night. Patients who were issued CPAP devices with time clocks were asked to return the programmed CPAP card for downloading CPAP usage data. Days of use and hours of use were combined to asses the mean hours of daily use. Of our 52 patients, three could not be contacted for follow-up compliance data.

Statistical Analysis

All statistical analyses were performed using SPSS Version 15.0.1 (SPSS, Inc., Chicago, IL). Continuous data is displayed as mean $\pm$ standard deviation (SD). Statistical significance was accepted when $P < 0.05$. The Levine's Test for Equality of Variances was used to determine statistically significant variances. The paired Student's t-test was used to compare preoperative versus postoperative mean values within each group. The Fisher's Exact test or the χ^2 test was used to test the association between categorical variables.

RESULTS

Data from 52 patients (42 males, 10 females), with a mean age of 43.1 $\pm$ 9.1 years (range: 12.8–68 years) and a BMI of 31.2 $\pm$ 5.0 kg/m^2 (range: 21.9–39.9 kg/m^2) patients who underwent preoperative and postoperative CPAP titration studies were included in the study However, in three patients CPAP compliance data could not be obtained. Table I compares PSG data collected

TABLE I.
Comparison of Polysomnography Data Collected Preoperatively to That Obtained at Six Months, Postsurgical Follow-up.

	Preoperative	Six-Month Postoperative	*P*
Body mass index (kg/m^2)	31.2 ± 5.0	31.2 ± 5.1	0.853
Apnea index	33.5 ± 23.6	8.9 ± 10.5	<0.0001
Apnea hypopnea index	63.2 ± 22.0	50.1 ± 19.7	<0.0001
Minimum SaO_2 (%)	71.9 ± 14.3	80.4 ± 7.8	<0.0001

Data listed as mean ± standard deviation. Statistical significance accepted when $P < 0.05$.
SaO_2 = oxygen saturation.

preoperatively to that obtained at 6 months postsurgical follow-up. Postoperative values for apnea index (AI), AHI, and minimum oxygen saturation (min SaO_2) were all significantly decreased from their preoperative levels (Table I).

Data on the ESS was assessed at three points: pretreatment, postoperatively (1–3 months), and after their postoperative CPAP titration study. The mean pretreatment ESS score was 16.5 ± 2.9. Even though this group of patients are those who failed to achieve postoperativeAHI scores that would qualify them as having had "successful" surgery, the mean postoperative ESS score was 10.1 ± 4.0, which is significantly better ($P < 0.01$) than the pretreatment ESS score. Ultimately, the patients were divided into two groups: CPAP users (CPAP used 4 hours/night) and CPAP nonusers (CPAP used for <4 hours/night on average). The mean postoperative (but pretitration) ESS score of the CPAP users was significantly higher (12.7 ± 2.3) compared with the ESS score of CPAP nonusers (7.9 ± 4.0; $P < 0.01$). After titration and reinstruction in CPAP usage, CPAP users had a clearly lower ESS mean score (3.9 ± 1.4) versus the CPAP nonusers (6.9 ± 3.5).

The CPAP apparatus compliance significantly increased from a mean 0.02 ± 0.14 hours per night prior to surgery to a 3.2 ± 2.6 hours per night following surgery ($P < .0001$). In addition, the optimal CPAP pressure setting decreased significantly for a preoperative value of 10.6 ± 2.1 cm H_2O to 9.8 ± 2.1 cm H_2O following surgery.

Based on CPAP titration data from the charts, 50 of the 52 patients (96.2%) studied were able to maintain optimal pressure settings without mouth leak, postoperatively. Of the 49 patients from whom CPAP compliance data was available, all were using the CPAP apparatus 1 hour or less per night preoperatively. Postoperatively, 23 (46.9%) were using the apparatus for 4 hours or greater each night. This difference was statistically different ($P < .0001$). The mean CPAP pressure for the 23 patients CPAP users was 10.1 ± 1.8 cm H_2O. This pressure was not significantly different than that of the CPAP nonusers (10.1 ± 2.2 cm H_2O).

DISCUSSION

The effectiveness of CPAP is undoubtedly high in treating those patients who use it regularly, but for those who refuse it the success rate is 0. It is to this subset of patients that surgical therapy can be useful. Surgery, however, does not cure all patients, and some patients are likely to have persistent disease. The question that then arises is: Does UAS adversely effect CPAP use?

Mortimore et al.[5] were the first to investigate this issue. In this study, nasal CPAP tolerance and compliance of 13 OSAHS without surgical intervention were compared to 13 patients who had undergone UPPP. All patients underwent nasal CPAP titrations when awake and in an erect position. Using this protocol, they found that all 13 untreated patients were able to reach maximum pressures of 20 cm H_2O, whereas all 13 patients treated with UPPP were intolerant of nasal CPAP at pressures within the normal therapeutic range and had significant mouth leak at 6.8 cm of H_2O. Based on these findings, they concluded that surgical intervention severely compromises the ability of patients to return to CPAP therapy. The major limitation of this study was that it was performed on a small number of awake, erect patients. Mortimer et al.[5] speculated that upper airway hypotonia associated with sleep may produce mouth leak at even lower pressure setting. However, this claim is highly debatable, as it is well known that the dynamics of the upper airway change considerable during sleep, and it is not prudent to extrapolate awake data to the sleep state. Because he did not use the same patients before and after surgery to compare the results, many other variables may have affected his findings. He did not attempt to match the groups by anatomic findings such as the Friedman tongue position (or modified Mallampati position).[10] These confounding factors as well as the small number of patients studied limit the broad applicability of these results.

A follow-up study conducted by Han et al.[4] in 2006 attempted to address these limitations. In this study, manual, nocturnal CPAP titrations of 31 newly diagnosed OSAHS patients were compared with 31 patients who underwent UPPP. They found that 5 (16%) of the post-UPPP group could not tolerate CPAP treatment due to severe mouth leak. Although a well-constructed study, the major limitation to this study was that only three patients underwent CPAP titrations before and after surgery. As in the Mortimer study, the use of an outside control group introduces many confounding factors that severely limit the findings.

This study was designed to use patients as their own controls. We believe that this protocol allows for a far more accurate assessment of the effect of surgery on subsequent CPAP use. All of the patients in this study had attempted the use of CPAP therapy prior to surgical intervention, but for various reasons did not comply with therapy. Although a surgical cure was not attained in these patients, almost all of them were able to attain optimal CPAP settings postoperatively. In this group the optimal pressure setting was reduced significantly by surgery.

This reduction in CPAP setting may improve patient compliance with CPAP therapy. Series et al,[6] documented increased compliance with the CPAP device

in patients with decreased CPAP requirements after nasal surgery. In a previous study by Friedman et al.,[7] CPAP settings were reduced in 44 patients after nasal surgery and the reduction of pressure was statistically significant in patients with severe OSAHS (AHI >30). This was also true in our study where CPAP compliance was significantly improved after surgical intervention. As all patients in our study refused to use CPAP preoperatively, their overall compliance was 0. These patients fell into the category of the greater than 50% of patients who refuse CPAP. The lack of response to surgery spurred many of these patients to reattempt CPAP therapy, and many of these patients were compliant. It is still unclear if the increase in compliance was a direct result of lowing CPAP pressures or other psychological factors, but surgery does seem to improve CPAP compliance in the subset of patients who refuse CPAP therapy prior to surgical intervention. Many patients are unwilling to accept surgery except as a last resort. Patients almost always attempt CPAP therapy first, before giving any consideration to surgery. Similarly, some patients will not psychologically accept CPAP therapy unless it is their only option; and they, therefore, opt for surgical intervention. When surgery fails, many of these patients are willing to reattempt CPAP. It is interesting to note that those patients who ultimately accepted CPAP had more complaints of daytime somnolence. Their mean postoperative ESS score was significantly higher than the CPAP nonuser group. This may have been a significant factor in motivating them for CPAP use.

Of our 52 patients, 2 (3.8%) were not able to attain optimal CPAP pressures. Both these patients had severe OSAHS (AHI >70) prior to surgical intervention. Despite their severe disease, they did not use CPAP. Although surgical intervention did provide some improvement in min SaO_2 and AI, the AHI largely remained unchanged. Both of these patients were in need of continued therapy. Although optimal CPAP pressure that reduced AHI to less than 5 could not be achieved after UAS, both patients could be titrated to achieve and AHI of less than 15. Both of these patients were very receptive to postoperative CPAP therapy and used it consistently for greater than 5 hours a night. Patients always still had the option to use a full face mask instead of nasal CPAP if the leak was significant.

Many factors may have impacted the strength of this study. Our major limitation was that this was a retrospective study; we were therefore limited to only patients who had pre- and postoperative CPAP titrations. Another major limitation of the retrospective design is that we were not able to record the maximum tolerated pressure (hCPAP). In both the Mortimer[4] and Han[5] studies postoperative patients had lower hCPAP pressures than the control group. Although there has been some speculation that hCPAP is an important indicator of the patient's ability to tolerate further adjustments to CPAP pressures in cases where significant BMI changes occur, this significance has not yet been determined. In this study BMI did not change significantly pre- and postoperatively, and we believe that our results accurately reflect ability of postsurgical patients to tolerate CPAP therapy. CPAP usage was calculated from CPAP smart cards when available, but in many cases it was based on patient interviews. This weakens the accuracy of that data.

Although a small percentage of patients could not achieve optimal nasal CPAP pressure to achieve an AHI less than 5, after UAS, they were still able to use nasal CPAP to achieve an AHI of less than 15. Over 96% of the patients were still able to use CPAP effectively and achieve an AHI <5. Overall CPAP pressures were also reduced after multilevel surgery and CPAP compliance was significantly improved.

CONCLUSIONS

This study demonstrates that multilevel upper airway surgery does not preclude the use of subsequent CPAP therapy. Ninety-six percent of the patients in this study were able to maintain optimal CPAP pressure settings after surgery without any difficulty. In this study, optimal CPAP pressures were also lower postoperatively. Although it is inconclusive whether pressure setting had a direct effect on patient compliance, patients were significantly more compliant with CPAP therapy postoperatively.

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