Impact of Upper Airway Surgery on CPAP Compliance in Difficult-to-Manage Obstructive Sleep Apnea

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Objective: To study the role of adjunctive upper airway surgery in obese patients with obstructive sleep apnea (OSA) who were poorly compliant with continuous positive airway pressure (CPAP) therapy.

Design: Retrospective study of obese patients with OSA and documented poor CPAP compliance who underwent noncurative upper airway surgery for anatomical obstruction. Data collected included polysomnogram (PSG) parameters, CPAP settings and compliance, and surgical complications.

Setting: An urban academic county hospital with an 8-bed sleep laboratory. Data were collected retrospectively from 2002 through 2005.

Patients: Subjects who met the following criteria: (1) documented OSA (apnea-hypopnea index [AHI] ≥5.0) treated with CPAP therapy, (2) poor CPAP compliance (<4 hours per night), (3) subjected to upper airway surgery, (4) repeated PSG after surgery revealed persistent OSA (AHI ≥5) requiring continued treatment with CPAP, and (5) availability of presurgery and postsurgery CPAP compliance data.

Main Outcome Measure: Compliance with CPAP.

Results: Data from 11 patients were available for analysis. Their PSG parameters revealed the mean AHI (79.0 before surgery vs 30.2 after surgery; \( P < .001 \)) and mean CPAP pressure setting (11.8 cm H\(_2\)O before surgery vs 10.4 cm H\(_2\)O after surgery; \( P = .09 \)) improved following surgery. A mean increase of 48.6 minutes in CPAP compliance was noted after surgery (\( P = .03 \)). Eight of the 11 patients improved their CPAP compliance following surgical intervention, including 5 who improved by more than 1 hour.

Conclusion: Upper airway surgery in select patients with OSA may improve CPAP compliance and should be considered as a potential adjunctive therapeutic measure in poorly compliant patients with OSA.


Obstructive sleep apnea (OSA) is a major health issue affecting 5% of the adult population.\(^3\) Recent data from the National Sleep Foundation\(^2\) suggest that the rate may be much higher as 26% of the general adult population meet high-risk criteria for OSA by the Berlin Questionnaire. Obstructive sleep apnea has been associated with numerous poor outcomes, including impaired quality of life,\(^3\) high accident rates,\(^3\) and increased cardiovascular morbidity and mortality.\(^3,6\) Treatment is aimed at alleviating symptoms, decreasing cardiovascular morbidity, and improving mortality.\(^3,6\)

In most cases, first-line therapy for OSA consists of treatment with positive airway pressure devices.\(^7\) This modality of treatment is highly effective for controlling OSA in the laboratory setting and for improving symptoms related to OSA.\(^7,8\) However, in those who accept treatment with continuous positive airway pressure (CPAP), compliance is often poor and may lead to suboptimal treatment or treatment failure.\(^9,10\) The National Commission on Sleep Disorders Research\(^11\) reported in 1993 that approximately 50% of the patients who received CPAP therapy discontinued it within the first year. Although recent advances in humidification, mask selection, and patient education can improve compliance,\(^12-15\) nightly usage remains poor in some patients who continue to use their CPAP for less than 4 hours per night. The reasons for poor compliance are varied, although nasal symptoms are frequently cited.\(^12,16-17\)

Controversy exists regarding the role of surgery in the management of OSA.\(^18,19\) Some authors\(^18\) recommend that surgery be considered as a first-line option for OSA...
therapy, whereas others10-22 feel upper airway surgery is an unproven treatment and should not be considered with few exceptions. There are a number of reasons to explain this disparity of opinion, some of which include the wide array of surgical options available, variable success rates reported in the literature, limited long-term outcomes, and potential for irreversible complications resulting from surgical intervention. In addition, the ability to accurately predict preoperatively who may benefit from which particular intervention has proven difficult.21

Numerous studies suggest that specific upper airway surgical procedures can improve the apnea-hypopnea index (AHI) in many cases.18,22 However, even when the AHI has improved, residual OSA can be clinically significant (AHI often exceeding 15 events per hour),10,22 and thus additional therapy following surgical intervention is often recommended. The impact of upper airway surgery on subsequent treatment with CPAP has not been well studied. There are conflicting data regarding the effect of surgery on postoperative CPAP pressure requirements.23-25 To our knowledge, only 1 study26 has examined CPAP compliance in the postoperative setting, suggesting CPAP compliance was worse in patients who had undergone uvulopalatopharyngoplasty (UPPP) compared with those who had not. However, in that study, postsurgery compliance was not compared with presurgery compliance. We hypothesized that upper airway surgery would improve CPAP compliance in poorly compliant patients with OSA with upper airway anatomical abnormalities.

METHODS

GENERAL STUDY DESIGN

A retrospective pilot study was performed at MetroHealth Medical Center (MHMC) in Cleveland, Ohio; MHMC is an urban academic hospital that serves as the county hospital for Cuyahoga County. The Center for Sleep Medicine at MHMC houses an 8-bed sleep laboratory. For the study, available data available from 2002 through 2005 were reviewed. The study was approved by the institutional review board at MHMC. Informed consent was not required.

SUBJECTS

Patients were identified from the sleep center’s database by searching for individuals who had undergone upper airway surgery prior to their sleep study. To be included in the study, patients had to meet the following criteria: (1) have documented OSA (AHI ≥ 5 by polysomnogram [PSG]) and receiving CPAP therapy, (2) have objectively documented poor CPAP compliance (<4 hours per night), (3) undergone upper airway OSA surgery, (4) undergone repeated PSG after surgery revealing persistent OSA (AHI ≥ 5) requiring further CPAP therapy, and (5) availability of presurgery and postsurgery CPAP compliance data. Obesity was not a requirement for study inclusion, although all patients meeting the inclusion criteria had a body mass index (BMI), calculated as weight in kilograms divided by height in meters squared, of at least 30. Data regarding demographics, PSG parameters, type of surgery, CPAP titrations, CPAP compliance before and after surgery, and complications following surgery were collected.

PSG FINDINGS

Each subject underwent a standard 15-channel PSG. Sandman software (Nellcor Puritan Bennett [Melville] Ltd, Kanata, Ontario, Canada) was used to collect data. Sleep was staged according to Rechtschaffen and Kales.21 Respiratory events were scored as follows: apnea was defined as cessation of airflow for at least 10 seconds with continued effort (obstructive) or lack of effort (central) to breath; hypopnea was defined as a reduction (≥30%) in airflow for at least 10 seconds accompanied by either an arousal or at least a 3% reduction in oxygen saturation. The AHI was calculated by dividing the number of respiratory events by the duration of sleep in hours. We titrated CPAP to eliminate respiratory disturbances, attempting to achieve an AHI of less than 5. Once this was accomplished, pressure adjustments could be made to eliminate snoring and reduce arousals. All studies were interpreted by 1 of 2 board-certified sleep physicians, who made determinations as to the optimal pressure setting for each patient and were unaware of this study.

CPAP COMPLIANCE

Compliance with CPAP was objectively measured using smart cards or by reading off the hour meter. Compliance was obtained after the subjects had been using their CPAP for 3 months. Following surgery, the mean time of the CPAP compliance check was 5.8 months, and the longest was 12.6 months. Prior to CPAP compliance checks, all patients had been seen by a sleep specialist or pulmonologist with sleep medicine training, and all had their CPAP mask interfaces optimized. No CPAP support sessions were held.

UPPER AIRWAY SURGERY

Patients were referred to an otolaryngologist (ear, nose, and throat [ENT] surgeon) by the sleep specialist to address surgical options for the patient’s OSA following documented poor CPAP compliance in the setting of an abnormal upper airway examination. The specific nature of the upper airway surgery offered was determined by the ENT specialist following direct upper airway examination via flexible endoscopy.

STATISTICAL ANALYSIS

The primary outcome measure was compliance with CPAP therapy; CPAP usage was reported in hours that the CPAP was pressurized per night. Four hours of use was considered to be 100% compliance, and hours of use totaling more than 4 hours were not reported. Compliance was analyzed using t test, and P < .05 was considered statistically significant. Secondary outcomes measured were BMI, Epworth Sleepiness Scale (ESS), AHI, and CPAP settings in centimeters of water before and after surgery. For analysis of the continuous variables, we used paired t test and Pearson correlation. Results were analyzed using SPSS statistical software (SPSS Inc, Chicago, Illinois).

RESULTS

Seventy patients were screened for enrollment in the study. Fifty-nine were excluded from analysis for the following reasons: 35 did not have CPAP compliance data available for analysis, 20 failed to have follow-up PSGs after surgery, and 4 had their OSA cured (AHI<5) by surgery.

Data on 11 patients were available for analysis. Their mean (SD) age was 49 (14) years (range, 26-67 years).
At baseline, the patients were morbidly obese (BMI, 41 [9]; range, 30-55) and had severe OSA (AHI, 79 [42] events per hour; range, 30-151 events per hour). Compliance with CPAP was poor, with a mean (SD) usage of 1 hour 58 minutes per night (range, 36-117 minutes). Of the surgical procedures performed, 36% of patients (4 of 11) underwent oral surgery alone and 64% (7 of 11) underwent combined oral nasal surgery (Table). Tonsillectomy, either alone or in combination, was performed in 82% of patients (9 of 11), and UPPP, always in combination with another procedure, was performed in 73% (8 of 11). The most common nasal surgery was a septoplasty (in combination with an oral procedure), performed in 55% of the study population (6 of 11).

Following surgery, the mean AHI improved from 79 to 30 events per hour (range of change in AHI, 11-72 events per hour) (P < .001) (Figure 1). Likewise, the mean CPAP requirement decreased from 11.8 cm H2O before surgery to 10.4 cm H2O after surgery, although this was not statistically significant (P = .09). Accompanying these changes, the mean CPAP compliance improved from a mean of 1 hour 58 minutes per night before surgery to 2 hours 46 minutes per night after surgery (P = .03) (Figure 2), an improvement of 49 minutes per night following surgery. Compliance with CPAP improved in 8 of the patients (73%) (interquartile range, 36-117 minutes). In 1 patient (9%), CPAP compliance did not change, and in 2 others (18%) it worsened. In 5 of the responders (63% of responders 45% of all subjects), compliance improved by more than 1 hour per night. The mean ESS on CPAP therapy decreased from 15.4 before surgery to 12.5 after surgery, although this was not statistically significant (P = .24).

The change in CPAP compliance after surgery did not correlate with either the change in the AHI (r²=0.2; P = .17) or the severity of the OSA after surgery (r²=0.05; P = .50). There was no change in mean BMI before surgery vs after surgery (41 vs 40; P = .50). All patients used a nasal interface and a heated humidifier both before and after surgery. No complications were reported following surgery.

Although CPAP is the primary treatment choice for most patients with OSA, poor compliance remains the major obstacle to effectively managing these patients. Traditionally, using CPAP for 4 hours per night for 75% of nights has been considered adequate.8 In support of this treatment, one study29 found a carryover effect from CPAP used for only 4 hours per night with a decrease in the AHI for the remainder of the night even though the patients were not using CPAP. However, recent data30 indicate that the more hours per night patients can use their CPAP, the better their functional outcomes. Measures to improve CPAP compliance are therefore essential for the optimal care of patients with OSA, and the present study suggests that adjunctive upper airway surgery should be considered as one such measure.

Sleep apnea surgery is typically undertaken with a curative intent, although a cure is often not achieved, especially in obese patients with severe OSA.31 Concern has been raised that some upper airway surgery, particularly UPPP, may lead to a loss of the soft palatal seal needed to pressurize the upper airway with CPAP, thus decreasing CPAP tolerance and adversely impacting CPAP compliance.32 In support of this finding, a retrospective study32 suggested that having undergone a UPPP was an independent risk factor for CPAP noncompliance (odds ra-

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**Table. Type of Surgery by Subject**

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<thead>
<tr>
<th>Subject</th>
<th>Type of Surgery</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>UP3, tonsillectomy</td>
</tr>
<tr>
<td>2</td>
<td>UP3, tonsillectomy</td>
</tr>
<tr>
<td>3</td>
<td>RF to palate and BOT, tonsillectomy, septoplasty</td>
</tr>
<tr>
<td>4</td>
<td>Tonsillectomy, turbinectomy, septoplasty</td>
</tr>
<tr>
<td>5</td>
<td>UP3, tonsillectomy, septoplasty</td>
</tr>
<tr>
<td>6</td>
<td>UP3, tonsillectomy, sinus antrostomy</td>
</tr>
<tr>
<td>7</td>
<td>UP3, septoplasty</td>
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<td>UP3, tonsillectomy</td>
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<tr>
<td>11</td>
<td>Tonsillectomy</td>
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Abbreviations: BOT, base of the tongue; RF, radiofrequency; UP3, uvulopalatopharyngoplasty.

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**Figure 1.** Apnea-hypopnea index (AHI) before and after surgery. Each symbol represents a unique individual. The dashes in the presurgery and postsurgery columns represent the mean values.

**Figure 2.** Continuous positive airway pressure (CPAP) compliance before and after surgery. Each symbol represents a unique individual. The dashes in the presurgery and postsurgery columns represent the mean values.
However, in both of these studies, CPAP compliance before vs after surgery was not compared, but rather CPAP compliance in patients who had undergone surgery was contrasted with compliance in those who did not undergo surgery. Furthermore, both of these studies examined UPPP surgery alone. None of the patients in our study who had a UPPP underwent this surgery in isolation but rather as part of a combined surgery. Although awake pressure tolerance measures were not obtained in our study, intolerance of CPAP during sleep was not found, and clinically significant oral leaking on CPAP was not documented.

The magnitude of the improved compliance seen in our patients may seem relatively low (mean, 48.6 minutes). However, this absolute increase in CPAP usage is comparable with other maneuvers advocated to enhance compliance.12-15 It is also likely that the absolute magnitude of improvement was underestimated in our study because data for more than 4 hours of CPAP usage per night were not available, and thus the incremental increase in the 3 patients who had a compliance of at least 4 hours per night after surgery was probably underestimated. It is worth noting that compliance increased by more than 1 hour in 45% of the patients (5 of 11).

The reason for the improvement in CPAP compliance following surgery is not entirely clear, although a reduction in the severity of the underlying OSA as well as in the CPAP pressure setting required to control the OSA could have contributed. However, our data did not find a correlation between either the change in severity of the OSA or the severity of the residual OSA after surgery and the improvement in compliance seen. Previous work15 has suggested that surgery may lead to increased comfort with CPAP in some patients. Because many of our patients were referred to the ENT surgeon owing to concerns that obstructing anatomic lesions were contributing to their poor compliance, it is conceivable that increased tolerance of CPAP resulting from surgical modification of their upper airway may account for the changes seen. Another possibility is that patients with residual OSA after surgery may be more motivated to use their CPAP because they now realize their treatment options are more limited. Because our study was retrospective, we were unable to assess the patients’ perception of comfort with CPAP or their motivation to use CPAP. Other maneuvers that may improve OSA (ie, weight loss) or CPAP compliance (ie, interface changes, humidification, CPAP support classes) do not seem to explain our findings.

An important limitation to this study is the small size and the considerable number of subjects who failed to meet the inclusion criteria for analysis. We were unable to verify CPAP compliance in 59% of the subjects excluded from the study (35 of 59 screened), mostly owing to the subjects either being lost to follow-up or the home health care agency’s inability or unwillingness to supply the compliance data. The possibility that these individuals were either more or less compliant with their CPAP therapy should be kept in mind when considering the results of this study. This highlights one of the real-life problems encountered when managing patients with OSA.

This small pilot study suggests that, in appropriately selected patients, upper airway OSA surgery may improve CPAP compliance in patients with OSA, even those who are morbidly obese. The approach requires collaboration between the sleep specialist and the ENT surgeon with an understanding before surgery that the goal is not to cure the OSA in these patients but rather to improve their chances of using their CPAP. Patients considered for this approach need to be aware of this intent before surgery.

Additional work is required to determine parameters by which to optimally select patients for adjunctive upper airway surgery. Furthermore, measures of sleepiness and quality of life, as well as long-term morbidity and mortality outcomes, need to be assessed for this approach to care. Despite these unresolved issues, this study suggests that adjunctive upper airway OSA surgery may be beneficial for some morbidly obese patients struggling to use their CPAP.

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Auckley. Acquisition of data: Chandrashekariah and Shaman. Analysis and interpretation of data: Chandrashekariah, Shaman, and Auckley. Drafting of the manuscript: Chandrashekariah, Shaman, and Auckley. Critical revision of the manuscript for important intellectual content: Auckley. Statistical analysis: Shaman. Administrative, technical, and material support: Shaman and Auckley. Study supervision: Auckley.

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