Tolerance of Positive Airway Pressure following Site-Specific Surgery of Upper Airway

Ho-Sheng Lin[*,#,1,2], Roger Toma[#,2], Cara Glavin[2], Mark Toma[2], M. Safwan Badr[3,4] and James A. Rowley[3]

[1]*Department of Surgery, John D. Dingell VA Medical Center, Detroit, MI, USA*

[2]*Department of Otolaryngology-Head and Neck Surgery, Wayne State University, Detroit, MI, USA*

[3]*Division of Pulmonary, Allergy, Critical Care & Sleep, Department of Medicine, Wayne State University, Detroit, MI, USA*

[4]*Department of Medicine, John D. Dingell VA Medical Center, Detroit, MI, USA*

Abstract: A significant proportion of patients may require the continued use of positive airway pressure (PAP) following upper airway surgery. The objective of this study is to determine whether site-specific surgical modification of upper airway improved tolerance to PAP treatment in those patients who continued to use PAP following surgery. Medical records of patients who underwent site-specific surgical modification of upper airway were identified on retrospective chart review. Of the 45 patients who had both preoperative and postoperative sleep studies and were successfully contacted, only 16 patients used PAP prior to the surgery and continued to use it following the surgery. Preoperative and postoperative AHI, lowest oxygen saturation, ESS, PAP pressure, PAP tolerability, number of hours per night of PAP use, and BMI were retrieved from medical records as well as phone interviews. Statistical analysis was performed using paired-samples t-tests in these 16 patients. Most of the 16 patients who continued to use PAP following the surgery did not "respond" to surgical treatment even though there was a statistically significant drop in AHI (p=0.027). Only 3 patients in this group were considered "responders" but they chose to continue the use of PAP because they continue to derive benefit from its use. Majority of these patients underwent UPPP in conjunction with some types of base of tongue procedure(s). Following surgery, statistically significant improvement in PAP tolerance (p=0.003), increased PAP use (p=0.015) and decrease in titrated PAP pressure (p=0.013) were noted. We found in this study that tolerance and compliance of PAP improved following site-specific upper airway surgery.

Keywords: Positive airway pressure, obstructive sleep apnea, site-specific surgery, compliance.

INTRODUCTION

Obstructive sleep apnea (OSA) is a disorder characterized by either complete or partial obstruction of the upper airway during sleep. The obstructions result in frequent arousals as well as oxyhemoglobin desaturations. Patients subsequently suffer from excessive daytime sleepiness and numerous cardiopulmonary sequelae [1, 2].

For patients diagnosed with OSA, some form of definitive treatment is indicated. Non- surgical options include the use of an oral device to increase the size of the upper airway or positive airway pressure (PAP). PAP is the most commonly used non-surgical option for treatment and is considered safe and effective. However, for various reasons [3, 4] compliance rates for PAP are poor ranging from 46% to 80% [5, 6].

Surgical approaches to treatment include a variety of options to increase the size or stabilize the upper airway to prevent collapse. Previously, surgery was directed at the level of the soft palate which was thought to be the main area of obstruction. The surgery most frequently performed was uvulopalatopharyngoplasty (UPPP). However, the effectiveness of this surgical treatment was brought into question by Sher *et al.* [7] who, in a meta-analysis, showed UPPP to be effective in less than 50% of the cases. At the same time, surgeons began to realize that obstructive sleep apnea is a disease entity which is more complicated than previously appreciated. The obstruction may involve multiple levels of the upper airway such as the level of the nose, soft palate, base of tongue, and epiglottis. As a result of this increased understanding of the complexity of the upper airway and pathogenesis of OSA, different surgical approaches have been developed to address the multi-level nature of upper airway narrowing. These surgical approaches, directed at the specific site(s) of obstruction (site-specific upper airway surgery) [8], can include Pillar procedure, UPPP, genioglossus advancement, hyoid myotomy and advancement, Repose tongue suspension, base of tongue resection, and radiofrequency treatment of base of tongue.

Surgical treatment for OSA remains the second line of treatment and should only be offered to patients who are not able to tolerate or unwilling to try PAP. Improvement in se-

*Address correspondence to this author at the Departments of Surgery and Otolaryngology/Head and Neck Surgery, John D. Dingell VA Medical Center and Wayne State University, 5 East University Health Center, 4201 St. Antoine, Detroit, MI 48201, USA; Tel: 313-577-0805; Fax: 313-577-8555; E-mail: hlin@med.wayne.edu

#The authors note that these two authors contributed equally.

1874-6209/08

verity of OSA can usually be achieved in properly selected patients using properly selected surgical techniques. However, despite proper selection of patients and techniques, a significant number of patients may still benefit from the use of PAP after surgery due to persistent obstruction. Treatment in this group of patients can be both challenging and difficult. Many sleep physicians felt that patients with persistent obstruction following UPPP are poor candidates for nasal PAP due to increased air leak through the mouth secondary to loss of the soft palatal seal. Surprisingly, this belief is rooted mainly on anecdotal evidence with very limited clinical data. There are only 2 studies that we can find in the English literature which showed that UPPP may compromise nasal CPAP treatment by increasing air leak through the mouth [9, 10].

Interestingly, we observed in our clinical practice that many patients, who continued to use PAP following surgery, actually reported improved tolerance of PAP postoperatively. Instead of relying on UPPP to treat all patients with OSA, we routinely emphasized the preoperative identification of the site(s) of airway obstruction in order to perform the appropriate surgical procedures directed toward the specific site(s) of obstruction. Although 2 previous studies have shown decreased tolerance of PAP therapy following UPPP, to the best of our knowledge, there has never been a study evaluating the change in PAP tolerance following site-specific upper airway surgery. In this study, we wanted to determine whether site-specific surgical modification of upper airway improved tolerance to PAP in those patients who continued to use PAP treatment following the surgery.

MATERIALS AND METHODS

Inclusion and Exclusion Criteria

Since we were interested in determining whether site-specific surgical modification of upper airway improved tolerance to PAP in those patients who continued to use PAP treatment following the surgery, we included only those patients who satisfied the following criteria:

1. History of prior upper airway surgery (such as UPPP, Pillar palatoplasty, genioglossus advancement, hyoid myotomy and advancement, and Repose tongue suspension) directed at specific site(s) of upper airway obstruction.
2. Availability of both preoperative and postoperative sleep studies.
3. Use or attempted use of PAP both before and after the surgery.
4. Verbal consent for a telephone interview.
5. Age greater than 18.
6. Documented diagnosis of OSA by a preoperative polysomnogram (PSG).

Patients were excluded if they did not meet any of the above criteria.

This study was approved by the Wayne State University Human Investigation Committee (HIC #: 125306M1E) and John D. Dingell VA Medical Center Clinical Investigation Committee (RCMS #: 2006-110258).

Surgical Procedure

All patients were encouraged to use PAP as first line of treatment for their OSA. Surgery was reserved for patients who were unable to tolerate or refuse to use PAP. Prior to the surgery, patients were evaluated in order to determine, to the best of our ability, the site of airway obstruction. This evaluation was based on both the examination of the soft tissue structures (tongue, tonsil, pharyngeal wall, epiglottis, etc.) as well as assessment of soft tissue collapsibility using the Mueller maneuver. Some patients also underwent sleep endoscopy with the use of propofol. If a patient was felt to have an obstruction at the level of the soft palate only, a procedure directed at the velopharyngeal level such as UPPP was performed. For those patients who were felt to have obstruction at both the level of soft palate and base of tongue, UPPP was performed in conjunction with some types of base of tongue procedures such as Repose tongue suspension, genioglossus advancement, hyoid myotomy and advancement, and coblation-assisted base of tongue resection. All surgeries were performed by or under the direct supervision of a single experienced sleep apnea surgeon (HSL) in a tertiary academic setting.

Review of Medical Records and Phone Interviews

A retrospective chart review was done on all patients who underwent site-specific upper airway surgery from April 2003 to September 2006. A total of 137 patients were identified but only 53 of these patients had both preoperative and postoperative sleep studies. We were successful in contacting 45 of these patients who consented to the phone interview.

During the phone interview, patients were asked to compare their ability to tolerate PAP before and after the surgery using a visual analog scale (VAS) from 0 to 10, with 0 being unable to tolerate at all and 10 being a very high degree of tolerance. They were also asked about the average number of hours of PAP used per night before and after the surgery. An Epworth Sleepiness Survey (ESS) was also conducted over the phone.

Preoperative and postoperative sleep studies were reviewed for body mass index (BMI, derived from weight and height), apnea-hyponea index (AHI), lowest oxygen saturation, and titrated PAP pressure. Clinical records were also reviewed for preoperative ESS and this was compared to the postoperative ESS obtained during the phone interview.

Analysis of Data

Paired-samples t-tests were performed using SPSS 15.0 (SPSS Inc., Chicago, IL) comparing preoperative and postoperative AHI, lowest oxygen saturation, ESS, PAP pressure, PAP tolerability, number of hours per night of use of PAP, and BMI.

RESULTS

Of the 53 patients who had both preoperative and postoperative sleep studies, 45 of these patients were contacted successfully and agreed to the phone interview. Seventeen of these patients never used PAP preoperatively or postoperatively and thus were excluded from further analysis. There were 12 patients who used PAP before but not after the surgery. Ten out of these 12 patients who discontinued PAP use

postoperatively were considered "responders" by the surgical criteria (defined as reduction of AHI greater than 50% with the final AHI less than 20) [8, 11, 12]. Two patients who did not "respond" to surgery refused to continue PAP use after the surgery because they felt better symptomatically and did not feel that PAP use was beneficial. Since we are focused on comparing the tolerability of PAP before and after surgery in this study, these 12 patients were also excluded from further analysis. Thus, only 16 of the 45 patients interviewed were included in the final analysis of this study (Fig. **1**).

As expected, most of the patients in this analysis group did not "respond" to surgical treatment. In fact, only 2 of the 16 patients in this group were considered "responders" but they chose to continue the use of PAP because they continue to derive benefit from its use. The majority of patients in this analysis group underwent UPPP in conjunction with some type of base of tongue procedure such as hyoid myotomy and advancement, genioglossus advancement, and/or repose tongue suspension. Five patients had UPPP only and one patient had a Pillar procedure (Table **1**). Fifteen of these 16 patients used nasal mask whereas one patient used facial mask. There was no statistical significant difference (p=0.63) between the preoperative BMI and the postoperative BMI. The mean AHI preoperatively was 65.1 and postoperatively was 42.1 (p=0.027) and the mean lowest oxygen saturation preoperatively was 79.8% and postoperatively was 82% (p=0.142) (Table **2**). The mean ESS was 13.3 preoperatively and dropped to 6.3 postoperatively (p=0.0001). Mean subjective PAP tolerability (N=16) preoperatively was 4.25 vs. 6.75 post-op (p=.003) (Table **2**). Mean PAP pressure (N=12) dropped from 11.5 preoperatively to 9.4 post-op (p=.013) (Table **2**). Four patients were not included in the statistical analysis because 1 patient could not be optimally titrated preoperatively and 3 patients did not undergo postoperative titration. There was an increase in mean hours per night of PAP use (N=16) from 4.1 hours preoperatively to 5.5 postoperatively (p=.015) (Table **2**).

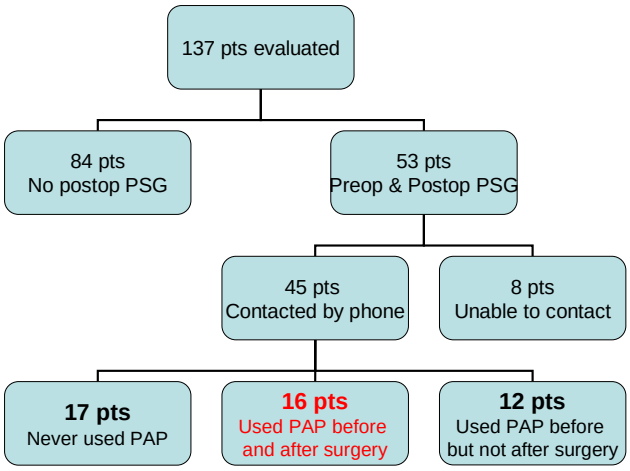

Fig. (1). Of the 137 patients identified, 84 patients did not have a postoperative sleep study, 8 patients were unable to be contacted, 17 patients never used PAP, and 12 patients stopped using PAP following the surgery. Thus, only 16 patients with both preoperative and postoperative sleep studies and who used PAP before and after the surgery were included in the final analysis.

DISCUSSION

Obstructive sleep apnea has remained a difficult medical problem to treat despite our increased understanding of the disease process as well as improvement in treatment modalities. Although PAP is an effective treatment for OSA, compliance remains a major issue. For those patients unable to tolerate PAP, surgical treatment may be their last option. However, many sleep physicians are reluctant to refer these patients to their surgical colleagues because of the belief that UPPP is often ineffective and that PAP treatment following UPPP failure is more difficult [10]. Surprisingly, there is limited data in the literature addressing the change in compliance of PAP following surgical treatment. Mortimore *et al*. showed that the mean maximal CPAP pressure tolerated by OSA patients following UPPP was only 14.5 cm H_2O which was significantly less than that in the group of OSA patients never treated with UPPP (p<0.001) [10]. In the laboratory setting, they found that patients with history of UPPP experienced air leak *via* the mouth at a mean CPAP pressure of 6.8 cm H_2O whereas patients without history of UPPP did not experience air leak even at a CPAP pressure of 20 cm H_2O [10]. However, these studies were performed with the subjects awake and may not really represent actual sleep state, where muscle hypotonia may permit better oral seal to occur. Mortimore *et al*. also showed that OSA patients with history of UPPP (n=8) has significantly lower compliance with mean machine run time of 3.5 hours per night compared with OSA patients without history of UPPP (n=16) with mean machine run time of 5.7 hours per night (p=0.01) [10]. It is unclear whether or not the authors take into account of the fact that patients who underwent UPPP may be less compliant to CPAP to start with. A better design to answer this clinically relevant question of whether or not UPPP benefited these patients would be to compare the preoperative and postoperative CPAP use in these OSA patients. Another study by Han *et al*. also showed compromised nasal CPAP use in OSA patients following UPPP. In this study, 5 out of 31 (16%) OSA patients with history of UPPP failed CPAP treatment due to a severe mouth air leak [9]. Of these 31 patients, only 3 have both preoperative and postoperative CPAP titration. Following the surgery, one of these patients required increased CPAP pressure, one required the same CPAP pressure, and one could not tolerate titration during REM sleep due to air leak at a pressure of 10 cm H_2O [9]. In contrast to the above studies, one paper by Masdon *et al*. published in the otolaryngology literature showed that UPPP may improve CPAP tolerability [13]. The authors identified 35 patients who underwent sleep study before and after UPPP and found that the CPAP pressure setting was decreased in 51.4%, unchanged in 20%, and increased in 28.6% of these patients following the UPPP. Unfortunately, only 6 of their patients used CPAP in a consistent basis both before and after the surgery. Four of these 6 patients reported improved CPAP comfort and 2 patients reported unchanged or worse CPAP comfort following UPPP [13].

The limited literatures on CPAP tolerance following surgery described above were all focused on OSA patients who have undergone UPPP procedure. To the best of our knowledge, there has never been a study evaluating the change in PAP tolerance following site-specific upper airway surgery, which may involve UPPP in addition to other base of tongue

Table 1. Preoperative and Postoperative BMI, AHI, Lowest Oxygen Saturation, ESS, PAP Pressure, Hours/Night of PAP Use, and Tolerability of PAP of the 16 Patients in this Study

Surgery	BMI Preop	BMI Postop	AHI Preop	AHI Postop	ESS Preop	ESS Postop	PAPp Preop	PAPp Postop	Hrs / night Preop	Hrs / night Postop	Toler-ance of PAP Preop	Toler-ance of PAP Postop
UPPP Genio	37.4	28.1	18	9	12	0	7.5	6	4	6	3	7
UPPP Hyoid Genio	34	34	50.9	19.7	21	18	9	9	7	7.5	0	8
UPPP Hyoid Genio	33	34.3	32.1	38	18	1	10	7	7	7	6	9
UPPP Hyoid Genio	37	37	81.2	46.9	13	10	10	11	4	4	5	7
UPPP Hyoid Genio	35	33	68.8	42.4	16	6	20	14	5.4	10	10	8
UPPP Hyoid Repose	27.4	27.4	29.7	32.9	16	8	10	7	6	6	8	9
UPPP Hyoid Repose	31	31	36.3	34.8	19	19	12	9.5	1	5	5	6
UPPP Hyoid Repose	37	35	83	32.5	8	3	13	NT	4	6	4	6
UPPP Hyoid Genio	42.8	45.5	103	100	21	7	UT	16	0	5	0	8
UPPP Hyoid Genio	35	35	58.5	80	3	2	12	10	7	7	8	7
UPPP	36.8	36.5	11.3	7.7	12	0	8	NT	2	0	3	5
UPPP	41	43	148	37.8	12	7	7	7	4	6	3	8
UPPP	34.5	36.3	79.3	63.3	8	4	15	8	4.5	5	3	4
UPPP	29.7	30	190	84	14	7	15	14	3	6.5	3	8
UPPP	25.8	26	27.7	25.6	10	1	16	NT	0	0	0	0
Pillar	28.8	28.8	24.8	19.5	9	7	10	10	7	7	7	8

PAPp=Positive airway pressure, UT = Unable to titrate, NT = Not titrated, UPPP = Uvulopalatopharyngoplasty, Genio = Genioglossus advancement, Hyoid = Hyoid myotomy and advancement, Repose = Repose tongue suspension.

Table 2. Paired Samples t-Test Comparing Mean BMI, AHI, Lowest Oxygen Saturation, ESS, PAP Tolerability, PAP Pressure, and Hours/Night Used before and After Surgery

Mean	N	Mean Preoperative (± SD)	Mean postoperative (± SD)	P value
BMI (pounds/inch^2)	16	34.137 (± 4.705)	33.806 (± 5.358)	0.630
AHI	16	65.150 (± 49.160)	42.131 (± 26.890)	0.027
Lowest Oxygen Saturation (%)	16	79.813 (± 7.867)	82.000 (± 7.023)	0.142
ESS	16	13.250 (± 5.066)	6.250 (± 5.700)	0.000
PAP Tolerability (VAS scale)	16	4.250 (± 3.000)	6.750 (± 2.266)	0.003
PAP Pressure (cm H_2O)	12	11.458 (± 3.677)	9.375 (± 2.638)	0.013
Hours/night Use (hours)	16	4.119 (± 2.422)	5.500 (± 2.536)	0.015

procedures. In this study, we identified patients who underwent site-specific upper airway surgery which involved preoperative identification of site of upper airway obstruction followed by surgical procedures directed at the site of airway obstruction. Of the 137 patients identified, 84 patients did not have a postoperative sleep study (a common problem in urban setting with poor patient compliance and follow-up), 8 patients were unable to be contacted, 17 patients never used PAP, and 12 patients stopped using PAP following the surgery. Thus, only 16 patients with both preoperative and postoperative sleep studies and who used PAP before and after the surgery were included in the final analysis. We showed statistically significant improvement in subjective PAP tolerance (using visual analog scale), decrease in titrated PAP pressure, and increase in PAP use per night following site-specific upper airway surgery. While 10 out of these 16 patients underwent multilevel upper airway surgery (UPPP in combination with genioglossus advancement, hyoid myotomy and advancement, and/or Repose tongue suspension), the remaining 6 patients only had surgeries involving the level of soft palate since preoperative assessment revealed obstruction only at the soft palate level.

Increased air leak through the mouth was demonstrated to be the main reason contributing to the increased difficulty with nasal CPAP use following UPPP [9, 10]. This increase in air leak was thought to be due to the loss of soft palatal seal following the UPPP. However, another possible contributing factor may be the persistent obstruction at the level of the base of tongue which was not addressed by the UPPP. Air flow from the PAP may be diverted away from base of tongue region and toward the path of least resistance out of the mouth. Thus, identification and surgical correction of airway obstruction at the base of tongue level, if necessary, may be important in order to allow continued or even improved use and tolerance PAP following surgery.

There are several limitations to our study. First, the number of patients included in this study is unfortunately small (n=16). However, we were able to achieve statistical significance despite this small number. Our data is further limited by the subjective nature of questions such as ESS and PAP tolerance. Finally, the number of hours of PAP use was based on self-reporting by patients and not on objective data obtained from compliance meters, which were not available until recently in our institutions. Despite these limitations, we believe the finding from this small pilot study is clinically significant and hopefully can serve to stimulate further research in this area. The finding that PAP tolerance and compliance improved following surgery should serve to support an increasingly important role for the use of site-specific upper airway surgery in patients noncompliant with PAP treatment. Surgery may benefit the majority of these patients by either eliminating the need for PAP in "responders" or improving the tolerance and compliance of PAP in "nonresponders". Thus, in addition to focusing on the use of surgery as a possible alternative to PAP, we should also direct our focus on the use of surgery as adjunct to PAP treatment. Indeed, we should redefine surgical success not just based on the amount of AHI reduction but also on the improvement in PAP tolerance and compliance following surgery. This combined approach will hopefully foster a more cooperative atmosphere between sleep medicine physicians and sleep apnea surgeons to work together to benefit those OSA patients unable to tolerate PAP.

CONCLUSIONS

Site-specific upper airway surgery may improve subjective tolerance and compliance to PAP in those patients who continued to require the use of PAP treatment following surgery. Although the finding from this study is promising, future prospective study will be needed to validate preliminary results from this study. If validated, this finding will have a significant clinical implication since it will help establish another important role for the use of surgical treatment in patients noncompliant with PAP therapy.

REFERENCES

[1] Marin JM, Carrizo SJ, Vicente E, Agusti AG. Long-term cardiovascular outcomes in men with obstructive sleep apnoea-hypopnoea with or without treatment with continuous positive airway pressure: an observational study. Lancet 2005; 365(9464): 1046-53.

[2] He J, Kryger MH, Zorick FJ, Conway W, Roth T. Mortality and apnea index in obstructive sleep apnea. Experience in 385 male patients. Chest 1988; 94(1): 9-14.

[3] Lin HS, Prasad AS, Pan CJ, Rowley JA. Factors associated with noncompliance to treatment with positive airway pressure. Arch Otolaryngol Head Neck Surg 2007; 133(1): 69-72.

[4] Lin HS, Zuliani G, Amjad EH, *et al*. Treatment compliance in patients lost to follow-up after polysomnography. Otolaryngol Head Neck Surg 2007; 136(2): 236-40.

[5] Kribbs NB, Pack AI, Kline LR, *et al*. Objective measurement of patterns of nasal CPAP use by patients with obstructive sleep apnea. Am Rev Respir Dis 1993; 147(4): 887-95.

[6] McArdle N, Devereux G, Heidarnejad H, Engleman HM, Mackay TW, Douglas NJ. Long-term use of CPAP therapy for sleep apnea/hypopnea syndrome. Am J Respir Crit Med 1999; 159(4 Pt 1): 1108-14.

[7] Sher AE, Schechtman KB, Piccirillo JF. The efficacy of surgical modifications of the upper airway in adults with obstructive sleep apnea syndrome. Sleep 1996; 19(2): 156-77.

[8] Riley RW, Powell NB, Guilleminault C. Obstructive sleep apnea syndrome: a review of 306 consecutively treated surgical patients. Otolaryngol Head Neck Surg 1993; 108(2): 117-25.

[9] Han F, Song W, Li J, Zhang L, Dong X, He Q. Influence of UPPP surgery on tolerance to subsequent continuous positive airway pressure in patients with OSAHS. Sleep Breath 2006; 10(1): 37-42.

[10] Mortimore IL, Bradley PA, Murray JA, Douglas NJ. Uvulopalatopharyngoplasty may compromise nasal CPAP therapy in sleep apnea syndrome. Am J Respir Crit Care Med 1996; 154(6 Pt 1): 1759-62.

[11] Kao YH, Shnayder Y, Lee KC. The efficacy of anatomically based multilevel surgery for obstructive sleep apnea. Otolaryngol Head Neck Surg 2003; 129(4): 327-35.

[12] Terris DJ, Kunda LD, Gonella MC. Minimally invasive tongue base surgery for obstructive sleep apnoea. J Laryngol Otol 2002; 116(9): 716-21.

[13] Masdon JL, Magnuson JS, Youngblood G. The effects of upper airway surgery for obstructive sleep apnea on nasal continuous positive airway pressure settings. Laryngoscope 2004; 114(2): 205-7.

Received: February 11, 2008 Revised: May 28, 2008 Accepted: May 29, 2008