Transoral Robotic Surgery for Obstructive Sleep Apnea
Perioperative Management and Postoperative Complications

Tiffany A. Glazer, MD; Paul T. Hoff, MS, MD; Matthew E. Spector, MD

IMPORTANCE Patients who undergo surgery for obstructive sleep apnea (OSA) have acceptable perioperative morbidity that is similar to that seen in other sleep-related surgical procedures.

OBJECTIVE To perform the first large-scale evaluation of perioperative management and postoperative complications in patients who undergo transoral robotic surgery (TORS) for OSA.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study from 2010 to 2013 of 166 adult patients with moderate to severe OSA (defined as apnea-hypopnea index, >20) who had experienced failure of conventional therapy with positive airway pressure and underwent TORS at an academic practice with follow-up greater than 3 months.

INTERVENTIONS Transoral robotic surgery with or without additional multilevel airway procedures.

MAIN OUTCOMES AND MEASURES Major and minor complication rates.

RESULTS There were 122 men and 44 women with a mean (SD) age of 54.6 (12.3) years. The mean (SD) American Society of Anesthesiologists (ASA) score was 2.3 (0.5). There were 11 major complications, including secondary bleeding requiring intervention (7 patients), pulmonary embolism requiring anticoagulation therapy (2 patients), aspiration requiring prolonged hospitalization (1 patient), and dysphagia resulting in gastrostomy tube dependence (1 patient). There were 32 minor complications, including dehydration and/or uncontrolled pain (16 patients), globus sensation (8 patients), bleeding (5 patients), lip burn (2 patients), and pharyngeal laceration during intubation (1 patient); the majority resolved without sequelae. Preoperative ASA score ($P = .003$) and number of procedures performed ($P = .004$) predicted a postoperative complication. Age ($P = .29$), body mass index ($P = .55$), apnea-hypopnea index ($P = .67$), lowest arterial oxygen saturation ($P = .63$), number of comorbidities ($P = .46$), and individual comorbidities did not predict a complication.

CONCLUSIONS AND RELEVANCE Transoral robotic surgery can be safely performed in patients with OSA with an acceptable complication rate. Complications are similar to those seen with other surgical treatments of OSA and were only predicted by ASA score and number of procedures performed.

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Obstructive sleep apnea (OSA) is a substantial health problem in the United States, affecting 2% to 4% of men and 1% to 2% of women between the ages of 30 and 69 years. Comorbidities such as hypertension, stroke, myocardial infarction, diabetes mellitus, and arrhythmias are more common in patients with OSA. Given the well-known association of OSA with cardiopulmonary and neurologic sequelae, the expansion of treatment options for these patients is critical. The most commonly used and recommended treatment for OSA is use of positive airway pressure (PAP). Whereas PAP is extremely effective in the treatment of OSA, its tolerability, adherence to its use, and its social stigma make it difficult for many patients.

Surgical management of OSA has appeal to both patients and providers as a single intervention that could limit health care costs and avoid the requirement of PAP. Surgical treatment for OSA aims to relieve obstruction by increasing the volume of the airway, bypassing the pharyngeal airway, or removing a specific pathologic lesion. Tonsillectomy, uvulopalatopharyngoplasty, transoral midline glossectomy, genioglossal advancement with hyoid suspension, maxillomandibular osteotomy and advancement, and use of oral appliances are measures that focus on individual subsites of obstruction and have had variability in their effectiveness. Tracheotomy has been used to bypass pharyngeal obstruction completely, although patients typically wish to avoid this intervention. Despite the multiple available procedures, current treatments continue to rely on careful patient selection and appropriate application of surgical interventions.

In 2 published case series, Vicini et al were the first group to present transoral robotic surgery (TORS) as an acceptable approach to the tongue base in patients with OSA. In their series of 10 and 20 patients, all patients first underwent routine tracheostomy followed by TORS base of tongue resection, with apnea-hypopnea index (AHI), minimum arterial oxygen saturation, and Epworth Sleepiness Scale (ESS) significantly improved after TORS. In a series of 27 patients with OSA, Friedman et al showed that similar outcomes could be achieved via TORS without routine tracheostomy. Although these studies have shown significant improvement in AHI, their patient numbers have been small. We sought to perform a large-scale evaluation of perioperative management and postoperative complications in patients who undergo TORS for OSA.

Methods

Preoperative Evaluation
This study was approved by the St Joseph Mercy Health System institutional review board, and a waiver of informed consent was obtained. The patients were consecutively evaluated by a single surgeon (P.T.H.) between December 2010 and November 2013. There were 166 adult patients with moderate to severe OSA (defined as AHI, >20) for whom conventional therapy with PAP had failed. Preoperative workup included a polysomnogram, completion of ESS, and detailed office examination followed by drug-induced sedated endoscopy. Demographic characteristics, preoperative polysomnogram results (including AHI and arterial oxygen saturation nadir), and ESS are summarized in Table 1. There were 122 men and 44 women with a mean age of 54.6 years. The mean American Society of Anesthesiologists (ASA) score was 2.3. This score is a 6-category physical status classification system defining an individual’s overall functional status: 1, a healthy person; 2, a person with mild systemic disease; 3, a person with severe systemic disease; 4, a person with severe systemic disease that is a constant threat to life; 5, a moribund person who is not expected to survive without the operation; 6, a declared brain-dead person whose organs are being removed for donor purposes.

The majority of patients were cleared for surgery through a preoperative general medicine clinic run by a nurse practitioner. Patients were allowed to continue taking low-dose aspirin but were required to stop taking nonsteroidal anti-inflammatory drugs, clopidogrel bisulfate, and warfarin sodium. Sixty-two patients were receiving preoperative anticoagulation therapy related to their comorbidities. Eighty-six patients received intraoperative subcutaneous heparin sodium for deep venous thrombosis prophylaxis. Comorbidities were collected from the medical record and included hypertension, coronary artery disease, cerebral vascular disease, diabetes mellitus, dyslipidemia, and chronic obstructive pulmonary disease. The mean number of comorbidities was 1.8.

Surgical Procedure
Transoral robotic surgery was used to address tongue base and supraglottic obstruction. It was either a stand-alone procedure or part of a multilevel operation including pharyngeal, palatal, and/or nasal surgery. Nasal surgery included septoplasty and/or inferior turbinate reduction, radiofrequency ablation, microdebridement, or adenoidectomy and was typically performed during drug-induced sedated endoscopy. Palatal surgery included uvuloplasty, palate z-plasty, uvulectomy, or uvulopalatopharyngoplasty. Pharyngeal surgery included tonsillectomy and lateral expansion sphincteroplasty. Tongue base surgery included lingual tonsillectomy, partial midline glossectomy, and epiglottectomy.

All 166 patients underwent lingual tonsillectomy via TORS as treatment of the OSA. Patients underwent a mean of

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value (N = 166)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>54.6 (12.3)</td>
</tr>
<tr>
<td>Sex, No.</td>
<td>Male 122 Female 44</td>
</tr>
<tr>
<td>ASA score, mean (SD)</td>
<td>2.3 (0.5)</td>
</tr>
<tr>
<td>BMI, mean</td>
<td>29 (4.6)</td>
</tr>
<tr>
<td>Apnea-hypopnea index, mean (SD)</td>
<td>40.9 (22.4)</td>
</tr>
<tr>
<td>Epworth Sleep Scale, mean (SD)</td>
<td>10.7 (5.8)</td>
</tr>
<tr>
<td>Lowest arterial oxygen saturation, mean (SD), %</td>
<td>80.4 (7.6)</td>
</tr>
</tbody>
</table>

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).
3.5 procedures including lingual tonsillectomy. The most common secondary procedures were epiglottectomy (79 patients), tonsillectomy (70 patients), and partial midline glossectomy (65 patients). Table 2 shows all procedures performed with their frequencies.

Transoral Robotic Surgery

A detailed description of the surgical technique has been previously published. Briefly, we used the Davis-Meyer mouth gag to obtain access. The Maryland dissector was used. The second arm was either the monopolar cautery set at 30J or 2 different laser options: the Revoxel LISA laser (thulium) or the OmniGuide carbon dioxide laser. The procedure began with an initial horizontal cut just posterior to the distal end of the tongue blade. This created an edge that was then grasped by the Maryland retractor. The incision was then deepened broadly, and a plane of dissection developed toward the vallecula. In 65 patients, a portion of the muscle was removed from the midline to further reduce the tongue base (partial midline glossectomy). For better visualization, it was helpful to divide the lingual tonsil mass vertically along the midline. The right and left lingual tonsil specimens were removed separately. A surgical technician measured the volume of tissue removed using a displacement technique: We used a measuring device composed of a syringe (20–60 mL) half filled with saline. The scrub nurse recorded the volume (in milliliters) of saline displaced, which gave us the volume of tissue removed. Bleeding was typically minimal. The mean volume removed was 7.9 mL.

Lingual tonsillectomy was occasionally followed by epiglottoplasty. The upper one-third of the suprahvoid epiglottis was removed. The epiglottis was held with the Maryland dissector and divided vertically along the midline. A right-angle cut was then made to both the right and left, removing the upper portion of the suprahvoid epiglottis. Mean total surgical time was 75.5 minutes.

Postoperative Care

All patients were admitted to the surgical intensive care unit (SICU) postoperatively. The median number of days in the SICU and hospital was 1 and 2, respectively. Patients were typically seen in the office 2 weeks and 3 months postoperatively. Immediate and delayed postoperative complications were recorded from the inpatient and outpatient medical record. Complications were categorized as major and minor. Major complications included return to the operating room or a complication requiring a prolonged hospitalization (pneumonia, deep venous thrombosis). Minor complications included return to the hospital for pain control, dehydration, or temporary injury from the procedure (bruising or burns of the lip and tongue) not necessitating further intervention.

Statistical Analysis

Statistical analysis was performed using SPSS software, version 20 (IBM), to create descriptive statistics of the population demographic characteristics. Exact tests (Fisher, χ²) were used for categorical variables and the Pearson correlation test was used for continuous variables. Logistic regression analysis was used for continuous variables. Logistic regression analysis was also used for categorical variables and the Pearson correlation test was used to test any significant correlations to determine independent predictors of a complication. The statistical analysis was performed in conjunction with the Center for Statistical Consultation and Research at the University of Michigan.

Results

There were no deaths in this study. There were a total of 43 complications in 41 patients (24.7%). Complications were classified as major (n = 11 [6.6%]) or minor (n = 32 [19.3%]) and are outlined in Table 3. The most common major complication was bleeding necessitating operative intervention (n = 7 [4.2%]).

All bleeding was controlled with a standard tonsillectomy operating room setup and did not require TORS. Bleeding was from the palatine tonsillar bed in 6 of the 7 patients and did not necessitate transfusion.

Two patients required long-term anticoagulation therapy for either deep venous thromboembolism or pulmonary embolus. These were diagnosed during the patients’ hospital stay, and whereas one patient had no comorbidities, the other patient had dyslipidemia, hypertension, and gout and was receiving preoperative prophylactic aspirin therapy, which was discontinued before surgery.
Table 4. Variables Correlated With Postoperative Complications

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.08</td>
<td>.29</td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.05</td>
<td>.55</td>
</tr>
<tr>
<td>Apnea–hypopnea index</td>
<td>0.03</td>
<td>.67</td>
</tr>
<tr>
<td>Lowest arterial oxygen saturation</td>
<td>0.06</td>
<td>.63</td>
</tr>
<tr>
<td>No. of comorbidities</td>
<td>0.09</td>
<td>.46</td>
</tr>
<tr>
<td>ASA score</td>
<td>0.23</td>
<td>.003</td>
</tr>
<tr>
<td>Anticoagulation therapy</td>
<td>0.14</td>
<td>.08</td>
</tr>
<tr>
<td>No. of adjunct procedures</td>
<td>0.22</td>
<td>.004</td>
</tr>
</tbody>
</table>

Abbreviation: ASA, American Society of Anesthesiologists.

Aspiration leading to prolonged hospital stay and dysphagia leading to gastrostomy tube dependence each occurred in 1 patient. The patient who developed aspiration was treated with antibiotics, and other than a prolonged hospitalization, had no long-term sequelae. The patient who developed gastrostomy tube dependence had undergone lingual tonsillectomy, partial midline glossectomy, epiglottoplasty, lateral pharyngoplasty, and palatoplasty. There were 29 patients who underwent 5 or more procedures, as this patient did, without developing dysphagia. The patient was given a swallowing exercise regimen, and a speech language pathology consult was placed; the gastrostomy tube was removed after 4 months, and the patient was able to resume a regular diet.

In terms of minor complications, the most common was dehydration or uncontrolled pain, occurring in 16 patients. These patients were administered intravenous fluids or narcotics and discharged home after a 23-hour hospitalization. Eight patients complained of globus sensation but were able to continue oral intake. Postoperative bleeding managed conservatively with hemostatic agents at the bedside occurred in 5 patients.

An analysis was performed to examine the correlation between preoperative variables and postoperative complications (Table 4). Both the number of procedures that were performed ($r = 0.22; P = .004$) and the preoperative ASA score ($r = 0.23; P = .003$) correlated with occurrence of a postoperative complication. Age, AHI, episodes of arterial oxygen desaturation, number of comorbidities or specific comorbidity, preoperative or intraoperative anticoagulant use, and body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) were not correlated with occurrence of a complication. Logistic regression analysis was performed to test the relationship between the covariates that were predictive. Both ASA score (odds ratio, 2.7 [95% CI, 1.4-5.6]; $P = .006$) and number of procedures performed (odds ratio, 1.6 [95% CI, 1.1-2.3]; $P = .008$) remained independent predictors of a complication.

Discussion

In this study, there was a 24.7% complication rate and a 6.6% incidence of major postoperative complications in 166 adult patients treated with TORS for OSA. Bleeding made up the majority of the major complications, and preoperative ASA score and number of procedures performed were the predictive factors for postoperative complication.

Although bleeding is the most common complication that we encountered, TORS, like tonsillectomy, is not associated with substantial intraoperative blood loss (mean blood loss, 19 mL). Surgeons can expect a postoperative hemorrhage rate similar to that seen in routine adult tonsillectomy. In a retrospective, multicenter study of 7748 adult tonsillectomies, Bhattacharyya and Kepnes$^{14}$ reported a posttonsillectomy hemorrhage rate of 4.8%. Our experience with 166 patients in the present study resulted in 12 (7.2%) postoperative bleeding episodes; of these, only 1 occurred from the tongue base in the region of the glosstonsillar sulcus. Two of the bleeding episodes occurred after resumption of anticoagulation therapy (clopidogrel) or initiation of anticoagulation for deep venous thrombosis. Bhattacharyya and Kepnes$^{14}$ also reported that 1.24% of patients present with a second postoperative hemorrhage; this did not occur in any of the patients in the present study.

All 7 major postoperative hemorrhages occurred within 10 days of the operation. All were controlled in the operating room with traditional cauterization or transoral suture ligation using a McVoy mouth gag and headlight. The 1 episode of bleeding in the glosstonsillar sulcus was controlled with electrocautery after exposing the site using a Steiner oropharyngoscope. It is important to recognize that in all cases, postoperative hemorrhage was controlled without the use of the da Vinci robot. It is incumbent on the TORS surgeon to communicate with his or her partners the expected sites of bleeding following TORS and to reassure them that either a traditional mouth gag, or in rare instances an oropharyngoscope, will get the job done.

Major complications other than hemorrhage are similar to those found in other surgical procedures for obstructive sleep apnea–hypopnea syndrome. Kezirian et al$^{15}$ reviewed the incidence of serious complications after uvulopalatopharyngoplasty in 2004. They found a major complication rate of 1.7%, including a fatality rate of 0.2% (7 of 3130). These complications included pneumonia, as well as cardiovascular complications, which is consistent with the prevalence of aspiration pneumonia (0.6%) and deep venous thrombosis and/or pulmonary embolism (1.2%) in our population.

It is our impression that the majority of patients experience mild prolonged dysphagia and globus sensation. Short-term dysphagia resulted in a mean 15-pound weight loss for patients; however, at 3 months after the operation, the mean BMI had returned to preoperative levels (preoperative BMI, 29.0; 3-month postoperative BMI, 28.2). The more troublesome complaint for patients is the persistent foreign-body sensation that can accompany routine swallowing. This symptom is not associated with a visible scar band, as demonstrated using either in-office fiberoptic laryngoscopy or, in rare cases, intraoperative palpation and direct visualization of the hypopharynx. It is our opinion that the globus sensation does not correlate with the extent of lingual tonsillectomy, partial midline glossectomy, or the addition of epiglottoplasty. Contributing factors may include the amount of energy used with monopolar cautery, thulium laser, or carbon dioxide laser; Coblation (ArthroCare) technology may minimize thermal
injury and be another method to investigate improved postoperative globus. Future studies will help to elucidate the nature of postoperative globus sensation.

A disadvantage of this retrospective study is the lack of objective data to document postoperative swallowing dysfunction. Fortunately, there was only 1 patient who required prolonged gastrostomy tube use (4 months); he was able to resume a regular diet with the help of prescribed swallowing exercises as administered by a certified speech and language pathologist. Our group is currently collecting prospective swallowing data using the validated Dysphagia Handicap Index.16

Our cohort experienced a 10% revisit rate within the first 2 weeks after surgery. Readmission was primarily a result of uncontrolled pain and associated dehydration. This is consistent with other studies, including a large review of revisits after tonsillectomy by Bhattacharyya and Kepnes,14 showing an 11.6% revisit rate. Magnuson et al recognized this problem early in their series and routinely place Dobhoff feeding tubes in their patients until they demonstrate adequate oral intake (J. S. Magnuson, MD, written communication, March 2012). Vicini et al8 encourage early return to an oral diet; however, their patients are typically hospitalized for 5 to 16 days as they await tracheostomy decannulation; dehydration is not an issue because the patients continue to receive intravenous crystalloid while hospitalized. At our institution, patients were discharged on postoperative day 1 (mean, 1.5 days) without a feeding tube. Seshamani et al27 reviewed the prevalence of complications after adult tonsillectomy, focusing on cost utilization. They found an emergency department admission rate of 10.7% and a hospital readmission rate of 1.8%. Patients whose indication for surgery was sleep apnea and tonsillitis also had a 1.7 times increased risk of readmission.

In an effort to improve our readmission rate and patient satisfaction, we are initiating a recovery protocol (Advance Recovery Protocol) modeled after the Enhanced Recovery Protocol18 developed for patients undergoing colorectal procedures here at our institution. In short, a visiting nurse will assess patients’ oral intake, pain scale, and hydration status on days 3, 5, 7, 10, and 14; if pain management or hydration status is inadequate, they will be admitted to our short-stay facility for rehydration and pain control optimization.

Although we did not collect data on changes in taste after lingual tonsillectomy, many patients experience persistent postoperative dysgeusia. Patients often describe either altered sense of taste or a bitter, metallic taste; this contributes to decreased oral intake, as well as diminished quality of life. Unfortunately, we made no measurement of taste before and after surgery, and it appears that this may resolve over time. We are currently looking at this sensory dysfunction in a prospective fashion to better characterize alterations in taste; it may be helpful to map the taste receptors along the posterior tongue using an empirical tool in order to better counsel patients as to their risk for postoperative dysgeusia.

Conclusions

Transoral robotic surgery can be safely performed in patients with OSA with an acceptable SICU and overall length of stay. Complications are similar to those seen with other surgical treatments of OSA and were predicted only by ASA score and number of procedures performed. Minor complications such as globus sensation and dysgeusia improve over several months but can persist.

REFERENCES


CORRECTION

Error in Figure: In the Original Investigation entitled “Use of SLC26A4 Mutation Testing for Unilateral Enlargement of the Vestibular Aqueduct,” published in the September 2013 issue of JAMA Otolaryngology–Head & Neck Surgery (2013;139[9]:907-913. doi:10.1001/jamaoto.2013.4185), panel B of Figure 3 on page 911 was typeset incorrectly. This article was corrected online.