Transoral robotic surgery vs. endoscopic partial midline glossectomy for obstructive sleep apnea

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Received 5 April 2017
Available online 23 June 2017

Abstract  Objective: To compare sleep-related outcomes in obstructive sleep apnea hypopnea syndrome (OSAHS) patients following base of tongue resection via robotic surgery and endoscopic midline glossectomy.
Methods: This was a retrospective study. A total of 114 robotic and 37 endoscopic midline glossectomy surgeries were performed between July 2010 and April 2015 as part of single or multi-level surgery. Patients were excluded for indications other than sleep apnea or if complete sleep studies were not obtained. Thus, 45 robotic and 16 endoscopic surgeries were included in the analysis.
Results: In the robotic surgery group there were statistically significant improvements in AHI [(44.4 ± 22.6) events/h–(14.0 ± 3.0) events/h, \( P < 0.001 \)] Epworth Sleepiness Scale (12.3 ± 4.6 to 4.5 ± 2.9, \( P < 0.001 \)), and \( O_2 \) nadir (82.0% ± 6.1% to 85.0% ± 5.4%, \( P < 0.001 \)). In the endoscopic group there were also improvements in AHI (48.7 ± 30.2 to 27.4 ± 31.9, \( P = 0.06 \)), Epworth Sleepiness Scale (12.6 ± 5.5 to 8.3 ± 4.5, \( P = 0.08 \)), and \( O_2 \) nadir (80.2% ± 8.6% to 82.7% ± 6.5%, \( P = 0.4 \)). Surgical success rate was 75.6% and 56.3% in the robotic and endoscopic groups, respectively. Greater volume of tissue removed was predictive of surgical success in the robotic cases (10.3 vs. 8.6 ml, \( P = 0.02 \)).

* This manuscript was presented at the AAO-HNSF annual meeting on September 29, 2015 as an oral presentation.
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Peer review under responsibility of Chinese Medical Association.
Conclusions: Both robotic surgery and endoscopic techniques for tongue base reduction improve objective measures of sleep apnea. Greater success rates may be achieved with robotic surgery compared to traditional methods.
at the same time as the BOT resection. Exposure of the base of tongue was obtained in most cases using a Crowe-Davis mouth gag with various size Davis-Myer tongue blades. For PMG cases, the Doppler probe was used to map out the lingual arteries. Thirty and seventy-degree Hopkins rods were used for visualization. Lingual tonsillar tissue and tongue muscle was then removed using the coblator device. For TORS cases, the DaVinci robotic system (Intuitive Surgical, Sunnyvale CA) with 5 mm EndoWrist instruments (a SputaTip for monopolar cauterization and Maryland Dissector) and 8 mm 3D endoscopes were used. Dissection was performed from the circumvallate papillae down to the base of the epiglottis and valleculae on each side. No epiglottidectomies were performed. Muscle was then resected from the circumvallate papillae down to the base of the epiglottis and valleculae on each side. No epiglottidectomies were performed. Muscle was then resected from each side in a similar fashion (up to 10 mm) and if needed additional muscle (up to another 5 mm) was removed in the midline. The amount of tissue removed was needed additional muscle (up to another 5 mm) was removed in the TORS group was 9.9 ml, and surgical success rates in the TORS group, with more tissue removed on average in those patients who responded: The results were analyzed with respect to various patient characteristics to determine if any factors were predictive of surgical success. There was noted to be a significant correlation between volume of tissue removed and surgical success rates in the TORS group, with more tissue removed on average in those patients who responded to surgery (10.3 ml vs. 8.6 ml, P = 0.02) (Tables 4 and 5).

### Results

Patient demographics and characteristics: There were 33 males (73%) and 12 females (27%) with a mean age of 48.2 ± 11.6 in the TORS group. There were 12 males (75%) and 4 females (25%) with a mean age of 46.3 ± 8.4 in the PMG group. The overall mean preoperative BMI was 32.3 ± 4.5 kg/m². Overall, twenty-three patients underwent prior upper airway procedures that included tonsillectomy, UPPP, pillar implants, turbinate reduction, and septoplasty. The mean Friedman stage was 2.6 ± 0.5. The mean overall ESS preoperatively was 12.4 ± 4.8 and the mean AH{sub}I preoperatively was 45.5 ± 24.6 (Table 1).

Surgical characteristics: The mean volume of tissue removed in the TORS group was 9.9 ± 2.1 ml. No tracheotomies were performed as part of the surgery. Of the 45 patients who underwent TORS, 6 patients received BOT resection alone and 31 underwent BOT resection in conjunction with other concurrent procedures. In the PMG group of 16 patients, 3 underwent single site surgery at the BOT alone. The additional upper airway surgeries included turbinectomy, tonsillectomy, septoplasty, and UPPP. All patients were monitored overnight in a surgical step-down unit and discharged home the following day.

Outcomes following TORS BOT surgery: There were statistically significant reductions in AH{sub}I, ESS and O{sub}2 nadir. The AH{sub}I decreased from (44.4 ± 22.6) events/h to (14.0 ± 3.0) events/h, with an average AH{sub}I reduction of 68% (P < 0.001). There were reductions in daytime somnolence measured by the ESS from 12.3 ± 4.6 to 4.5 ± 2.9 (P < 0.001). The O{sub}2 nadir was 82.0% ± 6.1% preoperatively and 85.0% ± 5.4% postoperatively (P < 0.001). Surgical success was defined as a final AH{sub}I < 20 events/h and an AH{sub}I reduction ≥50%. By this definition, there was a surgical success rate of 75.6% (34/45) (Table 2).

Outcomes following PMG surgery: The AH{sub}I decreased from (48.7 ± 30.2) events/h to (27.4 ± 31.9) events/h, with an average AH{sub}I reduction of 44% (P = 0.06). There were reductions in ESS from 12.6 ± 5.5 to 8.3 ± 4.5 (P = 0.08). The O{sub}2 nadir was 80.2% ± 8.6% preoperatively and 82.7% ± 6.5% postoperatively (P = 0.4). There was a surgical success rate of 56.3% (9/16) (Tables 2 and 3).

Comparison between single-level and multilevel surgical patients: The results were stratified based on whether patients underwent surgery at the level of the BOT only vs. multilevel upper airway surgery including BOT resection. Paired t tests were performed to analyze this data. There was no statistically significant difference in surgical response (P = 0.15).

Comparison between surgical responders and non-responders: The results were analyzed with respect to various patient characteristics to determine if any factors were predictive of surgical success. There was noted to be a significant correlation between volume of tissue removed and surgical success rates in the TORS group, with more tissue removed on average in those patients who responded to surgery (10.3 ml vs. 8.6 ml, P = 0.02) (Tables 4 and 5).

| Table 1 Patient demographics and baseline characteristics. |
|-----------------------------------------------------------|
| **Characteristic** | **TORS group** | **PMG group** |
| Males [cases, (%)] | 33 (73) | 12 (75) |
| Females [cases, (%)] | 12 (27) | 4 (25) |
| BMI (kg/m²) | 32.3 ± 4.8 | 32.5 ± 3.5 |
| Volume tissue (ml) | 9.9 ± 2.1 | NA |
| Preoperative AH{sub}I (events/h) | 44.4 ± 22.6 | 48.7 ± 30.2 |
| Preoperative ESS | 12.3 ± 4.6 | 12.6 ± 5.5 |
| Preoperative O{sub}2 nadir (%) | 82.0 ± 6.1 | 80.2 ± 8.6 |

TORS: transoral robotic surgery; PMG: partial midline glossectomy; AH{sub}I: apnea–hypopnea index; ESS: epworth sleepiness scale; NA: not available.

| Table 2 Preoperative vs. postoperative results (TORS group). |
|---------------------------------------------------------------|
| **Group** | **Apnea–hypopnea index (events/h)** | **Epworth sleepiness scale** | **O{sub}2 nadir (%)** |
| Preoperative | 44.4 ± 22.6 | 12.3 ± 4.6 | 82.0 ± 6.1 |
| Postoperative | 14.0 ± 13.0 | 4.5 ± 2.9 | 85.0 ± 5.4 |
| P value | <0.001 | <0.001 | <0.001 |

| Table 3 Preoperative vs. postoperative results (PMG group). |
|---------------------------------------------------------------|
| **Group** | **Apnea–hypopnea index (events/h)** | **Epworth sleepiness scale** | **O{sub}2 nadir (%)** |
| Preoperative | 48.7 ± 30.2 | 12.6 ± 5.5 | 80.2 ± 8.6 |
| Postoperative | 27.4 ± 31.9 | 8.3 ± 4.5 | 85.0 ± 5.4 |
| P value | 0.06 | 0.08 | 0.4 |
Complications: No intraoperative complications encountered. Nine patients experienced postoperative complications. Four patients experienced bleeding that was self-limited in the postoperative period. All bleeding resolved spontaneously by the time the patient was seen by an MD and no further treatment was required. One patient required inpatient treatment for pneumonia and dehydration postoperatively, however the pneumonia was judged not to be due to aspiration. Three other patients experienced postoperative dehydration requiring IV fluids administered in the emergency room. One patient complained of an increased gag sensation for several months postoperatively.

Discussion

In this series, we compare the clinical and polysomnographic data of 45 patients who underwent TORS and 16 patients who underwent endoscopic PMG for OSAHS. Although still a relatively novel surgical technique, robotic surgery for the management of OSAHS has shown great potential as a treatment option for the properly selected patient. Considering the known importance of obstruction at the level of the BOT, it is not surprising that the robot offers advantages with its improved access and visualization. Vicini et al\textsuperscript{16} first reported preliminary results on 10 patients treated with TORS for OSAHS. His described technique differs from ours in that he performed a tracheotomy in all patients. In a follow up study in 20 patients he reported statistically significant mean AHI reductions from (36.3 ± 21.1) events/h to (16.4 ± 15.2) events/h.\textsuperscript{17} Friedman et al\textsuperscript{14} showed that TORS for OSAHS could be safely performed without the need for a tracheotomy, which is the approach used in all of our cases. His report on 27 patients showed AHI improvements from (54.6 ± 21.8) events/h to (18.6 ± 9.1) events/h.\textsuperscript{14} These prior series all described patients who underwent TORS in conjunction with other upper airway procedures for OSAHS. Lin et al\textsuperscript{15} reported a 50% response rate with statistically significant reductions in AHI and ESS in 12 patients who underwent resection at the level of the BOT alone.

This study adds to the existing literature by reiterating the safety and effectiveness of TORS while also directly comparing it to more traditional methods performed by the same surgeon. Our results are comparable to those reported in other series. It is essential to appropriately select candidates for TORS, which includes targeting all of the hypertrophied or obstructing tissue for removal. Interestingly, in our study the only statistically significant difference noted that was predictive of surgical success was the volume of tissue removed, with a greater volume removed on average in those who responded to surgery. In the PMG group, volume of tissue was not recorded due to the fact that this technique ablates the tissue during removal.

In a recent study, Vicini et al report their results of single stage, multisite robotic-assisted surgery.\textsuperscript{18} This consisted of tongue base reduction, supraglottoplasty, nasal surgery if required, and a palate procedure. While they show that expansion sphincter pharyngoplasty was superior to UPPP, their results highlight that TORS is perhaps most effective when used as part of multilevel surgery, addressing obstruction at each level in which it is encountered. Our results showed similar success rates in single level and multilevel patients. However, when targeting the BOT alone, there was a trend toward higher success rates in the TORS group (83% vs. 66%). These results are limited by the retrospective nature of this study, and further clinical studies are necessary despite these encouraging results.

Conclusion

Our study provides further evidence that BOT resection as part of single or multilevel surgery can effect significant improvements in objective measures of OSA. Greater success rates may be achieved with TORS compared to traditional methods, and volume of tissue removed may be predictive of surgical success.

Conflicts of interest

None.

Financial disclosure

None.

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