Endoscopic Endonasal Pituitary Surgery: Impact of Surgical Education on Operation Length and Patient Morbidity

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Abstract

Objectives To determine the difference in operative times and associated complications for cases performed solely by attending-level surgeons versus cases assisted by surgeons-in-training for endoscopic endonasal pituitary surgeries.

Design Retrospective chart review.

Setting Tertiary-care academic medical center.

Participants A total of 228 patients having undergone endoscopic endonasal pituitary surgery from 2005 to 2011.

Main Outcome Measure Duration of surgery comparing attending only (AO) and trainee-assisted (TA) surgeries.

Results Thirty-seven (19%) of 198 cases were identified as AO surgeries, the remaining 161 (81%) were TA. Operative times (minutes) for the AO group were significantly shorter than the TA group (149.1 ± 54.8 vs 219.5 ± 83.7 , $p < 0.001$). The AO group had fewer intraoperative cerebrospinal fluid leaks (30% vs 39%, $p = 0.318$), decreased estimated blood loss (408 mL vs 523 mL, $p = 0.176$), fewer postoperative complications (27% vs 37%, $p = 0.268$), and shorter length of stay (3.5 vs 4.3 days, $p = 0.294$).

Conclusions This is the first study in otolaryngology or neurosurgery to compare operative times and outcomes for AO versus TA cases at a single academic institution. Operative times were significantly decreased and a trend toward a decrease in patient morbidity was noted for cases performed solely by attendings. The valuation of teaching activities in the operating room is a necessary first step toward optimizing the allocation of resources and funding of surgical education.

Keywords

- ▶ skull base surgery
- ▶ pituitary surgery
- ▶ residency training
- ▶ surgical education
- ▶ endoscopic endonasal approach

Introduction

In the current era of residency training, several factors provide an impetus for maximizing the efficiency of training

for surgical residents. From the trainee's perspective, the ever-increasing restrictions on resident work hours yield fewer hours of on-the-job training.¹ In a hospital culture that continues to emphasize patient safety issues, increased

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operative times expose patients to a higher risk of complications from anesthesia. Finally, from a financial perspective, longer operative durations lead to underutilization of valuable operating room time.

The acquisition of skills for endoscopic surgery follows a steep learning curve. Leach et al² demonstrated that 50 procedures marked the inflection point on the endoscopic trans-sphenoidal pituitary surgery learning curve. Smith et al demonstrated a significant fall in risk of diabetes insipidus (DI) and cerebrospinal fluid (CSF) leak after 34 endoscopic trans-sphenoidal skull base surgeries.³ Surgical simulation offers the potential of surgical education outside of the operating room, thereby shortening the learning curve in the operative setting. Because simulators have proven effective in laparoscopic surgical training,⁴ endoscopic simulators are currently under investigation for use in the field of skull base surgery. Current obstacles to the adoption of simulation technology include both costs of simulation equipment and questionable effectiveness.⁵ As a result, few residency programs currently incorporate simulation training into their standard otolaryngology and neurosurgery training curricula.

Given the increased morbidity and costs associated with longer operative times,⁶ we sought to determine the difference in operative times and associated complications for cases performed solely by attending-level surgeons versus cases assisted by surgeons-in-training for endoscopic endonasal pituitary surgeries.

Methods

The study protocol was approved by the University of Pittsburgh Institutional Review Board (IRB) in September 2011. A search from 2005 to present was conducted from the institution billing records using Current Procedural Terminology (CPT) coding for endoscopic pituitary resection. The search yielded 228 patients.

The electronic medical records were explored for the following documents: intraoperative record, anesthesia record, dictated operative report (neurosurgery and otolaryngology), and discharge summary. Inclusion criteria comprised the availability of all above-mentioned documents, primary pathology of the pituitary gland, and single-staged procedure. Surgeries involving concurrent placement of lumbar or extraventricular drain (EVD) were excluded, as information for duration of specific procedures within each case were not available. Of the initial 228 patients, 25 patients had a lumbar drain placed at the time of surgery, 2 patients had two-staged procedures, 1 patient had an EVD placed at the time of surgery, 1 patient had a mucosal melanoma of the paranasal sinuses extending into the pituitary region, and 1 patient had an incomplete record. After exclusion of these patients, 198 patient records were pursued for analysis.

Surgeries were categorized as attending only (AO) if both otolaryngology and neurosurgery operative reports listed only the respective attending surgeons. The operative report provided information regarding intraoperative complications, functional status of the tumor, tumor extension, and method of closure. Extrasellar extension comprised pituitary

masses extending beyond the boundaries of the sella turcica, as indicated in the postoperative diagnosis or narrative portion of the operative report. Tissue reconstruction involved the placement of autologous grafts or pedicled flaps, usually in the setting of an intraoperative CSF leak. Postoperative diagnoses were obtained from both the operative report and discharge summaries. Estimated blood loss (EBL) was retrieved from the anesthesia record and operative report in all but four cases for which this information could not be found. If "minimal EBL" was noted in the record, 10 mL was used as a surrogate measure. Length of stay and postoperative complications were gleaned from the discharge summaries. Major complications were defined as death or stroke within 24 hours of procedure or premature termination of the procedure. The intraoperative report provided start and end times for the surgical portion of the operation; anesthesia time was not included.

Normal distribution of the dependent variable was examined using a normal quantile plot test for non-normality. Two-tailed Student's *t*-tests were used to compare continuous variables between the AO and trainee-assisted (TA) groups, and two-sample test of proportion using a 95% confidence interval was used for testing the significance of differences in proportions between the two groups. *P* values less than 0.05 were considered significant. Statistical analyses were performed using STATA Statistical Software Release 10 (StataCorp LP 2007, College Station, TX, USA).

Results

We identified 198 endoscopic endonasal pituitary surgery cases that met our criteria for inclusion. Thirty-seven (19%) of these 198 cases were AO, whereas the remaining 161 cases (81%) were TA. A normal quantile plot test for non-normality demonstrated that the dependent main outcome variable, "duration of surgery," was normally distributed for both the AO and TA groups.

Though AO cases represented only 19% of the cases, ▶**Table 1** demonstrates the relative demographic similarity between the AO and TA groups when cases are broken down by their clinical characteristics. The mean age of patients, postoperative diagnoses, and other qualitative characteristics of the cases reviewed such as method of closure, extent of tumor, and endocrine functional status of the tumor were found in almost the same relative proportions in both the AO and TA groups. This allowed meaningful comparisons to be made between these two groups regarding outcomes including duration of surgeries, intra- and postoperative complications, and length of stay following surgery.

We further scrutinized our dataset to determine whether any differences existed between the AO and TA groups with respect to intra- or postoperative complications and length of stay following surgery (▶**Table 2**). Although none of the differences in parameters related to complications or length of stay reached statistical significance, there was a consistent trend toward the AO group having proportionally fewer complications and a shorter length of stay. The AO group had fewer intraoperative CSF leaks in comparison to the TA

Table 1 Clinical characteristics of cases by group

	Entire group (n = 198)	Attending only group (n = 37)	Trainee-assisted group (n = 161)
Age, mean $\pm$ SD	52.2 $\pm$ 16.6	53.1 $\pm$ 15.5	52.0 $\pm$ 16.9
Postoperative diagnosis, no. (% of group)			
Pituitary adenoma	155 (78%)	27 (73%)	128 (80%)
Recurrent pituitary adenoma	28 (14%)	5 (14%)	23 (14%)
Pituitary cyst	8 (4%)	2 (5%)	6 (4%)
Other	7 (4%)	3 (8%)	4 (2%)
Tissue reconstruction, no. (% of group)	158 (80%)	29 (78%)	129 (80%)
Extrasellar extension, no. (% of group)	140 (71%)	25 (68%)	115 (71%)
Functioning tumor, no. (% of group)	77 (39%)	15 (41%)	62 (39%)

Abbreviation: SD, standard deviation.

group (30% versus 39%). The AO group also had a mean EBL of 408 mL compared with 523 mL ($p = 0.18$) for the TA group. The most common postoperative complications were endocrine dysfunction manifesting as either DI controlled with desmopressin treatment (total, 18 [9%]; AO, 2 [5% of AO cases]; TA, 16 [10% of TA cases]), adrenal insufficiency managed with steroid replacement (total, 18 [9%]; AO, 4 [11% of AO cases]; TA, 14 [9% of TA cases]), or panhypopituitarism (total, 6 [3%]; AO, 1 [3% of AO cases]; TA, 5 [3% of TA cases]). Eight (4%) patients required further surgery for repair of CSF leak. Seven of these eight patients were found in the TA group, four of which required placement of lumbar drains and two required more than one procedure for a persistent CSF leak.

Notably, there were no AO cases in which postoperative epistaxis or respiratory failure occurred, whereas these complications were represented in 3% and 2% (including two resulting in death of the patient), respectively, of TA cases. Several "other" miscellaneous postoperative complications are noted in ►Table 2, though they were represented in

similar proportions among the AO and TA groups. There were no major complications reported among all cases.

Our primary outcome measure was duration of surgery. Overall, mean operative time (in minutes) for the AO group was significantly shorter than for the TA group (149.1 ± 54.8 vs 219.5 ± 83.7 , $p < 0.0001$). When duration of surgery was broken down into 100-minute intervals, it became apparent that TA cases tend to take longer on average than AO cases, which primarily fell into the 0-to-200-minute intervals. TA cases primarily fell into the 101-to-300-minute interval (►Fig. 1).

Greater differences in mean duration of surgeries between the AO and TA groups became apparent when the complexity of the cases was taken into account. We took both the extent of tumor invasion with respect to the boundaries of the sella turcica and the type of reconstruction necessary at the conclusion of a given surgery as surrogates for case complexity. Cases with either extrasellar tumor extension or closure involving tissue reconstruction were considered more complex. Under this stratification, the surgical aptitude of the

Table 2 Comparative outcomes: complications and length of stay by group

	Entire group (n = 198)	Attending only group (n = 37)	Trainee-assisted group (n = 161)	p Value
Intraoperative complications				
Intraoperative CSF leak: repaired, no. (% of group)	73 (37%)	11 (30%)	62 (39%)	0.318
Blood loss (mL), mean $\pm$ SD	503.1 $\pm$ 451.4	407.6 $\pm$ 287.8	523.2 $\pm$ 477.3	0.176
Postoperative complications, no. (% of group)	69 (35%)	10 (27%)	59 (37%)	0.268
Endocrine dysfunction	42 (21%)	7 (19%)	35 (22%)	0.705
Operative repair of CSF leak	8 (4%)	1 (3%)	7 (4%)	0.647
Epistaxis	5 (3%)	0	5 (3%)	N/A
Respiratory failure	3 (2%)	0	3 (2%)	N/A
Other	11 (6%)	2 (5%)	9 (6%)	0.965
Length of stay (days), mean $\pm$ SD	4.2 $\pm$ 4.5	3.5 $\pm$ 3.6	4.3 $\pm$ 4.7	0.294

Abbreviations: CSF, cerebrospinal fluid; SD, standard deviation.

Fig. 1 Grouped comparison of surgery durations for AO and TA cases. A higher proportion of TA cases are longer in duration than AO cases. When surgery durations are grouped in 100-minute intervals, the breakdown shown above is as follows: 0 to 100 min: AO, 6 cases (16% of AO cases); TA, 6 cases (4% of TA cases); 101 to 200 min: AO, 27 cases (73% of AO cases); TA, 73 cases (45% of TA cases); 201 to 300 min: AO, 3 cases (8% of AO cases); TA, 53 cases (33% of TA cases); 301 to 400 min: AO, 1 case (3% of AO cases); TA, 22 cases (14% of TA cases); 401 to 500 min: AO, 0 cases; TA, 7 cases (4% of TA cases).

attendings relative to trainees was made evident given that a significantly greater difference in mean duration of surgery existed between AO and TA cases when the cases were more complex (i.e., involved either extrasellar extension, ►Fig. 2a, or tissue reconstruction, ►Fig. 2b).

Discussion

To our knowledge, this is the first study in otolaryngology or neurosurgery to compare operative times and outcomes for AO versus TA cases at a single academic institution. The results indicate a 47% increase in operative times for pituitary surgeries in cases with participating surgical residents and

fellows. Notably, this difference was correlated with increasing case complexity. Operative times for tumors with extrasellar extent exhibited a greater difference between the AO and TA groups as indicated by the *p* values in ►Fig. 2a. Similarly, cases requiring closure involving tissue reconstruction demonstrated a wider gap in duration of operation between the two groups (►Fig. 2b). Although the TA group had a higher proportion of intraoperative CSF leaks, increased blood loss, postoperative complications, and increased length of stay, the data did not demonstrate statistically significant differences between the two groups for these outcomes.

The dichotomy between AO and TA surgeries at our institution was the result of differences in patient insurance plans requiring some patients to go to hospitals in which some trainees do not have operative privileges. Of note, the same surgeons operated at both the primary and satellite hospitals. There is no reason to believe that there exist different patient populations with regard to surgical complexity based on differences in insurance plans. ►Table 1 further highlights the nearly identical baseline clinical characteristics of the two groups.

This study bears several limitations. As a retrospective chart review, data collection remains less than ideal as we relied on the accuracy and precision of operative dictations performed by six different attending surgeons. The extent of resident or fellow involvement in TA cases is unknown and we did not collect information regarding the trainee's year of postgraduate training. The surgeries were performed at two hospitals within the academic institution leading to variation in operating room facilities and the experience of the surgical teams. It should be noted that the satellite hospital at which the majority of the AO surgeries were performed, however, possesses less experience in endoscopic endonasal surgeries. As a result, one would have anticipated longer operative times

Fig. 2 Comparison of operative times between groups based on tumor extent and method of closure. Mean duration of surgery is significantly longer with trainee assistance for more complex cases involving either extrasellar extension of tumor or a method of closure requiring tissue reconstruction. Mean durations of surgeries for attending only (AO), trainee-assisted (TA), and all cases grouped by extent of tumor relative to the boundaries of the sella turcica. The mean duration of surgery for TA cases is significantly longer than that of AO cases when there is extrasellar extension of tumor ($p < 0.001$). This difference decreases but remains significant when the tumor is confined to the sella ($p = 0.027$; A). Mean durations of surgeries for AO, TA, and all cases grouped by the method of closure utilized at the end of the surgery. The mean duration of surgery for TA cases is significantly longer than that of AO cases when tissue reconstruction is necessary ($p < 0.001$), but not when simple closures are performed ($p = 0.162$; B).

for AO cases performed at this institution, thereby further strengthening the significance of differences we observed between the AO and TA groups. We did not segregate surgeries performed early versus late in the academic year to adjust for the presumed trainee skill acquisition over time. We also were not able to account for the variability in operative "speed" of the attending surgeons given the retrospective data collection. In line with the learning curve of endoscopic surgery, we considered performing a regression of attending experience (years since training completion) and duration of surgery. However, given the small sample size (four neurosurgery and two otolaryngology attendings) and faculty turnover at our institution, it was not meaningful to do so.

The costs and complications associated with surgical training have been examined in other surgical disciplines including ophthalmology, general surgery, and orthopedics. In 2011, Hosler et al⁷ demonstrated that cataract surgeries were associated with higher costs and operative times during the first half but not the second half of the academic year. Babineau et al⁸ studied four common general surgery procedures both with and without the involvement of a postgraduate year 3 resident and demonstrated significantly higher operative times with resident involvement. In studying arthroscopic anterior cruciate ligament (ACL) reconstruction in 1997, Farnworth et al⁹ showed that the resident-assisted surgery group added \$228 to anesthesia costs and \$661 to operating room costs per surgery due to the increased case and anesthesia times.

In our study, there was an average difference of 70.4 minutes per case between the TA and AO groups. If one applies a conservative cost rate of \$20/minute for operating room time,¹⁰ operating room costs in the context of this study are increased by greater than \$1400 per case for the TA group. To place this number in perspective, a residency and fellowship training program such as our own that averages 100 endoscopic endonasal surgeries per year spends an additional \$140,000 in operating room costs from the increased operative times.

Surgical simulation devices have long been regarded as a potential method for training residents and fellows without the associated patient morbidity and resource consumption of training confined solely to the operating room. This teaching paradigm requires trainees to demonstrate proficiency in the simulation environment before proceeding to the operating room. The general surgery literature has been studying the benefits of laparoscopic simulation for 15 years.¹¹ In 2011, a randomized-controlled trial demonstrated that a simulation-based curriculum decreased operative time, improved trainee performance, and decreased intra- and postoperative complications and overnight stays after laparoscopic inguinal hernia repair.⁴

The field of endoscopic sinus and skull base surgery has evolved more slowly than general surgery with respect to the adoption of simulators as a training tool. A recent study by Fried et al¹² demonstrated the effectiveness and validity of a virtual reality sinus training model, further strengthening the

case for its adoption into training curricula. Equipped with the knowledge that sinus training models are effective and the training of surgical residents and fellows adds more than 1 hour to the operating time of pituitary surgeries, the need for adoption of endoscopic simulation technology becomes evident.

In conclusion, this study provides justification for economic investment in simulation technology to be incorporated into otolaryngology and neurosurgery residency and fellowship training curricula. Greater operative efficiency in the operating room will contribute to more efficient use of a limited resource, decreased patient morbidity, and decreased cost of care. With looming budget cuts in federal funding of graduate medical education, critical analysis of the economic costs of surgical education and effective solutions to mitigate these costs are essential.

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