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The Impact of Resident and Fellow Participation in Transsphenoidal Pituitary Surgery

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Objectives/Hypothesis: Postoperative complications is an important marker of healthcare quality. The aim of this study was to analyze the impact of resident and fellow participation on postoperative complications in transsphenoidal pituitary surgery in a multi-institutional setting.

Study Design: Retrospective analysis of population-based surgical registry.

Setting: Academic medical center.

Methods: The American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database was utilized to generate transsphenoidal pituitary surgery patient cohorts. The attending with resident and/or fellow group was compared to the attending alone based on demographics and preoperative and postoperative variables.

Results: A total of 469 cases were included in the analysis, with 315 performed with resident participation and 154 by attendings alone. The attending group had higher rates of diabetics (20.1% vs. 11.7%, $P = 0.015$) and patients with a history of previous percutaneous coronary intervention (6.0 vs. 1.6%, $P = 0.009$). Although the attending group demonstrated higher rates of surgical complications, and the resident/fellow group showed increased incidence in medical and overall complication rates, there was no statistical difference between the two groups. Multivariate analysis further demonstrated lack of significance in complication rates between attendings and residents/fellows.

Conclusion: Resident and fellow participation in transsphenoidal surgery is not associated with significant differences in surgical complications, medical complications, mortality, operating time, reoperation rates, or readmission rates when compared to attendings.

Key Words: Transsphenoidal pituitary surgery, resident, NSQIP, 30-day complications, outcomes, endoscopic surgery, morbidity and mortality, postgraduate year (PGY).

Level of Evidence: 4

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INTRODUCTION

Transsphenoidal pituitary surgery (TSPS) is a safe and effective surgical approach for the treatment of pituitary tumors, for which the main goal of treatment is total gross resection with preservation of normal pituitary function.[1–3] TSPS encompasses the endoscopic and microscopic approach, both of which have provided excellent results with low morbidity and mortality rates.[1–4] The endoscopic approach now predominates as an alternative to the microscopic approach and continues to gain popularity.[2] Transsphenoidal pituitary surgery requires a specific skill set, and training of the surgical resident is based on an educational paradigm in which supervised involvement in operative cases serves as an essential component.[5–7] The education of the surgical resident and fellow is critical in cultivating competent and safe surgeons who can provide high-quality patient care. The attending surgeon is responsible for delicately balancing the roles of skillful operator, educator of future surgeons, and patient advocate.

The effect of trainee participation on patient outcomes is receiving heightened attention, triggering an abundance of studies regarding this question across different surgical specialties. Currently, there is very limited literature on the impact of resident and fellow involvement on patient outcomes in otolaryngology and neurosurgery. The limited literature existing on this topic in otolaryngology is primarily single institutional studies focusing on thyroidectomies.[5] Even fewer studies, also mainly single institutional, are available regarding this topic in the field of neurosurgery.[8] The weakness of single institutional studies limit generalizability of the data. To mitigate this limitation, researchers have used the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database, which allows for nationwide sampling and incorporates various

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TABLE I.
Overall Patient Demographics and Characteristics in Transsphenoidal Pituitary Surgery

	Attendings and Residents/fellows N = 315	Attending Alone N = 154	*P* Value
Age cohorts (%)			
≤ 40 years	27.0	19.5	0.076
41–60 years	41.0	42.2	0.795
61–80 years	29.5	37.0	0.102
> 80 years	2.5	1.3	0.509
Sex (%)			
Male	45.9	54.1	0.116
Female	53.6	46.4	
Race (%)			
White	60.6	50.6	0.002*
Black	11.7	24.7	0.001*
Other	14.9	18.2	0.551
Unknown	12.7	6.5	0.041*
Obese (BMI > 30, %)	46.9	48.1	0.819
Comorbidities (%)			
Diabetes	11.7	20.1	0.015*
Current smoker	14.9	16.9	0.582
Dyspnea	6.0	7.1	0.644
Alcohol	1.3	2.0	0.686
Pneumonia	0.3	0.0	1.000
Weight loss	1.6	1.9	0.721
COPD	1.9	1.9	1.000
CHF	0.6	0.0	1.000
Previous PCI	1.6	6.0	0.009*
Previous cardiac surgery	1.3	3.3	0.156
Angina	0.6	1.3	0.598
PVD	0.3	0.7	0.543
Hypertension	43.2	48.1	0.319
TIA	1.0	2.7	0.220
CVA	1.6	2.0	0.717
CVA with no deficit	1.0	0.7	1.000
Disseminated cancer	0.6	1.3	0.601
Steroid use	9.2	11.0	0.531
Bleeding disorders	2.2	2.6	0.756
Chemotherapy	0.3	0.0	1.000
Radiotherapy	0.3	0.7	0.543
Systemic sepsis	1.6	2.0	0.718
Previous major operations	1.6	0.7	0.670
Wound infection	1.0	0.6	1.000
Functional status			
Independent	97.5	96.8	0.766
Totally or partially dependent	2.5	3.2	
ASA class (%)			
1 and 2	45.5	41.6	0.419
3 and 4	54.5	58.4	
Hyponatremia (< 135 mEq/L)	7.1	10.9	0.193
Hypoalbuminemia (< 3.5 g/dL)	8.3	8.7	1.000

*Statistically significant.

ASA = American Society of Anesthesiologists; BMI = body mass index; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; CPR = cardiopulmonary resuscitation; CVA = cerebrovascular accident; MI = myocardial infarction; OR = operating room; PCI = percutaneous coronary intervention; PVD = peripheral vascular disease; SSI = surgical site infection; TIA = transient ischemic attack.

TABLE II.
Postoperative Complications in Transsphenoidal Pituitary Surgery by Surgeon Training Status

	Attendings and Residents/Fellows N = 315	Attending Alone N = 154	*P* Value
Overall complications	7.6	5.8	0.480
Surgical complications overall (%)	1.3	1.9	0.689
Superficial SSI	0.3	0.0	1.000
Deep SSI	0.0	0.6	0.328
Organ/space SSI	0.3	0.0	1.000
Wound disruption	0.0	0.0	–
Blood transfusion within 72 hours	1.0	1.3	0.664
Medical complications overall (%)	7.0	3.9	0.185
Pneumonia	1.3	0.0	0.308
Unplanned reintubation	2.5	0.6	0.283
Urinary tract infection	2.5	1.3	
Deep vein thrombosis	1.6	1.3	1.000
Renal insufficiency	0.0	0.6	0.328
Pulmonary embolism	0.6	0.0	1.000
Ventilator > 48 hours	1.9	0.0	0.184
Acute renal failure	0.0	0.0	–
CVA with neurological deficit	1.6	0.0	0.177
Nerve Injury	0.0	0.0	–
Cardiac arrest requiring CPR	0.6	0.0	1.000
Myocardial infarction	0.0	0.0	–
Sepsis	2.2	0.0	0.102
Septic shock	1.0	0.0	0.554
Coma	0.0	0.0	–
Mortality	1.3	0.6	1.000
Total operating time, mean, minutes	151.1 ± 84.9	150.8 ± 62.9	0.971
Total anesthesia time, mean, minutes	239.8 ± 100.5	237.3 ± 79.3	0.786
Length of stay, mean, days	4.7 ± 8.2	4.7 ± 4.2	0.982
Return to OR (n = 163)	3.0	10.0	0.117
Readmission (n = 158)	7.7	10.7	0.703
Unplanned readmission	3.2	1.9	0.560

CPR = cardiopulmonary resuscitation; CVA = cerebrovascular accident; OR = operating room; SSI = surgical site infection.

types of institutions. To our knowledge, there is no large-scale study evaluating resident and fellow involvement and patient outcomes in TSPS. The purpose of this study is to evaluate the impact of resident and fellow involvement on perioperative outcomes in TSPS on a multi-institutional level.

MATERIALS AND METHODS

The 2005 to 2013 NSQIP participant user files were used to conduct a retrospective analysis. Transsphenoidal surgery patients were identified using Current Procedural Terminology code 62165. Patients without data on resident/fellow supervision (attending vs. attending and resident and/or fellow) and post-graduate year (PGY) of residents/fellows were excluded from the

TABLE III.
Multivariable Regression of Overall Complication Risk in Transsphenoidal Pituitary Surgery

	Overall Complication Rate (%)	*P* Value	Odds Ratio
Attendings and resident/fellow	7.6	0.334	1.511
Attending alone	5.8	Reference	Reference

Factors utilized for regression: age, race, gender, and significant comorbidities (diabetes and previous PCI).
Reference value indicates the odds within the AA group (1.0).
AA = attending alone; PCI = percutaneous coronary intervention.

TABLE IV.
Multivariable Regression of Surgical Complication Risk in Transsphenoidal Pituitary Surgery

	Surgical Complication Rate (%)	*P* Value	Odds Ratio
Attendings and resident/fellow	1.3%	0.453	0.550
Attending alone	1.9%	Reference	Reference

Factors utilized for regression: age, race, gender, and significant comorbidities (diabetes and previous PCI).
Reference value indicates the odds within the AA group (1.0).
AA = attending alone; PCI = percutaneous coronary intervention.

TABLE V.
Multivariable Regression of Medical Complication Risk in Transsphenoidal Pituitary Surgery

	Medical Complication Rate (%)	*P* Value	Odds Ratio
Attending and Resident/fellow	7.0%	0.102	2.260
Attending Alone	3.9%	Reference	Reference

Factors utilized for regression: age, race, gender, and significant comorbidities (diabetes and previous PCI).
Reference value indicates the odds within the AA group (1.0).
AA = attending alone; PCI = percutaneous coronary intervention.

analysis. Cases were divided into two groups: attending and resident/fellow (AR) and attending alone (AA). Analysis of the groups was conducted based on demographics, preoperative characteristics, and postoperative outcomes.

Preoperative characteristics include diabetes mellitus, current smoker, dyspnea, current alcohol use, pneumonia, ventilator use (< 48 hours prior to surgery), weight loss (> 10% in the 6 months prior to surgery), chronic obstructive pulmonary disease, congestive heart failure, previous myocardial infarction, previous percutaneous coronary intervention, previous cardiac surgery, angina, history of treatment for peripheral vascular disease, hypertension (requiring medication), history of transient ischemic attack, cerebrovascular accident (CVA) with or without neurological deficit, disseminated cancer, steroid use (< 30 days prior to surgery), bleeding disorders, dialysis (< 2 weeks prior to surgery), chemotherapy (< 30 days prior to surgery), radiotherapy (< 90 days prior to surgery), systemic sepsis, any previous major operations (< 30 days prior to surgery), wound infection, functional status (independent/dependent), ASA (American Society of Anesthesiologists) class, hyponatremia (< 135 mEq/L) and hypoalbuminemia (< 3.5 g/dL) (Table I).

Postoperative variables included overall complications, surgical complications, medical complications, overall mortality, reoperation rates, readmission rates, unplanned readmission rates, total operating time, total anesthesia time, and length of stay (Table II). Surgical complications included superficial, deep, and organ/space surgical site infections (SSI), wound disruption, and severe bleeding requiring blood transfusion. Medical complications included pneumonia, pulmonary embolism, ventilator use for > 48 hours, unplanned reintubation, urinary tract infection, deep vein thrombosis, renal insufficiency (increase in creatinine > 2 mg/dL above preoperative value), acute renal failure, CVA with neurological deficit, nerve injury, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, sepsis, and septic shock.

All statistical analysis was conducted via the use of SPSS version 22 (IBM, Armonk, NY). Pearson chi-square, Fisher exact, and independent 2-tailed *t* tests were used to determine statistical association between groups, with a *P* value of < 0.05 deemed statistically significant. Multivariate logistic regression (accounting for demographics and significant comorbidities) was used to compare rates of overall complications, surgical complications, and medical complications between the AR and AA groups (Tables 3–4, and V). This study is deemed exempt from the Rutgers New Jersey Medical School (Newark, NJ) institutional review board due to the fact that NSQIP contains de-identified patient information.

RESULTS

Our study identified 517 patients who had TSPS within the 2005 to 2013 NSQIP database. Of these, 48 were excluded due to lack of data on resident/fellow participation. A total of 469 patients were included in the analysis, with 315 in the AR group and 154 in the AA group.

Patient Demographics and Comorbidities

The majority of patients for both groups were between 41 to 60 years of age (Table I). The AR group had a higher percentage of females (53.6%), whereas the AA group had a higher percentage of male patients (54.1%). There were no statistically significant differences in age or gender among the two groups. The most common comorbidities present in > 10% of both groups were diabetes mellitus, current smoking status, and hypertension. The attending group had a higher rate of diabetic patients (20.1% vs. 11.7%, $P = 0.015$) and patients with a history of previous percutaneous coronary intervention (PCI) (6.0 vs. 1.6%, $P = 0.009$). There were no other significant differences among comorbidities between the two groups.

Operative Variables and Postoperative Complications

Overall complication rates (Table II) were higher in the AR group when compared to the AA group (7.6% vs. 5.8%, $P = 0.480$). Similarly, residents/fellows were associated with higher rates of medical complications (7.0% vs. 3.9%, $P = 0.185$). On the other hand, the AA group was associated with elevations in rates of surgical complications (1.9% vs. 1.3%, $P = 0.689$). These differences were not associated with any statistical significance, and furthermore there were no significant differences within specific surgical or medical complications among the two groups.

The AA group had higher rates of reoperation (10.0 % vs. 3.0%, $P = 0.117$), and the AR group had higher unplanned readmissions (3.2% vs. 1.9%, $P = 0.560$). However, these differences were similarly not statistically significant. In addition, analysis of mortality rates, total operating time, total anesthesia time, and postoperative length of stay revealed a lack of statistical significance between the two groups.

Multivariate Analysis

Multivariate logistic regression (Tables 3–4, and V) (accounting for age, race, gender, and statistically significant comorbidities) confirmed that resident/fellow participation was not associated with significant differences in overall complications (odds ratio [OR] 1.511, $P = 0.334$), surgical complications (OR 0.550, $P = 0.453$), or medical complications (OR 2.260, $P = 0.102$) when compared to the AA group.

DISCUSSION

Transsphenoidal pituitary surgery is a safe and effective option for the treatment of pituitary tumors. Nonetheless, it is not a procedure without risks considering the

vital anatomical structures within the operative field and potential serious complications that may occur,[9] and thus it requires a high level of training. Residents and fellows in training gradually acquire experience and the specific skill set necessary to carry out this procedure under the careful supervision of the expert surgeon. Ultimately, at the end of their instructional period, residents and fellows will have gained sufficient confidence and competency to perform the surgery and care for the patient independently.

Academic medical centers have the responsibility to maintain high patient care outcomes while training proficient surgical residents and fellows. Although the intraoperative experience is a pivotal component of surgical training, it can unfortunately afford inexperienced trainees the potential to negatively impact patient care. Despite the continued rise in number of TSPS performed and intensified scrutiny of surgical graduate education and quality of healthcare delivered, there is a lack of literature regarding the impact of resident and fellow participation on patient outcomes in TSPS.

This study contributes to the literature as the first multi-institutional study evaluating the effect of resident and/or fellow involvement in TSPS on patient outcomes. Our results demonstrated that resident/fellow involvement in TSPS is not associated with negative perioperative outcomes.

It is a commonly held belief that surgeries take longer when trainees are involved because of the inherent time needed to teach them and for them to learn and perform the newly acquired surgical skill, which a seasoned surgeon may be able to perform with instinctive familiarity.[10] As with the acquisition of any surgical skill, there is a learning curve of graded competency along which a trainee has to progress. Increased operative time and its association with negative perioperative outcomes and higher intraoperative costs to the institution has been well investigated and remains an area of concern regarding resident and fellow surgical participation and patient care.[5,6,11,12] In the current study, there was no difference in operative time between the AR and AA groups. In this analysis, trainee operative time (151.1 minutes) was comparable to that of the attendings (150.8 minutes). This may be attributed to the possibility that pituitary surgeries typically involve more senior-level residents and fellows[9] whose surgical competencies are closer to that of the attending surgeon. Intuitively, residents and fellows' operative times shorten as they advance in their training.[6,13] As evidenced in our data, of the 315 total residents and fellows, 210 of them were PGY4 or greater. These results support that the current otolaryngology and neurosurgery residency agenda ensures graded responsibility based on skill set of the resident and complexity of the procedure. This may demonstrate that the attending physician is selecting for appropriate resident and fellow performance and experience without compromising patient outcome in order to ensure patient safety while promoting education.

Our study showed that the AA group (1.9%) encountered more surgical complications than the AR group (1.3%), although the difference was insignificant. In the TSPS scenario, although generally more experienced, the attending physician may be more familiar with the traditional microscopic approach than the endoscopic approach because the considerable shift from the microscopic approach to the endoscopic approach has been a relatively recent one. The introduction of a new method at the beginning of a learning curve can contribute to more complications.[2,3,14] There is a steep learning curve associated with becoming familiar with the endoscope.[15,16] However, complications are significantly reduced after overcoming the learning curve, which varies from 17 to 50 surgeries according to a review of studies.[15] Additionally, the presence of another trained physician, the resident or fellow—especially one at the senior level during the operation—is potentially beneficial. This is a possible contributing factor to the lower surgical complication rate observed in the AR group, which consists of one attending surgeon and at least one resident/fellow. These surgeons in training may serve as a sounding board to the attending from preoperative decision making to postoperative management.[17] Several studies have demonstrated and discussed the potential protective effect of trainee participation on patient outcomes.[17–19]

Compared to the AA group, the AR group experienced more medical complications and overall complications. A resident or fellow's influence in patient care is not limited to the operating room but also on the floors during the postoperative period. The increased number of medical complications seen in the AR group can potentially be attributed to an inexperienced trainee's postoperative management or intensive care management skills rather than intraoperative skills.[20] It is important to be mindful that the surgical resident/fellow represents only one member of a multidisciplinary team that provides care to the patient and participates in multiple components of patient care, which may affect observed outcome.[18] This further supports the continued need for resident/fellow involvement in comprehensive patient care to allow the necessary opportunity for residents/fellows to develop and strengthen their postoperative management skills in real-life scenarios in which unanticipated problems may arise.

The AR group also had a higher number of mortalities (1.3%) than the AA group (0.6%), although also not significant. The higher number of mortalities seen with the AR group may be explained by the notion that academic affiliated institutions where residents and fellows are trained often take on more complex and technically challenging cases. Residents and fellows are often recruited into cases that are of educational value and sometimes assigned risky "teaching cases."[8,19,21] The AA group is most likely composed of physicians from teaching institutions or from private hospitals. Private hospitals may divert their more complicated patients and procedures to teaching institutions, which often serve as referral centers for such cases.[19] This can contribute to an unobserved bias and dilution of mortalities in the AA group compared to the AR group because resident and fellow involvement is inherently higher in academic centers. However, most importantly, the difference in number of mortalities between the AR and AA group was not significant, and therefore resident and fellow participation did not have a negative impact on surgical outcome.

There has been debate regarding the association between comorbidities of the patients and postoperative

complications. History of insulin-dependent diabetes and PCI have been demonstrated in a variety of surgeries as risk factors for complications.[22–27] Patients with diabetes mellitus or poor glycemic control are predisposed to bacterial infections, including SSI. Individuals with diabetes mellitus have a high incidence of small vessel disease, leading to impaired oxygen and nutritional delivery to peripheral tissue, delayed wound healing, and impaired leukocyte and monocyte functions.[27] The AA group had a higher rate of diabetic patients and history of previous PCI compared to the AR group. This may also explain the higher rate of surgical complications, which include SSI that the AA group experienced.

This study bears several limitations. Institutions evaluated from the ACS NSQIP database represent a subset of hospitals and may not be fully representative of all the centers in which residents and fellows are trained. The ACS NSQIP database also inherently has its own limitations. The database only collects postoperative outcomes within 30 days of initial operation; therefore, information regarding complications that may potentially appear later cannot be evaluated. Additionally, NSQIP only records whether there was resident or fellow participation and the highest level of trainee involved; it does not specify the number of trainees involved. Specialties of participating trainees are also not recorded and therefore cannot separate the data between trainees of the neurosurgery versus those of the otolaryngology service. The extent of the trainees involvement also cannot be determined. Their participation in the operation can range from assistance with retraction to shared planning and independent execution of a procedure. Attending surgeon-level factors such as technical proficiency of the attending surgeon also are unavailable. Those of newly graduated surgeons may differ from those of experienced surgeons who have achieved their level of mastery. Unfortunately, the database also does not capture specialty-specific outcomes, which can be of great clinical importance. Additionally, the database does not differentiate total operative times into otolaryngologic and neurosurgical portions; thus, reported numbers are difficult to generalize given the potential for limited validity with heterogeneous techniques.

Despite these limitations, the use of the large, multi-institutional ACS-NSQIP database remains a strength of this study. It provides robust clinical data, reviewed by trained clinicians, and audited for interrater reliability.[6,28] The results of this study demonstrate that resident and/or fellow participation in TSPS is safe with no meaningful clinical differences in patient outcomes, and supports the effectiveness of the current otolaryngology and neurosurgery surgical training paradigm, in which intraoperative involvement is paramount and skills are acquired primarily through experiential learning in the operating room.[5] This study reassures that resident and fellow participation does not risk adverse outcomes for the patient.

CONCLUSION

Resident and/or fellow involvement in transsphenoidal pituitary surgery is safe and does not significantly impact patient outcomes. The current surgical education paradigm for the training of otolaryngology and neurosurgery residents and fellows for transsphenoidal pituitary surgery is effective.

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