Comparative inpatient resource utilization for patients undergoing endoscopic or microscopic transsphenoidal surgery for pituitary lesions

Clinical article

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Object. An increasingly important measure in the health care field is utilization of hospital resources, particularly in the context of emerging surgical techniques. Despite the recent widespread adoption of the endoscopic transphenoidal approach for pituitary lesion surgery, the health care resources utilized with this approach have not been compared with those utilized with the traditional microscopic approach. The purpose of this study was to determine the drivers of resource utilization by comparing hospital charges for patients with pituitary tumors who had undergone either endoscopic or microscopic transphenoidal surgery.

Methods. A complete accounting of all hospital charges for 166 patients prospectively enrolled in a surgical quality-of-life study at a single pituitary center during October 2011–June 2013 was undertaken. Patients were assigned to surgical technique group according to surgeon preference and then managed according to a standard postoperative institutional set of orders. Individual line-item charges were assigned to categories (such as pharmacy, imaging, surgical, laboratory, room, pathology, and recovery unit), and univariate and multivariate statistical analyses were conducted.

Results. Of the 166 patients, 99 underwent microscopic surgery and 67 underwent endoscopic surgery. Baseline demographic descriptors and tumor characteristics did not differ significantly. Mean total hospital charges were $74,703 ± $15,142 and $72,311 ± $16,576 for microscopic and endoscopic surgery patients, respectively (p = 0.33). Furthermore, other than for pathology, charge categories did not differ significantly between groups. A 2-step multivariate regression model revealed that length of stay was the most influential variable, followed by a diagnosis of Cushing’s disease, and then by endoscopic surgical technique. The model accounts for 42% of the variance in hospital charges.

Conclusions. Study findings suggest that adoption of the endoscopic transphenoidal technique for pituitary lesions does not adversely affect utilization of resources for inpatients. The primary drivers of hospital charges, in order of importance, were length of stay, a diagnosis of Cushing’s disease, and, to a lesser extent, use of the endoscopic technique. This study also highlights the influence of individual surgeon practice patterns on resource utilization.

Key words • endoscopic surgery • hospital charges • resource utilization • transphenoidal surgery • pituitary surgery

Health care resource utilization is becoming an increasingly important metric and health economics concern. Resource utilization is particularly important to study in the context of emerging technologies that gain popularity and begin to replace traditional techniques, such as endoscopic endonasal transphenoidal surgery. Use of this technique is growing, and over the past decade, many surgeons have been transitioning their practice from microscopic speculum-based approaches to endoscopic approaches. The endoscopic pituitary approach has perceived advantages over the microscopic approach, which are driving the adoption of endoscopic surgery; such advantages include improved visualization of suprasellar and cavernous sinus extensions of pituitary adenomas. This approach also has perceived disadvantages, such as longer operative time and increased costs of disposable items in the operative theater. To date, the effect of endoscopic approaches on resource utilization has not been compared with that of traditional microscopic technique. To begin to determine the key drivers of resource utilization and to determine whether resource utilization varies according to technique, we compared inpatient hospital charges for patients undergoing direct endonasal microscopic transphenoidal surgery with those for patients undergoing binostril endoscopic transphenoidal surgery.
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Methods

This study was approved by the institutional review board at St. Joseph’s Hospital and Medical Center. Informed consent was not required.

Patient Population

Patients included in this report were from a single institution and were participating in a multicenter quality-of-life study (NCT01504399). Eligible patients were English- or Spanish-speaking adults identified in the outpatient neurosurgical clinics at the Barrow Pituitary Center during October 2011–June 2013. All had sellar pathology and underwent an endonasal surgical approach that involved the transsphenoidal corridor. Two neurosurgeons contributed patients to this study; one surgeon performs exclusively direct endonasal microscopic surgery, and one performs exclusively binostril endoscopic surgery.

Patients were managed according to a standard institutional protocol and standard set of orders that had been agreed upon by the investigators before the study began. The standard set of orders included surveillance for diabetes insipidus, postoperative MR imaging, measurement of relevant serum hormones, analgesia, nasal care, and bowel care.

Data Acquisition and Analysis

An accounting of all hospital charges for enrolled patients was obtained from the institution’s finance department. To facilitate analysis, after de-identification of charge data, a research nurse categorized all line items as follows: operating room, pharmacy, imaging, laboratory, bed, other diagnostics, pathology, respiratory therapy, physical therapy, recovery room, and medical supplies.

To limit the confounding effect of patients who were admitted through the emergency department, who may have been hospitalized before surgery, we analyzed charges incurred from the start of surgery until hospital discharge. We also tabulated patient demographics and information regarding pathology type, tumor size, and perioperative complications.

For statistical analyses, the dependent variable was hospital charges. For univariate analyses, continuous variables were analyzed by using an independent sample t-test and dichotomous variables were analyzed by using a chi-square test. We also constructed a 2-step multivariate linear regression model that examined covariates of interest from the univariate analyses. The log transformation of hospital charges was used, and the dependent variable of the regression model presented to adjust for skewness and kurtosis. p values less than 0.05 were considered significant. Statistical analyses were performed by using SPSS version 21 (IBM).

Results

We enrolled 166 patients, among whom 99 (60%) underwent microscopic transsphenoidal surgery and 67 (40%) underwent endoscopic transsphenoidal surgery. Data on hospital charges were available for all patients. Three patients were excluded from the analysis because total hospital charges exceeded 3 times the standard deviation above the mean. Demographics were similar for patients in the 2 groups (Table 1), with the exception of admission type (p < 0.001). More patients in the endoscopic surgery group were admitted urgently through the emergency department, reflecting the fact that the endoscopic surgeon covers more emergency calls than does the microscopic surgeon. The most common reason for urgent admission was apoplexy (12/18 patients, 67%).

Mean total hospital charges were similar between the groups ($74,703 ± 15,142 for microscopic surgery, $72,311 ± 16,576 for endoscopic surgery; p = 0.33). Furthermore, hospital charges did not differ significantly by category, with the exception of higher charges for pathology in the microscopic surgery group (p < 0.001) (Table 2). For both groups, total operative charges, which included billed operative time and disposable items, represented more than 60% of total hospital charges.

In terms of other drivers of resource utilization, an exploratory analysis of numerous covariates suggested that length of stay was positively correlated with hospital charges, r(166) = 0.66 (p < 0.001), and mean charges were higher for patients experiencing postoperative complications ($89,650 ± 27,840 vs $72,040 ± 12,881 for no complications; p = 0.02) and for patients with Cushing’s disease ($86,245 ± 6875 vs $72,936 ± 15,810 for patients without Cushing’s; p = 0.01) (Fig. 1). Factors not associated with hospital charges were patient age, patient sex, admission type, and tumor size.

When a 2-step multivariate linear regression model was constructed to determine the factors that independently predicted hospital charges (Table 3), the first step of the model revealed that length of stay was the primary driver of resource utilization (p < 0.001), when other predictors were held constant. In the second step of the model, surgical technique significantly predicted hospital charges, which were 2% lower for endoscopic surgery (p < 0.05). The presence of Cushing’s disease also emerged as a predictor, accounting for an additional 6% in hospital charges (p = 0.004). Hospital charges were not significantly predicted by patient age and complications. Although the presence of surgical complications was not predictive of total charges in our multivariate model, it should be noted that a simpler comparison of group means suggests a significantly higher average cost for patients with than without complications, as described above. Patients who experienced surgical complications also stayed in hospital significantly longer than those without complications (4.0 ± 1.9 days versus 2.3 ± 0.9 days, respectively, p < 0.01). As a result, the primary predictor of total charges was length of stay and the presence of surgical complications was not predictive of total charges.

Altogether, the regression model accounted for 42% of the variance in hospital charges. Figure 1 illustrates the association between hospital charges and several covariates.

Subgroup Analysis

Because the endoscopic surgery group included more urgently admitted patients, we separately analyzed charges in the subgroup of patients who were electively admitted (Table 4). Total charges did not statistically differ between groups (p = 0.45). A multivariate analysis of the elective
technique was significant at the trend level (p = 0.11) (Table 5). They reported that costs differed markedly, favoring the endoscopic technique; these findings suggest that biological factors, such as tumor physiology and anatomy, might play a more important role than surgical technique. Recently, Osmannally et al.15 performed a comparative cost analysis of endoscopic transsphenoidal surgery and sublabial transseptal microscopic surgery at a single institution and also found that length of stay was a key driver of costs. They reported that costs differed markedly, favoring the endoscopic approach. However, it should be noted that the groups were from different periods and that groups differed significantly in length of stay, which does not reflect contemporary standards, particularly for the group that underwent sublabial microscopic surgery. We speculate that our use of a standardized institutional postoperative set of orders limited differences in length of stay between groups. Our study is novel in 2 ways. To our knowledge, we are the first to examine utilization of resources for patients undergoing direct endonasal microscopic and endonasal endoscopic pituitary surgery, and we evaluated a contemporaneous cohort of patients rather than comparing historical cohorts.

Hospital charges are an accepted surrogate for resource utilization for surgical procedures, more specifically, pituitary surgery. Hospital charges represent the sum of all billed hospital services provided to patients during the inpatient perioperative period were not higher for patients who underwent binostril endoscopic pituitary surgery than for those who underwent direct endonasal microscopic pituitary surgery. According to multivariate analysis, hospital charges were on average 2% lower for the endoscopic technique patients than for the microscopic technique patients. This finding emerged only in the multivariate model and was described in the context of holding other predictors on the model constant. The only difference we noted between groups was that pathology charges were lower for patients in the endoscopic surgery group, which is explained by the endoscopic surgeon’s bias that intraoperative pathology assessment infrequently influences intraoperative decision making. According to the results of a 2-step regression model, the primary drivers of resource utilization were length of stay and the presence of Cushing’s disease independent of surgical technique; these findings suggest that biological factors, such as tumor physiology and anatomy, might play a more important role than surgical technique. Recently, Osmannally et al.15 performed a comparative cost analysis of endoscopic transsphenoidal surgery and sublabial transseptal microscopic surgery at a single institution and also found that length of stay was a key driver of costs. They reported that costs differed markedly, favoring the endoscopic approach. However, it should be noted that the groups were from different periods and that groups differed significantly in length of stay, which does not reflect contemporary standards, particularly for the group that underwent sublabial microscopic surgery. We speculate that our use of a standardized institutional postoperative set of orders limited differences in length of stay between groups. Our study is novel in 2 ways. To our knowledge, we are the first to examine utilization of resources for patients undergoing direct endonasal microscopic and endonasal endoscopic pituitary surgery, and we evaluated a contemporaneous cohort of patients rather than comparing historical cohorts.

Discussion

Introduction of new medical technology or a surgical technique affects utilization of hospital resources. As surgeons transition away from traditional microscopic approaches and move toward endoscopic visualization, endoscopic transsphenoidal surgery for pituitary lesions is being more commonly performed. The effect of this trend on resource utilization has not been evaluated until now. In this study, we learned that total hospital charges during the inpatient perioperative period were not higher for patients who underwent binostril endoscopic pituitary surgery than for those who underwent direct endonasal microscopic pituitary surgery. According to multivari-

<table>
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<th>TABLE 1: Patient demographics*</th>
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<td>Demographic</td>
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<td>age (yrs)</td>
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<td>type of admission</td>
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<td>length of stay (days)</td>
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<td>complications‡</td>
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<td>tumor size, mean (mm)</td>
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<td>giant adenoma§</td>
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<td>tumor type</td>
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<td>lumbar drain</td>
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<th>TABLE 2: Average hospital charge by category for the entire cohort, 166 patients*</th>
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<td>Category</td>
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<td>pharmacy</td>
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<td>room charge</td>
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<td>laboratory</td>
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<td>operating room</td>
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<td>PACU</td>
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<td>radiology</td>
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<td>medical supplies</td>
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<td>rehabilitation</td>
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<tr>
<td>other testing (EEG, EKG)</td>
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<tr>
<td>respiratory</td>
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<td>pathology</td>
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<td>total hospital charge</td>
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</table>

* Boldface indicates statistical significance. EEG = electroencephalography; EKG = electrocardiography; PACU = postanesthesia care unit.

-Data are indicated as no. (%) unless otherwise indicated. Boldface indicates statistical significance. ACTH = adrenocorticotropic hormone; NA = not applicable.

† Urgently admitted patients were seen at the emergency department or were transferred from another hospital for apoplexy (n = 12), chiasmopathy (n = 2), or incidental finding of a large adenoma (n = 1), diabetic ketoacidosis as an acute presentation of acromegaly (n = 1), symptomatic hyponatremia (n = 1), or vertebral compression fracture leading to diagnosis of Cushing’s disease (n = 1).

‡ Complications included temporary or permanent diabetes insipidus, CSF leak, hyponatremia, cardiac dysrhythmia, respiratory failure, delirium tremens, heart palpitations, vision decline, and meningitis.

§ Defined as greater than 40 mm height in the coronal plane.

¶ Rathke's cleft cyst, meningioma, pituitary cyst.
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during their hospital stay and include procedure, room, laboratory and diagnostic, and pharmacy charges. This type of analysis does not examine equipment costs, such as the cost of obtaining endoscopic equipment, because of the complexities of amortizing the costs of the equipment over its lifetime and calculating depreciation. The study of hospital charges has led to some insights into the drivers of resource utilization. For example, we previously stud-

Fig. 1. Box plot (A) and graph (B) demonstrating the associations between significant covariates and hospital charges. *p < 0.05; endo = endoscopic surgery; micro = microscopic surgery. In panel A, the lines in the middle of the boxes represent the median values. The bottom and top of the boxes represent the 25th and 75th percentiles, respectively. The whiskers represent the minimum and maximum distribution of the data.
cause we had access to all patient care information. Third, we were able to limit missing critical data elements because we were able to effectively study types of hospital charges. Fourth, we were able to ensure that complications were accurately coded because the physician team was able to verify the data collected by the research nurse, which helped limit the effect of miscoding on the outcome of the analysis.

Other aspects of the study design deserve further discussion. One observation described above is the association between outcome and surgeon experience. The study reported here exploited a unique situation in which 2 busy transsphenoidal surgeons practice at a single institution; one surgeon has an exclusively endoscopic practice and one has an exclusively microscopic practice. However, at initiation of the study, the surgeon who performed microscopic surgery had been practicing transsphenoidal surgery for 37 years and the other surgeon had been practicing endoscopic surgery for 2 years. The disparity in experience may have influenced the results in favor of the group who underwent microscopic surgery. Postoperative patients were managed by a standardized institutional set of orders that may have limited the hospital charge variation between groups but may also have limited the influence of surgeon experience on outcome. In addition, surgical approach was recommended by the treating surgeon. Because the surgeons in the study exclusively practiced one technique, surgical approach was not tailored to the patient. Therefore, there was no overt selection bias regarding surgical technique. For example, patients with giant adenomas were not preferentially distributed to the endoscopic surgery group, despite the fact that some might be of benefit for this population. Last, the analysis indicated that individual surgeon practice patterns differed with regard to intraoperative pathology assessment. Our study may contain other unrecognized differences in practice preferences, although we tried to limit such differences by following a standard institutional set of orders.

One other potential confounder in our study that de-
serves discussion is that more patients in the endoscop- 
cic surgery group were seen urgently for treatment. This 
group included patients with apoplexy and progressive 
chiasmopathy. We tried to account for this difference be- 
tween groups by analyzing hospital charges from the start 
of surgery through hospital discharge to avoid including 
emergency department charges or hospital charges that 
occur while the patients were awaiting surgery. Gener- 
ally, emergently admitted patients recovered promptly, as 
would be expected for those with straightforward cases of 
chiasmopathy or apoplexy. That being said, emergently 
admitted patients tend to have more complex cases than 
do elective patients, so our results might be biased in favor 
of the microscopic surgery group. To address this concern, 
we performed a subgroup analysis on the elective surgery 
cohort only and found no substantive differences in total 
hospital charges (Table 4) according to surgical technique 
or in the main predictors that emerged from the multivari- 
ate analysis (Table 5).

Our study suggests targets on which to focus efforts 
to improve utilization of resources for patients undergoing 
pituitary surgery. Because operative charges accounted 
for more than 60% of total charges, these charges are a 
rational first target. Furthermore, efforts to shorten length 
of stay, such as development of standard institutional sets 
of orders, may be valuable. Another opportunity lies in 
use of postoperative radiology. To assess extent of resec- 
tion, we obtain immediate postoperative MR images for 
most patients with nonfunctioning pituitary tumors and 
for some patients with functioning tumors. Biochemical 
studies are excellent markers for extent of resection and 
predict biochemical remission in functioning pitui- 
tary tumors.14,5,8,9 A straightforward opportunity to decrease re- 
source utilization in our practice would be to limit postop- 
erative MR imaging of functioning pituitary tumors that 
have early evidence of biochemical remission. Last, we 
 intraoperatively assess pathology, in part because we are 
curious to know the tumor pathology and in certain cases 
to help distinguish between normal gland and tumor, but 
rarely do the results alter our intraoperative decisions. The 
more limited use of intraoperative pathology services in 
the endoscopic surgery group explains why hospital 
charges were lower for patients in that group, illustrating 
how individual surgeon practice patterns can influence re-
source utilization.

Conclusions

This study examined utilization of inpatient hospital 
resources for patients undergoing either direct endonasal 
microscopic or binostril endoscopic transsphenoidal sur- 
gery for pituitary tumors. The data demonstrated that the 
primary drivers of hospital charges were length of stay 
and a diagnosis of Cushing’s disease. Hospital charges 
were also modestly lower when the endoscopic technique 
was used. This study suggests opportunities for limiting 
utilization of hospital resources for patients undergoing 
pituitary surgery and also illustrates the effect of individ- 
ual surgeon practice patterns on resource utilization.

Acknowledgment

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Department at St. Joseph’s Hospital and Medical Center for their 
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Disclosure

This study was funded by the Barrow Neurological Foundation. 
The authors report no conflict of interest concerning the materials 
or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation 
include the following. Conception and design: Little, White. Acqui- 
sition of data: Jahnke. Analysis and interpretation of data: Little, Chapple. Drafting the article: Little, Chapple. Critically revising the 
article: all authors. Reviewed submitted version of manuscript: all 
authors. Approved the final version of the manuscript on behalf of 
all authors: Little. Statistical analysis: Chapple. Study supervision: 
Little.

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### TABLE 5: Summary of hierarchical regression analysis for vari- 
ables predicting the logarithm of total hospital charges for the 
subgroup of 148 patients who underwent elective surgery†

<table>
<thead>
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<th>Variable</th>
<th>Model 1</th>
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<th>Model 2</th>
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<td>SE B</td>
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<td>B</td>
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<td>presence of Cush-</td>
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<td>endoscopic technique</td>
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<td>adjusted R²</td>
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<td>F for change in R²</td>
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<td>3.50**</td>
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† Values shaded in light gray correspond to Model 1. Values shaded in 
dark gray correspond to Model 2.

* p = 0.11; **p < 0.01; ***p < 0.001.

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