

## Original Article

# Safety and cost effectiveness of early discharge following microscopic trans-sphenoidal resection of pituitary lesions

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## Abstract

**Background:** Inpatient hospitalization following trans-sphenoidal resection of a pituitary neoplasm has traditionally involved a hospital stay of 2 days or more. It has been the policy of the senior pituitary neurosurgeon (GSA) since February 2008 to allow discharge home on postoperative day (POD) 1 if thirst mechanism is intact and the patient is tolerating oral hydration. The goal of this study was to evaluate the safety and cost-effectiveness of this practice.

**Methods:** We reviewed the charts of 30 patients, designated the early discharge group, who consecutively underwent microscopic trans-sphenoidal resection from February 2008 to December 2009. We then reviewed the charts of 30 patients, designated the standard discharge group, who consecutively underwent trans-sphenoidal resection from May 2007 to February 2008 before discharge home on POD1 was considered an appropriate option. Safety and cost-effectiveness of the two patient groups were retrospectively evaluated.

**Results:** Patients in the early discharge group went home, on average, on POD 1.3. Following exclusion of two outliers, the average date of discharge of patients in the standard discharge group was POD 2.2. The policy of early discharge saved an average of \$1,949 per patient—approximately 4% the total cost of the procedure. Trends toward decreased costs did not reach statistical significance. While no patient suffered any measurable morbidity as a result of early discharge home, 1 in 3 patients in the early discharge group required unscheduled postoperative re-evaluation—a figure significantly higher than the standard discharge group.

**Conclusions:** At a dedicated pituitary center with the resources to closely monitor outpatient endocrinological and postsurgical issues, early discharge home following trans-sphenoidal surgery is a safe option that is associated with an increase in the number of unscheduled postoperative visits and a trend toward lower costs.

**Key Words:** Diabetes insipidus, early discharge, pituitary surgery, SIADH, trans-sphenoidal

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## INTRODUCTION

The cost of medicine in the United States has commanded much attention in recent years. More money per person is spent on health care in the United States than in any other nation in the world.<sup>[21,30]</sup> In the context of rising costs, the medical and surgical communities have sought ways to cut spending without affecting quality of care. With this in mind, the safety and costeffectiveness of the policy of early discharge home following pituitary surgery at Vanderbilt University Medical Center (VUMC) between February 2008 and December 2009 is evaluated.

Pituitary adenomas are estimated to have an overall prevalence of 16.7% with an annual incidence of approximately 7,000 new cases/year.<sup>[14]</sup> The number of pituitary surgeries performed a year is considerable—the estimated annual caseload for all U.S. nonfederal hospitals between 1996 and 2000 was 5,410 cases per year.<sup>[4]</sup> The sum costs of these surgical procedures are significant and can be broken down into three categories: operative costs, postoperative inpatient costs, and postoperative outpatient costs [Figure 1].

Operative costs include the costs of the operating room and its staff, operating room equipment, and care provided by the anesthesiology and surgical teams. Operative time is the predominant factor in determining the total operative cost; the joint procedure with the ENT and neurosurgical teams has traditionally required approximately 2-3 hours to perform at our center. Previous reports have suggested

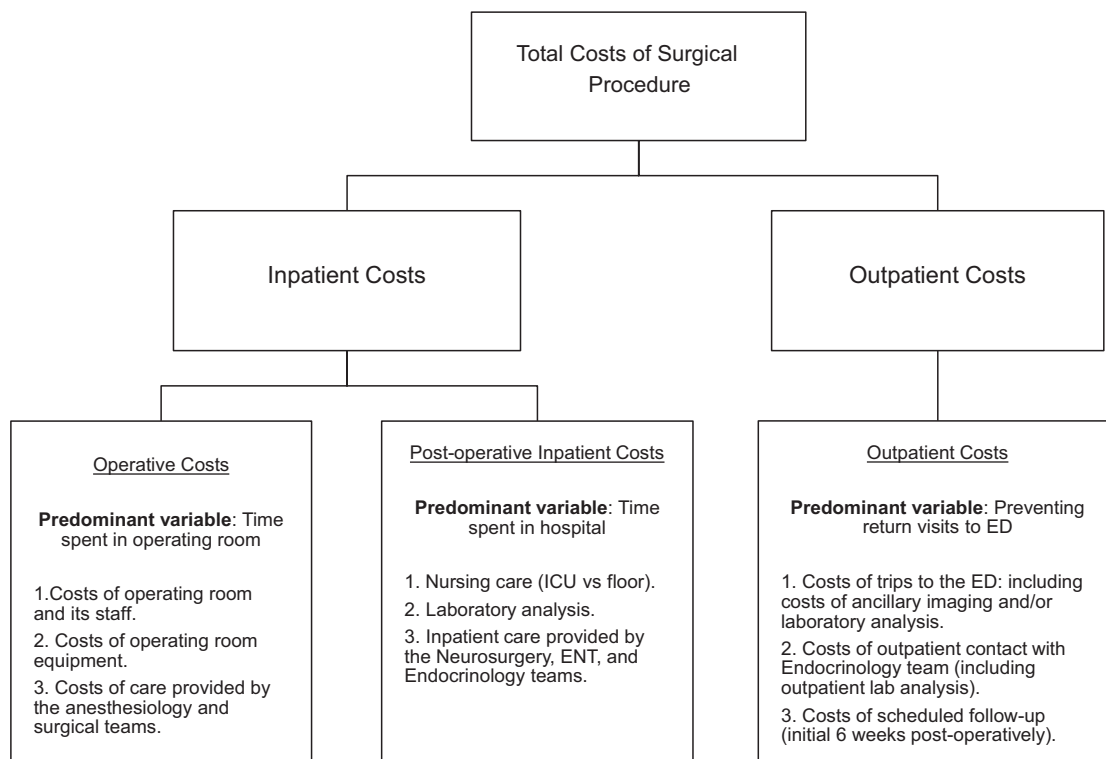
that endoscopic trans-sphenoidal resection of pituitary lesions may require less operative time than microscopic resection.<sup>[17]</sup> Operative costs, estimated to involve 31% of the total costs of inpatient care following trans-sphenoidal resection in a previous series of nine patients,<sup>[13]</sup> comprise a significant portion of the financial burden of surgery and are intimately linked to surgeon and site-specific characteristics (experience, preference for and familiarity with method of resection, etc.) that are not especially amenable to short-term modification.

Postoperative costs can be further subdivided into costs incurred during inpatient and outpatient care. Costs related to postoperative inpatient care are influenced by time spent in the hospital. Average length of stay following trans-sphenoidal resection is variable among institutions (see Table 1 for previously documented

**Table 1: Previously documented average lengths of stay following series evaluating both microscopic and endoscopic trans-sphenoidal resection of pituitary lesions**

| Series  | LOS microscopic | LOS endoscopic |
|---|-----------------|----------------|
| Higgins <i>et al.</i> , 2008 <sup>[17]</sup>    | 5.3             | 3.0            |
| O'Malley <i>et al.</i> , 2008 <sup>[25]</sup>   | 4.8             | 3.9            |
| White <i>et al.</i> , 2004 <sup>[29]</sup>      | 5.4             | 3.7            |
| Cappabianca <i>et al.</i> , 2002 <sup>[8]</sup> | 6.4             | 3.4            |
| Cho <i>et al.</i> , 2002 <sup>[9]*</sup>        | 5.3             | 3.2            |
| Cohen <i>et al.</i> , 1996 <sup>[13]</sup>      | 5.2             | —              |
| Average LOS                                     | 5.4             | 3.4            |

LOS: length of stay. \*=study only involved prolactinomas.



**Figure 1: Total costs of the surgical procedure broken down into subcategories**

average lengths of hospital stay for both microscopic and endoscopic trans-sphenoidal resection), which in turn produces great variability in the average cost of postoperative care. Postoperative inpatient costs include nursing care, laboratory analysis, and inpatient care provided by the Neurosurgery, Otolaryngology (ENT), and Endocrinology teams. Practices among institutions vary and neurosurgeons at many facilities, including VUMC, choose to send patients to an intensive care unit (ICU) setting for the first 24 hours following the surgical procedure for close neurological monitoring and strict measurement of fluid balance. At other institutions, patients are transferred directly from the postanesthesia care unit (PACU) to the floor postoperatively. A third group of institutions has developed an intermediate care setting (IMC) for patients following trans-sphenoidal resection who do not require invasive monitoring, but who are felt to necessitate more frequent assessments than can be delivered in a floor setting. In a study at the University of Florida, IMC charges were 16% less than comparable ICU charges in similar groups of patients following trans-sphenoidal resection.<sup>[13]</sup>

Postoperative outpatient costs have been defined as all expenditures relating to the operation incurred during the period of time following discharge from the hospital up to and including the date of the routine scheduled 6-week follow-up visit. Included in this figure are costs of unscheduled trips to the emergency department (ED), which often involve additional charges relating to ancillary imaging and/or laboratory analysis, in addition to any other costs relating to patient contact and/or evaluation prior to and including the scheduled 6-week follow-up visit. These figures include the costs of postoperative clinical communication between the patient and endocrinological team in addition to the costs of outpatient laboratory analysis ordered in those patients who report symptoms concerning for possible water and electrolyte imbalance following discharge. Scheduled visits 1 week following the operation in ENT clinic and approximately 6 weeks following the operation in neurosurgery and endocrinology clinics are also included in this group of costs.

Since February 2008, it has been the policy at VUMC for the senior pituitary surgeon (GSA) to encourage discharge home on postoperative day (POD) 1 following microscopic trans-sphenoidal resection of a pituitary lesion if thirst mechanism is intact and the patient is able to hydrate comfortably. The change in policy to allow for early discharge home in select patients was instituted through the collaborative efforts of members of the Vanderbilt Pituitary Center in February 2008. Early discharge is only made possible via extensive pre- and peri-operative education by the neurosurgical, otolaryngological, and endocrinological teams. Additionally, early discharge home would not be feasible

without readily available outpatient communication and surveillance with all services. Unanticipated outpatient contact at VUMC is usually initiated through the endocrinology service.

## MATERIALS AND METHODS

A total of sixty consecutive patients who underwent microscopic trans-sphenoidal resection of pituitary lesions between May 2007 and June 2009 by the GSA at VUMC were included in this retrospective study. Thirty of the patients in this group were underwent operations between May 2007 and February 2008, when discharge home on POD2 was the standard. The remaining 30 were operated between February 2008 and December 2009. In the latter group, discharge home on POD1 was allowed and even encouraged, when certain criteria were met.

Of the 30 patients in the group operated on prior to February 2008, 14 (47%) were male and 16 (53%) were female. A total of 87% of tumors were macroadenomas. One pituitaryoma and one Rathke's cleft cyst were included in this group. A total of 53% of tumors were non-secreting and 10% of were corticotroph adenomas associated with Cushing's disease.

Of the 30 patients operated after February 2008, 13 (43%) were male and 17 (57%) were female. A total of 83% of tumors were macroadenomas. Of the cases in this group that were pituitary adenomas, 40% of tumors were non-secreting and 17% of were corticotroph adenomas associated with Cushing's disease. A summary of these clinical data is available in Table 2.

### Description of the standard operative procedure

The following operative procedure is utilized by the senior pituitary surgeon (GSA) at Vanderbilt Pituitary center, who uses the microscope for sublabial trans-sphenoidal procedures. The patient is brought to the

**Table 2: Patient preoperative and operative characteristics of patients in both surgical groups**

| Preoperative and operative characteristics        | < Feb 2008    | > Feb 2008    |
|---|---------------|---------------|
| N, Patients                                       | 30            | 30            |
| Male/female                                       | 14/16         | 13/17         |
| Preoperative hypothyroidism                       | 11            | 6             |
| Preoperative visual field deficits                | 11            | 10            |
| Macroadenoma/microadenoma                         | 26/4          | 25/5          |
| Average size macroadenoma, cm (range, cm)         | 2.1 (1.3-4.1) | 2.5 (1.1-4.4) |
| Tumor consistency (soft/fibrous)                  | 29/1          | 29/1          |
| Pathology (nonsecreting adenoma/secreting/other*) | 16/9/5        | 12/14/4       |

\*Other=Rathke's cleft cyst (1/3), pituitaryoma (1/0), hemorrhagic necrosis (1/0), pathology indeterminate (2/1)

operating room, intubated, and placed in Mayfield pins. A navigation protocol MRI scan is registered to the patient using software included on a StealthStation (Medtronic, Inc.) to allow for intra-operative use of frameless stereotaxy. A hemitransfixion incision is made and followed by a subperichondrial dissection, which is carried posteriorly to the sphenoid rostrum, and inferiorly to the nasal floor along the entire length of the septum. The cartilaginous septum is disarticulated at the bony/cartilaginous junction and the sphenoid is entered bilaterally at the rostrum and opened widely. A sublabial incision is then made across the central incisors, taking care to ensure that a mucosal cuff remains. A Hardy retractor is then placed, allowing a clear view of the sella, and a drill is then used to remove the anterior sella floor. The dura mater is cauterized and opened with a cruciate incision. The pituitary lesion is then resected in the standard fashion using a combination of ringed curettes, pituitary instrumentation, and suction. Once the tumor is removed, the Hardy retractor is removed and the nose is returned to its normal anatomic position. The cartilaginous septum is fixated to the maxillary crest using an absorbable monofilament suture. The sublabial incision is then closed using an absorbable suture in a horizontal mattress fashion. The hemitransfixion incision is closed with an absorbable suture in a simple interrupted fashion. Several tacking sutures are placed through the septum to reapproximate the nasal mucosal flaps. Doyle splints are applied and sutured in place with a nonabsorbable monofilament suture. The patient is taken out of pins and extubated.

It is important to note that many centers across the country have transitioned from a microscopic to an endoscopic endonasal approach. While cost and quality of life comparisons between the two approaches is beyond the scope of this manuscript, it deserves mention that patients who undergo endonasal endoscopic approaches often require one or more additional postoperative visits for nasal debridement.

### Description of endocrinological postoperative protocol

All patients at VUMC receive stress dose glucocorticoids prior to the operation and are later discharged home on postoperative glucocorticoid supplementation for 6 weeks. The HPA axis testing is delayed until the 6 week postoperative endocrinology visit.

All patients are evaluated regarding their ability to orally hydrate postoperatively. Labs—including serum osmolality, serum sodium, and urine-specific gravity—are obtained every 6 hours, beginning at the completion of the surgical procedure. Any patient who communicates persistent difficulty in quenching his/her thirst or develops laboratory evidence of DI is placed on scheduled desmopressin. All patients diagnosed with DI are given a

prescription of as needed (PRN) desmopressin to fill in the event that they are not able to satisfy their thirst mechanism with oral hydration alone prior to discharge. Patients are instructed to drink to quench their thirst and to contact the Pituitary Center or Endocrinologist on-call (available 24 hours a day, 7 days a week) with persistent excessive urine output or other classic symptoms of water or electrolyte imbalance.

Operations are typically performed on Tuesdays, with discharge following uncomplicated cases on Wednesday afternoon. Following discharge, patients who report symptoms concerning for DI undergo laboratory analysis within 24 hours of symptom onset—this is accomplished in an outpatient clinic, whenever possible. In the setting of acute emergency, weekend events, or events that occur long distances from the medical center, labs are obtained in the ED. Routine laboratory analysis in the absence of symptoms following discharge is not conducted. All patients are formally reevaluated with serum and urinary laboratory analysis at 6 weeks time for the presence of DI.

Routine postoperative imaging is obtained immediately prior to the 6-week follow-up visit.

### Data collection

The sum operative costs of each patient were obtained as “charge data” from the VUMC Billing Department and assessed in a retrospective fashion. Study data were collected and managed using REDCap electronic data capture tools<sup>[16]</sup> (REDCap is a secure, web-based application based at Vanderbilt University designed to support data capture for research studies). Inpatient costs were broken down into operative costs and postoperative inpatient costs. Outpatient costs included the costs of all scheduled follow-up clinic visits in the initial 6-week period, in addition to the costs of all ED visits (which varied based on level of triage, laboratory assessments, and imaging obtained), and all costs related to postoperative telephone communication and labs scheduled in an outpatient setting. The costs of all services (ED visits, labs) provided at Vanderbilt were obtained directly from the VUMC Billing Department [Figure 2]. When services were obtained at outside facilities, the outside medical records were analyzed and costs were calculated based on specific figures provided by VUMC billing. The sum total cost of the surgical procedure was then calculated for each patient in the study. These figures were stratified based on the date of surgery (before or after February 2008) and compared.

### Statistical considerations

Statistical analyses were performed in Graphpad Prism 5.03 (Graphpad Software Inc., La Jolla, CA). An unpaired t-test was used to compare the following data sets: total costs, operative costs, postoperative inpatient costs, and postoperative outpatient costs in both the early and standard discharge groups. The unpaired t-test was

then repeated for total and postoperative inpatient costs following exclusion of two outliers from the standard discharge group. A final unpaired t-test was used to compare and assess the percentage of patients in each group requiring return unscheduled visits in the early and standard discharge groups for statistical significance.

## RESULTS

Despite trends toward lower postoperative inpatient and total costs (respective *P*-values of 0.169 and 0.188) in the early discharge group, no significant difference was observed. The difference in postoperative inpatient and total costs remained statistically insignificant (respective *P*-values of 0.24 and 0.42) after exclusion of two outliers who experienced prolonged hospital stays in the standard

discharge group. In addition to these findings, no significant difference was observed between operative and postoperative outpatient costs in the early and standard discharge groups. The results of these analyses are summarized in Figure 3. Regarding the percentage of patients in each group requiring return unscheduled visits, the early discharge group was found to have a significantly greater number of return unscheduled visits than the standard discharge group [*P* = .046, Figure 4].

A summary of postoperative complications and other characteristics of the two patient groups is provided in Table 3. Patients operated on during/after February 2008 were discharged home on an average of POD 1.3. A total of five patients in this group (16.7%) developed DI. These five patients were discharged home on an average

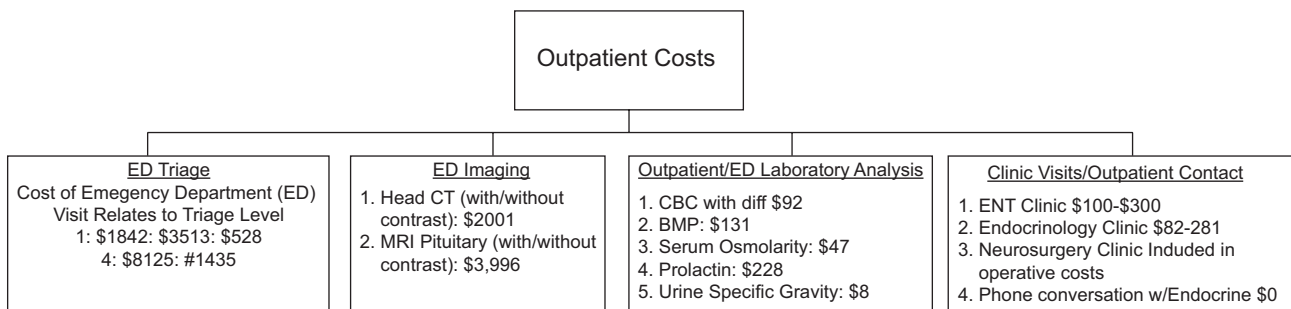


Figure 2: Charge data figures used to calculate outpatient costs

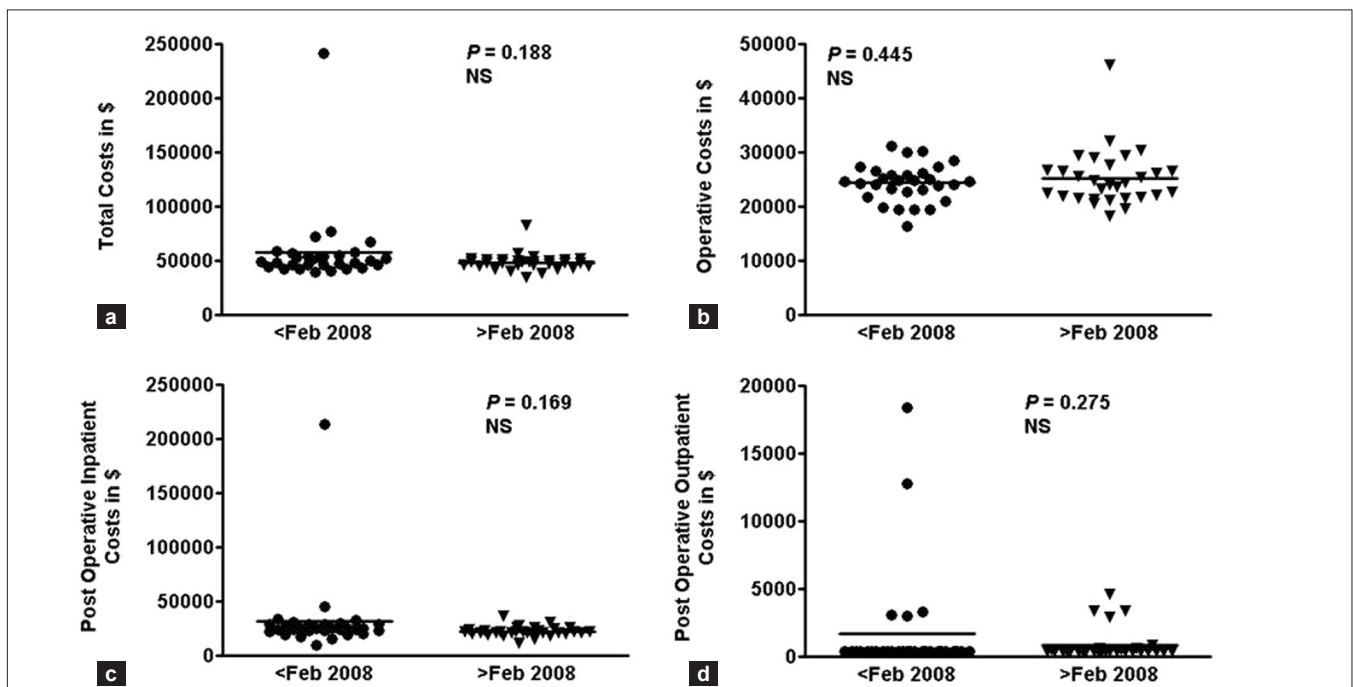
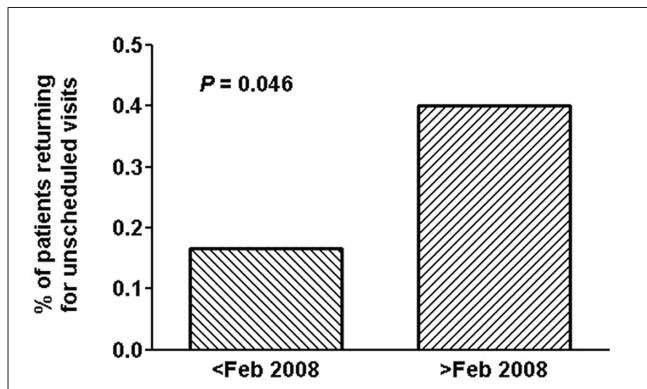


Figure 3: An unpaired t-test was used to compare the following data sets: (a) total costs, (b) operative costs, (c) postoperative inpatient costs, and (d) postoperative outpatient costs in both the early (<Feb 2008) and standard (>Feb 2008) discharge groups. Despite a trend toward lower postoperative inpatient and total costs, no significant difference between was observed in all individual cost measures. Differences in post-operative inpatient and total costs remained statistically insignificant after exclusion of two outliers who experienced prolonged hospital stays in the standard discharge group



of POD 1.6. None of these patients developed morbidity relating to early discharge from the hospital, although one patient [patient 51, see Table 4] was not diagnosed with DI until he developed characteristic symptoms following discharge. Of the 30 patients in the early discharge group, three patients (patients 39, 51, and 57) returned to the emergency department (ED) less than 36 hours following discharge with headache, polyuria secondary to DI, and passage of clots from the nose, respectively.



**Figure 4:** An unpaired t-test was used to compare the percentage of patients in each group requiring return unscheduled visits in the early and standard discharge groups. The early discharge group was found to have a significantly greater number of return unscheduled visits ( $P=0.046$ )

Additionally, two other patients (patients 53, 54) were asked to follow-up for outpatient laboratory analysis 2 and 3 days following the operation to rule out DI. These five visits cost a total of \$8,980 dollars and were thought

**Table 3: Postoperative characteristics of groups of patients operated on before and after February 2008, respectively. Patients with an intact thirst mechanism operated on after February 2008 have been routinely discharged on POD1**

| Postoperative characteristics                    | < Feb 2008 | > Feb 2008 |
|--|------------|------------|
| Major surgical complications: return to OR       | 0          | 1          |
| Surgical complications: CSF leak                 | 1          | 0          |
| Postoperative DI (mild/severe)                   | 4 (3/1)    | 6 (4/2)    |
| Average POD onset of DI                          | 1.3        | 1.4        |
| Discharged POD                                   | 3.0        | 1.3        |
| Patients with DI discharge POD                   | 2.7        | 1.6        |
| Postoperative hyponatremia                       | 2          | 0          |
| Number of ED visits postoperatively              | 4          | 5          |
| ED visits related to early discharge home        | n/a        | 2          |
| Number of outpatient endocrine labs              | 1          | 5          |
| Total number of unscheduled postoperative visits | 5          | 10         |
| Average operative costs                          | \$24,224   | \$25,218   |
| Average postoperative inpatient costs            | \$30,875   | \$22,437   |
| Average outpatient costs                         | \$1,669    | \$754      |
| Average total costs                              | \$56,768   | \$48,409   |

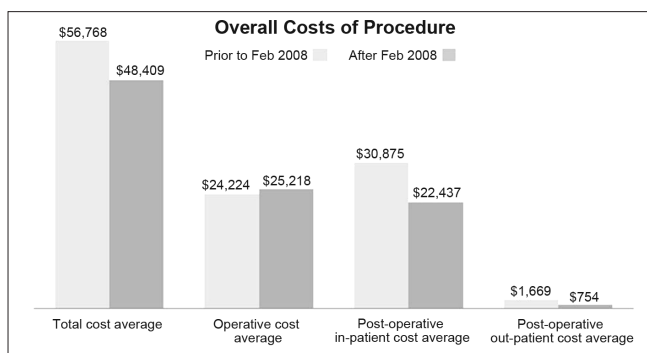
**Table 4: Patients requiring unscheduled reevaluation in the emergency department (ED), clinic, or outpatient laboratory (OP) postoperatively are listed. Those visits thought to be attributable to the practice of early discharge home are indicated in bold**

| Group            | Patient no. | Date of return visit | Setting       | Complaint                          | Diagnosis  | Cost to evaluate | Treatment                            |
|------------------|-------------|----------------------|---------------|------------------------------------|--|------------------|--------------------------------------|
| 5/2007 to 1/2008 | 4           | POD5                 | ED            | R eye blurry vision                | Swelling, residual tumor                         | \$12,400         | Steroids, readmission                |
|                  | 13          | POD6                 | ED            | Generalized weakness               | SIADH (Na=126)                                   | \$18,000         | Readmission, fluid restriction       |
|                  | 14          | POD6                 | ED            | Facial "fullness"                  | None   | \$2,600          | Removal of nasal splints, discharge  |
|                  | 26          | POD6                 | Clinic        | Lethargy                           | SIADH (Na=124)                                   | \$2,900          | Readmission, fluid restriction       |
|                  | 29          | POD45                | ED            | Low grade fever, left eye swelling | None   | \$2,700          | Discharge                            |
| 2/2008 to 6/2009 | 36          | POD15                | Clinic        | Polyuria                           | None   | \$460            | Discharge                            |
|                  | 38          | POD45                | OP            | Galactorrhea                       | Residual prolactinoma L cav sinus                | \$200            | Discharge, Cabergoline, radiosurgery |
|                  | <b>39</b>   | <b>POD2</b>          | <b>ED</b>     | <b>Headaches, blurred vision</b>   | <b>None, resolved spon</b>                       | <b>\$3,000</b>   | <b>Discharge</b>                     |
|                  | 42          | POD15                | Clinic        | 2 week f/u for DI                  | Persistent DI                                    | \$200            | Cont ddAVP                           |
|                  | <b>51</b>   | <b>POD2</b>          | <b>ED OSH</b> | <b>Polyuria</b>                    | <b>DI</b>  | <b>\$2,700</b>   | <b>PRN ddAVP</b>                     |
|                  |             | POD14                | ED            | Headaches                          | Idiopathic                                       | \$1,500          | Discharge                            |
|                  | <b>53</b>   | <b>POD2</b>          | <b>OP</b>     | <b>Polyuria</b>                    | <b>None</b>                                      | <b>\$140</b>     | <b>Discharge</b>                     |
|                  | <b>54</b>   | <b>POD3</b>          | <b>OP</b>     | <b>Polyuria</b>                    | <b>None</b>                                      | <b>\$140</b>     | <b>Discharge</b>                     |
|                  | <b>57</b>   | <b>POD1</b>          | <b>ED</b>     | <b>Passage of clots from nose</b>  | <b>Cleared with conservative mgmt (pressure)</b> | <b>\$3,000</b>   | <b>Discharge</b>                     |
|                  | 59          | POD13                | ED            | Persistent headaches s/p MVC       | Idiopathic                                       | \$2,530          | Discharge                            |

to have likely been preventable with additional day(s) of hospitalization. All other patients who returned to the ED or outpatient clinic for reevaluation are listed in Table 3.

Patients operated on or before February 2008 were discharged home on an average of POD 3.0. This figure includes two patients who experienced prolonged hospital stays of 7 and 21 days for postoperative CSF leak and respiratory distress, respectively. When these two outliers are excluded the remaining patients stayed an average of 2.2 PODs. A total of six patients (20%) in this group developed DI and were discharged home an average of 2.7 days following the surgery. In this group, no patients presented to the ED in the initial 36 hours following discharge, although four patients did return to the ED prior to 6-week follow-up for various causes [Table 4]. Notably, two of these patients were diagnosed with SIADH. One patient required outpatient laboratory analysis for complaints of lethargy at her 1-week follow-up appointment with ENT for splint removal. Otherwise, no patients in this group were scheduled for outpatient laboratory analysis—as the protocol at this time involved sending patients with symptoms concerning for water and electrolyte disturbance to the emergency department for further evaluation.

Average postoperative inpatient costs based on charge data were approximately \$8,438 (27.3%) less in patients operated on after February 2008 (approximately \$5,000 dollars per day of hospital stay). These differences in average total costs between the two groups are depicted in Figure 5. When the data from the standard discharge group were reanalyzed without the two outliers, charge data indicated that the policy of early discharge saved \$1,949 (or \$2,165 per day of hospital stay). It is important to note that no patient suffered any measurable morbidity relating to adrenal insufficiency (AI) or fluid imbalance



**Figure 5: Total costs of the surgical procedure in early and standard discharge groups broken down into subcategories. Average total costs based on charge data were approximately \$8,359 less in patients operated on after February 2008. When this data was reanalyzed without 2 outliers, charge data indicated that the policy of early discharge saved \$1,949 per patient (or \$2,165 per day of hospital stay)**

as a result of early discharge home. It is notable that the average LOS of the group operated on prior to February 2008 (3.0 days) is still considerably shorter than previously published average LOSs for microscopic resection [Table 1, average LOS for microscopic resection 5.4 days].

## DISCUSSION

Variability exists among different institutions regarding the postoperative care of patients who have undergone trans-sphenoidal resection of pituitary lesions. Below, common reasons that patients are kept in the hospital postoperatively for a prolonged period are addressed.

### Patients require monitoring for major surgical complications

Surgical complications following trans-sphenoidal resection of a pituitary lesion have traditionally been designated as either major or minor. Major complications are conditions that require reoperation, have the potential to result in permanent neurologic deficit, or are potentially fatal.<sup>[5]</sup> Major complications in the setting of pituitary surgery include stroke/damage to adjacent structures, CSF fistula requiring reoperation, and intrasellar/para-sellar hemorrhage. In one study of 1,240 consecutive patients who underwent trans-sphenoidal resection of a pituitary adenoma, intrasellar hemorrhage occurred in four (0.25%) patients.<sup>[5]</sup> All of these patients developed visual changes within a few hours of the termination of the surgical procedure and were taken back to the operating room for evacuation very soon after deterioration with full recovery of vision. Another notable postoperative complication is CSF fistula, which is considered a major surgical complication when surgery is required for repair.<sup>[11]</sup> It is notable that the need to reoperate for a CSF fistula is rare, as resolution often occurs with more conservative methods, including lumbar drain placement.<sup>[5]</sup> Time course of presentation of postoperative CSF fistula is an important factor to consider when contemplating early discharge home. In one study of 592 patients who underwent trans-sphenoidal surgery, 26 (4.4%) developed postoperative CSF leakage a mean of 25 days (ranging from 4 to 180 days) following the operation.<sup>[15]</sup> It is the authors' belief that further monitoring for these two complications in a patient who underwent an uncomplicated resection and who is otherwise asymptomatic 24 hours out from the procedure is not obligatory.

One other complication that sometimes arises well after the initial 24-hour postoperative period warrants further discussion. In patients with giant (>40 mm) pituitary neoplasms who undergo subtotal resection, hemorrhagic infarction in the subacute period following surgery has been described.<sup>[5]</sup> In the aforementioned study of 1,240

patients, 2 (4%) of 54 patients with giant (> 40 mm) pituitary adenomas developed hemorrhagic infarction of residual neoplasm in the subacute to chronic period following tumor resection; one death was directly related to the event. In the early discharge group of 30 patients, two patients with giant neoplasms (>4 cm) were treated. Both patients underwent uneventful subtotal resection and were discharged home on POD1. However, given the small number of patients in this series with giant pituitary neoplasms, readers should be reticent to draw firm conclusions regarding the safety of the protocol of early discharge home in this demographic.

In our series of 60 patients, one patient operated on after February 2008 required a return trip to the OR for visual deterioration relating to a parasellar hemorrhage detected 3 hours after surgery. Following return for hematoma evacuation, the patient's vision returned to baseline preoperative levels. While CSF leakage was encountered intraoperatively in 6 (10%) patients, there was only 1 postoperative CSF fistula (1.7%) in our series of 60 patients. This patient was treated successfully with a 5-day trial of lumbar drainage. Excluding one patient who required prolonged hospitalization for postoperative respiratory failure, the remaining four patients who suffered an intraoperative CSF leak but did not develop a postoperative CSF fistula were discharged home an average of 1.8 days following the operation. The overall rate of major complications in this series was 1/60 (1.7%).

Major surgical complications following trans-sphenoidal surgery are rare.<sup>[5]</sup> Furthermore, postoperative hemorrhage—the principle postoperative complication that often results in irreversible damage without prompt surgical intervention—occurs almost exclusively in the initial 24-hour period following trans-sphenoidal resection. Conclusively, the need for continued monitoring for neurological deterioration more than 24 hours following an otherwise uncomplicated trans-sphenoidal resection of a pituitary micro- or macro-adenoma may not be necessary.

### Patients require monitoring for minor surgical complications

Minor surgical complications following trans-sphenoidal resection involve oral and rhinological issues that can include epistaxis, nasal septal perforation, nose deformity, and tooth denervation. This group has also traditionally included transient neurological impairment of optic or other adjacent cranial nerves, when present.<sup>[5]</sup> Excluding epistaxis, this group of complications has not traditionally influenced length of hospital stay or required readmission for management. The postoperative incidence of epistaxis has ranged from 0.2 to 3.4%.<sup>[5,6,11]</sup> An inverse relationship has been described between the postoperative incidence of epistaxis and the experience of the operating team.<sup>[11]</sup>

The incidence of minor surgical complications is related

to the method of exposure and wound closure. Regarding our protocol for wound care, Doyle splints are removed at the first postoperative visit with the ENT surgical team—approximately 1 week following the surgery. Using this protocol, we have had few complications. In our series of 60 patients, one patient who underwent trans-sphenoidal resection after February 2008 and was discharged on POD1 returned to the ED for reevaluation following passage of a large clot from his nasal stents approximately 36 hours following surgery. This episode resolved with observation alone and the patient was discharged home from the ED later that evening. When early discharge following pituitary surgery is considered, patients should be counseled regarding the possibility of passage of nasal clots, in addition other minor oral and rhinological complications in the perioperative period.

### Patients require monitoring of hypothalamic—pituitary—adrenal axis function

Monitoring for hypothalamic—pituitary—adrenal (HPA) axis integrity may be performed in the early postoperative period or during the follow-up visit 6-8 weeks after discharge home on prophylactic glucocorticoid replacement. The authors have chosen to adopt the latter approach. High levels of accuracy regarding detection of postoperative AI using varying methods have been reported;<sup>[3]</sup> a recent study found an early postoperative morning total cortisol level >15 µg/dL to be a sensitive and accurate predictor of normal HPA function in the early postoperative period.<sup>[23]</sup> These studies offer hope that, in institutions that choose to assess HPA axis integrity in the postoperative inpatient period, prolonged hospitalization can be avoided.

### Patients require monitoring of diabetes insipidus

Water and electrolyte disorders (WED) are common following trans-sphenoidal resection of pituitary lesions and have been linked to intraoperative manipulation of the neurohypophysis.<sup>[1]</sup> In one series of 57 patients who remained in the hospital for 14 consecutive days with daily labs following trans-sphenoidal resection, postoperative WEDs occurred in 75% of the study population.<sup>[22]</sup> In this series, the median time to maximum diuresis in patients with isolated DI occurred on POD2 and the median nadir of hyponatremia (132 mEq/L) in patients with isolated hyponatremia occurred on POD9. It is notable that, while the prevalence of DI peaked on the second postoperative day, it also occurred as late as the 11th POD. Furthermore, despite a restrictive policy of desmopressin administration in the first two postoperative weeks, significant alteration of plasma osmolality in patients with DI was not encountered, indicating that patients were routinely able to compensate for DI using oral hydration alone. This report, consistent with the policy in place at VUMC, concluded that patients with an intact thirst mechanism and the ability to comfortably



hydrate rarely require desmopressin supplementation in the subacute period following trans-sphenoidal resection.

In our series of 60 patients, 8 patients (13%) were found to develop DI. Of these eight patients, two were found to have persistent DI at 6-week follow-up and were maintained on a scheduled regimen of desmopressin supplementation; DI had resolved in both of these patients at 2-year follow-up. The five patients operated on during/after February 2008 who developed DI were discharged after an average length of stay of 1.6 days. Notably, one of these patients was diagnosed with DI following discharge from the hospital on POD1. No patient suffered any measurable morbidity relating to fluid or electrolyte imbalance as a result of early discharge home.

In patients with an intact thirst mechanism following trans-sphenoidal surgery who are able to hydrate themselves comfortably, it is the authors' belief that—assuming outpatient communication with a dedicated endocrinology team is readily available—the presence of diabetes insipidus should not represent a contraindication to early discharge home. Furthermore, as not all patients who develop DI in the postoperative period do so in the first 24 hours, or even the first 7 days,<sup>[22]</sup> the possibility of future development of DI also should not represent a contraindication to discharge home.

### Patients require monitoring of hyponatremia

The prevalence of SIADH and hyponatremia following trans-sphenoidal surgery characteristically peaks approximately 7–9 days following the date of surgery.<sup>[22,31]</sup> For this reason, the majority of patients who experience symptoms (mild lethargy, headaches, malaise) relating to SIADH and hyponatremia have been discharged from the hospital by time of symptom onset. In a review of 241 patients who underwent trans-sphenoidal surgery by Zada *et al.*, 55 (23%) were found to have some degree of hyponatremia (defined

as a serum sodium level <135 mEq/L) as measured by laboratory analysis on POD7.<sup>[31]</sup> Eleven of the 241 patients (5%) became symptomatic relating to electrolyte imbalance and were readmitted to the hospital. Three of these patients were successfully treated with fluid restriction and salt tablets, while the remaining 8 required IV 3% NaCl. All patients did well with these forms of management.

While postoperative hyponatremia is a concern, symptomatic postoperative hyponatremia has not been a significant problem at our institution. In our review of 60 patients, two patients (3%) developed symptomatic hyponatremia relating to SIADH [patients 39 and 52, see Table 5]. Both of these patients were in the standard discharge cohort. While hyponatremia in these patients would likely have been detected with prolonged inpatient hospitalization, appropriate outpatient management prevented any serious complications.

### DISCUSSION OF COSTS

We were intrigued to find that the length of stay accounted for such a small fraction of the costs of inpatient hospital stay. For example, cutting the postoperative hospital stay in half (from two postoperative days to one) only decreased the costs associated with inpatient hospital stay by 8.7%. Review of cost data would be useful for further characterization of this trend. Charge data presented above indicate that the policy of early discharge home resulted in savings of approximately \$2,000 (or 4.4% of the total costs of the procedure) per patient. However, the benefits of cost savings associated with early discharge must be balanced against the risks and costs associated with outpatient access to medical care in the early postoperative period. In the analysis above, the practice of early discharge home resulted in a statistically significant increase in the number of unscheduled postdischarge return visits—specifically one in three patients required

**Table 5: Summary of all patients in this series diagnosed with diabetes insipidus (DI). Patients were diagnosed as having severe DI when the endocrinology team started scheduled desmopressin and mild DI when prn desmopressin was prescribed**

| Group     | Patient number | Severity of DI | Date of diagnosis | Date of discharge | OP DI regimen | Complications 2 <sup>nd</sup> to WED | DI status (6 wk f/u) | DI status (2 yr f/u) |
|-----------|----------------|----------------|-------------------|-------------------|---------------|--------------------------------------|----------------------|----------------------|
| <Feb 2008 | 2              | Mild           | POD2              | POD3              | prn DP        | no                                   | Resolved             | –                    |
|           | 11             | Severe         | POD1              | POD3              | sched DP      | no                                   | Persistent           | Resolved             |
|           | 15             | Mild           | POD1              | POD3              | prn DP        | no                                   | Resolved             | –                    |
| >Feb 2008 | 36             | Mild           | POD1              | POD2              | prn DP        | no                                   | Resolved             | –                    |
|           | 38             | Severe         | POD2              | POD2              | sched DP      | no                                   | Persistent           | Resolved             |
|           | 39             | Mild           | POD2*             | POD1              | prn DP*       | no                                   | Resolved             | –                    |
|           | 42             | Severe         | POD1              | POD2              | sched DP      | no                                   | Resolved             | –                    |
|           | 56             | Mild           | POD1              | POD1              | prn DP        | no                                   | Resolved             | –                    |

\*diagnosed with DI after discharge home. DP: desmopressin

some form of outpatient evaluation. However, because the majority of these visits were accomplished in an outpatient setting outside of the ED (average cost for evaluation in outpatient setting of early discharge group in Table 4: \$228), the practice remained cost-effective. In an institution without the ability to routinely provide outpatient endocrinological evaluation outside of the ED, the cost-effectiveness of this approach would be diminished (average cost for evaluation of early discharge group in ED in Table 4: \$2,546). More important than cost, however, are considerations of medical risk. It is notable that no patient suffered any measurable morbidity relating to water/electrolyte imbalance or any other complication as a result of early discharge home.

## CONCLUSIONS

Analysis of this series indicates that discharge on POD1 following trans-sphenoidal resection in patients with an intact thirst mechanism appears to be a safe option that is associated with an increase in the number of additional unscheduled visits for reevaluation. Early discharge was associated with a statistically insignificant trend in savings of approximately \$2,000 per patient. While patient safety does not appear to be a concern following early discharge, patients should be counseled about the increased likelihood that additional unscheduled outpatient visits for clinical and laboratory reevaluation may be necessary.

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