CLINICAL STUDY

Predictors of access to pituitary tumor resection in the United States, 1988–2005

Debraj Mukherjee, Hasan A Zaidi, Thomas Kosztowski, Kaisorn L Chaichana, Roberto Salvatori, David C Chang and Alfredo Quinones-Hinojosa

Brain Tumor Stem Cell and Neuro-Oncology Surgical Outcomes Research Laboratory, Department of Neurosurgery and Oncology, Johns Hopkins School of Medicine, 1550 Orleans Street, Cancer Research Building II, Room 253, Baltimore, Maryland 21231, USA, Division of Endocrinology, Department of Medicine, and Department of Surgery, The Johns Hopkins School of Medicine, Baltimore, Maryland 21231, USA

(Correspondence should be addressed to A Quinones-Hinojosa; Email: aquinon2@jhmi.edu)

Abstract

Objective: Surgery remains a common form of treatment for sellar and parasellar tumors involving the pituitary gland and adjacent structures. Studies have suggested that pituitary surgery procedures performed at high-volume centers are associated with less adverse outcomes, yet it remains unclear which types of patients are more likely to be admitted to such centers. We set out to determine which factors most influenced admission to these high-volume centers.

Methods: A retrospective analysis of the National Inpatient Sample over an 18-year period was linked to socioeconomic and environmental data contained within the Area Resource File. Only patients undergoing transsphenoidal surgery in the United States, >18-years-old were included. The primary outcome was admission to a high-volume (>25 pituitary surgeries/year) hospital.

Results: Overall, patients’ odds of admission to a high-volume center increased over an 18-year time period. However, African–Americans (odds ratio, OR = 0.46), Hispanics (OR = 0.28), and Asians (OR = 0.49) experienced declining odds of admission over time. Patients from high-income brackets (OR = 1.53) and from areas with higher neurosurgeon density (OR = 1.61) were more likely to be admitted to high-volume centers. Conversely, patients coming from counties with higher poverty (OR = 0.92) were less likely to be admitted to high-volume centers.

Conclusion: Racial and socioeconomic factors play a significant role in the admission of patients to high-volume pituitary surgery centers. This study demonstrates potential key policy areas for meaningful intervention to help ease disparities in access to quality care for surgical pituitary disease.

European Journal of Endocrinology 161 259–265

Introduction

The prevalence of clinically significant pituitary tumors has been reported to be as high as 94 ± 19.3 cases per 100,000 population (1). Tumors of the pituitary gland can cause syndromes due to over-secretion of one of the pituitary hormones. In addition, these tumors or tumors of the surrounding structures (i.e. meninges, nerve sheath) may have deleterious effects on the function of the gland and can cause visual abnormalities or chronic headache syndrome. Although there have been significant advances in medical and radiotherapeutic approaches for the treatment of sellar or parasellar masses, surgical resection, typically via the transsphenoidal route, remains the treatment of choice for a great majority of patients. Harvey Cushing was the first to show that patient outcome after hypophysectomy was directly related to surgical experience (2). He reported a lower complication rate over time for the transsphenoidal approach he had further developed during his tenure at the Johns Hopkins Hospital (2).

Today, the published complication rates of the transsphenoidal technique for diseases of the sellar region have dramatically dropped as compared with Cushing’s time, with several groups reporting a mortality rate between 0 and 1% (3–13). Despite these advances, the resection of sellar or parasellar masses still place patients at risk of significant morbidity, with as much as a fourth of all patients experiencing some form of morbidity as a result of surgery (14, 15).

Multiple reports have recently suggested that patients with surgical pituitary disease are much more likely to have improved surgical outcomes if diagnosed and treated by more experienced surgeons (16–21). Ciric et al. published the results of a United States national survey of neurosurgeons, which found that complication rates were inversely related to surgical experience (14) with similar results published in the United Kingdom (22, 23). Barker et al. compiled national inpatient data that suggest that among patients undergoing transsphenoidal pituitary adenoma resection, those who were admitted to high-volume centers...
had lower mortality rates, better hospital discharge disposition, and fewer complications (15). This direct association between provider volume and improved patient outcome is consistent with the reports from multiple surgical specialties, such as surgical oncology (20, 24, 25), cardiovascular surgery (19, 21, 26–30), abdominal surgery (31–37), urology (38), and ophthalmology (39). Recent reports in general surgery have indicated that referral to high-volume hospitals is dependent on racial and socioeconomic factors, with non-whites having a reduced likelihood of being admitted to high-volume institutions (40). Little is understood of whether disparity in access also exists among patients receiving pituitary surgery, where institutional caseload is intimately related to patient outcome.

This study seeks to identify predictive patient demographic and environmental characteristics associated with poorer access to high-quality endocrine surgery-based care, among adult patients with tumors of the pituitary gland and adjacent structures. By better understanding these determinants of referral to high-volume institutions, we seek to better understand barriers to quality care that may be amenable to targeted policy interventions in the future to improve patient outcomes.

Methods

Patient population

We obtained the National Inpatient Sample (NIS) in-hospital discharge database for the years 1988–2005, compiled by the Agency for Healthcare Research and Quality (Rockville, MD, USA) (41). The NIS database contains discharge information from a stratified random sample of 20% of all non-federal hospitals in 37 participating states. The database compiles discharge information on 100% of discharges from sampled hospitals, and thus can be used to obtain total volume information of specified procedures at individual hospitals. Over 1000 hospitals are sampled by the NIS, with more than seven million patient discharge records per year available in this database. This publicly available dataset was approved for use by the Johns Hopkins Institutional Review Board. This dataset was deemed as exempt from review as well.

Inclusion criteria included a primary ICD-9 diagnosis code for three forms of pituitary tumors: 237.0 (neoplasm of uncertain behavior of pituitary gland and craniopharyngeal duct), 194.3 (malignant neoplasm of the pituitary), and 227.3 (benign neoplasm of the pituitary), in addition to ICD-9 procedural codes specific for hypophysectomy (07.61, 07.62, 07.64, and 07.65). We chose to identify pituitary tumor patients by operative code rather than by diagnostic code given that the fidelity of coding for surgical procedures is likely to be much higher in an administrative database than the fidelity of coding diagnoses. Patients under 18 years of age were excluded from this study.

Outcomes

The primary outcomes assessed in this study were admission to a high-volume pituitary surgery hospital. A threshold of >25 pituitary surgeries per year was defined as a high-volume center, as previously described (15).

Patient-level covariates included age, gender, race, Charlson comorbidity index score, insurance status, income, and wealth. The Charlson comorbidity index serves as a measurement tool of patient comorbidities, accounting for a total of 22 conditions such as cardiac, vascular, pulmonary, neurologic, endocrine, renal, hepatic, gastrointestinal, and immune diseases, as well as any documented history of cancer (43). Income, which is a measure of actively incoming economic value, was assessed using the median household income of a patient’s county. These data were assessed through data elements inherent in the NIS. Hospital-level covariates included geographic region and high-volume hospital status. Environmental factors include poverty and neurosurgeon density. The following variables were used as reference groups in multivariate analysis: age 18–24, males, white race, uninsured, household income <$35 999, median home value <$104 000, and Northeast region.

Statistical analysis

Statistical analyses were performed using the software package STATA/MP 10 (College Station, TX, USA). Multivariate analysis was performed using multiple logistic regression models, adjusting for age, gender, race, Charlson score, insurance, income, wealth, poverty, geographic region and calendar year. A P value of <0.05 was considered to be statistically significant.
Results

Patient characteristics

A total of 21,717 patients undergoing transsphenoidal or transfrontal pituitary surgery were identified using ICD-9 diagnosis and procedural codes in the national sample of inpatients over an 18-year period (1988–2005). Patients had a mean (median) age of 50.4 (50) years and a slight majority were female (52.6%). The majority of patients were white (68.1%), with a significant number of blacks (15.0%) and Hispanics (10.5%). Patients had a mean Charlson index score of 0.34, and nearly all were insured (92.2%; Table 1).

The distribution of patients from all four income brackets was slightly positively skewed, with more patients in the >$60,000 income bracket (36.4%; Table 2). The mean percent per county of patients under the poverty line was 1.10% (median 1.05%). On average, there were 3.64 (median 2.51) neurosurgeons per 100,000 people per county.

Table 1 Patient characteristics and hospital characteristics of 21,717 pituitary tumor patients who underwent hypophysectomy, 1988–2005.

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>n</th>
<th>This study (%)^a</th>
<th>National census (%)^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, in years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (median)</td>
<td>50.4 (50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Racial distribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>10,570</td>
<td>68.1</td>
<td>69.13</td>
</tr>
<tr>
<td>African–American</td>
<td>2,334</td>
<td>15.0</td>
<td>12.06</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1,626</td>
<td>10.5</td>
<td>12.55</td>
</tr>
<tr>
<td>Asian</td>
<td>520</td>
<td>3.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Native American</td>
<td>43</td>
<td>0.3</td>
<td>0.74</td>
</tr>
<tr>
<td>Other</td>
<td>437</td>
<td>2.8</td>
<td>1.94</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>10,301</td>
<td>47.4</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11,416</td>
<td>52.6</td>
<td></td>
</tr>
<tr>
<td>Charlson index score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (median)</td>
<td>0.34 (0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insured</td>
<td>20,017</td>
<td>92.2</td>
<td></td>
</tr>
<tr>
<td>Uninsured</td>
<td>57</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>1,643</td>
<td>7.5</td>
<td></td>
</tr>
</tbody>
</table>

Patient distribution across hospitals

A majority of patients were seen at low-volume centers (68.4%). In this database, more patients were identified in the South (34.3%) than in the Midwest (19.1%), West (26.3%), or Northeast (20.3%; Table 1). The overall raw number of patients steadily increased over the 18-year period examined. Furthermore, the percent of patients admitted to high-volume centers and the odds of admission to high-volume centers increased with time (Fig. 1). Overall, there was no statistically significant difference between African–Americans (odds ratio, OR: 0.86; 95% confidence interval, CI: 0.74–1.00) and whites in access to high-volume centers (Table 3). On the other hand, Hispanic (OR: 0.53, 95% CI: 0.45–0.63) and Asian (OR: 0.78, 95% CI: 0.61–0.98) patients were significantly less likely to be seen at high-volume centers (Table 3). Across more narrow time periods, the odds of access to neurosurgical care at high-volume centers for African–Americans, Hispanics, and Asians was significantly reduced over time (Fig. 2). As compared with whites, Hispanics (OR: 1.83, 95% CI: 1.13–2.95), African–Americans (OR: 1.08, 95% CI: 0.75–1.57), and Asians (OR: 1.15, 95% CI: 0.61–2.19) had similar or slightly higher odds of being admitted to high-volume centers in the late 1980s and early 1990s (Fig. 2). Following a steady decline over time, however, African–Americans (OR: 0.46, 95% CI: 0.36–0.59), Hispanics (OR: 0.28, 95% CI: 0.21–0.37),

![Figure 1](https://www.eje-online.org)
Factors associated with access to high-volume centers

Factors associated with access to high-volume centers were searched using adjusted multivariate logistic regression. The factors associated with increase in odds of admission to high-volume centers (largest categorical ORs reported, all P values < 0.05) were age 25–34 (OR = 1.31, P = 0.03), median household income > $60 000 (OR = 1.53, P value < 0.001), and each 1% increase in neurosurgeon per 100 000 population (OR = 1.61, P value < 0.001; Table 3). The following factors were associated with reduced access to high-volume centers (largest categorical OR reported, P value < 0.05): age 75–84 years old (OR = 0.72, P value = 0.02), Hispanic race (OR = 0.53, P value < 0.001), Asian race (OR = 0.78, P value = 0.04), other race (OR = 0.69, P value = 0.02), and each 1% increase in poverty (OR = 0.92, P value < 0.001).

Discussion

The aim of our current study was to examine: i) the effects of traditional factors, such as race and socioeconomic status, on access to quality pituitary surgical care, and ii) previously un-examined variables such as neurosurgeon density and poverty index. To this end, we used a novel method of linking two national databases. We found that despite a national trend of increasing access to quality care among all patients, African-Americans, Hispanics, and Asians have experienced dramatically reduced odds of admission to quality centers for the surgical treatment of pituitary disease during recent years. These disparities fall along not only racial lines, but also socioeconomic lines, with patients from lower poverty and higher income areas having a much greater chance of admission to high-volume centers. To our knowledge, this is the first study that identifies specific factors that contribute to healthcare disparities among patients with pituitary disease. In addition to reinforcing the need for traditional approaches to improve healthcare access, such as enhancing healthcare knowledge in minority areas, our paper defines new targets for public health policy intervention in endocrinological and neurosurgical care. The results of our study are important in that we not only implicate traditional socioeconomic factors as being involved in reducing equity in healthcare access, but also add novel variables such as availability of neurosurgeons in a given area not previously thought to be involved in healthcare access disparities.

Previously published data support an association between admission to high-volume hospitals and improved outcomes, prompting some healthcare groups to use hospital case volume as a measure of the quality of medical care (19–21, 44, 45). Some have successfully proposed a move toward developing national centers of excellence for neurosurgical care (45, 46) in order to foster improved outcomes by
directing complex cases to a handful of institutions. Since the *Crossing the Quality Chasm* report in 1998 by the Institute of Medicine, the development of these national centers of excellence has been intimately tied to the effort of reducing racial and socioeconomic healthcare disparities prevalent in the United States. Although these high-volume centers have proven to confer a morbidity and mortality advantage to those who utilize them (45), little is known of whether these centers have managed to equally distribute quality surgical care to all types of patients (47).

Our findings demonstrated that, overall, only Hispanics and Asians experienced reduced access to quality pituitary surgical care as compared with their white counterparts, whereas African–Americans did not experience such disparities (Table 3). However, upon closer examination, we found that in spite of a national trend toward increasing admission to high-volume centers for surgical endocrine disease, African–Americans, Hispanics, and Asians have experienced reduced odds of admission to these centers in more recent years (2001–2005), where these groups were less than half as likely to be admitted to high-volume institutions as compared with Caucasians. While a causal relationship between the advent of centers of excellence and rising disparities cannot be assessed here, a closer look at why such trends are occurring needs to be further investigated.

Our report is in some ways similar to what was described by Liu *et al.* in the general surgical literature (40), who reported that African–Americans, Hispanics, and Asians have experienced poorer access to high-volume institutions for a majority of general surgical procedures. However, they utilized a dataset limited to California over a shorter period (2000–2004), without examining how these disparities have changed over time. Our present study makes the additional observation that despite a national trend of increased admission to high-volume centers and an emphasis on creating centers of excellence, racial minorities have experienced worse access to these centers. Several factors are implicated in creating an environment for these disparities to thrive. Basic cultural differences in approaching healthcare issues vary drastically between races (48), with minority patients more likely unaware of how to successfully traverse the modern healthcare environment. Even when successfully finding high-quality medical centers, seemingly trivial issues such as finding a way of traveling back and forth to distant high-volume centers (when they are dependent on public transportation) may represent a barrier for many minority patients benefiting from the institution (47). Of those who successfully arrive to the high-quality institutions, language differences may prevent many from requesting aggressive clinical care for their disease (49). Consequently, many minority patients seek healthcare providers with a similar racial and ethnic background in order to better convey their concerns, even at the risk of receiving treatment at low-volume centers (50). Finally, payer status has been implicated to be involved in determining quality of care (51, 52). It has been postulated that minority groups may likely pay for medical care from suboptimal sources, such as either out of pocket or low-reimbursement private insurance companies, resulting in referral to low-volume institutions with suboptimal care.

Our results are in agreement with many studies that report that wealth and income are associated not only with longevity (53), but are also negatively associated with neurological events (i.e. cerebrovascular accidents) (54) suggesting that wealthier patients may be receiving superior medical care. Such disparity requires intervention.

We also found that patients from counties with high neurosurgeon density experience a greater chance of admission to quality medical centers (Table 3). The availability of neurosurgeons across the United States has dwindled as the rates of graduating neurosurgical residents has failed to catch up with the growth of the US population, with demand currently skyrocketing (55). For example, Bryne *et al.* reports that with fewer trauma neurosurgeons available in Cook County, time to treatment for patients with emergent neurosurgical issues has increased (56). It may be possible that patients from counties with fewer neurosurgeons have limited interactions with these sub-specialized surgeons, and are therefore less likely to be referred to quality medical centers with surgeons performing a large number of these sub-specialized surgical procedures.

We have found that age plays an important role in access to high-volume centers for the surgical treatment of pituitary disease. Younger patients are much more likely than older patients to be admitted to high-volume centers (Table 3). This is in accord with previous studies in cerebrovascular accident patients, which demonstrate that older patients are less likely to receive adequate care after a cerebrovascular accident (57, 58). Another study found that older patients were less likely to receive critical care treatment (58), and Dunlop *et al.* reported that elderly patients were less likely to be transported to trauma centers than younger patients (59). A possible explanation may be the more widespread access to the internet in younger patients, which may provide information on where specialized neurosurgeons practice by either patient-based websites or websites kept by the medical centers.

Additionally, we find that females are much more likely to be admitted to high-volume institutions than males (Table 3). It is interesting to note that although some reports, such as those by Rudd *et al.*, note no association between female gender and access to care for cerebrovascular accident (57), other studies, such as those by Miles *et al.*, report that particular subsets of women may be more likely to be uninsured and have less access to the needed healthcare (60). We are the first to report, however, that among a national group...
of randomly selected patients undergoing surgical resection for pituitary-related disease, female gender is a positive predictor of admission to high-volume centers. A potential explanation may be the need to preserve pituitary and hormonal functions in women for reproduction, which may motivate referring physicians to send these patients to high-volume centers.

Our study is subject to the weaknesses inherent to all retrospective studies. Our dataset does not allow us to capture repeat hospital visits. This may potentially result in an under-representation of the true incidence of patients with pituitary disease undergoing transfrontal or transsphenoidal resection. However, such biases are likely to be distributed evenly. Considering the large number of data elements included in our study, we believe that our paper adequately characterizes the true patient care patterns across the United States. As such, we believe it provides critical information for future policy interventions for medical specialists in the future. Our data show that over time there has been an increase in the amount of patients with pituitary tumors being admitted to high-volume centers (Fig. 1), but at the same time, the odds of admission for African–Americans, Hispanics, and Asians have continued to steadily decline despite the fact that almost all patients have some form of insurance (Fig. 2 and Table 1). Using this database, it is impossible to test whether these disparities are due to an increase in admission of Caucasians, displacing the rest of the population, although it seems that these would be two independent forces.

We conclude that racial and economic disparities exist among the population of patients who are referred to high-volume centers for pituitary surgery. Policies should be directed toward modifying system and patient-level factors that propagate the racial, economic, and age-related biases found in the distribution of quality, complex pituitary surgical care nationwide.

Declaration of interest

The authors of this paper declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

Funding

This work was supported by the Johns Hopkins Department of Neurosurgery and the Johns Hopkins Department of Surgery.

References
