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Morbidity and mortality following acoustic neuroma excision in the United States: analysis of racial disparities during a decade in the radiosurgery era

Shearwood McClelland III, Hongfei Guo, and Kolawole S. Okuyemi

Department of Neurological Surgery, Boston University School of Medicine, Boston, MA (S.M.); Division of Biostatistics and Clinical and Translational Science Institute, University of Minnesota, Minneapolis, MN (H.G.); Department of Family Medicine, University of Minnesota Medical School, Minneapolis, MN (K.S.O.); Program in Health Disparities Research, University of Minnesota Medical School, Minneapolis, MN (S.M., K.S.O.)

Acoustic neuromas present a challenging problem, with the major treatment modalities involving operative excision, stereotactic radiosurgery, observation, and fractionated stereotactic radiotherapy. The morbidity/mortality following excision may differ by patient race. To address this concern, the morbidity of acoustic neuroma excision was assessed on a nationwide level. The Nationwide Inpatient Sample from 1994–2003 was used for analysis. Only patients admitted for acoustic neuroma excision were included (*International Classification of Diseases,* 9th edition, Clinical Modification = 225.1; primary procedure code = 04.01). Analysis was adjusted for several variables, including patient age, race, sex, primary payer for care, income in ZIP code of residence, surgeon caseload, and hospital caseload. Multivariate analyses revealed that postoperative mortality following acoustic neuroma excision was 0.5%, with adverse discharge disposition of 6.1%. The odds ratio for mortality in African Americans compared with Caucasians was 8.82 (95% confidence interval = 1.85–41.9, *P* = .006). Patients with high-caseload surgeons (more than 2 excisions/year), private insurance, and younger age had decreased mortality, better discharge disposition, and lower overall morbidity (*P* < .04). Neither hospital caseload nor median income were predictive factors. African Americans were 9 times more likely to die following surgery than Caucasians over a decade-long analysis. Given the relatively benign natural history of acoustic neuroma and the alarmingly increased mortality rate following surgical excision among older patients, African Americans, and patients receiving care from low-caseload surgeons, acoustic neuromas in these patient populations may be best managed by a more minimally invasive modality such as observation, fractionated stereotactic radiotherapy, or stereotactic radiosurgery.

Keywords: acoustic neuroma, health disparities, morbidity, mortality, neurosurgery.

Acoustic neuromas, also known as vestibular schwannomas, are defined as benign tumors arising from the Schwann cells of the vestibular portion of the eighth cranial nerve. Typically presenting with unilateral sensorineural hearing loss, tinnitus, and/or imbalance, the relative incidence of acoustic neuroma in the United States is 1/100 000 per year, with approximately 2500 new cases diagnosed annually.[1] The advent of the MRI era has allowed an increasing number of acoustic neuromas to be identified, many having been previously undetectable due to their small size.[2] Precision and delicacy are required in management of these lesions, since they arise near important structures (brainstem, adjacent cranial nerves) and tend to enlarge within the first 1–2 years of diagnosis.[3,4] The predominant goals of acoustic neuroma treatment are avoidance of injury to the brainstem and adjacent cranial nerves, and prevention of tumor growth.[5] To this end, 4 predominant treatment modalities for acoustic neuroma have emerged: observation, microsurgical

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Corresponding Author: Shearwood McClelland III, MD, Department of Neurological Surgery, Boston University School of Medicine, 88 East Newton Street, Robinson 4, Boston, MA 02118 (drwood@post.harvard.edu)

excision, stereotactic radiosurgery, and fractionated stereotactic radiotherapy.

The most traditional approach has been microsurgical excision, which provides the advantages of tumor removal and pathologic confirmation of diagnosis and the disadvantages of increased morbidity and mortality.[6,7] While some reports have argued for preservation of hearing as an advantage of microsurgical excision, this assertion has yet to be confirmed by class I evidence.[8,9] Observation has the advantage of the lowest morbidity and mortality but has the least likelihood of preventing tumor growth.[3] Stereotactic radiosurgery, available in the United States since 1987, has emerged as an attractive alternative for acoustic neuromas less than 3 cm, with the advantages of noninvasiveness, significantly less hospitalization, and decreased morbidity compared with operative intervention for comparable sized acoustic neuromas, with disadvantages of trigeminal nerve morbidity and risk of malignant transformation of the tumor.[10–13] Fractionated stereotactic radiotherapy has emerged since the 1990s as a viable treatment modality, with rates of tumor control comparable to stereotactic radiosurgery and reduced morbidity to the trigeminal nerve, and the disadvantages of higher total radiation dosage and significantly longer treatment course.[14–16]

Of these 4 modalities, the most traditionally performed for acoustic neuroma has been microsurgical excision. While several series have examined the morbidity and mortality of this procedure, there has been only 1 previous examination of whether morbidity of the procedure differs based on patient race.[17] To address this issue, the following study was performed using a large nationwide patient database over a 10-year period during which all 4 treatment modalities for acoustic neuroma were available and accessible in the United States.

Clinical Materials and Methods

Data Source

The Nationwide Inpatient Sample (NIS) hospital discharge database (overview available at http://www.hcup-us.ahrq.gov/nisoverview.jsp) covering the years 1994 through 2003, obtained from the Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality, was used as the data source for this study.[18] The NIS represents approximately 20% of all inpatient admissions to nonfederal hospitals in the United States. For these years, the NIS contains data on 100% of discharges from a stratified random sample of nonfederal hospitals, approximating a 20% representative subsample of all U.S. nonfederal hospital discharges. Because the NIS contains data on all patients discharged from sampled hospitals during the year (regardless of payer or patient age), it can be used to obtain the annual total volume of specified procedures at individual hospitals. Additionally, the surgeon who performed the principal procedure following admission is identified by a unique masked code.

Inclusion and Exclusion Criteria

The NIS database was searched to identify admissions to undergo surgery for acoustic neuroma. Included were admissions having a patient age of 18 years or older, a diagnosis code in the *Internationl Classification of Diseases*, 9th edition, Clinical Modification (ICD-9-CM) of 225.1 (benign neoplasm of cranial nerve), and an ICD-9-CM primary procedure code of 04.01 (excision of acoustic neuroma). The ICD-9 procedure codes do not allow distinction among the surgical approaches for acoustic neuroma excision.

Characteristics of Patients

In addition to race, patient age, sex, median household income for postal ZIP code of residence, primary payer (Medicare, Medicaid, private insurance, self-pay, no charge/other), type of admission (emergency, urgent, or elective), and admission source (emergency department, transfer from another hospital, transfer from long-term care, or routine) were coded in the NIS data. Subset analysis focused on comparisons between that subset and the reference group; for race, the reference group was Caucasian (ie, African American vs Caucasian), and for primary payer, the reference group was Medicare (ie, private insurance/health maintenance organization [HMO] vs Medicare).

Provider and Hospital Characteristics

The number of available beds (small, medium, or large bed-size facility), teaching status, hospital region (Northeast, Midwest, South, West), and location (rural, urban) were coded in the NIS data. Surgeon volumes of acoustic neuroma excisions were derived by counting the cases for each identified surgeon in the database. Surgeon volume was analyzed as either low caseload (fewer than 3 excisions per year) or high caseload (3 or more acoustic neuroma excisions per year).

Statistical Analysis

The characteristics of patients, providers, and hospitals were summarized by descriptive statistics. Results were expressed as mean (SD, median, and range) for continuous variables and frequency (percentage) for categorical variables. To examine the association between an outcome of mortality, postoperative morbidity, or adverse discharge disposition and the characteristics of patient age, gender, race, payer, admission type, income, surgeon caseload, and caseload of hospital, we fitted multiple logistic regression models on the outcomes with the aforementioned characteristics as covariates and reported the adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for each characteristic in the multivariate analysis. Extrapolations to the entire U.S. population were adjusted for the NIS stratified survey method in the logistic regression models by using PROC SURVEYLOGISTIC in the SAS statistical software program. All probability values shown are 2-tailed. Significance was defined as $P < .05$ with a 95% CI excluding the number one.

Patients were evaluated examining acoustic neuroma (*a*) as a primary diagnosis, (*b*) as one of the top 3 diagnoses, and (*c*) as one of the top 15 diagnoses. Overall morbidity was evaluated as a summation of postoperative morbidity, in-hospital mortality, and adverse discharge disposition. For subset analysis, in-hospital mortality and adverse discharge disposition were assessed individually and then in combination for assessment of morbidity. Potential complications of acoustic neuroma excision were identified using the following codes: postoperative neurological complications (including those secondary to infarction or hemorrhage), 997.00–997.09; hematoma complicating a procedure, 998.1–998.13; facial palsy, 351.0; any facial nerve disorder, 351; performance of a facial nerve graft or anastomosis of another cranial nerve to the facial nerve, 04.5, 04.6, 04.71–04.79; lagophthalmos, 374.20–374.22; corneal ulcer, keratoconjunctivitis, or other keratopathy, 370.00, 370.34, 370.35, 371.40, 371.49, 371.81, 371.89; blepharoplasty or tarsorrhaphy, 08.33–08.99; cerebrospinal fluid (CSF) otorrhea or rhinorrhea, 349.81, 388.61; hydrocephalus, 331.3–331.4; mechanical ventilation, 96.70–96.72; postoperative infection, 998.5, 998.51, 998.59; ventriculostomy placement, 02.2; deep vein thrombosis (DVT), pulmonary embolism (PE), or inferior vena cava (IVC) filter placement, 415, 415.11–415.19, 453.8, 453.9, 38.7; and transfusion of packed red blood cells, 99.04. The effect of general medical comorbidity was assessed using a set of 25 medical comorbidity markers previously described, which were added to provide a single comorbidity score ranging from 0 to 25.[19,20] To account for the severity of disease at presentation, multivariate analyses were performed first, including and subsequently excluding markers of advanced disease. These markers were defined as any hydrocephalus, ventriculostomy placement, and/or nonelective hospital admission.

Results

From 1994 through 2003, according to the NIS database, 10 297 adults sought admission for acoustic neuroma, of whom 4886 (47.5%) underwent surgical excision. Patients received surgery at a total of 374 hospitals, nearly 75% of which were classified as large bed size. By far the most common insurance type was private, comprising more than 73% of patients, with Medicare a distant second at nearly 16% (Table 1). More than two-thirds of patients received care by a surgeon performing at least 3 acoustic neuroma excisions per year; the remaining clinical characteristics are depicted in Table 1. Information on the treating surgeon was provided for 54.1% of the admissions, with 626 treating surgeons identified in the database. Nearly 90% of patients undergoing acoustic neuroma excision had no more than 1 medical comorbidity, and fewer than 2% had more than 2 comorbidities (Table 2). No patient receiving surgery had a comorbidity score higher than 5.

Mortality occurred in 22 patients following acoustic neuroma excision, providing an in-hospital postoperative mortality rate of 0.5% (22/4886). Of the 4266 patients with available discharge data, 16 required short-term rehabilitation and 244 required long-term rehabilitation. The remaining 3984 patients were discharged home, yielding a total adverse discharge disposition of 6.1% (260/4266). Of the nonfatal postoperative complications following acoustic neuroma excision, the most common was any facial nerve disorder (25.0%), followed by postoperative neurological complications (8.4%), blepharoplasty or tarsorrhaphy (4.1%), mechanical ventilation (4.1%), hydrocephalus (3.2%), CSF otorrhea or rhinorrhea (3.1%), corneal ulcer/keratoconjunctivitis or other keratopathy (2.1%), ventriculostomy placement (1.9%), performance of a facial nerve graft/anastomosis of another cranial nerve to the facial nerve (1.6%), lagophthalmos (1.5%), hematoma complicating a procedure (1.4%), transfusion of packed red blood cells (1.4%), DVT/PE or IVC filter placement (0.7%), and postoperative infection (0.5%). Of the 4886 patients, 1284 had at least 1 nonfatal postoperative complication, for an incidence of 26.3% (Table 3). The incidence of postoperative morbidity correlated with increasing patient comorbidity score, doubling from 25% in patients with no comorbidities to 50% in patients with more than 3 (Table 2). The incidence of in-hospital morbidity (patients with postoperative morbidity and/or mortality) was 26.7% (Table 3).

Multivariate analysis of mortality revealed that African American race was independently predictive of increased postoperative mortality in comparison with Caucasian race ($OR = 8.82$; 95% $CI = 1.85–41.9$; $P = .006$) following acoustic neuroma excision (Table 4). In addition to African American race, another independent predictor of mortality following acoustic neuroma excision was increased patient age ($OR = 1.07$; 95% $CI = 1.01–1.14$; $P = .031$); each year of age affected the likelihood of postoperative mortality by $[(1.07^{\text{age of patient-age of comparison patient}}) - 1]*100$, such that a 40 year old was 7% more likely to die following surgery than a 39 year old, 49% less likely than a 50 year old, and 97% more likely than a 30 year old (Table 4). A third independent predictor was surgeon caseload, as patients receiving surgery from providers performing more than 3 acoustic neuroma excisions per year were 78% less likely to die following surgery than those receiving surgery from providers performing 2 or fewer excisions per year ($OR = 0.22$; 95% $CI = 0.058–0.85$; $P = .027$). Factors not independently predictive of postoperative mortality included patient gender, admission type, primary payer, and hospital bed size (Table 4).

Table 1. Clinical characteristics of the 4886 adult patients from 1994 through 2003 who underwent acoustic neuroma excision

Characteristic	Value
Patient age (y)	
Mean	50.8
Standard deviation	13.2
Median	51.0
Range	18–92
Female (%)	53.7
Race (%)	
Caucasian	85.4
Hispanic	4.8
African American	3.7
Asian/Pacific Islander	3.2
Others	2.9
Primary payer (%)	
Medicare	15.9
Medicaid	4.2
Private insurance/HMO	73.1
Self-pay	3.1
No charge/other	3.7
Caseload of hospital (%)	
Large bed size	74.7
Small or medium bed size	25.3
Region of hospital (%)	
Northeast	16.7
Midwest	25.2
South	29.9
West	28.2
Admission type (%)	
Routine, birth, and others	94.8
Emergency/other/facility/court/law	5.2
Surgeon volume (%)	
Low	31.3
High	68.7
Median income (%)	
1	10.5
2	18.6
3	23.2
4	47.7

Note: Surgeon volume is defined as low if the operating surgeon performed only 1 or 2 acoustic neuroma excisions per year, and high if the surgeon performed ≥3 surgeries per year.
The median income has difference ranges across years.

Median Income ($)	1994–1997	1998–2002	2003
1	1 = 0–25 000	1 = 0–24,999	1 = 0–35 999
2	2 = 25 001–30 000	2 = 25 000–34 999	2 = 36 000–44 999
3	3 = 30 001–35 000	3 = 35 000–44 999	3 = 45 000–59 999
4	4 = 35 001 +	4 = 45 000 +	4 = 60 000 +

Multivariate analysis of adverse discharge disposition following acoustic neuroma excision also revealed 3 independently predictive factors: patient age, low surgeon caseload, and insurance status (Table 5). Increasing patient age increased the likelihood of adverse discharge disposition (OR = 1.04; 95% CI = 1.01–1.07; $P = .0019$); each year of age affected the likelihood of adverse discharge disposition by $[(1.04^{\text{age of patient-age of comparison patient}}) - 1]*100$, such that a 40 year old was 4% more likely to suffer

Table 2. Examination of general medical comorbidity in patients receiving acoustic neuroma excision from 1994 through 2003 using a medical comorbidity score

Comorbidity score	0	1	2	3	>3
Proportion of patients	62.9%	27.0%	8.3%	1.7%	0.2%
Incidence of postoperative morbidity	25.0%	27.5%	32.1%	24.4%	50%

Note: Score is derived from 25 comorbidity markers (range = 0–25). The majority of patients had no comorbidities; the incidence of postoperative morbidity correlated with increasing comorbidity. The maximum comorbidity score to receive surgery was 5.

Table 3. In-hospital morbidity (postoperative morbidity and/or mortality) in adult patients receiving acoustic neuroma excision in the United States from 1994 through 2003

Morbidity Following Acoustic Neuroma Excision	
Mortality	0.5%
Any facial nerve disorder	25.0%
Postoperative neurological complications (including those secondary to infarction or hemorrhage)	8.4%
Blepharoplasty/tarsorrhaphy	4.1%
Mechanical ventilation	4.1%
Hydrocephalus	3.2%
CSF otorrhea/rhinorrhea	3.1%
Corneal ulcer, keratoconjunctivitis, or other keratopathy	2.1%
Ventriculostomy placement	1.9%
Performance of a facial nerve graft/anastomosis of another cranial nerve to the facial nerve	1.6%
Lagophthalmos	1.5%
Hematoma	1.4%
Transfusion of packed red blood cells	1.4%
DVT/PE/IVC filter placement	0.7%
Postoperative infection	0.5%
Total (patients)	26.7%

adverse discharge disposition following surgery than a 39 year old, 32% less likely than a 50 year old, and 48% more likely than a 30 year old (Table 5). Surgeons with high caseloads reduced adverse discharge disposition by 70% compared with surgeons performing fewer than 3 acoustic neuroma excisions per year (OR = .30; 95% CI = 0.20–0.45; $P < .0001$). Private insurance/HMO reduced adverse discharge disposition by 52% (OR = 0.48; 95% CI = 0.27–0.87; $P = .017$); no other insurance status reached statistical significance. Factors not independently predictive of adverse discharge disposition included race, gender, admission type, median income, and hospital bed size (Table 5).

Multivariate analysis of postoperative morbidity (in-hospital morbidity and/or adverse discharge disposition) revealed 2 independently predictive factors: insurance status and surgeon caseload (Table 6). Private insurance/HMO status reduced postoperative morbidity by 51% (OR = 0.49; 95% CI = 0.36–0.66; $P < .0001$), while high surgeon caseload volume decreased postoperative morbidity by 42% (OR = 0.58; 95%

Table 4. Multivariate analysis of mortality following acoustic neuroma excision in adult patients from 1994 through 2003

Characteristic	OR (95% CI)	*P*-value
Patient		
Age (for 1 year increase)	**1.07 (1.01–1.14)**	**.031**
Female sex	0.32 (0.07–1.44)	.13
Race (White is reference group)		
African American	**8.82 (1.85–41.9)**	**.006**
Hispanic	–	
Asian/Pac Isl	–	
Others	–	
Admission type (routine vs birth and others)	0.19 (0.036–1.06)	.057
Primary payer (Medicare is reference group)		
Medicaid	–	
Private insurance/HMO	1.13 (0.20–6.10)	.89
Self-pay	–	
No charge/other	–	
Hospital bedsize (large vs small or medium)	0.35 (0.065–1.88)	.22
High surgeon volume (≥ 3 surgeries per year)	**0.22 (0.058–0.85)**	**.027**

Table 5. Multivariate analysis of adverse discharge disposition following acoustic neuroma excision in adult patients from 1994 through 2003

Characteristic	OR (95% CI)	*P*-value
Patient		
Age (for 1 year increase)	**1.04 (1.01–1.07)**	**.0019**
Female sex	0.99 (0.70–1.42)	.98
Race (White is reference group)		.19
African American	1.82 (0.81–4.10)	
Hispanic	1.92 (0.97–3.80)	
Asian/Pac Isl	2.02 (0.73–5.57)	
Others	1.53 (0.56–4.22)	
Admission type (routine vs birth and others)	0.56 (0.19–1.58)	.27
Primary payer (Medicare is reference group)		**.017**
Medicaid	1.24 (0.50–3.08)	
Private insurance/HMO	**0.48 (0.27–0.87)**	
Self-pay	0.29 (0.036–2.36)	
No charge/other	0.50 (0.13–1.83)	
Median income		.39
1 (reference group)	1	
2	0.82 (0.45–1.46)	
3	0.87 (0.53–1.44)	
4	0.64 (0.39–1.09)	
Hospital bed size (large vs small or medium)	1.09 (0.71–1.67)	.70
High surgeon volume (≥ 3 surgeries per year)	**0.30 (0.20–0.45)**	**<.0001**

Table 6. Multivariate analysis of overall morbidity (in-hospital morbidity and/or adverse discharge disposition) following acoustic neuroma excision in adult patients from 1994 through 2003

Characteristic	OR (95% CI)	*P*-value
Patient		
Age (for 1 y increase)	0.99 (0.99–1.01)	.89
Female sex	1.10 (0.83–1.46)	.51
Race (White is reference group)		.14
African American	1.17 (0.83–1.45)	
Hispanic	1.44 (0.85–2.44)	
Asian/Pac Isl	1.63 (0.88–2.98)	
Others	1.10 (0.63–1.89)	
Admission type (routine vs birth and others)	0.67 (0.41–1.07)	.089
Primary payer (Medicare is reference group)		<.0001
Medicaid	0.98 (0.56–1.71)	
Private insurance/HMO	**0.49 (0.36–0.66)**	
Self-pay	0.74 (0.33–1.68)	
No charge/other	0.63 (0.32–1.22)	
Median income		.77
1 (reference group)	1	
2	0.93 (0.65–1.32)	
3	0.90 (0.67–1.20)	
4	0.87 (0.66–1.14)	
Hospital bed size (large vs small or medium)	0.99 (0.79–1.25)	.95
High surgeon volume (≥3 surgeries per year)	**0.58 (0.46–0.71)**	<.0001

Table 7. Multivariate analysis of adverse discharge disposition following acoustic neuroma excision in adult patients from 1994 through 2003 after exclusion of markers of advanced disease

Characteristic	OR (95% CI)	*P*-value
Patient		
Age (for 1 y increase)	**1.04 (1.00–1.07)**	.029
Female sex	**1.71 (1.04–2.81)**	.034
Race		.26
White (reference group)	1	
African American	2.33 (0.88–6.14)	
Hispanic	1.51 (0.53–4.28)	
Asian/Pac Isl	2.68 (0.72–10.0)	
Others	2.13 (0.59–7.70)	
Primary payer (Medicare is reference group)		.26
Medicaid	1.14 (0.35–3.70)	
Private insurance/HMO	0.49 (0.21–1.10)	
Self-pay	–	
No charge/other	0.66 (0.13–3.45)	
Median income		.28
1 (reference group)	1	
2	0.52 (0.27–1.03)	
3	0.63 (0.30–1.30)	
4	0.62 (0.31–1.21)	
Hospital bed size (large vs small or medium)	0.93 (0.52–1.68)	.82
High surgeon volume (> = 3 surgeries per year)	**0.30 (0.18–0.49)**	<.0001

CI = .46–0.71; $P < .0001$). Neither patient age, gender, race, admission type, median income, nor hospital bed size was predictive of postoperative morbidity (Table 6).

Analysis excluding markers of advanced disease (nonelective admission, hydrocephalus, and/or ventriculostomy placement) was subsequently performed, eliminating 27.5% of the study population (Tables 7 and 8). This exclusion prohibited analysis of mortality in the multivariate model due to the small number of deaths. Increasing patient age, female sex, and low surgeon caseload were found to be independent predictors of adverse discharge disposition (Table 7). Lack of private insurance and low surgeon caseload were independent predictors of increased postoperative morbidity (Table 8).

Discussion

The natural history of acoustic neuroma is relatively benign, due to the fact that these lesions typically have benign histology and are slow growing (less than 2 mm per year) in nature.[21–23] However, over a period of several years, morbidity has the potential to increase given the proximity of vital structures (brainstem, lower cranial nerves) to these lesions as they grow, and there is a risk for hearing loss even in the absence of tumor growth.[23] Consequently, for many physicians and patients, the potential long-term morbidity of these lesions warrants the risks associated with surgical excision. Although much has been published regarding the morbidity of surgical intervention, there has been no examination of the role of the impact of patient race on morbidity and mortality following acoustic neuroma excision. This study was performed to address this void.

For optimal evaluation, a nationwide patient database was used to retrospectively analyze the morbidity/mortality of acoustic neuroma excision in the United States over a 10-year period during which all 4 treatment modalities for acoustic neuroma (surgical excision, observation, stereotactic radiosurgery, and fractionated stereotactic radiotherapy) were available in the United States. Since the origin of the Institute of Medicine initiative for addressing racial health care disparities began in 1993, the decade spanning 1994 through 2003 was chosen for analysis.[24]

The results indicate that following acoustic neuroma excision, African American patients were 9 times more likely to die than Caucasian patients; the absence of mortality data for races other than African American and Caucasian precluded mortality analyses of these races (Table 4). These findings for African Americans are disturbingly similar to a recently published analysis over a similar time period.[17] Despite this alarming finding, there were no racial differences in adverse discharge disposition or overall postoperative morbidity following acoustic neuroma excision (Tables 5 and 6).

Table 8. Multivariate analysis of overall morbidity (in-hospital morbidity and/or adverse discharge disposition) following acoustic neuroma excision in adult patients from 1994 through 2003 after exclusion of markers of advanced disease

Characteristic	OR (95% CI)	*P*-value
Patient		
Age (for 1 y increase)	0.99 (0.98–1.01)	.83
Female sex	1.25 (0.97–1.62)	.081
Race		.17
White (reference group)	1	
African American	1.31 (0.82–2.09)	
Hispanic	1.40 (0.74–2.64)	
Asian/Pac Isl	1.79 (0.90–3.57)	
Others	1.05 (0.49–2.28)	
Primary payer (Medicare is reference group)		.0030
Medicaid	1.13 (0.59–2.17)	
Private insurance/HMO	**0.58 (0.41–0.81)**	
Self-pay	0.97 (0.40–2.36)	
No charge/other	0.78 (0.38–1.59)	
Median income		.42
1 (reference group)	1	
2	0.81 (0.57–1.15)	
3	0.79 (0.58–1.08)	
4	0.81 (0.61–1.07)	
Hospital bed size (large vs small or medium)	0.94 (0.74–1.19)	.59
High surgeon volume (≥ 3 surgeries per year)	**0.65 (0.51–0.82)**	.0004

Another important finding was the role of private insurance in patient outcomes. Patients with private insurance persistently had decreased postoperative morbidity following acoustic neuroma excision, even after excluding patients with markers of advanced disease (Tables 6 and 8). Given the present debate regarding universal health care in the United States, this finding may play a role in the political arena as well as in the medical field. With regard to patient age, older patients were more likely to suffer adverse discharge disposition (even after exclusion of patients with advanced disease) and mortality; however, age was not predictive of increased overall postoperative morbidity.

Perhaps the most striking and correctable finding is the persistence of the impact of surgeon caseload in independently predicting outcome following acoustic neuroma excision. Whether the outcome measure was mortality, morbidity, or adverse discharge disposition, surgeons performing fewer than 3 acoustic neuroma excisions per year yielded significantly inferior patient outcomes than surgeons performing 3 or more acoustic neuroma excisions per year (Tables 4–6). These findings persisted even after markers of advanced disease were accounted for (Tables 7 and 8), and provide ample evidence that optimal surgical care of acoustic neuroma patients requires a surgeon performing on average at least 1 acoustic neuroma excision every 4 months. It is perhaps fortunate that over the 10-year period of this analysis, more than two-thirds of patients received care from a high-caseload surgeon, otherwise the morbidity/mortality findings may have proved of more concern. The finding regarding surgeon caseload is consistent with previous literature; however, our finding that hospital caseload did not predict outcome differs from previous literature.[20]

This study does have several limitations, most notably its retrospective nature and the relatively small representative sampling of the NIS database. Furthermore, the in-patient nature of the database limited the ability of this study to identify delayed postoperative complications, assess hearing postoperatively, or evaluate the permanency/resolution of certain complications (ie, facial nerve palsy), which can take months postoperatively to definitively evaluate. Another limitation is the inability to determine the size of the acoustic neuroma excised in every patient; therefore, it is possible that the racial disparities in mortality from this study could be explained primarily by African Americans harboring larger tumors prior to surgical excision. Finally, the database is unable to distinguish between preoperative and postoperative complications; for example, a patient presenting with a facial palsy preoperatively would have been counted as having the palsy as a postoperative complication. Nevertheless, the results from this study bring an important fact to light: African Americans in the United States with acoustic neuromas are 9 times more likely to suffer death after surgical excision in comparison with Caucasian patients. This finding should prompt further prospective investigation in order to determine whether there has been significant improvement since the end of 2003, the last year analyzed in this study.

Unfortunately, the NIS did not provide the ability to reliably examine morbidity following stereotactic radiosurgery, observation, or fractionated stereotactic radiotherapy. Consequently, each of these modalities for acoustic neuroma should be studied further in underrepresented minorities to determine whether they can improve on the morbidity findings from this study. However, given the significantly less invasive nature of each of these alternatives to surgery, it would be wise for practitioners and patients to be aware of these treatment modalities in counseling underrepresented minorities with acoustic neuromas, particularly in light of the disparities in mortality following surgical excision highlighted here. Given the striking mortality findings in this study, physicians treating underrepresented minorities (particularly African Americans) seeking microsurgical care for acoustic neuromas should be highly vigilant to seek surgeons with extremely high caseloads (ie, at least 1 acoustic neuroma excision per month) in order to optimally minimize postoperative mortality. Although steps such as the 1993 initiative by the Institute of Medicine and the 1998 goal set by the President of the United States of eliminating health care disparities by the year 2010 are noble and may have achieved some progress since inception, the results of this study indicate that there is still a long way to go before racial health care disparities will have been adequately addressed.

Conclusion

High surgeon caseload, private insurance, and younger patient age independently predict improved postoperative outcomes following acoustic neuroma excision. Although overall morbidity and adverse discharge disposition were similar regardless of race, African Americans were 9 times more likely to die following surgery than Caucasian patients over a decade-long analysis. Given the relatively benign natural history of acoustic neuroma and the alarmingly increased mortality rate following surgical excision among older patients, African Americans, and patients receiving care from low-caseload surgeons, acoustic neuromas in these patient populations may be best managed by more minimally invasive modalities such as observation, fractionated stereotactic radiotherapy, and stereotactic radiosurgery.

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