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Complications of Surgery for Sporadic Vestibular Schwannoma

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Abstract

Objectives. We sought to investigate the postoperative complications of vestibular schwannoma excision and determine their significant clinical predictors.

Study Design. Cross-sectional.

Setting. California Hospital Inpatient Discharge Datasets 1997-2011.

Subjects and Methods. Data for vestibular schwannoma excisions performed in California were extracted using the ICD-9-CM code "04.01 excision of acoustic neuroma." Demographics, principal payer, state of residence, comorbidities, as well as hospital case volume were examined as possible predictors. Postoperative complications and patient disposition were examined as outcome variables. Comorbidities and complications were identified using ICD-9-CM diagnoses and procedures codes.

Results. Overall, 6553 cases were examined. Comorbidities were present in 2539 (38.7%) patients. Postoperative complications occurred in 1846 (28.2%) patients; 1714 (26.2%) neurological and 337 (5.1%) medical complications. Patients' admission ended with death or further care (ie, skilled nursing facilities) in 260 (4.0%) cases. Mortality rate was 0.2%. No significant changes were observed over time. Multivariate analysis revealed that the odds of neurological complications were greater in the 2007-2011 period (OR = 1.51; 95% CI, 1.12-2.04), in patients with comorbidities (OR = 1.48; 95% CI, 1.16-1.88), and in hospitals with low case volume (OR = 1.69; 95% CI. 1.31-2.18). The odds of medical complications were also greater in the 2007-2011 period (OR = 1.69; 95%, CI 1.02-2.80). Female gender, non-Caucasian ethnicity, presence of comorbidities, and low hospital case volume were associated with greater odds of patients requiring further care.

Conclusion. Comorbidities and low hospital case volume were major risk factors for complications. No significant changes in rates of complications from vestibular schwannoma surgery were observed over the 15-year period.

Keywords

vestibular schwannoma, acoustic neuroma, tumor excision, surgery outcomes, surgery complications

Introduction

The past few decades have been witness to substantial changes in epidemiology, diagnostic modalities, and treatment philosophies of vestibular schwannoma (VS).[1] The incidence of VS has increased over recent decades mainly due to detection of increasingly smaller VS and heightened awareness of VS among clinicians.[2,3] Identification of smaller tumors or tumors in earlier stages has contributed to development of hearing preserving surgery and nonsurgical treatment options.[4-6] Conservative treatment modalities such as radiosurgery and observation with serial imaging are gaining popularity.[4,6-8]

Since the introduction of microsurgery by Dr William House in 1961, intraoperative mortality is no longer commonplace. Intraoperative mortality rates, reported by multiple studies, are less than 1%.[6,9,10] The primary goals of VS excision have evolved to include preserving normal hearing and facial nerve function, as well as avoiding brainstem injury and mortality.[4-6] Despite improvements in surgical techniques, intraoperative monitoring, and neuroanesthesia, complications continue to occur with considerable incidence.[4] The complication rates vary greatly depending on surgical approach, tumor size, surgeon caseload, and other factors.[4-6,9] Additionally, VS excisions have become increasingly centralized to higher volume centers,[3] and several studies have

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reported that surgeries in high volume centers are associated with fewer postoperative complications.[11,12]

Amid these dramatic changes in the treatment landscape of VS, our study aimed to capture how postoperative complication rates have evolved over the past 2 decades using the California Hospital Inpatient Discharge Datasets. Furthermore, we sought to investigate whether the incidence of postoperative complications could be correlated to potential predictors.

Methods

Data Source

The California Hospital Inpatient Discharge Datasets from 1997 to 2011 were obtained and merged. These data sets, collected by the California Office of Statewide Health Planning and Development (OSHPD), include data on all inpatient discharges from all licensed hospitals in California. The data sets are released in form of de-identified records that contain patient-level data such as demographics and diagnoses and procedures coded through International Classification of Diseases, 9th edition, Clinical Modification (ICD-9-CM). Information on data collection instruments and methodology is available on the website of OSHPD.[13] The data set does not contain identifiable patient information; thus, approval for this study by our institutional review board was not required.

The merged 1997-2011 data sets were reviewed and all cases enlisting the ICD-9-CM procedure code "04.01 excision of acoustic neuroma" were extracted. Neurofibromatosis type II cases were identified and excluded using the ICD-9-CM diagnosis code, "237.72 neurofibromatosis, type 2 [acoustic neurofibromatosis]." Seventeen cases with unspecified neurofibromatosis codes were also excluded due to potential miscoding.

Variables and Definitions

The outcome variables were (1) the proportion of patients who suffered from neurological complications, (2) the proportion of patients who suffered from medical complications, and (3) the proportion of patients who died, required "further care," or was not discharged directly. "Further care" included patients who were admitted to acute or long-term care facilities within the hospital or transferred to another hospital. The perioperative complications were identified through a review of the literature[14-16] and defined using the ICD-9-CM diagnosis and procedure codes (**Table 1**). Since the comorbidities and complications could have been present at any point during admission, it was difficult to determine whether hearing loss and tinnitus occurred pre- or postoperatively, and thus they were not analyzed.

The independent variables examined were as follows: years of study were grouped into three 5-year periods, 1997-2001, 2002-2006, and 2007-2011. Demographics including age (1-17, 18-64, and 65 years or older), gender, and ethnicity (Caucasian vs. non-Caucasian) were analyzed. Principal payer was recoded as Medicare, Medi-Cal (California's version of Medicaid, state program for the poor), private (ie, HMO or PPO), and other (ie, self-pay, worker's compensation, charity, county indigent programs, or other government and indigent programs: including out-of-state Medicaid). State of residence was classified into California versus other (ie, out of state, homeless), based on the recorded zip codes. Comorbidities were defined using ICD-9-CM diagnosis codes (**Table 1**). Hospital case volume was categorized into 0-99 cases and 100 or more cases over the study period.

Statistical Analyses

Changes in outcomes of surgeries were analyzed and their correlation with time was evaluated using linear regression analysis. Mean ± standard deviation (SD) was calculated for age. A multivariate logistic regression model was fit to determine whether any of the independent variables were associated with the occurrence of the neurological and medical complications, as well as patients who died or required further care. The output of the multivariate analysis was reported as odds ratio (OR) and 95% confidence interval (CI). Data analysis was performed using PASW Statistics 18.0 (SPSS, Inc., Chicago, Illinois). A P value of less than .05 was considered significant.

Results

A total of 6553 VS excisions were performed in California during 1997-2011. This number consisted of 2227 surgeries during 1997-2001, 2431 surgeries during 2002-2006, and 1895 during 2007-2011, reflecting a decline in number of surgeries (adjusted $R^2 = 0.27$; $P = .02$). The mean age of patients was 51.3 ± 14.8. The mean age slightly decreased, from 52.0 ± 14.7 in 1997-2001 to 50.1 ± 15.8 in 2007-2011; however, this change was not statistically significant ($P = .29$). Males comprised 48.5%, Caucasians comprised 82.9%, and California residents comprised 69.7% of this patient population. The principal payer was private insurance in 76.3%, Medicare in 10.7%, Medi-Cal in 3.5%, and "other" in 9.5% of cases. Comorbidities were present in 38.7% of the cases (2539 patients) (**Table 2**). The most common comorbidities were hypertension (21.2%), tobacco use (6.1%), and pulmonary disorders (5.3%). The percentage of patients with any comorbidities increased from 30.5% to 47.3% during 1997-2011 (adjusted $R^2 = 0.83$; $P < .001$).

Overall, 1846 (28.2%) suffered from at least 1 complication during their admission. This included 1714 (26.2%) patients who suffered from the neurological and 337 (5.1%) patients who suffered from the medical complications (**Table 3**). The most common neurological complication was facial nerve paralysis (8.7%). Fourteen patients died during their hospitalization, resulting in a mortality rate of 0.2%. In 4.0% (260) of cases, patients' admission ended with death or transfer to further care. There were no significant changes over time in the rates of complications or outcomes of surgeries (neurological complications $P = .45$; medical complications $P = .61$; further care/death $P = .30$).

The multivariate analysis revealed that the neurological complications were more likely to occur over time (**Table 4**). The odds of the neurological complications were 1.51

Table 1. List of ICD-9-CM codes used to define comorbidities and complications.

Comorbidities	ICD-9-CM codes	Complications	ICD-9-CM codes
Hypertension	401.1, 401.9, 402.10, 402.90, 404.10, 404.90, 405.11, 405.19, 405.91, 405.99	Nervous system complications not elsewhere specified	997.0-997.09
Tobacco use	305.1, 989.84, V15.82	Abducens paralysis	378.54, 951.3
Pulmonary abnormalities (pulmonary circulation disorders, chronic obstructive pulmonary disease)	416-416.9, 417.9, 490-492.8, 493-494.1, 496	Hydrocephalus	331.3, 331.4, 02.2, 02.3-02.39, 996.75, 02.4-02.43
Hypothyroidism	243-244.2, 244.8, 244.9	Cerebrospinal fluid leak	349.81, 03.31, 388.61
Diabetes mellitus	250-250.73, 250.90-250.93	Dysphagia	787.2-787.29
Obesity	278.0	Craniotomy and craniectomy	01.2-01.25
Cardiac abnormalities (chronic heart failure, cardiac arrhythmias, valvular diseases)	093.2-093.24, 394-397.1, 398.91, 402.11, 402.91, 404.11, 404.13, 404.91, 404.93, 424.0-424.91, 426.10, 426.11, 426.13, 426.2-426.53, 426.6-426.9, 427.0, 427.2, 427.31, 427.60,427.9, 428.0-428.9, 746.3-746.6, 785.0, V42.2,V43.3 V45.0, V53.3	Facial paralysis	351-351.9, 781.94, 951.4, 08.52, 04.5, 04.6, 04.71-04.79, 374.2-374.23, 370.34, 370.35, 370.40, 370.00, 371.40, 371.49, 371.81, 371.89
Depression	300.4, 301.12, 309.0, 309.1, 311	Iatrogenic cerebrovascular accident	997.02
Anemia	280.0-280.9, 281-281.9, 285.9	Meningitis	320-322.9
Vascular disorders (peripheral vascular disease, collagen vascular diseases)	440-440.9, 441.2, 441.4, 441.7, 441.9, 443.1-443.9, 447.1, 557.1, 557.9, 701.0, 710-710.9, 714-714.9, 720-720.9, 725, V43.4	Cerebral edema	348.5
Alcohol abuse	291.1, 291.2, 291.5, 291.8, 291.9, 303.90-303.93,305.00-305.03, V11.3	Trochlear paralysis	378.53, 951.1
Coagulopathy	286-286.9, 287.1, 287.3-287.5	Venous thrombosis	453.4-453.42, 453.8, 453.9
Drug abuse	292.0, 292.82-292.89,292.9,304-304.93, 305.2-305.93	Transfusion of packed erythrocytes	99.04
		Mechanical ventilation	96.7-96.72
		Hematoma/seroma	998.1-998.13
		Convulsion	436, 780.3-780.39
		Wound infection	998.5-998.59
		Pulmonary embolism	415.1-415.19
		Acute myocardial infarction	410-410.9
		Pneumonia	480-486

(95% CI, 1.12-2.04) in the 2007-2011 time period compared to 1997-2001. The odds of out-of-state patients having a neurological complication were 1.82 (95% CI, 1.22-2.72). Patients with comorbidities were 1.48 times (95% CI, 1.16-1.88) and patients undergoing surgery in hospitals with case volume of 0-99 were 1.69 times (95% CI, 1.31-2.18) more likely to suffer from the neurological complications. Medical complications were also more likely to occur over time (**Table 4**). The odds of the medical complications were higher in 2007-2011 (OR = 1.69; 95% CI, 1.02-2.80). Patients with private principal payers were less likely to suffer from the medical complications (OR = 0.27; 95% CI, 0.12-0.60).

The odds of patient admissions ending with further care or death was higher in females (OR = 1.64; 95% CI, 1.16-2.33) and non-Caucasians (OR = 1.64; 95% CI, 1.09-2.48) as presented in **Table 4**. Out-of-state residence (OR = 2.10; 95% CI, 1.18-3.73), comorbidities (OR = 1.60; 95% CI, 1.11-2.30), and low hospital case volume (OR = 1.66; 95%

Table 2. Comorbidities in patients undergoing vestibular schwannoma excision.

	Frequency (% of all patients)
Any comorbidities	2539 (38.7)
Hypertension	1389 (21.2)
Tobacco use	403 (6.1)
Pulmonary abnormalities (pulmonary circulation disorders, chronic obstructive pulmonary disease)	345 (5.3)
Hypothyroidism	327 (5.0)
Diabetes mellitus	309 (4.7)
Obesity	292 (4.5)
Cardiac abnormalities (chronic heart failure, cardiac arrhythmias, valvular diseases)	252 (3.8)
Depression	191 (2.9)
Anemia	162 (2.5)
Vascular disorders (peripheral vascular disease, collagen vascular diseases)	50 (0.8)
Alcohol abuse	35 (0.5)
Coagulopathy	35 (0.5)
Drug abuse	18 (0.3)

Table 3. Intra- and postoperative complications in patients undergoing vestibular schwannoma excision.[a]

	Frequency	% of all patients
Any complications	1846	28.2
Neurological complications	1794	26.2
Nervous system complications not elsewhere specified	995	15.2
Facial paralysis	573	8.7
Hydrocephalus	238	3.6
Cerebrospinal fluid leak	214	3.3
Dysphagia	149	2.3
Craniotomy and craniectomy	70	1.1
Abducens paralysis	67	1.0
Iatrogenic cerebrovascular accident	52	0.8
Cerebral edema	44	0.7
Convulsion	44	0.7
Intracranial hemorrhage	40	0.6
Meningitis	25	0.4
Trochlear paralysis	5	0.1
Medical complications	337	5.1
Transfusion of packed erythrocytes	138	2.1
Mechanical ventilation	83	1.3
Hematoma/seroma	78	1.2
Pneumonia	59	0.9
Wound infection	22	0.3
Venous thrombosis	18	0.3
Acute myocardial infarction	13	0.2
Pulmonary embolism	12	0.2

[a]Sum of percentages may exceed 100% since one patient could have more than one complication.

CI, 1.15-2.39) were also associated with higher odds of not being discharged to home. Patients with private principal payer were 0.46 (95% CI, 0.24-0.89) times less likely to require further care.

Discussion

This retrospective study of the VS cases in California showed the changing trends in comorbidities and complications in patients undergoing surgery. The number of

Table 4. Multivariate analysis of predictors of neurological and medical complications.[a]

		Neurological complications (OR [95% CI])	Medical complications (OR [95% CI])	Further care or death (OR [95% CI])
Time period	1997-2001	Reference	Reference	Reference
	2002-2006	**1.64 (1.23-2.18)**	1.07 (0.63-1.82)	0.89 (0.58-1.36)
	2007-2011	**1.51 (1.12-2.04)**	**1.69 (1.02-2.80)**	1.18 (0.78-1.79)
Age	1-17 years	Reference	Reference	Reference
	18-64 years	2.28 (0.47-11.13)	2.07*	2.11*
	65 years and over	3.05 (0.58-16.02)	1.02*	3.99*
Gender	Male	Reference	Reference	Reference
	Female	0.91 (0.72-1.15)	1.19 (0.78-1.80)	**1.64 (1.16-2.33)**
Ethnicity	Caucasian	Reference	Reference	Reference
	Non-Caucasian	1.21 (0.89-1.65)	1.60 (0.99-2.57)	**1.64 (1.09-2.48)**
Principal payer	Medicare	Reference	Reference	Reference
	Medi-Cal	1.70 (0.90-3.22)	0.85 (0.34-2.11)	0.78 (0.34-1.77)
	Private	0.97 (0.58-1.62)	**0.27 (0.12-0.60)**	**0.46 (0.24-0.89)**
	Other	0.88 (0.58-1.62)	0.37 (0.13-1.05)	0.60 (0.25-1.44)
State of residence	California	Reference	Reference	Reference
	Other	**1.82 (1.22-2.72)**	1.03 (0.45-2.37)	**2.10 (1.18-3.73)**
Any comorbidities	No	Reference	Reference	Reference
	Yes	**1.48 (1.16-1.88)**	1.40 (0.91-2.16)	**1.60 (1.11-2.30)**
Hospital case volume	100 cases or more	Reference	Reference	Reference
	0-99 cases	**1.69 (1.31-2.18)**	1.49 (0.96-2.31)	**1.66 (1.15-2.39)**

Abbreviations: OR, odds ratio; CI, confidence interval.
[a]Significant values are in bold.
[b]5% confidence interval could not be calculated, *P* = .99.

surgeries performed has slightly decreased, and the number of patients with comorbidities has increased, while the mean age of patients has remained the same. With the advent of better diagnostics, specifically the use of MRI, the number of VSs that are diagnosed yearly is increasing. In parallel, increasing numbers of VS cases are being serially watched, instead of immediate treatment.[2,6,7] Despite the current ability to detect smaller tumors, our study showed no significant change in the average age of patients who undergo surgical excision. This may reflect the trend that patients undergoing surgical resection are more carefully chosen. Although the mean age has not increased, the number of comorbidities has increased. It is likely that smaller tumors are being serially observed, and when growth of the tumor is detected, more patients of all ages are offered stereotactic radiosurgery to avoid the risk of operative complications. This indicates that patients diagnosed with larger tumors with neurological consequences, regardless of comorbid conditions, are still offered and undergo surgical resection.

The overall comorbidity rate was 38.7%, with the most common comorbid conditions being hypertension (21.2%), tobacco use (6.1%), and pulmonary conditions (5.3%). Endocrine problems, such as hypothyroidism and diabetes, were present in approximately 5% of the operative cases. The rates of these comorbid conditions are less than the adult prevalence rates in the US, as determined by the Centers for Disease Control and Prevention (hypertension 31.9%, tobacco use 19.0%, pulmonary disorders 6.3%, hypothyroidism 4.6%, obesity 35.9%, and diabetes 6.9%).[17] Surgical interventions are more limited to patients who are in general much healthier than the general public. Although patients are still healthier than the general public, on meta-analysis, the presence of comorbidities in patients undergoing surgery has increased with time. This may indicate that patients are electing to watch serially their tumor growth and if the tumor does enlarge significantly, then undergo either radiosurgery or microsurgery. This rate of increase in comorbid conditions may also indicate the changing trend in hospitals in coding discharge diagnoses and comorbid conditions. The Centers for Medicare and Medicaid Services changed their hospital reimbursement methodology for determining complications and the resultant change in reimbursement in 2007.[18] With the introduction of electronic medical records, coding of comorbid conditions and complications are more easily performed and trends in clinical outcomes can also be more easily reviewed.

The overall complication rate for VS surgery was 28.2% with the majority of the complications being nervous system related (26.2%) versus non–nervous system related (5.1%). The most common postoperative complications following VS surgery have been reported as facial paralysis, hearing loss, neurologic and vascular complications, cerebrospinal fluid (CSF) leakage, meningitis, and wound infection.[4-6,19] The most common complication in this study was nervous system complications, not elsewhere specified, at 15.2%, followed by facial nerve paralysis, which occurred in 8.7% of patients. Nervous system complications, not elsewhere specified could indicate a number of conditions, including facial nerve paresis. As shown in **Table 4**, neurological complications were almost 1.5 times more likely to occur in 2007-2011 compared with 1997-2001. Two causes to this increase in the complications are presumable. One relates to the increased use of radiosurgery and watchful waiting for smaller tumors. This may have resulted in surgical cases primarily being performed in patients with larger tumors. Other authors have reported this as well.[20] The second cause of this increased reports of complications may be related to the change in the Medicare reimbursement for post-surgical complications.[18]

The rates of facial nerve paralysis after VS excision vary from 3.3% to 42.5% depending on the tumor size, surgical approach, and use of intraoperative monitoring.[6] The 8.7% facial nerve paralysis rate in this study is low compared to what is documented in the literature. Given that facial nerve weakness is an expected outcome in some patients, it could be under-documented in the discharge diagnoses. Additionally, from these data, we could not determine the severity of facial paralysis as the ICD-9-CM codes would not indicate the degree of weakness or if it were transient.

The rate of CSF leakage varies greatly in the literature. Several studies showed a leak rate at approximately 9% to 13%,[21,22] independent of surgical approach taken. Other studies have shown rates as high as 30% with a retrosigmoid approach.[23] The overall leakage rate of 3.3% in this study is low compared to the commonly cited rates in the literature and is closer to the very low CSF rates, 0.8%[24] and 1.2%,[25] as reported by some authors. The data also included patients who had CSF leaks but were managed with conservative measures, ventriculostomy, or lumbar drains, and as a result, CSF leakage may not have been listed as a discharge diagnosis. It was difficult to determine which lumbar drains were placed prophylactically and which drains were placed as a treatment for CSF leak. The rate of meningitis is also very low at 0.4%, which is similar to and slightly lower than the literature.[4,23,26]

Mortality is low from VS surgery, usually <1% in large studies.[27] Similarly, the mortality rate in this study was 0.2%. Other medical complications of VS surgery include myocardial infarction, pneumonia, pulmonary embolism, and deep vein thrombosis. The traditional rates for these complications are similar to those for other major surgical procedures[28] and are similar to our results.

Comorbidities and low hospital case volume were associated with higher odds of neurological complications. As indicated in other studies,[11,12,16,18] high volume centers have lower complications rates and shorter postoperative stays. Locations where fewer than 100 cases were performed during the 15-year study period were significantly associated with neurological complications and would need further subacute or skilled nursing care (OR = 1.81; 95% CI, 1.41-2.31, and OR = 1.66; 95% CI, 1.15-2.39, respectively). This was in agreement with other studies that indicated the hospitals or providers with the highest volumes of VS surgeries had higher frequency of routine discharges and fewer complications. [11,12]

The main limitation of this study is that our data are dependent on the discharge diagnoses that were billed or coded. These diagnosis codes often under-document the actual prevalence of these comorbid conditions and perioperative complications. This is especially true for complications such as facial paralysis. As coding is performed by hospital coders based on the notes of clinicians, many of these comorbidities and complications may not have been included in the patient's daily or discharge notes. Another limitation is that the data sets do not record the size or location of the tumors. This could also add insight to interpreting the observed trends. Given that we reviewed only the discharge diagnosis, we cannot determine the long-term complications that might ensue from VS removal, specifically if there was residual or recurrent tumor. Hearing outcome, long-term imbalance, facial nerve outcome, and tinnitus could not be addressed with this current study because of the inability to determine pre-hospitalization hearing or long-term balance or facial nerve outcomes. Additionally, given that hearing loss is often a consequence of VS surgery, specifically for a translabyrinthine approach, this diagnosis is often under-recorded.

Conclusion

We investigated the changing trends in comorbidities and complications rates in California from 1997 to 2011. The number of surgeries performed has slightly decreased, and the number of patients with comorbidities has increased, while the mean age of patients has remained the same. The presence of comorbidities and low hospital case volume were major risk factors for complications. Most complications that occurred were neurological in nature. No significant changes in risk factors for complications from vestibular schwannoma surgery were observed over the 15-year period.

Author Contributions

Hossein Mahboubi, designing, analysis, and interpretation of data; drafting the article; final approval of the version to be published; **Omar H. Ahmed**, designing, acquisition of data, drafting the article, final approval of the version to be published; **Amy Y. Yau**, analysis and interpretation of data, drafting the article, final approval of the version to be published; **Yasmina C. Ahmed**, analysis and interpretation of data, drafting the article, final approval of the version to be published; **Hamid R. Djalilian**, designing and interpretation of data, drafting the article, final approval of the version to be published.

Disclosures

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