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Journal

The Laryngoscope, 130(2)

ISSN

0023-852X

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Publication Date

2020-02-01

DOI

10.1002/lary.27950

Peer reviewed

Published in final edited form as:

Laryngoscope. 2020 February ; 130(2): 482–486. doi:10.1002/lary.27950.

The Changing Landscape of Vestibular Schwannoma Diagnosis and Management: A Cross-Sectional Study

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Abstract

Objectives: To assess the current state of diagnosis and management of vestibular schwannoma (VS), treatment trends, and to evaluate the role of treatment setting and various specialists in treatment plan.

Methods: Patients diagnosed with VS completed a voluntary and anonymous survey. The questionnaires were distributed through Acoustic Neuroma Association website, Facebook page, and email newsletters from January to March 2017.

Results: In total, 789 VS patients completed the survey, of which 414 (52%) underwent surgery, 224 (28%) underwent radiotherapy, and 121 (15%) were observed. General otolaryngologists diagnosed 62% of responders, followed by primary care (11%) and neurotologists (10%). Patients who underwent surgery were significantly younger and had larger tumors compared to those treated with radiation or observation. The ratio of patients having non-surgical *vs.* surgical resection changed from 1:2 to 1:1 for the periods of 1979–2006 *vs.* 2007–2017, respectively. Neurosurgeons (40%) and neurotologists (38%) were the most influential in treatment discussion. Neurotologists ($p < 0.001$) and general otolaryngologists ($p = 0.04$) were more influential than neurosurgeons for the decision process in patients with smaller tumors. Patients treated at academic *vs.* non-academic private institutions reported similar tumor sizes ($p = 0.27$), treatment decisions ($p = 0.09$), and decision satisfaction ($p = 0.78$).

Conclusion: There is a continuing trend towards non-surgical management with approximately half of the patients opting for non-surgical management. In this cohort, the patients commonly presented with otologic symptoms and otolaryngologists made the most diagnoses. Neurotologists and neurosurgeons were the most influential in treatment discussion.

Keywords

Vestibular schwannoma; Acoustic Neuroma; Treatment trend; Influential specialist; Decision satisfaction

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Conflict of Interests: None

Financial Disclosure: None

Introduction

Vestibular schwannomas (VS) are benign tumors arising from the eighth cranial nerve and comprising 6–8% of all intracranial tumors.[1, 2] While the annual incidence of 1.1–1.7 per 100,000 people has remained steady, tumors have been diagnosed at smaller sizes over time.[3–6] After diagnosis, VS patients are faced with a multi-faceted decision-making process to manage their tumor via watchful observation, radiotherapy, or surgical resection. Retrospective studies of large cohorts demonstrated that 48–59% of patients underwent microsurgery and 21–24% underwent radiotherapy, with surgical resection correlating with younger age and larger tumor size.[3, 5, 6] With innovations in imaging and radiotherapy, some authors have begun to advocate for the benefits of observation and radiotherapy over surgical treatment.[3, 7–10] However, a review of VS treatment demonstrated that selection bias and confounding factors, such as age and pre-treatment status, limit comparing efficacy and safety across treatment modalities.[11]

It is yet unclear whether the rise in advocacy for conservative management is actually independent from the earlier detection of these tumors at smaller sizes. Both diagnosis and treatment of VS is continuously evolving where management can comprise of collaboration between neurotologists, neurosurgeons, and radiation oncologists, among others.[12–14] However, the specific roles and influence of these providers in diagnosis and treatment discussion have yet to be compared. This patient-centered study aims to assess the current state of diagnosis and management of VS, as well as to evaluate the role of treatment setting and various specialists' influence in treatment plan and satisfaction.

Materials and Methods

In collaboration with the Acoustic Neuroma Association (ANA) and after IRB approval from the University of California, Irvine, a comprehensive and anonymous survey was distributed to all ANA members from January to March 2017 using a secure and confidential RedCap interface (Nashville, TN).[15] The link to the survey was available on the ANA website, Facebook page, in addition to a notification sent to email-list members. A VS diagnosis was required to participate in the study. Survey questions were mostly in free-response, choosing the best answer, or checking all that apply formats. The survey evaluated patients' demographics, diagnosis information including involved physicians and VS tumor characteristics, treatment modality with the associated course and outcome, treatment centers, and influential specialists contributing to treatment.

Patients' eventual treatments were categorized into surgery, radiation, watchful observation, surgery-radiation combination, and undecided. The latter two treatments were excluded from some analyses due to a low response rate. Surgery cohort consisted of patients undergoing complete or incomplete resection, radiation cohort consisted of patients receiving stereotactic radiosurgery or radiotherapy, and watchful observation patients underwent serial magnetic resonance imaging (MRI) scans. In this manuscript we define conservative (non-surgical) management as either radiation or watchful observation. Since most questions were

optional to answer, not all tables' number breakdowns add up to 100% of the respective cohort.

PASW Statistics 18.0 software (SPSS Inc., Chicago, IL) was used for statistical analysis with a 0.05 alpha considered significant. Independent sample *t*-test and chi-square test were used for numerical and categorical variables, respectively. Univariate analysis of variance (ANOVA) was used to compare numerical variables among different cohorts; those that demonstrated a significant *p* value were further analyzed for subset comparison via Bonferroni's correction. Lastly, when comparing the treatments of patients diagnosed since 2007 versus those prior to that, the potential confounding effect of their tumor size at diagnosis was determined via a bivariate analysis using binary (surgery or conservative) or multinomial (surgery, radiation or observation) logistic regression.

Results

Demographics and Diagnosis

In total, 789 individuals diagnosed with VS completed the survey with an average age at diagnosis of 52.0 ± 11.8 years. Patients' demographics and different treatment modalities are summarized in Table 1. The tumor size diagnosed by different specialists and eventual treatments are compared in Table 2. One-way ANOVA showed a significant difference between specialists in diagnosed tumor size ($p = 0.003$). Multiple comparison analysis revealed that tumors diagnosed by general otolaryngologists ($p = 0.012$) and neurotologists ($p = 0.004$) were smaller than those diagnosed by neurosurgeons. There was no difference in treatment decision (i.e., surgery or non-surgical management) when comparing patients diagnosed by different specialists ($p = 0.607$).

While 60 (7.6%) patients had their tumors found incidentally, 726 (92.0%) patients obtained MRI due to concerning symptoms on presentation. The most common symptoms were hearing loss (n = 559, 70.8%), imbalance/dizziness (n = 304, 38.5%), tinnitus (n = 295, 37.4%), aural fullness (n = 232, 29.4%), and vertigo (n = 152, 19.3%). Overall, 704 (89.2%) patients experienced at least one of these symptoms.

Treatment Trend

One-way ANOVA showed that the surgically treated patients were younger and had larger tumor sizes compared to those treated with radiation (both $p < 0.001$) or observation (both $p < 0.001$). In Table 3, participants diagnosed between 2007 and 2017 (n = 580) were compared to those diagnosed prior to 2007 (n = 209) regarding their tumor size at diagnosis and their eventual treatment. Tumor size at diagnosis was smaller in the 2007–2017 cohort compared to the 1979–2006 period (1.87 *vs.* 2.33 cm, $p = 0.013$). The former cohort underwent surgery in 47.1% (n = 273) of cases versus non-surgical management in 48.1% (n = 279) of cases. This was significantly different than those diagnosed between 1979 and 2006, with 66.0% (n = 138) surgical and 31.1% (n = 65) non-surgical patients ($p < 0.001$). When we adjusted for tumor size as a possible confounder, there still was a significant difference between non-surgical *vs.* surgical management of the two time periods ($p = 0.002$).

Specialists and Treatment Centers

During the course of VS management, 700 (87.8%) patients had seen a neurosurgeon, 549 (68.9%) a neurotologist, 307 (38.5%) a radiation oncologist, and 39 (4.9%) a general otolaryngologist. Patients were asked which specific specialist played the most influential role in the discussion and decision of treatment. Of the 759 responders, 301 (39.7%) designated neurosurgeons, 287 (37.8%) neurotologists, 77 (10.1%) general otolaryngologists, and 50 (6.6%) radiation oncologists, with average tumor sizes of 2.34 ± 1.39, 1.79 ± 1.13, 1.88 ± 1.22, and 1.87 ± 1.26 cm, respectively ($p < 0.001$). Post-hoc analysis showed that neurotologists ($p < 0.001$) and general otolaryngologists ($p = 0.04$) were most influential in smaller tumor sizes compared to neurosurgeons.

Of those who specified their treatment setting (n = 684), 411 (60.1%) patients received treatment at academic institutions, 259 (37.9%) at private non-academic medical centers, and 14 (2.0%) at the Veteran Administration hospitals. There were no significant differences in treatment decision ($p = 0.09$), tumor size at diagnosis ($p = 0.27$), days of hospitalization ($p = 0.05$), or the most influential specialist in treatment discussion ($p = 0.36$) between academic and private non-academic centers' patients. On a scale of 1–5, there was no difference ($p = 0.78$) in satisfaction with treatment decision between receiving treatment at academic (3.87 ± 1.1) versus private non-academic (3.85 ± 1.1) institutions.

Discussion

This patient-centered study of VS patients demonstrates that there is a trend towards non-surgical management even when adjusted for the decreasing tumor size at diagnosis. The patients mostly presented with otologic symptoms and were diagnosed by otolaryngologists. Neurosurgeons and neurotologists were perceived as the most influential in discussing treatment and patients reported no meaningful differences between the treatment institutions.

Diagnosis

The common clinical symptoms experienced in VS patients are reported as hearing loss (57–95%), tinnitus (12–83%), vertigo/dizziness (14–75%), and trigeminal neuropathy (4–9%).[16–20] These wide ranges are partly due to the heterogeneity of tumor size and location (intracanalicular *vs.* mostly in cerebellopontine angle). Hearing loss was seen in most of our cohort (71%) who underwent initial diagnostic MRI, but tinnitus and imbalance/dizziness (both 38%) also represented a significant number of complaints leading to imaging. It is important to note that our five most common presenting symptoms were all otologic related. This is in agreement with our breakdown of diagnosing physicians, where otolaryngologists and neurotologists diagnosed more than 70% of the VS cases.

We also found that tumors diagnosed by neurosurgeons were larger than those diagnosed by neurotologists and general otolaryngologists. It may be because VS starts manifesting itself with otologic symptoms and thus naturally drawing the patient to otolaryngologists, as opposed to neurosurgeons who may receive referrals after a large enough tumor that has led to enough mass effect for neurologic symptoms or in an emergency department setting. Though not significant, we observed that patients diagnosed by neurosurgeons received

slightly higher rates of radiosurgery and lower rates of surgery even though they were shown to have larger average tumor size. This might be due to some neurosurgeons' higher level of comfort with radiosurgery versus surgical resection or the setting of their practice.

Treatment

Participants who underwent surgical resection were younger and had larger tumor sizes, which is consistent with other studies.[3, 5, 6] Our mean age at diagnosis (52.0 years) was comparable to a large epidemiological study (53.1 years),[5] but our average tumor size (1.12 cm) was consistent with that reported from a large meta-analysis (1.18 cm).[8] When separating the cohort into recently diagnosed (2007–2017) patients and those diagnosed prior to 2007, we observed a different treatment breakdown. Namely, non-surgical management has become more prevalent from a previous 1:2 (non-surgical to surgical) ratio to the 1:1 of the recent decade. This is consistent with the current body of literature suggesting the consideration of observation and radiation therapy for the appropriate tumors. This is due to earlier detection, more diagnoses in elderly patients with indolent tumors, better monitoring, limited number of regrowth in VS tumors, and avoiding surgical related complications.[3, 9, 10, 21–24]

The cohort diagnosed in 2007–2017 had a smaller tumor size at diagnosis, but we showed that there was a persisting trend toward non-surgical management even after adjusting for tumor size. It has been suggested that tumors ≤ 3 cm in the cerebellopontine angle are potential candidates for radiosurgery and that observation can show success for slow-growing and smaller VS tumors especially < 2cm total length.[3, 9, 22, 25–27] A portion of the surgical patients in this study, especially those diagnosed prior to 2007, fall within these ranges. This suggests that some of these patients could have benefitted from a discussion regarding conservative management as a viable option. Alternatively, it is also important to point out recent emerging evidence suggesting a possible association of poor long-term hearing outcomes with conservative management. Evidence from modern, conformal, low-dose radiation techniques demonstrated poor long-term hearing preservation rates, from 80% to 23% in 2-year and 10-year post-treatment hearing preservation rates, respectively.[28] Likewise, a 2018 study not included in this review showed a similar trend in 466 conservatively managed patients, demonstrating a drop of 94% to 44% in 1-year and 10-year serviceable hearing maintenance rates (defined as pure tone average ≤ 50 dB hearing loss and word recognition score ≥ 50%).[29] A 2019 literature review and institutional experience of hearing preservation surgery on small vestibular schwannomas concluded that though observation may have better short-term hearing function, active surgical treatment can offer a better chance of long-term hearing preservation.[30] With the trend toward smaller tumor size at diagnosis, all treatment options including risks and benefits associated with each should be discussed with patients whose tumor characteristics renders them candidates for such approaches.

Influential Specialists and Treatment Centers

Our data showed that neurosurgeons were closely followed by neurotologists as the most influential specialists in treatment discussion. Otolaryngologists or neurotologists who were most influential in almost half of the patients had patients with smaller tumor sizes

compared to those diagnosed by neurosurgeons. Of those who specified their treatment setting, 60% were treated at academic institutions compared to 38% receiving treatment at private non-academic institutions. A geographical analysis of access to cancer care centers suggested that 50% and 75% of the US population live within less than 30 minutes of academic and private facilities providing cancer care, respectively.[31] This implies that although more people are likely to live close to a private institution, most of our cohort sought treatment at an academic center. Studies suggest that many baseline confounders may be present including age, socioeconomic status, ethnicity, baseline morbidity, or hospital caseloads, rendering simple comparison challenging.[32–34] Regardless, we demonstrated that this study's patients receiving care at academic and non-academic private institutions had similar eventual treatment distribution and satisfaction with this decision.

Limitations

Although great effort was taken to ensure the validity of our findings, this study relied on retrospective self-reported data and lacked a control group. Moreover, diagnosis and management may be influenced by factors and confounders beyond the scope of this study such as patients or physicians' subjective preferences, access to care, and outside influencers such as online resources or family and support groups. The patient-physician relationship and the perception of bedside manners, knowledge, and time spent can vary from case to case as well.[35] Participation bias may also play a role because ANA members active in the online community were more likely to access and spend time completing the survey. Also, it is plausible to consider that patients with either poor or excellent outcomes may be more inclined to participate. The ANA members may also be socioeconomically different than the general population of VS patients. Lastly, some of the participants completed the survey long time after their initial diagnosis and treatment, which can lead to recall bias. In addition to recall bias, this difference of range of time from diagnosis/treatment to survey participation can influence the diagnosis and treatment regimens, as the standard-of-care guidelines may be determined or changed by the time period. Regardless of these limitations, this study's large cohort and extensive questions can offer additional insight, especially from the patients' perspective.

Conclusion

We found that patients diagnosed with VS from 2007–2017 had smaller tumor sizes along with an increase in non-surgical management. Otologic symptoms were the most common presenting symptoms in VS patients and accordingly, general otolaryngologists and neurotologists diagnosed the majority of patients. Patient treatment decision was influenced the most by neurosurgeons when tumors were larger, and otolaryngologists and neurotologists when the tumor size was smaller. Though more patients sought care at an academic center, treatment decision or satisfaction was similar to private institutions.

Acknowledgement

We sincerely thank the Acoustic Neuroma Association directors and members for their participation in facilitating this study.

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Table 1.

Vestibular schwannoma patients' demographics.

Treatment modality	N (%)	Tumor size (SD) in cm	Age at diagnosis (SD)	Female sex (%)	Years since diagnosis (SD)
Surgery	414 (52.5)	2.38 (1.33)	48.6 (11.3)	285 (68.8)	8.4 (8.4)
Radiation	224 (28.4)	1.72 (1.10)	55.6 (11.1)	139 (62.1)	6.3 (5.1)
Observation	121 (15.3)	1.12 (0.88)	57.2 (10.3)	73 (60.3)	5.4 (5.1)
Surgery+Radiation	14 (1.8)	2.98 (1.31)	42.4 (13.0)	9 (64.3)	5.2 (2.9)
Undecided	16 (2.0)	1.70 (1.18)	56.9 (7.5)	11 (73.3)	3.5 (5.6)
Total	789 (100)	2.02 (1.28)	52.0 (11.8)	517 (65.5)	7.2 (7.1)

SD: standard deviation.

Table 2.

Initial specialist diagnosing vestibular schwannomas and the respective frequency, average tumor size, and the eventual treatment modality.

	Diagnosing physician					*p* values
	Otolaryngologist	**PCP**	**Neurotologist**	**Neurosurgeon**	**Neurologist**	
N (% of 749*)	**486 (61.6%)**	**85 (10.8%)**	**81 (10.2%)**	**69 (8.7%)**	**28 (3.5%)**	
Tumor size (SD)	1.94 (1.28)	2.15 (1.41)	1.72 (1.06)	2.50 (1.28)	2.21 (1.16)	0.003
Treatment modality						0.372
Surgery	253 (52.1%)	39 (45.9%)	43 (53.1%)	33 (47.8%)	18 (64.3%)	
Radiation	131 (27.0%)	24 (28.2%)	20 (24.7%)	25 (36.2%)	5 (17.9%)	
Observation	77 (15.8%)	13 (15.3%)	15 (18.6%)	5 (7.2%)	3 (10.7%)	

* 749 is the number of responders that participated in this question. Undecided and surgery plus radiation patients were excluded from treatment modality's analyses.

PCP: primary care physician, SD: standard deviation.

Table 3.

Comparison of patients diagnosed within the last 10 years versus those diagnosed prior to that regarding their tumor size and eventual treatment.

	Diagnosing window		*p* value
	2007–2017	**1979–2006**	
N (% total)	**580 (73.3%)**	**209 (26.2%)**	
Tumor size (SD)	1.87 (1.24)	2.33 (1.41)	0.013
Treatment modality			<0.001 *
Surgery	273 (47.1%)	138 (66.0%)	
Radiation	179 (30.9%)	45 (21.5%)	
Observation	100 (17.2%)	20 (9.6%)	

Undecided and surgery plus radiation patients were excluded from treatment modality's analyses.

* *p* value remained significant after adjusting for size as a potential confounder via multinomial binary logistic regression ($p < 0.001$). SD: standard deviation.