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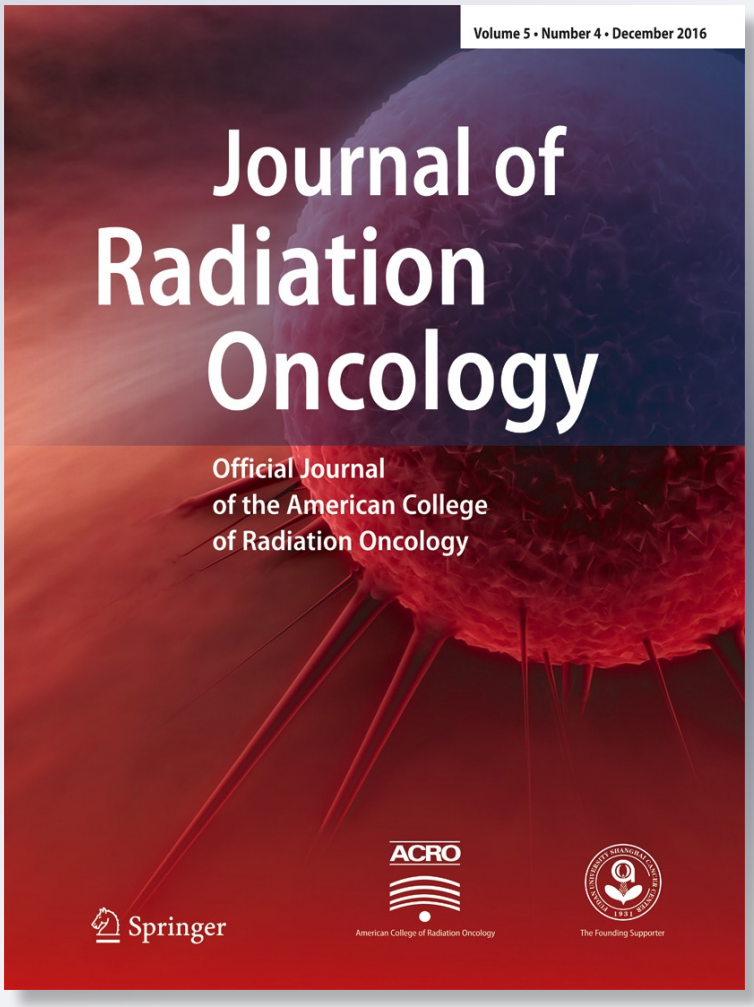

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ORIGINAL RESEARCH

Nonoperative management of acoustic neuroma in geriatric patients: a National Cancer Database analysis

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Abstract
Background and purpose The in-hospital mortality rate of surgery for acoustic neuroma (AN) is 0.5% and increases exponentially with age. There have been no studies examining the nationwide distribution of nonoperative management (radiation or observation) in the geriatric (≥ age 65) AN population.
Material and methods The National Cancer Database (NCDB) from 2004 to 2013 identified geriatric AN patients. Multivariable logistic regression adjusted for patient age, race, sex, income, geographic region, primary payer for care, tumor size, and comorbidities.
Results Of the 11,614 AN patients, 1725 (14.9%) were geriatric; median tumor size was 2.1 cm. Solitary treatment was administered as radiation (13%), observation (8.5%), and surgery (74.5%). Men (OR = 1.3, p = 0.03) and comprehensive cancer center (CCC) treatment (OR = 1.4, p = 0.02) were more likely to receive radiation. African-American race (OR = 1.5, p = 0.03) was associated with increased observation, while comorbidities (OR = 0.7, p = 0.03) were associated with decreased observation.
Conclusions Fifteen percent of the AN population is ≥ age 65, with surgery the most commonly used treatment modality. Male gender and CCC treatment independently predict receipt of radiation, while African-American race independently predicts receipt of observation. Given the proven impact of radiation on local control in AN, there is fertile ground for dissemination of radiation treatment for geriatric AN patients.

Keywords Acoustic neuroma · Geriatric · Radiation · Observation · Insurance status · National Cancer Database

Introduction

Defined as a benign tumor, an acoustic neuroma (AN) (also known as vestibular schwannoma) arises from Schwann cells, usually of the superior vestibular nerve [1]. In the USA, nearly 2500 new cases are diagnosed annually, with an overall incidence of 1/100,000 per year [2, 3]. Typically presenting with unilateral sensorineural hearing loss, tinnitus, and/or imbalance, the majority of ANs enlarge within 1–2 years of diagnosis, which can result in severe consequences due to the important structures in the vicinity of these lesions, namely the brainstem and adjacent cranial nerves [4, 5]. Comprehensive evaluation involves audiometric and vestibular testing and gadolinium-enhanced MRI [6]. Following evaluation, if AN is suspected and there are no acute signs of increased intracranial pressure (ICP) (i.e., hydrocephalus), there are four major treatment options: observation with serial MRIs, microsurgical excision, fractionated stereotactic radiotherapy (FSRT), and stereotactic radiosurgery (SRS).

The advantages of surgery for AN are immediate physical removal of the lesion and histologic confirmation of the diagnosis; in appropriately selected patients with serviceable hearing, surgery can also preserve hearing for patients treated with the middle fossa approach [7]. However, the biggest disadvantage of surgery is the operative mortality rate. While the advent of the operating microscope, multiple surgical

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approaches, and the increasing use of intraoperative monitoring have dramatically lowered postoperative mortality since the mid-twentieth century, the current in-hospital mortality rate following AN surgery is 1/200 (0.5%) [8, 9]. Furthermore, the percentage risk of in-hospital mortality following AN surgery increases exponentially with age by a factor of $[(1.07^{\text{age of patient} - \text{age of comparison patient}}) - 1] \times 100$, such that a 65-year-old patient is nearly three times (176%) more likely to die following surgery than a comparable 50 years old and nearly 5.5 times (443%) more likely to die in the hospital postoperatively than a comparable 40-year-old [9]. Finally, more than 30% of AN surgeries are performed by surgeons with an AN caseload of less than three per year; this increases in-hospital mortality by 22% compared with surgeons with an annual AN caseload of at least three [9].

Partially for these reasons, nonoperative management has gained popularity over the past decade for AN patients without acute signs of increased ICP; the nonoperative treatment modalities are radiation (FSRT or SRS) or observation [10]. However, there has been no analysis examining the utilization of these modalities in the geriatric (≥ age 65) population. This study was performed to fill this void by using a national cancer registry over a recent 10-year period.

Methods

Data source

The data source for this study was the National Cancer Database (NCDB). The NCDB is a hospital-based cancer registry sponsored jointly by the American College of Surgeons and the American Cancer Society. Comprised of more than 1400 facilities accredited by the American College of Surgeons' Commission on Cancer, the NCDB contains de-identified data on 70% of all newly diagnosed cancers in the USA [11]. The NCDB includes data on radiation therapy (i.e., dosage, technique, target) not contained in the Surveillance, Epidemiology, and End Results (SEER) database, and unlike SEER is able to distinguish single-fraction SRS from stereotactic radiotherapy [11, 12]. However, nonmalignant central nervous system tumors (such as AN) have only been included in NCDB since January 1, 2004. Consequently, this study utilized data from the most recent dataset, spanning 2004 through 2013.

Inclusion and exclusion criteria

Using the International Classification of Diseases for Oncology (ICD-O-3) codes, patients of age 65 and older with "neurilemmoma" and "neuroma" were selected using their corresponding ICD-O codes (9560 and 9570, respectively). From this group, patients were retained whose tumor primary site was listed as the "acoustic nerve," represented by ICD-O topography code of C72.4. Those patients comprised the primary cohort for this study. Any patients who did not have active follow-up information were excluded, in order to eliminate the possibility of analyzing patient data recorded from death certificates or at autopsy.

Treatment was categorized based on NCDB's site-specific surgery, radiotherapy, and radiation-surgery sequence variables. The "Radiation" group was defined as patients without microsurgery who had a radiation code indicating that radiotherapy had been performed at either a free-standing facility or a hospital inpatient radiation treatment center. The "Observation" group included all AN patients who did not receive microsurgery or radiation therapy.

Data collection

Demographic data for age, race, gender, income, geographic location, type of hospital (academic/research facility, comprehensive cancer center, community, integrated network), primary payer (Medicare, Medicaid, other government, private, no insurance), type of county (metropolitan or nonmetropolitan), education (high school graduate or not), region of the USA (East/Atlantic, Central, West), income (median household income at least $48,000 or not), medical comorbidities (the overall comorbidity burden was calculated using the Deyo comorbidity index, an adapted Charlson comorbidity index), and tumor size were analyzed in this study [13, 14].

Statistical analysis

The characteristics of patients and hospitals were summarized by descriptive statistics. Multivariable logistic regression [confidence interval (CI), odds ratio (OR), and hazard ratio (HR)] was performed to determine the effects of various patient and tumor characteristics on receipt of observation or radiation; results were expressed as mean (standard deviation, median, and range) for continuous variables and frequency (percentage) for categorical variables. Two separate multivariable analyses (Tables 2 and 3) were performed in order to determine the independent factors associated with receipt of radiation and observation for the treatment of geriatric AN. Each model controlled for age, gender, race, primary payer, income, education level, region of the USA, type of county, type of hospital, medical comorbidities, and tumor size. Significance was defined as a p value less than 0.05.

Results

Demographics of geriatric AN population

Of the 11,614 NCDB patients with AN, 1725 (14.9%) were at least 65 years of age. The mean age of these patients was 71

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Table 1 Patient demographics of geriatric (≥ age 65) acoustic neuroma population analyzed

		Number of patients	Percent
Gender	Female	929	54
	Male	796	46
Race	Black	61	4
	Other	129	7
	White	1535	89
Insurance	Government	20	1
	Medicaid	25	1
	Medicare	1371	79
	Private	253	15
	None	14	1
	Unknown	42	2
Wealthy	Income <48,000	688	40
	Income ≥48,000	1037	60
Educated	% no HSD <13%	1046	61
	% no HSD ≥13%	679	39
Metro	Population ≥250,000	1137	66
	Population <250,000 or not metro	588	34
Region	West	306	18
	Central	739	43
	East/Atlantic	680	39
Facility type	CCC	494	29
	Academic/research	1065	62
	Community	21	1
	Integrated network	145	8
Charlson/Deyo	0	1368	79
	1 or 2	357	21

HSD high school diploma, *CCC* comprehensive cancer center

(range 65–90), and 46% of patients were men. Seventy-nine percent had Medicare, 15% had private insurance, 1% had Medicaid, and 1% had other government insurance (Table 1). Two thirds of patients lived in an area with a population of at least 250,000, and 60% of patients had median household income of at least $48,000. Fewer than 40% of patients lived in a region with a relatively less educated population (at least 13% without a high school diploma). The majority of patients were treated at an academic/research facility type (62%), with 29% treated at comprehensive cancer centers, 8% treated at an integrated network, and 1% treated at community hospitals (Table 1).

The median tumor size was 2.1 cm (Table 2). One thousand two hundred eighty-five patients (74%) received surgery only, 225 patients (13%) received radiation only, and 147 patients (9%) received observation only; the remaining 68 (4%) received surgery and radiation.

Impact of patient demographics on access to nonoperative AN care in geriatric patients

Patients with private insurance (OR 0.7, 95% CI 0.5–1.0, $p = 0.005$) and comorbidities (OR 0.5, 95% CI 0.4–0.8, $p = 0.0005$) were less likely to receive radiation, while men (OR 1.3, 95% CI 1.0–1.7, $p = 0.03$) and comprehensive cancer center treatment (OR 1.4, 95% CI 1.0–1.8, $p = 0.02$) were more likely to receive radiation (Table 3). African-American race (OR 1.5, 95% CI 0.9–2.6, $p = 0.03$) predicted increased likelihood of receiving observation, while medical comorbidities (OR 0.7, 95% CI 0.5–1.0, $p = 0.03$) predicted decreased likelihood of observation as solitary treatment (Table 4).

Discussion

Previous population-based analysis of AN patients has indicated that increasing patient age is predictive of decreased use of surgery and increased likelihood of conservative management [3]. However, within the geriatric population, where surgeries carry a higher risk of mortality, there has not been an analysis of the distribution between radiation and observation management nor of the impact of patient demographics on treatment modality.

Table 2 Additional demographics of tumor size and treatment modalities utilized in the geriatric AN population

		Number	Percent
Age (years)	Range 65–90	Median 69	Mean 71
Year of diagnosis	Range 2004–2013	Median 2008	Mean 2008
Tumor size (mm)	Range 0–988	Median 21	Mean 32
Surgery	Surgery	1353	78
	No surgery or unknown	372	21
Treatment summary	Surgery only	1285	74
	Surgery and radiation	68	4
	Radiation only	225	13
	Observation only	147	9

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Table 3 Multivariate analysis regarding receipt of radiation for AN in geriatric patients

	OR	95% CI	*p* value
Female	1	–	–
Male	1.3	1.0–1.7	0.03
White	1	–	–
Black	1.1	0.6–2.2	0.48
Other	0.8	0.5–1.3	0.32
Medicare	1	–	–
Private insurance	0.7	0.5–1.0	0.005
Other	1.8	1.1–2.8	0.004
Less wealthy	1	–	–
Wealthy	0.9	0.6–1.2	0.40
Less educated	1	–	–
Educated	1.1	0.8–1.5	0.46
Not metropolitan	1	–	–
Metropolitan	1.2	0.9–1.6	0.25
East/Atlantic region	1	–	–
Central	0.7	0.5–1.0	0.15
West	0.8	0.5–1.1	0.56
Academic/research facility	1	-	-
CCC	1.4	1.0–1.8	0.02
Other	0.9	0.6–1.4	0.21
Charlson/Deyo 0	1	-	-
1 or 2	0.5	0.4–0.8	0.0005
Size	1.0	1.0–1.0	0.55

Table 4 Multivariate analysis regarding receipt of observation for AN in geriatric patients

	OR	95% CI	*p* value
Female	1	–	–
Male	1.1	0.9–1.4	0.33
White	1	–	–
Black	1.5	0.9–2.6	0.03
Other	0.6	0.4–1.0	0.01
Medicare	1	–	–
Private insurance	0.8	0.6–1.1	0.06
Other	1.4	0.9–2.2	0.06
Less wealthy	1	–	–
Wealthy	1.0	0.8–1.3	>0.99
Less educated	1	–	–
Educated	1.0	0.8–1.4	0.77
Not metropolitan	1	–	–
Metropolitan	1.1	0.8–1.4	0.57
East/Atlantic region	1	–	–
Central	0.7	0.5–0.9	0.11
West	0.7	0.5–0.9	0.18
Academic/research facility	1	–	–
CCC	1.2	0.9–1.5	0.12
Other	0.9	0.6–1.3	0.34
Charlson/Deyo 0	1	–	–
1 or 2	0.7	0.5–1.0	0.03
Size	1.0	1.0–1.0	0.58

Our findings indicate that nearly 15% of the AN population is at least 65 years of age, with surgery by far the most commonly used treatment modality despite the increased risks. Male gender and treatment at comprehensive cancer centers independently predicted receipt of radiation, while African-American race independently predicted receipt of observation. The finding that private insurance status independently predicted decreased receipt of radiation is surprising but is consistent with the fact that reimbursement can influence referral patterns and treatment decisions. This deserves further investigation.

Limitations

The limitations of this study include its retrospective nature and the possibility of incomplete/biased data reporting and/or miscoding during data submission to NCDB. Furthermore, there has been no verification that the NCDB data is representative of the AN population nationwide. While NCDB contains several important details, important aspects of outcome (local control, distant intracranial control, extracranial control, toxicities) were not available nor were other important treatment variables (volume of irradiated brain, treatment isodose lines, Karnofsky performance status); furthermore, it is not clear how patients initially treated with observation and then later treated with surgery or radiation following tumor progression were categorized in the NCDB. Another important aspect of treatment not recorded by NCDB is hearing status at presentation, since preservation of serviceable hearing (pure tone average <50 dB with speech discrimination score >50%) is viewed as an advantage of SRS over observation and some surgeries [15]. Finally, as with all AN cases involving observation or radiation, the rare possibility of a facial nerve schwannoma indistinguishable from an AN on imaging cannot be excluded.

Conclusions

In geriatric AN patients, surgery is by far the most commonly used treatment modality. For nonoperative management, African-American race independently predicts receipt of observation, while male gender and treatment at comprehensive cancer centers independently predict receipt of radiation. Given the proven impact of radiation therapy (FSRT and SRS) on local control in AN [16, 17], the relatively small proportion of geriatric patients receiving nonoperative treatment, and that postoperative mortality increases exponentially

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with age, there is fertile ground for dissemination of radiation treatment for patients age 65 and older with AN.

Compliance with ethical standards

Funding No funding support is associated with this study.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

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