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Sarcomas of the Paranasal Sinuses: An Analysis of the SEER Database

Elaine Martin, BS; Shannon Radomski, BA; Earl Harley, MD

Objective: To determine the demographics, treatment modalities, and overall survival of patients with sinonasal sarcoma.

Methods: All cases of primary sinonasal sarcomas diagnosed between the years of 2009 and 2014 were extracted from the National Cancer Institute's Surveillance, Epidemiology, and End Results database. Additional variables collected included age, gender, ethnicity, tumor histological subtype, tumor size, treatment modality, vitality status, and follow-up time. Kaplan-Meier survival curves were generated and overall survival was calculated.

Results: One hundred and four cases of sinonasal sarcoma were identified. The majority of patients were female (55%), white (76%), and non-Hispanic (84%), and the mean age was 47 ± 22 years. The most common tumor sites were the maxillary sinus, followed by the ethmoid, sphenoid, and frontal sinus. Forty six percent of tumors were rhabdomyosarcoma type. Most patients (66%) had some type of surgery, 64% received radiation, and 58% received chemotherapy as part of their treatment. Overall 1- and 5-year survival was 79% and 31%, respectively. There was no significant difference in survival based on patient gender, age, ethnicity, radiation, or chemotherapy treatment.

Conclusions: This study adds to the current literature of sinonasal sarcomas and is the first to report in detail the surgical interventions performed as well as characteristics about lymph node spread, tumor histology, and treatment outcomes since the advent of radiation and chemotherapy. As these tumors are so rare, continued study of the demographics, tumor characteristics, and long-term outcomes of this population is necessary to guide treatment modalities and strategies for otolaryngologists.

Key Words: Sarcoma, paranasal sinus neoplasms, rhabdomyosarcoma, otolaryngology, survival.

Level of Evidence: 2b

INTRODUCTION

Malignancies of the paranasal sinuses comprise less than 1% of overall malignancies, and sarcomas of the paranasal sinuses comprise only about 7% of all head and neck sarcomas.[1,2] In addition to being rare, these sarcomas have one of the worst survival rates among all head and neck sarcomas.[3] They often present insidiously, with obstructive symptoms and/or nasal discharge similar to that of chronic rhinosinusitis.[1] Resection is difficult due to their close proximity to the skull base and facial bones, although recent advances in treatment options have been made with the addition of radiation and chemotherapy regimens. The overall 5-year survival rate for sinonasal sarcomas is reported to be around 70%, with rhabdomyosarcoma having the worst survival (44%) of all histological types.[2,4,5] Grade, size, and surgical margin status, as well as increased age, male sex, rhabdomyosarcoma, and Kaposi sarcoma histology have also been identified as predictors of poor prognostic outcomes for sinonasal sarcomas.[3,6,7]

This paper explores trends in patients diagnosed with sinonasal sarcoma from 2009 to 2014 using the Surveillance, Epidemiology, and End Results (SEER) database, a large, federally funded database which provides information on cancer incidence and survival in the United States from 1973 to 2014. It currently includes approximately 28% of the US population.[8,9] The large scale of the SEER database makes it a useful resource for investigating rare cancers and reporting on survival and treatment trends. As the most recent study on this subject, published in 2012, analyzed the prognostic factors associated with sinonasal sarcoma from 1973 to 2008 using the SEER database,[7] this report will update and add to the current literature. The goal of this study is to investigate the demographics, clinical characteristics, incidence, treatment modalities, and outcomes of patients diagnosed with a sarcoma of the paranasal sinuses.

MATERIALS AND METHODS

The National Cancer Institute's SEER database provides population based information on cancer incidence, frequency, and survival data from the years 1973 to 2014. The most recent release of data from November 2016 was queried to identify all reported cases of sarcomas of the paranasal sinuses during the time period of 2009 to 2014. The query was limited to the

From the Georgetown University School of Medicine (E.M., S.R., E.H.), Washington, DC; and the Department of Otolaryngology–Head & Neck Surgery (E.H.), Georgetown University Hospital, Washington, DC.

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Send correspondence to Elaine Martin, BS, Georgetown University School of Medicine, 3900 Reservoir Rd NW, Washington DC 20007. Email: ecm102@georgetown.edu

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classification scheme for tumors of adolescents and young adults (AYA) Site Record/WHO 2008 codes for soft tissue sarcomas of the following subgroups: fibromatous neoplasm (5.1), rhabdomyosarcoma (5.2), other soft tissue sarcoma (5.3), specified soft tissue sarcoma (5.3.1), specified (excluding Kaposi sarcoma) (5.3.1.1), Kaposi sarcoma (5.3.1.2), and unspecified soft tissue sarcoma (5.3.2). The search was then limited to the following primary sites codes (based on the American Joint Committee on Cancer): maxillary sinus (C31.0), ethmoid sinus (C31.1), frontal sinus (C31.2), and sphenoid sinus (C31.3). Tumors with the primary site code of overlapping lesion of accessory sinuses (C31.8) and accessory sinus not otherwise specified (NOS) (C31.9) were excluded. Additional data extracted for each case included sex, age at diagnosis, race, ethnicity, tumor histological subtype, tumor size, tumor extension, tumor grade, tumor spread to lymph nodes, surgical treatment, radiation use and method, chemotherapy use, vital status at last follow-up, and time of last follow-up. These variables were extracted from the database by selecting the following SEER parameters during the query process: Sex, Age at Diagnosis, Race, Origin Recode NHIA (North American Association of Central Cancer Registries Hispanic/Latino Identification Algorithm), Histology Type (ICD-O-3), CS Tumor Size, CS Tumor extension, CS Lymph Nodes, Rx Summ-Surg Prim Site and Type, RX Summ-Radiation, Vital Status Recode, Grade, and Chemotherapy recode.[9,10]

The data was imported into JMP, version 13.1.0 (SAS Institute Inc., Cary, NC, USA). Tumor histological subtypes and location codes were based on the International Classification of Diseases for Oncology, Third Edition. Demographic and clinical characteristics of the cohort were analyzed using descriptive statistics. Kaplan-Meier survival curves were generated and compared using the log-rank test to elucidate survival differences between groups. A P value of $<.05$ was considered statistically significant. This study was deemed exempt from review by the Georgetown University Institutional Review Board. SEER data was accessed in compliance with the SEER Research Data user's agreement.

RESULTS

A total of 104 sarcomas of the paranasal sinuses were identified for the time period between 2009 and 2014 in the SEER database. Patient demographics are summarized in Table I. The majority of patients were female (55%), white (76%), and non-Hispanic (84%). The mean age was 47 $\pm$ 22 years. The most common tumor site was the maxillary sinus (62%), followed by the ethmoid sinus (24%), sphenoid sinus (11%), and frontal sinus (3%). Tumor histology is described in Table II. Forty-six percent of tumors were of rhabdomyosarcoma type. The most common rhabdomyosarcoma histologies were alveolar rhabdomyosarcoma (33.7%), rhabdomyosarcoma NOS (5.8%), and embryonal rhabdomyosarcoma (2.9%), followed by pleomorphic and spindle cell rhabdomyosarcomas (1.9%). The most common non-rhabdomyosarcoma histologies were sarcoma NOS (9.6%), spindle cell sarcoma (6.7%), malignant peripheral nerve sheath tumor (5.8%), giant cell sarcoma (4.8%), and malignant myoepithelioma (4.8%). Tumor characteristics such as mean size, grade, lymph node spread, and extension are listed in Table III. The mean tumor size was 4.6 $\pm$ 1.5 cm. Of patients whose tumor grade was reported in the SEER database, 50% were undifferentiated/anaplastic (grade IV), 21% were poorly differentiated (grade III), 21% were moderately differentiated (grade II), and 7% were well differentiated (grade I). Forty-six percent of all patients had unknown grade. Regarding lymph node extension, 72% of patients had no spread to lymph nodes, 15% had spread to a single positive ipsilateral lymph node, 10% had multiple positive ipsilateral lymph nodes, and 4% had positive bilateral or contralateral lymph nodes.

Among patients who were diagnosed with a tumor in the maxillary sinus, the most common tumor histology was alveolar rhabdomyosarcoma (28%), followed by sarcoma NOS (12%) and spindle cell sarcoma (9%). The mean tumor size in the maxillary sinus was 4.8 $\pm$ 1.6 cm. Of patients whose tumor characteristics were reported, the majority (77%) had no lymph node involvement, and approximately half (51%) were grade IV at the time of diagnosis. The mean age at diagnosis was 50.7 years old.

Considering patients with a sarcoma of the ethmoid sinus, the most common tumor histology was also alveolar rhabdomyosarcoma (52%), followed by malignant peripheral nerve sheath tumor (12%) and rhabdomyosarcoma NOS (8%). The mean tumor size in the ethmoid sinus was 4.2 $\pm$ 1.1 cm. Of patients whose tumor characteristics were reported, the majority (60%) had no lymph node involvement, whereas 28% had multiple positive lymph nodes. The mean age at diagnosis of patients with sarcomas of the ethmoid sinus was 44 years old.

With respect to tumors of the sphenoid sinus, the most common tumor histology was alveolar rhabdomyosarcoma (36%). The sphenoid sinus had the smallest mean tumor size at 4 $\pm$ 1 mm. In contrast to the older average age of patients diagnosed with maxillary and ethmoid tumors, the mean age at diagnosis for sphenoid sarcomas was 26.8 years old. The majority of sphenoid tumors (75%) were grade IV at the time of diagnosis.

Lastly, the tumor histology in the frontal sinus consisted of a malignant fibrous histiocytoma, malignant hemangiopericytoma, and sarcoma NOS. Of the three frontal sinus tumors identified, two were grade II and one was grade IV. The mean age at diagnosis of frontal sinus tumors was 72 years old.

Surgical, radiation, and chemotherapy treatments separated by primary site are summarized in Table IV. The majority of patients (66%) received some type of surgery as part of their treatment protocol. Most patients (64%) had beam radiation and 58% received chemotherapy. Forty-five percent of patients had radiation and chemotherapy, 39% had surgery and radiation, and 28% had surgery and chemotherapy. None of the patients with grade I tumors received chemotherapy or radiation. Of those with grade II tumors, 50% received radiation and 18% received chemotherapy. Of patients with grade III tumors, 83% received radiation and 75% received chemotherapy. Lastly, 67% of patients with grade IV tumors received radiation and 43% received chemotherapy.

Figure 1 shows the overall survival curve for all patients with paranasal sinus sarcomas. The mean follow-up time for all patients was 22 $\pm$ 17 months, and median follow-up time was 17 months. Of 104 patients,

TABLE I.
Demographic Characteristics of Patients with Paranasal Sinus Sarcomas.

	All Patients (n = 104)	Primary Site Maxillary sinus (n = 65)	Primary Site Ethmoid sinus (n = 25)	Primary Site Sphenoid sinus (n = 11)	Primary Site Frontal sinus (n = 3)
Age at diagnosis, years	47.2 ± 22.2	50.7 ± 20.8	44.0 ± 20.9	26.8 ± 21.6	72 ± 15.7
Sex					
Female	57 (55)	37 (56.9)	14 (56)	4 (36.4)	2 (66.7)
Male	47 (45)	28 (43.1)	11 (44)	7 (63.6)	1 (33.3)
Race					
White	79 (76)	47 (72.3)	20 (80)	9 (81.8)	3 (100)
Black	13 (12.5)	7 (10.8)	5 (20)	1 (9.1)	0 (0)
Asian/Pacific Islander	12 (9.8)	11 (16.9)	0 (0)	1 (9.1)	0 (0)
Ethnicity					
Hispanic	17 (16.4)	13 (20)	2 (8)	1 (9.1)	1 (33.3)
Non-Hispanic	87 (83.7)	52 (80)	23 (92)	10 (90.9)	2 (66.7)

Continuous variables expressed as mean ± standard deviation. Categorical variables expressed as number (percentage of category).

TABLE II.
Histological Subtypes of Paranasal Sinus Sarcomas by Primary Site.

	All Patients (n = 104)	Primary Site Maxillary sinus (n = 65)	Primary Site Ethmoid sinus (n = 25)	Primary Site Sphenoid sinus (n = 11)	Primary Site Frontal sinus (n = 3)
Histological Subtype					
Alveolar rhabdomyosarcoma	35 (33.7)	18 (27.7)	13 (52)	4 (36.4)	-
Sarcoma, NOS	10 (9.6)	8 (12.3)	1 (4)	-	1 (33.3)
Spindle cell sarcoma	7 (6.7)	6 (9.2)	1 (4)	-	-
Rhabdomyosarcoma, NOS	6 (5.8)	3 (4.6)	2 (8)	1 (9.1)	-
Malignant peripheral nerve sheath tumor	6 (5.8)	3 (4.6)	3 (12)	-	-
Giant cell sarcoma	5 (4.8)	4 (6.2)	-	1 (9.1)	-
Malignant myoepithelioma	5 (4.8)	4 (6.2)	1 (4)	-	-
Fibrous histiocytoma	4 (3.8)	2 (0.9)	-	1 (9.1)	1 (33.3)
Undifferentiated sarcoma	4 (3.8)	3 (4.6)	-	1 (9.1)	-
Embryonal rhabdomyosarcoma	3 (2.9)	1 (1.5)	1 (4)	1 (9.1)	-
Hemangiosarcoma	3 (2.9)	3 (4.6)	-	-	-
Fibromyxosarcoma	2 (1.9)	2 (3.1)	-	-	-
Leiomyosarcoma, NOS	2 (1.9)	1 (1.5)	1 (4)	-	-
Myofibroblastic sarcoma	2 (1.9)	2 (3.1)	-	-	-
Pleomorphic rhabdomyosarcoma	2 (1.9)	2 (3.1)	-	-	-
Spindle cell rhabdomyosarcoma	2 (1.9)	-	1 (4)	1 (9.1)	-
Desmoplastic small round cell tumor	1 (1)	-	-	1 (9.1)	-
Fibrosarcoma, NOS	1 (1)	1 (1.5)	-	-	-
Hemangiopericytoma	1 (1)	-	-	-	1 (33.3)
Kaposi sarcoma	1 (1)	1 (1.5)	-	-	-
Solitary fibrous tumor	1 (1)	-	1 (4)	-	-
Synovial sarcoma, biphasic	1 (1)	1 (1.5)	-	-	-

Categorical variables expressed as number (percentage of column).
NOS = not otherwise specified.

46 (44%) died during the follow-up period. Of the patients who died, 47% were in the 50 to 69 year age group and 24% were between 20 and 48 years old. At the time of last follow-up, 50% of patients with grade IV tumors were alive, 58% of patients with grade III tumors were alive, and 75% of patients with grade II tumors were alive.

For all patients, the overall 1-year survival was 79% and the overall 5-year survival was 31%. No significant

TABLE III.
Tumor Characteristics of Paranasal Sinus Sarcomas by Primary Site.

	All Patients (n = 104)	Primary Site Maxillary sinus (n = 65)	Primary Site Ethmoid Sinus (n = 25)	Primary Site Sphenoid Sinus (n = 11)	Primary Site Frontal Sinus (n = 3)
Tumor Grade*					
Well differentiated	4 (3.9)	3 (4.6)	1 (4.0)	0 (0)	0 (0)
Moderately differentiated	12 (11.5)	6 (9.2)	3 (12.0)	1 (9.1)	2 (66.7)
Poorly differentiated	12 (11.5)	8 (12.3)	3 (12.0)	1 (9.1)	0 (0)
Undifferentiated	28 (26.9)	18 (27.7)	3 (12.0)	6 (54.5)	1 (33.3)
Tumor size, cm†	4.6 ± 1.5	4.8 ± 1.6	4.2 ± 1.1	4.0 ± 1.0	-
CS, extension‡					
T2	11 (10.6)	6 (9,2)	3 (12.0)	2 (18.2)	0 (0)
T3	32 (30.8)	23 (35.4)	3 (12.0)	4 (36.4)	2 (66.7)
T4	9 (8.7)	0 (0)	6 (24.0)	3 (27.3)	0 (0)
T4a	13 (12.5)	12 (18.5)	1 (4.0)	0 (0)	0 (0)
T4b	37 (35.6)	23 (35.4)	12 (48.0)	1 (9.1)	1 (33.3)
CS, lymph node spread§					
No spread	74 (71.1)	47 (72.3)	15 (60.0)	9 (81.8)	3 (100)
Single positive ipsilateral regional node	15 (14.4)	10 (15.4)	3 (12.0)	2 (18.2)	0 (0)
Multiple positive ipsilateral nodes	9 (8.7)	4 (6.2)	5 (20.0)	0 (0)	0 (0)
Positive bilateral or contralateral nodes	3 (2.9)	1 (1.5)	2 (8.0)	0 (0)	0 (0)

Continuous variables expressed as mean ± standard deviation. Categorical variables expressed as number (percentage of column excluding unknown variables in each respective category).
*Unknown values excluded (n = 48, 46.2%).
†Unknown values excluded (n = 47, 45.2%).
‡Collaborative stage, version 1 (2004–2009), version 2 (2010–2014), unknown values excluded (n = 2).
§Collaborative stage, version 1 (2004–2009), version 2 (2010–2014), unknown values excluded (n = 3).

TABLE IV.
Treatment of Paranasal Sinus Sarcomas by Primary Site.

	All Patients (n = 104)	Primary Site Maxillary Sinus (n = 65)	Primary Site Ethmoid sinus (n = 25)	Primary Site Sphenoid sinus (n = 11)	Primary Site Frontal sinus (n = 3)
Surgical treatment	69 (66.4)	45 (69.2)	16 (64)	6 (54.5)	2 (66.7)
Local tumor excision	17 (16.3)	11 (16.9)	4 (16)	2 (18.2)	0 (0)
Simple/partial surgical removal	18 (17.3)	9 (13.8)	6 (24)	2 (18.2)	1 (33.3)
Total surgical removal	14 (13.5)	10 (15.4)	4 (16)	0 (0)	0 (0)
Radical surgery	11 (10.6)	10 (15.4)	0 (0)	0 (0)	1 (33.3)
Debulking	7 (6.7)	3 (4.6)	2 (8)	2 (18.2)	0 (0)
Surgery NOS	2 (1.9)	2 (3.1)	0 (0)	0 (0)	0 (0)
Radiation Treatment	67 (64.4)	40 (61.5)	18 (72)	8 (72.7)	1 (33.3)
Chemotherapy Treatment	60 (57.7)	35 (53.8)	16 (64)	9 (81.8)	0 (0)

Categorical variables expressed as number (percentage of column).
NOS = not otherwise specified.

differences were found in survival based on gender, race, age, radiation, or chemotherapy treatment. With regard to different primary sites, patients with a malignancy in the maxillary sinus had slightly longer median survival time (36 months) than the ethmoid (34 months) or sphenoid sinuses (30 months), although these differences were not statistically significant. Patients with non-rhabdomyosarcoma tumors survived somewhat longer than those with rhabdomyosarcoma tumors, however this difference was also not statistically significant (40 vs. 30 months, respectively; $P = .37$).

DISCUSSION

The SEER database allows for the study of rare malignancies, such as sinonasal sarcomas, that would otherwise be beyond the scope of individual institutional reports. Although the SEER database was used previously to study rare head and neck neoplasms,[7,11,12] to our knowledge, this report represents the most recent update on sarcomas of the paranasal sinuses. We analyzed the demographic characteristics of patients with sinonasal sarcoma and investigated the effects of recent advances in surgical, radiation, and chemotherapy treatment on patient survival.

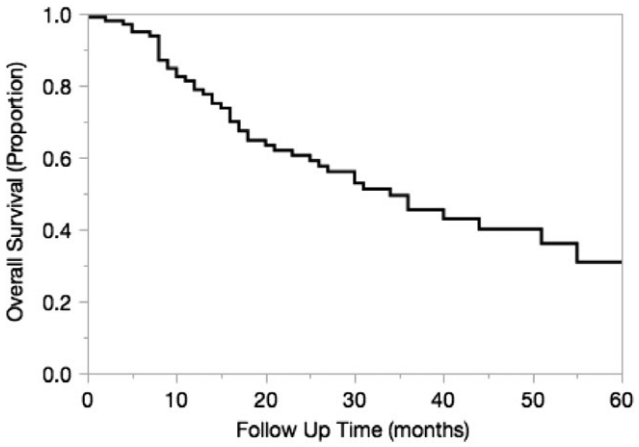

Fig. 1. Kaplan-Meier survival curve for patients with paranasal sinus sarcomas (n=104). Maximum follow up time was 60 months. The median follow up time was 17 months; 58 patients were censored.

Demographics

Despite having a smaller sample size than Wu et al., we found similar results for patient demographics and primary site locations.[7] Maxillary tumors are the most common, followed by ethmoid, sphenoid, and frontal sinus sarcomas. The majority of patients who are affected by sinonasal sarcoma are white, followed by black and other (defined as American Indian/Alaska Native, Asian/Pacific Islander). Our study found a majority of female cases (55%), however, prior studies reported a higher incidence of sinonasal sarcomas in males.[7,12]

Tumor histology is detailed more completely in this investigation than in prior studies using the SEER database. Alveolar rhabdomyosarcoma was the most common histological type, followed by sarcoma NOS, spindle cell sarcoma, malignant peripheral nerve sheath tumor, and rhabdomyosarcoma NOS. Half of patients whose tumor grade was reported had grade IV tumors, likely reflecting the long asymptomatic period of these malignancies prior to diagnosis. In comparison, a 2013 study of 167 head and neck sarcomas by Mattavelli et al. found most paranasal sarcomas to be grade III or less.[3] The majority of patients (72%) had no spread to lymph nodes, possibly indicating that late nodal spread may be a feature of sarcomas of the paranasal sinuses. Our results show that patients with maxillary sarcomas tended to be older (mean age 51 years) compared to patients with ethmoid (44 years) and sphenoid sarcomas (27 years). This observation could be further explored with larger studies in the future.

Tumor size is another characteristic not previously reported in SEER studies. Our report indicates that maxillary tumors were the largest with an average of 4.8 cm, compared to 4.2 cm in the ethmoid sinus, and 4 cm in the sphenoid sinus. This may reflect the higher capacity of the maxillary sinus, allowing for greater tumor expansion prior to becoming symptomatic. Size was found to be an independent prognostic factor for poor survival in Mattavelli et al., with most paranasal sarcomas measuring ≤ 5 cm^3.

Survival

The overall 1-year survival and 5-year survival for sarcomas of the paranasal sinuses in this study were 79% and 31%, respectively. This 5-year survival is lower than the 47% reported by Wu et al. and the 44% for nasal and paranasal sinus rhabdomyosarcomas reported by Callender et al.[5,7] This discrepancy may be due to nonstandardized reporting in the SEER database, which can result in incomplete data on a portion of patients, or the smaller sample size of this study. It is also possible that the cohort of patients in this study had more advanced tumors than those of Wu et al., leading to worse survival; however, grade or TNM staging is not mentioned in Wu et al. for comparison. Overall survival for all sarcomas of the head and neck has been reported as 66% to 70%, again illustrating the inferior outcomes of sinonasal sarcomas compared to sarcomas of the head and neck.[2,11]

Our study revealed that patients aged 20 to 48 showed the best survival, whereas Wu et al. demonstrated that patients aged <10 years old showed superior survival rates.[7] This discrepancy may be due to the fact that our study had shorter average follow-up time than Wu et al. (22 vs. 28 months, respectively) or due to the smaller sample size of this study.

We found no significant difference between male and female survival, which is consistent with prior literature with regards to tumors of the head and neck,[13,14] but inconsistent with Wu et al.'s study of paranasal sarcomas specifically, who found a significantly higher mortality rate in men.[7] Previous studies have found that tumor site did not significantly affect survival,[12,15] and our results were similar. In contrast, Wu et al. reported that sarcomas of the sphenoid sinus purveyed a significantly better prognosis than tumors of the maxillary or frontal sinus.[7]

Rhabdomyosarcoma has been demonstrated to have the worst prognosis of all head and neck sarcomas, and the head and neck is the most common site of rhabdomyosarcoma overall.[2,4,16] We observed a similar trend in our data, wherein patients with rhabdomyosarcoma survived for an average of 30 months and a those with non-rhabdomyosarcoma tumors showed a mean survival of 40 months. No other tumor histologies were found to have significantly worse survival, but the study of individual histological types was limited by the rarity of this disease and small sample sizes.

Treatment

With regards to surgical treatment, our results show that about 33% of patients had simple or local tumor excision, 24% had total or radical excision, and 34% had no surgery. The type of surgery performed as treatment for sinonasal sarcomas has not been previously reported and represents a new addition to the literature. However, the extent of radical excision was not specified in the SEER database, and whether this includes neck dissection or anterior skull base surgery is unclear.

Most patients had beam radiation (64%) and chemotherapy (58%), and 45% of patients were treated with

both. This is similar to findings by Mattavelli et al., in which 69% of patients received postoperative radiation therapy and 55% received chemotherapy.[3] Furthermore, the number of patients receiving radiation has increased from about half of patients diagnosed between 1973 to 2008 to 64% in those diagnosed from 2009 to 2014 based on the SEER database.[7] Participation in chemo- and radiation therapy was highest for patients with grade III tumors in our study and declined for those with grade IV tumors, likely reflecting the limited treatment options for advanced disease.

Importantly, we did not find any survival benefit to radiation therapy, which is consistent with prior reports from Wu et al. and Spiro et al.[7,17] The lack of benefit associated with radiation therapy may be that patients receiving radiation have worse initial prognoses or that the SEER database lacks disease-specific survival or information on locoregional control. Similarly, there was no overall survival benefit to chemotherapy. Again, this could be explained by selection bias; patients with more advanced disease may be more likely to receive chemotherapy.

There are several limitations to this study of a rare sinonasal malignancy as well as of a population-based study. The SEER database represents retrospective data collection with voluntary and at times inconsistent reporting. There is a lack of data regarding stage, grade, and disease-specific survival, and because of these limitations, it is difficult to draw conclusions about prognostic factors regarding these variables. Furthermore, sequence and site-specific details of surgical, chemotherapy, and radiation treatment are not detailed in the SEER database and would be valuable additions to this study. Lastly, while the SEER database covers 28% of the population, it includes a higher percentage of foreign born individuals (17.9%) compared to the general US population (12.8%),[8] a fact that should be taken into consideration when extrapolating this data.

CONCLUSION

Sarcomas of the paranasal sinuses are not only rare but have an extremely poor prognosis. This study adds to the current literature on these tumors and is the first to report in detail the surgical interventions performed as well as characteristics about lymph node spread, tumor histology, and treatment outcomes since the advent of radiation and chemotherapy. As these tumors are so rare, continued study of the demographics, tumor characteristics, and long-term outcomes of this population will be crucial to guide treatment modalities and strategies for otolaryngologists.

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