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Treatment and survival of patients with nonmalignant intracranial meningioma: results from the Surveillance, Epidemiology, and End Results Program of the National Cancer Institute

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Abstract

Object—The authors conducted a study to determine population-based estimates of survival following the diagnosis and treatment of nonmalignant intracranial meningioma in the US in the modern era.

Methods—Patients with nonmalignant intracranial meningioma were identified through the Surveillance, Epidemiology, and End Results (SEER) database for the years 2004–2007. Predictors of undergoing resection were identified and odds ratios calculated. Estimates of survival were calculated using Kaplan-Meier estimation method and Cox proportional hazards model.

Results—There were 12,284 patients with a diagnosis of nonmalignant intracranial meningioma included in the analysis. Only 55% had histological confirmation of the diagnosis of nonmalignant meningioma. Resection was used as an initial treatment in 43% of cases. Patients treated with surgery were more likely to be younger (OR 9.3, 95% CI 8.1–10.7, for resection in patients age 40–59 years compared with age > 80 years), male (OR 1.4, 95% CI 1.3–1.5, for males compared with females), white (OR 0.8, 95% CI 0.7–0.9, for black patients compared with white patients), and have larger tumors (OR 11.8, 95% CI 10.3–13.6, for tumors of the largest quartile compared with the smallest quartile). Patients treated with resection had a 3-year postdiagnosis survival estimate of 93.4% (95% CI 92.5%–94.3%) compared with 88.3% (95% CI 85.5%–90.6%) in patients not treated with resection ($p < 0.01$). Younger patient age, female sex, unilateral tumors, and resection were predictors of improved postdiagnosis survival after multivariate adjustment in patients with histologically confirmed meningiomas.

Conclusions—This analysis represents the first modern population-based analysis of treatment patterns and outcomes in US patients with nonmalignant intracranial meningioma. Over 85% of patients survive 3 years after diagnosis, and resection is associated with improved survival.

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This article contains some figures that are displayed in color on line but in black and white in the print edition.

Keywords

meningioma; surgery; survival; epidemiology; outcomes; SEER; oncology

MeningioMas now represent the most frequently reported primary brain tumor in the US.[4] As nonmalignant tumors have only recently begun to be formally registered, population-based information regarding the mortality rates following diagnosis and treatment of meningioma remains limited.[3,6] To date, the largest outcome study on intracranial meningioma in the US included 8891 patients in the NCDB and reported 2- and 5-year survival rates of 82% and 70.1%, respectively, for benign meningioma.[9] The role of treatment was examined in the NCDB project, which is based on data collected prior to 1992 from over 1000 US hospitals. The group reported that resection was associated with increased 5-year survival (75.1% with surgery compared with 49.9% without surgery).

Outside the US, population-based survival estimates for meningioma have been generated with data predating 1990s.[14,16,17] Nonpopulation-based data from within the US exists with the majority predominantly drawn from single-institution case series.[2,5,8,10] The passage of the Benign Brain Tumor Cancer Registries Amendment Act in 2002 (The Benign Brain Tumor Cancer Registries amendment Act, H.R. 5204) mandated the inclusion of benign intracranial tumors by the National Program of Cancer Registries.[15] As a result, the SEER program formally added nonmalignant CNS tumors to case definitions as of January 1, 2004. The aim of the current analysis was to evaluate the survival following diagnosis of nonmalignant meningioma in the US population now that follow-up data are available for a relatively large population-based cohort of patients.

Methods

Patient Identification

Patients with a diagnosis of meningioma were identified from the SEER database.[12] The SEER Program of the National Cancer Institute is a population-based tumor registry that contains data covering approximately 10%–26% of the US population depending on the year. The SEER Program added nonmalignant CNS tumors to case definitions as of January 1, 2004. Information concerning primary tumor type, patient demographics, initial cancer treatments, and survival are collected in the database.[15] Data from the most recent SEER data set from 2004–2007, ASCII text data, were used for this analysis.

Patients with a diagnosis of meningioma in the brain histology grouping variable were eligible for inclusion. This included histology codes 9530–9534 and 9537–9539. Only patients with an ICD for Oncology (ICD-O-3) behavior code of “benign” were included in the analysis. Spinal meningiomas were excluded through elimination of patients with topography codes for spinal cord (C72.0), cauda equina (C72.1), or spinal meninges (C70.9). All other intracranial primary sites were eligible for inclusion in the analysis. Individuals with more than a single primary cancer were excluded from the analysis. Likewise, patients diagnosed at death (with a reporting source of autopsy only or death certificate only) were not included in this analysis.

Age at time of diagnosis of meningioma, sex, race, and marital status were obtained from the SEER data. Age was analyzed initially as a continuous variable and then as a categorical variable for ease of data presentation with the following categories: age in years less than 20, 20–39, 40–59, 60–79, and greater than 80. Due to the small number of minority patients in the data set, race was coded for the analysis as white, black, and other. Marital status at

diagnosis was analyzed as the following 4 categories: single, married, divorced/separated/widowed, or unknown.

The size of the tumor was analyzed as categorical data based on quartiles for the largest reported dimension. The following size categories were used: 0–17, 18–27, 28–41, larger than 41 mm, and unknown size. The laterality of the tumor was analyzed as midline, left side, right side, bilateral sides, and unknown laterality. The information regarding histological confirmation of the diagnosis of meningioma and initial treatments were included.

Outcomes

The primary outcome for this study was postdiagnosis survival time. The date of death or censoring was obtained from the SEER data set. The initial analysis included descriptive statistics of clinical and demographic information using means, proportions, and standard deviations. Predictors of undergoing surgical treatment com pared with observation were identified and odds ratios calculated. One- and 3-year estimates of survival and 95% CIs were calculated using the Kaplan-Meier method. The effect of clinical and demographic covariates on the timing of the outcome was estimated using a Cox proportional hazards model. Separate analyses were performed for patients with and without histological confirmation of the diagnosis of meningioma. Hazard ratios were estimated with 95% CIs. All variables found to be significant at $p = 0.10$ in unadjusted analyses were included in multivariate analyses. Statistical significance was defined as a Type 1 error < 5%. All analyses were 2 sided and performed using SAS version 9.2 (SAS Institute).

Results

There were 15,259 patients with a diagnosis of benign, nonspinal meningioma identified in the SEER data set. There were 2819 patients excluded with more than a single primary cancer type and 156 patients excluded with a diagnosis of meningioma after death. The final study cohort included 12,284 patients. Of this cohort, histological confirmation of the diagnosis of meningioma was established in 55% (6737) of the patients. The remaining 45% (5547) of the patients had clinical and radiographic diagnoses only. Table 1 displays the descriptive clinical and demographic variables for the entire study cohort. The mean age at diagnosis of meningioma was 62 years ± 16 years (SD). The majority of patients were female (75%) and white (79%), with 53% of the patients married at the time of diagnosis. The interquartile range for maximal size of the tumor was 18–41 mm, although in 28% of patients tumor size data were not recorded. The majority of tumors were unilateral—43% left sided and 44% right sided. The location of the lesion was classified as “cerebral meninges” in 98% of cases, “brain” in 2%, and “cranial nerves” or “endocrine glands” in less than 1% of cases. Initial treatments included gross-total resection in 34%, subtotal resection in 9%, biopsy in 7%, and neither resection nor biopsy in 47% of patients. Radiation therapy was administered in 9% of patients.

There were significant differences in the clinical and demographic data in the patients who underwent resection (partial or complete) compared with those who underwent conservative management (biopsy or no surgical intervention). The predictors associated with undergoing resection are listed in Table 2. Increased odds of undergoing resection was associated with younger age, male sex, increasing tumor size, and lateral compared with midline tumors. Compared with patients older than age 80 years, those in the 40–59 age group had a 9-fold increase in the odds of undergoing resection (OR 9.3, 95% CI 8.1–10.7), whereas patients in the 20–39 age group had a 12-fold increase in the odds of undergoing resection (OR 12.5, 95% CI 10.4–14.9). Male patients were more likely to undergo resection than female patients (OR 1.4, 95% CI 1.3–1.5, for male vs female). The patient’s race was also

associated with the likelihood of undergoing resection, with black patients less likely to undergo resection than white patients (OR 0.8, 95% CI 0.7–0.9), although there was no difference between white patients and patients classified as other races. Marital status at the time of diagnosis was also associated with the treatment received. Divorced, widowed, or separated patients had lower chance of undergoing resection than married patients (OR 0.4, 95% CI 0.4–0.5). The odds of undergoing resection also increased with each quartile of tumor size. Tumors with a diameter equal to or greater than 42 mm were associated with an OR of 11.8 (95% CI 10.3–13.6) for resection compared with tumors less than 17 mm in diameter. Finally, patients who underwent radiation therapy had approximately half the odds of undergoing resection (OR 0.5, 95% CI 0.4–0.6) as those who did not undergo radiation therapy.

Overall survival after diagnosis of meningioma was analyzed separately for those patients with histological confirmation of the diagnosis and those without confirmation. For patients with a confirmed diagnosis (6737), the 1- and 3-year survival estimates were 95.4% (95% CI 94.8%–95.9%) and 92.4% (95% CI 91.5%–93.1%), respectively. For patients without histological confirmation (5547 cases), the 1- and 3-year survival estimates were 86.8% (95% CI 85.8%–87.7%) and 76.7% (95% CI 75.2%–78.2%), respectively. Figure 1 contains the Kaplan-Meier survival estimates according to histological confirmation of the diagnosis. There was a significant difference in the overall postdiagnosis survival ($p < 0.01$, log-rank test) in these 2 groups.

In cases involving a confirmed diagnosis of meningioma, postdiagnosis survival was evaluated in 5370 patients who underwent resection and compared with 1270 patients who underwent biopsy or no surgical intervention. Figure 2 contains the Kaplan-Meier survival estimates for these patients. There was a significant increase in overall survival associated with resection ($p < 0.01$, log-rank test). The estimated 3-year survival was lower in patients who underwent biopsy or no resection (88.3%, 95% CI 85.5%–90.6%) than in patients treated with resection (93.4%, 95% CI 92.5%–94.3%). The survival estimates for the patients with unknown data regarding type of treatment received are also shown in Fig. 2.

Univariate and multivariate Cox regression models were evaluated to determine the association of clinical and demographic variables with postdiagnosis survival. Separate models were used for patients with and without histological confirmation of a meningioma diagnosis. The unadjusted and adjusted hazard ratios with the 95% CIs associated with the variables are listed in Table 3. For patients with histological confirmation, on unadjusted analyses, increased hazard ratios for postoperative death were associated with male sex (HR 1.50, 95% CI 1.21–1.83), marital status of divorced/widowed/separated compared with single (HR 2.20, 95% CI 1.61–3.01), and larger tumor size (HR 1.72, 95% CI 1.05–2.83) for 42 mm or greater compared with tumors smaller than 17 mm. A decreased hazards ratio for postoperative death was associated with all age groups when compared with the 80 and older age group, unilateral compared with midline tumors (HR 0.52, 95% 0.38–0.69, for left compared with midline, and HR 0.47, 95% CI 0.35–0.64, for right compared with midline tumors), and for resection compared with biopsy or no surgical intervention (HR 0.61, 95% CI 0.48–0.76).

After multivariate adjustment, resection remained associated with a decreased hazards ratio for death compared with no surgery/biopsy (HR 0.75, 95% CI 0.59–0.95). Decreasing patient age as well as unilateral compared with midline tumors also remained associated with decreased hazard ratios for death. Male sex remained associated with an increased hazard ratio for death (HR 1.50, 95% CI 1.20–1.85). Size of the tumor and marital status were no longer significantly associated with the hazards ratio after multivariate adjustment.

For patients without histological confirmation, on unadjusted analyses, young age at diagnosis was also associated with a reduced hazard for postdiagnosis death. Likewise, the patients who underwent radiation treatment had lower death hazards compared with those that did not under radiation treatment (HR 0.30, 95% CI 0.22–0.41). An increase in death hazards was associated with male gender (HR 1.30, 95% CI 1.12–1.50), black compared with white race (HR 1.30, 95% CI 1.08–1.57), as well as increasing quartile of tumor size (HR 4.39, 95% CI 3.53–5.46 for tumors 42 mm or greater compared with tumors less than 17 mm). Married patients had lower death hazards compared with single patients (HR 0.68, 95% CI 0.54–0.85), while divorced, widowed, or separated patients had increased death hazards compared with single patients (HR 1.72, 95% CI 1.40–2.12).

Similar results were obtained after multivariate adjustment. Decreasing patient age and radiation treatment remained associated with decreased hazards for postdiagnosis death (HR 0.46, 95% CI 0.33–0.64, for radiation treatment). Male sex (HR 1.54, 95% CI 1.31–1.80), black compared with white individuals (HR 1.30, 95% CI 1.08–1.57), and increasing quartile of tumor size remained associated with increased risk of death hazards. Married patients also had decreased death risk compared with single patients (HR 0.64, 95% CI 0.51–0.80); however, divorced, widowed, or separated patients no longer had increased risk of death compared with single patients.

Finally, 1- and 3-year estimates of postdiagnosis survival times were calculated for patients with confirmed meningioma according to sex and surgical treatment. As shown in Table 4, the 1- and 3-year survival estimates for all tumor sizes treated with resection were greater than 90%. For patients treated without resection, the survival estimates decreased, with nonsurgically treated male patients having the lowest overall survival.

Discussion

Commencing in January of 2004, benign intracranial tumors were included in the SEER registry as a result of the Benign Brain Tumor Cancer Registries Amendment Act. This report represents the first modern population-based analysis of trends and outcomes for over 12,000 US patients with intracranial meningioma using the SEER data set. As such, this analysis provides data specific to the US population that were previously unavailable and may be more generalizable than previously published single-center or single-surgeon case series.

There were several notable findings from this analysis. First, 45% of patients in the SEER registry with a diagnosis of meningioma have histological confirmation of the diagnosis. Given that these radiographic diagnoses may have included tumors other than nonmalignant meningioma, these patients were considered separately for the survival analyses in this study. For patients in whom the diagnosis of nonmalignant meningioma was histologically confirmed, the overall postdiagnosis 1- and 3-year survival estimates were 95.4% and 92.4%, respectively. Patients who underwent resection had significantly increased overall survival than patients treated without resection. This finding of increased survival in resection-treated patients is consistent with the findings of the NCDB, in which a 5-year survival of 75.1% was estimated for patients who underwent resection compared with a 49.9% estimate in patients who did not undergo surgery.[9] Although exact estimates were not provided for 1- and 3-year time points in the NCDB analysis, it appears that the survival rates from the current report are markedly higher, possibly representing a trend of improved outcomes since the 1980s.

Our analysis also identified clinical and demographic factors that are associated with selection for meningioma resection. As might be expected based on prior reports of

increased surgical morbidity and mortality rates in the elderly, the age of the patient was strongly associated with treatment with resection.[1,13] Younger patients had up to 15 times the odds ratio of undergoing resection than elderly patients. Interestingly, the sex and race of the patient were also associated with differences in the utilization of surgical treatment. Male patients were more likely than female patients to undergo resection. This finding is interesting given the noted 2-fold increase in meningioma prevalence for women and the fact that survival rates in women were higher than those in men. It is possible that this may be related to differences in age and tumor size at diagnosis that influenced selection for surgery (although these variables were controlled for in analyses). A higher percentage of male patients presented with tumors of the largest quartile than females (24% of males had tumors ≥ 42 mm compared with only 15% of females), whereas females had a higher percentage of individuals older than age 80 years at presentation (18% for females, 14% for males). Likewise, black patients were less likely to undergo resection than white patients. There were no obvious explanations for this finding because there were no differences in tumor size at diagnosis between white and black patients, and a larger percentage of white patients were of age 80 or greater (18% for white patients, 14% for black patients). As such, it is possible that this finding may be related to other factors such as variable access to health care in black patients compared with white patients, a finding that has been reported and explored for other brain tumors.[11]

The size and location of the meningioma were also significantly associated with the likelihood of undergoing resection as well as postdiagnosis survival. The smallest quartile of tumors (< 17 mm in diameter) represented 6% of surgically treated lesions compared with 30% of tumors that were not resected. Likewise, the largest quartile of meningiomas (≥ 42 mm in diameter) represented 28% of surgically treated tumors compared with 9% of tumors that were not resected. Interestingly, despite the increased likelihood of resection for larger tumors, there was no effect of tumor size on the adjusted death risk in patients with a confirmed meningioma diagnosis. Additionally, unilateral, nonmidline tumors were associated with decreased risk of postdiagnosis death, likely in part due to the involvement of venous sinuses in midline tumors. In prior analyses, tumor size and location has not been uniformly included in outcome analyses. In a single-institution series from the 1980s, tumors located in sites that allowed for complete excision were associated with increased probability of survival-free recurrence, although size was not analyzed.[10] In another large single-institution series of 342 patients with benign meningiomas, lesion size was not associated with recurrence rates or survival, but in the NCDB lesion size was an independent predictor of mortality in multivariate analyses.[7,9]

There are several limitations of this analysis that must be considered when interpreting this our findings. First, the SEER data set only provides information on the first course of treatments for the tumor. Therefore, it is not possible to obtain information about tumor recurrence and subsequent treatments that may be important factors in long-term survival. Data on chemotherapy are not included, although it is extremely rare for a benign meningioma to be treated with such therapy after the initial diagnosis and, hence, is not likely of significant importance in these analyses. Second, there is very limited clinical information about the patients other than the details of the tumor. As such, it is not possible to stratify for medical comorbidites that may be important in the selection of a treatment strategy or overall survival. Additionally, our study involved a retrospective analysis and as such is subject to unbalanced confounders that may influence outcomes such as survival. Multivariate adjustment was used to help address this concern, but only limited clinical information is provided in the data set, and it is likely that there are important differences between patients selected for surgery that are not evident in the SEER data. Furthermore, given that this analysis is based on data obtained from coded clinical information derived from numerous sites, the potential for inaccurate coding exists. Finally, no details of the

facility or provider of treatment are given for analysis. It is possible that treatment patterns and outcomes are influenced by the center providing care, and these factors could not be evaluated in this analysis.

Conclusions

This analysis represents the first modern population-based analysis of treatment patterns and outcomes in US patients with nonmalignant intracranial meningioma. We demonstrated that over 85% of patients survive 3 years after diagnosis and that resection is associated with improved survival. There also appear to be differences in the selection of patients for resection based on age, sex, race, and clinical features of the meningioma. We anticipate that these data will provide generalizable information useful to clinicians treating patients with nonmalignant intracranial meningiomas.

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Abbreviations used in this paper

NCDB	National Cancer Database
SEER	Surveillance, Epidemiology, and End Results

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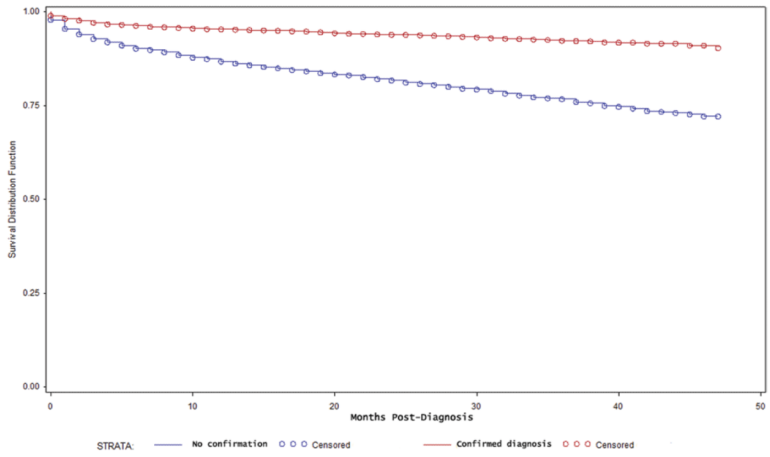

Fig. 1.

Kaplan-Meier survival estimate for patients with a histological confirmation of the diagnosis of nonmalignant meningioma *(red)* and without a histological confirmation *(blue)*. Survival is displayed as months postdiagnosis.

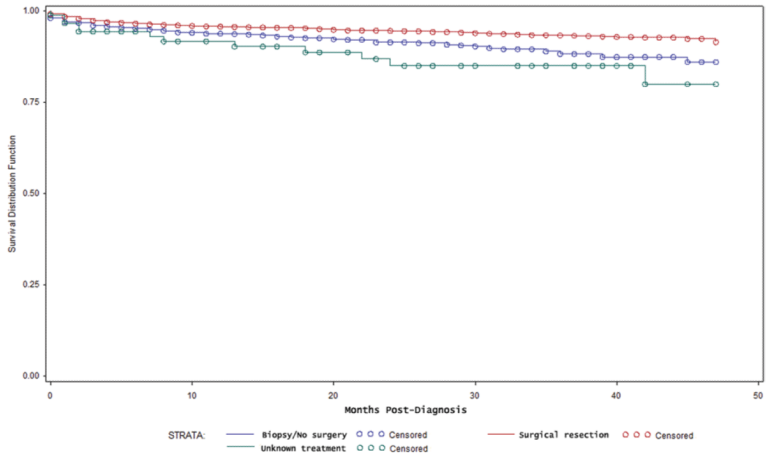

Fig. 2.

Kaplan-Meier survival estimate for patients with histologically confirmed meningioma according to type of treatment received: resection *(red)*, biopsy/no resection *(blue)*, unknown treatment *(green)* ($p < 0.01$, log-rank test). Survival is displayed as months postdiagnosis.

TABLE 1

Demographic and clinical profile of 12,284 patients with a diagnosis of nonmalignant intracranial meningioma in the SEER database from 2004–2007 included in the study cohort

Variable	Percentage/Value (no. of patients)
age category (yrs)	
<20	0.5% (56)
20–39	8% (930)
40–59	37% (4505)
60–79	38% (4661)
≥80	17% (2132)
mean age at diagnosis (yrs)	62 ± 16
sex	
male	25.0% (3077)
female	75.0% (9207)
race	
white	79% (9728)
black	11% (1346)
other	10% (1210)
marital status	
single	16% (1913)
married	53% (6538)
divorced/widowed/separated	26% (3218)
unknown	5% (615)
year of diagnosis	
2004	23% (2861)
2005	25% (3108)
2006	26% (3181)
2007	26% (3134)
histology	
tissue diagnosis	55% (6737)
radiographic diagnosis	45% (5547)
size of tumor (quartile)	
<17 mm	19% (2356)
18–27 mm	17% (2129)
28–41 mm	17% (2147)
≥42 mm	18% (2152)
unknown	28% (3500)
side of tumor	
midline	10% (1184)
left	43% (5300)
right	44% (5401)
bilateral	2% (278)

Variable	Percentage/Value (no. of patients)
unknown	1% (121)
surgical treatment	
total resection	34% (4222)
partial resection	9% (1151)
biopsy	7% (868)
no surgery or biopsy	47% (5812)
unknown	2% (231)
radiation treatment	
any radiation	8.9% (1088)
no radiation	90.2% (11082)
unknown	1.0% (114)

TABLE 2

Demographic and clinical predictors of undergoing surgical treatment for nonmalignant intracranial meningioma in 12,053*

Variable	Surgical Treatment (partial or total)	Observation (biopsy or no surgery)	OR for Resection (95% CI)
age category			
less than 20	<1% (34)	<1% (21)	**10.5 (6.1–18.1)**
20–39	11% (614)	5% (305)	**12.5 (10.4–14.9)**
40–59	48% (2579)	28% (1841)	**9.3 (8.1–10.7)**
60–79	35% (1901)	40% (2660)	**5.0 (4.3–5.7)**
≥80	5% (245)	28% (1853)	reference
sex			
male	50% (1526)	50% (1497)	**1.4 (1.3–1.5)**
female	43% (3847)	58% (5251)	reference
race			
white	45% (4302)	55% (5299)	reference
black	38% (509)	62% (815)	**0.8 (0.7–0.9)**
other	47% (562)	53% (634)	1.1 (1.0–1.2)
marital status			
single	50% (947)	50% (939)	reference
married	51% (3274)	49% (3174)	1.0 (0.9–1.1)
divorced/widowed/separated	30% (953)	70% (2235)	**0.4 (0.4–0.5)**
unknown	33% (199)	67% (400)	**0.6 (0.5–0.7)**
year of diagnosis			
2004	46% (1287)	54% (1537)	**1.3 (1.2–1.4)**
2005	47% (1442)	53% (1623)	**1.4 (1.2–1.5)**
2006	45% (1415)	55% (1721)	**1.3 (1.1–1.4)**
2007	40% (1229)	60% (1867)	reference
size of tumor (quartile)			
<17 mm	6% (322)	30% (1976)	reference
18–27 mm	12% (660)	22% (1443)	**2.4 (2.1–2.8)**
28–41 mm	22% (1173)	14% (940)	**6.4 (5.6–7.4)**
≥42 mm	28% (1531)	9% (598)	**11.8 (10.3–13.6)**

Variable	Surgical Treatment (partial or total)	Observation (biopsy or no surgery)	OR for Resection (95% CI)
unknown	31% (1687)	26% (1723)	**5.3 (4.7–6.0)**
side of tumor			
midline	38% (438)	62% (719)	reference
left	45% (2348)	55% (2891)	1.1 (0.9–1.3)
right	45% (2389)	45% (2934)	**1.4 (1.0–1.3)**
bilateral	57% (157)	43% (117)	**1.8 (1.4–2.3)**
unknown	35% (41)	65% (77)	0.8 (0.6–1.2)
radiation treatment			
any radiation	6% (313)	11% (767)	**0.5 (0.4–0.6)**
no radiation	94% (5025)	88% (5954)	reference
unknown	<1% (35)	<1% (27)	1.5 (0.9–2.5)

[*] Two hundred thirty-one patients with unknown surgical treatment information were not included. Bolded values indicate statistical significance ($p < 0.05$). Reference = reference group used to calculate the odds ratio.

TABLE 3

Univariate and multivariate Cox regression model analysis of clinical and demographic factors associated with postdiagnosis death hazards*

Variable	Hazard Ratio	
	Unadjusted (95% CI)	Adjusted (95% CI)
histologically confirmed diagnosis		
age category (yrs)		
<20	**0.06 (0.01–0.46)**	**0.05 (0.01–0.39)**
20–39	**0.04 (0.02–0.07)**	**0.04 (0.02–0.08)**
40–59	**0.07 (0.06–0.10)**	**0.08 (0.06–0.11)**
60–79	**0.22 (0.17–0.28)**	**0.23 (0.18–0.30)**
≥80	reference	reference
sex		
male	**1.50 (1.21–1.83)**	**1.50 (1.20–1.85)**
female	reference	reference
race		
white	reference	
black	1.31 (0.97–1.77)	NS
other	0.80 (0.55–1.17)	NS
marital status		
single	reference	reference
married	0.92 (0.68–1.23)	0.76 (0.56–1.03)
divorced/widowed/ separated	**2.20 (1.61–3.01)**	1.13 (0.81–1.57)
unknown	**1.86 (1.18–3.02)**	1.26 (0.78–2.03)
year of diagnosis		
2004	1.45 (1.03–2.03)	**1.49 (1.06–2.09)**
2005	0.99 (0.70–1.42)	1.05 (0.74–1.50)
2006	1.02 (0.71–1.46)	1.03 (0.72–1.48)
2007	reference	reference
size of tumor (quartile)		
<17 mm	reference	reference
18–27 mm	0.75 (0.41–1.37)	0.71 (0.39–1.30)
28–41 mm	1.32 (0.79–2.21)	1.03 (0.61–1.73)
≥42 mm	**1.72 (1.05–2.83)**	1.29 (0.78–2.14)
unknown	**1.67 (1.02–2.73)**	1.37 (0.83–2.25)
side of tumor		
midline	reference	reference
left	**0.52 (0.38–0.69)**	**0.48 (0.36–0.66)**
right	**0.47 (0.35–0.64)**	**0.45 (0.33–0.60)**
bilateral	1.37 (0.86–2.18)	1.28 (0.80–2.06)
unknown	0.32 (0.08–1.31)	0.29 (0.07–1.18)

Variable	Hazard Ratio	
	Unadjusted (95% CI)	Adjusted (95% CI)
treatment		
radiation	0.70 (0.44–1.12)	NS
no radiation	reference	NS
unknown	0.32 (0.04–2.28)	NS
surgical treatment		
partial/total resection	**0.61 (0.48–0.76)**	**0.75 (0.59–0.95)**
none/biopsy	reference	reference
unknown	1.50 (0.83–2.73)	1.09 (0.59–2.02)
unconfirmed diagnosis		
age category		
<20	**0.00 (0.00–0.00)**	**0.00 (0.00–0.00)**
20–39	**0.05 (0.02–0.13)**	**0.5 (0.2–0.15)**
40–59	**0.08 (0.06–0.11)**	**0.11 (0.8–0.15)**
60–79	**0.29 (0.25–0.34)**	**0.34 (0.30–0.40)**
≥80	reference	reference
sex		
male	**1.3 (1.12–1.50)**	**1.54 (1.31–1.80)**
female	reference	reference
race		
white	reference	reference
black	**1.23 (1.03–1.50)**	**1.30 (1.08–1.57)**
other	0.83 (0.65–1.05)	1.02 (0.79–1.30)
marital status		
single	reference	reference
married	**0.68 (0.54–0.85)**	**0.64 (0.51–0.80)**
divorced/widowed/ separated	**1.72 (1.40–2.12)**	0.96 (0.77–1.20)
unknown	0.92 (0.65–1.30)	0.77 (0.54–1.10)
year of diagnosis		
2004	1.67 (0.93–1.47)	NS
2005	1.03 (0.81–1.29)	NS
2006	1.14 (0.91–1.43)	NS
2007	reference	NS
size of tumor (quartile)		
<17 mm	reference	reference
18–27 mm	**1.39 (1.06–1.58)**	1.17 (0.96–1.43)
28–41 mm	**2.33 (1.90–2.84)**	**1.80 (1.46–2.20)**
≥42 mm	**4.39 (3.53–5.46)**	**3.28 (2.63–4.09)**
unknown	**1.59 (1.32–1.91)**	**1.51 (1.26–1.83)**
side of tumor		
midline	reference	NS

Variable	Hazard Ratio	
	Unadjusted (95% CI)	Adjusted (95% CI)
left	1.10 (0.89–1.38)	NS
right	0.92 (0.74–1.51)	NS
bilateral	1.29 (0.79–2.10)	NS
unknown	1.13 (0.64–2.02)	NS
treatment		
radiation	**0.30 (0.22–0.41)**	**0.46 (0.33–0.64)**
no radiation	reference	reference
unknown	0.72 (0.37–1.38)	1.75 (0.65–4.69)

* NS = not significant. Bolded values indicate statistical significance ($p < 0.05$). Reference = reference group used to calculate the hazard ratio.

TABLE 4

One-year and 3-year survival estimates of survival according to sex and surgical treatment for patients with a confirmed diagnosis of nonmalignant intracranial meningioma

Treatment	No. of Patients	1-Year Survival (95% CI)	3-Year Survival (95% CI)
female patients			
resection	3844	96.4% (95.7%–96.9%)	94.0% (92.9%–94.8%)
no resection	937	94.1% (92.2%–95.5%)	91.1% (88.4%–93.2%)
male patients			
resection	1526	94.2% (92.8%–95.3%)	91.8% (89.9%–93.4%)
no resection	335	93.3% (89.7%–95.6%)	81.1% (73.7%–86.5%)