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Factors Influencing Outcome in Meningioma Surgery

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Introduction

The overall incidence of meningiomas is increasing due to a widespread use of improved neuroimaging techniques for closed head injuries, nonspecific neurologic symptoms (such as headache and dizziness), or paranasal sinus problems. In addition, the aging population is growing. Therefore, neurosurgeons are increasingly experiencing management dilemmas for certain group of patients such as those with incidental meningiomas in all age groups, patients with significant comorbidities, young patients with small tumors, elderly patients with large tumors, and elderly patients with mild symptoms.

For any given disease, the treatment and when it should be administered are determined by the following three factors: (1) a thorough knowledge of the natural history of the disease, (2) benefits of the treatment, and (3) risks of the particular treatment.

Natural History of Meningiomas

The natural history of meningiomas, the knowledge of which is critical in formulating management plans, is poorly understood. The majority of the limited literature on meningiomas' natural history focuses on the elderly population, which results in a significant selection bias. In general, the sample sizes in these studies are relatively small, and the follow-up period is short. In addition, there is a considerable variability in the growth rates among meningiomas.

Kuratsu and colleagues reviewed the incidence and clinical features of asymptomatic meningiomas [1]. They defined 196 patients (39% of their series) as asymptomatic in their series. The incidence was significantly higher in patients over the age of 70. Of these, 63 were conservatively treated and had a follow-up of more than 1 year. Tumor growth was detected in 32% of these patients with an average follow-up of 28 months. Patients with calcification on computed tomography (CT) and/or with hypointensity on T2-weighted magnetic resonance imaging (MRI) appeared to grow at a slower rate. In the series of Yoneoka and colleagues, 24% of the 37 patients with incidental meningiomas showed growth during a mean follow-up of 4 years [2]. They found that younger patients and a larger initial tumor size increased the incidence of tumor growth. The study of Nakamura and colleagues revealed similar findings [3]. In their series of 41 patients with incidental meningiomas, who were managed conservatively, the mean absolute and relative annual growth rates were reported as 0.8 cc and 14.6%, respectively. They also found that these values were higher in younger patients, but their data did not show any correlation with the initial size of the tumor. In this study, when patients were followed for up to 8 years, all incidental meningiomas showed some growth. Olivero and colleagues looked at the growth pattern of 45 patients with incidental meningiomas [4]. Of these patients 22% showed growth, with an average follow-up of 29 months for the stable group and 47 months for the group that showed growth. Their average annual tumor growth rate was 0.24 cc. Niiro and colleagues analyzed their series of 40 patients who were over the age of 70 and had incidental meningiomas with an average follow-up of 38 months [5]. In their series the incidence of tumor growth was 35%. They found that presence of calcification on imaging studies lowered the incidence of growth, whereas a larger tumor size was an unfavorable factor. Nakasu and colleagues analyzed the changes of growth pattern in meningiomas in 31 tumors with a median follow-up of 10 years [6]. They found that atypical meningiomas showed an exponential tumor growth, whereas benign meningiomas were likely to show either exponential or linear growth or no growth. No growth was correlated with the presence of calcification.

It is important to note that the incidence of tumor growth increases in studies with a longer follow-up. Bindal and colleagues reviewed their series of 40 patients with skull base meningiomas whose tumors were managed conservatively [7]. Mean follow-up was 76 months. Tumor growth was detected in none at 1-year, 3% at 2-year, 20% at 5-year, and 58% at 10-year follow-ups. Van Havenbergh and colleagues analyzed their series of 21 patients with conservatively managed

petroclival meningiomas [8]. In this study, the average follow-up was 82 months. Tumor growth was detected in 76% of patients, 63% of which was associated with functional deterioration. Jung and colleagues looked at the long-term growth rates of subtotally resected petroclival meningiomas [9]. With an average follow-up of 48 months, they detected the progression-free survival period and 5-year progression-free survival rate as 66 months and 60%, respectively. The annual growth rate of the residual tumor was 5 cc.

Benefits of Meningioma Surgery

Benefits of meningioma surgery are not as readily quantifiable as risks. However, there are two basic benefits of meningioma surgery, which are conceptual in nature: (1) alteration of the natural history, with a chance to cure when Simpson grade 1 resection is performed, and (2) reversal or improvement of neurologic signs and deficits.

In this context, we consider the tumor size and neurologic signs/symptoms as benefit factors for the patient. The larger the tumor, the greater is the benefit for the patient following surgery. Similarly, when the patient presents with neurologic signs and symptoms, there is a potential for reversal, improvement, or stabilization of symptoms following surgery. The more severe or reversible the symptoms are, the greater the benefit would be for the patient.

Risk Factors in the Surgical Management of Meningiomas

Similar to the reports on the natural history of meningiomas, the majority of the studies on the surgical outcome of meningiomas and assessment of risk factors also focus on the elderly population. Meixensberger and colleagues reviewed their results of 385 patients with intracranial meningiomas and analyzed the factors influencing the outcome [10]. Among the factors that are known to the surgeon preoperatively, age, preoperative co-morbidity as assessed by the American Society of Anesthesiology (ASA) score [18], and medial sphenoid wing location were found to be related to an unfavorable outcome. McCarthy and colleagues used the 9827 meningioma cases from the National Cancer Database [11]. In that study, they looked at factors associated with survival in patients with meningiomas. The factors which influenced the 5-year survival, and which were available to the surgeon to guide in the preoperative decision-making process, were tumor size and patient age. Buhl and colleagues reviewed their series of 66 patients over the age of 70 [12]. Their results suggested that tumor location (convexity), lack of significant medical co-morbidity, and smaller tumor size along with less peritumoral edema were associated with a more favorable outcome. Cornu and colleagues also found the preoperative ASA and Karnofsky scores as well as skull base or posterior fossa location as unfavorable factors affecting outcome in this age group [13]. Caroli and colleagues developed a scale to predict the outcome in the elderly population using clinical and radiologic data [14]. In the literature, the data on the outcome of meningioma surgery in the elderly population are controversial. For example, the study of D'Andrea and colleagues suggest that surgery in this group of patients is relatively safe when their preoperative ASA score and overall Karnofsky score are favorable [15]. On the contrary, the review of the Nationwide Patient Sample Database by Bateman and colleagues suggests caution when considering surgery in the elderly patients with meningiomas [16].

In general, the most common factors associated with outcome following meningioma surgery include the co-morbidity and age of the patient, size and location of the tumor, and the presence and severity of neurological signs and symptoms. However, there is ambiguity regarding what constitutes a "significant" co-morbidity, a "complex" location, "old" age, "large" size, or which signs or symptoms are "significant." Therefore, the current surgical decision-making process is more "art" than "science," based on the surgeon's "gut feeling" due to the lack of systematic evidence-based guideline.

Risk Factors in Personal Series

In light of the limited information available in the literature, we decided to analyze a single surgeon's (senior author) experience to determine the factors (such as co-morbidity, location, age, size, symptoms) influencing the outcome of patients undergoing surgery for intracranial meningiomas. In addition, we included the history of previous surgery at the same operative site, as well as radiation treatment in the analysis. A retrospective analysis was performed on 300 consecutive patients who had resection of intracranial meningioma by the senior author between January 2000 and December 2004. This group represents the second half of the approximately 600 patients treated surgically by the senior author, and this latter group was selected for analysis to remove the effect of the learning curve in the surgical outcome of meningioma patients. Outcome at 6 weeks was assessed using the Glasgow Outcome Scale (GOS) [17]. A GOS of 4 and 5 were accepted as favorable outcome. Postoperative neurologic and medical morbidities were also recorded.

Results

There were 69 males and 231 females with an average age of 55 (range 23–83). There were 126 patients (42%) in the ASA I, 144 (48%) in the ASA II and 30 patients (10%) in the ASA III groups. The tumor was in the "low-risk"/simple location in 94 patients (31.3%), "moderate-risk" in 115 (38.4%), and "high-risk" in 91 patients (30.3%). Age was 60 or below in 187 patients (62.3%), 61–70 in 69 (23%), and 71 or above in 44 patients (14.7%). Tumor size was 2 cm or smaller in 65

TABLE 19.1. Significant Risk Factors Associated with Outcome at 6 Weeks.

	Outcome			
Risk factors	GOS 5	GOS 4	GOS 1–3	*p*-value
Co-morbidity				
ASA I ($n = 126$)	115 (91.3%)	11 (8.7%)	—	
ASA II ($n = 144$)	120 (83.3%)	16 (11.1%)	8 (5.6%)	
ASA III ($n = 30$)	16 (53.3%)	8 (26.7%)	6 (20%)	<0.001
Age				
<61 yr ($n = 187$)	170 (90.9%)	16 (8.6%)	1 (0.5%)	<0.001
61–70 yr ($n = 69$)	48 (69.6%)	12 (17.4%)	9 (13%)	
>71 yr ($n = 44$)	33 (75%)	7 (15.9%)	4 (9.1%)	
Size				
<2.1 cm ($n = 65$)	64 (98.5%)	1 (1.5%)	—	<0.001
2.1–4 cm ($n = 115$)	98 (85.2%)	13 (11.3%)	4 (3.5%)	
>4.1 cm ($n = 120$)	89 (74.2%)	21 (17.5%)	10 (8.3%)	
Symptoms/ Signs				
Asymptomatic ($n = 110$)102 (92.7%)	6 (5.5%)	2 (1.8%)	0.009	
Mild ($n = 60$)	44 (73.3%)	10 (16.7%)	6 (10%)	
Severe ($n = 130$)	105 (80.8%)	19 (14.6%)	6 (4.6%)	
Previous surgery				
Yes ($n = 40$)	24 (60%)	10 (25%)	6 (15%)	<0.001
No ($n = 260$)	227 (87.3%)	25 (9.6%)	8 (3.1%)	
Previous radiation treatment				
Yes ($n = 15$)	9 (60%)	3 (20%)	3 (20%)	0.012
No ($n = 285$)	242 (84.9%)	32 (11.2%)	11 (3.9%)	

patients (21.7%), 2.1–4 cm in 115 patients (38.3%), and 4.1 cm or above in 120 patients (40%). One hundred and ten patients (36.7%) were asymptomatic, 60 (20%) had mild symptoms, and 130 (43.3%) had severe symptoms. Forty patients (13.3%) were operated previously on the same location and 15 patients (5%) had prior radiation treatment.

At 6 weeks, the GOS was 5 in 251 patients (83.7%), 4 in 35 (11.7%), and 3 in 10 patients (3.3%). No patient had a GOS of 2 at 6 weeks. The mortality rate (GOS 1) was 1.3% (4/300). The factors found to affect the outcome are listed in Table 19-1. With multivariate analysis, co-morbidity and age showed a stronger impact (Table 19-2).

Postoperative neurologic and medical complications were encountered in 41 (13.7%) and 16 patients (5.3%), respectively, the most frequent being cranial nerve deficits (18) for neurologic and deep venous thrombosis (9) for medical complications. Tumor location significantly associated with both neurologic and medical complications, and existing medical co-morbidity showed association with medical complications (Tables 19-3 and 19-4).

Among the risk factors that were assessed, medical co-morbidity, age, size, presenting symptoms and signs, as well as a history of previous surgery and radiation treatment were found to be influencing the early outcome at 6 weeks following surgery. With one risk level decrease in medical co-morbidity and age, the risk of unfavorable outcome decreased by 87% and 60%, respectively. Tumor location, on the other hand, was found to be a strong determinant of postoperative neurologic complications. One risk level decrease in tumor location decreased the risk of neurologic complication by 63%. In summary, our results supported the available data in the literature, which suggest that medical co-morbidity, tumor location, age, tumor size, presenting symptoms/signs, as well as prior history of surgery and radiation treatment are indeed significant factors that influence the operative outcome in meningioma surgery.

TABLE 19.2. Odds of Having Unfavorable Outcome (GOS 1–3) at 6 Weeks.

Factor	Odds ratio	95% Confidence interval
Co-morbidity[a]		
Per risk level decrease	0.13	0.04–0.43
Age[b]		
Per risk level decrease	0.40	0.17–0.92

[a] With one risk level decrease, unfavorable outcome decreases 87%.
[b] With one risk level decrease, unfavorable outcome decreases 60%.

TABLE 19.3. Significant Risk Factors Associated with Postoperative Complications.

Risk factors	Yes	No	*p*-value
Neurologic complications			
Location*			
Simple ($n = 94$)	6 (6.4%)	88 (93.6%)	
Moderate ($n = 115$)	12 (10.4%)	105 (89.6%)	
Complex ($n = 91$)	23 (25.3%%)	66 (74.7%)	<0.001
Medical complications			
Co-morbidity			
ASA I ($n = 126$)	2 (1.6%)	124 (98.4%)	0.018
ASA II ($n = 144$)	10 (6.9%)	134 (93.1%)	
ASA III ($n = 30$)	4 (13.3%)	26 (86.7%)	
Location			
Simple ($n = 94$)	1 (1.1%)	93 (98.9%)	0.08
Moderate ($n = 115$)	8 (7%)	108 (93%)	
Complex ($n = 91$)	7 (7.7%)	84 (92.3%)	

*For definition of simple, moderate and complex locations, please see Chapter 20.

TABLE 19.4. Odds of Having Neurologic and Medical Complications.

Factor	Odds ratio	95% Confidence interval
Neurologic complications		
Location[a]		
Per risk level decrease	0.37	0.22–0.62
Medical complications		
Co-morbidity[b]		
Per risk level decrease	0.35	0.15–0.85
Location[c]		
Per risk level decrease	0.43	0.20–0.95

[a] With one risk level decrease, neurologic complications decrease 63%.
[b] With one risk level decrease, medical complications decrease 65%.
[c] With one risk level decrease, medical complications decrease 57%.

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