Clinical Neurology and Neurosurgery 180 (2019) 34–39

Contents lists available at ScienceDirect

Clinical Neurology and Neurosurgery

journal homepage: www.elsevier.com/locate/clineuro

Risk factors for preoperative and late postoperative seizures in primary supratentorial meningiomas

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A R T I C L E I N F O

Keywords:
Meningioma
Seizure
Risk factors
Outcome

A B S T R A C T

Objective: We performed a retrospective study to identify factors associated with preoperative and late postoperative seizures in primary supratentorial meningiomas.

Patients and methods: Between July 2003 and December 2014, we extracted 303 consecutive patients who underwent primary resection for supratentorial meningiomas at a single institution. Univariate analysis and multivariate logistic regression analysis were performed to determine the associations of seizure occurrence and outcome.

Results: Forty-nine (16.2%) of the total 303 patients presented with preoperative seizures. The risk factors independently associated with preoperative seizures were vasogenic edema (OR 4.44, $p = 0.001$), parasagittal or parafalcine location (OR 2.20, $p = 0.020$), and absence of neurologic deficit (OR 0.30, $p = 0.003$). Among these patients, 33 (67.3%) were seizure free postoperatively (Engel Class I). Of the 303 patients, we observed late postoperative seizures in 35 (11.6%) patients. The associated risk factors included history of preoperative seizure (OR 3.96, $p = 0.002$), bigger tumor size (OR 1.04, $p = 0.002$), and continuation of anti-epileptic drugs (OR 4.74, $p = 0.001$). We analyzed that meningiomas with a largest diameter of greater than 45.5 mm were 4.2 times more likely to have late postoperative seizures than those with less diameter (HR 4.20, $p < 0.001$). Ten (28.6%) of the 35 patients with late postoperative seizures experienced poor seizure control. The independently associated predictive factors were high grade meningiomas (WHO Grade II or III) (OR 10.66, $p = 0.030$) and history of postoperative adjuvant therapy (OR 12.58, $p = 0.040$).

Conclusions: Identifying factors associated with preoperative or late postoperative seizures may help guide treatment strategies, eventually improving the quality of life for patients with meningiomas.

1. Introduction

Meningiomas are one of the most common intracranial tumors. They accounts for approximately 33.8% of all primary intracranial tumors reported in the United States [1]. Seizures are one of the most commonly presenting symptoms, occurring in approximately 10–50% of patients with meningiomas [2–6]. The association between seizures and meningiomas has a long history. In 1935, Dr. Groff reported the incidence and character of epilepsy in a series of 291 meningiomas [7]. Since then, many articles have been published regarding this association; however, there are still many unanswered questions with respect to the risk factors of and ways to control seizures in patients with meningiomas.

The purpose of this study was to (1) identify the incidence of seizures in patients undergoing primary resection of supratentorial meningiomas; (2) investigate the risk factors associated with preoperative seizures and predictors of late postoperative seizures; and (3) evaluate the predictive factors associated with the management of late

Abbreviations: AEDs, anti-epileptic drugs; EOR, extent of resection; GTR, gross total removal; MRI, magnetic resonance imaging; ROC, receiver operating characteristic; WHO, World Health Organization

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https://doi.org/10.1016/j.clineuro.2019.03.007
Received 17 April 2018; Received in revised form 4 March 2019; Accepted 10 March 2019
Available online 11 March 2019

postoperative seizures. Regardless of whether or not seizures can be managed with medical therapy, they are considered to be a significant cause of morbidity and poor quality of life. Therefore, proper understanding of these features is imperative to preventing seizure occurrence and guiding treatment strategies for patients with intracranial meningiomas. This is especially important considering the increase in meningioma detection due to the widespread availability of various neuroimaging modalities [8,9].

2. Patients and methods

2.1. Patient population

This was a retrospective cohort study of patients with meningioma who underwent primary resection of supratentorial meningiomas at Seoul National University Bundang Hospital between July 2003 and December 2014. To determine the effect of high grade meningioma on postoperative seizure outcome, we included all patients with a tissue-proven diagnosis of meningioma, regardless of the World Health Organization (WHO) grade. As the patients were diagnosed between 2003 and 2014, the diagnosis was based on 2007 WHO classification of tumors of the central nervous system. Patients with infratentorial, recurrent, or multiple meningiomas were excluded from the analysis to create a more uniform patient population. A diagram of patient selection is shown in Fig. 1.

2.2. Data collection

The clinical, operative, and hospital course records were reviewed. Information collected from the medical records included the following: Patient demographics, presenting symptoms, seizure occurrences, neuroimaging, neurological function, histology, adjuvant therapy, and tumor recurrence.

The characteristics of magnetic resonance imaging (MRI) included the following: the size of lesions (largest diameter based on gadolinium enhancement, excluding the dural tail if present), location of tumor (convexity, parasagittal/parafalcine, sphenoid wing, planum sphenoidale, olfactory groove, intraventricular), presence of vasogenic edema (pre-existing peritumoral edema was graded from a prior study [10] on axial T2-weighted and/or fluid-attenuated inversion recovery MRI), cystic portion (any cystic meningiomas according to Nauta's classification [11]), and calcification. The extent of resection (EOR) was confirmed using postoperative MRI within the first 48 h post-surgery as well as operative records: Simpson Grade I and II were defined as the gross total removal (GTR) of tumor and Simpson Grade III or above as non-GTR.

The primary endpoint variables were seizure status and control of seizure. The seizure status was assessed at each postoperative outpatient visit. Controlled seizure was defined as no recurrence of seizures for at least two years, whether on antiepileptic treatment or not [12–14].

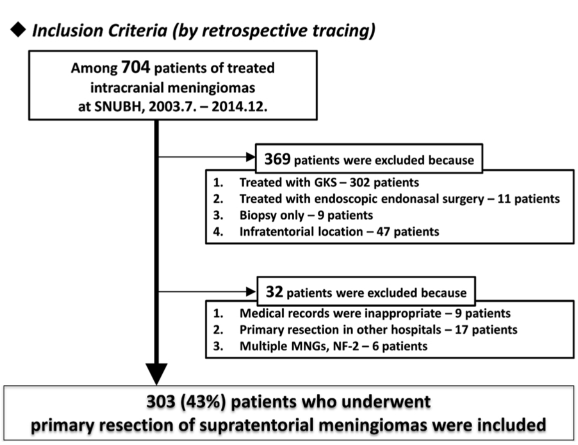

Fig. 1. Diagram of patient selection.
GKS, gamma knife surgery; NF-2, neurofibromatosis type 2.

2.3. Anti-epileptic drugs (AEDs)

Preoperatively, patients were started on AEDs if they developed seizures. In the perioperative period, patients were generally continued on their same preoperative AEDs regimen. Postoperatively, patients with preoperative seizures were continued on AEDs for at least one or two months, and then weaned. AEDs were continued indefinitely if signs of seizures persisted.

To date, there have not been any established guidelines for using AEDs in patients undergoing surgery for meningioma without any history of preoperative seizures. In our institution, a standard seizure prophylaxis policy was constituted: preoperative loading of AEDs and discontinuation within a month postoperatively, if there is no evidence of clinical seizures [15–17]. The choice of specific AEDs was based on the preference of the clinician.

2.4. Postoperative seizures

For seizures appearing after surgery, a distinction is normally made between those occurring within one week after surgery (early seizures) and those occurring later (late seizures) [17,18]. Likewise in this study, early postoperative seizure was defined as the onset of seizures within the first week of surgery, and late postoperative seizure was defined as onset of seizures beyond the first week of surgery. Early seizures are considered to be an acute symptom and not associated with a similar risk of recurrence as late seizures [17,19].

2.5. Statistical analysis

All analyses were performed using SPSS 21 (IBM, Chicago, Illinois, USA). The categorical data were analyzed using Pearson chi-square test and Fisher's exact test. The continuous variables were presented as the mean ± standard deviation for parametric data. For an intergroup comparison, Student's *t*-test was used for parametric data and the Mann-Whitney U test for non-parametric data. The cut-off value was the point closest to the point of perfect classification (sensitivity and specificity), as determined by using a receiver operating characteristic (ROC) curve with a discrimination power of tumor diameter. Cox proportional hazards regression was used to determine the hazards ratio for the occurrence of late postoperative seizures.

All variables associated with seizures in univariate analysis ($p < 0.10$) were then included into a stepwise multivariate logistical regression model. P values of less than 0.05 were considered significant.

3. Results

3.1. Patient population

A total of 303 patients underwent primary resection for supratentorial meningioma during the study period. The mean age was 54.1 ± 12.6 (11–82) years at the time of surgery, a total of 215 (71.0%) patients were women. The mean follow-up duration was 49.3 ± 31.6 (1–137) months. Forty-nine patients (16.2%) presented with seizures; while 70 (23.1%) patients presented with headaches, 49 (16.2%) with visual deficits, 40 (13.2%) with motor deficits, 16 (5.3%) with memory impairment, 15 (5.0%) with language difficulty and 27 (8.9%) with incidental findings. The mean tumor size in diameter was 42.69 ± 16.35 mm. The tumor location was variable: 113 (37.3%) tumors in the cerebral convexity, 79 (26.1%) in the parasagittal/parafalcine area, 38 (12.5%) in the sphenoid wing, 32 (10.6%) in the tuberculum sella, 20 (6.6%) in the olfactory groove, 9 (3.0%) in the ventricle, 7 (2.3%) in the tentorial area, and 5 (1.7%) in the planum sphenoidale. Gross total removal (GTR) was achieved in 215 (71.0%) patients. The study population included 251 (82.8%) benign meningiomas (WHO grade I), 44 (14.5%) WHO grade II meningiomas, and 8 (2.6%) WHO grade III meningiomas, according to 2007 WHO classification. Postoperatively, newly-developed neurologic deficit occurred in 34 (11.3%) patients.

Most of the patients (n = 294 [97.0%]) were on AEDs before surgery, according to our institutions' policy. As mentioned above, the type of AED was based on the surgeon's preference: Majority (n = 237 [78.2%]) had taken valproate and 49 (16.2%) patients had levetiracetam. There was no association between the type of perioperative AEDs and postoperative seizures (p = 0.555).

3.2. Factors associated with preoperative seizures

Patients with preoperative seizures were less frequently presented with preoperative neurologic deficit (p = 0.002). They had tumors that caused vasogenic edema (p < 0.001), which were presented with a cystic portion (p = 0.02), commonly found in the parasagittal/parafalcine area (p = 0.003), and less frequently in the tuberculum sella area (p = 0.009). There was no gender difference (p = 0.19).

The risk factors that were associated with preoperative seizures according to the multivariate analysis were presence of vasogenic edema (OR 4.44, 95% CI 1.780–11.021, p = 0.001), parasagittal/parafalcine tumor location (OR 2.20, 95% CI 1.115–4.327, p = 0.02), and absence of preoperative neurologic deficit (OR 0.30, 95% CI 0.133 – 0.661, p = 0.003). No other clinical or imaging factors were found to be associated with preoperative seizures (Table 1).

3.3. Seizure outcomes and early postoperative seizures

Seizure status and patient population are illustrated in Fig. 2. In our study population, 49 (16.2%) out of the 303 patients experienced postoperative seizures. Among them, 19 (38.8%) patients had preoperative seizures, and 30 (11.8%) had no history of preoperative seizures. Early postoperative seizure within the first week after surgery occurred in 14 (4.6%) patients, and among them, 2 (14.3%) patients continued to have seizures during the long-term follow-up. Early postoperative seizures showed no association with history of preoperative seizures (p = 0.25).

Of the 49 patients presented with seizures, the majority of them (33 patients, 67.3%) remained seizure free during the entire postoperative follow-up periods (54.5 ± 33.8 months) (Engel Class I). Four (8.2%) patients had early postoperative seizures, and 1 (25.0%) of those patients experienced prolonged seizures beyond the first week after surgery throughout the long-term follow-up. The patient had convexity meningioma in the left precentral gyrus. With continued use of AEDs postoperatively, she had no seizures over the following 2 years.

Among the 254 patients without history of preoperative seizures, 10 (3.9%) patients had early postoperative seizures. Nine of them had no seizure recurrence after the first week of surgery, and the remaining 1 (10%) patient continued to have seizures throughout the follow-up period. This patient had convexity meningioma near the sagittal sinus in the right postcentral gyrus; after subtotal removal of tumor, he had poorly controlled partial seizures. He was under AEDs adjustment via outpatient visits.

Table 1
Risk factors of Preoperative seizures.

Variables	OR (95% CI)	p value
Vasogenic edema	4.44 (1.780 – 11.02)	0.001
Parasagittal/Parafalcine location	2.20 (1.115 – 4.327)	0.020
Preoperative neurologic deficit	0.30 (0.133 – 0.661)	0.003

Factors that are independently associated with any preoperative seizures in stepwise multivariate logistic regression analysis.
OR, odds ratio; CI, confidence interval.

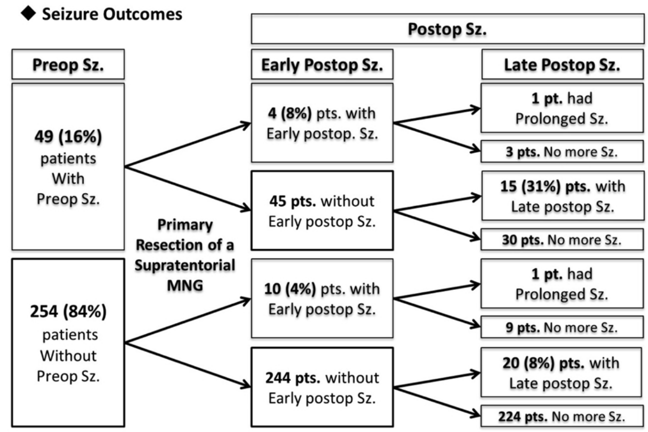

Fig. 2. Seizure status and patient population.
Preop, preoperative; Sz, seizure; Postop, postoperative; MNG, meningioma; Pt, patient.

3.4. Late postoperative seizures and seizure control

Thirty-five (11.6%) patients of our study population had late postoperative seizures. Of the 49 patients presented with seizures, 15 (30.6%) patients had late postoperative seizures. Twenty (7.9%) of the 254 patients without history of preoperative seizures experienced late postoperative seizures (Fig. 2). The mean interval between operation and late postoperative seizures was 17.6 ± 17.3 months. Most of the patients (n = 28 [80%]) experienced their first late postoperative seizures within two years, and almost half of the patients (n = 17 [48.6%]) underwent late postoperative seizures within a year after surgery. Among the 35 patients, 14 (40.0%) patients were under prophylactic AEDs and 21 (60.0%) patients stopped AEDs on a specific time.

According to the univariate analysis, factors with p < 0.10 of late postoperative seizures were as follows (Table 2): Age (p = 0.030), female gender (p = 0.050), history of preoperative seizures (p < 0.001), history of preoperative embolization (p = 0.001), lager tumor size (p < 0.001), tumor location other than tuberculum sella (p = 0.030), history of postoperative adjuvant therapy (p = 0.001), recurrence of tumor (p = 0.089), and continuation of AEDs prophylaxis (p < 0.001).

According to the binary logistic regression analysis, history of preoperative seizures (OR 3.96, 95% CI 1.637–9.558, p = 0.002), larger tumor size (OR 1.04, 95% CI 1.014–1.068, p = 0.002), and continuation of AEDs (OR 4.74, 95% CI 1.909–11.771, p = 0.001) were significantly associated with late postoperative seizures (Table 3).

We plotted the ROC curve and decided the most appropriate cut-off point for tumor diameter. Fig. 3 shows that area under curve of the tumor diameter was 0.706 (95% CI 0.628 – 0.783, p < 0.001), and the cut-off value was 45.5 mm. According to the Cox regression analysis, meningiomas with the largest diameter of greater than 45.5 mm were shown to be a significant risk factor for late postoperative seizures (HR 4.191, 95% CI 1.990–8.824, p < 0.001); meningiomas with the largest diameter of greater than 45.5 mm were 4.2 times more likely to experience postoperative seizures than those with the largest diameter of less than 45.5 mm (Fig. 4).

Seizure management was assessed in accord with the medical records. Controlled seizure was defined as no fits during a period of at least 2 years. Fifteen (42.9%) patients out of the 35 patients with late postoperative seizures had one episodic seizure attack and no recurrent seizures during the follow-up period. Among these 35 patients with late

Table 2
Univariate analysis according to the occurrence of Late Postoperative seizures.

Variables	Late Postoperative Seizures, n (%)		
	No (n = 268)	Yes (n = 35)	p value
Age (mean)	54.69 ± 12.59	49.89 ± 12.02	0.030*
Female gender	195 (72.8%)	20 (57.1%)	0.050
Preoperative Neurologic deficit	102 (38.1%)	12 (34.3%)	0.660
Preoperative Seizures	34 (12.7%)	15 (42.9%)	< 0.001*
Preoperative Embolization	145 (54.1%)	29 (82.9%)	0.001*
Radiographics			
Tumor size (mm)	41.41 ± 16.26	52.49 ± 13.64	< 0.001*
Tumor Location			
Convexity	100 (37.3%)	13 (37.1%)	0.980
Parasagittal/Parafalcine	68 (25.4%)	11 (31.4%)	0.440
Sphenoidal	33 (12.3%)	5 (14.3%)	0.780
Tuberculum sella	32 (11.9%)	0 (0.0%)	0.030*
Planum sphenoidale	5 (1.9%)	0 (0.0%)	1.000
Olfactory groove	18 (6.7%)	2 (5.7%)	1.000
Tentorial	5 (1.9%)	2 (5.7%)	0.180
Intraventricular	7 (2.6%)	2 (5.7%)	0.270
Cerebral edema	161 (60.1%)	26 (74.3%)	0.100
T2SI High	72 (26.9%)	14 (40.0%)	0.100
Cystic portion	16 (6.0%)	4 (11.4%)	0.260
Calcification	147 (54.9%)	20 (57.1%)	0.790
Perioperative outcomes			
Non-GTR	76 (28.4%)	12 (34.3%)	0.460
High Grade (WHO Gr. II/III)	43 (16.0%)	9 (25.7%)	0.150
Postoperative Complications	74 (27.6%)	10 (28.6%)	0.900
Postoperative new deficits	30 (11.2%)	4 (11.4%)	1.000
Postoperative Adjuvant Therapy	51 (19.0%)	15 (42.9%)	0.001*
Tumor Recurrence	39 (14.6%)	9 (25.7%)	0.089
AEDs Continuation	19 (7.1%)	14 (40.0%)	< 0.001*

*, statistical significance; GTR, gross total resection; AEDs, anti-epileptic drugs; SI, signal intensity.

Table 3
Predictors of Late Postoperative Seizures and Uncontrolled Late postoperative seizures.

Predictors of Late Postoperative Seizures.			
Variable	Univariate (p-value)	Multivariate (p-value)	OR (95% CI)
Preoperative Seizures	**< 0.001**	**0.002**	**3.96 (1.637–9.558)**
Preoperative Embolization	**0.001**		
Tumor Size	**< 0.001**	**0.002**	**1.04 (1.014–1.068)**
Postoperative Adjuvant Therapy	**0.001**	0.060	2.19 (0.953–5.016)
AEDs Continuation	**< 0.001**	**0.001**	**4.74 (1.909–11.77)**
Tumor Recurrence	**0.080**		
Predictors of Uncontrolled Late postoperative seizures.			
Variable	Univariate (p value)	Multivariate (p value)	OR (95% CI)
High grade Meningioma (WHO Grade II or Grade III)	**0.001**	0.030	10.66 (1.183 – 96.07)
Postoperative Adjuvant Therapy	**0.001**	0.040	12.58 (1.099 – 144.1)

All variables associated with late postoperative seizures in univariate analysis ($p < 0.10$) were then included into a stepwise multivariate logistical regression model. Values with $p < 0.05$ were considered significant.
OR, odds ratio; CI, confidence interval; AEDs, anti-epileptic drugs.

postoperative seizures, seizures were under control in 25 (71.4%) patients. The remaining 10 (28.6%) patients had poorly controlled seizures and with continued AEDs adjustments via outpatient visits. The factors associated with loss of seizure control according to the multivariate analysis were high grade meningioma, i.e. WHO Grade II or Grade III meningioma (OR 10.66, 95% CI 1.183–96.072, p = 0.030),

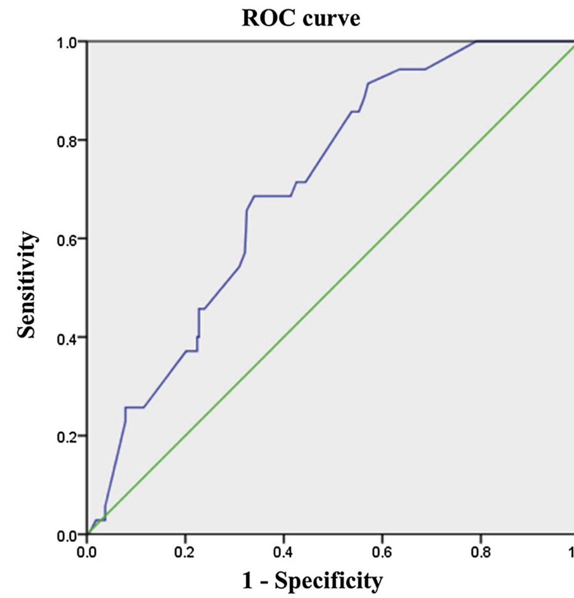

Fig. 3. ROC curves for tumor diameter to predict late postoperative seizure (AUC 0.706, 95% CI 0.628 – 0.783, $p < 0.001$).

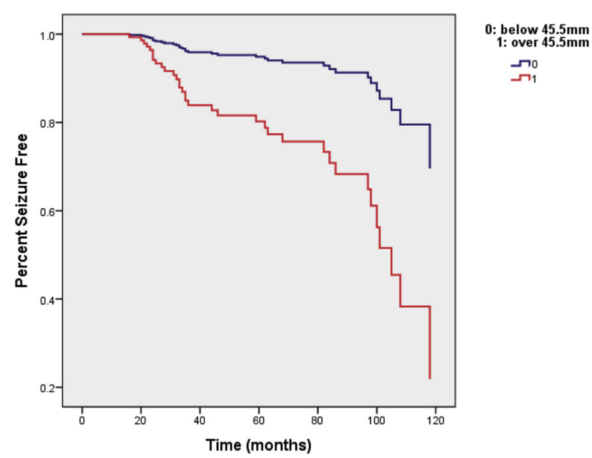

Fig. 4. Cox regression analysis evaluating the occurrence of late postoperative seizures according to tumor size.

and history of postoperative adjuvant treatment (OR 12.58, 95% CI 1.099–144.068, p = 0.040) (Table 3). The association between loss of seizure control and non-GTR of tumor (p = 0.050), or tumor recurrence (p = 0.080) trended toward, but did not reach statistical significance.

4. Discussion

4.1. Risk factors for preoperative seizures

We showed that peritumoral edema may be the factor most strongly related to preoperative seizures. Various studies in the past have reported a correlation between vasogenic edema and seizure occurrences [2,3,5,17,20–22]. It has been estimated that 30%–60% of patients with meningiomas have signs of cerebral edema [20,23,24]. Although the pathogenesis of peritumoral edema of meningiomas still remains unknown, the breakdown of blood-brain barrier and pial invasion are believed to be associated [23,25]. It has also been postulated that edema formation is due to mechanical factors from tumor compression on brain parenchyma or draining veins, excretion of vasogenic factors, such as vascular endothelial growth factor, or hypoplasia of draining vessels [23,25]. Even so, the presence of edema usually suggests a more infiltrative type of meningioma, with a greater tendency to cause seizures. Moreover, peritumoral edema fluid contains a high concentration of glutamate, which may trigger hyperexcitability and epileptogenesis [18].

Seizures occurred more often in patients with a tumor located in the parasagittal or parafalcine area, while showing less often in patients with a tumor located in the tuberculum sellae area. Many previously published studies described a high rate of preoperative seizures in the non-skull base lesions, such as parasagittal or convexity meningiomas [2,4,5,17]. Non-skull base meningiomas often grow for a long period of time, eventually reaching a considerable size before the occurrence of any neurological deficits; as such, they might contribute to the increasing amount of epileptogenic cortical gray matter [4]. In particular, the propensity for parasagittal/parafalcine meningiomas to cause seizures has been previously reported [2,26]. This area is adjacent to the sagittal sinus and meningiomas located in this area have a possibility to cause venous congestion and severe edema, which has been suggested to cause epileptogenesis.

Presence of preoperative neurologic deficits has been less frequently associated with preoperative seizures, consistent with the finding of some prior papers [21,22]. Considering the increase in meningioma detection and widespread availability of neuroimaging [8,9], this may be explained by the diagnosis of the tumor prior to the occurrence of neurological deficits or just after a seizure attack. Otherwise, as mentioned above, meningiomas would reach a considerable size and involve epileptogenic cortical gray matter before the occurrence of any neurological deficits. We assume early-diagnosed meningiomas display symptoms or neurologic deficits before they would disrupt the peritumoral functional environment driving epileptogenesis.

4.2. Predictors of late postoperative seizures

In many previous studies, it has been suggested that there is no association between early and late postoperative seizures [2,18,19]. The occurrence of early postoperative seizures may be related to factors such as excessive intraoperative cortical stretching, as well as early-stage cerebral edema and postoperative electrolyte disorders. If these factors are avoided, early postoperative seizures may resolve without causing epileptogenic foci [19]. We focused on late postoperative seizures after the resection of meningioma and its outcome. According to the multivariate analysis, history of preoperative seizures, larger tumor size, and continuation of AEDs were significantly associated with the occurrence of late postoperative seizures. Like our study, various reports have found a significant relationship between the history of preoperative seizures and the occurrence of postoperative seizures [19,26–29].

A correlation between tumor size and seizure frequency of both preoperative seizures and postoperative seizures has been reported in many previous studies [2,30]. In our study, we found that tumors with a largest diameter of greater than 45.5 mm have about 4.2 times the risk of developing postoperative seizures than those with less than 45.5 mm diameter. Local pressure may increase with tumor size, leading to cortical compression, which is a suspected factor for epileptogenicity [2,30]. Tumor size has also been associated with edema as a consequence of venous congestion or leptomeningeal tumor infiltration [2].

History of preoperative embolization showed to be a possible risk factor for postoperative seizure, which was not significant in the multivariate analysis. To the best of our knowledge, there have only been a few studies that specifically addressed the association between seizure risk and embolization. Because various embolic materials were used in these studies, a direct comparison was inappropriate; however, a report of a new onset of seizures post-embolization was not uncommon [31]. Although the mechanism is not clear, the development of edema and inflammation surrounding the tumor may play a role. However, further studies are necessary.

Previous papers have suggested many other risk factors for postoperative seizures. The location of supratentorial meningioma may also influence the occurrence of postoperative seizures [3,32]. Moreover, incomplete resection of meningioma may continue to irritate the cortex and result in a higher incidence of postoperative seizures [32]. The association between tumor progression and postoperative seizures remains unclear; however, Chan et al. indicated that tumor progression involving the parasagittal area or convexity may be a significant risk factor for postoperative seizures [33]. There has also been a report that suggested permanent postoperative neurological deficits as a significant risk factor for late postoperative seizures [18]. However, we found no significant relationship between the abovementioned factors and postoperative seizures.

4.3. Effect of AEDs

To date, there have not been any defined guidelines or a clear consensus on the appropriate use of AEDs for postoperative seizures. Temkin had pointed out that traditional AEDs may reduce up to 40%–50% of seizures in the first week after neurosurgery, as compared with a placebo or no treatment [15]. However, there has not been clear evidence showing that AEDs can effectively reduce the occurrence of late postoperative seizures [13,17].

In our study, continuation of AEDs was independently associated with late postoperative seizures. Among the 35 patients who experienced late postoperative seizures, 14 (40.0%) patients continued receiving AEDs even after the first postoperative week. Many factors were considered to decide the continuation of AEDs: Age, preoperative motor disturbance, Simpson grade, early postoperative seizures, new permanent postoperative neurologic deficits, postoperative radiotherapy, and tumor progression [18]. The time how long to continue AEDs is entirely upon physician' preference. The patients at risk for postoperative seizure might not quit AEDs, so there might be a selection bias regarding the retrospective design of our study. Therefore, a careful consideration and future research regarding the use of AEDs is necessary.

In this paper, late postoperative seizures had happened in the mean duration of 17.6 months. Patients with risk factors for late postoperative seizure would benefit from enough use of prophylactic AEDs at least more than 18 months. In particular, patients with a history of preoperative seizures or large tumor size may benefit from an extended use of AEDs of at least 18 months after surgery.

4.4. Limitations

There are several limitations to consider when interpreting our findings. First, there may be biases in patient selection, given the retrospective nature of this study. Second, this study was designed to neither evaluate patients who presented seizures nor the effects of surgery on prolonged seizure control. The duration and control of seizure before surgery and its own long-term follow-up may evaluate the seizure outcome for meningioma patients. Third, it is unclear to whether surgery or AEDs contributed to seizure management. Last, we did not evaluate the follow-up images after adjuvant radiotherapy, which may have changed from the immediate postoperative images.

Despite these limitations, our study represented large and homogeneous cohorts, who were treated surgically at a single institution. Moreover, we used a multivariate analysis to control for confounding variables. Even if our data are not completely new in the literature, we believe that our findings offer useful insights into the management of patients undergoing primary resection of meningioma. However, a well-designed prospective study is still needed to present better data to further assist clinical decision making.

5. Conclusion

The predictors significantly associated with late postoperative seizures were history of preoperative seizure, bigger tumor size, and continuation of AEDs. It was suggested that meningiomas with the largest diameter of greater than 45.5 mm were 4.2 times more likely to experience late postoperative seizures. High grade meningioma or history of postoperative adjuvant treatment was associated with uncontrolled seizure.

Seizure are not uncommon among patients with meningiomas, and contribute to their quality of life. The efforts to identify the factors associated with preoperative and postoperative seizures may help guide treatment strategies, improving the quality of life for patients with meningiomas.

Declarations of interest

None.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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