

THE CORRELATION BETWEEN CEREBRAL EDEMA AND OUTCOME OF SURGICAL TREATMENT OF OLFACTORY GROOVE MENINGIOMA

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Olfactory groove meningiomas are benign tumors that grow along the midline floor of the anterior cranial fossa, from the cribriform plate to tuberculum sellae, and account for 4-10% of the intracranial meningiomas; they are benign and rather slow growing tumors. Women are more affected than men. The basic treatment of olfactory groove meningiomas is surgical. Complications of surgical treatment occur in 1/3 of the patients in the course of the long-term follow-up, the most frequent of which are cerebrospinal fistula, epileptic seizures, postoperative hygromas, pneumonias, embolism, whereas the lethal outcome is reported in 3% of the operated patients, reaching even 11% in the patients with extremely large olfactory groove meningiomas.

The aim of the paper was to determine whether the presence of peritumoral edema in the patient having olfactory groove meningioma can affect the more frequent occurrence of postoperative complications, and whether the preventive removal of the edematous parts of the frontal brain lobe covering olfactory groove meningioma can reduce the rate of complications and lethal outcome.

The paper included 35 patients (24 women and 11 men) operated for olfactory groove meningioma. The tumor and edema volumes were calculated and the results were correlated with the occurrence of postoperative complications and lethal outcome.

Of great importance was the analysis of preventive removal of malatic and edematous parts of the frontal lobe of the brain.

Surgical treatment of large olfactory groove meningioma accompanied by high degree of peritumoral brain edema is associated with high risk of complications, primarily with reactive edema and hemorrhage. The preventive removal of malatic and edematous parts of the frontal lobe of the brain is a useful operative procedure which significantly reduces the postoperative risk of edema, hemorrhage and lethal outcome. *Acta Medica Medianae 2014;53(2):22-27.*

Key words: olfactory groove meningioma, surgical treatment, peritumoral edema, complications

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Introduction

Olfactory groove meningiomas are benign tumors that grow along the midline floor of the anterior cranial fossa, from the cribriform plate to tuberculum sellae. During their growth, they show symmetrical increase in the volume, spread towards the frontal sinus, sagittal sinus and cerebral falx, and back towards the optic chiasm which they may dislocate and thus jeopardize the eyesight (1, 2). According to various sources, they account for 4-10% of the intracranial meningiomas; they are benign and rather slow growing tumors (3,

4). They slowly invade and dislocate the brain tissue, and therefore their clinical presentation is rather late, practically when the tumor reaches significant proportions and when compression causes visual and mental disturbances (5,6). Rarely, olfactory groove meningiomas show invasive properties by destroying the tough membrane, skull, and by making the subcutaneous propagation, when they are called atypical or malignant and when they show a significant propensity for recurrence (7). Due to their size and property to capture the contrast medium, they are easily detected by means of computerized tomography (CT) or magnetic resonance (MR) (8). Women are more affected than men, especially in their reproductive age, when a significant concentration of progesterone and estrogen receptors in the aforesaid tumors is detected, which can point to a causal relationship between the sex hormones and meningioma, especially in the case of anaplastic forms of olfactory groove meningioma (9). The basic treatment of olfactory groove meningioma is

surgical, and various authors, depending on its location, prefer different surgical approaches: bifrontal, unilateral subfrontal or frontopterional approach (8). Complications of surgical treatment occur in 1/3 of the patients in the course of the long-term follow-up, the most frequent of which are cerebrospinal fistula, epileptic seizures, postoperative hygromas, pneumonias, embolism, whereas the lethal outcome is reported in 3% of the operated patients, reaching even 11% in the patients with extremely large olfactory groove meningiomas (10,11).

Aims

The aim of the paper was to determine whether the presence of peritumoral edema in a patient having olfactory groove meningioma can affect the more frequent occurrence of postoperative complications, and whether the preventive removal of the edematous parts of the frontal lobe covering olfactory groove meningioma can reduce the rate of complications and lethal outcome.

Methods

The paper included 35 patients (24 women and 11 men), mean age 51.6 years (34-72 years of age), operated on at the Clinic of Neurosurgery, Clinical Center Niš, in the period 1999-2013. Postoperative diagnosis of olfactory groove meningioma was set applying CT or MR diagnostics. Angiography was performed only if large meningiomas reached the anterior clinoid processes, so that we could estimate their position with regard to the internal carotid artery, and plan safe surgery. Before surgery, a thorough neurological examination was performed. For all olfactory groove meningiomas the greatest diameter was determined in all three planes, on the basis of which the tumor volume was calculated according to the formula - $V_t = a \times b \times c \times \frac{1}{2}$ and the tumors were divided into the following categories: small ($V_t \leq 15 \text{ cm}^3$), medium-sized ($15-60 \text{ cm}^3$) and large ($>60 \text{ cm}^3$) meningiomas. Using the same formula, the cerebral edema volume was calculated in the way that the tumor volume was subtracted from the complex volume (tumor+edema), and edemas were thus categorized as small ($V_e \leq 25 \text{ cm}^3$), medium-sized ($V_e 25-75 \text{ cm}^3$) and large ($>75 \text{ cm}^3$) edemas.

On the third postoperative day, a routine cranial CT scan was performed on the basis of which the presence of possible surgical complications was determined as well as the extent of surgical removal according to the Simpson Grading System:

I Complete removal of tumor, with excision of its dural attachment and of any abnormal bone.

II Complete removal of tumor and its visible extensions with coagulation of its dural attachment.

III Complete removal of the intradural tumor, without resection or coagulation of its dural attachment or its extradural extensions.

IV Partial removal of tumor.

V Biopsy.

Among the immediate surgical complications, the CT helped us follow the occurrence of postoperative edema, hematoma, infarction, hygroma; among clinical manifestations there were cerebrospinal fluid (CSF) fistula, neurological events, cranial and extracranial infections, deep vein thrombosis.

The length of hospital stay and occurrence of lethal outcome were also determined.

The results were compared with the preoperative degree of edema and after undertaking the preventive removal of the edematous adjacent layers of the frontal lobe.

Before being transferred to home care (11 days on average), the functional patient status was estimated using the Karnofsky Performance Scale:

KPS 80-100 - Minimal complaints, able to carry on normal activity and to work.

KPS 60-70 - Unable to work; able to live at home and care for most personal needs.

KPS ≤ 50 - Unable to care for self.

Results

Analysis of preoperative tumor volume (V_t) and preoperative edema volume (V_e) demonstrated that only 1/5 of the operated tumors belonged to the category of small tumors, whereas 57% of olfactory groove meningiomas were diagnosed and operated on when their volume exceeded 60 cm^3 , i.e. when their diameter was over 5 cm (Table 1, Figure 1).

The most common surgical approaches were the bifrontal in 30 (85.71%) patients, unilateral subfrontal in 3 (8.57%) and pterional in 2 (5.71%) patients. The pterional and unilateral subfrontal approaches were applied only for the treatment of small and several medium-sized tumors with small peritumoral edema.

Table 1. Division of peritumoral edema (V_e) and size of meningioma (V_t)

$V_e \backslash V_t$	Small ($< 15 \text{ cm}^3$)	Medium-sized ($15-60 \text{ cm}^3$)	Large ($\geq 60 \text{ cm}^3$)	Σ
Small ($\leq 25 \text{ cm}^3$)	2 (5,71 %)	4 (11,42 %)	1 (2,86 %)	7 (20,00%)
Medium-sized ($25-75 \text{ cm}^3$)	1 (2,86 %)	2 (5,71 %)	5 (14,29 %)	8 (22,86 %)
Large ($\geq 75 \text{ cm}^3$)	1 (2,86 %)	7 (20,00%)	12 (34,29 %)	20 (57,14 %)
Σ	4 (11,42 %)	13 (37,14 %)	18 (51,43 %)	35 (100,00 %)

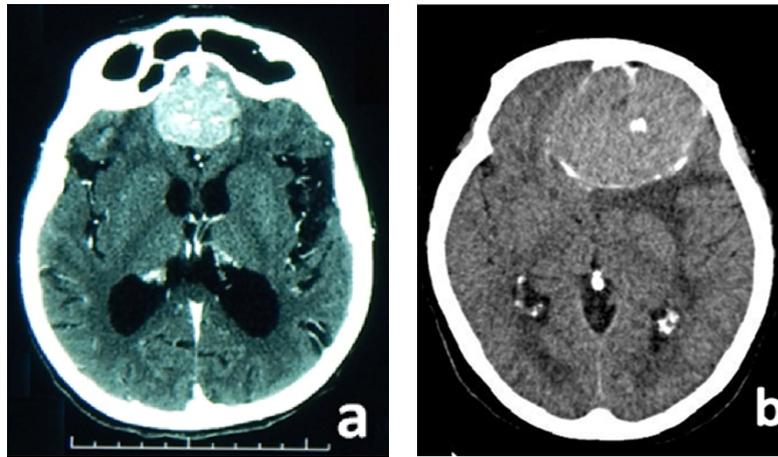


Figure 1. CT scan in a patient with small (a) and a patient with large (b) olfactory groove meningioma

Table 2. Frequency of complications with respect to the size of surgically treated meningiomas (small ≤15 cm³; medium-sized 15-60 cm³; large >60 cm³) (N=35)

Tumor size	Post op. hematoma	Reactive edema	Cerebral infarction	Hygroma	CSF leak	Epileptic seizures	Local infection	Diabetes insipidus	Pneumonia	Deep vein thrombosis	Complications in total
Small					1		1				2
Medium-sized	1			1		1			1		4
Large	3	2	1		2	1	1	1	1	1	13
Complications in total	4	2	1	1	3	2	2	1	2	1	19

Table 3. Frequency of complications with respect to the size of peritumoral edema of surgically treated meningiomas (small ≤25 cm³; medium-sized 25-75 cm³; large >75 cm³) (N=35)

Size of peritumoral edema	Post op. hematoma	Reactive edema	Cerebral infarction	Hygroma	CSF leak	Epileptical seizures	Local infection	Diabetes insipidus	Pneumonia	Deep vein thrombosis	Complications in total
Small							1				1
Medium-sized				1	1	1					3
Large	4	2	1		2	1	1	1	2	1	15
Complications in total	4	2	1	1	3	2	2	1	2	1	19

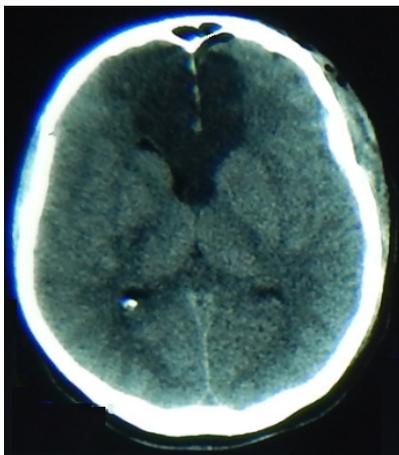


Figure 2. Cranial CT scan in the patient operated for large olfactory groove meningioma undergoing the preventive bilateral removal of edematous and malacic parts of the frontal lobe. There is neither reactive cerebral edema nor postoperative hemorrhage; there is a swelling of pericranium on the left due to myofascial flap preparation.

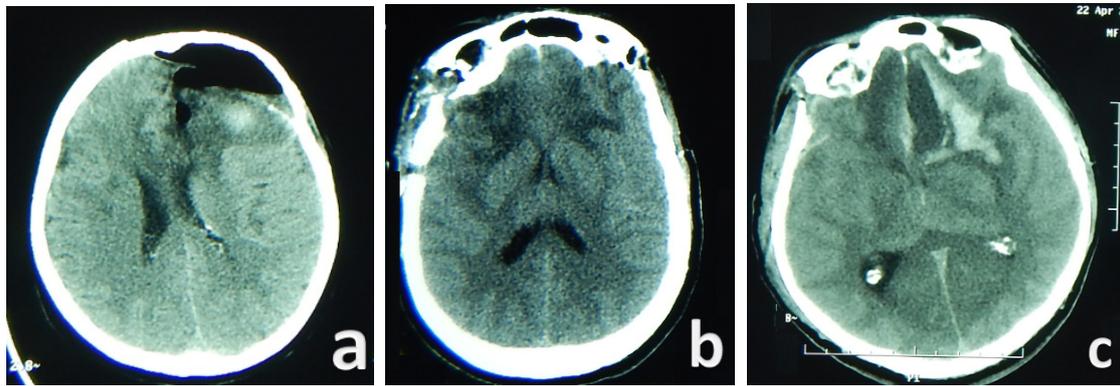


Figure 3. Postoperative cranial CT scans in the patients operated for olfactory groove meningioma, with the following complications reported: a) hygroma in the patient with unilateral subfrontal approach; b) bifrontal ischemia c) reactive cerebral edema in the operative field

Simpson grade I removal was accomplished in 27 (77.14%) patients, whereas in the remaining 8 (22.86%) patients the Simpson grade II removal was achieved.

Radical surgery with preventive bilateral removal of malatic and edematous changes in the frontal lobe covering meningiomas was performed in 9 patients, i.e. 6/12 (50%) in the cases of large tumors and large perifocal edema and 3/5 (60%) in the cases of medium-sized olfactory meningiomas with large peritumoral edema (Figure 2). In all the patients with a large tumor and large cerebral edema in whom the Simpson grade I removal was accomplished (12/35), and for the prevention of meningitis and cerebrospinal fluid leak, a myofascial flap was intradurally positioned, serving as „a live barrier“.

The analysis of postoperative complications registered up to discharge from hospital demonstrated the presence of complications in 19/35 (54.28%) operated olfactory groove meningiomas (Table 2 and 3). Postoperative hemorrhage was found in 4/35 (11.42%), cerebrospinal fluid leak in 3/35 (8.57%), whereas 2/35 (5.71%) patients had reactive edema, epileptical seizures or local infection. Among patients who had postoperative hematoma or reactive edema (in total 6/35), only one patient belonged to the group in which the preventive removal of malatic and edematous parts of the frontal lobe was accomplished. All large tumors with large peritumoral edema, and without the preventive removal of malatic and edematous parts of the frontal lobe were accompanied by complications such as postoperative hemorrhage or reactive edema.

Additional surgery in patients operated for olfactory groove meningioma was undertaken in 7/35 (20%) patients, of which in two patients decompression was done to remove the postoperative hematoma or reactive edema, and in two patients for cerebrospinal fluid leak. In one patient, tracheotomy was performed because of the breathing problems. Preoperative cerebrospinal fluid drainage was not done.

The average length of hospital stay was 14.38 days (11.28 days for small tumors with small peritumoral edema vs. large tumors with

large peritumoral edema in the case of which the length of hospital stay was 19.86 days).

At the time of discharge from hospital, the average KPS score was 84.6 in the group having undergone preventive removal of malatic and edematous parts of the frontal brain lobe when compared to the group of large tumors with large edema, in which the edematous parts were not removed preventively.

During the hospital stay, out of 35 patients operated for olfactory groove meningioma, 6 (17.15%) patients died, of whom five from intracranial complications (4 from reactive edema or hemorrhage, 1 from cerebrospinal fluid leak and meningitis associated with sepsis), whereas one patient died of pneumonia. Among the diseased, 4/6 (66.66%) belonged to the patients with large tumors and large peritumoral edema in whom the preventive removal of malatic and edematous parts of peritumoral brain tissue was not performed.

Discussion

The removal of olfactory groove meningiomas, especially when categorized as large meningiomas, is the surgery in duration of several hours, particularly in the case of tumor propagation towards the optic chiasm and internal carotid artery, when there is a high risk of damaging them regardless of the use of a microscope. An attempt to make a clear operative field for brain traction using spatulas consequently leads to additional damage of already edematous and malatic parts of the cortex and more common occurrence of complications. Therefore, certain authors prefer the preventive cerebrospinal fluid drainage at the beginning of surgery, followed by gradual intratumor reduction of olfactory groove meningioma (12,13). As cerebrospinal fluid drainage can lead to brain herniation when intracranial pressure is increased due to meningioma growth, we did not practice this intervention. This fact could explain a growing number of early postoperative complications (54.28% vs. 11.80%).

It is well known that brain tissue, when stimulated by increased tumor pressure or its

metabolites, can fail in the regulation of the blood-brain barrier. Under these circumstances the formation of cerebral edema is possible. Great importance is attached to the aspartic and arachidonic acids, as well as leukotrienes C4. According to some authors, under certain conditions, the brain can produce in the vicinity of tumor 3-5 ml of edema /hour, which means that such potential of the brain tissue can, immediately after tumor removal and due to high decompression, lead to reactive brain edema, ruptures and hemorrhage. That is why some mechanisms must be used to prevent a re-expansion of the edematous brain. In our case, the preventive removal of the edematous, malatic brain proved to be very efficient, as this category of patients had no such complications.

The preventive removal of the malatic and edematous parts of the brain at the beginning of surgery reduces the need for the brain tissue traction and significantly increases patient safety in surgery, without consequences in the mental or motoric status of the patient.

The size of olfactory meningiomas is a significant prognostic factor in the postoperative manifestations of complications and total survival. If a large tumor is associated with large peritumoral edema, the risk of complications is high. Therefore, the preventive removal of malatic and edematous parts of the frontal brain lobe is recommended, as this procedure does not diminish the patient's working abilities.

Conclusion

Surgery of large olfactory groove meningiomas accompanied with high degree of peritumoral cerebral edema is associated with high risk of complications, primarily reactive edema and hemorrhage.

The preventive removal of the malatic and edematous parts of the frontal brain lobe is a useful operative procedure which significantly reduces the risk of edema, hemorrhage and lethal outcome.

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KORELACIJA MOŽDANOG EDEMA I ISHODA OPERATIVNOG LEČENJA OLFAKTORNOG MENINGEOMA

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Olfaktorni meningeomi predstavljaju tumore prednje lobanjske jame koji su pozicionirani u srednjoj liniji iznad kribriiformne lamine sve do tuberkuluma sele. Čine 4-10% intrakranijalnih meningeoma i karakterišu se sporim rastom, zbog čega ih i nazivaju benignim tumorima. Žene češće obolevaju. Osnovni način lečenja olfaktornih meningeoma je operativni. Komplikacije hirurškog lečenja olfaktornih meningeoma javljaju se u periodu dužeg praćenja kod trećine operisanih, pri čemu su najčešće komplikacije cerebrospinalne fistule, epi napadi, postoperativni higromi, hematomi, pneumonija, embolije krvnih sudova, dok se smrtni ishod prosečno javlja kod 3% operisanih, pri čemu u grupi bolesnika sa ekstremno velikim olfaktornim meningeomima dostiže 11%.

Rad ima za cilj da utvrdi da li prisustvo peritumorskog edema kod obolelog od olfaktornog meningeoma može uticati na češću pojavu postoperativnih komplikacija, te da li preventivno uklanjanje edematoznih delova frontalnog režnja mozga, koji naležu na olfaktorni meningeom, može smanjiti učestalost komplikacija i smrtnog ishoda.

Rad obuhvata 35 operisanih (24 žene, 11 muškaraca) od olfaktornog meningeoma. Izračunavana je zapremina tumora i edema, a rezultati korelirani sa pojavom postoperativnih komplikacija i smrtnosti.

Posebno je analiziran značaj preventivnog uklanjanja malatičnih i edematoznih delova frontalnih režnjeva.

Operacija velikih olfaktornih meningeoma, istovremeno praćenih velikim stepenom peritumorskog moždanog edema, u vezi je sa visokim rizikom komplikacija, pre svega sa reaktivnim edemom i hemoragijom. Preventivno uklanjanje malatičnih i edematoznih delova mozga frontalnih režnjeva je koristan operativni postupak, koji značajno smanjuje postoperativni rizik edema, krvarenja i smrtni ishod. *Acta Medica Medianae 2014;53(2):22-27,*

Ključne reči: *olfaktorni meningeom, hirurško lečenje, peritumorski edem, komplikacije*