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Prognostic Factors for Parasagital Meningiomas Recurrence

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Abstract: *the study is relevant due to high prevalence of this type of pathology. Meningiomas account for 18% to 34% of all primary brain tumors. Parasagital meningiomas occur in 24.3% to 38.6% of cases. Despite their predominantly benign nature, parasagital meningiomas are more likely to recur/continue growing than meningiomas in other areas (18% to 40%). The key purpose of the study was to analyze the prognostic factors of parasagital meningiomas recurrence/continued growth, which will eventually improve surgical treatment outcomes. We conducted a retrospective and prospective analysis of 199 parasagital meningioma patients who were treated in Mechnikov Dnipropetrovsk Regional Clinical Hospital, Dnipropetrovsk Regional Council, from 2000 to 2021 inclusive. This article is based on a comparative analysis of the results of examination and surgical treatment and further analysis of pathohistological conclusion in two study groups. The first group included 180 (90.5%) patients with no recurrence/continued growth and second group included 19 (9.5%) patients with detected postoperative parasagital meningioma (PM) recurrence/continued growth. The selected patients were analyzed for demographic data (gender, age); computed tomography and magnetic resonance brain imaging results before and after adding an intravenous contrast (in terms of key characteristics); angiographic studies data (computed tomography angiography/ selective digital subtraction cerebral angiography); surgical radicality; pathohistological conclusions; recurrence-free period duration (one to 20 years after the surgery). In the follow-up period, 19 (9.5%) patients had PM recurrence/continued growth. In the first year after the surgery, only 2 of those patients had continued PM growth; within 5 years (60 months), 12 patients; within 10 years, 17 patients; the percentage of no- recurrence patients, based on censored data (recurrence-free survival), was 99.0% (95% CI, 97,6-100), 93,1% (95% CI, 89.3-96.9). and 87.5% (95% CI, 81.6-93.4) in the above follow-up periods. The actual median time to recurrence in our study was 44.1 (25.7; 85.4) months. It means that the majority (12 of 19 patients; 63.2%) of continued PM growth was detected within 5 years after the surgery. The last case of PM recurrence was diagnosed after 13 years (154.5 months) of the follow-up. Thus, recurrence-free 5- and 10-year survival in PM patients is as follows: in case of total tumor removal (Simpson I), 96.0% and 85.5%, respectively; in case of non-radical removal (Simpson II-V), 88.9% ($p<0.05$) and 81.9% ($p<0.05$), respectively. At the same time, non-radical surgery in type I-II SSS invasion by the PM reduces 5- and 10-year recurrence-free survival to 86.6% ($p<0.01$) and 78.3% ($p<0.01$), respectively; in case of tumor size of up to 54 mm, the indicators are 95.5% and 91.4%; with tumor size >54 mm, they are as low as 87.5% ($p<0.001$)*

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and 72.5% (p<0.001); in case of type I-III or V-VI SSS damage according to M. P. Sindou and J. E. Alvernia, 94.0% and 89.1%; and in case of type IV invasion, 66.5% (p<0.01) and 43.5% (p<0.001); in female patients, 95.2% and 88.5%; in male patients, 84.8% (p<0.05) and 73.0% (p<0.01). According to the Cox regression proportional hazards model, the relative risk of tumor recurrence/continued growth increases by: 7.04 times (95% CI, 2.33-21.2) in case of initial PM size >54 mm (p<0.001); 5.57 times (95% CI, 1.27-24.34) in case of non-radical (Simpson II-V) tumor removal during primary intervention (P<0.05); 10.1 times (95% CI, 1.31-78.1) in case of type I-II SSS invasion by the PM or incomplete (Simpson II-V) tumor removal (p<0.05); 3.25 times (95% CI, 1.32-8.02) in male patients (p<0.01); 3.33 times (95% CI, 1.10-10.12) in case of type IV SSS invasion (according to M.P. Sindou and J.E. Alvernia) (p<0.05). Adequate analysis of the results obtained will help the neurosurgeons plan the optimal surgery volume and ensure further postoperative recurrence-free period and improved long-term treatment outcomes.

Keywords: meningioma, prognosis, recurrence, risk factors, superior sagittal sinus, treatment outcome.

Introduction

Meningiomas account for 18% to 34% of all primary brain tumors. Parasagital meningiomas occur in 24.3% to 38.6% of cases. According to existing studies, parasagital meningiomas are more likely to recur/continue growing than meningiomas in other areas (18% to 40%). Low-grade meningiomas are the most common parasagital meningiomas (Behzadmehr et al., 2021, Balik et al., 2020, Cucu et al., 2020). Topographic and anatomical tumor connections with the surrounding intracranial structures is the key problem in trying to prevent the recurrence. Neoplasm location in close proximity to the superior sagittal sinus and the involvement of the sinus and parasagital emissary veins in the pathological process complicate the task of radical (Simpson I), and still safe, surgical removal. (Salah et al., 2019, Cucu et al., 2020). In this regard, the neurosurgeon is faced with a choice: either to attempt a radical (Simpson I) parasagital meningioma resection at the cost of a high risk of severe irreversible intraoperative and postoperative complications or opt to more gentle surgery, maintaining/improving the patient's functional state but, at the same time, exposing the patient to a higher risk of meningioma recurrence/continued growth.

It was found that parasagital meningioma mostly recurs in male patients (up to 70%). Continued tumor growth is more common in patients under 60 (61.5%) vs. patients over 60 (38.5%) (Balik et al., 2020).

According to the literature, the average time to recurrence is 97 months (59 to 135 months) for atypical meningiomas (WHO's grade II). At the same time, 77% of patients had recurrence-free survival in 5 years and 46% in 10 years. However, for benign meningiomas (WHO's grade I) there was no significant difference between 5- and 10-year recurrence-free survival — 98% and 93%, respectively. Based on 7 studies, the WHO's grade I parasagital meningioma recurs, in average, in 11.4% of patients; WHO's grade II, in 25% to 55.1% of patients. Moderate- to low-grade meningiomas (grades II-III) recur in up to 61% of patients (Behzadmehr et al., 2021, Balik et al., 2020).

In case of type II-VI superior sagittal sinus invasion according to M.P. Sindou and J.E. Alvernia, the 2-year recurrence reaches 33.3%; type I invasion according to M.P. Sindou and J.E. Alvernia, 8.3% (in average). In patients with type I-III sinus invasion according to M.P. Sindou and J.E. Alvernia, the risk of recurrence is significantly lower than in patients with more aggressive (type IV-VI) sinus lesion according to M.P. Sindou and J.E.Alvernia: 4.2% vs. 9.4%, respectively. However, there was no significant difference in the recurrence rate between the following groups of patients: type I vs. type II-VI; type I-II vs. type III-IV, and type I-IV vs. type V-VI according to M.P. Sindou and J.E. Alvernia. The risk of recurrence demonstrates insignificant dependence on the meningioma location expressed in a third of the superior sagittal sinus (Behzadmehr et al.,

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2021). However, there are isolated reports that 54% to 70% of all recurrences are in the middle third of the superior sagittal sinus, which is associated with topographic and anatomical characteristics of meningioma in this particular area (Balik et al., 2020).

After radical (Simpson I) removal of parasagital meningioma as low as 1% of patients have any recurrence; after a substantially total removal (Simpson I-II), 12.2%; and after subtotal removal (Simpson III-V), up to 24% (Behzadmehr et al., 2021, Cucu et al., 2020).

Results of imaging studies (computed tomography and magnetic resonance imaging) belong to other prognostic factors of tumor recurrence. Such factors, particularly, include neoplasm volume, which in almost 70% of cases exceed the average value. In some studies, (Nakasu et al., 2020, Siempis et al., 2020, Huang et al. 2019), almost 100% of recurrences had fuzzy edges of meningioma on magnetic resonance imaging, while other researchers reported no such association (Behzadmehr et al., 2021, Balik et al., 2020). In addition, it is reported that the majority of patients (61.5%) with recurrent meningioma experienced severe perifocal brain edema (Nakasu et al., 2020, Siempis et al., 2020).

Such conflicting data is still a subject of debate and raise questions about the role of the identified factors in the re-growth of meningioma. That is why the objective of our study was to determine the prognostic factors for parasagital meningioma recurrence/continued growth based on literature review and analysis of our own clinical experience.

Objective

Improving surgical parasagital meningiomas treatment outcomes by determining prognostic factors for their recurrence/continued growth.

Materials and Methods

We conducted retrospective and prospective analysis of 199 (100%) parasagital meningioma patients who were treated in Mechnikov Dnipropetrovsk Regional Clinical Hospital, Dnipropetrovsk Regional Council, from 2000 to 2021 inclusive.

This article is based on a comparative analysis of the results of examination and surgical treatment and further analysis of pathohistological conclusion in two study groups. The first group included 180 (90.5%) patients with no recurrence/continued growth and second group included 19 (9.5%) patients with detected postoperative parasagital meningioma (PM) recurrence/continued growth.

The selected patients were analyzed for demographic data (gender, age); computed tomography and magnetic resonance brain imaging results before and after adding an intravenous contrast (in terms of key characteristics); angiographic studies data (computed tomography angiography/selective digital subtraction cerebral angiography); surgical radicality; pathohistological conclusions; recurrence-free period duration (one to 20 years after the surgery).

Surgical radicality was identified according to Simpson I-V scale (Gatterbauer et al., 2017). The risk of recurrence was analyzed individually in the category of patients who had radical (Simpson I) parasagital meningioma removal, which is understood as macroscopically total tumor removal with matrix excision, and in the category of patients with non-radical removal (Simpson II-V).

Meningioma malignancy was determined according to the WHO World Health Organization (WHO) classification (Goldbrunner et al., 2016): Grade I = benign meningioma, Grade II = atypical meningioma, Grade III = anaplastic meningioma.

Brain computed tomography (CT) was performed using Optima CT660 | GE Healthcare, which assessed the meningioma's impact on adjacent bone: hyperostosis, bone destruction, extracranial tumor spread.

Brain magnetic resonance imaging (MRI) was performed using Toshiba Excelart Vantage 1.5 T. Key neuroimaging (T2WI, T1WI, DWI, and T1WI modes + intravenous contrast, axial, sagittal, and coronal planes) results included: location relative to the superior sagittal sinus (anterior, middle, posterior thirds); tumor size based on its largest linear size; tumor edges contrast (the edges were considered "clear" when a gap filled with cerebrospinal fluid was seen around the tumor perimeter); brain invasion (described if it was impossible to draw boundaries between the tumor and the surrounding brain tissue); signal intensity

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(hyper-, hypo-, isointensive, homogeneous, heterogeneous); intratumoral inclusions (necrosis, hemorrhage, cysts, calcification); presence and severity of perifocal edema.

Computed tomography angiography was performed using PHILIPS Mx 8000 IDT. Selective subtraction digital cerebral angiography was performed in the Endovascular Center, Mechnikov Dnipropetrovsk Regional Clinical Hospital, Dnipropetrovsk Regional Council, using Innova IGS 540 (GE Healthcare). Ultravist 370 and Visipaque 320 contrast agents were used for angiographic studies. The superior sagittal sinus damage degree was based on M.P. Sindou and J.E. Alvernia classification (types I-VI) (Ricci et al., 2017). The risk of parasagital meningioma recurrence was individually assessed in patients with types I-II, III-IV, and V-VI superior sagittal sinus damage according to M.P. Sindou and J.E.Alvernia.

Meningioma re-growth after its radical (Simpson I) removal was considered as its *recurrence*. Residual tumor growth was called the *continued growth* of a meningioma. This term was also used to describe the transformation of a lower-grade meningioma to a higher-grade meningioma (e.g., from the WHO's grade I to grade II) (Buerki et al., 2018). In our study, tumors that had continued growth included those that underwent Simpson II-V removal.

Postoperatively, all patients were subjected to dynamic monitoring by a neurologist and serial follow-up computed tomography and magnetic resonance imaging. The first follow-up brain magnetic resonance imaging was performed 6 months after the surgery, thereafter it was performed annually (subject to stable neurological status). If existing neurological symptoms worsened or new symptoms were detected, an unscheduled follow-up brain MRI was performed.

Data was processed and analyzed using STATISTICA 10 (StatSoft ® Inc., USA, license no. STA862D175437Q) and SPSS 17.0 (IBM, USA). Based on the law of quantitative data distribution (Shapiro-Wilk test), the following parametric and nonparametric characteristics and comparison methods were used: for normal distribution — arithmetic mean (M), standard deviation (SD), and Student's t score (t); for abnormal distribution — median (Me), interquartile range (LQ; HQ), and Mann-Whitney value (U). Probability of differences in categorical data was estimated using the Pearson chi-square value ($\chi 2$) without Yates chi-square correction. Prognostic significance of various factors for assessing the probability of postoperative tumor recurrence was determined using ROC analysis by determining the point of differentiation of indicator values in the recurrence and no-recurrence groups and calculating the area under ROC curve (AUC) and operational characteristics (sensitivity, specificity). The recurrence-free survival indicators depending on certain factors (predictors) were analyzed using the life tables, Kaplan-Meier curves, and the Cox proportional hazards regression model with the risk ratio (RR) calculated in a 95% confidence interval (95% CI). Differences in survival rates in the early follow-up period were assessed using the Gehan-Wilcoxon Test (GWT); in the entire follow-up period, using the log rank test (LRT). The critical level of statistical significance when testing all hypotheses (P) was assumed to be ≤ 0.05 and the trend was assessed for $p<0.1$.

Results

In the follow-up period, 19 (9.5%) patients had PM recurrence/continued growth. In the first year after the surgery, only 2 of those patients had continued PM growth; within 5 years (60 months), 12 patients; within 10 years, 17 patients; the percentage of no- recurrence patients, based on censored data (recurrence-free survival), was 99.0% (95% CI, 97,6-100), 93,1% (95% CI, 89.3-96.9). and 87.5% (95% CI, 81.6-93.4) in the above follow-up periods. The actual median time to recurrence in our study was 44.1 (25.7; 85.4) months. It means that the majority (12 of 19 patients; 63.2%) of continued PM growth was detected within 5 years after the surgery. The last case of PM recurrence was diagnosed after 13 years (154.5 months) of the follow-up.

A comparative analysis of key characteristics of patients and neoplasms in 2 study groups was used to determine the factors associated with the post-surgery PM recurrence (see Table 1).

As can be seen from Table 1, the first group (no recurrence) was dominated by female patients — 133 (73.9%), the age of patients ranged from 19 to 75 and averaged 53.9±12.1 years. In the second group (recurrence), there were 9 female patients

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Table 1. General characteristics of patients and neoplasms in the study groups

Characteristics		Group 1 (no recurrence) n=180	Group 2 (with recurrences) n=19	Statistical significance of inter-group differences
Gender	Female	133 (73.9%)	9 (47.4%)	χ2=5.91; p=0.015
	Male	47 (26.1%)	10 (52.6%)	
Age, years	18-44	34 (18.9%)	2 (10.5%)	χ2=0.81; p=0.368
	45-59	79 (43.9%)	13 (68.4%)	χ2=4.16; **p=0.041**
	60-75	67 (37.2%)	4 (21.1%)	χ2=1,96; p=0,162
	Average age, M±SD	53.9±12.1	55.8±9.6	t=0.67; p=0.506
Parasagital meningioma location relative to the superior sagittal sinus	Anterior third	56 (31.1%)	5 (26.3%)	χ2=0,19; p=0,666
	Middle third	99 (55.0%)	10 (52.6%)	χ2=0.04; p=0.844
	Posterior third	25 (13.9%)	4 (21.1%)	χ2=0,71; p=0,400
	Left	84 (46.7%)	10 (52.6%)	χ2=0.245; p=0.62
	Right	78 (43.3%)	7 (36.9%)	χ2=0,296; p=0,586
	Bilateral	18 (10.0%)	2 (10.5%)	χ2=0,005; p=0,942
Average size, IU (LQ; HQ) (mm)		48 (35; 60)	60 (55; 75)	U=842.5; **p<0.001**
SSS invasion according to M.P. Sindou and J.E. Alvernia	Type I	112 (62.2%)	12 (63.2%)	χ2=0.006; p=0.936
	Type II	13 (7.2%)	1 (5.3%)	χ2=0,10; p=0,751
	Type III	16 (8.9%)	-	χ2=1.84; p=0.175
	Type IV	10 (5.6%)	4 (21.1%)	χ2=6.31; **p=0.012**
	Type V	11 (6.1%)	1 (5.3%)	χ2=0,02; p=0,883
	Type VI	18 (10.0%)	1 (5.3%)	χ2=0.45; p=0.504
	Category I-II	125 (69.4%)	13 (68.4%)	χ2=0,08; p=0,927
	Category III-IV	26 (14.5%)	4 (21.1%)	χ2=0,59; p=0,444
	Category V-VI	29 (16.1%)	2 (10.5%)	χ2=0.41; p=0.523

(47.4%) and 10 male patients (52.6%), p<0.05 between the groups; average age was 55.8±9.6 (p>0.05). According to the WHO classification by age, the first group's age category of 18 to 44 included 34 (18.9%) patients; age category of 45 to 59 included 79 (43.9%) patients, and age category of 60 to 75 included 67 (37.2%) patients. In the second study group, 2 (10.5%) patients were assigned to the first age category, 13 (68.4%) to the second, and 4 (21.1%) to the third. Despite the absence of significant differences between the groups in terms of average patient's age, patients from the age category of 45 to 59 dominated the recurrence group (p<0.05).

We found no significant association between the PM location relative to the superior sagittal sinus (SSS) and tumor recurrence (p>0.05). In the first group, PM located in the anterior third of the SSS occurred in 56 (31.1%) patients, the middle third in 99 (55.0%) patients, and the posterior third in 25 (13.9%) patients. 84 (46.7%) had meningiomas growing to the left, 78 (43.3%) growing to the right, and 18 (10.0%) had bilateral meningiomas. 5 (26.3%) patients had recurrent meningiomas in the anterior third of the SSS, 10 (52.6%) in the middle third, and 4 (21.1%) in the posterior third. Among them, 10 (52.6%) patients had a tumor node on the left side of the sinus, 7 (36.9%) on the right side, and 2 (10.5%) patients had bilateral tumor spread. Average meningioma size in the second group was 1.3 times higher than in the first group — 60 (55; 75) (mm) vs. 48 (35; 60) (mm), p<0.001.

According to M.P. Sindou and J.E. Alvernia, 112 (62.2%) patients of the first group had type I

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SSS invasion, 13 (7.2%), had type II; 16 (8.9%) had type III, 10 (5.6%) had type IV, 11 (6.1%) had type V, and 18 (10.0%) had type VI. 125 (69.4%) patients were categorized to type I-II according to M.P. Sindou and J.E. Alvernia, 26 (14.5%) to types III-IV, and 29 (16.1%) to type V-VI sinus occlusion. In the recurrence group, parasagital meningiomas invaded the SSS as follows: type I according to M.P. Sindou and J.E. Alvernia, 12 (63.2%) patients; type II, 1 (5.3%); type III, 0 (0%); type IV, 4 (21.1%); type V, 1 (5.3%); type VI, 1 (5.3%). Type I-II category included 13 (68.4%) patients, type III-IV 4 (21.1%) patients, and type V-VI 2 (10.5%) patients. In terms of the SSS invasion by the tumor, the recurrence group had higher frequency of type IV sinus occlusion: 21.1% vs. 5.6% in the no-recurrence group ($p<0.05$).

127 of 180 (70.6%) patients in the first group underwent brain magnetic resonance imaging (MRI) with intravenous contrast added in 88 (69.3%) cases. 73 (57.5%) patients had hyperintensive meningioma, 8 (6.3%) hypointensive, 16 (12.6%) isointensive, and 30 (23.6%) heterogeneous (see Table 2). Perifocal edema was detected in 46 (36.2%) patients, intratumoral necrosis in 37 (29.1%), dural tail in 29 (22.8%), and signs of brain tissue tumor invasion in 9 (7.1%). In the second group, 12 of 19 (63.2%) patients underwent brain MRI with intravenous contrast added in 10 of 12 (83.3%) cases. Hyperintensive meningioma was diagnosed in 7 (58.3%) patients, isointensive in 2 (16.7%), heterogeneous in 3 (25.0%), with no cases of hypointensive PM. Perifocal edema was detected in 5 (41.7%) patients, intratumoral necrosis in 5 (41.7%), and dural tail in 3 (25.0%). 3 (25.0%) patients of the second group had fuzzy meningioma edges and signs of brain tissue tumor invasion, which significantly exceeded the value in the first group (7.1%) with $p<0.05$.

119 (66.1%) patients of the first group underwent brain computed tomography (CT); in 64 (53.8%) cases, intravenous contrast was added. Among the bone manifestations of meningioma, hyperostosis was detected in 27 (22.7%) patients, bone destruction in 21 (17.6%) patients (see Table 2). Similar brain CT scan was performed in 14 (73.7%) patients of the second group; in 50.0% of cases (7 of 14), intravenous contrast was added. Among the bone manifestations of meningioma, hyperostosis was detected in 3 (21.4%) patients and bone destruction in 2 (14.3%) patients.

Study groups comparison in terms of selected brain MRI and CT results (see Table 2) showed no dependence of PM recurrence/continued growth on signs of adjacent bone invasion, T2WI signal intensity, presence of perifocal edema, intratumoral inclusions, or signs of dural tail ($p>0.05$). At the same time, patients with MR signs of brain tumor invasion had significantly higher ($p<0.05$) PM recurrence rate.

Radical (Simpson I) surgical meningioma removal in the first group was achieved in 90 (50.0%) patients (see Table 2). The remaining 90 (50.0%) patients underwent non-radical (Simpson II-V) tumor removal. Among them, 56 (31.1%) patients had Simpson II removal, 14 (7.8%) Simpson III, and 20 (11.1%) Simpson IV. In the second study group, radical surgery was only performed in 2 (10.5%) cases, which is significantly less than in the no-recurrence group ($p=0.001$). The remaining 17 (89.5%) patients underwent non-radical surgery, 11 (57.9%) of which had Simpson II removal, 2 (10.5%) Simpson III, and 4 (21.1%) Simpson IV.

Note that the frequency of continued PM growth was significantly higher after non-radical removal of type I-II SSS invasion neoplasms — 92.3% vs. 43.2% ($p<0.001$) (see Table 3). In SSS type III-IV and V-VI invasion tumors, there was no significant association between continued growth surgical radicality ($p>0.05$). That is, the risk of PM recurrence increases if type I-II SSS invasion tumor is not totally removed.

According to histological examination of removed neoplasm specimens, 169 of 199 PMs (84.9%) were benign (grade I), 14 (7.0%) met the criteria of grade II (atypical meningioma), and 16 (8.1%) grade III (anaplastic meningioma). At the same time, recurrence/continued growth of grade I PMs was detected in 14 (8.3%) patients, grade II in 3 (21.4%), and grade III in 2 (12.5%).

Analysis of histological PM structure in the study groups (see Table 2) showed that among 155 (86.1%) benign meningiomas in the first group, mixed meningiomas were diagnosed in 39 (21.7%) cases, meningoteliomatous in 54

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Table 2. Comparative study groups characteristics in terms of results of diagnostic and histological studies and surgeries

Characteristics		Group 1 (no recurrence)	Group 2 (with recurrences)	Statistical significance of inter-group differences
Magnetic resonance brain imaging (n1=127, n2=12)				
T2WI mode density	Hyperintensive	73 (57.5%)	7 (58.3%)	$\chi2$=0.003; p=0.954
	Hypointensive	8 (6.3%)	-	$\chi2$=0.80; p=0.370
	Isointensive	16 (12.6%)	2 (16.7%)	$\chi2$=0.16; p=0.688
	Heterogeneous	30 (23.6%)	3 (25.0%)	$\chi2$=0.01; p=0.915
Perifocal edema		46 (36.2%)	5 (41.7%)	$\chi2$=0.14; p=0.708
Intrathumoral inclusions		37 (29.1%)	5 (41.7%)	$\chi2$=0.82; p=0.366
Dural tail		29 (22.8%)	3 (25.0%)	$\chi2$=0,03; p=0,865
Brain invasion		9 (7.1%)	3 (25.0%)	$\chi2$=4.46; p=0.035
Computed tomography brain imaging (n1=119, n2=14)				
Hyperostosis		27 (22.7%)	3 (21.4%)	$\chi2$=0.01; p=0.915
Bone destruction		21 (17.6%)	2 (14.3%)	$\chi2$=0.10; p=0.753
Surgical intervention characteristics (n1=180, n2 = 19)				
Surgical radicality according to Simpson grading scale	Simpson I	90 (50.0%)	2 (10.5%)	$\chi2$=10.77; p=0.001
	Simpson II-V	90 (50.0%)	17 (89.5%)	
	Simpson II	56 (31.1%)	11 (57.9%)	$\chi2$=5.52; p=0.019
	Simpson III	14 (7.8%)	2 (10.5%)	$\chi2$=0.18; p=0.675
	Simpson IV	20 (11.1%)	4 (21.1%)	$\chi2$=1.60; p=0.206
	Simpson V	-	-	
Histological neoplasm examination (n1 = 180, n2 = 19)				
Meningioma malignancy and histological type according to the World Health Organization (WHO) classification	Grade I	155 (86.1%)	14 (73.7%)	$\chi2$=2.07; p=0.150
	Mixed	39 (21.7%)	2 (10.5%)	$\chi2$=1.30; p=0.254
	Meningoteliomatous	54 (30.0%)	9 (47.4%)	$\chi2$=2.40; p=0.122
	Fibrous	23 (12.8%)	1 (5.3%)	$\chi2$=0.92; p=0.339
	Transitional	3 (1.7%)	-	$\chi2$=0.32; p=0.571
	Psamomatous	32 (17.8%)	2 (10.5%)	$\chi2$=0.64; p=0.424
	Angiomatous	3 (1.7%)	-	$\chi2$=0.32; p=0.571
	With severe lymphoplasmocytic infiltration	1 (0.6%)	-	$\chi2$=0.11; p=0.745
	Grade II (atypical)	11 (6.1%)	3 (15.8%)	$\chi2$=2.46; p=0.117
	Grade III (anaplastic)	14 (7.8%)	2 (10.5%)	$\chi2$=0.18; p=0.675

Note: n_1 = the number of patients in the study group 1; n_2 = the number of patients in the study group 2

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Table 3. Surgical radicality depending on the SSS invasion by parasagital meningioma in the study groups

Radical meningioma removal	SSS damage according to M.P. Sindou and J.E. Alvernia classification					
	I-II		III-IV		V-VI	
	Group 1 (n=125)	Group 2 (n=13)	Group 1 (n=26)	Group 2 (n=4)	Group 1 (n=29)	Group 2 (n=2)
Simpson I	71 (56.8%)	1 (7.7%)	4 (15.4%)	–	15 (51.7%)	1 (50.0%)
Simpson II-IV	54 (43.2%)	12 (92.3%)	22 (84.6%)	4 (100.0%)	14 (48.3%)	1 (50.0%)
Statistical significance of inter-group differences	$\chi2$=11.38; p<0.001		$\chi2$=0.71; p=0.399		$\chi2$=0.002; p=0.962	

(30.0%), fibrous in 23 (12.8%), transient in 3 (1.7%), psamomatous in 32 (17.8%), angiomatous in 3 (1.7%), and meningiomas with severe lymphoplasmocytic infiltration in one case (0.6%). 11 (6.1%) patients had moderate-grade meningiomas (grade II) and 14 (7.8%) had low-grade meningiomas. In the continued PM growth group, benign meningiomas were detected in 14 (73.7%) patients, including mixed meningiomas in 2 (10.5%) cases, meningoteliomatous meningiomas in 9 (47.4%) cases, fibrous meningioma in 1 (5.3%) case, and psamomatous meningiomas in 2 (10.5%) cases. Grade II (atypical) meningioma was detected in 3 (15.8%) patients and grade III (anaplastic) meningioma in 2 (10.5%).

In general, study groups' indicators comparison in terms of histological PM structure showed insignificant differences (p>0.05), which can be explained by low number of cases of grade II and grade III PMs (14 and 16 cases, respectively) and sufficiency of surgical intervention during primary tumor removal. The first, no-recurrence, group, among 12 patients of moderate- and low-grade PM with type I SSS invasion according to M.P. Sindou and J.E. Alvernia, 7 (58.3%) underwent radical surgery (Simpson I); in the second group, 4 patients with type I sinus occlusion underwent Simpson II surgery (p=0.042 based on χ^2). The above may indicate a low informative value of tumors malignancy to predict the risk of postoperative PM recurrence/continued growth, which requires further research.

Significant differences between the study groups based on comparative analysis allowed determining the factors (predictors) associated with postoperative PM recurrence. In particular, tumor recurrence occurs significantly more often in men than in women (low direct correlation, r=0.17, p=0.015) and in the 45 to 59 age group (low direct correlation, r=0.14, p=0.042). Higher risk of tumor recurrence (r=0.26, p<0.001) is associated with increased tumor size, type IV SSS invasion according to M. P. Sindou and J. E. Alvernia (r=0.18, p=0.012), and Simpson II-V incomplete tumor removal (r=0.23, p=0.001), especially in case of type I-II SSS invasion (r=0.29, p<0.001). According to the MRI, the risk of PM recurrence can be reliably indicated by such neuroimaging sign of meningioma brain invasion as fuzzy tumor edges (low direct correlation, r=0.18, p=0.035). At the same time, in cases of radical tumor removal (Simpson I), recurrence was significantly less common (inverse correlation is low: r=-0,23, p<0,001).

Predictive potential of the above factors for PM recurrence/continued growth was assessed using ROC analysis and Cox proportional hazards regression models. The latter made it possible to assess the predictors impact on the risk of recurrence within 20 years (240 months) of the follow-up, given all primary data, including incomplete (censored) data.

The ROC analysis demonstrated that non-radical (Simpson II-V) PM removal and large tumor sizes have the highest prognostic potential in determining the risk of continued PM growth, especially in type I-II SSS invasion (see Fig. 1, Table 4).

With an initial PM size of >54 mm (area under ROC curve, 0.754 (95% CI, 0.688-0.812)), the rel-

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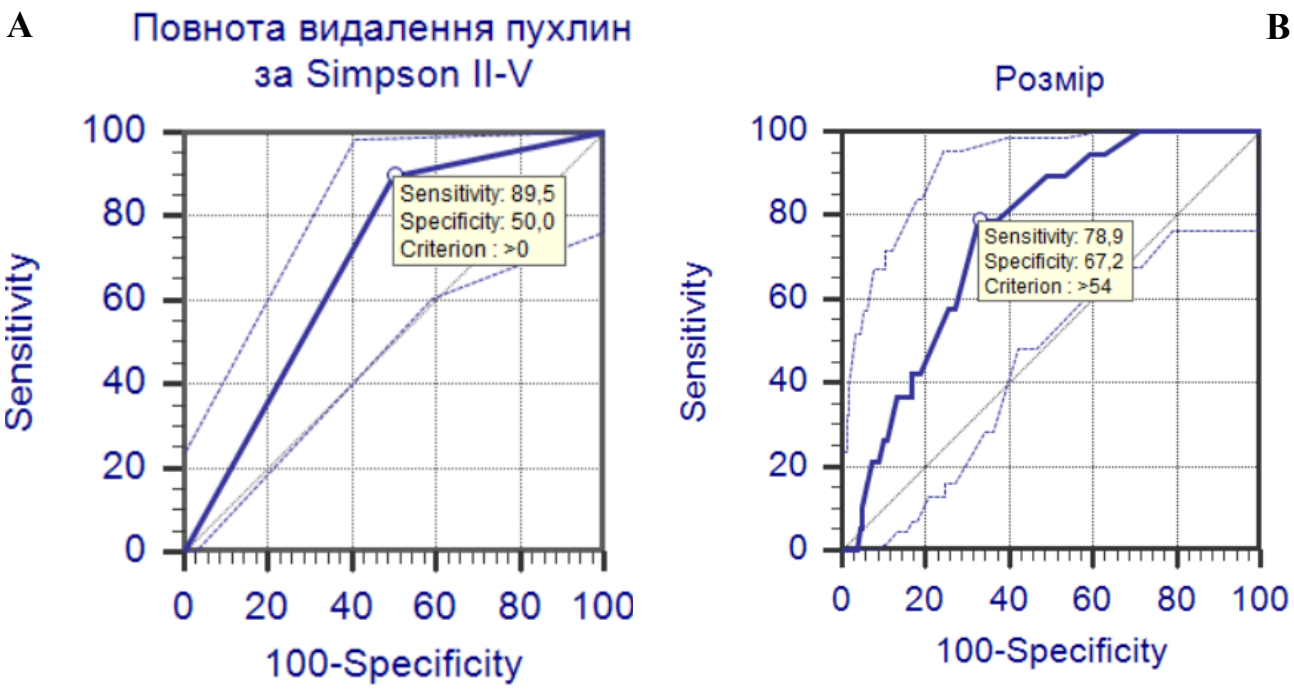

Fig. 1. ROC curves of surgical radicality (A) and PM size (B) in determining the risk of continued PM growth within 20 years of the follow-up

Table 4. Prognostic significance of individual factors associated with postoperative PM recurrence

Indicator	ROC analysis				Cox model	
	Criterion (cut-off threshold)	Area under the ROC curve (AUC, 95% CI)	AUC significance level (p)	Se/Sp (%)	RR (95% CI)	Signif-icance level (p)
Patient's gender	male	0.633 (0.562-0.700)	0.046	52.6/73.9	3.25 (1.32-8.02)	0.01
Age, years	45-59	0.623 (0.551-0.690)	0.087	68.4/56.1	2.27 (0.86-6.01)	0.098
SSS invasion according to M.P. Sindou and J.E. Alvernia classification)	IV	0.577 (0.508-0.647)	0.099	21.1/94.4	3.33 (1.10-10.12)	0.034
MRI sign of brain tissue tumor invasion	Yes	0.590 (0.503-0.672)	0.177	25.0/92.9	3.56 (0.96-13.17)	0.057
Surgical radicality according to Simpson grading scale	II-V	0.697 (0.628-0.760)	0.005	89.5/50.0	5.57 (1.27-24.34)	0.023
Surgical radicality in type I-II SSS invasion by the PM	II-V	0.746 (0.664-0.816)	<0.001	92.3/56.8	10.1 (1.31-78.1)	0.027
Tumor size, mm	>54	0.754 (0.688-0.812)	<0.001	78.9/67.2	7.04 (2.33-21.2)	<0.001

Notes: Se/Sp = criterion sensitivity/specificity; RR = relative risk of PM recurrence or continued growth based on censored data.

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Table 5. Cumulative recurrence-free survival of PM patients depending on prognostically significant factors

Indicator	Criterion (cut-off threshold)	Recurrence-free survival (according to life tables)*		
		after 1 year	after 5 years	after 10 years
Patient's gender	female (n=142)	0/99.6 (98.7-100)	5/95.2 (91.4-99.0)	8/88.5 (81.4-95.5)
	male (n=57)	2/96.4 (91.6-100)	7/84.8 (74.6-95.0)	9/73.0 (58.5-87.5)
SSS invasion according to M.P. Sindou and J.E. Alvernia classification)	I-III, V-VI (n=185)	2/98.9 (97.4-100)	9/94.0 (90.3-97.8)	13/89.1 (83.4-94.9)
	IV (n=14)	0/96.3 (86.2-100)	3/66.5 (41.2-91.8)	4/43.5 (16.8-70.3)
Surgical radicality according to Simpson grading scale	I (n=92)	0/99.5 (97.9-100)	1/96.0 (91.4-100)	2/85.5 (72.5-98.5)
	II-V (n=107)	2/98.1 (95.5-100)	11/88.9 (82.7-95.1)	15/81.9 (73.7-90.2)
Surgical radicality according to Simpson grading scale in type I-II SSS invasion by the PM	I (n=72)	0/99.3 (97.4-100)	1/94.9 (89.2-100)	1/85.1 (71.7-98.4)
	II-V (n=66)	2/97.0 (92.8-100)	8/86.6 (78.3-95.0)	11/78.3 (67.3-89.2)
Tumor size, mm	≤54 (n=125)	1/99.2 (97.6-100)	4/95.5 (91.5-99.4)	4/91.4 (85.2-97.7)
	>54 (n=74)	1/98.6 (95.9-100)	8/87.5 (79.3-95.7)	13/72.5 (59.0-86.0)

*Notes: *Actual number of patients who experienced PM recurrence or continued growth within the specified follow-up period /recurrence-free survival based on the censored data in % (95% CI).*

ative risk of tumor recurrence (according to Cox regression) increased by 7.04 times (95% CI, 2.33-21.2) vs. smaller tumor sizes ($p<0.001$) (see Table 4). Moreover, this criterion has high sensitivity (78.9%) and specificity (67.2%). Non-radical (Simpson II-V) tumor removal during primary intervention increases the risk of unfavorable prognosis by 5.57 times (95% CI, 1.27-24.34); in case of type I-II SSS invasion by the PM, by 10.1 times (95% CI, 1.31-78.1), with high sensitivity indicators (89.5% and 92.3%, respectively).

As for other identified PM recurrence predictors, based on censored data, male gender (BP=3.25) and type IV SSS invasion according to M.P. Sindou and J.E. Alvernia had a statistically significant effect ($p<0.05$) (RR=3.33) (see Table 4). Moreover, the latter criterion has a low sensitivity (21.1%) and high specificity (94.4%). Statistical significance of continued PM growth risk indicators in patients aged 45 to 59 and MRI signs of brain tissue invasion by the tumor met the trend criteria ($p<0.1$).

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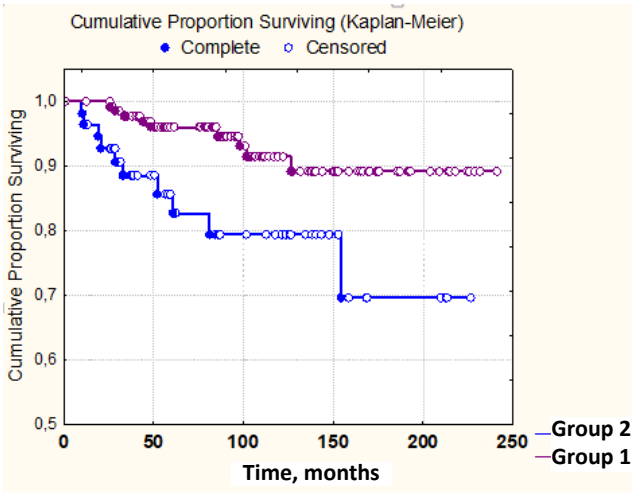
Fig. 2. Cumulative Kaplan-Meier curves for the PM recurrence/continued growth depending on the patient's gender.



Notes: 1. Group 1 = female patients; group 2 = male patients. 2. Statistical significance of inter-group differences according to the GWT criteria: p=0.004, LRT criteria: p=0.009.

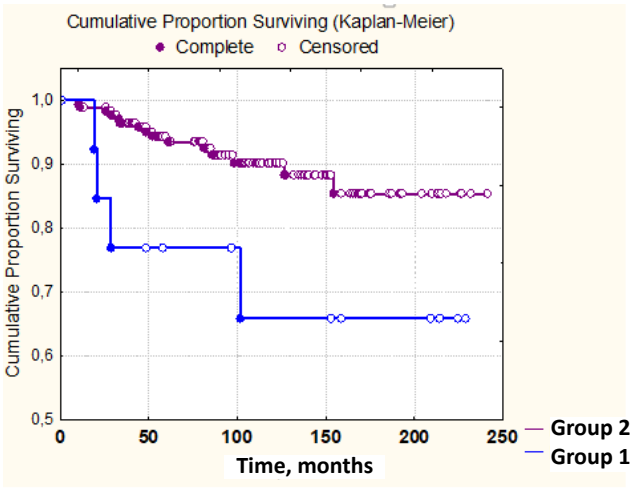
Table 5 and Figs. 2-6 show recurrence-free survival and cumulative Kaplan-Meier curves for PM recurrence/continued growth within 20 years of postoperative follow-up, depending on statistically significant (p<0.05) impact factors.

As can be seen from Figure 2 and Table 5, the longest recurrence-free period was demonstrated by female patients, both in the first (GWT: p=0.004) and during the entire follow-up period (LRT: p=0.009). In the shortest follow-up period (1 year) 2 of 57 male patients sustained a recurrence; within 5 years, 7; and within 10 years, 9. Respectively, 96.4%, 84.8% and 73.0% of male patients remained in the state of remission. Female patients had no recurrences within the first year after the surgery, 5 of 142 patients had recurrences within 5 years, and 8 had continued tumor growth within 10 years. At the same time, the recurrence-free survival in female patients in the same periods were 99.6%, 95.2%, and 88.5%, respectively, which is higher than in male patients by, in average, 3.2% (p>0.05), 10.4% (p<0.05), and 15.5% (p<0.01), respectively.

As can be seen from Fig. 3 and Table 5, patients with types I-III and V-VI SSS lesions according to M.P. Sindou and J. E. Alvernia (group 1) had significantly higher cumulative survival (GWT: p=0.006, LRT: p=0.021) vs. patients with type IV invasion (group 2). Within 5 years of the follow-up, only 9 of 185 patients with type I-III and V-VI SSS lesion had tumor recurrence and 94.0% of patients remained in the state of remission; within 10 years of the follow-up, 13 patients experienced continued PM growth and respective recurrence-free survival was 89.1%. In the type IV SSS damage group, in the above periods, 3-4 of 14 patients had PM recurrence and 66.5% and 43.5% of patients remained in the state of remission, respectively. Therefore, in case of type IV SSS lesion, the 5-year recurrence-free survival of PM patients is 1.4 times lower (p<0.01) and the 10-year survival is 2.0 times lower (p<0.001) than in case of type I-III or V-VI SSS invasion according to M.P. Sindou and J. E. Alvernia.

Comparative analysis of the Kaplan-Meier recurrence-free survival curves depending on the PM primary surgery radicality also showed significant discrepancies between the indicators (GWT: p=0.011, LRT: p=0.014) (see Fig. 4). The total number of patients who had PM recurrence or continued PM growth within 1, 5, and 10 years of the follow-up was, respectively, 0, 1, and 2 of

Fig. 3. Cumulative Kaplan-Meier curves for the PM recurrence/continued growth depending on the SSS damage.



Notes: 1. Group 1: types I-III, and V-VI according to M.P. Sindou and J.E. Alvernia; Group 2: type IV; 2. Statistical significance of inter-group differences according to the GWT criteria: p=0.006; LRT criteria: p=0.021

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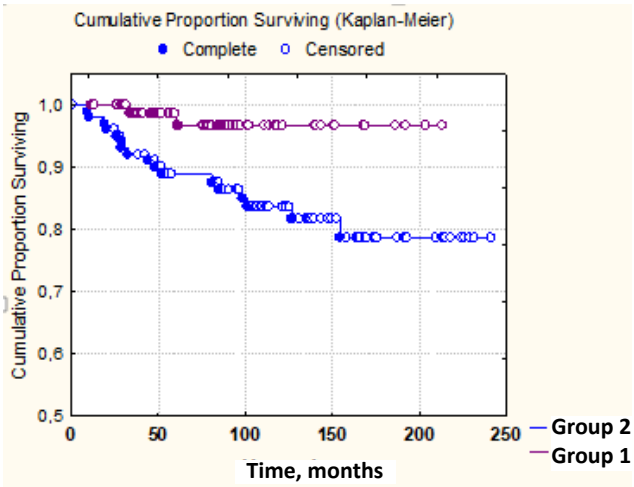
Fig. 4. Cumulative Kaplan-Meier curves for the PM recurrence/continued growth depending on surgical radicality.



Notes: 1. Group 1: Simpson I; group 2: Simpson II. 2. Statistical significance of inter-group differences according to the GWT criteria: p=0.011, LRT criteria: p=0.014.

92 patients who underwent radical (Simpson I) surgery (group 1). At the same time, 99.5%, 96.0%, and 85.5% of the patients remained in the state of remission (see Table 5). Among the 107 patients in the second group, who underwent incomplete (Simpson II-V) tumor removal, 2, 11, and 15 patients had tumor recurrence within 1, 5, and 10years of the follow-up, respectively, and 98.1%, 88.9%, and 81.9% of patients remained in the state of remission, which is less than the first group indicators by 1.4% (p>0.05), 7.1% (p<0.05), and 3.6% (p<0.05).

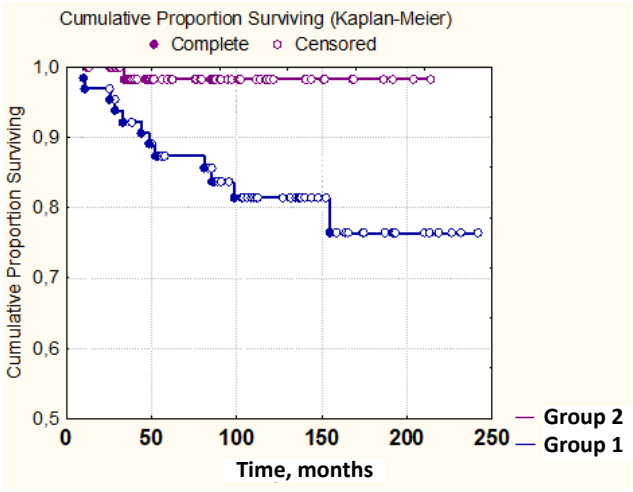
The impact of radical PM removal on the recurrence-free period duration within 20 years of the follow-up was more pronounced in case of type I-II SSS invasion (see Fig. 5, Table 5). In case of total tumor removal (Simpson I), only one of 72 patients had tumor recurrence within 5-10 years; the recurrence-free survival made 94.9% and 85.1%, respectively; on the other hand, 8-11 of 66 patients with incomplete tumor removal (Simpson II-V) had continued PM growth within 5 and 10 years of the follow-up, respectively. 86.6% and 78.3% of patients remained in the state of remission, which is, respectively, by 8.3% (p<0.01) and 6.8% (p<0.01) less than in the first group.

Significant differences between cumulative recurrence-free survival were noted when comparing Kaplan-Meier curves for different tumor sizes (GWT: p<0.001, LRT: p<0.001) (see Fig. 6). For instance, 4 of 125 patients with a tumor size ≤54 mm (group 1) had tumor recurrence in the 5-year follow-up period and 95.5% of the patients remained in the state of remission. In the group with a meningioma size >54 mm (group 2), 8 of 74 patients had tumor recurrence in the same follow-up period; the recurrence-free survival made 87.5%, which is by 8.0% less than in the first group (p<0.001). 4 patients in the first group and 13 patients in the second group had tumor recurrence within 10 years of the follow-up. The percentage of patients who did not demonstrate PM growth in this period in the second group was 18.9% less than in the first group — 72.5% vs. 91.4% (p<0.001).

Discussion.

In the studied category of patients, there was no significant association between parasagital meningioma recurrence or continued growth and CT/MRI signs of perifocal brain edema reported by other studies (Nakasu et al., 2020, Siempis et al., 2020, Huang et al. 2019) and no significant

Fig. 5. Cumulative Kaplan-Meier curves for the PM recurrence/continued growth depending on surgical radicality in types I-II SSS lesions according to M.P. Sindou and J. E. Alvernia.



Notes: 1. Group 1: Simpson I; group 2: Simpson II. 2. Statistical significance of inter-group differences according to the GWT criteria: p=0.009, LRT criteria: p=0.007.

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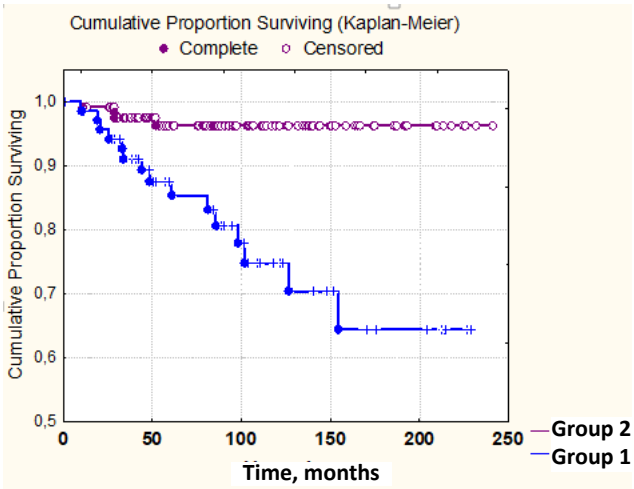
Fig. 6. Cumulative Kaplan-Meier curves for the PM recurrence/continued growth depending on tumor size.



Notes: 1. Group 1: tumor size ≤ 54 mm; group 2: tumor size > 54 mm. 2. Statistical significance of inter-group differences according to the GWT criteria: p=0.001, LRT criteria: p=0.001.

association with the computed tomography characteristics of the tumor (Yu et al., 2020).

However, the resulting prognostic factors of parasagital meningioma recurrence/continued growth in this study are consistent with the data from known literature sources (Behzadmehr et al., 2021, Balik et al., 2020, Cucu et al., 2020, Salah et al., 2019, Siempis et al., 2020). However, we found that recurrence-free 5- and 10-year survival in PM patients is as follows: 1) in case of total tumor removal (Simpson I), 96.0% and 85.5%, respectively; in case of non-radical removal (Simpson II-V), 88.9% (p<0.05) and 81.9% (p<0.05), respectively. At the same time, non-radical surgery in type I-II SSS invasion by the PM reduces 5- and 10-year recurrence-free survival to 86.6% (p<0.01) and 78.3% (p<0.01), respectively; in case of tumor size of up to 54 mm, the indicators are 95.5% and 91.4%; with tumor size >54 mm, they are as low as 87.5% (p<0.001) and 72.5% (p<0.001); in case of type I-III or V-VI SSS damage according to M. P. Sindou and J. E. Alvernia, 94.0% and 89.1%; and in case of type IV invasion, 66.5% (p<0.01) and 43.5% (p<0.001); in female patients, 95.2% and 88.5%; in male patients, 84.8% (p<0.05) and 73.0% (p<0.01). According to the Cox regression proportional hazards model, the relative risk of tumor recurrence/continued growth increases by: 1) 7.04 times (95% CI, 2.33-21.2) in case of initial PM size >54 mm (p<0.001); 5.57 times (95% CI, 1.27-24.34) in case of non-radical tumor removal during primary intervention (Simpson II-V) (P<0.05); 10.1 times (95% CI, 1.31-78.1) in case of type I-II SSS invasion by the PM or incomplete tumor removal (Simpson II-V) (p<0.05); 3.25 times (95% CI, 1.32-8.02) in male patients (p<0.01); 3.33 times (95% CI, 1.10-10.12) in case of type IV SSS invasion (according to M.P. Sindou and J.E. Alvernia) (p<0.05).

The identified prognostic factors for parasagital meningioma recurrence or continued growth shall be taken into account when planning the scope of surgical intervention and selecting the tactics of postoperative follow-up and patients' treatment.

Conclusions

1. The patient's gender must be taken into account when planning a particular surgical strategy for parasagital meningioma removal as men are more likely to experience tumor recurrence or continued growth.
2. Preoperative diagnosis of parasagital meningiomas must necessarily include brain CT/MRI with intravenous contrast and cerebral vascular system angiographic examination (CT angiography, selective subtraction digital cerebral angiography), followed by tumor size determination and the nature of its invasion into the superior sagittal sinus, as the tumor size of >54 mm and type IV SSS lesion according to M.P. Sindou and J.E. Alvernia is a significant risk factor for tumor recurrence/continued growth.
3. Surgical radicality shall be as close as possible to total (Simpson I) removal of parasagital meningioma, which will minimize the risks of postoperative tumor recurrence or continued growth, especially in case of meningiomas that extend to both walls of the superior sagittal sinus (type IV according to M.P. Sindou and J.E. Alvernia).
4. Adequate analysis of the results obtained will help the neurosurgeons plan the optimal surgery volume and ensure further postoperative recurrence-free period and improved long-term treatment outcomes.

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Conflict of interest

The authors state that there is no conflict of interest.

Consent to publication

All procedures performed for patients during the study comply with ethical standards of institutional and national ethics committees and the Declaration of Helsinki (1964), as amended, or similar ethical standards. All patients have provided their informed and voluntary written consent to participate in the study.

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A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of article

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Прогностичні фактори рецидиву/продовженого росту парасагітальних менінгіом

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Анотація: актуальність дослідження полягає в широкій розповсюдженості даної патології. Менінгіоми складають 18-34% від усіх первинних пухлин головного мозку. Серед них, парасагітальні менінгіоми зустрічаються в 24,3-38,6 % спостережень. Незважаючи на переважно доброякісний характер парасагітальні менінгіоми схильні до рецидиву/продовженого росту частіше ніж менінгіоми інших локалізацій (від 18% до 40%). Основною метою дослідження є вивчення прогностичних факторів рецидиву/продовженого росту парасагітальних менінгіом, що в подальшому впливатиме на покращення результатів хірургічного лікування. Нами проведено ретроспективний та проспективний аналіз 199 хворих із парасагітальними менінгіомами, які знаходились на лікуванні в комунальному підприємстві «Дніпропетровська обласна

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клінічна лікарня імені І.І. Мечникова» Дніпропетровської обласної ради» в період з 2000 по 2021 рік включно. В основу даної роботи покладено порівняльний аналіз результатів обстеження, хірургічного лікування та подальший аналіз патогістологічного заключення в двох групах спостереження. До першої групи включено 180 (90,5%) пацієнтів, що не мали рецидиву/ продовженого росту, а в другій групі спостереження 19 (9,5%) хворих із виявленим рецидивом/ продовженим ростом парасагітальної менінгіоми (ПМ) після хірургічного втручання. Серед відібраних пацієнтів проведено аналіз демографічних даних (стать, вік); результатів комп'ютерної томографії та магнітно-резонансної томографії головного мозку до та після внутрішньовенного контрастування за основними характеристиками; даних ангіографічних досліджень (комп'ютерно-томографічної ангіографії / селективної субтракційної дігітальної церебральної ангіографії); радикальності хірургічного втручання; результатів патогістологічних заключень; а також тривалість безрецидивного періоду (від одного до 20 років після проведеного хірургічного лікування). Протягом періоду спостереження рецидив/ продовжений ріст ПМ відзначено у 19 пацієнтів (9,5%). З них впродовж першого року після втручання зафіксовано лише 2 випадки продовженого росту ПМ, за 5 років (60 міс.) – 12, за 10 років – 17, а відсоток пацієнтів без рецидиву з урахуванням цензурованих даних (безрецидивна виживаність) склав 99,0 (95% ДІ 97,6-100) %, 93,1 (95% ДІ 89,3-96,9) % і 87,5 (95% ДІ 81,6-93,4) % відповідно до вищевказаних термінів спостереження. Фактична медіана часу до виникнення рецидиву в нашому дослідженні склала 44,1 (25,7; 85,4) місяці. Тобто більшість випадків продовженого росту ПМ зафіксовано протягом перших 5 років після втручання – 12 з 19 (63,2%). Останній випадок рецидиву ПМ відзначений через 13 років (154,5 міс.) спостереження. Таким чином, показники безрецидивної 5-ти і 10-ти річної виживаності у пацієнтів з ПМ: при тотальному видаленні пухлини (за Simpson I) становлять 96,0% і 85,5%, при нерадикальному підході (за Simpson II-V) – 88,9% ($p<0,05$) і 81,9% ($p<0,05$). При цьому нерадикальність хірургічного втручання при I-II типі інвазії ПМ у ВВС зменшує показники 5-ти і 10-ти річної безрецидивної виживаності до 86,6% ($p<0,01$) і 78,3% ($p<0,01$) відповідно; при розмірі пухлини до 54 мм становлять 95,5% і 91,4%, а при розмірах >54 мм зменшуються до 87,5% ($p<0,001$) і 72,5% ($p<0,001$); при ураженні ВСС I-III та V-VI типів за класифікацією M. P. Sindou and J. E. Alvernia дорівнюють 94,0% і 89,1%, а у випадках IV типу інвазії – 66,5% ($p<0,01$) і 43,5% ($p<0,001$); у пацієнтів жіночої статі становлять 95,2% і 88,5%, у чоловіків – 84,8% ($p<0,05$) і 73,0% ($p<0,01$). За результатами регресійного аналізу пропорційних ризиків Кокса відносний ризик рецидивування/ продовженого росту пухлини збільшується: в 7,04 разу (95% ДІ 2,33-21,2) при початковому розмірі ПМ понад 54 мм ($p<0,001$); в 5,57 разу (95% ДІ 1,27-24,34) при нерадикальному характері видалення пухлини при первинному втручанні (Simpson II-V) ($p<0,05$); в 10,1 разу (95% ДІ 1,31-78,1) при I-II типі інвазії ПМ у ВВС та неповному видаленні пухлини (Simpson II-V) ($p<0,05$); в 3,25 разу (95% ДІ 1,32-8,02) у пацієнтів чоловічої статі ($p<0,01$); в 3,33 разу (95% ДІ 1,10-10,12) при IV типі інвазії у ВВС (за M.P. Sindou and J.E. Alvernia) ($p<0,05$). Адекватний аналіз отриманих результатів допоможе нейрохірургу спланувати оптимальний об'єм хірургічного втручання із подальшим післяопераційним збільшенням тривалості безрецидивного періоду та покращенням віддалених результатів лікування.

Ключові слова: верхній сагітальний синус, менінгіома, прогноз, результати лікування, рецидив, фактори ризику.