# Intracranial meningioma case series

## 2023

A total of 130 patients who were pathologically diagnosed as having WHO grade I meningiomas and who underwent post-operative GKRS were retrospectively reviewed in a single center.

Results: Of the 130 patients, 51 patients (39.2%) presented with radiological tumor progression with a median follow-up time of 79.7 months (ranging from 24.0 to 291.3 months). The median time to radiological tumor progression was 73.4 months (ranging from 21.4 to 285.3 months), whereas 1-, 3-, 5-, and 10-year radiological progression-free survival (PFS) was 100, 90, 78, and 47%, respectively. Moreover, 36 patients (27.7%) presented with clinical tumor progression. Clinical PFS at 1, 3, 5, and 10 years was 96, 91, 84, and 67%, respectively. After GKRS, 25 patients (19.2%) developed adverse effects, including radiation-induced edema (n = 22). In a multivariate analysis, a tumor volume of ≥10 ml and falx/parasagittal/convexity/intraventricular location were significantly associated with radiological PFS [hazard ratio (HR) = 1.841, 95% confidence interval (CI) = 1.018-3.331, p = 0.044; HR = 1.761, 95% CI = 1.008-3.077, p = 0.047]. In a multivariate analysis, a tumor volume of ≥10 ml was associated with radiation-induced edema (HR = 2.418, 95% CI = 1.014-5.771, p = 0.047). Of patients who presented with radiological tumor progression, nine were diagnosed with malignant transformation. The median time to malignant transformation was 111.7 months (ranging from 35.0 to 177.2 months). Clinical PFS after repeat GKRS was 49 and 20% at 3 and 5 years, respectively. Secondary WHO grade II meningiomas were significantly associated with a shorter PFS (p = 0.026).

Conclusions: Post-operative GKRS is a safe and effective treatment for WHO grade I intracranial meningiomas. Large tumor volume and falx/parasagittal/convexity/intraventricular location were associated with radiological tumor progression. Malignant transformation was one of the main cause of tumor progression in WHO grade I meningiomas after GKRS [1)]

## 2022

Champeaux-Depond et al. processed the Système National des Données de Santé, the French administrative medical database to retrieve appropriate patients' case of surgically treated meningiomas. The Pohar Perme relative survival (RS) method was implement.

A total of 28,778 patients were identified between 2007 and 2017 of which 75% were female. Median age at surgery 59 years. Cranial convexity was the most common (24.7%) location and, benign meningioma represented 91.5% of all meningioma. Median follow-up was 3.5 years interquartile range [3.4-3.5]. At data collection, 2,232 patients were dead. The five-year survival relative to the expected survival of an age- and gender-matched French standard population was 96.2% 95% confidence interval (CI)[95.7-96.8]. Meningioma absolute excess risk of death was 973/100,000 person-years 95%CI[887-1068] (p< .001). The related standardised mortality ratio was 1.8 95%CI[1.7-1.9] (p< .001). In the adjusted model, male gender (hazard ratio [HR] =1.39, 95%CI[1.27-1.54], p< .001), age at surgery (HR=0.97, 95%CI[0.97-0.97], p < .001), type 2 neurofibromatosis (HR=2.95, 95%CI[1.95-4.46], p < .001), comorbidities HR=1.39, 95%CI[1.36-1.42], p < .001), location (HR=0.8, 95%CI[0.67-0.95], p= .0111), pre-operative embolization, (HR=1.3, 95%CI[1.08-1.56], p= .00507), cerebro-spinal fluid shunt, (HR=2.48, 95%CI[2.04-3.01], p < .001),

atypical (HR=1.3, 95%CI [1.09-1.54], p= .00307) or malignant histology (HR=1.86, 95%CI[1.56-2.22], p< .001), redo surgery (HR=1.19, 95%CI[1.04-1.36], p= .0122) and radiotherapy (HR=1.43, 95%CI[1.26-1.62], p < .001) were established as independent predictors of RS.

This unique study highlights the excess mortality associated with meningioma disease. Many factors such as gender, age, location, histopathological grading, redo surgery influence the RS [2].

# 2021

A study prospectively followed 108 women with 262 intracranial meningiomas and documented progestin cyproterone acetate (PCA) use. A per-meningioma analysis was conducted. Changes in meningioma volumes over time, and meningioma growth velocities, were measured on magnetic resonance imaging (MRI) after stopping PCA treatment.

Mean follow-up time was 30 (standard deviation [SD] 29) mo. Ten (4%) meningiomas were treated surgically at presentation. The other 252 meningiomas were followed after stopping PCA treatment. Overall, followed meningiomas decreased their volumes by 33% on average (SD 28%). A total of 188 (72%) meningiomas decreased, 51 (20%) meningiomas remained stable, and 13 (4%) increased in volume of which 3 (1%) were surgically treated because of radiological progression during follow-up after PCA withdrawal. In total, 239 of 262 (91%) meningiomas regressed or stabilized during follow-up. Subgroup analysis in 7 women with 19 meningiomas with follow-up before and after PCA withdrawal demonstrated that meningioma growth velocity changed statistically significantly (P = .02). Meningiomas grew (average velocity of 0.25 mm3/day) while patients were using PCA and shrank (average velocity of -0.54 mm3/day) after discontinuation of PCA.

Ninety-one percent of intracranial meningiomas in female patients with long-term PCA use decrease or stabilize on MRI after stopping PCA treatment. Meningioma growth kinetics change significantly from growth during PCA usage to shrinkage after PCA withdrawal [3].

# 2019

Patients underwent neuropsychological assessment (NPA) using CNS Vital Signs 1 day before (T0), and 3 (T3) and 12 (T12) months after surgery. Patients' sociodemographically-corrected scores on 7 cognitive domains were compared to performance of a normative sample using one-sample z tests and Chi-square tests of independence. Reliable change indices with correction for practice effects were calculated for individual patients. Linear mixed effects models were used to identify preoperative predictors of performance at T12.

At T0, 261 patients were assessed, and 229 and 82 patients were retested at T3 and T12, respectively. Patients showed impaired cognitive performance before and after surgery, and although performance improved on the group-level, cognitive scores remained significantly lower than in the normative sample up to T12. On the individual level, performance remained stable in the majority of patients. Better preoperative performance, younger age, male sex, and higher educational level predicted better late cognitive performance.

Meningioma patients face serious and persistent pre- and postsurgical cognitive deficits. A preoperative NPA together with sociodemographic characteristics may provide valuable information

on the late cognitive outcome of individual meningioma patients. These results can help to inform patients and clinicians on late cognitive outcomes at an early stage, and emphasizes the importance of presurgical NPA and timely cognitive rehabilitation [4].

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Medical records were retrospectively reviewed for all intracranial meningioma cases which diagnosed and underwent surgery at Bezmialem Vakif University Hospital between 2012 and 2017. All cranial grade I and grade II meningioma patients constituted the core sample for this study.

This series included 104 (69 female, 35 male) patients, with a median age of 57.3 years. The mean preoperative course was 23.0 ± 40.5 months. The most common symptom was headache (76%) and followed by seizure (24%), weakness (18%) and visual disturbances (14%). Seventy one (68.2%) patients were diagnosed as WHO grade I meningioma and 33 (31.8%) were WHO grade II, grade III meningiomas were excluded from study due to small number of patients. Subtypes of meningioma includes 5 angiomatous (4,8%), 6 fibroblastic (5.7%), 1 meningothelial (0,9%), 11 psammomatous (10,5%), 3 secretory (2,8%), 43 transitional (41,3%) and 33 atypical (31,7%) meningiomas. There is a strong correlation with Phosphohistone H3 (PHH-3) and Ki-67 (p:0,001>) and mitosis index (p:0,001 > ) although there is no correlation with STAT3 (p:0,260). There is a strong correlation with STAT-3 and Ki-67 (p:0,013), although there is no correlation with mitosis index (p:0,085) and PHH-3 (p:0,260).

In the study they also obtain same results with Ki-67 and mitotic index, although correlation with PHH-3 and STAT-3 is firstly determined and there was no statistically significant relation were observed. Depends on the STAT-3 cell proliferation feature, inactivation of these pathways may predict new chemotherapies for grade II meningiomas [5].

## 2018

Neuropsychological data (CNS Vital Signs) and MRI were collected in 224 meningioma patients one day before surgery in Tilburg. Sociodemographically corrected scores were calculated for 7 cognitive domains. Tumors were semiautomatically segmented and mapped into MNI-space for use in Statistical Region of Interest analyses. For each cognitive domain, De Baene et al. tested whether larger proportions of tumor overlap with each of the 150 defined regions were associated with worse performance.

After multiple comparison (Bonferroni) and lesion volume correction, larger proportions of tumor overlap with both the left middle and superior frontal gyrus were associated with worse complex attention scores. Larger proportions of tumor overlap with the left middle frontal gyrus were associated with worse cognitive flexibility scores. For the other domains, no association between tumor overlap with a region and cognitive performance was found.

The current results suggest that, compared to patients with a meningioma at other locations, patients with a meningioma at the left middle frontal gyrus are at potential risk for worse performance on cognitive flexibility and complex attention whereas patients with a meningioma at the left superior frontal gyrus are at potential risk for worse performance on complex attention [6].

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Patients undergoing resection of an intracranial meningioma at the University Hospital Zurich

2000-2013 (N = 741) were reviewed for the inclusion of preoperative embolization in the management strategy. Annotations included demographics, radiographic, surgical, histological and hematological parameters, cardiovascular risk factors, pre- and postoperative neurological function and gene methylation-based classification. Binary regression and Cox proportional hazards models were applied to determine factors associated with outcome.

Pre-operative embolization was performed in 337 patients (42%). Cardiovascular events after surgery comprised mostly Deep-Vein Thrombosis (N = 39) and pulmonary embolisms (N = 64). On multivariate analyses of post-operative cardiovascular adverse events controlling for established risk factors, there were associations with embolization (OR 2.38, 95% CI 1.37-4.00), and with female gender (OR 2.18, 95% CI 1.17-4.08). Recurrence-free survival (RFS) of embolized patients was less favorable among patients with WHO grade II or grade III meningiomas (median RFS: 4.3 vs. 7.0 years, P = 0.029) or in patients with intermediate or malignant gene methylation subtype meningiomas (median RFS: 2.0 vs. 8.2 years, P = 0.005).

Pre-operative meningioma embolization may cause adverse outcomes. Randomized trials to determine benefit-risk ratios are warranted to clarify the role of pre-operative embolization for the treatment of meningioma patients [7].

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Twenty-eight patients (28 meningiomas) underwent successful preoperative meningioma embolization. The mean (±SD) patient age was 56 (±13) years, and 18 patients (64%) were women. The mean tumor size was 49 cm3. One, 2, or 3 arterial pedicles were embolized in 21 (75%), 6 (21%), and 1 (4%) case, respectively. The embolized pedicles included branches of the middle meningeal artery in 19 cases (68%), the internal maxillary artery in 8 (29%), the ascending pharyngeal artery in 2 (7%), and posterior auricular, ophthalmic, occipital, and anterior cerebral arteries in 1 each (4%). The embolysates used were Onyx alone in 20 cases (71%), NBCA alone in 3 (11%), coils+particles and Onyx/NBCA in 2 each (7%), and Onyx+coils in 1 (4%). The median degree of tumor devascularization was 60%. Significant neurological morbidity was incurred by 1 patient (4%) who developed symptomatic peritumoral edema after Onyx embolization.

For appropriately selected skull base meningiomas supplied by dura mater-based arterial pedicles without distal cranial nerve supply, preoperative embolization with current embolysate technology affords substantial tumor devascularization with a low complication rate [8].

## 2017

All histologically proven intracranial meningiomas that underwent resection in a single centre between April 2009 and April 2014 were reviewed and classified according to the 2016 edition of the Classification of the Tumours of the CNS. Only patients who had two pre-operative scans that were at least 3 months apart were included in the study. Two authors performed the volumetric measurements using the Slicer 3D software independently and the inter-rater reliability was assessed. Multiple regression analyses of factors affecting the VGR and VDE of meningiomas were performed using the R statistical software with $p < 0.05$ considered to be statistically significant.

Of 548 patients who underwent resection of their meningiomas, 66 met the inclusion criteria. Sixteen cases met the exclusion criteria (NF2, spinal location, previous surgical or radiation treatment,

significant intra-osseous component and poor quality imaging). Forty-two grade I and 8 grade II meningiomas were included in the analysis. The VGR was significantly higher for grade II meningiomas. Using receiver-operator characteristic (ROC) curve analysis, the optimal threshold that distinguishes between grade I and II meningiomas is 3 cm3/year. Higher histological grade, high initial tumour volume, MRI T2-signal hyperintensity and presence of oedema were found to be significant predictors of higher VGR.

Reliable tools now exist to evaluate and monitor volumetric growth of meningiomas. Grade II meningiomas have significantly higher volumetric growth rate (VGR) compared with grade I meningiomas and growth of more than 3 cm3/year is strongly suggestive of a higher grade meningioma. A larger, multi-centre prospective study to investigate the applicability of velocity of growth to predict the outcome of patients with meningioma is warranted [9)].

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The clinical features of intracranial meningiomas in 70 consecutive intracranial meningioma patients that underwent surgical treatment at the affiliated hospital of University of Occupational and Environmental Health between 2007 and 2013 were assessed. In addition, patient selection and surgical management of intracranial meningioma in elderly patients was discussed. Preoperative factors, including symptoms, tumor location, tumor size, Karnofsky Performance Scale (KPS) score and American Society of Anesthesiology (ASA) score, and postoperative factors, including pathological diagnosis, tumor proliferation index (Ki-67), resection rate (Simpson grade), length of hospital stay and discharge destination were retrospectively analyzed in patients aged ≥75 years (n=16; elderly group) and <75 years (n=54; younger group). Outcomes were assessed 6 months after surgery. Multivariate logistic regression revealed that tumor resection rate (Simpson grade III-V) was an important predictor of surgical complications (odds ratio, 5.662; 95% confidence interval, 1.323-24.236; P=0.0194). Perioperative morbidity was not correlated with age (>75 years), tumor location, tumor size, KPS score or ASA score. Thus, the present study indicated that age is not associated with surgical outcome in elderly meningioma patients. Regardless of patient age, the decision to perform surgical resection should be made on an individual basis wherein tumor characteristics and the general health of the patient are considered [10)].

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Preoperative tumor embolization of meningiomas decreases intraoperative bleeding and shortens operation time. However, in meningiomas predominantly vascularized by the internal carotid artery (ICA) or vertebral artery (VA) branches, embolization of external carotid artery feeder branches may lead to a hemodynamic increase in blood supply from the ICA or VA, whereas embolization of ICA or VA feeder branches with particle embolic agents may be associated with complications.

Between July 2015 and July 2016, data from all presurgical embolizations performed in our institution were prospectively collected. Information on tumor type, location, size, eventual bone erosion, complications, devascularization percentage, and estimated blood loss was analyzed.

Tumors of four patients (two meningioma, two endolymphatic sac tumor) were embolized using direct puncture. 3D XperGuide planning software was used in all procedures. Embolization was feasible in all cases. In one case, a small craniotomy was specifically performed to allow needle positioning. In all cases n-butyl cyanoacrylate was used. No ischemic or hemorrhagic complications related to embolization occurred. Complete or near complete devascularization was obtained in all cases. In one case, surgery was not performed and the patient was monitored. Resection was complete without significant blood loss in two cases, and resection was incomplete but satisfactory in one case.

In selected cases, 3D-guided direct puncture of intracranial tumors appears safe, feasible, and efficient for preoperative embolization [11].

## 2016

From January 2006 to June 2015, 157 consecutive patients (98 females; mean age = 48.3 years) who suffered from meningiomas and were preoperatively referred for embolization were retrospectively analyzed. Glubran (n = 40) and PVA (n = 55) were used to devascularize tumors. Sixty-two patients were not embolized because of dangerous anastomosis or other tumor characteristics. Intraoperative blood loss, intraoperative time, degree of angiographic devascularization and embolization-related complications were analyzed.

The intraoperative blood loss and operative time were significantly lower in the Glubran-embolized versus non-embolized group. Furthermore, Glubran embolization significantly reduced intraoperative blood loss and operative time for meningiomas that received their primary blood supply from the ICA and/or VA compared with PVA embolization.

Preoperative meningioma embolization with Glubran decreases intraoperative blood loss and operative time. Furthermore, embolization with Glubran produces more effective devascularization compared with PVA for meningiomas supplied by the ICA and/or VA. Thus, Glubran may represent a better embolic agent for this meningioma subtype [12].

## 2015

Park et al. present a retrospective case series of 5 females at our institutions (age ranged 21-72 years, mean 54.6 years) diagnosed with LD of an intracranial meningioma after surgery between 1998 and 2013. A database search revealed 45 cases with LD of meningioma in the English literature. Characteristic features were analyzed and compared.

The incidence rate at our institutions of LD of meningioma was 0.9% (5/534). World Health Organization (WHO) grade was distributed as follows: I : 2, II : 2, and III : 1. Time to LD ranged from 2.5 months to 6.9 years; the patient with WHO grade III had the shortest interval to LD. The patient with an intraventricular meningioma (WHO grade II) had the second shortest interval to LD (1.7 years), and simultaneously revealed both LD and extraneuronal metastases. Four of 5 patients showed a disease progression, with the survival ranging from 1 month to 3.8 years after LD. Based on the literature, the initial tumor was an intraventricular meningioma in 9 patients, and their time to LD was shorter on average (mean 1.9 years). Histologically, 26 of 45 (58%) were initially diagnosed with a WHO grade II or III meningioma, and 6 of 19 patients (32%) with WHO grade I revealed malignant transformation.

This study shows that intraventricular location and histologically aggressive features seem to increase the chance of LD of meningioma [13].

# 2002

Records for 50 patients with meningiomas who underwent preoperative embolization between 1993 and 1999. We divided the patients into two groups, i.e., those who underwent surgical resection of their meningiomas < or =24 hours after embolization and those who underwent surgery more than 24 hours after embolization. The extent of embolization, intraoperative blood loss, duration of surgery, and length of the hospital stay were compared for the two groups. Postoperative pathological specimens were examined for assessment of the extent of vascularity and necrosis caused by embolization.

Intraoperative blood loss was greater for the immediate group than for the delayed group (29% with blood loss of >1000 ml [median, 475 ml] versus 0% with blood loss of >700 ml [median, 337.5 ml]; P = 0.01). There were no statistically significant differences between the groups with respect to tumor volume, extent of embolization, degree of devascularization, necrosis, duration of surgery, or length of the hospital stay.

Contrary to previous studies that emphasized a need for tumor removal immediately after embolization, to prevent revascularization, surgical resection of meningiomas should be delayed more than 24 hours after embolization, because there is less intraoperative blood loss [14)].

# 2000

In 30 consecutive patients, trisacryl gelatin microspheres (150-300 microm) were used for the preoperative superselective embolization of meningiomas (group 1). Thirty other consecutive patients had embolization with PVA particles of 45 to 150 microm (n = 15, group 2) and of 150 to 250 microm (n = 15, group 3). Extent of devascularization, intraoperative blood loss, blood transfusion, and hemostasis at the time of surgery were recorded for every patient. The inflammatory reaction, the extent of necrotic areas, and the most distal intravascular location of the embolic agent (arterial, arteriolar, precapillary, capillary) were recorded.

There was no significant difference in the extent of angiographic devascularization among the groups. Intraoperative blood loss differed significantly between groups 1 and 2 and groups 1 and 3, but not between groups 2 and 3. The trisacryl gelatin microspheres were located more distally in tumor vessels than were the PVA particles of either size. The extent of intratumoral necrosis was not significantly different between the two embolic agents. In all groups there was a mild inflammatory tissue reaction in the vicinity of the embolic agent.

Trisacryl gelatin microspheres may be effective in the preoperative embolization of meningiomas, producing significantly less blood loss at surgery than seen with PVA particles of either size, possibly because of the significantly more distal vascular penetration of the microspheres [15)].

# 1993

In 34 patients with intracranial meningiomas, CT, MR, 1H MR spectroscopy, MR volumetric measurements, intraoperative ultrasound, and histopathologic findings were used to compare the efficacy of two embolization techniques: 1) administration of 150- to 300-microns PVA particles in the usual suspension, and 2) administration of 50- to 150-microns PVA particles in a highly diluted

suspension.

Angiography after embolization demonstrated the total elimination of tumor blush in all patients. Contrast-enhanced MR after the administration of 150- to 300-microns PVA particles revealed a reduction of tumor enhancement in only two out of 14 patients. Only after the use of small particles could significant tumor necrosis be depicted on MR and confirmed histopathologically after surgery. In 12 of 20 patients, 30% to 95% of the whole tumor was necrotic with 17% to 20% reduction of tumor volume in four cases, leading to recovery from the initial neurologic deficits. In three of 20 patients without sufficient steroid medication before the treatment, tumor swelling occurred. Postembolization MR disclosed a tumor volume increase of 10% to 20% in these patients. 1H MR spectroscopy of the tumors showed an increase of lactate and aliphatic lipid compounds after embolization, indicating tumor infarction. Surgical removal of effectively embolized meningiomas without significant blood loss was possible. The appearance of the tumor at operation, ultrasound examination, and the histopathologic examination of different parts of the tumor confirmed the preoperative MR findings suggesting necrosis.

Extended microembolization with 50- to 150-microns PVA particles improves the surgical treatment of meningiomas, as compared with larger particle embolization. It may also be the only treatment required in older or high-risk patients. The protective effect of steroid medication before the endovascular treatment of meningiomas is suggested by this study [16)].

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