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Original Article

Preoperative embolization of meningiomas: Single center experience

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Abstract

Aim: The aim of this study was to investigate the contribution of polyvinyl alcohol particle embolization to meningioma surgery.
Materials and Methods: The study included 24 patients (19 women, 5 men) who were operated for meningioma at our institution between October 2018 and October 2019. Ten patients underwent tumor embolization with polyvinyl alcohol particles before meningioma surgery, while the other 14 patients were operated directly without embolization. Groups were constituted as with embolized and non-embolized before surgery.Patient and tumor characteristics, embolization procedure, operative blood loss, operative time, and complications were compared between patients with and without preoperative embolization.
Results: The patients ranged in age between 28 and 79 years, with a mean age of 54.16±10.50. Mean operative time was 4.59 hours for the embolized patients and 4.72 hours for the non-embolized patients (p>0.05). Mean hemoglobin values were decreased by 1.25 g/dl in the embolized patients and 1.35 g/dl in the non-embolized patients (p>0.05).
Conclusion: There were no significant differences in operative time, intraoperative blood loss, or change in hemoglobin level between meningioma patients who underwent preoperative embolization with polyvinyl alcohol particles and those who did not.

Keywords: Digital subtraction angiography; meningioma; polyvinyl alcohol

INTRODUCTION

Meningiomas are the most common non-glial extra-axial and largely benign tumors (1,2). Surgery is the primary treatment method for symptomatic meningiomas, and radiotherapy can also be used in some cases. As meningiomas are believed to develop from the dura mater, they are often fed by the dural branches of the external carotid artery (ECA). Conventional angiography is not considered necessary unless embolization is planned. Embolization is performed after selective ECA catheterization demonstrates the tumor is supplied mainly by the ECA. Preoperative embolization (POE) was first described by Manelfe et al. (3). In recent studies, POE embolization was reported to reduce intraoperative blood loss and operative time. The current study presents our surgical experiences pertaining to blood loss, operative time, and embolization. We compared operative time, amount of intraoperative blood loss, changes in hemoglobin (Hb) level, and complications in patients with and without POE, and evaluated the surgical benefit of POE.

MATERIALS and METHODS

This retrospective analysis included 24 patients (19 women, 5 men; mean age, 54.16 ± 10.50) who were operated due to meningiomas between October 2016 and October 2018. All patients were evaluated preoperatively with contrast-enhanced magnetic resonance imaging (MRI). The decision to perform POE was based on tumor size (≥ 3 cm), degree of contrast enhancement, location, and the surgeon's estimate of the contributions of POE to the operation. Ten of the patients underwent POE, while 14 did not. Embolized patients underwent meningioma surgery within a mean of 1.4 days. The effects of POE on operative time and intra- and postoperative blood loss were evaluated. We also examined surgical and embolization-related complications and performed subgroup analyses.

Tumors were classified based on their size, location, and histological subtype. Angiography and embolization characteristics included feeder vessels (dural and/or pial), embolized vessels, degree of embolization, and neurological complications related to embolization. Ethics

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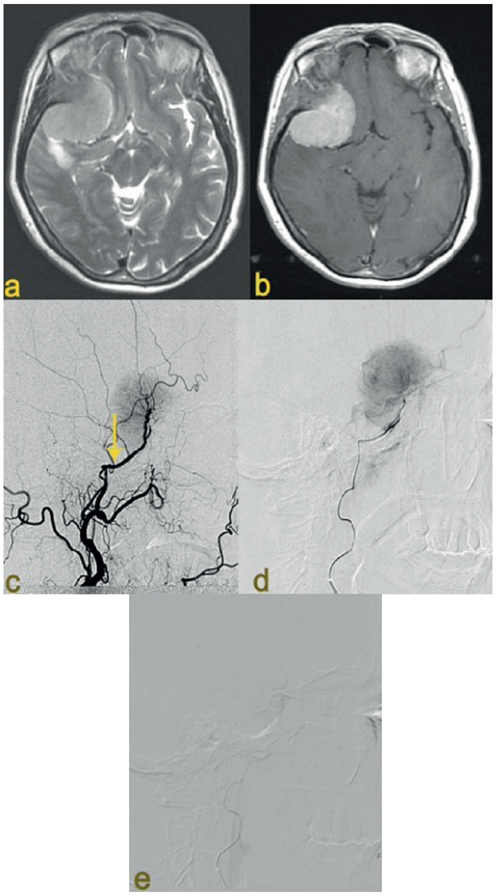
committee approval was obtained for the study (Sivas Cumhuriyet University School of Medicine Decision No: 2019-08 / 05. Date: 07.08.2019).



MMA: Middle Meningeal Artery

Figure 1. A 66-year-old woman with intracranial meningioma. a: Axial T2-weighted MR imaging shows typical meningioma with perilesional edema and hyperostosis, on the right side sphenoid wing; b: Axial postcontrast T1-weighted MR imaging shows homogenous contrast enhancement of the meningioma; c: Lateral pre-embolization DSA right ECA injection demonstrates hypervascular tumor blush from the MMA; d,e: After superselective catheterization of the MMA ,pre-embolization angiography showed hypervascular tumoral blush, whereas post-embolization angiography demonstrated complete devascularization of tumor blush (lateral views)

Embolization Procedure

General Electric Innova monoplane angiography device was used to perform the neuroangiography and embolization procedures. The embolization was initiated by puncturing the right main femoral artery with a 5F introducer sheath. All patients were given 2500 U of heparin intravenously. With 4-dimensional DSA and bilateral ECA catheterization, the dural and pial feeders of the tumor and its venous drainage pattern were determined. The presence of dangerous anastomoses was evaluated angiographically and after confirming predominant ECA supply, the tumor feeders were catheterized with a combination microcatheter–microguidewire (Progreat 2.9 F, 0.021 inch microguidewire coaxial system, Terumo Corporation ,Tokyo, JAPAN), then embolized with 250–355 μm polyvinyl alcohol particle (PVA, Contour, Boston Scientific, Natick, Massachusetts,USA) particles. The patients underwent meningioma surgery 1 to 3 days after the embolization procedure. For all embolized patients, the percentage of embolization was reported by comparing pre-embolization and post-embolization DSA images (Figure 1). Based on comparison of pre-and post-embolization DSA images, embolization of 90% or more was considered complete embolization and less than 90% was considered partial embolization. Embolization was not performed in patients with DSA findings of small or tortuous tumor feeders or predominant pial supply. The DSA and embolization procedures were performed by five years experienced interventional neuroradiologist; meningioma surgeries were performed by a neurosurgical team experienced in tumor resection.

Statistical Analysis

The data obtained from the study were entered into SPSS 22.00 (company name?) software. As parametric test assumptions were not met (Kolmogorov–Smirnov), The data obtained from the study were entered into SPSS 22.00 (IBM Corp., Armonk, NY., USA) software. As parametric test assumptions were not met (Kolmogorov–Smirnov), when comparing two independent groups, Mann-Whitney U test was used and Fisher's Exact test and chi-squared test with Monte Carlo modelling were used to evaluate the groups in terms of counting data. In this study, $\alpha = 0.05$, $\beta = 0.20$, $(1-\beta) = 0.80$ when received, it was decided to include 14 non-embolized and 10 embolized individuals, and the power of the test ($p = 0.80427$) was found. Type I error level was set to 0.05.

RESULTS

Patient and Tumor Characteristics

The study included 24 patients (age range 28–79, mean age 54.16 ± 10.50 years) who underwent operations for meningiomas. Tumor diameter ranged between 10 and 90 mm. The most common locations were the convexity (12 patients, 50%) and the parafalcine region (4 patients, 16.66%). Although the difference in tumor size between the groups was insignificant, mean and median tumor size were larger in patients who did underwent POE compared to those who did not. This difference was a result of patient number. The most common histopathological subgroups were transitional (29.16%) and fibroblastic (20.83%). According to the World Health Organization (WHO) classification, 19 cases were grade 1 (benign), 3 were grade 2 (atypical), and 2 were grade 3 (anaplastic). There was no significant difference between the two groups in terms of sex, tumor size, or tumor histopathology, while mean age was slightly higher among the embolized patients (60.60 ± 14.36 vs. 49.57 ± 9.65 years). Patient and tumor characteristics are shown in detail in Table1.

Embolization Outcomes

POE was performed using 250–355 μm PVA particles in all patients. Exclusive dural supply was detected in 3 of the 10 patients who underwent embolization, while both dural and weak pial supply was detected in 7 patients.

The middle meningeal artery (MMA) was used for embolization in 8 patients, the superficial temporal artery (STA) in 3 patients, bilateral MMA in 2 patients, and bilateral STA in 1 patient. All patients had complete embolization (≥90%) and were operated within 24 to 72 hours after embolization (70% on the first day, 20% on the second day, and 10% on the third day after embolization). Neurological complications related to the procedure were not observed in any of the patients who underwent POE. Angiography and embolization results are shown in Table 2.

Surgery Outcomes

There was no significant difference between patients with and without POE in terms of operative time (p=0.256), change in Hb values in pre- and postoperative complete blood count analysis (p=0.681), or volume of blood used during surgery (p=0.65). A certain amount of blood used for embolized and non-embolized patient groups during the surgery is as follows. Blood was used in 5 non-embolized patients. Of them, 3 patients received 1 unit, 1 patients received 2 units and 1 patients received 3 units of blood. On the other hand, 1 unit of blood was used for each of 2 embolized patients. Postoperatively, 1 patient had upper extremity paralysis, 1 patient had early left hemiparesis, 1 patient had wound site infection, and 1 patient had pulmonary atelectasis. Surgical outcomes are shown in Table 3.

Table 1. Patient and Tumors features

Menengiomas	TOTAL n(%)	NPOE n (%)	POE n (%)	p
Female/Male	19 (76.16%)/5 (20.83%)	12 (85.7%)/2 (14.3%)	7 (70%)/3 (30%)	p>0.05
Age (mean±SD)	54.16±10.50	49.57±9.65	60.60±14.36	p<0,05
Diamater (mm)/median	10-90/43.26	10-60/39.61	30-90/54.66	p>0.05
Location	24 (100%)	14 (100%)	10 (100%)	NPOE (p>0.05)
Convexity	12 (50%)	7 (50%)	5 (50%)	POE (p>0.05)
Sphenoid wing	3 (12.5%)	0 (0%)	3 (30%)	
Parafalcine	4 (16.7%)	2 (14.3%)	2 (20%)	
P. sfenodale/ olfactory groove	2 (8.3%)	2 (14.3%)	0 (0%)	
Tentorial	3 (12.5%)	3 (21.4%)	0 (0%)	
Histological subtype	24 (100%)	14 (100%)	10 (100%)	p>0.05
Atypical	3 (12.5%)	1 (7.1%)	2 (20%)	
Meningothelial	5 (21%)	4 (28.6%)	1 (10%)	
Angiomatous	2 (8.3%)	1 (7.1%)	1 (10%)	
Anaplastic	2 (8.3%)	0 (0%)	2 (20%)	
Transitional	7 (29.1%)	3 (21.4%)	4 (40%)	
Fibroplastik	5 (20.8%)	5 (35.8%)	0 (0%)	
WHO grade	24 (100%)	14 (100%)	10 (100%)	p>0.05
I	19 (79.1%)	13 (92.8%)	6 (60%)	
II	3 (12.6%)	1 (7.1%)	2 (20%)	
III	2 (8.3%)	0 (0%)	2 (20%)	

NPOE; Non-preoperative embolization, POE; Preoperative embolization, WHO; World Health Organization. in table 1, MannWhitney U test and Fisher's Exact test and chi-squared test with Monte Carlo modelling were used

Table 2. Embolization characteristics

Embolized vessel	n (%)
Middle meningeal artery	8 (57.1%)
Superficial temporal artery	3 (21.4%)
Bilateral Middle meningeal artery	2 (14.2%)
Bilateral Superficial temporal artery	1 (7.14%)

Table 3. Surgical outcomes

	POE	NPOE	p
Operation time (hours) Mean ± SD (min – max)	4.72 ±3.15 (2.00 - 10.30)	4.59 ±1.14 (3.15 - 7.00)	0.25
Intraoperative blood use	20%	35.7%	0.65
Change in Hb levels (g/dl) Mean ± SD	1.35 ±0.82	1.25±0.81	0.68
Operative complication rate	7.1%	10%	0.55

NPOE; Non-preoperative embolization POE; Preoperative embolization, SD; Standard deviation, in table 3 Mann-Whitney U test and Fisher's Exact test and chi-squared test with Monte Carlo modelling were used

DISCUSSION

Endovascular embolization has been used for many years for tumors and provides significant contributions to surgical treatment (4,5). The purpose of embolization is to occlude the feeding vessel of the tumor to ensure tumor necrosis and reduce intraoperative blood loss (6,7-9) There are different results in the literature regarding surgical results related to the degree of POE (10,5). In our study, there was no significant difference between patients with and without POE in terms of operative time, change in Hb values in pre- and postoperative complete blood count analysis or blood used during surgery. Przybylowski et al. in their study, they reported that meningioma embolization to reduce tumor vascularity did not cause changes in surgical outcomes in terms of blood loss in a series of 104 cases, 52 of which underwent POE and 52 of which did not undergo PE (10). Barros et al., retrospectively examined the DSA of 139 patients with meningioma and reported that 78% of the cases were successfully embolized. They also mentioned that tumor characteristics can be used to predict the probability of preoperative meningioma embolization and reported that parasagittal and convexity meningiomas are more likely to reach full angiographic embolization (5). In our cases, 5 are convexity, 2 are parasagittal and 3 are sphenoid wing tumors, all of which are completely embolized. In a study of 28 patients with skull base meningioma, no relationship was found between arterial nutrition, anatomical location, and the degree of devascularization (11). Manaka et al. in a study involving 69 patients, showed that POE reduced the duration of the operation and the blood loss during the surgery (12). In a study by Grand et al., it is reported that the amount of blood loss during surgery is parallel with the contrast enhancement degree of the lesion in contrast-enhanced MRI (13). In a comprehensive retrospective case-controlled study using different embolizing agents, it was reported that POE did not change the duration of the operation, complications and tumor resection degree, but reduced blood loss during surgery (14). In a case-controlled study by Iacobucci et al using PVA particles, it is stated that if tumor devascularization is fully achieved with POE, embolization shortens the operation time, but does not affect the blood loss during surgery (15). In the same study, POE in meningiomas was recommended in cases where the tumor size is greater than 4 cm, the tumor feeders originate from ECA with an estimated devascularization rate more than 90% and the tumor is located in deep regions or eloquent areas (15). Similar indications for POE were also specified in the study of Raper et al. and embolization was recommended when at least 50% of the tumor is fed by ECA (14). We performed embolization procedures in our study considering similar criteria. Wen Li et al. in their perfusion study with the flat-detector tomography featured DSA device for hypervascular tumors, they suggested that embolization reduced surgical time and operative blood loss (16). Bendozus et al. in their study, they compared the tumors with partial and complete embolization and showed that complete embolization leads to decreased blood loss during surgery (17). However, in other studies, a significant relationship between the degree of POE and the degree of blood loss or resection could not be shown (18,19). In the literature, the rate of complication development due to the POE has been reported as 1.6-4.6% and the mortality rate as less than 0.5% (20,7). Several embolizing agents can be used for POE (coils, particles, glue, or onyx-like agents) (21). In daily practice, PVA particles are most commonly used as embolizing agents. PVA particles come in different sizes, and small particles (45–150 μm) are more likely to cause complications (22-24).

We used bigger than 100 μm particles, which are known to be safer in terms of embolization. In our study, no neurological complications or mortality related to embolization were observed. The time of surgery after POE is controversial in the literature. In many centers, surgery is performed within 24-72 hours after embolization. Some authors suggested that surgery should be performed within 1-7 days after embolization to avoid revascularization (25). In another study, it was suggested that tumor softening, and surgical resection were better if the surgical procedure was performed 7-9 days after POE (26). Due to the risk of intra-tumoral bleeding and edema that may develop after POE, tumors located in the posterior fossa and spinal canal that pose a high risk, should be premedicated with high-dose steroids before embolization and surgery should not be delayed more than 24 hours (27). In the study conducted by Gruber et al. with 14 patients, control MRI was obtained at the 6th and 48th hours after embolization with microsphere particles and tumor vascularity and ischemia were evaluated. A significant decrease in tumor perfusion was observed with ischemic changes at the sixth hour, and no significant change was observed in the findings after 48 hours. With these results, they suggested that patients can be taken into surgery early after embolization, but the bleeding rate during the procedure may be higher than in late surgery (28). In our study, the patients were operated within 1-3 days after POE.

LIMITATIONS

The limitation of our study is that the number of subjects is relatively small. There are no cases of tumor embolization which is located posterior fossa and skull base. It does not always seem possible to quantify the effect of POE.

CONCLUSION

As a result, in our study, the effect of POE on the duration of the operation and the amount of bleeding was not detected. These results are explained by the fact that the study was conducted with a small number of patient groups. The POE and surgical procedure depend on personal experience and this may affect the results. Therefore, more comprehensive and multicenter case-controlled studies are needed.

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Competing Interests: The authors declare that they have no competing interest.

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Ethical Approval: Sivas Cumhuriyet University approved the study. Approval date and number: 07.08.20129, 2019-08/05.

REFERENCES

1. Toh CH, Castillo M, Wong AM, et al. Differentiation between classic and atypical meningiomas with use of diffusion tensor imaging. AJNR Am J Neuroradiol 2008;29:1630-5.
2. Perry A, Stafford SL, Scheithauer BW, et al. Suman VJ, Lohse CM. Meningioma grading: An analysis of histologic parameters. Am J Surg Pathol 1997;21:1455-65.
3. Manelfe C, Lasjaunias P, Ruscalleda J. Preoperative embolization of intracranial meningiomas. AJNR Am J Neuroradiol 1986;7:963-72.
4. Singla A, Deshaies EM, Melnyk V, et al. Controversies in the role of preoperative embolization in meningioma management. Neurosurg Focus 2013;35:e17.
5. Carli DF, Sluzewski M, Beute GN, et al. Complications of particle embolization of meningiomas: frequency, risk factors, and outcome. AJNR Am J Neuroradiol 2010;31:152-4.
6. Hirschl R, Caragine L.P. Endovascular techniques for tumor embolization. Winn HR (editor). Youmans Neurological Surgery. 6th Edition. Philadelphia, United States of America: Elsevier Saunders; 2011.p.224–1228.
7. Przybylowski CJ, Zhao X, Baranoski JF, et al. Preoperative embolization versus no embolization for WHO grade I intracranial meningioma: a retrospective matched cohort study. J Neurosurg 2020;27:1-8.
8. Raper DM, Starke RM, Henderson F Jr, et al. Preoperative embolization of intracranial meningiomas: efficacy, technical considerations, and complications. AJNR Am J Neuroradiol 2014;35:1798-804.
9. Mefty OA, Abdulrauf SI, Haddad GF. Meningiomas. Winn HR. Youmans Neurological Surgery. 6th Edition. Philadelphia: Elsevier Saunders; 2011.p.1426-49.
10. Wakhloo AK, Juengling FD, Van Velthoven V, et al. Extended preoperative polyvinyl alcohol microembolization of intracranial meningiomas: assessment of two embolization techniques. AJNR Am J Neuroradiol 1993;14:571-82.
11. Shah AH1, Patel N, Raper DM, et al. The role of preoperative embolization for intracranial meningiomas. J Neurosurg 2013;19:364-72.
12. Manaka H, Sakata K, Tatezuki J, et al. Safety And Efficacy Of Preoperative Embolization In Patients With Meningioma. J Neurol Surg B Skull Base 2018;79:328-33.
13. Barros G, Feroze AH, Sen R, et al. MR. Predictors of preoperative endovascular embolization of meningiomas: subanalysis of anatomic location and arterial supply. J Neurointerv Surg 2020;12:204-8.
14. Gruber P, Schwyzer L, Klinger E et al. Longitudinal Imaging Of Tumor Volume, Diffusivity, And Perfusion After Preoperative Endovascular Embolization In Supratentorial Hemispheric Meningiomas. World Neurosurg 2018;120:357-64.
15. Wen LI, Zhang X, Zhang Qr et al. Flat-Detector Computed Tomography PBV Map In The Evaluation Of Presurgical Embolization For Hypervascular Brain Tumors. J Neurointerv Surg 2017;9:1139-44.
16. Rodiek SO, Stolzle A, Lumenta CB. Preoperative embolization of intracranial meningiomas with Embosphere microspheres. Minim Invasive Neurosurg 2004;47:299-305.
17. Bendszus M, Rao G, Burger R, et al. Is There A Benefit Of Preoperative Meningioma Embolization?. Neurosurgery 2000;47:1306-12.
18. Ilyas A, Przybylowski C, Chen Cj,et al. Preoperative Embolization Of Skull Base Meningiomas: A Systematic Review. J Clin Neurosci 2019;59:259-64.
19. Brandel Mg, Rennert Rc, Wali Ar, et al. Impact Of Preoperative Endovascular Embolization On Immediate Meningioma Resection Outcomes. Neurosurg Focus 2018;44:e6.
20. Dowd CF, Halbach VV, Higashida RT. Meningiomas: the role of preoperative angiography and embolization. Neurosurg Focus 2003;15:e10.
21. Lacobucci M, Danieli L, Visconti E, et al. Preoperative embolization of meningiomas with polyvinyl alcohol particles: The benefits are not outweighed by risks. Diagn Interv Imaging 2017;98:307-14.
22. Kizilkilic O, Kocer N. Embolization in meningiomas. Turkish J Neurosurgery 2011;21:178-81.
23. Przybylowski Cj, Baranoski JF, See Ap, et al. Preoperative Embolization Of Skull Base Meningiomas: Outcomes In The Onyx Era. World Neurosurg 2018;116:e371-9.
24. Grand C, Bank WO, Balériaux D, et al. Gadolinium-enhanced MR in the evaluation of preoperative meningioma embolization. AJNR Am J Neuroradiol 1993;148:563-9.
25. Richter HP, Schachenmayr W. Preoperative embolization of intracranial meningiomas. Neurosurgery 1983;13:261-8.
26. Kai Y, Hamada J, Morioka M, Yano S, Todaka T, UshioY. Appropriate interval between embolization and surgery in patients with meningioma. AJNR Am J Neuroradiol 2002;23:139-42.
27. Men S. Preoperative embolization in Head-Neck tumors. Trd Sem 2018;6:98-108.
28. Borg A, Ekanayake J, Mair R, et al. Preoperative particle and glue embolization of meningiomas: indications, results and lessons learned from 117 consecutive patients. Neurosurgery 2013;73:244-51.