Preoperative embolization of intracranial meningioma

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Preoperative embolization(POE) of intracranial meningioma is performed worldwide. Although clear evidence of the effectiveness of POE has not been reported in the literature, the technique plays an important role in open surgery, especially for large or skull base meningiomas. The purposes of embolization include: 1)induction of tumor necrosis, resulting in a safer operation, 2)reduction in intraoperative bleeding, and 3)decrease in operative time. Knowledge of the functional vascular anatomy, embolic materials, and endovascular techniques is paramount to ensure safe embolization.

Indication

Tumor vascularity can now be determined using arterial spin labeling and Dynamic Susceptibility Weighted Contrast-Enhanced Perfusion Imaging, allowing the neurosurgeon or neurointerventionalist to assess patient candidacy for Preoperative embolization of intracranial meningioma [1)].

Tumor embolization may become an in-office treatment under certain conditions, such as in cases of poor general condition, multiple meningiomas, recurrent and refractory cases, difficult surgery and cases where re-irradiation is difficult after post-radiation therapy [2)].

Procedure

The standard procedure is as follows: 1)embolization is performed several days before open surgery; 2)in cases with strong peritumoral edema, steroid administration or embolization may be performed immediately prior to surgery; 3)patients undergo the procedure under local anesthesia; 4)the microcatheter is inserted as close as possible to the tumor; 5)particulate emboli are the first-line material; 6)embolization is occasionally performed with N-butyl cyanoacrylate(NBCA)glue; and 7)if possible, additional proximal feeder occlusion with coils is performed. The JR-NET study previous showed the situation regarding intracranial tumor embolization in Japan. Endovascular neurosurgeons should fully discuss the indications and strategies for POE with tumor neurosurgeons to ensure safe and effective procedures [3)].

The superiority and usefulness of liquid material over particles for embolization have been a topic of debate due to differences in materials and techniques. The use of particles in embolization may reduce intraoperative bleeding, but not in all cases can it be used safely. Therefore, a thorough understanding of the characteristics of both approaches and their relative advantages in clinical practice is essential to opt for the appropriate material according to the case [4)]

Efficacy

There is no standardized system to assess the efficacy or extent of embolization during the embolization procedure. We sought to establish a purely angiographic grading system to facilitate consistent reporting of the outcome of meningioma embolization and to characterize the anatomic and other features of meningiomas that predict the degree of devascularization achieved through preoperative embolization.

Matsoukas et al. identified patients with meningiomas who underwent preoperative cerebral angiography and subsequent resection between 2015 and 2021. Demographic, clinical, and imaging data were collected in a research registry. We defined an angiographic devascularization grading scale as follows: grade 0 for no embolization, 1 for partial embolization, 2 for majority embolization, 3 for complete external carotid artery embolization, and 4 for complete embolization.

Eighty consecutive patients were included, 60 of whom underwent preoperative tumor embolization (20 underwent angiography with an intention to treat but ultimately not embolization). Embolized tumors were larger (59.0 vs 35.9 cc; P = .03). Gross total resection, length of stay, and complication rates did not differ among groups. The distribution of arterial feeders differed significantly across tumors in a location-specific manner. Both the tumor location and the identity of arterial feeders were predictive of the extent of embolization. Anterior midline meningiomas were associated with internal carotid (ophthalmic, ethmoidal) supply and lower devascularization grades (P = .03). Tumors fed by meningeal feeders (convexity, falcine, lateral sphenoid wing) were associated with higher devascularization grades (P < .01). The procedural complication rate for tumor embolization was 2.5%.

Angiographic outcomes can be graded to indicate the extent of tumor embolization. This system may facilitate consistency of reported angiographic results. In addition, arterial feeders vary in a manner

predicted by tumor location, and these patterns correlate with typical degrees of devascularization achieved in those tumor locations [5)]

Complications

Hemorrhage (intratumoral and SAH), cranial nerve deficits (usually transient), stroke from embolization through ICA or VA anastomoses, scalp necrosis, retinal embolus, and potentially dangerous tumor swelling. Some meningiomas (e.g. olfactory groove) are less amenable to embolization.

Preoperative embolization has been an option for adjunctive treatment of intracranial meningiomas, but it remains used in only a minority of cases [6)].

Systematic review and meta-analysis

In 2021 a systematic review and meta-analysis aimed to evaluate the safety profile of the procedure and to compare outcomes in embolized versus non-embolized meningiomas. PubMed was queried for studies after January 1990 reporting outcomes of Preoperative embolization. Pertinent variables were extracted and synthesized from eligible articles. Heterogeneity was assessed using I2, and a random-effects model was employed to calculate pooled 95% CI effect sizes. Publication bias was assessed using funnel plots and Harbord's and Begg's tests. Meta-analyses were used to assess estimated blood loss and operative duration (mean difference; MD), gross-total resection (odds ratio; OR), and postsurgical complications and postsurgical mortality (risk difference; RD). Thirty-four studies encompassing 1782 preoperatively embolized meningiomas were captured. The pooled immediate complication rate following embolization was 4.3% (34 studies, n = 1782). Although heterogeneity was moderate to high (I2 = 35-86%), meta-analyses showed no statistically significant differences in estimated blood loss (8 studies, n = 1050, MD = 13.9 cc, 95% CI = -101.3 to 129.1), operative duration (11 studies, n = 1887, MD = 2.4 min, 95% CI = -35.5 to 30.8), gross-total resection (6 studies, n = 1608, OR = 1.07, 95% CI = 0.8-1.5), postsurgical complications (12 studies, n = 2060, RD = 0.01, 95% CI = -0.04 to 0.07), and post-surgical mortality (12 studies, n = 2060, RD = 0.01, 95% CI = 0-0.01). Although POE is relatively safe, no clear benefit was observed in operative and postoperative outcomes. However, results must be interpreted with caution due to heterogeneity and selection bias between studies. Well-controlled future investigations are needed to define the patient population most likely to benefit from the procedure [7)].

Shah et al. analyzed new therapeutic options for the embolization of intracranial meningiomas, as well as the future of meningioma treatment through recent relevant cohorts and articles. They investigate various embolic materials, types of meningiomas amenable to embolization, imaging techniques, and potential imaging biomarkers that could aid in the delivery of embolic materials. They also analyze perfusion status, complications, and new technical aspects of endovascular preoperative embolization of meningiomas. A literature search was performed in PubMed using the terms “meningioma” and “embolization” to investigate recent therapeutic options involving embolization in the treatment of meningioma. They looked at various cohorts, complications, materials, and timings of meningioma

treatment. Liquid embolic materials are preferable to particle agents because particle embolization carries a higher risk of hemorrhage. Liquid agents maximize the effect of devascularization because of deeper penetration into the trunk and distal tumor vessels. The 3 main imaging techniques, MRI, CT, and angiography, can all be used in a complementary fashion to aid in analyzing and treating meningiomas. Intraarterial perfusion MRI and a new imaging modality for identifying biomarkers, susceptibility-weighted principles of echo shifting with a train of observations (SW-PRESTO), can relay information about perfusion status and degrees of ischemia in embolized meningiomas, and they could be very useful in the realm of therapeutics with embolic material delivery. Direct puncture is yet another therapeutic technique that would allow for more accurate embolization and less blood loss during resection [8].

Preoperative embolization of skull base meningioma

Preoperative embolization of skull base meningioma

Case series

Akimoto et al. retrospectively reviewed the medical records of 186 patients with WHO grade I meningiomas who underwent surgical treatment at our hospital between January 2010 and December 2020. We used propensity score matching to generate embolization and no-embolization groups (42 patients each) to examine embolization effects.

Results: Preoperative embolization was performed in 71 patients (38.2%). In the propensity-matched analysis, the embolization group showed favorable recurrence-free survival (RFS) (mean 49.4 vs 24.1 months; Wilcoxon p=0.049). The embolization group had significantly less intraoperative blood loss (178±203 mL vs 221±165 mL; p=0.009) and shorter operation time (5.6±2.0 hours vs 6.8±2.8 hours; p=0.036). There were no significant differences in Simpson grade IV resection (33.3% vs 28.6%; p=0.637) or overall perioperative complications (21.4% vs 11.9%; p=0.241). Tumor embolization prolonged RFS in a subanalysis of cases who experienced recurrence (n=39) among the overall cases before variable control (mean RFS 33.2 vs 16.0 months; log-rank p=0.003).

Conclusions: After controlling for variables, preoperative embolization for meningioma did not improve the Simpson grade or patient outcomes. However, it might have effects outside of surgical outcomes by prolonging RFS without increasing complications [9]

Rapper et al. performed a retrospective review of patients undergoing intracranial meningioma resection between (March 2001 to December 2012). Comparisons were made between embolized and nonembolized patients, including patient and tumor characteristics, embolization method, operative blood loss, complications, and extent of resection. Logistic regression analyses were used to identify factors predictive of operative blood loss and extent of resection.

Results: Preoperatively, 224 patients were referred for embolization, of which 177 received embolization. No complications were seen in 97.1%. There were no significant differences in operative duration, extent of resection, or complications. Estimated blood loss was higher in the embolized

group (410 versus 315 mL, P=.0074), but history of embolization was not a predictor of blood loss in multivariate analysis. Independent predictors of blood loss included decreasing degree of tumor embolization (P=.037), skull base location (P=.005), and male sex (P=.034). Embolization was not an independent predictor of gross total resection.

Conclusions: Preoperative embolization is a safe option for selected meningiomas. In our series, embolization did not alter the operative duration, complications, or degree of resection, but the degree of embolization was an independent predictor of decreased operative blood loss [10)]

This study is based on personal experience with about 100 embolized meningiomas and on the experience of others. Embolization is performed during the same session as diagnostic angiography. The appropriate embolic materials (absorbable or nonabsorbable) are chosen according to the location of the tumor, the size of the feeding arteries, the blood flow, and the presence of any potentially dangerous vessels (dangerous anastomoses between external carotid artery and internal carotid or vertebral arteries, arteries supplying the cranial nerves). Preoperative embolization appeared to be very useful in large tumors with pure or predominant external carotid artery supply (convexity meningiomas), in skull-base meningiomas, and in middle fossa and paracavernous meningiomas. It was also useful in falx and parasagittal meningiomas receiving blood supply from the opposite side and in posterior fossa meningiomas. CT low densities demonstrated after embolization did not always correlate with necrosis on microscopic examination, and large areas of infarction could be found despite normal CT. Embolic material was found on pathologic examination in 10%-30% of cases; fresh or recent ischemic and/or hemorrhagic necrosis consistent with technically successful embolization was demonstrated in 40%-60% of cases. With careful technique complications are rare [11)]

Case reports

A case of hemorrhage in a parasellar meningioma shortly after embolization of the dural cavernous carotid artery branches supplying the tumor. This represents the first report of hemorrhage within a meningioma resulting from embolization with small (50 to 150-microns) polyvinyl alcohol particles, as well as the first reported case of hemorrhage complicating meningioma embolization from internal rather than external carotid artery branch embolization. We also review previously reported cases of postembolization hemorrhage from meningiomas [12)].

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