Safety and Efficacy of Preoperative Embolization in Patients with Meningioma

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Abstract

Preoperative embolization for intracranial meningioma has remained controversial for several decades. In this study, we retrospectively reviewed our experience of embolization using particulate embolic material and coil to clarify the therapeutic efficacy, safety, and risk of complication.

Methods We reviewed 69 patients who underwent embolization with particulate embolic material followed by surgical resection. An additional 6 procedures were included for patients in whom recurrence was treated, for a total of 75 procedures of preoperative embolization. We analyzed the following clinical data: age, sex, tumor size pathology, complications related to embolization, and surgeon's opinion on the intraoperative ease of debulking and blood transfusion. Embolization was performed mainly from the branches of the external carotid artery.

Results No allogenic blood transfusions were needed for any patients. The surgeon had the opinion that whitening and softening of the tumor allowed for easy debulking during decompression of the tumor in most of the patients. Hemorrhagic complications were seen in two patients after embolization. Emergency tumor removal was performed in both of those patients, and they were recovered well after surgery. Transient cranial nerve palsy was seen in one patient. One ischemic complication and one allergic complication occurred.

Conclusion Preoperative embolization could give us an advantage in surgery for meningioma. The procedure reduces intraoperative blood loss and operating time by softening the tumor consistency. However, we must pay attention to the possibility of embolic complications and keep the preparation of emergency craniotomy, particularly in patients with large meningiomas.

Keywords

- meningioma
- preoperative embolization
- endovascular technique
- surgical treatment

Introduction

Surgery for large hypervascular meningioma is still challenging because of encountering significant intraoperative bleeding. Preoperative embolization of the feeding vessels may be one of the solutions to reduce such bleeding, facilitate resection, and shorten operating time.^{1,2} However, risk of complica-

tions following this adjuvant preoperative embolization has been reported by several authors.^{3–5} Therefore, meticulous endovascular manipulation with full understanding of the potential risks is essential.

Polyvinyl alcohol (PVA) particles are the most commonly used embolic agent in Western countries.^{2,6} Yet, several authors have reported the risks of preoperative embolization using PVA

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particles,^{7,8} whereas the other authors have stressed the usefulness of n-butyl cyanoacrylate (NBCA).^{9,10} In Japan, the only material officially approved for preoperative embolization is Embosphere (Nippon Kayaku Co., Ltd) (trisacryl gelatin microspheres), which has been widely used in recent years.¹¹

In this study, we reviewed our experience with preoperative embolization using particulate embolic materials for meningioma to clarify its efficacy and safety.

Material and Methods

Patients and Methods

Of 183 patients, 69 with meningioma received embolization before surgical treatment in our institute between October 2007 and December 2017. Among these patients, a total of 75 procedures were performed, which included a second procedure for 6 patients with recurrence, and were retrospectively reviewed. The characteristics of the patients and their tumors are shown in ►Table 1. The indications for preoperative embolization were carefully discussed by the attending neurosurgeons. Subsequent tumor resection was performed in most of the patients on the next day after embolization. We collected the following clinical data: age, sex, tumor size and pathology, complications related to embolization, and surgeon's impression of the ease of the procedure and blood transfusion during surgery. The degree of embolization was classified into three groups: "excellent" as comfortable operating field whitened and softened more than 80% of the tumor, "moderate" as encountering a little bit bleeding without any trouble (20–80%), and "poor" as less than 20%. All patients consented to the use of all clinical information including images and other clinical data for this study.

Endovascular Procedure

The target vessels for embolization were selected based on diagnostic angiography, which usually included the middle

meningeal artery (MMA) and occasionally another feeding artery arising from the external carotid artery (ECA). Critical vessels such as the ophthalmic artery, meningohypophyseal trunk, inferolateral trunk of the internal carotid artery (ICA), and pial vessels were not embolized. Most procedures were performed through the transfemoral route under local anesthesia. Heparin (60–80 units/kg) was injected intravenously, and the activated clotting time was maintained at twice compared with control level. A 5- or 6-Fr guiding

Table 2 Results of the preoperative embolization

No. of procedures		75	
Tumor volume (milliliters)	Maximum	136.3	
	Minimum	2.7	
	Mean	40.6	
Target vessel	Middle meningeal artery	65 (86.7%)	
	Internal maxillary artery	18 (24%)	
	Accessory meningeal artery	13 (17.3%)	
	Occipital artery/posterior auricular artery	6 (8%)	
	Ascending pharyngeal artery	3 (4%)	
	Superficial temporal artery	2 (2.7%)	
	Posterior meningeal artery	1 (1.3%)	
	Anterior/posterior ethmoidal artery	1 (1.3%)	
Embolitic material	PVA	50 (66.7%)	
	Embosphere	25 (33.3%)	
	Coil	74 (98.7%)	
Tumor devascularization	Complete	14 (18.7%)	
	Partial	61 (81.3%)	
Complication		Intratumoral hemorrhage	2 (2.7%)
		Wire perforation	1 (1.3%)
		Coil migration	1 (1.3%)
		Allergic reaction	1 (1.3%)
		Double vision	1 (1.3%)
	Symptomatic	Yes	5 (6.7%)
		No	1 (1.3%)
	Procedure-related	Yes	2 (2.7%)
		No	4 (5.3%)
Medial interval between embolization and surgical resection (day)		1	
Mean operative time (minutes)		374	
Mean blood loss (milliliters)		214	
Allogenic transfusion		0(0%)	

Table 1 Summary of the patient's data

No. of cases		69
Mean age (years)		62.2
Sex	Male	30
	Female	39
Tumor location	Sphenoid ridge	18 (26.1%)
	Convexity	17 (24.6%)
	Parasagittal region	11 (15.9%)
	Anterior skull base	6 (8.7%)
	Tentorium	5 (7.2%)
	Cerebellopontine angle	3 (4.3%)
	Petroclivus	2 (2.9%)
	Middle fossa	2 (2.9%)
	Clinoidal region	2 (2.9%)
	Cavernous sinus	2 (2.9%)
	Falx	1 (1.4%)

Table 3 Clinical summary of patients with complications

Case no.	Age	Sex	Tumor location	Tumor volume (milliliters)	Target vessel	Embolic materials	Tumor devascularization	Pial supply	Adverse events	Procedure related	Symptomatic
1	54	Female	SR	57	MMA, IMA, AMA	PVA + coil	Partial	+	Allergic reaction	Yes	Yes
2	44	Male	CO	112.9	MMA	PVA + coil	Partial	-	Intratumoral hemorrhage	No	Yes
3	66	Male	SR	3.4	MMA, AMA	PVA + coil	Partial	+	Infarction (COIL migration)	Yes	Yes
4	77	Female	SR	19.9	MMA, IMA, AMA	PVA + coil	Partial	-	Wire perforation	Yes	No
5	54	Female	SR	25.5	MMA	Embosphere + coil	Partial	+	Intratumoral hemorrhage	No	Yes
6	39	Male	CPA	16.9	AMA	Embosphere + coil	Partial	-	Double vision	No	Yes

Abbreviations: AMA, accessory meningeal artery; CO, convexity; CPA, cerebellopontine angle; IMA, internal maxillary artery; MMA, middle meningeal artery; SR, sphenoid ridge.

catheter was placed in the ECA or the common carotid artery. A 1.7- to 2.6-Fr microcatheter was advanced into the feeder vessel as close to the dural attachment of the tumor as possible. Particles (PVA particles or Embosphere) were injected rhythmically with ventricular systole until we observed reduction of the tumor staining. Finally, coils were placed to secure the proximal ligation.

Results

In the 69 patients (mean age 62.2 years: range 44–84 years; 30 men, 39 women) who underwent preoperative embolization followed by surgical resection, a total of 75 procedures were performed because a second procedure was needed in 6 patients who experienced recurrence of the tumor, including 4 patients with atypical meningioma. The tumors were located in the sphenoid ridge (►Fig. 1) (18 [26.1%]), convexity (17 [24.6%]), parasagittal region (11 [15.9%]), anterior skull base (6 [8.7%]), tentorium (5 [7.2%]), cerebellopontine angle (3 [4.3%]), petroclivus (2 [2.9%]), middle fossa (2 [2.9%]), clinoidal region (►Fig. 2) (2 [2.9%]), cavernous sinus (2 [2.9%]), and falx (1 [1.4%]).

The results of preoperative embolization are summarized in ►Table 2. The average time of the surgeries was 374 minutes, and the mean blood loss was 214 mL. No allogenic blood transfusions were needed during the perioperative period in any of the patients. The degree of embolization was classified into three groups: excellent, moderate, and poor. The excellent group was seen in 40 patients (57%), the moderate group in 28 (42%) patients, and the poor group in 1 (1%) patient. In most of the operations, the surgeons felt comfortable during the internal decompression of the tumor because the tumor was whitened and softened as a result of embolization effect.

We experienced six (8%) cases of embolization-related complications. The details of the patients are shown in ►Tables 2 and 3. Intratumoral hemorrhage (►Fig. 2) occurred in two patients, wire perforation in one patient, mild hemiparesis due to an ischemic event in one patient, transient abducens nerve palsy in one patient, and allergic reaction in one patient. Symptomatic complications occurred in 5 (6.7%) patients. Procedure-related complications occurred in 2 (2.7%) patients. Both patients with intratumoral hemorrhage underwent emergency craniotomy and recovered without any neurologic deficit after surgery. The other two symptomatic patients spontaneously improved. An asymptomatic MMA venous shunt due to guide wire perforation occurred in one patient, and an allergic skin reaction probably caused by contrast material was seen in another. There was no difference in characteristics of complication between the PVA group and Embosphere (►Table 3).

Discussion

The aim of preoperative embolization for large intracranial meningioma is the reduction of its vascularity to reduce intraoperative blood loss, shorten operating time, and improve patient's quality of life.^{1,6} Effective reduction of vascularity could require embolization of intratumoral

Fig. 1 A 60-year-old female presented with headache. (A) Axial contrast-enhanced T1-weighted magnetic resonance imaging (MRI) showing a right sphenoid ridge meningioma invading the lateral wall of the orbit. (B) Lateral right external carotid angiogram showing a tumor stain fed by the middle meningeal artery. (C) Lateral right external carotid angiogram demonstrating the disappearance of tumor stain. (D) Postoperative MRI showing the total removal of the tumor.

vessels rather than proximal ligation, for which small particles and liquid embolic material are both possibly suitable. In this study, excellent or moderate embolization was performed in most of the patients. Even moderate embolization could reduce surgeon's stress during surgery. Several authors have stressed the validity of preoperative embolization using NBCA as the embolic material rather than particulate material due to a decreased frequency of major complication.^{9,10} However, NBCA has a strong affinity for the intimal walls of vessels, and it adheres to and hardens the network of abnormal vessels surrounding a tumor, thereby increasing the hardness of the tumor. Furthermore, NBCA spreads unevenly within a tumor, resulting in heterogeneity of the embolized area.¹² Additionally, liquid embolic materials carry a risk of migration to the intraparenchymal vessels through dangerous anastomoses or vasa nervosa. In addition, it is technically difficult to use NBCA due to its adhesiveness. In contrast, particulate material is able to infiltrate homogeneously into the tumor itself, which is the most likely

reason why embolized tumor tissue becomes more whitened and softened than when using NBCA. In this study, the surgeon felt very comfortable during the internal decompression of the tumor in most of the procedures.

Embosphere is the only approved material in Japan for preoperative embolization, and it is been increasingly used in our institute. In general, embolization using particulate material could achieve complete embolization in some situation. On the other hand, it carries a higher risk of intratumoral hemorrhage and edema. The pathophysiology of the intratumoral hemorrhage is not fully understood, but there are several hypothesized mechanisms such as follows: collateral vessels receive increased flow, which leads to rupture; embolic agents penetrate into the draining veins, which may impede outflow;¹³ continuous injection of the embolic agent increases pressure in the feeder arteries, which leads to rupture; and strenuous manipulation of the catheter or forceful test injection causes damage to the vessels.¹⁴ We inject particles gently to avoid increases pressure in feeder

Fig. 2 A 48-year-old female with right clinoidal meningioma who suffered from intratumoral hemorrhage after preoperative embolization. (A) Axial contrast-enhanced T1-weighted magnetic resonance imaging (MRI) showing a right clinoidal meningioma. (B) Lateral right external carotid angiogram showing a tumor stain fed by the middle meningeal artery. (C) Lateral right external carotid angiogram after embolization using particle (100–300 μ m) and coils demonstrating total devascularization. (D) Lateral right internal carotid angiogram after embolization showing extravasation of the contrast media in the tumor (arrow). (E) Axial computed tomography (CT) image immediately after embolization showing hematoma and contrast medium in the tumor and subdural hematoma. (F) Postoperative MRI showing total removal of the tumor.

arteries. To prevent the intratumoral hemorrhage, we choose relatively large-sized particles, inject gently as possible, and avoid inserting microcatheters too distally. In addition, recanalization of the feeders could result in intratumoral hemorrhage or peritumoral edema. Thus, we placed coils for proximal ligation to prevent recanalization. It is possible that early surgical resection after embolization can reduce development of abnormal collateral flow. Therefore, we usually planned surgical resection on the next day after embolization. Nevertheless, in this study, hemorrhagic complications were seen in 2 (2.6%) patients. Both patients underwent emergency craniotomy and tumor removal and subsequently achieved good recovery. In both patients, it was easy to surgically remove the tumor involving hemorrhagic clots and necrotic tissues.

Preoperative embolization does not always achieve complete obliteration of the tumor because feeders of meningioma include vessels that would be dangerous to embolize, such as the dural branches of the ICA and the pial arteries. Embolization of these dangerous arteries would likely result in symptomatic complications. Incomplete obliteration might cause a shift in the blood supply to a meningioma, with multiple feeders that included branches from the ICA and ECA.¹⁴ In this study, complete embolization was angiographically achieved in only 14 (18.7%) patients. Even so, preoperative embolization may contribute to reduced blood loss during the surgery.

As endovascular techniques and instruments continue to be developed, risks involved in these procedures are gradually declining. However, a small risk of complications still exist, and the indication for preoperative embolization remains controversial, that is, whether it should be consid-

ered a standard practice or should it be performed only in the specific setting of large hypervascular tumors. To support the rationale for preoperative embolization in patients with a large meningioma, its benefits would need to outweigh its disadvantages. A large prospective study would provide more precise data on the overall risk–benefit balance regarding this procedure.

Conclusion

We performed preoperative embolization using appropriate size of PVA or Embosphere associated with coils. Preoperative embolization could give us an advantage in surgery for meningioma. The procedure reduces intraoperative blood loss and operating time because it causes softening of tumor consistency. However, we must pay attention to the possibility of complications and keep in mind the possibility of emergency craniotomy, particularly in patients with large meningiomas. Further meticulous clinical study is warranted to clarify an appropriate timing of embolization and size of the embolic material.

Conflict of Interest

The authors declare no conflict of interest.

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