Preoperative Embolization of Meningiomas with N-Butyl Cyanoacrylate

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Summary

Meningiomas are often embolized before their surgical resection to reduce blood loss during surgery. Polyvinyl alcohol (PVA) particles have been the most frequently used material for embolization of meningiomas. We have used n-butyl cyanoacrylate (NBCA) as the first-choice material since 2001. Thirty-one meningiomas were embolized with NBCA. We report the result of embolization of meningiomas with NBCA in comparison with PVA particles.

Introduction

As their removal is curative, the primary treatment for meningiomas is surgical resection¹. These tumors tend to be highly vascularized and intraoperative bleeding renders their resection difficult. To reduce bleeding during surgical resection, these tumors are often embolized²⁻⁵. This reduces blood loss during surgery, makes surgical resection easier, reduces the time required for surgery, and consequently makes the procedure safer.

Successful embolization has been obtained with different embolic materials⁶. Polyvinyl alcohol (PVA) particles are used most frequently, however they carry a certain risk of eliciting adverse events such as hemorrhage and neurological deficits⁷⁻⁹. We found that n-butyl cyanoacrylate (NBCA) is a satisfactory embolic agent for the preoperative embolization of meningiomas, as we believe NBCA carries lower risk of hemorrhagic and ischemic complications than PVA particles. Here we discuss our experience with use of this embolic material in patients undergoing meningioma surgery.

Materials and Methods

Since 2001 we have used NBCA for the preoperative embolization of meningiomas in 31 consecutive patients treated in our hospital. They were 12 males and 19 females whose ages ranged from 12 to 81 years. Embolization with the patient under local anesthesia was usually performed one to two days before surgery. We used a standard femoral approach. Briefly, a 5 Fr guiding catheter (Guider, Boston Scientific, Natick, MA, USA) was navigated beyond the carotid bifurcation. Then a microcatheter was coaxially introduced and advanced in the feeding artery to be as close as possible to the tumor. Based on the caliber, tortuosity and length of the feeding artery, we used Magic STD, Magic 1.8-MP, Magic 1.2-FM (BALT, Montmorency, France), Marathon (ev3, Plymouth, MN, USA), Fastracker-10 or Excelsior SL-10 (Boston Scientific, Natick, MA, USA) microcatheters. To reduce pain, we first injected 5 ml of 0.4% lidocaine via the microcatheter. This was followed by the delivery of a 5% glucose solution. Then a 17-25% mixture of NBCA (Histoacryl, B. Braun, Melsungen, Germany) and lipiodol (Lipiodol Ultra Fluide, Guerbet, Roissy, France), warmed to reduce viscosity, was injected via the middle meningeal artery.

Results

Over a ten year period from 2001 to 2011, 31 patients underwent preoperative embolization of meningiomas at our institution. The 31 sites of meningiomas were: sphenoid ridge (n=8), convexity (n=10), parasagittal (n=5), falx (n=1), olfactory groove (n=1), clinoid (n=1), cerebel-

Figure 1 Case 1. Contrast-enhanced T1-weighted image of MRI (A) shows a medial sphenoid ridge meningioma. Antero-posterior view of right internal carotid angiogram (B) and lateral view of external carotid angiogram (C) demonstrate tumor stain supplied from both internal and external carotid arteries. Injection of n-butyl cyanoacrylate in the tumor vessels through the microcatheter advanced via the middle meningeal artery (D) resulted in complete obliteration of tumor stain confirmed by internal carotid (E) and external carotid (F) injection of contrast after embolization.

lopontine angle (n=1), and cerebellar convexity (n=4) (Table 1). Overall we catheterized 46 feeding pedicles. In 38 of 46 procedures (83%) the embolization material was NBCA. In the other eight embolizations (17%) we injected PVA particles or pieces of gelatin sponge because vessel tortuosity prevented advancing the microcatheter close enough to the tumor or beyond dangerous anastomoses. Of the catheterized feeding arteries, 85% (39/46) were contributions derived from the external carotid artery, i.e. middle meningeal artery (n=31), accessory meningeal artery, (n=3), occipital artery (n=4), and the deep temporal artery (n=3). Al-

though superficial temporal arteries often contributed to the feeders, they were not embolized to preserve the blood supply to the scalp. Feeders from the internal carotid and vertebral artery were embolized only when they could be accessed safely, these feeders included branches from the ophthalmic artery (n=3), tentorial artery (n=1), distal anterior cerebral artery (n=1) and posterior meningeal artery (n=2).

Total devascularization of the tumor was achieved in three patients; their tumors did not bleed at all during piece-by-piece resection (Figures 1 and 5).

Subtotal devascularization was accom-

Table 1 Presentation of 31 cases.

Case No.	Age / Sex	Location of tumor	Size of tumor (cm)	Pedicles embolized	Embolic result	Interval* (days)	Histology	Surgical result**	Clinical result
1	70 f	rt sphenoid ridge	3.0×3.8×3.7	rt MMA	excellent	2	meningotheial	2	improved
2	64 m	rt parietal parasagittal	6.7×4.8×5.5	rt MMA	good	2	angiomatous	1	unchanged
3	41 f	lt frontal parasagittal	4.3×4.3×3.0	bil MMA	good	2	anaplastic	1/recurr	improved
4	46 m	lt parietal convexity	3.4×3.5×4.0	lt MMA	good	2	meningotheial	1	improved
5	34 f	rt sphenoid ridge	2.8×3.3×2.6	rt MMA	fair	1	meningotheial	1	unchanged
6	43 m	rt frontal convexity	6.1×3.4×4.2	rt MMA	good	6	meningotheial	1	improved
7	81 f	lt frontal convexity	4.8×5.2×2.4	bil MMA	fair	2	atypical	3	improved
8	50 f	olfactory groove	4.0×4.8×5.2	rt OphA	fair	1	angiomatous	2	improved
9	64 m	rt frontal convexity	4.2×4.1×5.1	rt MMA	good	1	atypical	2	unchanged
10	58 f	lt cerebellar convexity	3.7×4.6×4.7	lt OccA	excellent	2	fibrous	2	improved
11	35 f	lt parietal falx	2.3×2.3×2.0	lt OccA, lt MMA	good	1	fibrous	2	improved
12	51 m	rt frontoparietal parasagittal	6.2×4.7×4.8	rt MMA	good	2	meningotheial	4	unchanged
13	75 f	lt parietooccipital parasagittal	6.6×4.9×6.0	bil MMA	fair	2	atypical	3	unchanged
14*	43 f	lt frontoparietal parasagittal	2.9×3.3×3.0	bil MMA	good	2	anaplastic	4/recurr	unchanged
15	55 m	rt frontal convexity	4.3×5.5×3.3	rt MMA	fair	2	meningotheial	1	improved
16	46 m	lt sphenoid ridge	6.0×6.2×6.7	lt MMA	good	1	meningotheial	5	unchanged
17	77 f	rt sphenoid ridge	4.2×4.1×4.5	rt MMA	fair	2	atypical	2/recurr	improved
18	67 f	rt parietal convexity	3.1×3.1×3.0	rt MMA	good	2	transitional	1	unchanged
19	74 f	rt sphenoid ridge	6.0×5.5×6.0	rt MMA, rt AMA	fair	1	atypical	2/recurr	improved
20	61 f	rt cerebellar convexity	4.5×4.5×4.7	rt MMA, rt PMA	poor	no surgery			
21	57 f	lt cerebellar convexity	5.2×5.4×5.1	lt PMA	good	1	fibrous	3	improved
22	53 f	lt frontal convexity	4.0×4.4×5.0	lt MMA, lt AMA	fair	2	fibrous	2	improved
23	74 m	rt sphenoid ridge	4.0×5.6×5.8	rt MMA, rt AMA	fair	2	atypical	2	unchanged
24	57 f	lt frontal convexity	2.6×3.1×3.5	lt MMA	fair	1	microcystic	1	unchanged
25	59 m	lt frontal convexity	3.3×5.1×3.4	rt MMA, lt OphA.	good	1	atypical	2	improved
26	62 m	lt sphenoid ridge	4.3×5.5×5.2	lt MMA	good	1	transitional	3	improved
27	12 m	lt clinoid	3.7×3.7×3.4	lt tentorial a, lt deep temporal a	fair	2	angiomatous	4	improved
28	69 f	rt sphenoid ridge	3.7×4.9×4.6	rt MMA, rt OphA	partial	2	angiomatous	2	improvd
29	41 f	rt CP angle	5.0×5.9×5.9	rt OccA	good	2	transitional	4	unchanged
30	54 m	rt frontal convexity	4.1×5.8×3.3	bil MMA, rt ACA	good	2	angiomatous	3	improved
31	63 f	rt cerebellar convexity	3.4×3.5×4.0	rt MMA, rt OccA	excellent	2	fibrous	1	improved

* interval between embolization and surgery. ** Simpson classification. ACA = anterior cerebral artery; AMA = accessory meningeal artery; bil = bilateral; CP angle = cerebellopontine angle; lt = left; MMA = middle meningeal artery; NBGA = n-butyl cyanoacrylate; OccA = occipital artery; OphA = ophthalmic artery; PMA = posterior meningeal artery; PVA = polyvinyl alcohol; rt = right

Figure 2 Case 9. Embolization from bilateral middle meningeal artery. Contrast-enhanced T1-weighted image of MRI (A) shows a convexity meningioma on the left side. Left external carotid angiogram (B) shows the tumor stain supplied from the left middle meningeal artery (MMA). Embolization with NBCA from the left MMA (C) ended up with proximal occlusion and right external carotid angiogram after the first embolization (D) demonstrates supply to the tumor from the contralateral MMA. Anteroposterior view of the injection of NBCA from the right MMA (E) penetrates not only into the tumor but also into the distal part of the falcine artery which is also feeding the tumor.

plished in 15 cases and more than half of the tumor was embolized in 11 cases (Figures 2-4). Although preoperative embolization was found to be useful during resection of these tumors, its benefits were difficult to evaluate. Embolization resulted in partial devascularization in two cases.

In one the embolic material did not reach the tumor and although feeder occlusion was obtained the tumor continues to be fed by inaccessible collateral feeders. In the other case embolization of the main feeder was aborted due to complications.

Embolization-related complication arose in one case. The vertebral artery was dissected during navigation of the microcatheter into the posterior meningeal artery. This resulted in brainstem infarction and surgical resection of the tumor was cancelled.

Unlike other studies after embolization with particles, we encountered no instances of peri- or intra-tumoral bleeding after embolization.

Discussion

NBCA can be delivered with a wider range of microcatheters than particles and its use allows more distal navigation of the microcatheter. When the catheter tip is close enough to the origin of tumor vessels, NBCA enters intratumoral vessels and other feeders simultaneously (Figure 2). Since the feeders and intratumoral vessels are thus occluded at the same time, unlike solid embolic materials, NBCA prevents intratumoral bleeding. In addition, as the required injection pressure is lower when NBCA is the embolic material, this may avoid the elicitation of hemorrhagic complications¹⁰.

On the other hand, if the microcatheter is wedged, NBCA can penetrate into unopacified "dangerous" anastomoses or into the pial vessels through the intratumoral anastomosis. Wedged embolization should be performed only when the catheter is distal enough and when there is no pial supply. In such cases, wedged embolization is highly effective.

Figure 3 Case 12. Superselctive embolization of a convexity meningioma. Contrast-enhanced T1-weighted image of MRI (A) shows a convexity meningioma. Antero-posterior view (B) and lateral view (C) of the right external angiogram shows two branches of the middle meningeal artery feeding the tumor. Superselective injections of NBCA through the two branches (D, E) penetrated into the tumor vessels.

Using NBCA, embolization of pial supply vessels can be performed with techniques applied to address brain arteriovenous malformations¹¹ (Figure 5). Their occlusion is highly useful in patients undergoing meningioma surgery when the tumors are highly vascularized by the pial supply. We perform embolization of the pial supply when a significant portion of the tumor is supplied from the pial vessels and embolization of dural supply did not obliterate enough of the tumor vessels.

Unlike PVA particles, the mixture consisting of NBCA and lipiodol is radiopaque. This avoids overlooking the migration of embolic material into dangerous anastomoses. On the other hand, if the microcatheter is far from the tumor, NBCA embolization may more easily result in proximal occlusion than embolization with particles.

Upon warming, the NBCA mixture becomes less viscous and this may allow it to penetrate more easily and deeply into the feeding vessels. We believe that even if the embolization ends up with proximal occlusion of the feeding ves-

sels, it is still beneficial for preoperative purpose and carries a lower risk of hemorrhagic complications than distal PVA embolization. Although we currently recommend using this liquid embolic material for each meningioma embolization, when the microcatheter tip cannot be advanced close enough to the tumor, the use of other embolic materials such as PVA particles should be considered.

We performed preoperative embolization of meningiomas under local anesthesia because of the difficulty of accessing general anesthesia in the angio-suite in our institute. Although NBCA induces pain when injected into the dural vessels, injection of 5 ml of 0.4% lidocaine in advance reduces the pain significantly.

The preoperative embolization of meningiomas is not free of complications. Especially in cases where access to the feeders is difficult or the feeders are related to dangerous anastomoses, the possible risks of embolization, irrespective of the material used, must be weighted against anticipated benefits in patients for the

Figure 4 Case 30. Embolization of contribution from pial vessel. Axial, coronal and sagittal images of contrast-enhanced T1-weighted images (A-C) show a convexity meningioma. Right internal carotid angiogram performed after embolization through the branches of bilateral middle meningeal artery (D) demonstrates pial contribution of the tumor from a branch of the anterior cerebral artery. This branch was catheterized with a flow-guided microcatheter and embolized with the same technique as that of arteriovenous malformation (E). Tumor stain from pial contribution disappeared after the embolization (F).

surgical removal of meningiomas. Although embolization of meningiomas with Onyx (ev3, Plymouth, MN, USA) is also reported to be safe and effective¹², the use of Onyx for meningiomas is not approved in Japan. We have no experience of Onyx embolization of meningiomas and hence cannot comment on this embolic agent.

Conclusion

Preoperative embolization of meningiomas with NBCA, a safe and effective embolic material, facilitates their surgical resection. However, the indication for preoperative embolization must be carefully assessed on a case-by-case basis.

Figure 5 Case 31. Embolization of an infratentorial meningioma. Axial, coronal and sagittal images of contrast-enhanced T1-weighted images (A-C) show an infratentorial meningioma. Right external carotidogram (D) demonstrates feeders from the middle meningeal artery and the occipital artery. Use of a flow-guided microcatheter allowed superselective injections of NBCA through the middle meningeal artery (E) and through the transosseous branch of the occipital artery (F).

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