Preoperative Embolization of Cerebellar Hemangioblastomas with a Liquid Embolic Material (NBCA) by the “Plug and Push” Technique

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Objective: We retrospectively reviewed patients who had undergone preoperative embolization of cerebellar hemangioblastomas with a liquid embolic material, N-butyl cyanoacrylate (NBCA), by the plug and push technique.

Methods: The subjects were six patients who had undergone preoperative embolization of cerebellar hemangioblastomas in our hospital between April 2016 and October 2017. In all patients, a microcatheter was selectively guided into a feeder, and tumor embolization with low-concentration NBCA, which had been diluted with oily contrast medium, was performed using the plug and push technique before tumor resection based on approval by the Ethics Review Board of our hospital.

Results: The male-to-female ratio was 5:1. The mean age was 33.8 ± 10.7 years. The tumor type was evaluated as nodular in three patients and solid in three patients. The mean nodular size was 26 ± 8.9 mm. The mean interval from embolization until surgery was 1.3 days (1–4 days). In all patients, the procedure could be accomplished. The mean concentration of NBCA was 19.4% ± 1.4%. Concerning the embolization effects, cerebral angiography showed complete occlusion in four patients and partial occlusion in two patients. There was no embolization-related complication or adverse event. Under suboccipital craniotomy, total tumor resection was possible in five patients, whereas one patient required blood transfusion.

Conclusion: Preoperative embolization of cerebellar hemangioblastomas with low-concentration NBCA by the plug and push technique may be useful for accomplishing tumor resection although catheter adhesion on infusion must be considered.

Keywords: hemangioblastoma, N-butyl cyanoacrylate, plug and push

Introduction

Hemangioblastomas are classified as a benign Grade I brain tumor according to the World Health Organization (WHO) classification. They account for 1.5%–2.5% of all intracranial tumors. Most lesions develop in the cerebellum, accounting for 10% of all cerebellar tumors.1) Hemangioblastomas are characterized by abundant blood vessels in the tumor parenchyma, and massive hemorrhage may occur during resection. However, recent studies indicated the efficacy of preoperative tumor embolization with N-butyl cyanoacrylate (NBCA).2)

In this study, we report patients in whom intra-tumor embolization with low-concentration NBCA by the plug and push technique before tumor resection of cerebellar hemangioblastomas led to favorable embolization effects, suggesting its usefulness for obtaining the accuracy and safety of tumor resection, and review the literature.

Subjects and Methods

We retrospectively reviewed six patients with cerebellar hemangioblastomas who had undergone preoperative embolization and tumor resection between April 2016 and
October 2017 with respect to the following items. The use of NBCA during preoperative embolization was explained to all patients and their families based on approval by the Ethics Review Board of our hospital.

In all patients, the Marathon microcatheter (Medtronic, Minneapolis, MN, USA) was selectively guided into a feeder through the lumen of a guiding catheter under general anesthesia so that it reached an area adjacent to the tumor. Selective angiography was performed through the microcatheter to confirm that the feeder is appropriate for embolization. Subsequently, low-concentration NBCA diluted with oily contrast medium, which had been sufficiently heated, was infused into the tumor using the plug and push technique. Concretely, it was infused upward so that there might be no air involvement when connecting a 1-cc syringe containing diluted NBCA with the hub of a microcatheter so that the liquid surface might be flat. After confirming cast formation related to slight NBCA ejection at the microcatheter end, the 1-cc syringe at hand was slowly pushed so that NBCA might slowly permeate the tumor. When NBCA regurgitated to the level of the distal tip marker at the Marathon microcatheter end, infusion was completely stopped, and the microcatheter was promptly removed.

We examined the age, sex, tumor site/morphology, nodular size, presence or absence of Von Hippel–Lindau disease (VHL), feeder that was embolized, concentration of NBCA, embolization effects on cerebral angiography, embolization-related complications, degree of tumor resection, and outcome during follow-up (30 days after surgery).

## Results

The background of the six patients is shown in Table 1. The male-to-female ratio was 5:1. The mean age at the time of treatment was 33.8 ± 10.7 years. Type 2 VHL was present in two patients. The tumor sites consisted of the cerebellar hemisphere in three patients, cerebellar vermis in two patients, and medulla oblongata in one patient. The tumor morphology was evaluated as solid in three patients and cystic in three patients. The mean nodular size was 26 ± 8.9 mm. The main feeders consisted of the posterior inferior cerebellar artery in four patients, anterior inferior cerebellar artery in one patient, and superior cerebellar artery in patient. No provocation test was conducted in any patient. On selective angiography through a microcatheter, only tumors were visualized in five patients, but the cerebellum distal to the tumor was visualized in one patient with a cerebellar vermis lesion. The short
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Present illness: Detailed examination of headache (cerebral MRI) had revealed several tumor lesions of the cerebellum a few years previously (Fig. 1a). Thereafter, headache exacerbated. Surgery was planned. Initially, preoperative embolization of a cerebellar vermis tumor was performed. Endovascular treatment: Embolization of a hemangioblastoma of the cerebellar vermis (Fig. 1b), involving the left superior cerebellar artery as a feeder, was performed, but the microcatheter end was adjacent to the tumor (Fig. 1c). During the slow injection of NBCA, the cast was extended into the tumor (e). The tumor stain was decreased at the middle part of the tumor after the embolization (f). NBCA: n-butyl cyanoacrylate

Representative Case 2: A 39-year-old male.
Complaint: Posterior cervical pain.
Medical history: Not contributory.

Present illness: Headache with posterior cervical pain had persisted for 6 months, and gradually deteriorated. The patient consulted our department.
Physical examination on admission: Consciousness was clear. There was no cerebral/neurologic symptom. There was no papilledema or nuchal rigidity.
Imaging: Contrast-enhanced cephalic MRI revealed a solid mass, partially containing a cystic component, involving the medulla oblongata to cerebellar vermis (Fig. 2a and 2b). Cerebral angiography showed a darkly stained tumor involving the caudal and rostral branches as feeders among the right anterior inferior cerebellar arteries (Fig. 2c and 2d).

Endovascular treatment: For tumor resection, it is the most difficult to exfoliate a tumor from the Tegmentum of the pons. The main purpose of preoperative embolization was to embolize the caudal branch among the anterior inferior cerebellar arteries primarily flowing in this site. Under general anesthesia, a 6 Fr FUBUKI (Asahi Intecc Co., Ltd., Tokyo, Japan) was inserted into the left vertebral artery as a guiding catheter. Through its lumen, the Marathon microcatheter was selectively guided into the right anterior inferior cerebellar artery using a Traxcess 14 microguidewire (Terumo Corporation, Tokyo, Japan). In addition, it was exchanged for a TENROU1014 (Kaneka Medix Corp., Tokyo, Japan) to put forward furthermore. Initially, it was inserted to an area adjacent to the tumor through the rostral branch. Through the same site, 20% NBCA diluted with oily contrast medium was slowly infused using the plug and push technique. Subsequently, the Marathon microcatheter was selectively guided into the caudal branch, and 20% NBCA was infused (Fig. 2e), leading to the disappearance of the darkly stained tumor (Fig. 2f).

Tumor resection: Tumor resection under suboccipital craniotomy was performed the following day. Under general anesthesia, the patient was placed in the prone position, and a hockey-stick-type skin incision was established. Suboccipital craniotomy was performed, and the tumor was exfoliated/extirpated from the medulla oblongata and cerebellar vermis on the rostral side. However, cluster-like glue was scattered in the inner area of the tumor, and hemostasis on the extirpated surface was favorable (Fig. 3a). In addition, surgical operations were started on the caudal side, and we attempted to exfoliate the tumor from the Tegmentum of the pons/midbrain, resulting in marked bradycardia/hypotension and cardiac arrest for a few seconds. We considered it difficult to continue exfoliation operations, and selected partial tumor resection. The volume of intraoperative blood loss was 400 cc. Autoinfusion alone was performed, and surgery was completed. Postoperative MRI showed a residual tumor in the Tegmentum of the pons (Fig. 3b), but there was no postoperative hemorrhage.

Postoperative course: After surgery, there was no neurologic deficit, and the course was favorable. The patient was discharged 10 days after surgery.
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Discussion

Von Hippel–Lindau (VHL) disease is autosomal dominant inheritance-mediated hereditary multiple tumor syndrome that causes cerebrospinal hemangioblastomas, retinal hemangioblastomas, renal cell carcinoma, pheochromocytomas, and pancreatic/renal/epididymal lesions.\(^4\) Of patients with VHL disease, those without pheochromocytomas are regarded as having type 1 VHL disease, and those with it as having type 2 VHL disease.\(^3\)

Hemangioblastomas are classified as a benign Grade I brain tumor that frequently develops in the cerebellum of adults according to the WHO classification. They are closely associated with an autosomal dominant hereditary disease, VHL disease, but solitary hemangioblastomas that do not belong to VHL disease are present. Some cerebellar hemangioblastomas complicated by VHL disease show a slight increase in the stuttering growth pattern in comparison with solitary hemangioblastomas, and many lesions become symptomatic.\(^5\) Furthermore, the type of hemangioblastoma is classified into two: cystic and solid based on the tumor morphology.\(^6\)

Hemangioblastomas are characterized by the presence of abundant blood vessels in the tumor parenchyma; after resection, hemostasis is sometimes difficult. Therefore, when performing tumor resection, feeders should be treated, and, as a rule, the tumor should be resected as a mass by exfoliating it from the periphery.

On the other hand, solid cerebellar hemangioblastomas measuring $\geq 30$ mm are difficult to resect for the following reasons:\(^7\) intra-tumor blood flow is abundant, and the courses of feeders, such as the anterior inferior cerebellar artery, involve the deepest area, making feeder treatment during tumor resection under suboccipital craniotomy difficult.

Large, solid tumors make it difficult to maintain an operation space; the degree of difficulty in tumor resection is high.\(^8\) Recent studies indicated the efficacy of preoperative embolization of hemangioblastomas with NBCA.\(^2\) The results suggest that the treatment response and risk of complications depend on embolization materials. In particular, when performing embolization with solid embolization materials, uneven intra-tumor embolization related to the large capillary floors of cerebellar hemangioblastomas may lead to an imbalance in the intra-tumor capillary floor pressure, causing intra-tumor hemorrhage.\(^9\) On the other hand, a study reported that the incidence of hemorrhagic complications after embolization with liquid embolization materials was lower than after embolization with granular embolization materials.\(^10\)

In this study, prior to tumor resection of cerebellar hemangioblastomas, we performed embolization using the plug and push technique after diluting NBCA with oily contrast medium so that its adhesiveness may be reduced. Favorable embolization effects were achieved, and this method was useful for establishing the accuracy and safety of tumor resection. Previously, the plug and push technique had been adopted as a procedure to continuously infuse an embolization material, utilizing the non-adhesiveness of Onyx, in patients with cerebral arteriovenous malformations (AVM), contributing to an improvement in the AVM nidus embolization rate.\(^11\) On the other hand, Ohnish et al.\(^12\) slowly infused low-concentration NBCA through the middle meningeal artery using the plug and push technique for preoperative embolization of meningiomas, and reported that a low-concentration-related reduction in the adhesiveness of NBCA to a microcatheter and a prolonged infusion time contributed to favorable, effective embolization.
Concerning preoperative embolization of cerebellar hemangioblastomas with Onyx, only case reports have been published, but we compared Onyx with NBCA for tumor embolization, as shown in Table 2. As the former’s merits, its non-adhesiveness facilitates discontinuation/slow infusion in comparison with NBCA, making it possible to embolize hemangioblastomas while understanding the vascular structure. In addition, its diffusion facilitates embolization of feeders to be embolized alone. On the other hand, the limitations of Onyx include a high material cost, difficulty in long-distance infusion in the presence of slow blood flow related to a thin vascular diameter, and deviation to the venous side.\(^\text{13}\) In this study, we infused ≤20% NBCA using the plug and push technique to treat cerebellar hemangioblastomas with abundant tumor vessels, and intra-tumor infiltration through fine blood vessels in the absence of catheter adhesion led to favorable, effective preoperative embolization. However, the adhesiveness of NBCA in comparison with Onyx must be considered. In particular, when adopting the plug and push technique, NBCA regurgitation at the time of infusion may increase the risk of microcatheter adhesion, making removal difficult. Both surgeons and assistants should pay attention to the grade of regurgitation; sufficient observation and much attention are necessary.

For preoperative embolization with low-concentration NBCA, the risk of regurgitation-related microcatheter adhesion should be considered, but we infused the embolization material into the tumor while predominantly embolizing a feeder of which the treatment during tumor resection was expected to be difficult, contributing to bleeding control during subsequent tumor resection. In addition, total tumor resection could be switched to partial tumor resection without difficulties in hemostasis at the tumor stump even when exfoliation from the dorsal side of the brainstem, such as the midbrain/bridge, was difficult. This procedure was extremely effective.

### Conclusion

Preoperative embolization of cerebellar hemangioblastomas, rich in blood vessels, with low-concentration NBCA by the plug and push technique is useful for achieving extirpation through favorable embolization effects although catheter adhesion at the time of infusion must be considered.

### Disclosure Statement

There is no conflict of interest regarding this article.

### References