Endovascular Treatment of Ruptured Aneurysms Associated With Fenestrated Basilar Artery

—Two Case Reports—

Yutaka KAI, Jun-ichiro HAMADA*, Motohiro MORIOKA, Shigetoshi YANO,
Shodo FUJIOKA**, and Jun-ichi KURATSU

Department of Neurosurgery, Graduate School of Medical Sciences, Kumamoto University,
Kumamoto, Kumamoto; *Department of Neurosurgery, Graduate School of Medical Sciences,
Kanazawa University, Kanazawa, Ishikawa; **Department of Neurosurgery,
Saiseikai Kumamoto Hospital, Kumamoto, Kumamoto

Abstract

Two patients with ruptured aneurysm associated with fenestrated basilar artery (BA) were treated using the endovascular approach. Angiography showed these patients had different types of BA bifurcation. One type had two points of bifurcation and a bridging artery in the BA fenestration, with the aneurysm at the bifurcation of the right loop of the fenestration. The aneurysm had different appearances on right and left vertebral angiograms. The other type had only one point of bifurcation, and the appearance of this aneurysm was similar on both angiograms. To ensure successful embolization, bilateral vertebral angiography should be performed for complete assessment of the morphological characteristics of aneurysm associated with fenestrated BA.

Key words: basilar artery, fenestration, interventional neurosurgery

Introduction

Saccular aneurysms of the vertebrobasilar junction are rare and often associated with basilar artery (BA) fenestration. The BA is formed at around the 5–9 mm fetal stage by fusion of paired longitudinal neural arteries. Failure of this fusion may result in fenestration anywhere along the course of the BA, but most often in the proximal portion.¹⁵⁾ Vertebrobasilar junction aneurysms usually occur at the proximal portion of the fenestration. Surgical treatment of these aneurysms is difficult because of the complex geometry of the fenestration, the proximity of the lower cranial nerves, the presence of multiple small perforating arteries to the brain stem, and difficulties in obtaining adequate surgical exposure.^{2,3,5,7,9,10,13,15,18,19)} Therefore, endovascular treatment of such intracranial aneurysms is now widely accepted. Twenty-seven aneurysms associated with fenestrated BA were treated with coil embolization,^{1,6–8,11,12,14,16–18,20,21)} successfully in most cases without new neurological deficits in any

patient, but technical complications were encountered.

We used the endovascular approach to treat two patients with ruptured aneurysm associated with fenestrated BA exhibiting different morphological characteristics.

Case Reports

Case 1: A 44-year-old woman suffered sudden onset of headache. Computed tomography (CT) showed subarachnoid hemorrhage (SAH). Right vertebral angiography demonstrated fenestrated BA and a bridging artery in the bilateral loops of the fenestration. A saccular aneurysm arose from the bifurcation of the right loop of the fenestration and the bridging artery (Fig. 1). There was no aneurysm formation at the junction of the left loop of the fenestration and bridging artery (Fig. 2). The right vertebral artery (VA) was catheterized using a 6.0-Fr guiding catheter (Medikit Co. Ltd., Tokyo). A tracker-10 microcatheter (Target Therapeutics, San Jose, Calif., U.S.A.) was inserted, and the aneurysm was embolized with Guglielmi detachable coils (GDCs) (total length 8 cm). Embolization occluded the right

- Fig. 1** Case 1. Right vertebral angiogram showing a saccular aneurysm arising from the bifurcation of the right loop of the fenestrated basilar artery and a bridging artery. The bridging artery connected the bilateral loops of the fenestrated basilar artery.
- Fig. 2** Case 1. Left vertebral angiogram showing the bridging artery and bilateral loops of the fenestrated basilar artery. There was no aneurysm arising from the bifurcation of the left loop of the fenestrated basilar artery and bridging artery.
- Fig. 3** Case 1. Left vertebral angiogram showing obstruction of the aneurysm. The right loop of the fenestrated basilar artery is not visualized.

- Fig. 4** Case 2. Right vertebral angiogram showing an aneurysm arising from the proximal site of the fenestrated basilar artery. No bridging artery is visualized.
- Fig. 5** Case 2. Left vertebral angiogram showing the aneurysm seen in the right vertebral angiogram (Fig. 4).
- Fig. 6** Case 2. Left vertebral angiogram showing obstruction of the aneurysm. The bilateral loops of the fenestrated basilar artery were preserved.

loop of the fenestration and the bridging artery. The last coil slightly protruded into the aneurysm orifice. The right posterior inferior cerebellar artery (PICA) was spared and refilled from the right VA. The posterior circulation of the BA, left PICA, and bilateral anterior inferior cerebellar arteries was provided normally through the left VA. Left vertebral angiography demonstrated complete disappearance of the aneurysm (Fig. 3). The patient's postoperative course was uneventful and she returned home with no neurological deficits.

Case 2: A 43-year-old man suffered sudden onset of headache. On admission, CT showed SAH. Right vertebral angiography demonstrated a saccular

aneurysm arising from the proximal site of the fenestrated BA. There was no bridging artery (Fig. 4). The aneurysm had the same appearance on both right and left vertebral angiography (Fig. 5). A 6.0-Fr guiding catheter was introduced into the left VA and selective angiography was performed. The aneurysm arising from the proximal site of the fenestrated BA was completely embolized with GDCs (total length 33 cm). Post-embolization bilateral vertebral angiography demonstrated complete disappearance of the aneurysm and preservation of the surrounding vessels (Fig. 6). His postoperative course was uneventful and he was able to return to work without neurological deficits.

Fig. 7 A: Case 1. Type A basilar artery fenestration. Note the bridging artery in the bilateral loops of the fenestrated basilar artery. B: Case 2. Type B basilar artery fenestration. There is no bridging artery.

Discussion

Surgical treatment of 20 aneurysms associated with fenestrated BA resulted in total occlusion of 14 of 17 clipped aneurysms and incomplete clipping of the other three aneurysms.³⁾ Thirteen patients experienced postoperative transient lower cranial nerve paresis, one manifested permanent severe neurological deficit, and one patient died.³⁾ Others have reported encountering difficulty with the surgery and attempted different treatment approaches.^{5,10,15,18)}

Endovascular occlusion with GDCs is an accepted alternative to surgical clipping of posterior circulation aneurysms. Treatment was successful in most of the 27 aneurysms associated with fenestrated BA without the development of new neurological deficits, but technical complications were encountered in several cases.^{1,6-8,11,12,14,16-18,20,21)} A patient treated with GDC embolization developed BA embolus during the procedure and required thrombolytic therapy with urokinase, but developed a neurological deficit that was not resolved.⁷⁾ Occlusion of the VA at the approach site occurred during the embolization procedure in two patients, although both were asymptomatic.^{11,21)} These findings stress the importance of acquiring anatomical information regarding the aneurysms associated with BA fenestration.

Angiography revealed that our two patients had different types of BA bifurcation (Fig. 7). Case 1 had two bifurcation points and a bridging artery in the BA fenestration (Type A). Case 2 had a single bifurcation at the proximal site of the fenestration (Type B). Patients with Type A bifurcation are at risk for developing aneurysms at both bifurcation sites.

One patient with two aneurysms within the same fenestrated BA may be illustrative of this situation.³⁾ Moreover, the more complex vascular structures in patients with Type A bifurcation may cause greater hemodynamic stress. According to our classification, of the 27 previously reported cases, 10 had Type A and 17 had Type B bifurcations.

Bilateral vertebral angiography was required to identify the Type A bifurcation because the aneurysm blood flow was not sufficiently demonstrated by unilateral angiography. The aneurysm and the BA fenestration were visualized by contrast injection into the unilateral VA in some cases, and the angiographic compartments of some aneurysms showed better opacification by injection into a specific VA.⁷⁾ The aneurysms in our patient with Type A bifurcation were better visualized by right than left vertebral angiography. During coil placement, compartmental access was easier via the specific VA that best opacified the compartment. Such hemodynamic and angiographic patterns require bilateral vertebral angiography for complete evaluation of vertebrobasilar junction aneurysms with associated BA fenestration. Although bilateral guiding catheters placed simultaneously may compromise the flow within the vertebrobasilar system, approaching each aneurysm from the contralateral VA provided the best direct access to aneurysms associated with BA fenestration.¹⁸⁾

We suggest that the development of Type A and Type B bifurcations depends on embryological mechanisms. BA fenestration is probably caused by failure of fusion of two primitive neural arteries or by the persistence of the cranial part of a primitive lateral vertebrobasilar anastomosis.⁴⁾ The vascular structures of the Type A bifurcation support the second embryological mechanism.

Appropriate and safe surgical treatment of aneurysms associated with BA fenestration requires understanding of the anatomical structure of the vascular duplications. Bilateral vertebral angiography should be obtained to assess the morphological characteristics.

References

- 1) Bavinszki G, Killer M, Gruber A, Reinprecht A, Gross CE, Richling B: Treatment of basilar artery bifurcation aneurysms by using Guglielmi detachable coils: a 6-year experience. *J Neurosurg* 90: 843-852, 1999
- 2) Becker DH, Hamilton RD: Saccular aneurysm associated with fenestrated basilar artery: case report. *Neurosurgery* 5: 695-697, 1979
- 3) Campos J, Fox AJ, Vinuela F, Lylyk P, Ferguson GG, Drake CG, Peerless SJ: Saccular aneurysms in basilar artery fenestration. *AJNR Am J Neuroradiol* 8:

- 233–236, 1987
- 4) De Caro R, Parenti A, Munari PF: Fenestration of the vertebro-basilar junction. *Acta Neurochir (Wien)* 108: 85–87, 1991
 - 5) Drake CG: The surgical treatment of aneurysms of the basilar artery. *J Neurosurg* 29: 436–446, 1968
 - 6) Eskridge JM, Song JK: Endovascular embolization of 150 basilar tip aneurysms with Guglielmi detachable coils: results of the Food and Drug Administration multicenter clinical trial. *J Neurosurg* 89: 81–86, 1998
 - 7) Graves VB, Strother CM, Weir B, Duff TA: Vertebrobasilar junction aneurysms associated with fenestration: treatment with Guglielmi detachable coils. *AJNR Am J Neuroradiol* 17: 35–40, 1996
 - 8) Guglielmi G, Vinuela F, Duckwiler G, Dion J, Lylyk P, Berenstein A, Strother C, Graves V: Endovascular treatment of posterior circulation aneurysms by electrothrombosis using electrically detachable coils. *J Neurosurg* 77: 515–524, 1992
 - 9) Hernesniemi J, Vapalahti M, Niskanen M, Kari A: Management outcome for vertebrobasilar artery aneurysms by early surgery. *Neurosurgery* 31: 857–861, 1992
 - 10) Hoffman WF, Wilson CB: Fenestrated basilar artery with an associated saccular aneurysm. Case report. *J Neurosurg* 50: 262–264, 1979
 - 11) Islak C, Kocer N, Kantarci F, Saatci I, Uzma O, Canbaz B: Endovascular management of basilar artery aneurysms associated with fenestrations. *AJNR Am J Neuroradiol* 23: 958–964, 2002
 - 12) Kanematsu M, Satoh K, Nakajima N, Hamasaki F, Nagahiro S: Ruptured aneurysm arising from a basilar artery fenestration and associated with a persistent primitive hypoglossal artery. Case report and review of the literature. *J Neurosurg* 101: 532–535, 2004
 - 13) Matricali B, van Dulken H: Aneurysm of fenestrated basilar artery. *Surg Neurol* 15: 189–191, 1981
 - 14) Nagashima H, Okudera H, Orz Y, Kobayashi S, Nakagawa F: Endovascular treatment of basilar trunk aneurysm associated with fenestration of the basilar artery. *Neurosurg Rev* 22: 219–221, 1999
 - 15) Nakasu Y, Nakasu S, Kidooka M, Handa J: Aneurysm at the fenestration of basilar artery — case report. *Nippon Geka Hokan* 51: 344–348, 1982
 - 16) Nichols DA, Brown RD Jr, Thielen KR, Meyer FB, Atkinson JL, Piepgras DG: Endovascular treatment of ruptured posterior circulation aneurysms using electrolytically detachable coils. *J Neurosurg* 87: 374–380, 1997
 - 17) Pierot L, Boulin A, Castaings L, Rey A, Moret J: Selective occlusion of basilar artery aneurysms using controlled detachable coils: report of 35 cases. *Neurosurgery* 38: 948–953, 1996
 - 18) Saatci I, Cekirge HS, Karcaaltincaba M, Basgun N, Berker M, Timurkaynak E, Ozcan OE: Endovascular treatment of kissing aneurysms at the fenestrated basilar artery. Case report with literature review. *Surg Neurol* 58: 54–58, 2002
 - 19) Sugita K, Kobayashi S, Takemae T, Tada T, Tanaka Y: Aneurysms of the basilar artery trunk. *J Neurosurg* 66: 500–505, 1987
 - 20) Tasker AD, Byrne JV: Basilar artery fenestration in association with aneurysms of the posterior cerebral circulation. *Neuroradiology* 39: 185–189, 1997
 - 21) Yoon SM, Chun YI, Kwon Y, Kwun BD: Vertebrobasilar junction aneurysms associated with fenestration: experience of five cases treated with Guglielmi detachable coils. *Surg Neurol* 61: 248–254, 2004

Address reprint requests to: Y. Kai, M.D., Department of Neurosurgery, Graduate School of Medical Sciences, Kumamoto University, 1-1-1 Honjo, Kumamoto, Kumamoto 860-8556, Japan.
e-mail: ykai@kaiju.medic.kumamoto-u.ac.jp