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Intra-aneurysmal embolization for subarachnoid hemorrhage due to rupture of an aneurysm located at the anterior spinal artery and vertebral artery: illustrative case

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BACKGROUND A vertebral artery–anterior spinal artery (VA-ASA) aneurysm is very rare. The authors report a case of successful coil embolization of a ruptured aneurysm of the VA-ASA.

OBSERVATIONS A 54-year-old man with World Federation of Neurosurgical Societies grade II subarachnoid hemorrhage presented with an aneurysm located at the region involving the origin of ASA on the VA. Endovascular treatment was chosen to prevent rerupture and preserve the perforating branches. The catheter shape was modified with steam forming to allow access to the aneurysm. Partial embolization was performed to preserve the ASA. The authors also prevented further rupture. On day 16, angiography showed thrombosis within the aneurysm and preserved blood flow in the ASA despite a neck remnant. The patient was discharged home with a modified Rankin Scale score of 0. Careful follow-up has been continued.

LESSONS Endovascular coiling in the acute phase of rupture of a VA-ASA aneurysm achieved favorable results. The aneurysm could be safely treated by selecting the appropriate device and catheter geometry.

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KEYWORDS intracranial subarachnoid hemorrhage; vertebral artery–anterior spinal artery aneurysm; endovascular; computational fluid dynamics

An anterior spinal artery (ASA) aneurysm is a rare disease usually associated with vascular lesions such as cerebral arteriovenous malformations and aortic stenosis.[1] The etiology of aneurysms may be related to hemodynamic stress.[2–4] The present case involves subarachnoid hemorrhage caused by a ruptured aneurysm at the vertebral artery (VA)-ASA with severe meandering of the VA without any vascular lesion. Coil embolization around the rupture point was successfully performed.

Illustrative Case

A 54-year-old man presented with severe subarachnoid hemorrhage, World Federation of Neurosurgical Society grade II, and neuroimaging showed a 2-mm-diameter aneurysm at the left VA-ASA (Fig. 1). Digital subtraction angiography also showed a 2-mm-diameter aneurysm at the left VA-ASA, as well as the hypoplastic right VA and the posterior inferior cerebellar artery end. No other aneurysms were found in other areas (Fig. 2).

Endovascular treatment was selected as less invasive and was possible despite the steep angulation of the vessel by devising a catheter shape. A 4-French ASAHI FUBUKI HARD guiding catheter (Medtronic) was guided into the right femoral artery coaxially with a 4-French HHA microcatheter (MEDIKIT) into the V3 segment of the left VA. The microcatheter was placed into the aneurysm using a Headway 45° guidewire (MicroVention Terumo) with a sharp bend induced by steam forming. The aneurysm was bifurcated from the posterior neck proximal to the ASA. Framing was performed with a Target 360 Nano 2-mm × 3-cm detachable coil (Stryker Neurovascular). Space remained at the neck of the aneurysm, so we attempted to insert an additional Target Nano 1-mm × 2-cm detachable coil (Stryker Neurovascular), but the microcatheter was

ABBREVIATIONS ASA = anterior spinal artery; VA = vertebral artery.

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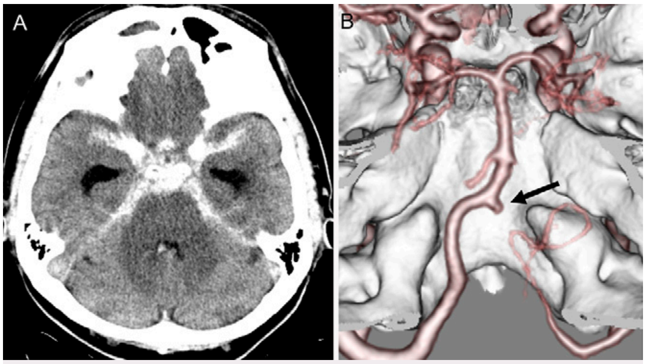

FIG. 1. A: Initial noncontrast axial computed tomography (CT) scan showing diffuse subarachnoid hemorrhage. **B:** Three-dimensional CT angiogram detected a small aneurysm (*arrow*) located at the left VA and ASA bifurcation.

pushed out of the aneurysm and could not be accommodated, so only the first microcatheter was used. Confirmatory imaging showed that the rupture point was suppressed by the coil and the ASA was preserved. The procedure was completed after determining that the objective had been achieved in Raymond-Roy class II (Fig. 3). Cerebral angiography was performed on postoperative day 16, which showed that the aneurysm was thrombosed despite a neck remnant and that blood flow was preserved in the ASA. The post-operative course was good, with no symptoms of cranial nerve loss, and the patient had a modified Rankin Scale score of 0 after onset. The patient was evasive and did not wish to undergo angiography and was followed up with magnetic resonance imaging. There were no findings of recurrence at 3 or 6 months.

Discussion

VA-ASA Aneurysm

Several cases of subarachnoid hemorrhage due to rupture of ASA aneurysms have been reported.[2,3,5–7] ASA aneurysms are known to form within the spine and on the feeders of cerebral arteriovenous malformations. Intracranial cases are rare. Hemodynamic stress may be involved in the pathogenesis of these cases. However, this case is a small side wall aneurysm involving the ASA with the VA. Such aneurysms have not been reported, suggesting that this location is unlikely for aneurysms to occur.

Presumed Mechanism of Occurrence

In this case, the VA was meandering and the ASA branched from the greater curvature side of the bent point. This shape is similar to the bifurcation angles at the internal carotid–ophthalmic artery and internal carotid–anterior choroidal artery junctions, the preferred sites of aneurysms, suggesting that the sharp meandering of the VA may be related to the aneurysm development due to the direction of blood flow and the bifurcation angle of the ASA. On the basis of this hypothesis, blood flow analysis of this case using the Ziostation (Ziosoft) and Hemoscope (EBM) showed sharp meandering of the V3–4 segments and increased blood velocity in the vessel. The tortuosity of the VA (proximal end of the V3

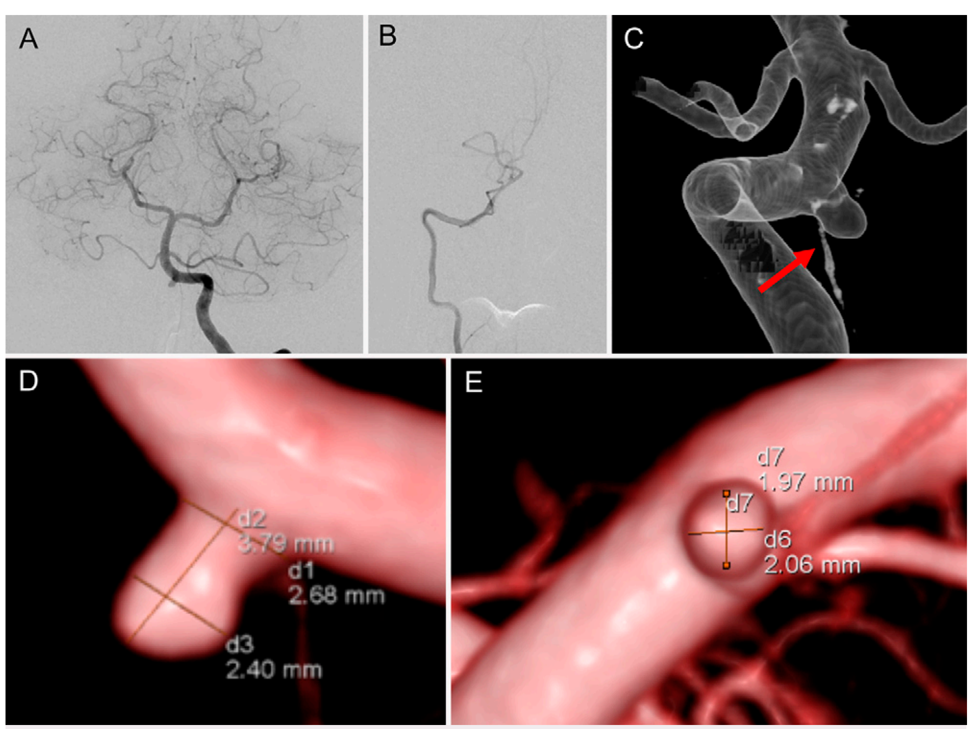

FIG. 2. Left VA angiogram (**A**) showing an aneurysm at the bifurcation with the ASA. Right VA angiogram (**B**) showing the hypoplastic VA and the posterior inferior cerebellar artery end. Digital subtraction angiograms showing the ASA from the proximal neck (**C**, *arrow*) and a 2.5 × 2.4 × 2.0–mm VA and ASA bifurcation aneurysm (**D and E**).

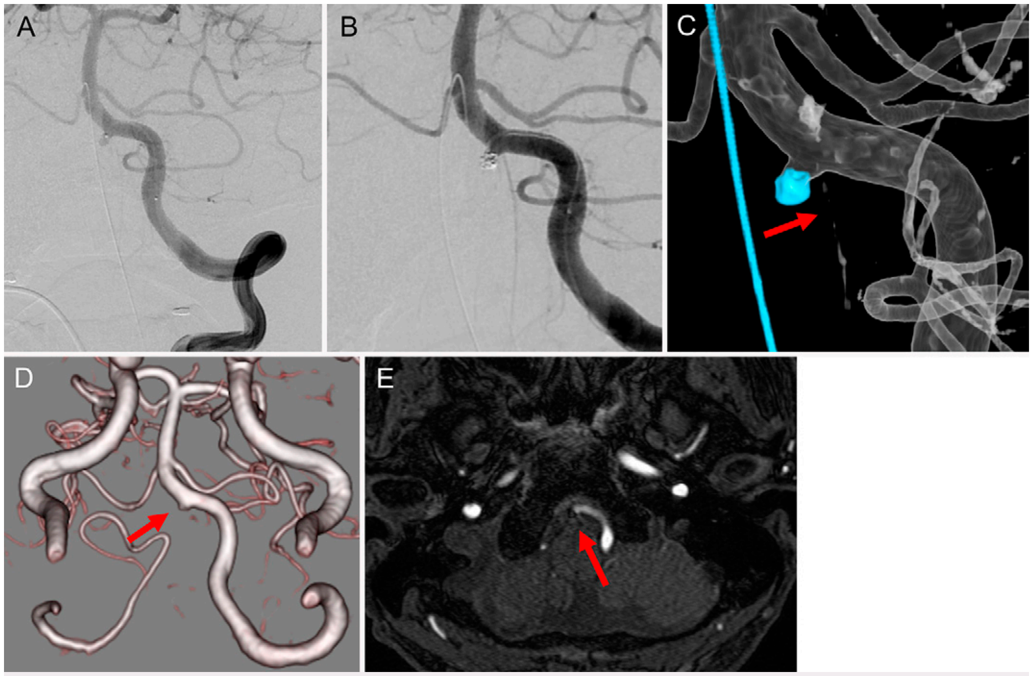

FIG. 3. A: Digital subtraction angiogram showing a shaped microcatheter could be guided into the aneurysm. **B:** An additional coil was initially inserted into the neck of the aneurysm, but the microcatheter was pushed out of the aneurysm. **C:** Endovascular treatment was performed with partial embolization around the rupture point, and the ASA (*arrow*) was preserved. Magnetic resonance angiography (**D**) and time of flight (**E**) 6 months after surgery showing high signal of blood flow in the neck of the aneurysm (*arrows*) but no change from the immediate postoperative findings.

segment–vertebrobasilar junction) was severe, and the tortuosity index was high (Fig. 4). Aneurysms tend to occur on the greater curvature or bifurcation at bent points, which are subject to vascular stress.[8–11] There have been reports that disrupted flow patterns affect aneurysm wall weakening via long-term wall remodeling. They found that ruptured aneurysms have more complex flow patterns and narrower impingement jets than do unruptured aneurysms.[12] Thus, small aneurysms, as in our case, with a large turbulent and complex flow pattern plus a strong meandering parent vessel and a strong impingement jet into the aneurysm, tend to cause aneurysm rupture. We suspect that the aneurysm in this case may have occurred due to hemodynamic stress, leading to rupture.

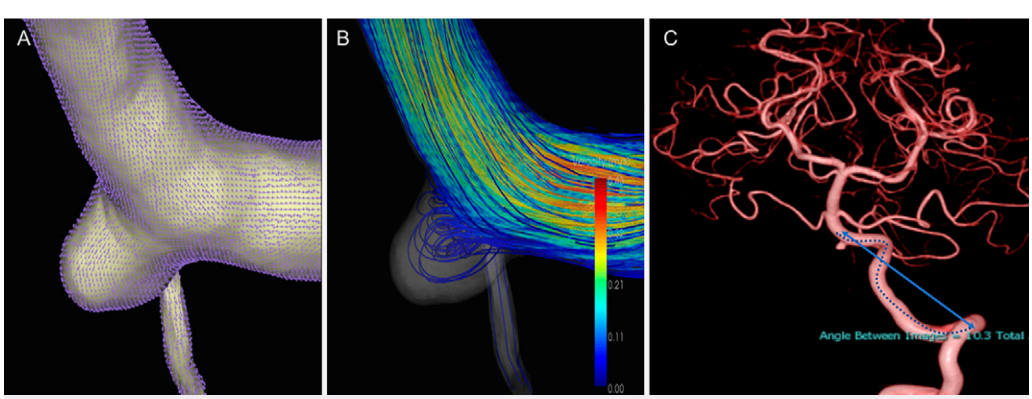

FIG. 4. A: Visualization of hemodynamic parameters showing that the velocity was increased on the greater curvature side of the bent point of the VA. **B:** Velocity vectors showing multiple vortices that vary at the aneurysm and at the bifurcation of the ASA. **C:** Wall shear stress direction and streamline measurement used computed tomography angiography on a workstation incorporating Ziostation (Ziosoft) and Hemoscope (EBM). Measurement of the tortuosity index as the arterial segment length (*dotted line*) divided by the Euclidean distance (*solid double-arrow line*). Measurement of the tortuosity index of the VA (proximal end of the V3 segment–vertebrobasilar junction) in the three-dimensional model showed high tortuosity.

Observations

Small aneurysms such as in this case are considered difficult to treat endovascularly, so direct surgery (clipping) has been considered the first choice. However, in practice, clipping of the posterior circulation is difficult and not less invasive. Endovascular treatment of such small aneurysms has now become possible due to advances in devices, including the development of a number of small coils. In the present case, the aneurysm was located at the bifurcation between the VA and the ASA and could be accessed and treated despite the sharp angle by using a catheter of appropriate shape. This case demonstrates that endovascular treatment is useful for small aneurysms if the device is appropriately selected.

Lessons

We report a case of successful coil embolization of a ruptured aneurysm of the VA-ASA bifurcation. The ASA bifurcated from the greater curvature side of the VA with severe tortuosity. Although VA-ASA aneurysms are extremely rare, we suggest that hemodynamic stress on the greater curvature side at the bifurcation of the ASA caused the aneurysm to form. The aneurysm could be safely treated by selecting the appropriate device and catheter geometry.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Otaki, Yonezawa, Kohyama. Acquisition of data: Otaki, Kagoshima. Analysis and interpretation of data: Otaki, Kagoshima. Drafting the article: Otaki, Kagoshima, Kohyama. Critically revising the article: Otaki, Yoshimoto. Reviewed submitted version of manuscript: Otaki, Yoshimoto. Approved the final version of the manuscript on behalf of all authors: Otaki. Statistical analysis: Otaki. Administrative/technical/material support: Otaki, Kohyama. Study supervision: Otaki, Yoshida, Kohyama, Yoshimoto.

Supplemental Information

Previous Presentations

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