Case Report

"Clip Anchor-Assisted Coil Embolization" for Endovascular Parent Artery Occlusion of Intracranial Traumatic Aneurysm

Hitoshi Fukuda, MD,* Toshio Yanagawa, MD,* Fumihiko Horikawa, MD,* Norio Nakajima, MD,* Masashi Kitagawa, MD,* Benjamin Lo, MD,† and Keisuke Yamada, MD*

Traumatic cerebral aneurysms are histologically dissecting aneurysms or pseudoaneurysms, thus requiring parent artery occlusion for cure. Combination of endovascular parent artery occlusion and extracranial-intracranial bypass is considered optimal to obtain complete obliteration of the aneurysm and to avoid hemodynamic hypoperfusion. However, endovascular parent artery occlusion of the supraclinoid internal carotid artery (ICA) is at risk of ischemic complications due to distal coil protrusion to adjacent perforating arteries or distal embolism of the thrombi generated in the coil mass. A 20-year-old man presented with progressive left optic neuropathy following motor vehicle accident. Radiological examination revealed left supraclinoid ICA aneurysmal formation with dissecting change. We treated this traumatic supraclinoid ICA aneurysm by combination of endovascular parent artery occlusion and high-flow bypass in the hybrid operating room. An aneurysmal clip was applied on the ICA just distal to the aneurysm prior to coil embolization, and worked as a scaffold for subsequent filling coils and as a blockade for the distal emboli. This "clip anchor-assisted coil embolization" technique resulted in optimal parent artery occlusion for the traumatic aneurysm of the supraclinoid ICA with minimal risks of residual blood flow, intraoperative rupture, and thromboembolic complications.

Key Words: Traumatic cerebral artery aneurysm—hybrid operating room—parent artery occlusion—coil embolization—clip ligation—extracranial-intracranial bypass

Introduction

Traumatic cerebral artery aneurysms are histologically pseudoaneurysms or dissecting aneurysms in most cases, and require parent artery occlusion for cure.[1,2] When a traumatic aneurysm is located at the supraclinoid segment of the internal carotid artery (ICA), endovascular ICA occlusion by detachable coils with or without bypass surgery is often performed to prevent recanalization of the aneurysm through collateral flow to the ICA.[3-5] However, endovascular occlusion of the supraclinoid ICA is still associated with ischemic complications due to distal coil protrusion to adjacent perforating arteries or distal embolism of the thrombi generated in the coil mass.[6,7] In this article, we treated a patient

Abbreviations: ICA, internal carotid artery; MCA, middle cerebral artery

From the *Department of Neurosurgery, Amagasaki General Medical Center, Amagasaki, Osaka Japan; and †Department of Neurology and Neurosurgery, Montreal Neurological Institute and Hospital, McGill University Health Centre, Montreal, Quebec, Canada.

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Address correspondence to Hitoshi Fukuda, MD, Department of Neurosurgery, Amagasaki General Medical Center, 2-17-77, Higashinaniwa-cho, Amagasaki, Osaka, 660-8550 Japan. E-mail: fukudaharpseal@gmail.com.

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with traumatic supraclinoid ICA aneurysm by combination of endovascular parent artery occlusion and high-flow bypass in the hybrid operating room. Microsurgical clip ligation of the ICA just distal to the aneurysm before embolization effectively blocked distal coil migration and potential embolism from the coil mass.

Clinical Presentation

A 20-year-old man was injured by a motor vehicle accident. He was neurologically intact and his traumatic intracranial hemorrhage was minimal (Fig 1A). A routine MR angiogram for head high-energy trauma revealed no vascular lesion (Fig 1B). Four weeks later, he complained of his progressive left visual disturbance. Ophthalmologic examination revealed visual acuity 20 of 60 and irregular visual field defect on his left eye.

Repeat MR angiogram showed aneurysmal change on his supraclinoid segment of the left ICA (Fig 1C), and it was also depicted on his CT angiogram (Fig 1D). Conventional and 3D-rotational catheter angiography confirmed a 4 mm saccular aneurysmal dilatation with dissecting change of his left supraclinoid segment ICA (Fig 1E, F). Together with radiological examination, delayed onset of his visual symptoms suggested compressive optic neuropathy due to growing traumatic aneurysm. The patient tolerated balloon test occlusion of his left ICA but the circulation time of his left cerebral hemisphere markedly extended, so we chose high-flow bypass to compensate for therapeutic ICA occlusion.[8,9]

Operation was performed in the hybrid operating room, where both operative equipment and flat-panel detector angiography (Siemens, Berlin, Germany) were available. Standard left fronto-temporal craniotomy was made, and the superficial temporal artery was harvested. Simultaneously, ipsilateral cervical carotid artery bifurcation was exposed through longitudinal skin incision, and his left radial artery was harvested for high-flow bypass. After dural opening, the Sylvian fissure was opened to expose the middle cerebral artery (MCA). The distal part of the intracranial ICA was also exposed, but neither the frontal lobe base was retracted nor the aneurysm was exposed to avoid manipulation on the potential fragile aneurysmal wall. The superficial temporal artery was anastomosed with the cortical segment of the MCA in end-to-side fashion. His free radial artery graft was passed through the subcutaneous tunnel from the cervical region to the craniotomy, and the distal and proximal ends of the graft were anastomosed with the M2 portion of the MCA and the external carotid artery (high-flow bypass), respectively (Fig 2A). Immediately after the high-flow bypass was completed, the origin of the cervical ICA was clamped with Bulldog forceps, and a Sugita aneurysmal clip was applied on the intracranial ICA just proximal to the orifice of the posterior communicating artery (Fig 2B). Subsequently, the Bulldog forceps were removed and a 4-French 10 cm sheath introducer was placed in the cervical ICA through puncture of the common carotid artery. Under systemic heparinization, an Excersior SL-10 microcatheter (Stryker Neurovascular, Fremont, CA) was advanced with the aid of a CHIKAI 0.014-in. microguidewire (ASAHI INTECC, Seto, Japan) in the true lumen of the dissecting segment of the ICA (Fig 2C). A 4 mm Target XL mini 360soft (Stryker Neurovascular, Fremont, CA) as the first framing coil was placed in the ICA just distal to the aneurysmal dilatation, and additional 4-1.5 mm filling coils tightly packed supraclinoid-ophthalmic- cavernous segments of the ICA (Fig 2D). Distal protrusion of these coils was successfully blocked by the aneurysmal clip on the ICA, and no coils were placed in the aneurysmal sac. Common carotid angiogram through the 4-French sheath confirmed complete occlusion of the paraclinoid ICA and patency of the bypasses. A schematic illustration summarizing operative procedures is shown in Fig 2E.

His postoperative 3D-CT angiogram revealed disappearance of the aneurysm with parent artery occlusion by the clip and the coils, as well as bypass patency (Fig 2F). The patient's postoperative course was uneventful without ischemic events (Fig 2G). His left visual acuity partially improved to 20 of 40 at the 1-month ophthalmologic checkup.

Discussion

Growing traumatic aneurysms can be associated with rupture, thus, intervention to exclude the aneurysm from intracranial circulation is recommended.[1,2] Traumatic aneurysms are histologically pseudoaneurysms or dissecting aneurysms where direct clipping of the aneurysmal neck is not feasible. Because traumatic aneurysm wall is fragile, coil placement in the pseudolumen with or without stent should be also avoided. Flow diverters would be promising by reducing inflow to the aneurysm without manipulating the pseudolumen of the traumatic aneurysms. However, intraaneurysmal blood flow remains for several months until the flow diverting effect causes complete thrombosis of the aneurysm.[10] The risk of rupture of this clinically unstable aneurysm is not negligible during this period. Surgical trapping strategy of the aneurysm between cervical ICA ligation and distal clip placement, with extracranial-intracranial bypass, is another option. Yet, when the traumatic aneurysm involves the supraclinoid segment of the ICA, potential anastomotic collateral flow through the ophthalmic artery, the meningohypophyseal trunk, and the inferolateral trunk may still connect with the aneurysm.[3-5] Thus, we performed endovascular parent artery occlusion with detachable coils in order to completely block the blood flow to the aneurysm and to avoid manipulation of the fragile

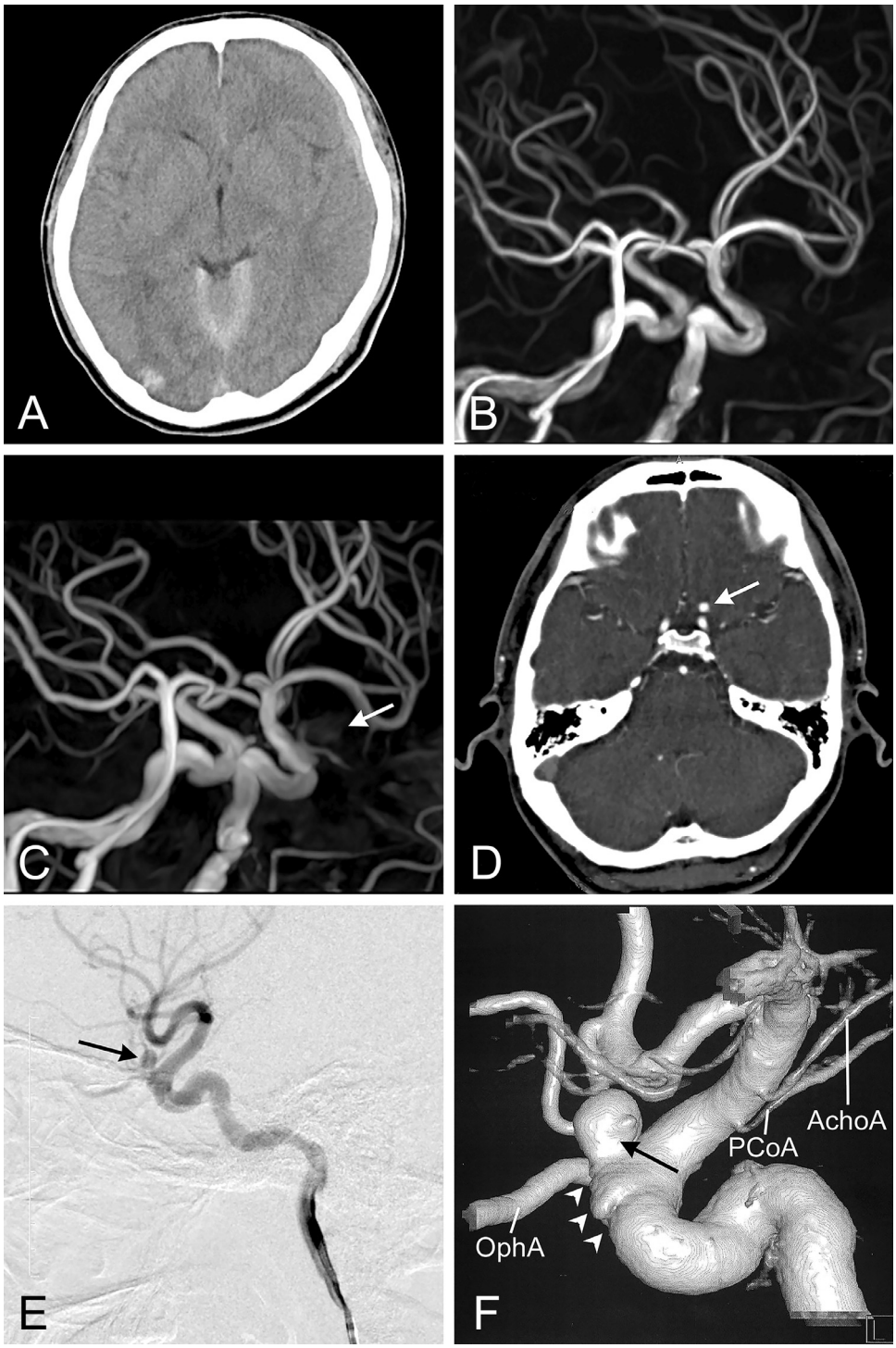

Figure 1. *Images obtained from a 20-year-old man who has a motor vehicle accident and subsequent traumatic aneurysmal formation. (A) Initial head CT scan shows acute subdural hematoma at the left cerebral convexity and beneath the cerebellar tentorium, as well as contusional hemorrhage at his right occipital lobe. (B) Initial MR angiogram shows no intracranial aneurysm formation. (C) Repeat MR angiogram obtained 4 weeks after the motor vehicle accident shows aneurysmal formation at the left supraclinoid internal carotid artery (ICA). (D) CT angiogram also shows abnormal enhanced mass (*arrow*) adjacent to the left intracranial ICA. (E) A lateral view of left internal carotid angiogram. A saccular aneurysm (*arrow*) is seen at the supraclinoid segment of the left ICA. (F) 3D-rotational left internal carotid angiogram shows the saccular aneurysmal change (*arrow*) and irregular dilatation (*arrowheads*) on the supraclinoid ICA. The orifices of posterior communicating and anterior choroidal arteries are located just distal to the aneurysm. Abbreviations: AchoA, anterior choroidal artery; OphA, ophthalmic artery; PCoA, posterior communicating artery.*

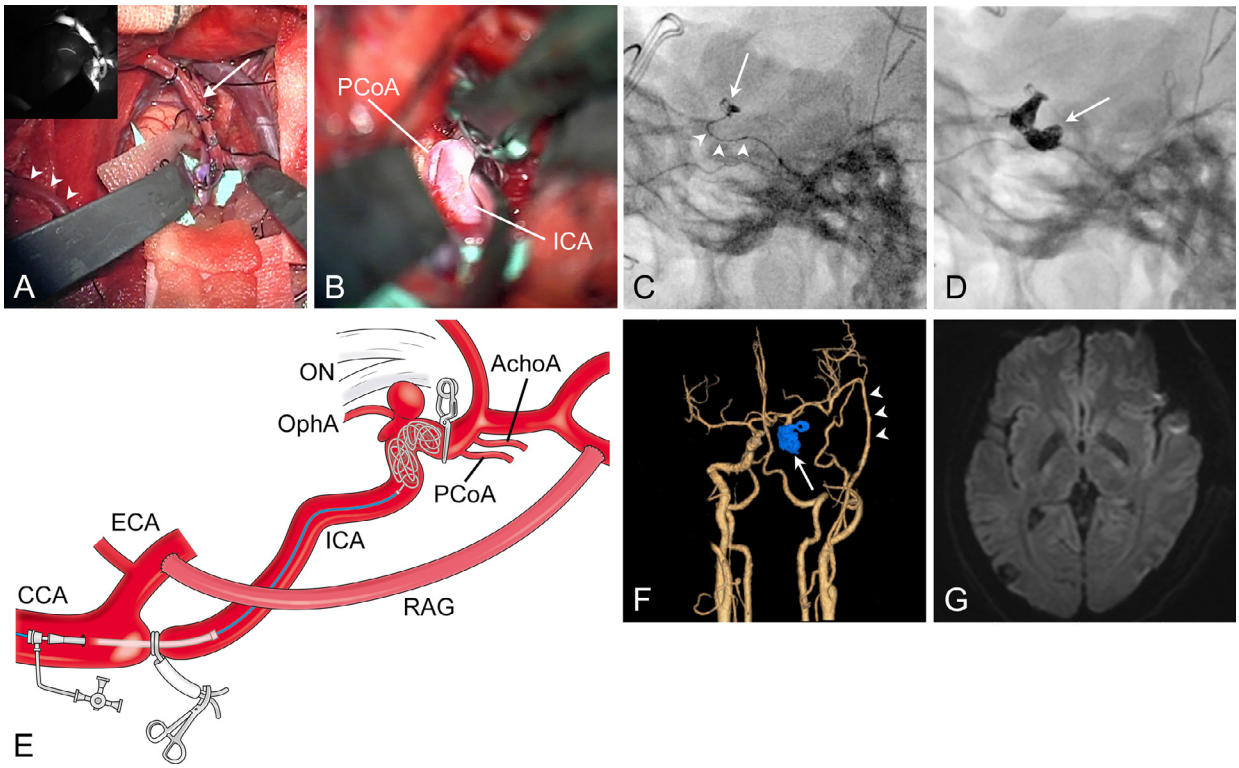

Figure 2. *Intraoperative photographs, a schematic illustration of the operative strategy, and postoperative imaging. (A) High-flow bypass using a radial artery graft* (arrow) *is completed. Low-flow bypass using superficial temporal artery* (arrowheads) *is also set. Indocyanine green videoangiography shows patency of the high-flow bypass* (inset). *(B) An aneurysmal clip is applied to the left internal carotid artery (ICA) just proximal to the orifice of the posterior communicating artery. (C) A lateral view of fluoroscopy obtained at the beginning of coil embolization. The tip of the SL-10 microcatheter* (arrowheads) *reaches distal ICA where the aneurysmal clip* (arrow) *is applied. (D) A lateral view of fluoroscopy obtained at the end of endovascular ICA occlusion. Platinum coils are tightly packed in the supraclinoid- ophthalmic- cavernous segment of the ICA* (arrow). *(E) A schematic illustration of the operative strategy in the present case. (F) Postoperative 3D-CT angiogram shows obliteration of the left intracranial ICA with the clip and the coils* (arrow) *and patency of the high-flow bypass* (arrowheads). *(G) Post-operative diffusion-weighted MR imaging shows no cerebral infarction. Abbreviations: AchoA, anterior choroidal artery; CCA, common carotid artery; ECA, external carotid artery; ICA, internal carotid artery; ON, optic nerve; OphA, ophthalmic artery; PCoA, posterior communicating artery; RAG, radial artery graft.*

aneurysmal wall,[4,11] following high-flow bypass in the hybrid operating room.[8,12]

Even though extracranial-intracranial bypass provides sufficient blood flow, endovascular parent artery occlusion of the supraclinoid ICA can be associated with ischemic complications unrelated to hemodynamic hypoperfusion.[7] One such mechanism is direct obliteration of critical perforating arteries close to the aneurysm, including posterior communicating or anterior choroidal arteries, by deployed coils. In the cylinder-like ICA lumen, deployed coils readily protrude distally and can cause perforator obstruction (Fig 3A).[6,7,13] As illustrated in our case, "scaffold" clip placement just distal to the aneurysm would hold deployed coils in position. It is not the case with endovascular ICA occlusion for unclippable large or giant aneurysms, where the scaffold for subsequent coils can be created by rough placement of several coils first in the aneurysm (Fig 3B).[3] In our case of traumatic dissecting aneurysm, creating a coil scaffold in the aneurysmal false lumen carries a high risk of aneurysmal rupture due to limited space in the aneurysm and potential fragility of the pseudoaneurysm wall (Fig 3A). Another possible mechanism is thromboembolism through thrombus formation in the coil mass. As coils are deployed while anterograde flow remains, distal embolism is one of the inherent complications of endovascular parent artery occlusion.[7] In principal, distal clip placement serves as a barrier for thrombus migration, decreasing thromboembolic risks.

In summary, our clip anchor-assisted endovascular parent artery occlusion strategy provided a scaffold for the deployed coil mass and prevented potential thrombi from distal migration, contributing to complete aneurysm occlusion while avoiding thromboembolic complications in the treatment of the traumatic dissecting aneurysm at the supraclinoid ICA. Once high-flow bypass was performed by wide opening of the Sylvian fissure, clip application to the distal ICA in the carotid cistern is neither challenging nor time-consuming. To the best of our knowledge, this is the first description of detailed technical aspects of distal clip application as a scaffold for subsequent coils in endovascular parent artery occlusion with bypass. Simultaneous use of microsurgical clipping and endovascular coiling is a unique advancement in a hybrid-operating room.[12] We hope one-stage multimodality as in the present case will

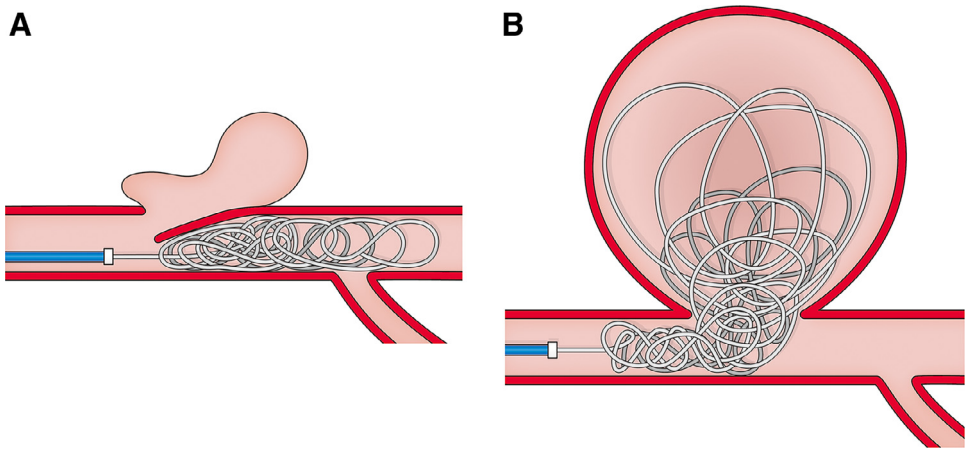

Figure 3. *Schematic illustrations describing coil behavior during endovascular parent artery occlusion of intracranial internal carotid artery. (A) In the traumatic aneurysm case, deployed coils migrate distally and obliterate the orifice of the adjacent perforating artery. (B) In the true giant or large aneurysm case, several coils are roughly placed in the aneurysm first and work as a scaffold. Additional filling coils are anchored by the intraaneurysmal coil scaffold and stabilized, enabling controlled tight packing at the coil-luminal interface without obliterating the adjacent perforating artery.*

be also effectively applied to other complex cerebrovascular disorders.

Conclusion

Our clip anchor-assisted endovascular parent artery occlusion strategy provided a scaffold for the deployed coil mass to remain in position and prevented potential thrombi from distal migration, in the treatment of the traumatic aneurysm at the supraclinoid ICA. The simultaneous use of coil embolization of the parent artery, extracranial-intracranial bypass, and distal clipping, was available in a hybrid operating room.

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