

Side-to-Side Bypass between Bilateral Distal Anterior Cerebral Arteries and Surgical Trapping of a Pseudoaneurysm from the Anterior Communicating Artery: Lessons Learnt

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Background: Treatment options for a ruptured anterior communicating artery (ACoA) pseudoaneurysm are limited. In most cases trapping of the ACoA is the best treatment option. Occasionally, bypass surgery is warranted to ensure blood flow to the contralateral anterior cerebral artery (ACA) in cases with one dominant A1. We report a case of an ACoA pseudoaneurysm presenting with delayed subarachnoid hemorrhage following surgical clipping of an unruptured ACoA aneurysm, with a review of the literature. **Case description:** A 74-year-old female had undergone surgical clipping of a 1.2-cm-sized unruptured ACoA aneurysm through the left supraorbital keyhole approach. During the operation, there had been a small tear between the aneurysm neck and the right proximal A2, and the tear point was controlled by clipping of the tear site. One month later, she was admitted again because of subarachnoid hemorrhage. Cerebral angiography showed a probable pseudoaneurysm from the previous tear site. The patient had a dominant left A1 with a right A1 aplasia. The pseudoaneurysm was treated with side-to-side bypass between the distal ACAs and subsequent trapping of the ACoA harboring a pseudoaneurysm. Both the distal ACAs were preserved; however, post-hemorrhagic neurological sequelae remained. **Conclusions:** Side-to-side bypass between distal ACAs and surgical trapping of the ACoA for the ruptured ACoA pseudoaneurysm was a good rescue option to prevent rebleeding and preserve blood supply to the contralateral ACA territory.

Keywords: anterior communicating artery, distal anterior cerebral artery, pseudoaneurysm, side-to-side bypass

Introduction

Pseudoaneurysms differ from true aneurysms in that all three vascular layers of the arterial wall are disrupted pathologically, and the vessel becomes surrounded by a hematoma that prevents blood extravasation.¹⁾ Most pseudoaneurysms form as a result of blunt or penetrating head

trauma but can also result from surgical treatment or diagnostic procedures.^{2–7)} Iatrogenic pseudoaneurysms rarely occur after clipping of intracranial aneurysms. In most cases, the treatment of choice for pseudoaneurysms is segmental trapping of the parent artery harboring the pseudoaneurysms.²⁾ However, trapping is not feasible in cases with major perforators from the parent artery or potential reduction in downstream blood supply because of poor collateral channels. Bypass followed by trapping of the parent artery can be considered when hemodynamic insufficiency is expected. Several cases of anterior cerebral artery (ACA) pseudoaneurysms related to trauma, tumor or sinusitis have been reported.^{3–6,8–11)} Most of these cases were treated with clipping or coil embolization, except two cases in which the parent artery harboring a pseudoaneurysm was trapped. We present our experience of side-to-side bypass between distal ACAs and subsequent surgical trapping of the anterior communicating artery (ACoA) to prevent rebleeding of a ruptured ACoA pseudoaneurysm in a patient with a unilateral dominant A1.

Case Report

A 74-year-old female presented with an altered mentality. Non-contrast computed tomography (CT) of the head showed a subarachnoid hemorrhage and associated hydrocephalus. One month prior, she had undergone surgical clipping of a 1.2-cm-sized unruptured ACoA aneurysm and a left anterior choroidal artery (AChA) aneurysm through the left supraorbital keyhole approach (Fig. 1A). Coil embolization was not feasible because of the tortuosity of the proximal access route. During the operation, there had been a small tear and bleeding at the junction of the aneurysm neck and right proximal A2, which had been controlled with clipping at the tear point (Fig. 1B). Cerebral angiography showed a de novo formation of the pseudoaneurysm at the previously clipped tear point (Figs. 1C and 1D). Endovascular trapping, direct clipping or surgical trapping of the ACoA were inappropriate because of the presence of a tortuous proximal route, atretic right A1 and no clippable leaflet around the pseudoaneurysm. Alternatively, bypass between the distal ACAs and trapping of the ACoA harboring the pseudoaneurysm was planned. As the superficial temporal artery was too small to perform a microanastomosis between the cortical ACA and the superficial temporal artery, side-to-side bypass between the bilateral pericallosal arteries was performed through a right interhemispheric approach (Figs. 2A–2D). The superior walls of each

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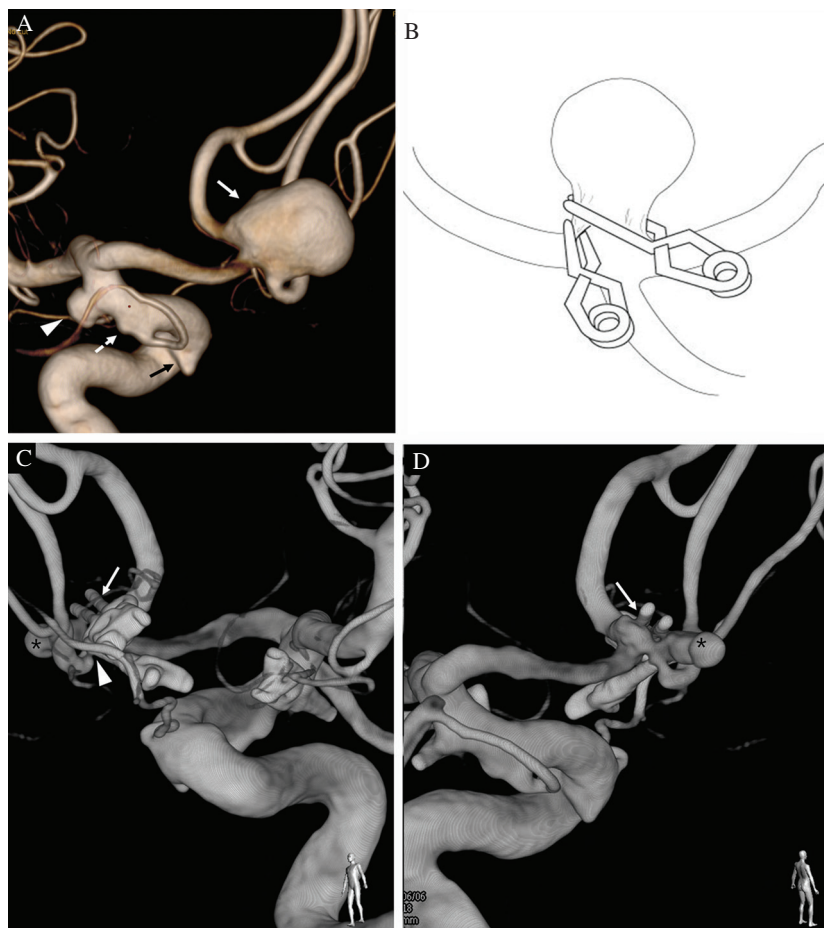


Fig. 1 The patient's 3D rotational angiography (3DRA) taken before surgical clipping showed four aneurysms—ACoA (white arrow), Lt. AChA (arrow head), Lt. paraclinoid internal carotid artery (ICA) (black arrow), and Lt. posterior communicating artery (PCoA) (dotted arrow) (A) and schematic drawing of aneurysm clipping in the first operation (B). Pseudoaneurysm (*) was observed immediately adjacent to the clipping site by 3DRA (C, D). Aneurysmal neck (arrow), tear point (arrow head).

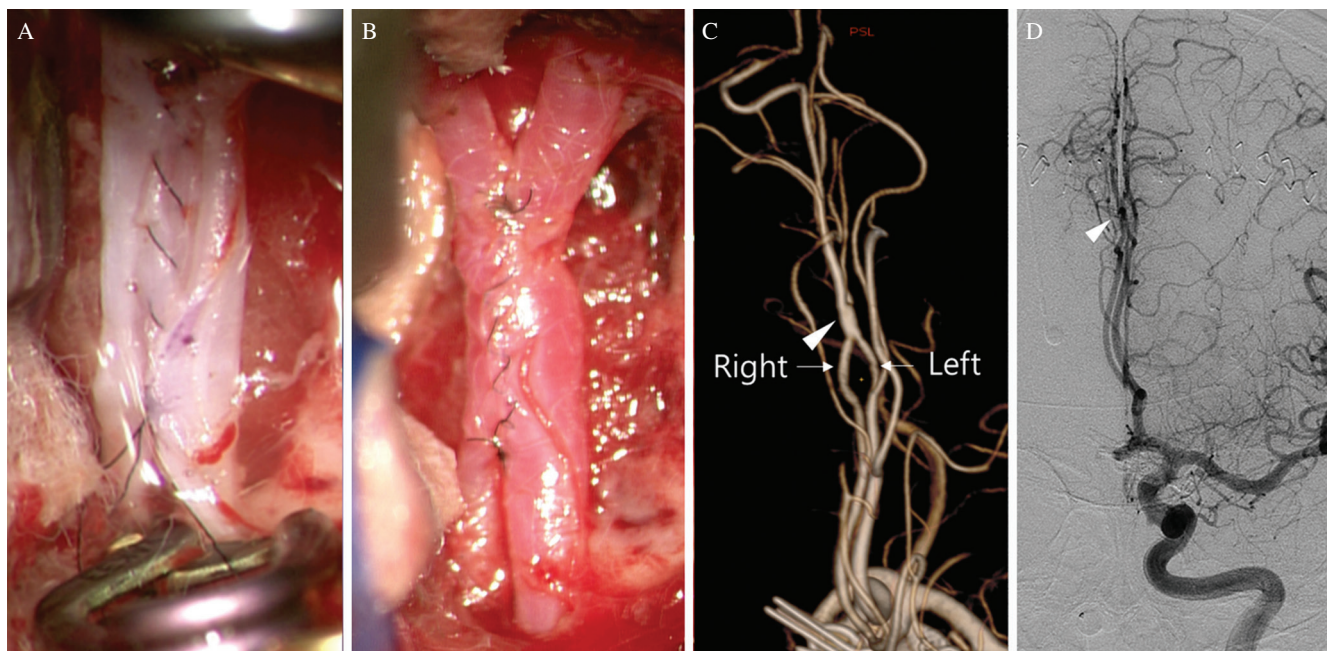


Fig. 2 Intra-operative images of A3–A3 side-to-side anastomosis (A, B). Postoperative 3DRA (C) and digital subtraction angiography (DSA) (D) showed filling of both the ACA branches (arrows) through the bypass (arrow head).

pericallosal artery were incised at a length of 5 mm, and an anchoring suture was performed at each end. Then, the inferior and superior walls of the pericallosal arteries were sutured in a continuous manner. The clamping time was approximately 80 min, during which there was no change in the intraoperative physiologic monitoring. Microvascular Doppler and microscope-based indocyanine green fluorescence angiography showed a patent blood flow within both the pericallosal arteries through the microanastomosis site. Subsequently, surgical trapping of the ACoA was done through the previous supraorbital corridor. After several attempts of clipping, the ACoA segment harboring the pseudoaneurysm was clipped with a fenestrated clip, with an additional clipping at the right proximal A2 segment to ensure the segment flow arrest, preserving perforators around the ACoA (Fig. 3A). Postoperative cerebral angiography showed the complete exclusion of the ACoA pseudoaneurysm and the restored bilateral distal ACAs (Fig. 3B). After the rescue surgery and management of the subarachnoid hemorrhage, a moderate degree of neurological sequelae remained (cognitive dysfunction without focal neurologic deficit).

Discussion

Pseudoaneurysms can occur by unexpected vascular damage during brain surgery. It is estimated that only 1.1% of transsphenoidal procedures result in the formation of pseudoaneurysms in the ICA.¹² The occurrence of pseudoaneurysms has been reported following other intracranial procedures, such as transcallosal surgery for astrocytoma⁷ and pterional craniotomies.¹³ Several cases about iatrogenic ACA pseudoaneurysms have been described in the literature (Table 1).^{3–6,8–11} In our case, a pseudoaneurysm occurred in association with surgical clipping of the cerebral aneurysm. During the previous surgical manipulation, a small tear at the neck occurred. The bleeding from the tear site was controlled by simple clipping; however, a pseudoaneurysm developed from the tear site. Intracranial arteries have thinner media and adventitia, lacking external elastic lamina with diminished vasa vasorum compared to other arteries in the body. These characteristics make intracranial arteries more likely to develop pseudoaneurysms

in cases of iatrogenic injury.¹⁴ When arterial wall damage is suspected, routine imaging follow-up is recommended at 6 and 12 months post-operatively because of the risk of changes to the damaged vascular wall.¹³ Some researchers have suggested that short-term follow-up is necessary, because there may be obvious changes in blood vessels in just 4 weeks.¹⁵ A short-term imaging follow-up could have discovered our patient's pseudoaneurysm before its rupture.

The treatment of pseudoaneurysms should be approached cautiously, since the pseudoaneurysm wall, composed of hematomas and lacking vascular wall components, is prone to rupture during manipulation. Some pseudoaneurysms can be treated with conventional clipping or endovascular techniques, similar to true aneurysms. However, in our case, the lack of free wall space surrounding the pseudoaneurysm, which was located where the right proximal A2 was originating from the ACoA, prevented us from performing clipping of the pseudoaneurysm. An endovascular approach was not feasible because of the proximal tortuosity of the pseudoaneurysm. Therefore, trapping was the most appropriate choice for our case. In addition, the patient's contralateral A1 aplasia rendering a bypass surgery before trapping is necessary.

The ACoA has anatomical complexity and diversity, which makes ACA revascularization more challenging.¹⁶ In our case, we initially considered a superficial temporal artery (STA)–anterior cerebral artery (ACA) bypass. STA–ACA bypass is a traditional extracranial (EC)–intracranial (IC) bypass with which many vascular neurosurgeons are familiar.¹⁷ However, the patient's angiography showed that bilateral STAs, less than 0.5 mm in diameter, were too narrow to be used in the bypass. Subsequently, we considered three alternatives—ACA–ACA side-to-side bypass, STA–RA (radial artery)–ACA bypass or ACA–RA–ACA interposition graft—described by Sanai et al.¹⁸ EC–IC bypass is generally preferred over IC–IC bypass. This is because in the EC–IC bypass, a surgeon has the option of retrying if the connection fails and only one ACA needs to be clamped, allowing for surgery while maintaining the opposite side ACA flow. However, IC–IC bypass has a few advantages, including (1) it does not require an extracranial donor artery, (2) it spares

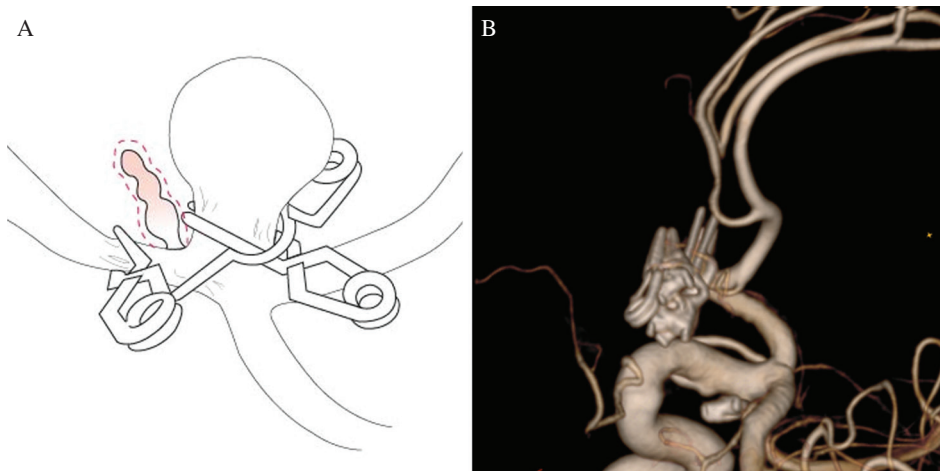


Fig. 3 Schematic drawing of trapping in the second operation of the pseudoaneurysm (A). Pseudoaneurysm was completely obliterated (B).

Table 1 Literature review of cases treated with iatrogenic ACA pseudoaneurysms

Authors and Year	Age	Sex	Primary disease/ surgical approach	Location of pseudoaneurysm	Size of pseudoaneurysm (mm)	Treatment	Outcome
Alba et al. (2014)	61	Female	Anterior cranial fossa meningioma/-	A1	2.5	Trapping of Lt. A1	mRS 2
Cosgrove et al. (1983)	36	Female	ACoA aneurysm/ pterional app.	ACoA	15	Clipping of pseudoaneurysm	mRS 1
Ryu et al. (2005)	44	Female	OrbFrA aneurysm/ interhemispheric app.	OrbFrA	–	Additional clipping and wrapping of aneurysm	–
Wewel et al. (2014)	66	Female	Chronic sinusitis/ ESS	Lt. A2	2.3	Coiling of pseudoaneurysm	mRS 4
Tokunaga et al. (2001)	61	Female	TS meningioma/ frontotemporal app.	ACoA	8	Coiling of pseudoaneurysm	mRS 6
Horowitz et al. (2005)	7 days	Male	hydrocephalus, EVD	A3	2	Coiling of pseudoaneurysm	mRS 1
Shoja et al. (2011)	66	Male	ACoA aneurysm/ frontotemporal	ACoA	<6	Clipping of pseudoaneurysm	mRS 2
Munich et al. (2015)	mid 60s	–	Chronic sinusitis/ ESS	FrPoLA	–	Occlude the FrPoLA (with coil)	mRS 4

ACoA: anterior communicating artery, ESS: endoscopic sinus surgery, EVD: external ventricular drainage, FrPoLA: frontopolar artery, mRS: modified Rankin Score, OrbFrA: orbitofrontal artery, TS: tuberculum sellae.

patient's additional incisions, and (3) the caliber-matched artery can be used immediately and protected within the cranium. Considering these factors, we cautiously chose ACA–ACA side-to-side bypass for the patient.

For the side-to-side bypass, neighboring arteries must be available that are similar in size. The ideal length of arteriotomy is known to be about three times larger than the diameter of the vessel.¹⁹⁾ Surgeons must be careful to avoid tension when suturing both arteries. ACA–ACA side-to-side bypass can be particularly challenging, because the procedure occurs in a deep and narrow surgical space and can damage both ACAs if failure occurs. Furthermore, both ACAs should be clamped during the bypass procedure, which makes reducing surgery time and minimizing potential complications crucial. Surgeons should continue practicing the procedure.

Conclusion

A pseudoaneurysm was treated successfully, although the patient has had a neurological sequelae. First, preventing iatrogenic pseudoaneurysms from occurring in the first place is most important. If bleeding occurs during aneurysm surgery, it is advisable to closely observe the occurrence of an ensuing pseudoaneurysm, especially within a short time period. When a pseudoaneurysm is identified, occlusion of the parent artery should be considered first. Treatment methods should be selected considering various factors, such as the location of the pseudoaneurysm and the adjacent vessel structure. Bypass surgery should be considered, in case clipping or trapping of the pseudoaneurysm might interfere with collateral flow.

Conflicts of Interest Disclosure

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

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