Giant intracranial aneurysms are often unclippable due to wide necks, adherent branches, atherosclerotic tissues, and intraluminal thrombus. These lesions often cannot be treated by means of coil placement for similar reasons, or if treated by coil embolization, they are associated with increased rates of incomplete occlusion and aneurysm recurrence. Therefore, trapping with distal revascularization is a therapeutic option for many giant aneurysms. Anterior communicating artery giant aneurysms are more challenging than others because afferent and efferent arteries may not be accessible through a standard pterional approach.

Access to A2 segments distal to a giant ACoA aneurysm often requires additional interhemispheric exposure with a bifrontal craniotomy, particularly when a bypass is performed. Furthermore, bypass options for distal A2 segments are limited. The STA does not reach to the anastomotic depth of the interhemispheric fissure, or if it does, is too small in caliber. Extracranial-to-intracranial (EC-IC) bypasses with interposition grafts have been described, including STA-ACA bypass and cervical ECA-ACA bypass. Intracranial-to-intracranial (IC-IC) bypasses with interposition grafts have also been described, including MCA-ACA bypass. These bypasses require long interposition grafts that may be associated with lower long-term patency rates and vulnerability to occlusion along their calvarial course. In situ bypasses avoid the problem of interposition grafts, bringing the ACAs together distally with a side-to-side anastomosis. These bypasses successfully address the hemodynamic needs of one outflow artery, but may not address those of 2 outflow arteries.

The azygos anterior cerebral artery bypass: double reimplantation technique for giant anterior communicating artery aneurysms

Technical note

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The authors introduce the azygos anterior cerebral artery (ACA) bypass as an option for revascularizing distal ACA territories, as part of a strategy to trap giant anterior communicating artery (ACoA) aneurysms. In this procedure, the aneurysm is exposed with an orbitozygomatic-pterional craniotomy and distal ACA vessels are exposed with a bifrontal craniotomy. The uninvolved contralateral A2 segment of the ACA serves as a donor vessel for a short radial artery graft. The contralateral pericallosal artery (PcaA) and the callosomarginal artery (CmaA) are connected to the graft in the interhemispheric fissure using the double reimplantation technique. Three anastomoses create an azygos system supplying the entire ACA territory, enabling the surgeon to trap the aneurysm incompletely. Retrograde flow from the CmaA supplies the ipsilateral recurrent artery of Heubner, and the aneurysm lumen thromboses.

The azygos bypass was successfully performed to treat a 47-year-old woman with a giant, thrombotic ACoA aneurysm supplied by the A1 segment of the left ACA, with left PcaA and CmaA originating from the aneurysm base. The authors conclude that the azygos ACA bypass is a novel option for revascularizing PcaA and CmaA, as part of the overall treatment of giant ACoA aneurysms. (DOI: 10.3171/2010.8.JNS10277)

Key Words • anastomosis • azygos anterior cerebral artery bypass • bypass • double reimplantation • giant aneurysm • trapping

Abbreviations used in this paper: ACA = anterior cerebral artery; ACoA = anterior communicating artery; AP = anteroposterior; CmaA = callosomarginal artery; EC = extracranial; ECA = external carotid artery; IC = intracranial; ICA = internal carotid artery; ICG = indocyanine green; MCA = middle cerebral artery; PcaA = pericallosal artery; RAG = radial artery graft; STA = superficial temporal artery.
The azygos anterior cerebral artery bypass

This report describes the azygos ACA bypass. A single outflow artery from the ACoA complex is preserved as a donor artery, and the contralateral pericallosal and callosomarginal arteries are connected with a short radial artery graft in the interhemispheric fissure using the double reimplantation technique. Three anastomoses create an azygos system supplying the entire ACA territory bilaterally, enabling the aneurysm to be occluded indirectly.

**Surgical Technique**

The standard orbitozygomatic-pterional craniotomy is enlarged with a bifrontal extension, just across the midline, to access both the afferent A1 segment of ACA and the efferent PcaA and CmaA. A pterional dural flap is opened, and a second dural flap is opened based on the superior sagittal sinus. With standard microdissection, the afferent A1 segment, recurrent artery of Heubner, and ACoA complex are exposed subfrontally. Interhemispheric fissure dissection exposes the genu of the corpus callosum, the bilateral A2 segments of the ACAs, and their PcaA and CmaA branches.

With the patient in barbiturate-induced electroencephalographic burst suppression, the contralateral donor artery (ACA or PcaA) is trapped between temporary aneurysm clips. A radial artery graft (RAG) is connected to the donor artery with an end-to-side anastomosis using running continuous 9-0 nylon suture, providing brisk flow to the graft. The distal end of the graft is then routed through the interhemispheric fissure in a loop that arcs alongside the ipsilateral PcaA. This recipient artery is then trapped between temporary aneurysms clips and connected to the graft with a side-to-side anastomosis. Temporary clips on the RAG are opened to reperfuse the territory of the recipient PcaA. The graft is then cut to end at the ipsilateral CmaA. This recipient artery is then trapped between temporary aneurysm clips and connected to the graft with an end-to-side anastomosis. All clips are removed and patency of all anastomoses is confirmed by means of indocyanine green (ICG) angiography.

The exposure shifts subfrontally and a permanent clip is placed on the distal A1 segment to occlude the aneurysm proximally. Returning to the interhemispheric fissure, a second permanent clip is placed on the proximal portion of CmaA, closing one efferent trunk from the aneurysm. It is important to avoid placing a third clip on the proximal portion of PcaA, as this would trap the recurrent artery of Heubner and produce a caudate infarct. The PcaA is left open to supply retrograde flow to the recurrent artery through the aneurysm, resulting in an incomplete aneurysm trapping. Another ICG angiogram after aneurysm trapping confirms flow to the distal ACA territories from the bypass.

**Case Report**

This 47-year-old woman presented with a seizure. On neurological examination, she had normal language function, intact cranial nerves, full strength in her arms and legs, and some gait imbalance. Computed tomography angiography of the head demonstrated a giant, thrombotic ACoA aneurysm measuring 4 cm in diameter (Fig. 1). It had thickened calcified walls, significant mass effect in the right frontal lobe, and surrounding edema, without subarachnoid hemorrhage. Magnetic resonance imaging confirmed these findings (Fig. 1). Digital subtraction angiography showed a relatively small aneurysm lumen (Fig. 2). The left A1 segment of ACA filled the aneurysm, and the outflow arteries (left PcaA and left CmaA) originated from the aneurysm base. The right ACA did not fill the aneurysm.

The aneurysm was deemed unclippable. The azygos ACA bypass was performed, revascularizing the distal left PcaA and CmaA with the bypass, and the aneurysm was trapped (Fig. 3). Postoperative right carotid angiography demonstrated a patent bypass, with the right ACA supplying its ipsilateral territories as well as the bypass graft to the contralateral PcaA and CmaA territories (Fig. 4). Retrograde flow in the left PcaA filled the base of the aneurysm and the recurrent artery of Heubner. Most of the aneurysm lumen was thrombosed. Left carotid angiography demonstrated an A1 segment stump, no aneurysm filling, and no contribution to distal ACA territories.

Postoperatively, the patient maintained her baseline strength and sensation. At 3 months follow-up, she had occasional headaches and returned to her normal activities (Glasgow Outcome Scale score of 5, good recovery) (Fig. 5). An angiogram at that time showed a patent bypass and no residual aneurysm. The patient continues to do well at late follow-up (17 months).
The azygos ACA bypass is introduced as a novel option for revascularizing the PcaA and CmaA as part of the overall treatment of giant ACoA aneurysms. It requires 2 end-to-side anastomoses and 1 side-to-side anastomosis, and unilateral preservation of the A1-A2 junction with antegrade blood flow to the distal A2 segment. This construct allows the surgeon to trap, proximally occlude, or coil the ACoA aneurysm without having to preserve antegrade blood flow in the ipsilateral A1 or A2 segments.

The azygos ACA bypass is an application of the double reimplantation technique, as previously described for giant aneurysms on the MCA and distal ACA. This double reimplantation technique limits ischemia time in each artery to what is normally required for a single anastomosis. The donor anastomosis between the right PcaA and the RAG

![Fig. 2. Digital subtraction angiography.](image)

- **A:** An AP view (left ICA injection) demonstrating elevation of the A1 segment from the aneurysm mass, relatively small luminal volume of the ACoA aneurysm, and filling of the left pericallosal and callosomarginal arteries.
- **B:** Lateral view in the late arterial phase (left ICA injection) showing the separate origins of the PcaA and CmaA at the aneurysm base.
- **C:** An AP view (right ICA injection) demonstrating that the aneurysm did not fill from the right A1 segment.

**Discussion**

The azygos ACA bypass is introduced as a novel option for revascularizing the PcaA and CmaA as part of the overall treatment of giant ACoA aneurysms. It requires 2 end-to-side anastomoses and 1 side-to-side anastomosis, and unilateral preservation of the A1-A2 junction with antegrade blood flow to the distal A2 segment. This construct allows the surgeon to trap, proximally occlude, or coil the ACoA aneurysm without having to preserve antegrade blood flow in the ipsilateral A1 or A2 segments.

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![Fig. 3. Intraoperative photographs.](image)

- **A:** The orbitozygomatic-pterional approach exposed the left A1 segment for proximal control. A large recurrent artery of Heubner was seen. The bifrontal approach exposed both PcaA and CmaA in the interhemispheric fissure. The second anastomosis (first distal anastomosis, C) was a side-to-side connection between the left PcaA and the RAG. The deep sutures are placed from inside the lumen of these 2 arteries, whereas the superficial sutures (D) are placed from outside the lumen. Note the first (proximal) anastomosis between the RAG and the right PcaA in the upper right corner. The third anastomosis (second distal anastomosis) was completed (upper left corner in E), with the RAG making a circular loop in the interhemispheric fissure. The left A2 segment was then occluded with a clip (F), as was the left PcaA as it exited the aneurysm. (Note the clip between the A2 segments, to the right of the third anastomosis.)
readies the bypass graft to restore blood flow to each artery immediately upon reimplantation. The first recipient anastomosis is opened by advancing the temporary clamp distally on the graft while the second recipient anastomosis is performed. With successive reimplantation, the clamp time for each efferent artery was around 30 minutes and did not produce neurophysiological changes or clinical deficits.

The azygos ACA bypass is entirely intracranial and protected from extracranial trauma or compression. Its short graft length should improve its long-term patency. It requires a looping configuration to separate the anastomoses and enable the surgeon to suture each one comfortably. The caliber of the radial artery matches that of the interhemispheric arteries. We performed this bypass with the intention of trapping and debulking the aneurysm, and therefore combined the pterional and bifrontal craniotomies. However, the bypass could also be performed through a bifrontal craniotomy, leaving the aneurysm occlusion for a separate endovascular stage and sparing the patient a pterional craniotomy.

Infarcts related to the recurrent artery of Heubner can be debilitating, and incomplete trapping with retrograde supply of the recurrent artery of Heubner was performed in our case, rather than complete trapping and aneurysm debulking. The alteration of flow in our patient’s aneurysm resulted in its thrombosis over time, and the risk of rupture from this residual flow was deemed low.

Other revascularization strategies have been used for trapping giant ACoA aneurysms. The in situ A2-A2 bypass is an elegant bypass that will revascularize ACA territories when the bifurcation into PcaA and CmaA occurs distal to the aneurysm. In our case, the left PcaA and CmaA originated from the aneurysm base and one A2-A2 bypass would not have revascularized both arteries. Two A2-A2 bypasses could have revascularized both ipsilateral efferent arteries, but this approach would require temporary occlusion of 4 rather than 3 arteries, and the CmaAs are not always adjacent like the PcaAs. The RAG can be mobilized easily and trimmed to lie alongside recipient arteries without tension on arterial tissues during the anastomosis. A single in situ A2-A2 bypass can be combined with an MCA-ACA bypass, using an RAG, as described by Sekhar et al. Sekhar has also fashioned a “Y” radial artery graft from the MCA that connects to the distal ACA segments. The azygos ACA bypass is but another option that employs these established anastomosis techniques.

**Disclosure**

The authors report no conflict of interest concerning the mater-
Author contributions to the study and manuscript preparation include the following. Conception and design: Lawton. Acquisition of data: Lawton. Drafting the article: Lawton, Mirzadeh. Critically revising the article: all authors. Reviewed final version of the manuscript and approved it for submission: all authors.

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Please include this information when citing this paper: published online September 24, 2010; DOI: 10.3171/2010.8.JNS10277.

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