Superior cerebellar artery–posterior cerebral artery bypass: in situ bypass for posterior cerebral artery revascularization

Technical note

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Iatrogenic pseudoaneurysms are rare but serious complications of transsphenoidal surgery, and an iatrogenic pseudoaneurysm of the posterior cerebral artery (PCA) has been reported just once in the literature. The authors encountered such a case with a new P1 segment PCA pseudoaneurysm after endoscopic transsphenoidal resection of a pituitary adenoma. The aneurysm proved ideal for a novel intracranial–intracranial bypass in which the superior cerebellar artery (SCA) was used as an in situ donor artery to revascularize the recipient P2 segment. The bypass allowed aneurysm trapping without causing ischemic stroke or neurological morbidity. This case represents the first reported surgical treatment of an iatrogenic PCA pseudoaneurysm. Endovascular occlusion with coils was an option, but dolichoectatic morphology requires sacrifice of the P1 segment, with associated risks to the thalamoperforators and circumflex perforators. The SCA-PCA bypass was ideal because of low-flow demands. Like other in situ bypasses, it requires no dissection of extracranial arteries, no second incision for harvesting interposition grafts, and has a high likelihood of long-term patency. The SCA-PCA bypass is also applicable to fusiform SCA aneurysms requiring revascularization with trapping. This case demonstrates a dangerous complication that results from the limited view of the posterolateral surgical field through the endoscope and the imprecision of endoscopic instruments.

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Key words • iatrogenic cerebral aneurysm • transsphenoidal surgery • fusiform posterior cerebral artery aneurysm • in situ bypass • vascular disorders • side-to-side anastomosis

Iatrogenic aneurysms are a potential complication of any intracranial surgery performed in the subarachnoid space adjacent to cerebral arteries.2,6,7,17 Arteries can be weakened by incomplete laceration, aggressive manipulation, or tumor invasion, which is unmasked by resecting the tumor.4 Arterial injury can cause immediate intraoperative hemorrhage, or it can lead to aneurysm formation and hemorrhage perioperatively. These iatrogenic pseudoaneurysms are absent on preoperative imaging, have nonsaccular morphology, are located in the surgical field, are not located at the usual branch points around the circle of Willis, and require definitive treatment.

We encountered such a case in a patient with a new P1 segment PCA pseudoaneurysm after endoscopic transsphenoidal resection of a pituitary adenoma. This complication is rare; most aneurysms associated with transsphenoidal resection affect the cavernous internal carotid artery, anterior cerebral artery, or basilar artery.5 The fusiform morphology of this aneurysm and the absence of PCoA collateral precluded endovascular coiling and, instead, required trapping and bypass. This aneurysm proved ideal for a novel intracranial–intracranial bypass in which the SCA was used as an in situ donor artery to revascularize the recipient P2 segment. This bypass technique and the patient’s clinical course are described.

Case Report

History

This 27-year-old woman developed headache, amenorrhea, and visual deficits. After MRI and endocrine evaluation, she was diagnosed with a prolactinoma and managed medically with bromocriptine. She became noncompliant with her medication for more than 6 months and presented to an outside hospital with visual deterioration and a complete bitemporal hemianopsia. Brain MRI revealed significant growth of her adenoma (Fig. 1). She underwent an endoscopic transsphenoidal subtotal resection with the goal of decompressing the optic nerves. Mi-
nor intraoperative bleeding was noted by the neurosurgeon and easily controlled.

Postoperatively, the patient was slow to wake up and had a new left hemiplegia. Computed tomography scanning of the head showed intraventricular hemorrhage involving the third and fourth ventricles and hydrocephalus (Fig. 2 left). An external ventricular drain was placed, but the patient's condition worsened with declining mental status and diabetes insipidus. Repeat head CT revealed an infarct in the right thalamus, and CT angiography revealed a right-sided P1 segment PCA aneurysm (Fig. 2 right). The patient was transferred to our medical center for further management.

Examination

Cerebral angiography (Fig. 3) demonstrated a right fusiform P1 segment pseudoaneurysm projecting anteriorly with a proximal perforator trunk (artery of Percheron). The right PCoA was not visualized and the right superficial temporal artery was diminutive. Endovascular options were considered, but aneurysm occlusion would have compromised PCA flow distally and potentially the artery of Percheron proximally. The patient was referred for surgical trapping with PCA revascularization. A preoperative Allen test performed with Doppler ultrasonography revealed thrombosis of both radial arteries due to multiple arterial lines, precluding MCA-PCA bypass with radial artery graft. Therefore, an SCA-PCA bypass was planned.

Operation

A right orbitozygomatic craniotomy was performed, the Sylvian fissure was widely split, and the temporal lobe was mobilized posteriorly to expose the PCA from the basilar apex to the tentorial incisura. The P2 and s2 segments coursed in parallel and were easily approximated lateral to the oculomotor nerve (Fig. 4A). These segments were isolated between temporary clips, and arteriotomies were made in each vessel. A side-to-side anastomosis was constructed with a continuous 9-0 suture (Fig. 4B and C). Indocyanine green videoangiography confirmed the patency of the anastomosis (Fig. 4D).

The pseudoaneurysm was identified proximally and the basilar trunk was dissected for proximal control. The aneurysm was fragile and ruptured while dissecting the proximal P1 segment. A temporary clip was placed on the basilar trunk to control the bleeding, and the aneurysm was trapped between permanent clips on the proximal and distal P1 segments, carefully preserving the artery of Percheron (Fig. 4E and F). A second indocyanine green (ICG) angiogram confirmed anterograde filling of the P2 segment and retrograde filling of the P1 segment through the SCA-PCA bypass.

Postoperative Course

A postoperative catheter angiogram confirmed complete exclusion of the aneurysm with a patent SCA-PCA bypass (Fig. 5). The patient recovered steadily and was...
transferred to a rehabilitation facility. At 3 months, she was living at home independently with a persistent but mild left hemiparesis (Grade 4/5 strength).

Discussion

Posterior Cerebral Artery Pseudoaneurysm After Endoscopic Endonasal Surgery

Endoscopic endonasal surgery for pituitary tumors and other anterior skull base pathology has increasing appeal to patients and neurosurgeons as a minimally invasive alternative to larger, open craniotomies. However, the present case demonstrates a dangerous complication that results from the surgeon’s limited view of the posterolateral surgical field and the imprecision of endoscopic instruments. We speculate that the P1 segment of the PCA and one of its thalamoperforators were injured during the resection, weakening the artery wall and causing the thalamic infarct and hemiplegia. Pseudoaneurysm formation and intraventricular hemorrhage were probably delayed, but clearly iatrogenic. Caution is required in the depths of the surgical field, particularly when arteries are behind or encased by pathology.

Internal carotid artery pseudoaneurysm formation after transsphenoidal or endoscopic endonasal surgery occurs frequently enough to be reported and characterized in the literature. However, the incidence of PCA pseudoaneurysm formation after transsphenoidal or endoscopic endonasal surgery is not known. Numerous authors have reported PCA pseudoaneurysm formation after blunt or penetrating trauma, but there are only 2 reported cases of iatrogenic aneurysms of the PCA. Ciceri et al. described a P2 segment pseudoaneurysm that was found after surgical removal of a mesial temporal hemangioblastoma. The aneurysm was coiled, and then coiled again 1 year later after recurrence. The aneurysm became giant in size at 5-year follow-up, but the patient refused further treatment. The same authors also described a P1 segment pseudoaneurysm diagnosed angiographically after acute bleeding during transsphenoidal resection of a pituitary tumor. The aneurysm was treated with parent artery occlusion, but the patient died of intracranial hypertension. Therefore, our case represents the only reported surgical treatment for an iatrogenic PCA pseudoaneurysm.

Fig. 4. A: Through an orbitozygomatic craniotomy and a pretemporal approach, P1 and s1 segments were exposed. B: The back wall of the side-to-side anastomosis was sewn first intraluminally. C: The anterior wall was completed next with a running suture extraluminally. D: Intraoperative videoangiography with indocyanine green (ICG) dye demonstrated a patent bypass. E: Aneurysm trapping required 1 miniclip on the afferent P1 segment that preserved the perforator trunk and 2 clips on the efferent P1 segment. F: Retrograde flow from the bypass filled the P1 segment.

Fig. 5. Postoperative left vertebral artery angiograms (lateral [left] and anteroposterior [right] views) showing complete occlusion of the aneurysm and a patent SCA-PCA bypass.
Management Strategy

Although some authors advocate conservative management of iatrogenic pseudoaneurysms by invoking a benign natural history, most recommend treatment, particularly when there is associated hemorrhage, progressive enlargement, and/or negative preoperative studies. These pseudoaneurysms are sometimes just a hole in the artery “tamponaded” by hematoma. The intraoperative rupture with minimal manipulation in our case attests to their fragility and high risk of rehemorrhage.

Several treatment options were considered for our PCA pseudoaneurysm. Endovascular occlusion with coils is straightforward, but the aneurysm’s dolichoectatic morphology would have required sacrifice of the P1 segment, with attendant risks to the thalamoperforators and circumflex perforators. The PCoA can supply the P2 segment and distal PCA territories in some patients, but our patient had no angiographically apparent PCoA. The MCA collateral to the occipital lobe can be tested in cooperative patients with a balloon test occlusion, allowing safe PCA sacrifice in patients in whom the test can be tolerated without changes in vision. However, our patient was intubated and catheterization of the PCA would have been risky with this pathology. Endovascular treatment with stent-assisted coiling or flow diverters might have preserved PCA flow but might not have excluded the entire pathology and would have required antiplatelet agents.

Direct microsurgical clipping is not an option for pseudoaneurysms. Trapping has similar risks of perforator infarction, but direct inspection is superior to angiography in visualizing perforators and excluding them from the trapped segment. The artery of Percheron was seen intraoperatively and preserved. Furthermore, microsurgery allows for revascularization of the PCA. Bypass options included an extracranial-intracranial STA-PCA bypass, an occipital–cortical PCA bypass, MCA-PCA bypass with radial artery graft, and an in situ SCA-PCA bypass. The occipital artery–PCA bypass is not a robust bypass, and the occipital exposure does not provide simultaneous access to the aneurysm. A small STA prevented us from performing the STA-PCA bypass, and occluded radial arteries prevented us from performing the MCA-PCA bypass. A saphenous vein graft was another option, but the caliber and flow demands of the P2 segment do not require such a large graft. The MCA-PCA bypass is a high-flow bypass suited to revascularizing the basilar quadrification after basilar artery occlusion; in this case, only the PCA required revascularization. The SCA-PCA bypass was ideal because of the low-flow demands. Like other in situ bypasses, it requires no dissection of extracranial arteries, no second incision for harvesting interposition grafts, and has a higher likelihood of long-term patency because it is a direct communication between 2 arteries.

Technique for a PCA-SCA Bypass

In 2005, the senior author (M.T.L.) proposed the SCA-PCA side-to-side bypass as an in situ bypass for revascularizing the distal PCA or SCA, but he had not performed it. This case represents our first SCA-PCA bypass, 7 years later. In the meantime, Saito et al. performed an SCA-PCA bypass before trapping a ruptured P2 segment fusiform aneurysm. They used a side-to-side anastomosis (P2–s2 segment) similar to ours, except that they used interrupted sutures. Their technique differed in their use of a subtemporal approach, and their aneurysm differed in its location on the P2 segment. In contrast, we treated a P1 segment aneurysm (Fig. 6 left) with an orbitozygomatic craniotomy and a pretemporal approach, which has the advantages of gentler retraction on the temporal lobe and...
simultaneous access to the basilar apex.\textsuperscript{18} The subtemporal approach provides less exposure of P\textsubscript{1} segment aneurysms and may not provide proximal control of the basilar artery in case of intraoperative rupture, which was essential in our case. Even for many proximal P\textsubscript{1} segment aneurysms like that reported by Saito et al., we prefer the anterior trajectory of the transt Sylvian approach. The SCA-PCA bypass is also applicable to fusiform SCA aneurysms requiring revascularization with trapping (Fig. 6 right), with the PCA serving as the donor artery.\textsuperscript{9,10}

The SCA-PCA bypass requires that donor and recipient arteries lie in close proximity and come together without tension on the sutures. A long arteriotomy 3 times the diameter of the arteries ensures brisk cross-filling of the recipient artery. With side-to-side anastomosis, the deep suture line is sewn intraluminally, requiring the needle to be passed from outside the lumen to inside the lumen after tying the knot. After running continuous sutures from one end of the arteriotomy to the opposite end, the needle is again passed from inside the lumen to outside the lumen. The stitches are tightened and tied to the end of the second knot. The superficial suture line is sewn extraluminally in continuous fashion. With the fragility of pseudoaneurysms, it is important to complete the bypass before dissecting the aneurysm, in case of intraoperative rupture.

Conclusions

Iatrogenic PCA pseudoaneurysms are a rare but serious complication of endoscopic transsphenoidal surgery. Their management is daunting and should be addressed by experienced multidisciplinary teams. The SCA-PCA bypass provides an efficient solution by allowing deliberate occlusion of the P\textsubscript{1} PCA segment without the risk of ischemic stroke and neurological morbidity that would have occurred otherwise. This in situ bypass also saves time and effort compared with other revascularization options for complex PCA aneurysms.

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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