CASE REPORT

Pipeline endovascular reconstruction of traumatic dissecting aneurysms of the intracranial internal carotid artery

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SUMMARY

A 22-year-old woman was involved in a motor vehicle collision resulting in multiple facial fractures and extensive internal carotid artery (ICA) injury including a right carotid-cavernous fistula, complex dissection flap and dissecting aneurysms. Endovascular coil embolization was initially performed to treat the cavernous carotid fistula and then again on two separate occasions to treat expanding dissecting aneurysms. Parent vessel reconstruction of the right ICA was subsequently performed with the Pipeline embolization device, resulting in complete anatomical restoration of this vessel.

BACKGROUND

Intracranial dissecting aneurysms are an uncommon but well recognized complication of both blunt and penetrating head trauma. Such lesions constitute less than 1% of all intracranial aneurysms in large series.^{1 2} Advances in endovascular devices and techniques have begun to shift the clinical management of dissecting aneurysms over the past decade from deconstructive modalities towards parent vessel preservation when feasible. Endovascular flow diversion devices such as the Pipeline embolization device (PED) (Covidien; Irvine, California, USA) may play a larger role in treating complex post-traumatic aneurysms in the future.

CASE PRESENTATION

A 22-year-old woman presented to the trauma resuscitation unit following a motor vehicle collision. She was found unresponsive with a Glasgow Coma Scale score of 5 T (E1, V1, M3) and had multiple right facial fractures. A head CT revealed right-sided LeFort II and sphenoid wing fractures. Additionally, there was subarachnoid hemorrhage in the perimesencephalic cisterns and diffuse cerebral edema. The right superior ophthalmic vein was dilated and concerning for a right carotid-cavernous fistula.

TREATMENT

A cerebral angiogram revealed a complex high-flow direct right carotid-cavernous fistula (figure 1) with rapid venous drainage into the bilateral cavernous sinuses and superior ophthalmic veins. Severe retrograde cortical venous reflux into the cerebellar parenchymal veins was also noted. At least two distinct tears in the horizontal cavernous segment as well as complex dissection flaps were present in the right internal carotid artery (ICA).

An angiographic balloon occlusion test within the cervical right ICA was performed and demonstrated delayed angiographic collateral flow to the right cerebral hemisphere, necessitating preservation of the artery. Balloon-assisted embolization of the right carotid-cavernous fistula was subsequently performed, resulting in subtotal occlusion of the fistula and decreased cortical venous reflux. Complete occlusion of the fistula was deemed impossible at this time without assistance of a stent, given the large tears in the vessel.

A repeat angiogram 2 weeks later revealed interval complete thrombosis of the fistula without any residual arteriovenous shunting. However, a large dissecting aneurysm of the distal cavernous right ICA and a dissecting horizontal segment ICA aneurysm developed in the interim. Focal 60% stenosis was now present proximal to the cavernous right ICA as well (figure 2). Endovascular coil embolization of the large dissecting aneurysm was performed at this time.

OUTCOME AND FOLLOW-UP

A 2-month follow-up cerebral angiogram demonstrated spontaneous improvement of the 60% stenosis to a residual 35% stenosis. Recurrent filling noted within the distal cavernous right ICA aneurysm worsened in the interim and was embolized with coils. Residual filling of the horizontal

Figure 1 Lateral digital subtraction angiography image showing a high-flow traumatic right carotid-cavernous fistula with rapid venous shunting (arrow).

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Figure 2 Lateral digital subtraction angiography image showing interval thrombosis of the coiled right cavernous-carotid sinus and associated fistula without evidence of arteriovenous shunting, a large dissecting aneurysm of the distal cavernous right internal carotid artery (ICA), a dissecting cavernous segment ICA aneurysm at the site of carotid-cavernous fistula embolization (arrow) and focal 60% stenosis proximal to the cavernous segment of the right ICA (block arrow).

cavernous segment right ICA pseudoaneurysm was mildly increased in size. A dissection flap was again seen in the cavernous right ICA (figure 3).

A 7-month follow-up angiogram demonstrated continued growth of the twice coil embolized distal cavernous segment aneurysm, now also seen herniating into the right sphenoid sinus on MRI. The other cavernous segment aneurysm was stable. At 11 months, a 3.5×30 mm PED was deployed in the intracranial right ICA, fully covering the two aneurysms, the

Figure 3 Lateral digital subtraction angiography image at 2-month follow-up showing spontaneous improvement in the previously seen 60% stenosis to a residual 35% stenosis (block arrow), worsening of recurrent filling within the coiled distal cavernous right internal carotid artery (ICA) dissecting aneurysm (white star), a mild increase in the size of the residual filling of the cavernous segment right ICA dissecting aneurysm at the site of the previous fistula (arrow) and a dissection flap in the cavernous segment of the right ICA (curved arrow).

Figure 4 Lateral digital subtraction angiography image immediately after deployment of the Pipeline embolization device in the intracranial right internal carotid artery (ICA) showing mild residual narrowing within the cavernous right ICA.

dissection flap and the stenosis. Balloon angioplasty was then performed to optimally oppose the PED to the treated vessel. Improved flow through the vessel and stagnation of contrast material within the covered aneurysms was present on immediate post-procedure angiography (figure 4). Six months after the PED placement, an angiogram demonstrated complete anatomical reconstruction of the ICA (figure 5).

DISCUSSION

Traumatic intracranial dissecting aneurysms are uncommon, accounting for less than 1% of all aneurysms.^{1 2} Compared with spontaneous dissecting aneurysms, multiple mechanisms can act in concert in the traumatized brain, including increased intracranial pressure, hemodynamic impairment and shearing forces on

Figure 5 Lateral digital subtraction angiography image 6 months after deployment of the Pipeline embolization device in the intracranial right internal carotid artery (ICA) showing no residual intraluminal arterial abnormalities. Coil masses (stars) are present within the previously treated dissecting aneurysms.

the traumatic vessel and brain parenchyma, making treatment of traumatic dissections a unique therapeutic challenge.

Appropriate management of intracranial dissecting aneurysms remains difficult and controversial. Most studies focus on spontaneous dissecting aneurysms of the vertebrobasilar system. Conservative management with anticoagulation was initially adopted for unruptured dissecting vertebral artery aneurysms.³ However, Naito *et al* later showed that the risk of bleeding from unruptured dissecting vertebral artery aneurysms was higher than previously thought, supporting the argument for definitive treatment of unruptured lesions.⁴ In contrast, enlarging or ruptured intracranial dissecting aneurysms require prompt intervention. Once ruptured, the risk of rebleeding is quite high, approaching 70% within the first 24 h.⁵ Options for treatment of dissecting intracranial aneurysms were previously limited to surgical clipping and deconstructive strategies. Surgical clipping, however, is often difficult due to vessel wall friability and the risk of intraoperative rupture.⁶ Deconstructive techniques are useful but not always feasible when there is a lack of adequate collateral blood flow.

With the evolution of endovascular techniques, increasing efforts have been made to preserve parent vessel patency. Mathis *et al* completed a literature review of ICA sacrifice after clinical passage of a balloon occlusion test and revealed nine (4.7%) permanent strokes in 192 patients, supporting the argument for parent vessel preservation when feasible.⁷ Flexible self-expanding intracranial stents have been used and postulated to work by several mechanisms in the treatment of cerebral dissecting aneurysms. By exerting a low intrinsic radial force, these stents may help to stabilize the vessel wall and compress dissected layers to maintain a patent lumen. Furthermore, some stents can help to reduce blood flow into an aneurysm, promoting stagnation and thrombosis within the aneurysm while also providing a scaffold for intimal flap repair and reconstruction of the vessel wall.⁸⁻⁹

Most published results of intracranial dissections remain confined to case reports and small series on spontaneous dissection rather than traumatic injury. Lim *et al* described a case of a traumatic pseudoaneurysm of the left supraclinoid ICA treated using stent-assisted coil embolization with a stent-in-stent technique.¹⁰ Complete obliteration of the pseudoaneurysm was seen on post-procedure digital subtraction angiography and on 12-month follow-up angiography. In a case series of nine distal cervical and intracranial dissections, Ansari *et al* observed immediate spontaneous thrombosis of five small dissecting aneurysms after Neuroform stent placement with confirmed occlusion on follow-up imaging.¹¹ Three large dissecting aneurysms required stent-assisted coil embolization and one required recoiling at 6 months. Zhao *et al* described the treatment of 14 acute symptomatic dissecting aneurysms using the Solitaire stent, although no lesions were specified to be traumatic in etiology.¹² The majority (86%) of the dissecting aneurysms were reconstructed using multiple overlapping stents with (n=9) or without (n=3) coils. Immediate partial occlusion was observed in 12 patients (86%) and follow-up angiographic results revealed recurrence in one patient (7%) which ultimately resolved after implantation of an additional Solitaire stent. Although favorable technical and clinical outcomes were achieved in the series of both Ansari *et al* and Zhao *et al*, the frequent use of multiple overlapping stents and the need for stent-assisted coil embolization suggest that flow-diverting devices may have a role in treatment.

Flow diversion devices may represent an advance in the treatment of dissecting aneurysms. De Barros Faria *et al* reported the use of the PED stent to treat 23 dissecting aneurysms, of which

91% were in the posterior circulation.¹³ Total occlusion was demonstrated in 69.5% of patients and increased to 87.5% at 3-month follow-up. Small aneurysms demonstrated higher indices of total occlusion (85.7%) compared with large (71.5%) and giant (55.5%) aneurysms. Yeung *et al* reported successful obliteration of four dissecting vertebral aneurysms using the PED alone.¹⁴ No patient showed evidence of recurrence, in-stent thrombosis or side branch occlusion in angiographic reassessment at a mean of 22 months after treatment. Neither report specifies a direct association of intracranial arterial dissection with known major head trauma.

Reports of treating traumatic intracranial dissecting aneurysms in the anterior cerebral circulation with the PED are sparse. To our knowledge, Amenta *et al* was the first to highlight the use of the PED in the setting of iatrogenic cavernous ICA trauma after endoscopic sinus surgery.¹⁵ Complete exclusion of a traumatic carotid pseudoaneurysm and successful reconstruction of the left ICA lumen was achieved with the PED alone in that case. The PED, however, may not be optimal in certain acute cases due to the necessity of an antiplatelet regimen before and after stent repair. In fact, Kadkhodayan *et al* reported an unsuccessful attempt at preserving the ICA below the skull base with the PED after trauma due to rebleeding while the patient was on dual antiplatelet therapy.¹⁶

Our case is the first report of successful parent vessel reconstruction of a multifocal intracranial right ICA injury using the PED after major head trauma and highlights a potentially effective solution to treat complex intracranial vascular injuries. The PED was favored in this case over traditional stents due to its ability to flow-divert using a single device as well as operator concern for recurrence after use of traditional stents for treatment of the patient's recurrent dissecting aneurysms already refractory to multiple prior endovascular coilings. In our patient we used this device in the chronic phase when she was able to tolerate a dual antiplatelet regimen. While no definitive conclusions can be drawn from a single report, this case highlights the fact that the PED is yet another tool in the neurointerventionalist's armamentarium for endovascular treatment of intracranial vascular injuries. Larger studies with long-term follow-up are needed to better evaluate the efficacy and safety of the PED in this setting.

Learning points

- ▶ Appropriate management of traumatic intracranial dissecting aneurysms remains challenging and controversial.
- ▶ Endovascular treatment of traumatic intracranial arterial aneurysms using the PED is a potentially viable option when parent vessel preservation is necessary.
- ▶ Necessity of an antiplatelet regimen before and after stent repair may preclude the use of the PED in certain acute traumatic cases.

Contributors VP performed the literature search and drafted the initial article. DG revised the article for important intellectual content. GJ managed the clinical case, conceived the idea for the case report, revised the article for important intellectual content and is the guarantor for the finished article.

Patient consent Obtained.

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