Traumatic carotid artery–cavernous sinus fistula treated with a covered stent

Report of two cases


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The authors describe the cases of two patients with unilateral traumatic carotocavernous fistulas in whom a self-expanding covered stent was successfully used to obliterate the fistula after failed occlusion with detachable balloons and coils. They discuss this option as a primary therapeutic modality in cases in which detachable balloons or coils, with or without a bare stent, have failed to obliterate the fistula. The placement of a covered stent to occlude the lesion from the outset may represent a new therapeutic approach to the treatment of these lesions.

KEY WORDS • carotid artery–cavernous sinus fistula • internal carotid artery • covered stent • embolization

C AROTICOCAVERNOUS fistulas are abnormal communications between the CA and the cavernous sinus. They may be direct with immediate shunting of blood from the ICA to the cavernous sinus, or indirect, associated with slower filling of the cavernous sinus through a dural arteriovenous communication. Traumatic CCFs are usually direct and unilateral. In contrast, most bilateral CCFs are indirect. The widely accepted treatment of a direct CCF has been detachable balloon–based endovascular occlusion of the fistula; more recently, coils, with or without an uncovered stent, have been used to obliterate the lesion. We describe the use of a covered stent as an alternative to other endovascular treatments.

Case Reports

Case 1

Presentation and Examination. This 28-year-old man was involved in a high-speed motor vehicle accident and suffered a severe traumatic brain injury. His initial GCS score was 3; his respiration was spontaneous, and his left pupil, dilated to 6 mm, was not reactive. The right pupil was 2 mm in diameter and reactive. There was no ocular injury. There was blood in both external auditory canals. A ventricular catheter was inserted in the emergency department for intracranial pressure monitoring.

The initial CT studies showed frontal and temporal lobe contusions as well as facial and basilar skull fractures involving both petrous temporal bones, extending on the left into the carotid canal and sphenoid sinus. A CA duplex scan and a magnetic resonance angiogram demonstrated no evidence of dissection of the CA or vertebral artery. Additional imaging studies revealed fractures of the C-2, C-3 and T-12 vertebral bodies as well as a spinal epidural hematoma requiring a thoracic halo brace and anterior C2–3 stabilization and fusion. A pulmonary contusion and a left hemopneumothorax were also noted. Four days after admission, a left eye pulsatile exophthalmos developed. Cerebral angiography revealed a left-sided CCF (Fig. 1).

Operation. The CCF was initially treated using 10 detachable coils, including fiber coils, after a detachable balloon failed to occlude the lesion. This reduced the blood flow rate in the fistula (Fig. 2). The following day, repeated angiography showed brisk flow in the fistula prior to coil insertion. A decision was made to attempt to place a covered stent (Boston Scientific/Scimed, Maple Grove, MN), instead of sacrificing the ICA, and this was successful (Fig. 3 left). A 3-month course of clopidogrel (75 mg) and a 6-month course of aspirin (300 mg) were instituted. The pulsatile exophthalmos resolved after stent placement. The pupils remained fixed and dilated.

Postoperative Course. The patient’s progress was slow and his GCS score was still 3 at 6 weeks after the injury. Repeated cerebral angiography 6 months postinjury showed stable, total occlusion of the CCF and good ICA patency. Minimal intimal hyperplasia was observed along the anteri-
or margin of the proximal end of the stent (Fig. 3 center and right). Nearly 1 year after the injury, cerebral CT scanning demonstrated a 1-cm infarct in the left anterior capsule extending to the caudate nucleus. Brain atrophy was also present. By this stage, some voluntary movement and speech had been achieved.

Case 2

Presentation and Examination. This 20-year-old man sustained a severe closed head injury in a high-speed motorcycle accident and was admitted to the intensive care unit with a GCS score of 4; signs of bilateral rhinorrhea and otorrhea were apparent. The initial CT scan revealed petechial hemorrhages predominantly within the left temporal lobe, a small amount of extraaxial blood, diffuse traumatic subarachnoid hemorrhage, and evidence of pneumocephalus. Extensive basilar skull fractures involving the sphenoid and petrous temporal bones bilaterally were identified. Fracture lines traversing the foramen lacerum on both sides raised the possibility of an ICA injury. Prompt magnetic resonance angiography revealed no abnormality of the ICA or vertebral arteries. The patient remained dependent on a ventilator in the intensive care unit; there was clinical and radiological/neuroimaging evidence of a severe diffuse axonal head injury.

Two weeks following the accident, left eye exophthalmos, chemosis, conjunctival edema and a left orbital bruit developed. Emergency CT scanning of the orbits confirmed the presence of a markedly ectatic left superior ophthalmic vein and enlargement of the left cavernous sinus, consistent with a CCF. Four-vessel angiography confirmed the presence of a direct traumatic CCF draining via the superior ophthalmic vein and the angular vein of the face (Fig. 4 left). We observed distal arterial flow into the middle and anterior cerebral artery regions. No definite intercavernous sinus filling was documented. Contralaterally, there was a small pseudoaneurysm of the right ICA along the anterior margin (likely traumatic in origin). A persistent trigeminal artery was also present.

Operation. Following a successful angiographic balloon occlusion tolerance test, an attempt was made to close the fistula by using a 14 × 7.8–mm detachable silicone balloon, but this did not occlude the fistula because of a large linear tear and dissection in the cavernous portion of the ICA (Fig. 4 center). Subsequently, a 4 × 31–mm covered nitinol stent (Symbiot; Boston Scientific/Scimed) was successfully inserted to occlude the fistula while maintaining ICA patency (Figs. 4 right and 5). Following the procedure, we initiated a 6-month course of anticoagulation therapy (clopidogrel and aspirin).

Postoperative Course. During the next 2 weeks, the left eye exophthalmos and chemosis completely resolved. Spontaneous symmetrical extraocular movements were noted, but a left afferent pupillary defect persisted. Because of the severity of the diffuse axonal head injury (resulting in a marked receptive dysphasia), visual acuity could not be assessed. Follow-up angiography studies obtained 2 weeks, 2 months, and 7 months after the procedure demonstrated no contrast leakage, stent migration, or in-stent stenosis (Fig. 6). There was no narrowing of the CA lumen within or at the stent–ICA junction. Opacification of the ophthalmic artery beyond the stent was normal. There was no increase in the size of the small contralateral right ICA pseudoaneurysm.

Technical Considerations

Once the decision was made to attempt to place a covered...
stent in these cases, a 280-cm exchange guidewire was used to replace the No. 7 French guiding catheter in the ICA with a No.8 French guide catheter. A Royal Flush Plus catheter (Cook Inc., Bloomington, IN), which is a 120-cm long, No.6 French straight catheter with a tapered tip, was placed coaxially via the guide catheter to provide a smoother transition. Systemic heparin was continued to maintain an activated clotting time of 2.5-fold that of baseline. An Excelor 1018 microcatheter (Boston Scientific/Target, Fremont, CA) was advanced over a Transend Ex Soft tip 0.014-in microguidewire (Boston Scientific/Target) and placed in the middle cerebral artery. The microguidewire was exchanged for a Cross-IT 100XT 0.014-in 190-cm guidewire (Guidant Corporation, Santa Clara, CA) in which a 145-cm ACS DOC guidewire extension (Guidant Europe S.A., Diegem, Belgium) was used. This ensured a stiffer system over which a 4 × 20-mm Symbiot-covered stent could be navigated across the linear tear in the horizontal segment of the cavernous ICA. In Case 2, we used a stent measuring 4 × 31 mm, as the guide catheter had to be advanced into the petrous segment of the ICA to allow for successful placement.

The Symbiot covered stent is a flexible, nitinol, self-expanding stent, sandwiched between two layers of polytetrafluoroethylene, and approved for use with coronary saphenous vein grafts. The stent is premounted on a Monorail delivery catheter with a crossing profile of 0.079 in. At the time of publication, Boston Scientific/Scimed does not recommend the use of the Symbiot stent for cerebrovascular applications. We recognize the “off label” use of this product in these two cases.

**Discussion**

Based on pathogenesis, hemodynamics, and angiographic anatomy, Barrow, et al., classified CCFs into four types: Type A fistulas are direct, high-flow shunts between the ICA and the cavernous sinus which usually occur after trauma or rupture of a caroticocavernous aneurysm; Type B are dural shunts between meningeal branches of the ICA and the cavernous sinus; Type C are dural shunts between meningeal branches of both the ICA and external CA and the cavernous sinus; and Type D are dural shunts between meningeal branches of the external CA and the cavernous sinus.

Type B, C, and D lesions are low-flow dural fistulas that are spontaneous in origin, often idiopathic, and have a

**Fig. 3.** Case 1. Repeated angiograms obtained the following day (not shown) demonstrated a recurrence of brisk flow in the fistula. **Left:** Lateral left ICA angiogram acquired after insertion of a Symbiot covered stent resulting in exclusion of the fistula. **Center:** Six-month follow-up angiogram showing no recurrence of the fistula, ICA patency, and minimal intimal hyperplasia (straight arrow) at the proximal edge of the stent. **Right:** Magnified nonsubtracted lateral angiogram showing the stent (curved arrow) with coils.

**Fig. 4.** Case 2. **Left:** Left lateral ICA angiogram revealing a high-flow CCF draining via the superior ophthalmic vein. **Center:** Lateral left ICA angiogram obtained after inflation of a 14 × 7.8–mm detachable balloon (arrow), which failed to occlude the fistula. The balloon was subsequently deflated and removed. Note the large, linear dissection flap/tear (asterisks) in the cavernous ICA. **Right:** Lateral ICA angiogram acquired after insertion of the Symbiot covered stent, showing total occlusion of the CCF.
tendency to resolve spontaneously.\textsuperscript{11} Although closure of Types B, C and D may occur spontaneously, most traumatic CCFs are high-flow and spontaneous resolution is rare.

Traumatic aneurysms of the ICA (separate from CCF) are rare, may be true or false lesions, and are usually associated with a cranial base fracture. The rare surgery-related complication of CA laceration in the cavernous and petrous segments may occur during transsphenoidal surgery and myringotomy procedures in the setting of CA dehiscence or petrous temporal bone surgery.\textsuperscript{3,13} False aneurysms tend to increase in size and may be associated with catastrophic bleeding and ischemic complications.

Type A CCFs require treatment because of the morbidity they cause and their low incidence of spontaneous resolution. In 1973 Parkinson\textsuperscript{16} reported on the direct surgical repair of a CCF; the procedure, however, required cardiac standstill and was associated with significant neurological morbidity. Further advances in microneurosurgery and a better understanding of the cavernous sinus anatomy significantly improved outcomes in the surgical treatment of these lesions.\textsuperscript{8,10,19} Since Serbinenko\textsuperscript{21} first introduced the detachable balloon technique for occlusion of CCFs in 1974 and Debrun, et al.,\textsuperscript{6} further refined this technique by using latex detachable balloons, significant progress has been made in the endovascular treatment of such lesions.\textsuperscript{22} Most authors now agree that the best treatment for direct and indirect CCFs involves the endovascular approach.\textsuperscript{11,25} Depending on the clinical and radiological/neuroimaging presentation of the lesion, various approaches and embolization materials are available.\textsuperscript{1,2} Currently, most authors agree that endovascular obliteration of the fistula with detachable silicone balloons\textsuperscript{7,11,12,21} or thrombogenic coil–based occlusion\textsuperscript{14,26} is safe and effective.

The detachable balloon technique is considered by most surgeons to be the optimal initial therapy for Type A CCF. It may not, however, succeed in many cases, as illustrated in Case 1. A wide array of coils, including fibered coils, is now available that can be inserted via microcatheters, which can negotiate tight corners more easily than when mounted with a detachable balloon. Packing the cavernous sinus with coils in this way has also expanded the role of the transvenous approach when the aforementioned techniques fail. Access to the cavernous sinus may be achieved via the superior opthalmic vein by performing a cutdown technique or via the anterior facial vein from the jugular vein. The inferior petrosal sinus is another conduit that may be used via the internal jugular vein. With the insertion of the coils directly into the cavernous sinus, there is the potential risk of coil dislodgment into the ICA, especially if the defect is large, as it was in our Case 1. In this instance stents play an important role.

In the patient in Case 2, a direct high-flow CCF was associated with the presence of a contralateral traumatic pseudoaneurysm. An attempt to occlude the fistula by placing a detachable balloon failed. Insertion of an intraluminal stent resulted in the immediate obliteration of the fistula and the
Covered stent–treated caroticocavernous fistula

restoration of the circulation in the ipsilateral ICA. Repeat-
ed angiography 7 months postoperatively confirmed a nor-
mal patent ICA and no fistula recurrence. These results in-
dicate that placement of intraluminal covered stents on their
own may be an effective treatment of CCFs.

The use of bare (porous) stents, in association with coils, in
the treatment of wide-necked true and false aneurysms has
been more recently described. Covered stents are widely
used in cardiovascular interventions, and their ap-
lication has only recently been attempted in the skull base
and intracranial vasculature; there are only four reports in
the literature. In the first report of the use of intracranial
polytetrafluoroethylene-covered stent surgery, Redekop, et
al. 20 described two patients with traumatic petro cavernous
ICA lesions in whom JoStents (JoMed, Helsingborg, Swe-
den) were implanted. One stent thrombosed within a week,
and the other stent demonstrated patency at the 3-month fol-
low-up examination.

Although successful endovascular stent treatment of ex-
tracranial CAs has been described recently in the litera-
ture, 5,17,20 to our knowledge a covered stent has never been
placed as rostral as the cavernous ICA. Recently, an in-
eration stents was a major obstacle to their placement in the
intracavernous portion of the ICA; however, the new more
flexible stents such as the Symbiot allow successful treat-
ment of fistulas located in the cavernous sinus. Ours is also
the first published report of high-flow CCFs in which a cov-
ered stent alone was inserted. At the 6-month follow-up ex-
amination, both stents were patent and there was no signif-
ificant neointimal hyperplasia.

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