CASE REPORT

Double-barrel extracranial–intracranial bypass surgery followed by endovascular carotid artery occlusion in a patient with an extracranial giant internal carotid artery aneurysm due to Ehlers–Danlos syndrome

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ABSTRACT
Objective In this case report we describe a successful interdisciplinary approach (including flow redirection and endovascular occlusion) applied to a patient with a continuously growing extracranial giant aneurysm of the right internal carotid artery (ICA) due to known Ehlers–Danlos syndrome.

Case presentation A 42-year-old man with a continuously growing extracranial giant aneurysm of the right ICA sought treatment after failed surgery of a similar lesion of the left ICA. A multidisciplinary consultation was held at the end of 2008.

Treatment strategy The treatment strategy consisted of flow redirection in order to secure sufficient cerebral perfusion prior to surgical trapping of the carotid aneurysm. Flow redirection was achieved by placement of a double-barrel extracranial–intracranial bypass. Subsequent surgical trapping failed due to the extreme size of the aneurysm, making certain identification of surrounding structures impossible. The aneurysm was then successfully occluded by neuroradiological intervention. In a further procedure, a large intraneurysmal hematoma was surgically removed to reduce the remaining bulging aneurysm sac.

Conclusions This case report describes a successful interdisciplinary approach for the treatment of a rare giant extracranial ICA aneurysm in a patient with Ehlers–Danlos syndrome. Treatment options for this type are few and carry high risks. Flow redirection via extracranial–intracranial bypass followed by endovascular occlusion appears to be a good treatment approach.

INTRODUCTION
Ehlers–Danlos syndrome (EDS) is a group of inherited connective tissue disorders caused by a defect in collagen synthesis. The clinical presentation varies widely based on the type of EDS.1 Joints, skin and blood vessels are typically affected, the latter being the problem in the case presented in this paper. Some types of EDS lead to fragile blood vessels resulting in cystic medial necrosis with a high tendency to aneurysms at any location of the vascular system.2 We report an interdisciplinary treatment approach in a middle-aged man with a continuously growing giant extracranial aneurysm of the right internal carotid artery (ICA) caused by type IV EDS.

CASE REPORT
A 42-year-old man with EDS type IV was admitted to our department with a rapidly progressive cervical pulsatile and painful swelling on the right side (figure 1). Apart from the swelling, a neurological examination also showed right-sided palsy of the hypoglossal nerve. The patient’s history indicated that, in 1999, direct revascularization using a vessel graft to treat an extracranial giant aneurysm of the left ICA had failed due to technical problems in performing an adequate anastomosis causing left hemispheric ischemia. Neurological impairment such as right-sided hemiparesis or aphasia was not seen at the current presentation.

Radiology
Cerebral digital subtraction angiography (DSA) showed a giant aneurysm of the right ICA (C1 segment) measuring 10×7×7 cm, extending from the carotid bifurcation to the base of the skull (figure 2). A largely diluted basal artery and left posterior communicating branch indicating compensatory supply to the left hemisphere was also demonstrated. A Doppler-controlled balloon occlusion test of the right ICA revealed a moderate insufficiency of the middle cerebral artery (MCA) territory and additional collateralization of the right hemisphere via the ophthalmic branches. MRI demonstrated ischemic lesions of the left hemisphere as a result of the previous occlusion of the left ICA.

Technique
The radiological findings were then thoroughly discussed in an interdisciplinary conference including neuroradiological, neurological and neurosurgical colleagues in order to achieve a low-risk and adequate treatment of the growing aneurysm of the right ICA. The agreed strategy consisted of securing right cerebral perfusion via flow redirection through a double-barrel extracranial–intracranial bypass followed by surgical trapping of the aneurysm. The double-barrel bypass was successfully placed from the superficial temporal artery to two M4 cortical branches of the right MCA (figure 3). Both branches showed sufficient flow in postoperative angiographic studies. Prior to definite occlusion, a temporary ICA occlusion test was conducted using an eclipse...
balloon in order to confirm sufficient contrast perfusion of the right hemisphere through the previously placed tandem bypass (figure 4). The occlusion test showed good flow through the bypass and additional ophthalmic collateral filling, so we were able to proceed with the permanent elimination of the aneurysm from the circulation. Surgical trapping of the aneurysm failed due to the risk of sacrificing the external carotid artery. A decision was therefore made to occlude the aneurysm by means of endovascular coiling. Two separate sessions were needed to occlude both the distal and proximal segments of the giant aneurysm. The distal segment was successfully occluded with platinum spiral coils (figure 5). A stent was then placed in the right external carotid artery to secure its patency and, from there, stent-supported coiling was performed to occlude the proximal segment (figure 6). Secure proximal placement of the coils was not possible in a single-catheter technique owing to the high flow turbulence within the aneurysm sac. By using a double-catheter method, two coils could be placed simultaneously directly outside the stent wall facing the proximal segment of the extracranial ICA. Immediately after the procedure the patient had a transient ischemic attack with latent left-sided hemiparesis which regressed within 48 h. Ischemic lesions were excluded in post-procedural non-enhancement CT scans. Minor surgery was later performed to drain the residual hematoma in the aneurysm sac. The bulging skin collapsed instantly, reducing the large visible swelling on the patient’s neck. The patient recovered rapidly from the individual procedures without any additional impairment and was discharged in an unaltered clinical/neurological condition.

**Clinical follow-up**

Follow-up at 2 months revealed a good clinical result without any deficits with slight recurrence of the swelling on the right side of the neck. CT and CT angiography showed a hypodense non-enhancing filling of the remaining aneurysm sac. Density measurements indicated the filling to be serous fluid which was safely drained via CT-assisted puncture. Again the swelling collapsed immediately, leaving the patient with a good cosmetic result (figure 7). The patient died a year later due to a ruptured aneurysm of the splenic artery.

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**Figure 1** (A) Frontal and (B) lateral views showing a large pulsatile swelling on the right side of the neck in a patient with Ehlers–Danlos syndrome with a giant extracranial internal carotid artery aneurysm.

**Figure 2** Angiographic study prior to treatment showing the contrast in the giant extracranial internal carotid artery aneurysm measuring 10x7x7 cm.

**Figure 3** Angiographic study demonstrating patent superficial temporal artery–middle cerebral artery bypass with sufficient contrast (lateral view).
DISCUSSION
Extracranial giant ICA aneurysms are rare lesions and treatment is often accompanied by a high risk of morbidity and mortality.\(^{3,4}\) Surgical resection with reconstruction is considered to be the best therapeutic option for these extracranial vascular pathologies.\(^{4,5}\) In the case presented here, surgical treatment had been attempted for a similar lesion of the left EICA but failed due to the dimensions of the lesion and led to ischemic stroke. An alternative treatment method for the abovementioned lesion of the right EICA in this patient was therefore sought. A well-accepted approach for giant and complex intracranial ICA aneurysms is the combination of flow redirection followed by definitive exclusion of the aneurysm from the circulation.\(^{6-8}\) A transcranial Doppler-controlled balloon occlusion test performed during the initial diagnostic angiography revealed moderate insufficiency of the right MCA territory, so a STA–MCA bypass was seen as adequate in this case. After interdisciplinary consultation, we decided to apply this combined approach to this extracranial ICA aneurysm in order to prevent further ischemic events.

Exclusion from the circulation can be achieved either through surgical trapping or by endovascular occlusion.\(^{6,9,10}\) Both methods are reported to be equally acceptable. Extracranial–intracranial bypass and aneurysm exclusion can be carried out as a single-stage or two-stage procedure.\(^{11}\) If aneurysm exclusion is performed as surgical trapping, the single-stage procedure under a single anesthesia is the more common protocol.\(^{11}\) To avoid the increased risk of postoperative bleeding, a two-stage procedure with anticoagulation after the endovascular occlusion of the aneurysm should be considered. Given the fact that the patient had already had an ischemic stroke of the left hemisphere due to ICA ligation after failed surgery, we decided to apply the aforementioned standard methods for intracranial ICA aneurysms to this giant aneurysm of the right EICA. At first we chose a single-stage strategy in which we planned to place an extracranial–intracranial bypass with subsequent open surgical trapping in one procedure. Trapping failed again due to the extreme dimensions of the aneurysm at the bifurcation, making it impossible to trap the aneurysm and not the external ICA. As mentioned above, endovascular occlusion is a well-accepted

![Figure 4](image1.png)
(A) Internal carotid artery (ICA) occlusion test during cerebral angiography. (B) Anteroposterior view of patent contrast via extracranial–intracranial bypass during temporary ICA occlusion.

![Figure 5](image2.png)
Angiographic study showing coiling of the distal segment of the right internal carotid artery (lateral view).

![Figure 6](image3.png)
Angiographic study showing stent-assisted proximal occlusion of the right internal carotid artery.

A combination of flow redirection using cerebral bypass surgery and endovascular occlusion is a rational treatment method for intracranial aneurysms and also seems to be a valid option for high-risk extracranial giant ICA aneurysms, even in a patient with EDS.

CONCLUSIONS

A combination of flow redirection using cerebral bypass surgery and endovascular occlusion is a rational treatment method for intracranial aneurysms and also seems to be a valid option for high-risk extracranial giant ICA aneurysms, even in a patient with EDS.

REFERENCES