Emergency Extracranial-to-Intracranial Bypass after Thromboembolic Occlusion of the Middle Cerebral Artery Following GDC Embolization of a Ruptured ACoA Aneurysm

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Summary

We report a case of thromboembolic occlusion of the middle cerebral artery after endovascular treatment of a ruptured anterior communicating artery aneurysm. When fibrinolytic therapy failed to recanalize the occluded vessel, an emergency extracranial-to-intracranial bypass was performed. This intervention rescued our patient from cerebral infarction. This case demonstrates the importance of the offering this procedure at neurointerventional centers.

Introduction

Since the introduction of Guglielmi detachable coils (GDC) in the early 1990s^{1,2}, endovascular treatment of cerebral aneurysms has become a widely used procedure with well-documented safety and efficacy³⁻⁷. It offers a true alternative to microsurgical clipping in many patients, especially in those with posterior circulation aneurysms. Potential complications of this therapy include intraprocedural aneurysm rupture, catheter induced vascular damage or spasm, coil displacement and thromboembolism. We report about a patient who underwent acute revascularization with an extracranial-to-intracranial bypass (EC-IC) after thromboembolic middle cerebral artery (MCA) occlu-

sion following GDC embolization of an acutely ruptured anterior communicating artery aneurysm (ACoAA).

Case Report

A 54-year-old woman suffered two subsequent subarachnoidal haemorrhages (SAH) within three days. Because the patient complained only of mild headache and nuchal rigidity, diagnosis was missed until day 10 after the first aneurysm rupture. On admission to our hospital she was in clinical grade Hunt and Hess I. The diagnosis was established after a lumbar tap; CT did not show subarachnoid blood at that time; an angiography demonstrated a 3 x 6 mm sized bilobulated ACoAA (figure 1A). Due to marked elevated transcranial Doppler (MCA R 100 cm/s, L 115 cm/s) the endovascular option was chosen. GDC embolization was performed uneventfully under general anaesthesia. After placement of the first coil the patient was fully anticoagulated with i.v. heparin, obtaining an activated partial thromboplastin time (APTT) > 100 seconds. A control angiography at the end of the procedure showed the aneurysm occluded (figure 1B); the angiogram was otherwise unremarkable (figure 2A,B).

After awakening from anaesthesia the patient exhibited a marked hemiparesis on the

Figure 1 Angiography showed a 3 x 6 mm sized bilobulated ACoA aneurysm as the source of the subarachnoid haemorrhage (A). The ruptured aneurysm could be completely occluded using GDC coils (B).

left side combined with facial nerve palsy. Immediate angiographic control showed the M1 segment of the right MCA occluded distally to the anterior temporal branch and the lenticulostriate arteries (figure 2C,D). An attempt at intraarterial thrombolytic (2 mg Actilyse, Antepase / Boehringer Ingelheim) and mechanical recanalisation of the occluded MCA failed (figure 2E,F). Therefore the patient was transferred to the operating room without delay for an emergency revascularization. A bypass between the superficial temporal artery and a

cortical branch of the occluded MCA was performed. The patient made a good clinical recovery. Upon her discharge 18 days after revascularization she complained only of slight clumsiness of her left hand but was otherwise neurologically intact. CT on the day of discharge demonstrated an area of low density in the right fronto-opercular region (figure 3).

Astonishingly, control angiography six weeks later showed an unremarkable filling of the right MCA, the previous occluded M1 segment being completely recanalized. In the last control angiography two years after initial treatment the bypass was found to be still open, the coiled aneurysm was totally obliterated (figure 4).

Discussion

Transient ischemic attacks or even ischemic stroke following neuroendovascular procedures are well known complications. They can be the consequence of parent artery occlusion during the intervention, air embolism, distal embolization of a thrombus out of the treated aneurysm or of a thrombus formed at the catheter or coil surface, or distal thromboembolic vessel occlusion due to a dislodged plaque, e.g. from the internal carotid artery as suspected in our case. To avoid thromboembolic complications, patients are systemically anticoagulated with heparin intra- and postprocedurally for up to several days and long term aspirin might be initiated³. Nevertheless clinical relevant thromboembolic complication rates after GDC embolization have been reported to be as high as 28%, leading to permanent neurological deficit in up to 5% of the patients³⁻¹¹. Studies using transcranial Doppler sonographic monitoring¹² or MR imaging¹³⁻¹⁶ estimate the frequency of clinical silent thromboembolic events to be even over 60%.

Management of this complication is controversial, especially in patients with ruptured aneurysms. It is common sense that additional systemic heparin together with intravascular

Figure 2 The final angiogram at the end of the GDC embolization showed the aneurysm occluded and an otherwise unremarkable angiogram (A,B). After secession of anaesthesia the patient showed a marked left haemiparesis. An immediate control angiography demonstrated a MCA occlusion on the right side (C,D). Intraarterial fibrinolytic therapy and an attempted mechanical recanalisation could not reopen the occluded vessel (E,F).

Figure 3 CT at discharge demonstrated an area of low density in the right fronto-opercular region.

volume expansion and pharmacological elevation of blood pressure should be initiated to optimize collateral flow.

As a rescue manoeuvre superselective intra-arterial infusion of a fibrinolytic agent can be used in combination with mechanical clot fragmentation. Cronquist et al¹⁷ reported their experience with selective intraarterial Urokinase infusion. In 53% of the patients complete recanalisation of the occluded vessel could be accomplished and in 60% a good clinical recovery was seen on long term follow-up. However, in half of the patients with a ruptured aneurysm treated in this series, a devastating rebleeding occurred due to the use of Urokinase, which underscores the potential high risk of a fibrinolytic intervention in patients with acutely ruptured aneurysms that are only occluded by coil and thrombus¹⁸. The increased case fatality rate occurring after the use of thrombolytic therapy was also highlighted in the recent International Subarachnoid Haemorrhage Trial (ISAT)⁷.

A platelet aggregation inhibitor, glycoprotein IIb-IIIa inhibitor, is reported as an alternative drug to dissolve thrombus and regain ves-

sel patency in the case of a thromboembolic event¹⁹⁻²⁵. Glycoprotein IIb-IIIa inhibitor is well known to prevent thrombotic and ischemic complications in coronary interventions. Initial neurovascular applications are promising but further evaluation is needed to prove efficacy and safety, especially in regard to the risk of producing a fatal rehaemorrhage in patients with acutely ruptured aneurysms.

Another way to treat thromboembolic vessel occlusion was shown by Shin et al²⁶. They described the emergency surgical recanalisation of an occluded A1 segment of the anterior cerebral artery after GDC embolization of a ruptured ACoAA. The vessel occlusion occurred due to the protrusion of a coil from the aneurysm into the parent artery. Surgical removal of the coil and subsequent direct application of Urokinase succeeded in re-establishing blood flow. The authors point out that the availability of an emergency vascular neurosurgical team for prompt surgical intervention was critical for the rescue of their patient²⁶.

In our case a different surgical approach was chosen. Fibrinolytic therapy could not dissolve the occluding thrombus in our patient and mechanical fragmentation of the thrombus with the guidewire was not possible due to its solid nature. As our patient had sustained two proven SAHs, we were reluctant to administer higher doses of the fibrinolytic agent for the above mentioned reasons and a rescue manoeuvre using an EC-IC bypass to the deprived vascular territory was initiated^{17,27}. Sufficient revascularization could be achieved by this measure and the patient finally had a good clinical course. We believe that the additional collateral flow to the occluded MCA-territory provided by the bypass protected functionally affected neurons from permanent structural damage, until spontaneous reopening of the main trunk of the MCA occurred.

Revascularization techniques using different types of bypasses are well known in the treatment of complex intracranial aneurysms that are not suitable for microsurgical clipping or endovascular coil treatment. These include fusiform aneurysms, wide necked giant aneurysm or aneurysms incorporating perforating or branch vessels^{27,28}. In the treatment of these lesions an EC-IC bypass is established in an elective fashion before occlusion of the parent artery. By using this approach subsequent cere-

Figure 4 Follow-up angiographies demonstrated stable obliteration of the coiled aneurysm. Astonishingly, there was an unremarkable filling of the right MCA with the previous occluded M1 segment being completely recanalized (A,B). The bypass was found to be still open (STA: superficial temporal artery; arrow: STA-MCA anastomosis), filling a precentral MCA branch and retrograde the proximal MCA and a frontal MCA branch (C,D). Shown is the last control two years after initial treatment.

bral ischemia due to the planned vessel occlusion can be avoided. Moreover, as our experience shows, the technique of acute EC-IC bypass surgery is able to prevent cerebral infarction after unintentional occlusion of a main brain artery. Therefore this technique should be available for a neurovascular team at large neurointerventional center to provide a treatment option in cases where other techniques

fail to reestablish flow to vascular territories of obstructed main brain vessels.

Conclusions

Based on our report, emergency revascularisation using an EC-IC bypass should remain an option to consider in the case of accidental thromboembolic vessel occlusion.

References

- Guglielmi G, Viñuela F et Al: Electrothrombosis of saccular aneurysms via endovascular approach. Part 1: Electrochemical basis, technique, and experimental results. *J Neurosurg* 75: 1-7, 1991.
- Guglielmi G, Viñuela F et Al: Electrothrombosis of saccular aneurysms via endovascular approach. Part 2: Preliminary clinical experience. *J Neurosurg* 75: 8-14, 1991.
- Viñuela F, Duckwiler G, Mawad M: Guglielmi detachable coil embolization of acute intracranial aneurysm: perioperative anatomical and clinical outcome in 403 patients. *J Neurosurg* 86: 475-482, 1997.
- Cognard C, Weill A et Al: Intracranial berry aneurysms: angiographic and clinical results after endovascular treatment. *Radiology* 206: 499-510, 1998.
- Eskridge JM, Song JK: Endovascular embolization of 150 basilar tip aneurysms with Guglielmi detachable coils: results of the Food and Drug Administration multicenter clinical trial. *J Neurosurg* 89: 81-86, 1998.
- Bavinski G, Killer M et Al: Treatment of basilar artery bifurcation aneurysms by using Guglielmi detachable coils: a 6-year experience. *J Neurosurg* 90: 843-852, 1999.
- Molyneux A, Kerr R et Al: International Subarachnoid Aneurysm Trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial aneurysms: a randomised trial. *Lancet* 360: 1267-1274, 2002.
- Gruber A, Killer M et Al: Clinical and angiographic results of endosaccular coiling treatment of giant and very large intracranial aneurysms: a 7-year, single-center experience. *Neurosurgery* 45: 793-803; discussion 803-804, 1999.
- Murayama Y, Viñuela F et Al: Embolization of incidental cerebral aneurysms by using the Guglielmi detachable coil system. *J Neurosurg* 90: 207-214, 1999.
- Pelz DM, Lowrie SP, Fox AJ: Thromboembolic events associated with the treatment of cerebral aneurysms with Guglielmi detachable coils. *Am J Neuroradiol* 19: 1541-1547, 1998.
- Derdeyn CP, Cross DT 3rd et Al: Postprocedure ischemic events after treatment of intracranial aneurysms with Guglielmi detachable coils. *J Neurosurg* 96: 837-843, 2002.
- Klotzsch C, Nahser HC et Al: Detection of microemboli distal to cerebral aneurysms before and after therapeutic embolization. *Am J Neuroradiol* 19: 1315-1318, 1998.
- Bendszus M, Koltzenburg M et Al: Silent embolism in diagnostic cerebral angiography and neurointerventional procedures: a prospective study. *Lancet* 354: 1594-1597, 1999.
- Biondi A, Oppenheim C et Al: Cerebral aneurysms treated by Guglielmi detachable coils: evaluation with diffusion-weighted MR imaging. *Am J Neuroradiol* 21: 957-963, 2000.
- Rordorf G, Bellon RJ et Al: Silent thromboembolic events associated with the treatment of unruptured cerebral aneurysms by use of Guglielmi detachable coils: prospective study applying diffusion-weighted imaging. *Am J Neuroradiol* 22: 5-10, 2001.
- Soeda A, Sakai N et Al: Thromboembolic events associated with Guglielmi detachable coil embolization of asymptomatic cerebral aneurysms: evaluation of 66 consecutive cases with use of diffusion-weighted MR imaging. *Am J Neuroradiol* 24: 127-132, 2003.
- Cronqvist M, Pierot L et Al: Local intraarterial fibrinolysis of thromboemboli occurring during endovascular treatment of intracerebral aneurysm: a comparison of anatomic results and clinical outcome. *Am J Neuroradiol* 19: 157-165, Comment: *Am J Neuroradiol* 19: 190, 1998.
- Bavinski G, Talazoglu V et Al: Gross and microscopic histopathological findings in aneurysms of the human brain treated with Guglielmi detachable coils. *J Neurosurg* 91: 284-293, 1999.
- Lempert TE, Malek AM et Al: Rescue treatment of acute parent vessel thrombosis with glycoprotein IIb/IIIa inhibitor during GDC coil embolization. *Stroke* 30: 693-695, 1999.
- Cloft HJ, Samuels OB et Al: Use of abciximab for mediation of thromboembolic complications of endovascular therapy. *Am J Neuroradiol* 22: 1764-1767, 2001.
- Ng PP, Phatouros CC, Khangure MS: Use of glycoprotein IIb-IIIa inhibitor for a thromboembolic complication during Guglielmi detachable coil treatment of an acutely ruptured aneurysm. *Am J Neuroradiol* 22: 1761-1763, 2001.
- Workman MJ, Cloft HJ et Al: Thrombus Formation at the Neck of Cerebral Aneurysms during Treatment with Guglielmi Detachable Coils. *Am J Neuroradiol* 23: 1568-1576, 2002.
- Kwon OK, Lee KJ et Al: Intraarterially administered abciximab as an adjuvant thrombolytic therapy: report of three cases. *Am J Neuroradiol* 23: 447-451, 2002.
- Alexander MJ, Duckwiler GR et Al: Management of intraprocedural arterial thrombus in cerebral aneurysm embolization with abciximab: technical case report. *Neurosurgery* 50: 899-901; discussion 901-902, 2002.
- Mounayer C, Piotin M et Al: Intraarterial administration of Abciximab for thromboembolic events occurring during aneurysm coil placement. *Am J Neuroradiol* 24: 2039-2043, 2003.
- Shin YS, Lee KC et Al: Emergency surgical recanalisation of A1 segment occluded by a Guglielmi detachable coil. *J Clin Neurosci* 7: 259-262, 2000.
- Martin NA, Kureshi I, Coiteiro D: Bypass techniques for the treatment of intracranial aneurysms. *Operative Tech Neurosurg* 3: 255-270, 2000.
- Hoh BL, Putman CM et Al: Combined surgical and endovascular techniques of flow alteration to treat fusiform and complex wide-necked intracranial aneurysms that are unsuitable for clipping or coil embolization. *J Neurosurg* 95: 24-35, 2001.

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EDITORIAL COMMENT

This single case report describes the potential role of an emergency EC-IC bypass procedure in a patient who has undergone coiling of an aneurysm and developed an acute neurological deficit in the distribution of a different arterial territory (unrelated to the coiled aneurysm vessel). The authors postulate that neurological improvement was related to the emergency EC-IC bypass, but follow-up angiography demonstrated spontaneous re-canalization of the previously occluded vessel coinciding with improved neurological outcome. Such evolution might in fact be more in favor of breaking up of the embolic clot being responsible for improvement rather than the EC-IC bypass itself. While the MCA branch, which was used for the EC-IC bypass, might have been critical for the preservation of circulation to the motor cortex, the reality is that EC-IC bypass towards an occluded vascular territory can hardly be advocated in acute stroke patients as the patency of the distal vasculature involved and the status of the brain is unknown. Emergency thrombectomy, however, can be proposed as a method to improve circulation towards the normal pacified territory.

The discussion includes the surprising finding of vessel occlusion not in the territory of the aneurysm vessel. Therefore the coiling procedure itself probably had little to do with the procedural related complication which was likely to be caused by a flaw in the overall angiographic technique. While the premise of the authors that interventional treatment is best performed at an institution which can deal with endovascular procedure related complications, the notion that EC-IC in this particular case report resulted in improved clinical outcome is probably unproven and highly speculative.

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