



Original Article

Extracranial–intracranial bypass in the treatment of complex or giant internal carotid artery aneurysms

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ABSTRACT

Objectives: Direct microsurgical clipping or endovascular coiling for complex and giant internal carotid artery (ICA) aneurysms is usually risky and leads to inadequate occlusion of the aneurysm. Extracranial–intracranial (EC–IC) bypass may help eliminate neurological complications.

Materials and methods: We retrospectively reviewed patients with intracranial aneurysms who were treated with the assistance of EC–IC bypass from July 2002 to February 2014. Six patients with complex ICA aneurysms were identified, and their clinical characteristics were analyzed. There were two men and four women ranging in age from 40 to 76 years. Three of these patients presented with hemorrhage, and two with compression with visual impairment. One aneurysm was an incidental finding during a physical examination.

Results: Three of the six ICA complex aneurysms were large or giant sized, one was an ICA blood blister-like aneurysm, one was a dissecting aneurysm, and one was a pseudoaneurysm due to tumor invasion. Bypass was performed with superficial temporal artery–middle cerebral artery anastomosis. The follow-up period ranged from 2 to 103 months (mean 36.67 months). The postoperative bypass patency rate was 100%. One patient had cerebellar intracerebral hemorrhage and one had temporary ptosis. There was no bypass surgery-related morbidity. The modified Rankin scale showed good outcomes in four of the six patients.

Conclusions: Cerebral revascularization plays an important role in the treatment of complex ICA aneurysms that have a significant mass effect on the optic nerve or require occlusion of the parent ICA as a salvage procedure.

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1. Introduction

Intracranial aneurysms can be treated by microscopic clipping or endovascular coil embolization with good outcomes. However, both procedures have high complication rates and low success rates for aneurysm sac obliteration, such as in the case of large and giant aneurysms or aneurysms with complex anatomy. Complex anatomy can be characterized by dolichoectatic morphology, intraluminal thrombi, atherosclerotic tissue in the neck, arterial branches incorporated into the aneurysm base, or a broad neck

[1,2]. Complex intracranial aneurysms may be managed by parent artery occlusion or trapping to obliterate the aneurysm or redirect blood flow, thus avoiding the high morbidities of direct clipping or coiling.

Extracranial–intracranial (EC–IC) bypass involves revascularization of the cerebral arteries through extracranial arterial grafts [3]. Although bypass was first designed for cerebral ischemic disease, it has shown potential efficacy in patients who cannot tolerate cerebral arterial occlusion, such as those with postoperative infarction or neurological damage due to prolonged ischemic time during complex or giant aneurysm clipping.

Giant and complex aneurysms of the internal carotid artery (ICA) usually present with mass effect over the optic pathway, resulting in several types of visual impairment [4]. These symptoms are closely related to characteristics such as the size of the aneurysm, duration of visual symptoms, calcification of the aneurysm

Conflict of interest: none.

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wall, and intraluminal thrombosis [5]. Furthermore, it has not yet been confirmed whether surgical clipping or endovascular coiling achieves a better visual outcome. We reviewed patients with complex ICA aneurysms who were treated with surgical clipping or endovascular coiling. All of these procedures were supplemented by EC–IC bypass. An analysis of the characteristics of complex ICA aneurysms (e.g., visual impairment) is presented, and the role of EC–IC bypass during surgery for giant or complex aneurysms is also discussed.

2. Materials and methods

We retrospectively reviewed the medical records and imaging results of patients who underwent treatment from July 2002 to February 2014. Among the 307 patients with aneurysms treated with microsurgical clipping or endovascular coiling, bypass therapy was performed in six patients with ICA segment aneurysms (Table 1).

2.1. Patients

There were two men and four women in this study. Their ages ranged from 40 to 76 years. Four patients received two EC–IC anastomoses via the superficial temporal artery (STA) frontal and parietal branches to the middle cerebral artery (MCA). They underwent 10 EC–IC surgery procedures for complex cerebral aneurysms. Three of these patients had unruptured aneurysms and three had ruptured aneurysms, including one with active tumor bleeding. One of the three unruptured aneurysms was an incidental finding during a regular physical examination. The other two were detected during evaluation of poor vision and transient ischemic attack. One of the three patients with ruptured aneurysms had nasopharyngeal carcinoma and active nasal bleeding. Cerebral digital subtraction angiography (DSA) revealed rupture of a right ICA pseudoaneurysm due to tumor invasion. One patient received emergency EC–IC bypass owing to an aneurysm neck tear during aneurysm clipping. The third patient was diagnosed after she suffered severe headaches and became comatose.

2.2. Preoperative survey

Cerebral computed tomography (CT) angiography and cerebral DSA were routinely carried out when spontaneous subarachnoid hemorrhage (SAH) was found.

One of the three ruptured aneurysms was Hunt and Hess (H&H) Grade 3 and the other two were Grade 5. The Fisher grades of these cases are shown in Table 1. One aneurysm was located in the petrous segment, two in the ophthalmic segment, and three in the communicating segment of the ICA. The aneurysms ranged from 2.8 mm to >50 mm.

Emergency external ventricular drainage (EVD) was done to treat patients with SAH-related hydrocephalus and consciousness disturbance. Delayed aneurysm surgery was performed for high-grade H&H cases.

Brain magnetic resonance imaging (MRI) and visual field examination were used in the two visual impairment cases. Cerebral DSA was necessary for the differential diagnosis of the suprasellar lesion, which included pituitary adenoma, craniopharyngioma, meningioma, and aneurysm.

2.3. Strategy of bypass surgery for aneurysms

Initially, a balloon occlusion test was performed prior to the bypass surgery. This test took 30 minutes. If transient ischemic symptoms such as limb weakness or consciousness deterioration were noted, the test was deemed positive. When the test was negative, ICA sacrifice without bypass was indicated. However, Case 1 passed the balloon occlusion test prior to the bypass and received ICA sacrifice without bypass. The test result had been a false negative, and the patient had a symptomatic ischemic stroke. Emergency EC–IC bypass was then performed. A 25% false negative rate for the balloon occlusion test has been reported [6]. After Case 1, we changed our strategy. If a long duration of ischemia during aneurysm surgery and a potential ICA sacrifice was planned, EC–IC bypass was performed first. Then, a balloon occlusion test was done to check if a symptomatic stroke was possible after ICA sacrifice. If the patient did not pass the test, another bypass surgery such as an anterior cerebral artery (ACA)-to-ACA bypass was performed prior to the aneurysm surgery. If the patient passed the test, aneurysm therapy was performed immediately (Fig. 1).

2.4. Postoperative evaluation

Cerebral angiography was performed postoperatively to check the bypass patency and aneurysm clipping. Brain MRI was conducted in the outpatient department to follow up the bypass and aneurysm clipping. Visual field examination was used to evaluate the patients who had preoperative visual impairment. In addition, the Rankin scale was used to evaluate the clinical outcome.

2.5. Surgical procedures

EC–IC bypass with the STA to the frontal and temporal M3 branches of the MCA was carried out first. End-to-side anastomosis of the STA to the MCA, as described in detail previously, was performed [3]. At least a 5-cm length of the frontal branch of the STA was dissected from the subcutaneous layer of the scalp on the surgical side. The branch was transected and occluded with a temporary aneurysm clip. A 1% diluted heparin solution was used to irrigate the endovascular lumen to prevent thrombus formation. Then, a 3 × 2-cm² craniotomy was performed, and the Sylvian

Table 1
Clinical characteristics of aneurysms.

Cases	Age (y)/sex	Preoperative GCS	Presenting symptoms	Location	Aneurysm morphology	Size (mm)	Fisher grade	H&H grade	Preaneurysm tx surgery
1	46/F	E4V5M6	Incidental finding	Left ICA C7	Saccular	20	1	1	None
2	54/M	E1VTM1	Deep coma	Left ICA C7	Blister	2.8	4	5	EVD
3	53/M	E4V5M6	Right homonymous hemianopsia	Left ICA C7	Saccular	25.2	1	1	None
4	40/F	E4V5M6	Left homonymous hemianopsia	Right ICA C6	Saccular	15.3	1	1	None
5	76/F	E3VTM4	Deep coma	Right ICA C2–3	Fusiform	90	1	5	None
6	43/F	E3VTM5	Deep coma	Right ICA C6	Fusiform	5.4	4	3	EVD

EVD = external ventricular drainage; GCS = Glasgow Coma Scale; H&H grade = Hunt and Hess grade; ICA = internal carotid artery.

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