# Recovery of Visual and Ophthalmologic Symptoms After Treating Large or Giant Internal Carotid Artery Aneurysm by High-Flow Bypass with Cervical Ligation

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OBJECTIVE: **Large or giant internal carotid artery (ICA) aneurysms often cause visual deficits and cranial nerve palsy. The aim of this study was to investigate the efficacy of ligation of the ICA with high-flow bypass.**

METHODS: **We retrospectively analyzed the findings from patients with visual deficit and ophthalmologic symptoms due to ICA aneurysms. In addition, we analyzed the recovery factors associated with the visual deficit and ophthalmologic symptoms postoperatively, focusing on the type of cranial nerve palsy, aneurysm size, location, and the time to treatment from first symptoms.**

RESULTS: **We identified 38 patients (35 women, 3 men) with a mean age at surgery of 63.6 years (range, 24–81 years) with visual and ophthalmologic symptoms due to large or giant internal carotid aneurysm. Aneurysms ranged in size from 15–50 mm (mean, 25.2 mm). Visual disturbance (7 cases, 18%) and ophthalmoplegia (31 cases, 82%) were the only preoperative cranial nerve palsies. Aneurysms were completely thrombosed in 94.7% of cases (36/38). Visual disturbance improved in 28.5% of cases (2/7), and ophthalmoplegia improved in 87.1% of cases (27/31). Time to therapy from developing a visual disturbance was longer than time to therapy from developing ophthalmoplegia ($P = 0.001$). Time to therapy was significantly associated with recovery from cranial nerve palsy ($P < 0.0001$). The recovery of visual disturbance was worse than that of ophthalmoplegia ($P = 0.001$).**

CONCLUSION: **Early treatment is recommended when the visual and ophthalmologic symptoms are present because treatment delay is a risk factor for nonimprovement of symptoms.**

## INTRODUCTION

Large or giant internal carotid artery (ICA) aneurysms often cause neurologic deficits, such as visual disturbance or ophthalmoplegia, because of oculomotor, trochlear, or abducens nerve palsies.[1,2] Although various surgical strategies have been reported for these aneurysms, no definitive treatment policy has been established.[3,4] ICA ligation with high-flow bypass has been shown to thrombose aneurysms,[5,6] but the efficacy of this treatment to produce aneurysm thrombosis and symptomatic improvement remains unclear. In addition, there are no reports on the recovery factors for neurologic deficits using this strategy. We evaluated the efficacy of ICA ligation with high-flow bypass to reduce the rate of thrombosed aneurysm and preoperative neurologic deficits. We specifically focused on deficits caused by large or giant internal carotid aneurysms that could not be clipped or trapped. In addition, we analyzed the relationship between improvement of neurologic deficit and clinical factors.

## MATERIALS AND METHODS

### Study Design

We conducted a retrospective analysis of the clinical and imaging data of patients treated at our institution. The study is reported in accordance with the "Strengthening the Reporting of Observation Study in Epidemiology" criteria. Written informed consent was obtained from all patients.

**Key words**
- High-flow bypass
- Large aneurysm
- Oculomotor nerve palsy
- Ophthalmoplegia
- Visual disturbance

**Abbreviations and Acronyms**
3DCTA: 3-dimensional computed tomography angiography
ICA: Internal carotid artery
STA: Superficial temporal artery

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### Participant Selection and Data Collection

We performed high-flow bypass for 133 patients (cavernous portion aneurysm, 65 cases; supraclinoid portion, 30 cases; ruptured blister-like aneurysms, 27 cases; and others, 11 cases) at our hospital and associated institutions from 1997–2015. We identified and retrospectively analyzed the results for patients who underwent cervical internal carotid ligation with high-flow bypass. Patients were required to have had a preoperative neurologic deficit (visual disturbance or ophthalmoplegia) at the time of operation. We reviewed data from patient charts, including the admission data, laboratory work-up, imaging studies, operative records (including video), and any follow-up reports. The location of the aneurysm was also recorded.[7]

### Preoperative and Postoperative Examination

Patients underwent 3-dimensional computed tomography angiography (3DCTA) or angiography before the operation to examine the orientation, size, neck width, and exact morphology of the aneurysm. Visual acuity and visual field examinations were conducted to assess for the presence of cranial nerve palsy before the operation. At 6 months after the operation, all patients were assessed for improvement of visual disturbance and cranial nerve palsy by an ophthalmologist or 2 neurosurgeons. We also reviewed patients for the presence of cerebral infarction, radiographic outcome, and recurrence and requirement for retreatment by 3DCTA or angiography. We analyzed the statistical differences between postoperative improvement in ophthalmic disturbance and type of cranial nerve palsy with age, sex, aneurysm size, and time with ophthalmic disturbance before therapy. In addition, we analyzed the risk factors of retreatment of an aneurysm.

### Surgical Strategy and Technique

At our institution, all symptomatic unruptured aneurysms are treated. To reduce blood flow to the aneurysm and thrombosis, we selected cervical ICA ligation with high-flow bypass for cases of large or giant symptomatic aneurysms located in the proximal ophthalmic artery. These aneurysms did not require clipping or trapping because retrograde blood flow through the radial artery graft passed through the ophthalmic artery with the end of the aneurysm, and then the aneurysms were thrombosed. The advantage of this strategy is that it precludes manipulation of clipping or trapping, such as opening of the sylvian fissure or cavernous sinus, or drilling of the clinoid process. We selected aggressive universal revascularization with high-flow bypass when parent artery occlusion was needed, without balloon occlusion testing, because of the risk of cerebral infarction. We have previously reported the surgical technique for high-flow bypass in detail.[5,8-10] We dissected 2 branches of the superficial temporal artery (STA) and first performed M2 or M3 bypass, followed by extracranial-intracranial graft–radial artery–M2 bypass. At that time, the other branch of STA was cannulated to maintain an arterial line and a temporary clip was placed on the main trunk of the STA. The ICA occluded temporarily, and the radial artery graft was released. At that time, the cannulated STA showed cerebral perfusion pressure after using this strategy. Continuous monitoring of cerebral perfusion pressure during the procedure is necessary for detecting decrease in pressure due to graft kinking, twisting, or thrombosis. Next, we performed 3 internal carotid ligations with 2-0 Nurolon sutures (Figure 1). In order to thrombose aneurysms, we did not administer antiplatelet drugs. We did not select the endovascular treatment, such as coiling and flow diverting stent, because both strategies have the disadvantage of requiring antiplatelet therapy; coiling included the risk of recanalization and retreatment.

### Statistical Analysis

All statistical analyses were performed using Graph Pad Prism (version 6.01; Graph Pad Software Inc., San Diego, California, USA). Variables were expressed as mean ± standard deviation, median (25th–75th percentile), or number of patients (%), as appropriate. The Mann-Whitney test was used to assess factors relating to postoperative neurologic deficit and age, aneurysm size, and time with deficit before treatment. The chi-square test was used to assess factors relating to postoperative neurologic deficit and sex, term to therapy (>6 months), and location of nerve palsy. The Mann-Whitney test was used to assess factors relating to retreatment of an aneurysm, age, and aneurysm size. The chi-square test was used to assess factors relating to retreatment of an aneurysm, sex, and aneurysm location. Statistical significance was set at $P < 0.05$.

## RESULTS

### Patient Characteristics

The characteristics of the included patients and their aneurysms are shown in Table 1. We included 38 patients (3 men and 35 women) with a mean age of 63.6 years (range, 24–81) at surgery. Preoperative visual disturbance and ophthalmoplegia were present in 7 and 31 cases (oculomotor nerve palsy, 20 cases; trochlear, 4 cases; and abducens, 7 cases), respectively. Aneurysms ranged from 15–50 mm (mean, 25.2 mm) in size

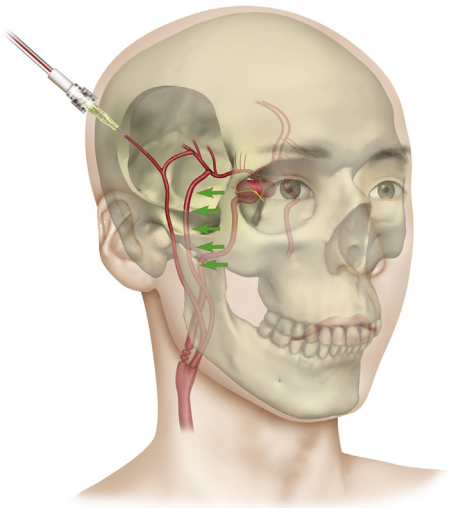

**Figure 1.** Schematic diagram for ligation of the cervical internal carotid artery with high-flow bypass. Arrow = radial artery graft.