Intra-aneurysmal Coil Embolization for Large or Giant Carotid Artery Aneurysms in the Cavernous Sinus

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Abstract

This study evaluated the effectiveness of intra-aneurysmal coil embolization for large or giant carotid artery aneurysms in the cavernous sinus in seven patients treated by intra-aneurysmal coil embolization from 2001 to 2010. Only one patient showed improved neurological symptoms caused by aneurysmal mass effect during the mean follow-up period of 53.4 ± 27.3 months. Neurological symptoms caused by the aneurysms remained unchanged in two patients, and deteriorated in four. Intra-aneurysmal coil embolization is not considered an effective treatment option for large or giant carotid artery aneurysms in the cavernous sinus.

Key words: cavernous sinus, intra-aneurysmal coil embolization, giant aneurysm, large aneurysm

Introduction

Large or giant aneurysms of the internal carotid artery (ICA) in the cavernous sinus (CS) frequently present with neurological symptoms caused by mass effect on the cranial nerves (CNs). These symptoms include ophthalmoplegia caused by compression of the oculomotor nerve (CN III), trochlear nerve (CN IV), and/or abducens nerve (CN VI) in the CS, and/or facial sensory impairment caused by compression of the first branch of the trigeminal nerve (CN V). The goal of treatment for symptomatic ICA aneurysm in the CS is resolution of these CN dysfunctions. Mainstays of treatment include occlusion of the proximal ICA and endovascular embolization of the aneurysm, although proximal ICA occlusion is still considered the gold standard for treatment of aneurysms in this area. Several previous studies reported high clinical improvement rates (80–94%) after proximal ICA occlusion for symptomatic ICA aneurysms in the CS. Proximal ICA occlusion decreases intra-aneurysmal pressure, and may improve the symptoms by alleviating the aneurysmal mass effect. Potential shortcomings of the ICA occlusion technique include ischemic complications from interruption of ICA blood flow, and development of a separate aneurysm in the collateral circulation secondary to increase in compensatory blood flow. Intra-aneurysmal embolization using platinum coils with or without stenting has been recently employed, although effects of the embolization on the aneurysm symptoms are controversial. Intra-aneurysmal embolization could maintain blood flow in the carotid artery. However, increased mass effect caused by the coils may result in worsening of symptoms, and the aneurysms may recanalize from coil compression by the blood flow, especially in large or giant aneurysms.

The present retrospective study evaluated clinical results immediately after intra-aneurysmal coil embolization for large or giant ICA aneurysms in the CS, and evaluated the long-term outcome of patients undergoing intra-aneurysmal coil embolization.

Patients and Methods

Seven even patients, 2 males and 5 females aged from 51 to 80 years (mean 64 years), with large or giant aneurysms of the ICA in the CS were treated by intra-aneurysmal coil embolization from February 2001 to August 2010 (Table 1). The mean maximum diameter of the aneurysms was 18.4 mm (range
Table 1 Characteristics of patients and aneurysms

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)/Sex</th>
<th>Cranial nerve palsy</th>
<th>Maximum diameter of aneurysm (mm)</th>
<th>Balloon occlusion test</th>
<th>Adjunctive technique</th>
<th>Symptoms at most recent follow up</th>
<th>Reoperation</th>
<th>Follow-up period (mos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80/F</td>
<td>III</td>
<td>10</td>
<td>intolerant</td>
<td>none</td>
<td>improved</td>
<td>—</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>72/F</td>
<td>III, IV</td>
<td>14</td>
<td>tolerant</td>
<td>balloon</td>
<td>unchanged</td>
<td>—</td>
<td>87</td>
</tr>
<tr>
<td>3</td>
<td>71/M</td>
<td>III</td>
<td>15</td>
<td>tolerant</td>
<td>none</td>
<td>unchanged</td>
<td>—</td>
<td>83</td>
</tr>
<tr>
<td>4</td>
<td>52/F</td>
<td>III</td>
<td>16</td>
<td>tolerant</td>
<td>stent</td>
<td>deteriorated</td>
<td>—</td>
<td>28</td>
</tr>
<tr>
<td>5</td>
<td>58/M</td>
<td>V, VI</td>
<td>30</td>
<td>intolerant</td>
<td>stent</td>
<td>deteriorated</td>
<td>ICA occlusion</td>
<td>38</td>
</tr>
<tr>
<td>6</td>
<td>64/F</td>
<td>none</td>
<td>15</td>
<td>tolerant</td>
<td>balloon</td>
<td>deteriorated</td>
<td>ICA occlusion</td>
<td>70</td>
</tr>
<tr>
<td>7</td>
<td>51/F</td>
<td>none</td>
<td>29</td>
<td>tolerant</td>
<td>stent</td>
<td>deteriorated</td>
<td>—</td>
<td>49</td>
</tr>
</tbody>
</table>


10–30 mm). Case 1 aged older than 79 years showed ischemic symptoms during balloon test occlusion (BTO), and underwent intra-aneurysmal embolization. Case 7 who had undergone left ICA occlusion with superficial temporal artery (STA)-middle cerebral artery (MCA) anastomosis for a giant aneurysm of the left ICA in the CS, underwent intra-aneurysmal embolization for another aneurysm of the right ICA. Cases 2–6, all aged less than 73 years, received explanations of the benefits and risks of both treatments. Intra-aneurysmal embolization was selected at the patient’s discretion, and informed consent was obtained.

Antiplatelet therapy was started at least 5 days before the procedure, consisting of orally administered aspirin (100 mg) or clopidogrel (75 mg). Intra-aneurysmal coil embolization was performed under general anesthesia. Percutaneous access was gained through the femoral artery. A 6-Fr guiding catheter was advanced into the ICA, and a microcatheter was introduced into an aneurysm. The aneurysm was embolized with detachable platinum coils. If a broad aneurysm neck was present, we employed either angioplasty of the neck using a balloon catheter or stent placement in the parent artery.

Neurosurgeons and neuro-ophthalmologists evaluated the neurological symptoms immediately before and after the operation, at discharge, and as outpatients. In patients undergoing additional treatment, neurological evaluation performed immediately before the subsequent treatment was regarded as the last neurological evaluation after the previous treatment.

Successful occlusion of the aneurysm was evaluated by cerebral angiography immediately after the procedure, and 6 months after the procedure. Magnetic resonance (MR) imaging/MR angiography or cerebral angiography was then performed at one-year intervals.

**Results**

Table 1 shows the clinical characteristics of the 7 patients. Cases 6 and 7 were asymptomatic before the procedure. Case 6 had an ICA aneurysm in the CS which increased from 5-mm to 15-mm diameter on MR angiography during a 6-year follow-up period. Case 7 had aneurysms of the bilateral ICAs in the CS, and the symptomatic aneurysm of the left ICA in the CS was treated with proximal ICA occlusion. The right ICA aneurysm increased from 10-mm to 29-mm maximum diameter on MR angiography during a follow-up period of 4 years, so we decided to perform intra-aneurysmal embolization.

Embolization was performed with detachable bare platinum coils (Guglielmi detachable coils; Stryker, Kalamazoo, Michigan, USA) in all seven patients, with additional bare coils (TRUFILL DCS ORBIT™ Detachable Coil; Codman, Johnson & Johnson, Miami, Florida, USA, or MicroPlex coil system; Terumo, Tokyo) in five patients (Cases 3–7), and additional bioactive coils (Matrix2; Stryker) in one patient (Case 1). Coil embolization was performed using neck angioplasty with a balloon catheter (HyperForm 4 mm × 7 mm; ev3 Endovascular Inc., Plymouth, Minnesota, USA) in Cases 2 and 6. Coil embolization was assisted by stent placement (Driver; Medtronic Inc., Minneapolis, Minnesota, USA) in the ICA covering the aneurysm neck though an 8-Fr guiding catheter in Cases 4, 5, and 7. Post-procedure angiography showed that complete occlusion of the aneurysm was achieved in four aneurysms (Cases 1–3 and 6) and near-complete occlusion in three (Cases 4, 5, and 7).

The mean follow-up period was 53.4 ± 27.3 months (range 18–87 months). At last clinical evaluation, the neurological symptoms caused by the aneurysms had improved in one patient (Case 1).
remained unchanged in two (Cases 2 and 3), and deteriorated in four (Cases 4–7). Case 1 with neurological improvement had an aneurysm with 10-mm maximum diameter and neck balloon angioplasty was not necessary during the procedure. The follow-up period was the shortest at 18 months in Case 1. Of the four patients with neurological deterioration, two patients (Cases 4 and 5) showed neurological improvement soon after the procedures, then deteriorated during the follow-up period. CN III palsy initially showed improvement at 4 months, then became worse at 18 months post-procedure in Case 4. CN V/VI palsies improved completely 8 months after the procedure, but symptoms recurred one year after the procedure in Case 5. Cases 6 and 7 showed no neurological impairment before the treatment. CN III palsy occurred 3 months after the procedure in Case 6, and CN VI palsy the day after the procedure in Case 7.

Additional therapy was performed in Cases 5 and 6. ICA occlusion, which was associated with external carotid artery-MCA bypass using a radial artery graft, was performed with 1–0 silk sutures at the cervical portion 14 months after the initial procedure in Case 5. The symptoms improved one month after the second procedure. Proximal ICA occlusion was performed using detachable balloons with STA-MCA anastomosis, but CN III palsy remained complete 24 months after the third procedure in Case 6.

Radiological follow-up examinations showed coil compaction in the aneurysms in all cases. The entire aneurysm, including the embolized portion of the aneurysm by platinum coils, enlarged in Cases 4 and 5, and remained unchanged in Cases 1–3, 6, and 7. Cases 4 and 5 showed symptom deterioration following transient improvement, but angiography showed near complete occlusion immediately after embolization, then coil compaction and enlargement of the aneurysm was demonstrated on angiography performed at the time of symptom deterioration.

**Illustrative Case 1:** An 80-year-old woman experienced left ptosis and diplopia due to left CN III palsy, and was referred to our hospital 2 weeks after the onset of the symptoms. MR angiography and conventional angiography demonstrated an aneurysm with a maximum diameter of 10 mm in the left ICA of the CS portion (Fig. 1A). BTO indicated intolerance for temporary ICA occlusion. She underwent coil embolization one and a half months after presentation because of her age and the narrow neck of the aneurysm (Fig. 1B). The neurological symptoms completely improved one month after the procedure. No neurological symptoms recurred during a follow-up period of 18 months. Angiography taken 18 months post-procedure demonstrated near complete occlusion of the aneurysm (Fig. 1C).

**Illustrative Case 4:** A 52-year-old woman experienced left ptosis secondary to left CN III palsy, and was referred to our hospital 6 months after the onset of the symptoms. MR angiography and conventional angiography demonstrated an aneurysm with a maximum diameter of 16 mm in the left ICA of the CS portion (Fig. 2A). BTO indicated tolerance for temporary ICA occlusion. She chose to undergo coil embolization, which was performed 8 months after presentation (Fig. 2B). The ptosis demonstrated partial improvement 4 months after the procedure, although limitation of left eye movement towards the medial side occurred one and a half years after the procedure. Left carotid angiography taken at the recurrence of the CN III palsy revealed a partially recanalized aneurysm due to coil compac-
tion and enlargement of the aneurysm (Fig. 2C). Additional embolization was not performed because of the small residual aneurysm. The CN III palsy remained stable during a follow-up period of 28 months.

**Discussion**

Of the seven patients treated with intra-aneurysmal embolization, only one patient showed improved symptoms from aneurysmal mass effect caused by an aneurysm with a maximum diameter of 10 mm. The relatively small size of the aneurysm might have resulted in the good clinical results after the procedure, because of less coil compaction after embolization and smaller mass effect of the aneurysm. Neurological symptoms improved transiently soon after treatment, but deteriorated afterwards in two patients. The suspected mechanism of transient improvement was reduction of intra-aneurysmal pressure by coil embolization. Coil compaction and/or enlargement of the aneurysms were seen on angiography when the neurological symptoms deteriorated. Increase in the intra-aneurysmal pressure caused by coil compaction and/or mass effect of the enlarged aneurysm was possibly related to the deterioration of the neurological symptoms. Four patients had worsening of symptoms following the procedure, possibly due to increased mass effect of the aneurysms caused by intra-aneurysmal thrombosis enhanced by coil embolization, and/or inflammatory reaction induced by the coils.

Intra-aneurysmal coil embolization associated with stent placement for eight symptomatic large or giant ICA aneurysms in the CS resulted in symptom improvement in five of the eight patients (62.5%) during the mean follow-up period of 35.8 months (16–58 months). Of the seven patients treated with intra-aneurysmal coil embolization, only one patient showed improved symptoms from aneurysmal mass effect caused by an aneurysm with a maximum diameter of 10 mm. The relatively small size of the aneurysm might have resulted in the good clinical results after the procedure, because of less coil compaction after embolization and smaller mass effect of the aneurysm. Neurological symptoms improved transiently soon after treatment, but deteriorated afterwards in two patients. The suspected mechanism of transient improvement was reduction of intra-aneurysmal pressure by coil embolization. Coil compaction and/or enlargement of the aneurysms were seen on angiography when the neurological symptoms deteriorated. Increase in the intra-aneurysmal pressure caused by coil compaction and/or mass effect of the enlarged aneurysm was possibly related to the deterioration of the neurological symptoms. Four patients had worsening of symptoms following the procedure, possibly due to increased mass effect of the aneurysms caused by intra-aneurysmal thrombosis enhanced by coil embolization, and/or inflammatory reaction induced by the coils.

Intra-aneurysmal coil embolization associated with stent placement for eight symptomatic large or giant ICA aneurysms in the CS resulted in symptom improvement in five of the eight patients (62.5%) during the mean follow-up period of 35.8 months (16–58 months). Two symptomatic cavernous aneurysms were treated with intra-aneurysmal coil embolization, resulting in improved neurological symptoms in one patient with a large aneurysm and unchanged in another with a giant aneurysm during follow-up periods of 29 and 23 months, respectively. Two symptomatic cavernous aneurysms were treated with endosaccular coiling, and neurological symptoms improved in one patient with a giant aneurysm and were unchanged in another with a large aneurysm during follow-up periods of 18 and 51 months, respectively.

In this study, only one of the seven patients undergoing coil embolization exhibited improvement in neurological symptoms. None of the three patients undergoing intra-aneurysmal embolization assisted by stent placement in the parent artery exhibited good clinical results during the follow-up periods.

This was not consistent with the previous study that showed relatively favorable results of intra-aneurysmal coil embolization. The discrepancy of clinical results between the present and the previous studies might be explained by the relatively short follow-up period of the previous study, which may have overlooked late deterioration of clinical symptoms, as observed in the two patients in the present study, or the small sample sizes of both studies.

In our study, a coronary stent (Driver) was used to assist the intra-aneurysmal coil embolization, because intracranial stents were not approved by the Ministry of Health, Labour and Welfare in Japan until June 2010. The Driver stent has a similar construction profile, including a cell diameter of 1 mm, to other stents made exclusively for intracranial use. In spite of the similar construction profiles, the results of the intra-aneurysmal coil embolization using an intracranial stent might be different from those obtained in the present study.

The present study demonstrated that more than 80% of patients with large or giant carotid artery aneurysms in the CS showed unfavorable outcomes after intra-aneurysmal coil embolization. Considering the previously reported high clinical improvement rates (80–94%) achieved by proximal ICA occlusion for symptomatic ICA aneurysms in the CS, intra-aneurysmal coil embolization cannot be regarded as an effective treatment option for large or giant ICA aneurysms in the CS to obtain good clinical outcomes.

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