Single-Stage Extracranial Carotid Artery Stenting and Intracranial Aneurysm Coiling: Technical Feasibility and Clinical Outcome

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Key words: aneurysm, carotid stenting, coil embolization

Summary

The coexistence of carotid artery stenosis and cerebral aneurysm in a patient presents challenges for treatment decision-making. The purpose of this study was to evaluate the technical feasibility and clinical outcome after single-stage extracranial carotid artery stenting (CAS) and ipsilateral intracranial aneurysm coiling in a single institution.

From March 2005 to February 2011, 17 patients with 21 aneurysms underwent single-stage CAS and coiling for ipsilateral aneurysms. There were symptomatic atherosclerotic carotid stenoses with unruptured aneurysms in eight, ruptured or symptomatic aneurysms with simultaneous asymptomatic carotid stenoses in two and asymptomatic lesions in seven. CAS was followed by aneurysm coiling in all 17 patients. Clinical and radiological data were reviewed.

There were two procedure-related complications: acute in-stent thrombosis in one and premature aneurysmal rupture in the other. After aneurysm coiling, complete occlusion was demonstrated in 17 aneurysms and near-total occlusion in four. No neurological deficit was found at discharge and follow-up outcomes were excellent in all the patients (mean, 32.9 months). Follow-up imaging studies were performed in all the patients, including neck CT angiography in 14 (mean, 26.1 months), brain MR angiography in 14 (mean, 31.2 months), and convention-

al angiography in three (mean, 14.7 months). They revealed two asymptomatic, mild carotid re-stenoses and one major aneurysmal recanalization requiring re-coiling.

A single-stage CAS and coiling procedure appears to be feasible and the complication rate seems to be reasonable. We suggest that there is no need for separate therapeutic procedures when a patient has carotid artery stenosis and accompanying ipsilateral intracranial aneurysm.

Introduction

The coexistence of a cerebral aneurysm and ipsilateral cervical carotid artery stenosis poses a therapeutic dilemma regardless of treatment modality. For example, if carotid artery stenosis is treated first, the subsequent sudden rise in cerebral perfusion pressure may increase the potential risk of aneurysmal rupture^{1,2}, and conversely, if aneurysm repair under general anesthesia is conducted initially, the consequent decrease in cerebral blood flow through the stenotic carotid artery may lead to ipsilateral hypoperfusion stroke. Particularly, endovascular treatment would add the risk of thromboembolic complications because devices for coiling should pass through the stenotic carotid artery with plaques. Furthermore, separate treatment sessions require additional admission, fasting and costs.

In an effort to overcome this dilemma, single-stage carotid artery stenting (CAS) followed by aneurysm coiling has been performed at our institution in recent years. The purpose of this study was to evaluate the procedural complications and clinical outcomes of this single-stage combined procedure.

Patients and Methods

One thousand two hundred and fifty-seven patients harboring 1559 aneurysms underwent aneurysm coiling from March 2005 to February 2011. During the period, a series of 334 patients with 366 carotid stenoses were revascularized by CAS. Of these, 17 patients with 21 aneurysms (1.35% for aneurysm and 5.09% for carotid stenosis) underwent CAS and aneurysm coiling in a single session (Table 1). Twelve of the patients were men and five were women

with a mean age of 64.3 years (range 42 to 75 years). Stenosis grade was assessed according to NASCET criteria. Aneurysm dimensions were measured using three-dimensional angiography which was calibrated regularly. Eight of the patients presented with transient ischemic attacks (TIAs) due to symptomatic carotid stenoses greater than 50% and incidental aneurysms. Two patients (Case 9 and 10) were admitted with a ruptured posterior cerebral artery aneurysm of Hunt-Hess grade 2 and with the third nerve palsy owing to the posterior communicating artery aneurysm, respectively. Seven patients underwent cerebrovascular imaging for screening purpose, and were found to have asymptomatic carotid artery stenoses greater than 50% and incidental aneurysms. Indication of treatment for small (<5 mm) unruptured aneurysm included risk factors for aneurysmal rupture such as: 1) a family history of subarachnoid hemorrhage (SAH), 2) any evi-

Table 1 Demographics and lesion characteristics.

Patient	Sex	Age	Carotid lesion	Stenosis (%)	Aneurysm site	Aneurysm size (mm)
1	M	67	Rt, symptomatic	70	ICA-ophthalmic	5.4
2	F	42	Rt, symptomatic	78	Acom	5.7
3	M	69	Lt, symptomatic	73	ICA-Pcom	4.0
4	M	55	Rt, symptomatic	74	MCA	5.2
5	M	69	Lt, symptomatic	70	Acom	5.4
6	M	69	Lt, symptomatic	85	Acom	9.1
7	M	65	Lt, symptomatic	63	ICA-ophthalmic	8.3
8	M	65	Lt, asymptomatic	>90	ICA-Pcom	6.2
9	F	59	Rt, asymptomatic	.*	Rt PCA P1-Pcom# Rt SCA	6.3 5.2
10	F	75	Rt, asymptomatic	50	ICA-Pcom§	7.7
11	M	65	Rt, asymptomatic	80	Acom	4.4
12	M	74	Rt, asymptomatic	62	A2-3	5.7
13	F	60	Lt, asymptomatic	70	ICA-Acho MCA	3.7 4.1
14	M	66	Rt, asymptomatic	60	ICA-Pcom	8
15	M	70	Rt, asymptomatic	60	Acom	5.0
16	M	68	Lt, asymptomatic	52	Acom MCA	4.2 3.4
17	F	55	Rt, asymptomatic	50	Acom A2-3	4.1 6.3

*: multiple crimped, web-like stenosis suggestive of fibromuscular dysplasia

#: ruptured aneurysm, §: right oculomotor nerve palsy

Rt: right; Lt: left; ICA: internal carotid artery; Acom: anterior communicating artery; Pcom: posterior communicating artery;

MCA: middle cerebral artery; PCA: posterior cerebral artery; SCA: superior cerebellar artery; Acho: anterior choroidal artery.

dence of increase in size on follow-up images, 3) presence of co-existing blebs or daughter sacs on angiography, and 4) the patients' concerns. In all cases carotid artery stenosis hindered the passage of a guiding catheter for coiling. Thus, CAS was performed before coil embolization to avoid the potential risk of a distal embolism related to introduction of the guiding catheter.

For 16 patients with unruptured aneurysms, aspirin (100 mg/d) and clopidogrel (75 mg/d) were given at least three days before the procedure. Intravenous heparin (3000 IU) was administered when a vascular access was achieved

and subsequently at 1000 IU per hour with monitoring of the activated clotting time. In the patient with subarachnoid hemorrhage, heparinization was started when contrast filling disappeared in the aneurysm dome. In doing so, CAS was done without heparinization in this particular patient. Immediately after the procedure, dual antiplatelet therapy was instituted.

For the CAS procedures, placement of a protective filter device, predilation, and stent deployment were performed sequentially, and postdilation was additionally applied if significant residual stenosis remained. Open cell stents were deployed in 14 patients and closed-cell stents in three. After CAS, a 6 or 7-F guiding catheter was passed through the stent to access a cerebral aneurysm; a microcatheter was introduced into the aneurysm, then the aneurysm was occluded with detachable coils.

Following the above procedures, all the patients were placed on life-long aspirin administration (100 mg/day) and three-month clopidogrel medication (75 mg/day). Neck computed tomography (CT) angiography and brain magnetic resonance (MR) angiography were used to follow the stented carotid arteries and embolized aneurysms in 14 patients. In the remaining three patients that underwent stent-assisted aneurysm coiling, conventional angiography was performed.

Results

CAS was successfully performed in all 17 cases. There were two procedure-related complications (11.8%). These were acute in-stent thrombosis in one patient and premature rupture of the aneurysm during coiling in the other. The patient with acute in-stent thrombosis had symptomatic carotid stenosis (of 70%) and an unruptured ophthalmic artery aneurysm (Figure 1). He had taken anti-platelet medication prior to the procedure. In-stent thrombi were observed at the end of coiling following CAS, and these were completely resolved by the intra-arterial infusion of Abciximab (10 mg). No procedure-related symptoms or neurological deficits occurred afterwards.

The patient with premature rupture of the aneurysm during coiling presented with oculomotor nerve palsy and had a 7.7 mm posterior communicating artery aneurysm. During compact coil packing a coil protruded outside the aneurysmal dome. After injection of protamine sulfate and completion of the coil placement, no further leakage of contrast media was detected. The patient complained of mild headache for several days, but no other neurological deficit was detected during the admission period or at discharge.

Total procedure time was 109.4 ± 51.1 minutes

(mean±standard deviation, range 50 - 262 minutes; median 99 minutes) from initial angiography to completion angiography. In the case with a complication of in-stent thrombi, the total procedure time was 134 minutes, which included the time required for the original procedures and the intra-arterial infusion of Abciximab. Procedure time exceeded three hours in two patients: case 5 with an unruptured lobulated anterior communicating artery aneurysm (186 minutes), case 9 with two technically challenging posterior circulation aneurysms that were approached via the internal carotid artery (ICA) and then the posterior communicating artery because of extreme tortuosity of the vertebral artery (262 minutes). Mean procedure time for CAS and coil embolization were 30.4 ± 14.9 minutes (median, 28 minutes) and 79.1 ± 61.1 minutes (median, 75 minutes), respectively. There were no fluoroscopy-induced radiation injuries such as skin erythema or alopecia.

Aneurysm coiling required a special technique in four cases: balloon-remodeling in one and stent assistance in three. The anatomical outcomes of coiling were rated as complete occlusion for 17 aneurysms and near-total occlusion (90-95% occlusion) in the remaining four.

Within 48 hours after procedures, six patients (6/7 in symptomatic carotid stenosis) underwent control MR imaging. One showed multiple small acute embolic infarctions in the ipsilateral frontal cortex. However, no neurological deficit was observed. Clinical follow-ups ranged from 12 to 77 months (mean: 32.9 months). During the follow-up period, one patient (patient 5) showed TIA of right-sided motor weakness without an acute ischemic lesion on diffusion-weighted MR imaging. Another patient with asymptomatic carotid stenosis (patient 13) suffered from multifocal tiny embolic acute infarctions in contralateral hemisphere at 28 months follow-up. The patient with oculomotor nerve palsy showed a complete recovery at three months follow-up.

All the patients underwent follow-up imaging 12 months or more after the procedures (CT angiography, mean 26.1 months; MR angiography, mean 31.2 months; conventional angiography, mean 14.7 months). There were two asymptomatic mild re-stenoses (<30%) at the CAS sites. The coiled aneurysms were stable without recanalization except one (8 mm sized, posterior communicating artery aneurysm, initially complete occluded), which was retreated

successfully by additional coil embolization at 14 months after the first treatment. In this second stage of aneurysm coiling, it was not difficult to place the guiding catheter through the previous stent.

Discussion

The co-existence of a cerebral aneurysm and ipsilateral carotid artery stenosis is rarely encountered in clinical practice. But it poses difficulties in management decision-making when encountered. The aneurysmal rupture risk after carotid endarterectomy (CE) is presumed to be low based on the 90 patients with aneurysms treated by CE in the NASCET trial group³. During an average five-year follow-up, only one patient had SAH six days after CE. Although some reports suggest no increased risk of rupture in asymptomatic aneurysms after carotid revascularization^{2,4}, several studies have concluded that the treatment of either condition may provoke events related to the other lesion, which include subarachnoid hemorrhage after revascularization of carotid artery stenosis and perioperative stroke related to carotid artery stenosis after aneurysmal treatment^{1,5}. The sequence of treatment and the number of sessions are the critical issues that should be addressed. Planning surgical treatment for both diseases raises concerns regarding which lesion should be treated first.

Iwata et al.⁶ reported the successful treatment for both lesions by staged endovascular treatment of coiling and subsequent CAS. However, we believe that endovascular treatment should first target the carotid artery stenosis. Coiling would induce plaque irritation and distal embolism due to placement of a guiding catheter if adopted as a first procedure. We also believe that immediate aneurysm occlusion following CAS would be more beneficial than delayed aneurysm occlusion to reduce the risk of an untoward event. The single-stage procedure also eliminates the need for an additional admission, the accompanying cost and patient discomfort. In the present study, one transient complication (5.9%) was encountered after single-stage CAS plus coiling. Another complication of procedural aneurysm rupture was related to the aneurysm coiling procedure. No patient experienced periprocedural morbidity or mortality, and in the follow-up period no symptomatic in-stent restenosis occurred at least 12

months after procedures. There was one major recanalization (4.8%) of aneurysm coiling, which was treated by second aneurysm coiling. Thus, periprocedural and postprocedural complication rate in our study seems to be reasonable, compared with an overall risk of adverse outcomes in the range of 4-6% for unruptured aneurysm coiling⁷ and CAS⁸, respectively.

We coped with the risk of embolic events due to the passage of a guiding catheter through a high-grade stenosis. Distal positioning of the guiding catheter principally reduces risks related to aneurysm coiling since better control of devices becomes possible intracranially. The advantage of more proximal guiding catheter positioning must be weighed against the risk of aneurysm coiling with difficult control of a micro-catheter.

From the technical point of view, a closed-cell stent might have the advantage of an easy guiding catheter passage through the stent. On the contrary, shortcomings of the closed-cell stent need to be considered, including straightening of the parent vessel and shortening of the stent after deployment. We adopted an open-cell stent in the patient with a tortuous curvature of ICA. There were no technical difficulties in passage of the guiding catheter through the open-cell stents.

Acute in-stent thrombosis occurred in one patient on antiplatelet medication. This may have been associated with clopidogrel resistance and/or prolonged guiding catheter placement inside the carotid stent. The clopidogrel resistance test was not performed in this patient. As for prolonged guiding catheter placement, attention should be paid to the position and direction of the catheter tip. Although the catheter was safely placed through the stented segment initially, increased device resistance during aneurysmal coil placement may make the guiding catheter withdraw from the first place and the catheter tip may be rotated to any directions inside the stent. This would increase the risk of thrombogenesis. We recommend that a clopidogrel resistance test be performed preoperatively and the guiding catheter movement be checked carefully during the single-stage procedure.

Simultaneous treatment of our cases poses some issues. First, is treatment of an unruptured aneurysm justified according to the aneurysm

size and location as shown by the ISUIA study⁹? However, ISUIA data are subject to many criticisms. To date, for smaller aneurysms (>4 mm) in patients with a life expectancy of more than ten years treatment is recommended if it can be done safely. We previously clarified the indication of small aneurysm. Second, CE of asymptomatic carotid artery stenosis was shown to be beneficial in the ACAS trial¹⁰. Although no trial for CAS versus medical treatment in asymptomatic carotid artery stenosis exists, in some cases the reason for CAS is not necessarily to treat the lesion for stroke risk reduction, but for surgical planning and access to the distal aneurysm¹¹. The rationale for treating the lesion was to improve endovascular access to the aneurysm and reduce the thromboembolic risk.

Recently, several other studies¹¹⁻¹³ reported the results of procedures similar to the present study. The results of these studies concur, with the exception of the development of in-stent thrombosis in one patient in our study. We believe that our findings add substance to their good results.

In terms of study limitations, the number of cases was not large enough to allow the current results to be generalized. Second, CAS was performed in heterogeneous conditions, which included symptomatic and asymptomatic atherosclerotic stenosis and fibromuscular dysplasia. The indication for treatments mostly depended on aneurysmal characteristics rather than on symptoms and degrees of carotid stenosis. Third, not all the patients underwent MR imaging in the immediate postprocedural period (e.g. within 48 hours) to document complications of CAS and coil embolization. It is our policy to perform postprocedural imaging only in cases of relevant symptoms.

Conclusion

The single-stage CAS and aneurysm coiling seems to be technically feasible and complication rates are similar to those encountered when each procedure is performed separately, although more evidence is required. The elimination of the requirement for an additional separate procedure may prove helpful in the future in reducing patients' suffering and costs.

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