Efficacy of a Self-Expandable Porous Stent as the Sole Curative Treatment for Extracranial Carotid Pseudoaneurysms

Peng Roc Chen[1], Nancy J. Edwards[1,2], Aditya Sanzgiri[1], Arthur L. Day[1]

■ OBJECTIVE: **Extracranial carotid pseudoaneurysms are uncommon vascular lesions. Even with conservative management complications can happen, such as delayed cerebral embolization or symptoms due to flow limitation. Although endovascular therapy can be curative, literature demonstrating a preferred technique is scant. Our goal was to evaluate the use of 1 technique only—the deployment of overlapping self-expandable porous stents—to treat a series of extracranial carotid pseudoaneurysms.**

■ METHODS: **From 2008 to 2014, 14 consecutive cases of symptomatic extracranial carotid pseudoaneurysms were managed with single or multilayer porous stents at our institution. Each patient underwent a standardized angiographic follow-up at 6 months. Twelve patients also received a follow-up computed tomography angiogram at 12 months, and yearly thereafter (median radiographic follow-up, 38 months). The total clinical follow-up period ranged between 6 and 69 months (median, 46 months).**

■ RESULTS: **In our series, each of the extracranial carotid pseudoaneurysms appeared to be the result of carotid artery dissection with associated carotid stenosis at the origin of every pseudoaneurysm. Endovascular treatment consisted of 1–3 layers of self-expandable porous stents placed without balloon angioplasty. Immediately after stenting angiographic images were notable for stagnant opacification of the pseudoaneurysm through the stent(s). All pseudoaneurysms were completely obliterated by the 6-month follow-up angiogram and remained so throughout the radiographic follow-up period. Complications were minimal, consisting of 1 patient developing a mild Horner's syndrome after treatment that resolved during clinical follow-up.**

■ CONCLUSIONS: **Extracranial carotid pseudoaneurysms can be successfully obliterated with the use of porous, self-expandable stents.**

INTRODUCTION

Extracranial carotid pseudoaneurysms are rare vascular lesions, often originating from an underlying spontaneous or traumatic carotid dissection.[1-3] Although conservative therapy (including the use of antithrombotics) is often used, occasionally these pseudoaneurysms will not heal and may instead result in symptoms due to pseudoaneurysm enlargement, thromboembolism, or compromised flow within the parent vessel.[4] Surgical ligation has historically been associated with a stroke rate as high as 12%–30%.[5,6] Reconstructive surgery with resection and reanastomosis of the carotid artery is feasible, although adequate surgical exposure can be challenging depending on the location of the pseudoaneurysm (e.g., those located in the high cervical region or at the craniocervical junction).[7] In the past decade, endovascular techniques have been increasingly used for these lesions, although there has yet to be a consistent definitive technique to address pseudoaneurysms. In general, there are only case reports or small series using a variety of treatment approaches such as coil embolization,[8] porous stent-assisted coil embolization,[9-12] covered stent placement,[13,14] and overlapping porous stent placement.[15] This lack of consensus regarding endovascular technique in part prompted our present study. We hypothesized that 1 technique—the use of single or overlapping porous stents alone—could be curative for most if not all extracranial carotid pseudoaneurysms.

Key words
- Dissection
- Extracranial carotid
- Flow directing
- Overlapping
- Porous stents
- Pseudoaneurysm

Abbreviations and Acronyms
CTA: Computed tomography angiogram
PED: Pipeline embolization device

From the Departments of [1]Neurosurgery and [2]Neurology, University of Texas Medical School at Houston, Houston, Texas, USA

To whom correspondence should be addressed: Peng Roc Chen, M.D. [E-mail: peng.r.chen@uth.tmc.edu]

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METHODS

The study design and data registry were performed prospectively at a single tertiary trauma and cerebrovascular center. Throughout 2008 to 2014, P.R.C. treated 14 consecutive cases of symptomatic extracranial carotid pseudoaneurysms with the off-label use of single layer or overlapping layers of self-expandable porous stents (Cordis PRECISE stent system). Data presented here include patient demographics, clinical presentation, before imaging studies of the treatment lesion, immediately aftertreatment angiography, 6-month follow-up conventional angiography or computed tomography angiography (CTA), CTA follow-up at 12 months and yearly thereafter, and clinical follow-up at 6 weeks, 3, 6, and 12 months, and yearly thereafter.

Patient Selection Criteria

Our inclusion criteria for endovascular intervention in this study included the following: 1) patients with extracranial carotid pseudoaneurysms; and 2) patients referred to us by stroke neurologists or trauma neurosurgeons for recurrent transient ischemic attack or stroke, even while therapeutically on anticoagulants or dual antiplatelet agents (generally aspirin and clopidogrel); or 3) patients with progressive neurological symptoms (ipsilateral hemicrania, neuropathy, syncope) due to rapidly enlarging pseudoaneurysms.

Endovascular Procedure and Technique

Before the procedure, patients were preloaded orally with aspirin (325 mg/day) and clopidogrel (75 mg/day) for 5 days or with aspirin (650 mg) and clopidogrel (300 mg) the day before and the morning of the procedure. The Cordis PRECISE stent system was deployed for every case in this series. All procedures were done under general anesthesia. Femoral artery access was achieved using micropuncture technique with the placement of a 7-French sheath. Heparin (5000 units) was then administrated intravenously to bring the activated clotting time to $2\frac{1}{2}$ to 3 times baseline. A 7-French straight Envoy guiding catheter was placed at the proximal portion of the affected internal carotid artery with the use of a telescoping technique. An Excelsior 14 microcatheter along with a Transcend EX 14 microwire or Asahi EX 14 microwire were coaxially advanced through the guiding catheter to the internal carotid artery, then passed through the segment of stenosis at the pseudoaneurysm origin and through the pseudoaneurysm itself. The Excelsior microcatheter was exchanged with the PRECISE stent with its monorail delivery system. The stent was deployed across the pseudoaneurysm and the stenotic segment of the carotid artery. If the immediate stent CTA revealed flow stagnation (e.g., delayed contrast filling) within the pseudoaneurysm, no further stents were used. If there was no evidence of flow stagnation, additional stent(s) were deployed within the initial stent, overlapping the previous one, until delayed contrast filling of the pseudoaneurysm was observed. For the additional stent(s), we used the same diameter stent or 1 mm larger inside the initial stent. The proximal end of the subsequently placed stent(s) covered the proximal end of the initial one, and so on. Balloon angioplasty was not required in any of these patients. Heparinization was routinely reversed using protamine at the end of the procedure. Patients were then prescribed dual antiplatelet therapy with aspirin 325 mg and clopidogrel 75 mg daily for 6 weeks, followed by monotherapy with clopidogrel 75 mg daily for an additional 6 weeks, then aspirin 325 mg daily indefinitely.

Radiologic Follow-Up

Six months after stenting, conventional follow-up angiograms were performed in all but 3 patients, who were followed-up with CTA instead due to their limited financial resources. Twelve of the 14 patients received additional follow-up CTAs 12 months after the procedure, and yearly thereafter for a median radiology follow-up of 38 months.

RESULTS

Baseline Clinical Characteristics

From 2008 to 2014, 14 consecutive cases of symptomatic extracranial carotid pseudoaneurysms were managed with single or multilayer porous stents at our institution. Retrospective review of our institution's neurotrauma database revealed during the 5-year period of our study, 330 patients were diagnosed with cervical carotid dissection on screening vascular imaging. Among these, 57 patients had evidence of grade III dissection with pseudoaneurysm formation. Fifty-one of these patients were managed with anticoagulant or antithrombotic therapy alone by our trauma neurosurgeons and presumably did not develop additional neurological symptoms. Six of these patients were considered treatment failures and were referred to us for consideration of endovascular treatment due to 1) recurrent thromboembolic events, or 2) symptoms due to progressive mass effect from the pseudoaneurysm. For instance, 1 patient (patient 3; Table 1) presented with a large pulsatile cervical mass and frequent syncopal episodes triggered by tactile pressure on the mass. Imaging revealed a giant-sized pseudoaneurysm compressing the carotid body. The other 8 patients in our clinical series were referred to us by stroke neurologists for recurrent transient ischemic attack/stroke due to 1) thromboembolic events even after appropriate trials of anticoagulation or dual antiplatelet therapy, or 2) pseudoaneurysm-related limitations in flow. For instance, 2 of these patients (patients 10 and 13; Table 1) presented with recurrent hypoperfusion border zone infarcts likely related to severe stenosis of the carotid artery at the origin of the pseudoaneurysm.

The baseline clinical characteristics of all the patients are displayed in Table 1.

Baseline Radiographic Findings and Results Immediately After Stenting

Radiographically, the pseudoaneurysms ranged from 7–70 mm in diameter, with a median diameter of 10 mm. In every patient, carotid stenosis was noted at the origin of the pseudoaneurysm. The degree of stenosis ranged from 20%–90% (Table 1). One to 3 layers of self-expandable porous stents were deployed, without the need of balloon angioplasty, as described in detail in the Methods section. Stents were overlapped until the immediate CTAs after stenting confirmed stagnation of contrast flow within the pseudoaneurysm. In all patients, the carotid lumen was restored without any evidence of artery stenosis. In 6 patients, a single porous stent was sufficient to create flow stagnation in the pseudoaneurysm (Figure 1). Other cases—such as the giant