Relationship between Angiographic Results and Morphology in Sidewall Intracranial Aneurysms after Stent-Assisted Coil Embolization

Kouhei Nii, MD, PhD, Hiroshi Aikawa, MD, PhD, Masanori Tsutsumi, MD, PhD, Ayumu Eto, MD, Minoru Iko, MD, PhD, Kimiya Sakamoto, MD, PhD, Ritsuro Inoue, MD, PhD, Takafumi Mitsutake, MD, Hayatsura Hanada, MD, and Kiyoshi Kazekawa, MD, PhD

Background: Stent-assisted coil embolization (SACE) is used to address wide-necked or complex aneurysms. However, as they may recanalize after SACE, predictors of recanalization are needed. We investigated the relationship between follow-up angiographic results and the morphology of sidewall (SW) aneurysms in patients treated by SACE. *Methods:* Between September 2010 and September 2014, we performed 80 SACE procedures for SW intracranial aneurysms. Angiographic findings, obtained immediately after the procedure, 3-6 months thereafter, and when aneurysmal recanalization was suspected on MR angiogram scan, were recorded. Morphologically, the SW aneurysms were classified as "outside" (OS) and "partially inside" (PI) based on the curve of the axes of the proximal or distal parent artery with respect to the aneurysmal neck. Follow-up angiographic studies on OS- and PI SW aneurysms were compared. *Results:* On the initial angiograms, we classified 42 aneurysms as OS and 38 as PI. Immediately after SACE, there was no significant difference in the angiographic findings on OS and PI aneurysms. However, on follow-up angiograms, there was a significant difference in the rate of spontaneous improvement (4 of 42 [OS] versus 21 of 38 [PI], $P = .001$). We performed additional coil embolization to treat 3 recanalized OS aneurysms. *Conclusions:* SW aneurysms classified morphologically as PI tended to occlude progressively even after incomplete occlusion by SACE. In contrast, aneurysms classified as OS must be observed carefully after SACE. **Key Words:** Angiographic results—intracranial aneurysm—morphology—sidewall—stent-assisted coil embolization.

Introduction

Stent-assisted coil embolization (SACE) for intracranial aneurysms decreases coil protrusion into the parent artery and it is especially accepted for wide-necked or complex aneurysms.[1-3] As self-expanding stents allow denser aneurysm packing with increased neck coverage, they may improve treatment durability by a combination of flow diversion and fibroelastic tissue formation along the aneurysmal neck.[4,5] Therefore, intracranial stents have broadened the scope of endovascular aneurysm repair, but the long-term durability of aneurysm treatment with SACE remains to be determined. Some predictors of

From the Department of Neurosurgery, Fukuoka University Chikushi Hospital, Fukuoka, Japan.

Received June 19, 2015; revision received September 29, 2015; accepted November 1, 2015.

Address correspondence to Kouhei Nii, Department of Neurosurgery, Fukuoka University Chikushi Hospital, 1-1-1 Zokumyoin, Chikushino, Fukuoka 818-8502, Japan. E-mail: k.nii@cis.fukuoka-u.ac.jp.

1052-3057/$ - see front matter

http://dx.doi.org/10.1016/j.jstrokecerebrovasdis.2015.11.001

aneurysm recanalization after SACE are a large aneurysmal size, incomplete initial aneurysm occlusion, the location and morphology of the aneurysm, and the type of stent.[6-9] We investigated the relationship between follow-up angiographic findings and the morphology of sidewall (SW) aneurysms in patients treated with SACE.

Materials and Methods

This study received approval by our institutional ethics board; patient informed consent was obtained. We retrospectively evaluated clinical and radiological data of patients with unruptured cerebral saccular aneurysms who underwent SACE procedures between September 2010 and September 2014 at our institute. We excluded patients who did not undergo conventional post-SACE angiographic evaluation. Follow-up studies were available for 113 of 127 SACE procedures (89%); 80 of the SACE-treated aneurysms were SW aneurysms and 33 were bifurcation (BIF) aneurysms. Wide-necked aneurysms (dome : neck ratio < 2.0 and/or neck length > 4 mm) were treated by SACE. For at least 7 days before SACE, the patients received dual or triple antiplatelet therapy selected by the individual patient's physician.[10] Dual antiplatelet therapy consisted of aspirin (100 mg daily) and clopidogrel (75 mg daily) or cilostazol (200 mg daily); and triple antiplatelet therapy consisted of aspirin (100 mg daily), clopidogrel (75 mg daily), and cilostazol (100 mg daily).

All patients were treated under general anesthesia; heparin was administered before stent placement. Enterprise Vascular Reconstruction Device (VRD) (Codman, Raynham, MA) stents were placed in the first 65 of the 113 SACE procedures and Neuroform stents (Stryker, Fremont, CA) in the subsequent 48. To place the microcatheters, we used the jailing technique during conventional SACE. Trans-cell microcatheter placement was the second-line method in cases where the microcatheter deviated between the stent and the wall of the parent artery.

All procedural complications and neurological events were recorded and all patients underwent diffusion-weighted magnetic resonance imaging before and within 5 days after the procedure to check for new intracranial lesions. Neurological events were categorized as transient ischemic attacks (neurological deficit lasting for <24 hours), minor stroke (neurological deficit lasting for >24 hours with a National Institutes of Health Stroke Scale score [NIHSS] score < 4), and major stroke (neurological deficit lasting for >24 hours, NIHSS score > 4).

Angiographic findings were recorded immediately after the procedure, 3-6 months thereafter, and when aneurysmal recanalization was suspected on magnetic resonance angiogram (MRA) scan. The same projections as in the initial working angle were used to compare the angiograms. Angiographic findings obtained immediately after SACE were classified as complete occlusion (CO), neck remnant (NR) (aneurysmal body occlusion with minimal residual filling with coils at the neck), and body filling.[11] On follow-up angiograms, any further filling of the aneurysmal neck or body was defined as "recanalization," decreased filling as "improvement," and stable filling as "stable."[12] Additional coil embolization was performed when recanalization was detected.

We used intraoperative 3-dimensional (3D) digital subtraction angiograms (DSAs) to classify the SW aneurysms based on their morphology. When the axes of the proximal and distal parent arteries within 5 mm from the aneurysm neck curved outward, the aneurysm was recorded as an "outside (OS)" SW aneurysm. When the axes of the proximal and/or distal parent artery within 5 mm from aneurysm neck curved inward, the aneurysm was defined as "partially inside (PI)" (Fig 1). BIF aneurysms were excluded.

The characteristics, clinical outcomes, and angiographic results were compared in patients with OS and PI SW aneurysms. Continuous variables were expressed as the mean ± 1 standard deviation. Categorical variables were expressed in terms of percentages. The Fisher exact test was used for categorical variables and the Mann–Whitney *U*-test for continuous variables. A *P* value less than .05 was considered statistically significant.

Results

Table 1 shows the patient characteristics and clinical outcomes. Of 80 SW aneurysms, 42 were recorded as OS and 38 as PI on the initial 3D angiograms. The patients were 16 men (20.0%) and 64 women (80.0%); their mean age was 63.0 ± 14.2 years. All aneurysms were asymptomatic. The baseline characteristics were not significantly

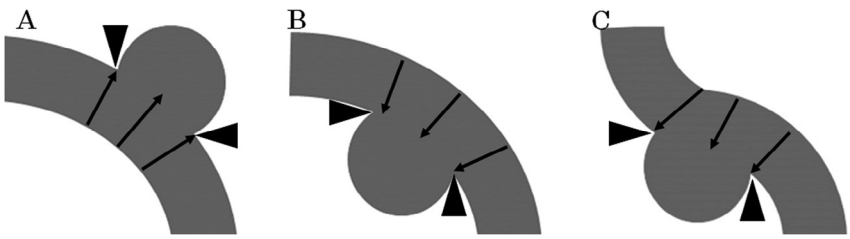

Figure 1. *Based on their morphology, sidewall aneurysms were classified as OS and PI aneurysms. In OS aneurysms, the axes of the proximal and distal parent arteries within 5 mm from the aneurysm neck (A: arrows) curved outward with respect to the aneurysm (A: arrowheads). In PI aneurysms, the axes of the proximal and/or distal parent artery within 5 mm from the aneurysm neck (B and C: arrows) curved inward toward the aneurysm (B and C: arrowheads). Abbreviations: OS, outside; PI, partially inside.*