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Tools and techniques

Treatment of distal anterior cerebral artery aneurysms with the Pipeline Embolization Device

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ABSTRACT

Aneurysms of the anterior cerebral artery (ACA) located distal to the anterior communicating artery complex (ACOM) remain challenging to treat with surgical clip reconstruction as well as with endovascular coil-embolization strategies. We have treated five complex geometry distal ACA aneurysms with endoluminal reconstruction using the Pipeline Embolization Device (PED). Two aneurysms were of the dysplastic fusiform type. Three aneurysms were of complex saccular configuration. Three aneurysms were treated electively at the outset with PED. One patient had previously undergone aborted clip reconstruction, and one was treated for recurrent aneurysm growth after coil embolization. The mean diameter of the ACA in this cohort was 1.96 mm proximal to the aneurysm and 1.79 mm distal to the aneurysmal segment. A single PED of 2.5 mm inner diameter was the sole treatment in four cases. Two PEDs, telescopically overlapped across the aneurysm, were used in the remaining case. All devices were deployed successfully. No parent artery occlusion or stenosis was observed. In all cases an associated branch vessel arising from the vicinity of the aneurysm or incorporated into its neck was covered by the endoluminal construct. At follow-up angiography, robust antegrade flow was maintained in the jailed branch. One patient experienced asymptomatic, delayed occlusion of the jailed branch. Complete aneurysm occlusion was seen in all patients. We confirm that PED can be deployed in parent vessels smaller than 2 mm diameter, and that endoluminal reconstruction with the PED may be a safe and effective treatment alternative for selected distal ACA aneurysms.

1. Introduction

Distal ACA aneurysms are defined as aneurysms arising from the ACA distal to the ACOM complex. They account for 5–10% of all intracranial aneurysms [1–3]. Open surgery, including: clip reconstruction or in-situ bypass with aneurysm trapping, achieves high occlusion rates but at the cost of significant peri-procedural morbidity and mortality [2,4,5]. Endovascular coil-embolization strategies allow for complete or near-complete aneurysm occlusion in up to 80% of cases [6,7], but with significant peri-procedural complications approaching 10%; similar to rates of untoward events with open surgery [8].

Given the small size of the distal ACA, its occasional tortuosity, and the complexity of the aneurysm morphologies, endovascular complications often arise from aneurysm perforation injuries (related to the diminished control over microcatheters and microwires [8,9], particularly in the context of a relatively small aneurysm), and thromboembolic events due to coil mass instability, particularly when treating an "unfavorable" neck geometry in the face of the small parent vessel diameter [10]. Flow diversion strategies using minimally porous endoluminal devices (MPEDs) such as the Pipeline Embolization Device (PED™; Covidien Neurovascular, Irvine, CA) have gained popularity in such circumstances given their ability to reconstruct the diseased arterial segment from the

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endoluminal side without having to enter the aneurysm sac with a microcatheter or microwire.

MPED constructs have initially been shown to be an effective treatment option for large, complex neck aneurysms, mostly of the proximal internal carotid artery [11–16]. Possible indications for their utility beyond the Circle of Willis have been suggested by reports of successful MPED-endoluminal treatment of aneurysms of the M1 segment [17–19], the MCA bifurcation [18–20], the ACOM complex [18,19], and the posterior cerebral artery [21]. However, the perceived stiffness and relatively large sizes of their delivery platforms, and the narrow range of available device diameters have been felt to limit to their use in distally located arteries. Descriptions of endoluminal reconstruction using MPEDs for aneurysms arising from the ACA distal to the ACOM complex have therefore remained sparse with limited follow up [18,19,22,23,24].

We report and discuss our experience with the use of the PED for five complex distal ACA aneurysms. We illustrate that the current device generation can be safely deployed in distally located arterial segments smaller than 2 mm, and conclude on the basis of our results that endoluminal reconstruction using the PED is a comparatively safe and effective treatment alternative for a carefully selected subset of these challenging lesions.

2. Methods and materials

This study was approved by the respective Committees on Human Research at the New York University and North-shore Long Island Jewish Health System Medical Centers and was conducted in accordance with Health Insurance Portability and Accountability Act regulations. The prospectively maintained Pipeline databases at each institution were retrospectively reviewed to identify patients with distal ACA aneurysms treated with the PED between 2008 and 2014. Baseline patient and aneurysm characteristics were collected as were follow-up examinations and imaging results. The indications for endoluminal reconstruction for each case were discussed and approved by an interdisciplinary neurovascular board composed by neurointerventionalists and vascular neurosurgeons.

2.1. Preoperative management

All patients were started on dual antiplatelet therapy (daily clopidogrel 75 mg and salicylic acid 325 mg) five days prior to the procedure. A response was confirmed using P2Y12 assay (VerifyNow™; Accumetrics, San Diego, CA) which was obtained in all patients directly preceding the procedure and thereafter daily until discharge. *Interventional procedure:* Four-vessel diagnostic digital subtraction angiography (DSA) including three-dimensional reconstructed images was performed directly preceding the embolization procedure in all patients. All embolization procedures were performed via a standard transfemoral approach under general anesthesia. Intravenous (IV) heparin boluses were given during the procedure based on the patient's weight in both institutions, and titrated for an activated clotting time of >200 s at one institution. We employed a tri-axial system utilizing an intravascular guide sheath (Neuron™ MAX; Penumbra, Alameda, CA), accommodating up to 6 French intermediate guiding catheters (DAC® 0.44/115; Stryker Neurovascular, Fremont, CA or Navien™ 058, Covidien Neurovascular, Irvine, CA) housing a coaxially introduced microcatheter (Marksman™, 150 cm; ev3 Neurovascular, Irvine, CA). PEDs were deployed using previously described methods of unsheathing and delivery-wire advancement [16]. A single PED of 2.5 mm diameter was the sole treatment in four cases (patients #1, #2, #3 and #5). The remaining patient was treated with two overlapped, telescoping PEDs measuring 2.5 mm and 2.75 mm diameter, respectively (patient #4). During deployment of the PED, the leading wire was carefully monitored under continuous biplane fluoroscopic road mapping to prevent vessel perforation or its engagement into small branch vessels. Following removal of the delivery catheters, a control DSA was performed in the working and standard projections. A non-contrast head computed tomography (CT) scan was routinely performed following the embolization procedure. In the absence of intracranial hemorrhage, an IV heparin infusion was continued for 12 h according to the institution protocol. *Post procedure management:* Dual antiplatelet therapy was continued for a minimum of three months, after which dual antiplatelet regimen was re-evaluated for each individual case. In two patients Plavix was discontinued after MRA with and without contrast demonstrated aneurysmal occlusion and parent vessel patency at 3 and 4 month postoperatively. In the third patient, Plavix was halved at 1 year and discontinued at 2 years post procedure. In the forth patient, Plavix was halved at 6 month, and reduced to every third day at 9 month. In the last patient Plavix was discontinued at 6 month. All patients were maintained on low dose Aspirin.

MRA imaging with and without contrast was performed within 3–4 months in two cases. Follow-up DSA was performed at 5 to 14-months post-embolization in all cases.

Table 1
Demographic, angioarchitectural, and outcome characteristics.

Case	Age (sex)	Location	Sac size (mm)	Neck size	Proximal parent vessel diameter (mm)	Distal parent vessel diameter (mm)	Number of PEDs	PED size (mm)	Immediate result	Final result
1	58 (F)	A2/A3	4	NA Fusiform	1.95	1.75	1	2.5 × 14	Marked Stagnation	Complete aneurysm occlusion (14 months DSA)
2	57 (F)	A2/A3	6.2	4.2 Saccular	1.93	1.79	1	2.5 × 16	Immediate occlusion	Complete aneurysm occlusion (12 month DSA)
3	64 (M)	A3	4	2.3 Saccular	1.74	1.42	1	2.5 × 10	Mild stagnation	Complete aneurysm occlusion (12 months DSA)
4	75 (M)	A2	10.2	8.7 Fusiform	2.21	2.0	2	2.5 × 16 2.75 × 10	Marked stagnation	Complete aneurysm occlusion (14 months CTA)
5	51 (F)	A2/A3	3 (recurrent sac of previously ruptured ACA aneurysm)	4.64 Saccular	1.97	1.99	1	2.5 × 14	Marked Stagnation	Complete aneurysm occlusion (5 months DSA)

CTA, Computerized Tomography Angiogram; DSA, Diagnostic Subtracted Angiography; NA, Not Applicable; PED, Pipeline Embolization Device.