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Pipeline embolization of posterior communicating artery aneurysms associated with a fetal origin posterior cerebral artery

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ABSTRACT

Background and purpose: Flow diversion may have advantages in the treatment of posterior communicating artery (PComA) aneurysms associated with a fetal origin posterior cerebral artery (PCA), which can be challenging to treat with conventional techniques. However, a PComA incorporated into the aneurysm may prevent or delay aneurysm occlusion. Also, coverage of a fetal origin PCA risks infarction of a large vascular territory. The purpose of this study was to examine the safety and effectiveness of using the Pipeline Embolization Device (PED) to treat PComA aneurysms associated with a fetal origin PCA.

Patients and methods: Retrospective review of PComA aneurysms associated with a fetal origin PCA treated with the PED at two neurovascular centers was performed. Periprocedural complications and clinical and angiographic outcomes were reviewed.

Results: Seven female patients underwent a total of seven PED procedures to treat seven PcomA aneurysms associated with a fetal origin PCA. The symptomatic complication rate was 14% (1/7) per patient and 13% (1/8) per procedure. Angiographic follow up was obtained for 6 of 7 aneurysms. Follow-up DSA at 5–7 months after treatment demonstrated complete occlusion of 17% (1/6) of aneurysms. One aneurysm was retreated with a second PED and occlusion was demonstrated 36 months after the second treatment, yielding an overall complete occlusion rate of 33% (2/6).

Conclusions: PED treatment was largely ineffective at treating PComA aneurysms associated with a fetal origin PCA, and should only be considered when conventional treatment options, including microsurgical clipping, are not feasible.

1. Introduction

The Pipeline Embolization Device (PED; Medtronic Neurovascular, Irvine, CA) received FDA approval in 2011 for the treatment of aneurysms larger than 10 mm in size with necks larger than 4 mm located from the petrous to superior hypophyseal segments of the internal carotid artery (ICA). Although successful off-label use of the device to treat ICA aneurysms smaller than 10 mm in size has been widely reported [1–7], Pipeline embolization of posterior communicating artery (PComA) aneurysms associated with a hypoplastic ipsilateral P1 segment, or fetal origin posterior cerebral artery (PCA), raises two important concerns. First, the large PComA incorporated into the neck or dome of the aneurysm may maintain flow to the aneurysm and prevent occlusion [8]. Second, although the pressure gradient is supposed to maintain flow to branch vessels covered with the PED, occlusion of a fetal origin PCA carries a higher risk of a large territory infarction. However, these concerns must be balanced against the reality that PComA aneurysms can be challenging to treat with conventional techniques. Microsurgical clipping of PComA aneurysms is effective and durable, but preservation of PComA flow is not always possible, and backflow from a large PComA may persistently fill the aneurysm after clip placement [9]. Coil embolization is possible but

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also carries substantial risk of occluding PComA flow, and is also limited in effectiveness by a relatively high recurrence rate, exceeding 30% in the International Subarachnoid Hemorrhage Trial [10]. Thus, despite the perceived risks, flow diversion may have advantages in the treatment of PComA aneurysms with a fetal origin PCA. The purpose of this study was to examine the clinical and angiographic outcomes of Pipeline embolization of these aneurysms.

2. Patients and methods

Institutional review board approval was obtained to retrospectively review the neurointerventional databases of two high-volume neurovascular centers for PComA aneurysms treated with the PED between January 2012 and January 2016. Digital subtraction angiography (DSA) images were reviewed to identify all cases in which the P1 segment of the PCA ipsilateral to the PComA was hypoplastic, defined as a diameter smaller than 1 mm, or absent.

Demographic information, clinical history, and outcomes were collected from electronic medical records. Pre- and post-procedural functional status were measured with the modified Rankin scale (mRS). Procedural details, including periprocedural complications, were collected from operative reports. Aneurysm size (largest diameter in any dimension), morphology (saccular or fusiform), and relationship to the PComA were assessed on DSA.

Written informed consent was obtained prior to all procedures, which included a discussion of available management options, including open surgical treatment and imaging surveillance. We also discussed with each patient the risks and benefits of different endovascular treatment options, including coil embolization, stent- or balloon-assisted coil embolization, and flow diversion. In each case, the decision to treat was based on the relative risks of treatment compared with imaging surveillance, which for unruptured aneurysms was estimated by the International Study of Unruptured Intracranial Aneurysms [11], consensus of opinion at an institutional multidisciplinary vascular conference, and patient preference. All patients received periprocedural antiplatelet therapy and platelet function testing per individual institution protocol. Intra-procedural heparin was administered to achieve an activated clotting time 2–3 x baseline. PEDs were deployed in the ICA using a triaxial system comprising a 5 or 6 French Shuttle sheath (Cook Medical; Bloomington, IN), Navien or ReFlex 0.058 inch intermediate catheter (Medtronic Neurovascular; Irvine, CA), and Marksman 0.027 inch microcatheter (Medtronic Neurovascular; Irvine, CA) used through femoral access. No aneurysms were treated with adjunctive coiling.

Follow-up MR or DSA was reviewed for aneurysm occlusion, stenosis within the PED, and patency of the branch vessels covered by the PED. For post-treatment angiographic surveillance, follow-up interval and imaging modality were chosen by the treating physician. Angiographic outcomes were classified as complete aneurysm occlusion, aneurysmal neck remnant, or residual aneurysm. For aneurysms with incomplete occlusion, pre-treatment and follow-up aneurysm volumes were calculated using the AngioCalc aneurysm volume calculator (www.angiocalc.com), and a percent aneurysm volume reduction was calculated as follows: 100–[(follow-up volume/initial volume)*100].

3. Results

Seven female patients underwent a total of seven PED procedures to treat seven PcomA aneurysms associated with a fetal origin PCA (Table 1). All aneurysms were saccular, with a mean size of 9.2 mm (range, 5.4–16.0 mm). In all cases, the PComA was incorporated into the aneurysm neck. Five of 7 aneurysms were recurrences after previous coil embolization; patients 1 and 7 had not been previously treated. No previous aneurysm treatment had required the use of a stent or flow diverter. Patient 2 initially presnted with subarachnoid hemorrhage, was treated initially with coiling, and underwent PED treatment for a recurrence. The remaining aneurysms were discovered incidentally.

All aneurysms were initially treated with a single PED. In patient 2, a second device was placed after 6-month follow up DSA showed residual aneurysm filling (82% volume reduction). The PEDs ranged from 3.25–4.5 mm in diameter and 12–30 mm in length.

Clinical and angiographic outcomes are listed in Table 1. There were no deaths. The symptomatic complication rate was 14% (1/7) per patient and 13% (1/8) per procedure. Patient 3 developed word-finding difficulty 6 days after PED treatment, and MRI demonstrated scattered punctate embolic infarcts in the right cerebral hemisphere. The patient was discharged home with a mRS of 0. This patient received aspirin 81 mg and prasugrel 10 mg for one month before the procedure, and platelet function testing (VerifyNow, Acriva Diagnostics; San Diego, CA) returned 185 P2Y12 Reaction Units two days before the procedure and 180 P2Y12 Reaction Units at the time of the thromboembolic event. There were no instances of intra-procedural or delayed intracranial hemorrhage.

Angiographic follow up was obtained for 6 of 7 aneurysms. Follow-up DSA at 5–7 months after treatment demonstrated complete occlusion of 17% (1/6) of aneurysms. In patient 2, follow-up DSA 36 months after treatment with a second PED showed complete aneurysm occlusion. Thus, the overall complete occlusion rate at last angiographic follow up was 33% (2/6). Volume reduction of 86% was achieved in an additional case (patient 5). Illustrative cases are presented in Figs. 1 and 2.

In all seven cases, the PED covered the PComA, ophthalmic artery, and anterior choroidal artery origins. In patient 2, both PEDs covered all three of these branch vessels. At last angiographic follow up, all PComA and anterior choroidal arteries were patent with normal flow. One ophthalmic artery was occluded at 6-month DSA follow up (14%; 1/7), though this patient did not appreciate any change in her vision. In patient 5, flow in the ophthalmic artery was mildly reduced immediately after the PED was deployed, but flow had returned to normal at 6-month DSA follow up.

4. Discussion

In this case series of seven PComA aneurysms associated with fetal origin PCAs, flow diversion with the PED achieved complete aneurysm occlusion in only 33% (2/6) of cases with angiographic follow up. The procedural complication rate was 13% (1/8), owing to one case of embolic stroke, from which the patient made a full recovery. All fetal origin PCAs and anterior choroidal arteries were patent at last angiographic follow up, and there was one case of asymptomatic ophthalmic artery occlusion (14%; 1/7).

Four previous studies have described angiographic outcomes after Pipeline embolization of PComA aneurysms associated with fetal orign PCAs [12–15]. Three of these studies included a collective 11 aneurysms, none of which were occluded at last angiographic follow up (Table 2). This observation led the authors of each paper to conclude that flow diversion is not an effective treatment for these aneurysms. In contrast, Daou et al. [13] reported a 67% (4/6) occlusion rate of aneurysms originating on a PComA supplying a fetal origin PCA. Procedural details and durations of angiographic follow up for these cases were not reported separately from the rest of the cohort. In aggregate, fetal PComAs remained patent in all 17 previously reported cases of PED treatment of fetal origin PComA aneurysms.

The 33% (2/6) occlusion rate in the present series, and the 67% (4/6) occlusion rate reported by Daou et al. [13], indicate that flow diversion can result in successful treatment of some PComA aneurysms with an incorporated fetal PCA. Still, these data suggest that aneurysms incorporating a fetal PCA are far less likely to occlude after PED placement than other anterior circulation aneurysms [1–7]. Flow diverters induce slow, turbulent blood flow within the aneurysm, ultimately leading to thrombosis, while the device acts as a scaffold for neointimal proliferation and remodeling of the parent artery [16,17]. However, flow to branch vessels arising from the aneurysm may maintain flow to