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Patency of the posterior communicating artery after flow diversion treatment of internal carotid artery aneurysms

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ABSTRACT

Background and purpose: Cerebral aneurysm treatment with the Pipeline Embolization Device (PED) often mandates device placement across the ostia of arteries of the Circle of Willis. We determined the patency rates of the posterior communicating artery (Pcomm) after placement across its ostium a PED and studied neurologic outcomes in these patients.
Methods: We analyzed, retrospectively, a consecutive series of patients in whom a PED was placed across the ostium of Pcomm while treating the target aneurysm. Pcomm arterial flow after PED placement was graded on a 3-point scale at post-operative angiography and follow-up angiography. Data on pre-treatment aneurysm rupture status, concomitant coiling, number of PEDs used, and neurologic status at follow-up were collected.
Results: Eleven patients with 13 aneurysms were included in this study. All patients had an ipsilateral posterior cerebral artery arising from the basilar artery (P1). In the immediate post-procedural setting, four patients (36%) had diminished Pcomm flow rates. After a mean follow-up of 12.6 ± 6.7 months, three Pcomm arteries (27%) were occluded and two Pcomm arteries (18%) had diminished flow. Of patients with diminished flow/occluded Pcomm at follow-up, 80% (4/5) had diminished flow at initial post-procedure angiography compared to none of the six patients without diminished/occluded flow immediately post treatment. No patients suffered new neurologic symptoms at follow-up.
Conclusions: Approximately one half of Pcomm arteries demonstrated occlusion or decreased flow at follow-up if the ostia are covered with a flow diversion device. Covering the Pcomm ostium in patients with a P1 did not result in any neurologic deficits.

1. Introduction

Flow diverter devices such as the Pipeline Embolic Device (PED, eV3/Covidien, Irvine, CA) are increasingly being used in the embolization of intracranial aneurysms as both alternatives and adjuncts to endovascular coiling [1–4]. The PED is approved in the United States for treatment of intracranial aneurysms of the internal carotid artery proximal to the origin of the posterior communicating artery (Pcomm). However, these devices are being increasingly used in locations other than the proximal intracranial internal carotid artery (ICA). Histologic studies have demonstrated that after disrupting flow into the aneurysmal sac, flow diverters result in aneurysmal thrombosis and eventual sealing of the aneurysm ostium through neointimal proliferation across device struts [5]. Computation fluid dynamic studies have demonstrated that upon deployment of flow diverters, mean intra-aneurysmal flow velocities and wall shear stress are significantly reduced resulting in aneurysmal occlusion [6]. While flow diverters limit aneurysmal blood flow, blood flow into large vessels and perforating vessels covered by the device is generally preserved [5]. While many in vitro and experimental models have demonstrated long-term patency rates of branch vessels covered by PED, the long term patency of major branch vessels is not well established [7–9]. In this study we assessed the immediate and long term patency rates of the Pcomm artery in patients following the placement of a PED across the Pcomm artery ostium.

2. Methods

After Institutional Review Board approval, we retrospectively examined a consecutive series of patients undergoing treatment

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of intracranial aneurysms with the PED in which the PED was placed across the ostium of the Pcomm artery from January 2011 to June 2012. Inclusion criteria were the following: (1) Patients >18 years old, (2) PED placed across the ostium of the Pcomm artery for treatment of a wide-necked or large/giant aneurysm, (3) follow-up clinical exam and angiogram at 6 months. Patients who did not receive follow-up were excluded from analysis. All patients in this study were included in the International Retrospective Study of Pipeline Embolization Device (IntrePED) Registry (ClinicalTrials.gov Identifier: NCT01558102) which is assessing the post-market safety and efficacy of Pipeline embolization in the treatment of intracranial aneurysms.

All patients undergoing treatment were premedicated with aspirin and clopidogrel and full anticoagulation was maintained during the procedure (target activated clotting time between 250 and 300 s). Following the procedure, patients were maintained on dual antiplatelet therapy for 3 months. After 3 months, clopidogrel was discontinued and aspirin was continued indefinitely. This antiplatelet regimen was the same in all patients and no platelet responsiveness studies were used in these cases. All of the procedures were performed with the patient under general anesthesia. A bi- or triaxial access technique and, in all cases, a Marksman (ev3) microcatheter, were used to obtain distal access past the segment of the vessel harboring the target aneurysm. Pipeline Embolization Devices were sized to match the maximum diameter of the target vessel. One or multiple devices were used at the discretion of the operators to maximize the changes of complete aneurysm occlusion and/or to ensure adequate coverage of the aneurysm neck and of a segment of parent artery proximal and distal to it. Digital subtraction angiography was performed at two frames per section prior to and following placement of the PED.

Determination of Pcomm artery patency was made for each patient immediately after the original procedure and at the follow-up angiography obtained furthest from the initial procedure by a blinded investigator. A note was also made of any subjectively determined change in flow patterns (slowing of angiographic flow after PED deployment and/or at follow-up). Pcomm artery patency was scored on a three point scale: (1) patent: similar filling of the Pcomm when comparing pre- and post-treatment angiograms, (2) diminished flow but patent: decreased or delayed filling of Pcomm when comparing pre-and post-treatment angiograms, (3) occluded: no filling of the Pcomm on post-treatment angiograms. All patients underwent a detailed clinical examination before the procedure, immediately after the procedures, the following day and at each corresponding follow-up angiogram. In addition to Pcomm artery patency, patient age, gender, aneurysm rupture status, aneurysm occlusion at follow-up (complete = no flow within the aneurysm, near complete = minimal (<10%) residual flow and incomplete $\geq$ 10% residual flow), aneurysm maximum size, the use of concomitant coiling, previous coiling, and the presence, symmetry and size of the ipsilateral first segment of the posterior cerebral artery (P1) and Pcomm arteries were assessed. Asymmetry was defined as ipsilateral P1 or Pcomm segment <50% size in diameter of the contralateral P1 or Pcomm respectively.

2.1. Statistical analysis

Summary statistics are presented for all data available using means $\pm$ standard deviations for continuous variables and frequency tabulations for categorical variables. All statistical analyses were performed using JMP 9.0.

3. Results

3.1. Patient and aneurysm characteristics

A total of 11 patients (9 women and 2 men) with 13 aneurysms were included in this study. Mean patient age was 52.0 $\pm$ 11.6 years (range 32–68). Aneurysm sizes ranged from 2 mm to 27 mm with a mean of 11.7 $\pm$ 7.8 mm. Eleven aneurysms were unruptured and two were previously ruptured. The two ruptured aneurysms were treated with coil embolization in the acute phase and staged Pipeline placement after patients had recovered from the acute subarachnoid hemorrhage (SAH). One patient had concomitant coiling and six patients had prior coiling of the treated aneurysm. Initially, one PED was placed in nine patients and two PEDs were placed in two patients. One patient had a recurrence which was treated with an additional pipeline (Fig. 1), thus, in total, three patients had two PEDs placed. At last follow-up, nine aneurysms (81.8%) demonstrated complete or near-complete occlusion, one aneurysm (9.1%) demonstrated incomplete occlusion and did not receive further treatment and one aneurysm (9.1%) recurred and required further treatment with an additional PED which did not affect Pcomm patency. Of the two patients with incomplete occlusion, one patient had incorporation of a large Pcomm into the aneurysm.

3.2. Angiographic and clinical results

A summary of angiographic and clinical data for the eleven patients included in this study is provided in Table 1. Representative cases are provided in Figs. 1 and 2. Following placement of the PED across the ostium of the Pcomm artery, seven patients (64%) had a patent Pcomm artery on initial post-treatment angiography while four patients (36%) had diminished flow but the Pcomm artery remained patent

Follow-up times ranged from 6 to 26 months with a mean follow-up of 12.6 $\pm$ 6.7 months. No patient was lost to follow-up. On follow-up examination, six patients (55%) had a patent Pcomm artery. All six of these patients had patent Pcomm arteries on initial post-procedural angiogram. Two patients had diminished flow (18%) in patent Pcomm arteries. Both of these latter patients had diminished but patent Pcomm arteries on initial post-procedural angiogram. Three patients (27%) had occluded Pcomm arteries at follow up. Of these patients, at immediate post treatment angiography one had a patent Pcomm artery, and two had diminished flow. One patient had fibromuscular dysplasia and on the last follow-up angiogram demonstrated complete occlusion of the internal carotid artery proximal to the PED stent. In this patient the Pcomm filled in a retrograde fashion following vertebral artery injection. One of the three patients also had a vertebral artery injection which demonstrated no evidence of retrograde Pcomm flow. No patients had new neurologic symptoms on follow-up examination.

All patients had an ipsilateral P1 segment present on the initial angiogram. The P1 segment was symmetric or larger than the contralateral P1 in 8 patients (72%). Asymmetry was seen in 3 (27%) cases. The size of the ipsilateral Pcomm artery was greater than or equal to the size of the contralateral Pcomm artery in 10 cases (90.9%).

3.3. Determinants of Pcomm patency

Mean ipsilateral Pcomm artery size was 1.7 $\pm$ 0.6 mm for patients with Pcomm arterial occlusion at follow-up compared to 1.9 $\pm$ 0.7 mm for patients without occlusion. Mean ipsilateral Pcomm artery size was 1.7 $\pm$ 0.7 mm for patients with diminished flow or occlusion at follow-up compared to 2.0 $\pm$ 0.6 mm for patients with patent Pcomm arterial flow. The ipsilateral Pcomm