Pipeline Embolization Device in Treatment of 50 Unruptured Large and Giant Aneurysms

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■ INTRODUCTION: **Treatment of large (≥20 mm) and giant (≥25 mm) intracranial aneurysms is challenging and can be associated with a high rate of morbidity and mortality. The Pipeline Embolization Device (PED) has been used effectively for the treatment of intracranial aneurysms achieving a high rate of complete occlusion. However, its safety and efficacy in treatment of large and giant aneurysms has not been evaluated fully.**

■ METHODS: **A retrospective analysis of consecutive aneurysms treated with PED between 2009 and 2016 at 3 academic institutions within the United States was performed. Large (≥20 mm) and giant aneurysms (≥25 mm) were selected for evaluation of occlusion and complication rates following treatment with PED.**

■ RESULTS: **A total of 50 large and giant aneurysms were individually treated using PED. Aneurysms were fusiform (74%) or saccular (26%) in morphology. PED alone was used for treating 78% of the aneurysms, whereas PED with adjunctive coiling was used for treating 22%. The median length of angiographic follow-up was 13 months (mean follow up 20.4 months). At last follow-up, complete or near-complete occlusion (90–100%) was achieved in 76.9% of aneurysms. Symptomatic thromboembolic complications were encountered in 12% of procedures and symptomatic hemorrhagic complications in 8%.**

■ CONCLUSIONS: **The use of PED for the treatment of large and giant intracranial aneurysms is associated with good occlusion rates, but also a greater complication rate compared to aneurysms of smaller size. There was no significant difference in occlusion rate based on aneurysm shape or size, number of PEDs placed, or adjunctive coiling.**

INTRODUCTION

Large (≥20 mm) and giant (≥25 mm) intracranial aneurysms pose a significant challenge for both surgical and endovascular treatments and often are associated with a high recurrence rate and an increased rate of procedural morbidity and mortality.[1-3] The Pipeline Embolization Device (PED) was approved by the Food and Drug Administration for the treatment of wide-necked cerebral aneurysms of the internal carotid artery (ICA) greater than 10 mm in adults.[4] Nonetheless, PED has evolved to become a mainstay for the treatment of intracranial aneurysms with varying morphologies, sizes, and anatomical locations.[5-10] Despite its approval for wide neck aneurysm, only a few reports limited by small numbers of aneurysms have evaluated the use of PED in the treatment of unruptured large and giant aneurysms.[11-13] In one case series of 47 aneurysms, the findings were limited by the small aneurysm size (≥15 mm) and short duration of follow-up.[12] Moreover, although the use of adjunctive coiling with PED placement has been reported in a few large series,[14-16] it rarely has been evaluated for unruptured aneurysms of this size.

Key words
- Aneurysm
- Complications
- Giant
- Intracranial
- Large
- Occlusion
- Pipeline

Abbreviations and Acronyms
DSA: Digital subtraction angiography
ICA: Internal carotid artery
mRS: modified Rankin Scale
PED: Pipeline Embolization Device

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METHODS

A retrospective analysis of consecutive aneurysms treated with PED placement between 2009 and 2016 at 3 academic institutions in United States was performed. All adult patients with large (≥20 mm) and giant (≥25 mm) intracranial aneurysms treated with PED placement with or without adjunctive coiling were included. Aneurysms with both saccular and fusiform morphology in all intracranial locations were included. Institutional review board approval was obtained at all 3 centers before the commencement of the study. The following information was collected: patient demographics, aneurysm and treatment characteristics, procedural complications, and angiographic and functional outcomes. For saccular aneurysms, both maximal aneurysms diameter and neck size were measured. For fusiform aneurysms, both aneurysm length and width were measured.

Procedure Details

Patients received aspirin 325 mg and clopidogrel 75 mg daily for 3–14 days before the intervention. Platelet function testing was performed routinely with whole blood lumi-aggregometer, light transmission aggregometry, or VerifyNow (Accriva Diagnostics, Township, New Jersey, USA). Clopidogrel nonresponders were identified based on established cut-off values at the individual institutions and were guided by the manufacturer's recommendations. If a patient was identified as a clopidogrel responder, the clopidogrel was continued. If a patient was identified as a clopidogrel nonresponder, the choice to continue on same dose of clopidogrel, administer a one-time 600 mg clopidogrel boost dose within 24 hours' of the commencement of the procedure, or switch to ticagrelor was at the discretion of the interventionalist performing the procedure. Patients underwent local anesthesia with sedation or general anesthesia at the discretion of the individual institutions, and all patients were anticoagulated with heparin throughout the procedure. The type of guide catheter and microcatheter used for PED deployment also was at the discretion of the individual institution. The deployment and apposition of the PED to the ICA wall was documented by fluoroscopy. Dual antiplatelet therapy was continued for at least 3 months after the procedure and aspirin indefinitely thereafter.

Angiographic and Clinical Outcome

Angiographic outcome was assessed with digital subtraction angiography (DSA), magnetic resonance angiography, or computed tomography angiography based on follow-up protocols used at each individual institution. Aneurysm occlusion on follow-up DSA imaging was assessed by the treating interventionalist. Follow-up magnetic resonance angiograms were assessed by a radiologist and the treating interventionalist. Occlusion was categorized as complete or near-complete occlusion (90%–100%) and partial occlusion (<90%). Functional outcomes were assessed with the modified Rankin Scale (mRS) at last follow-up.

Thromboembolic complications occurring from the date of the procedure up to the last follow-up were included. Intraprocedural thromboembolic complications were identified on DSA as either thrombus formation, slow filling of a previously normally filling vessel, or vessel dropout. Postprocedural thromboembolic complications were identified via a combination of clinical and radiographic findings. Postprocedural imaging was performed at the discretion of the individual institutions and was only obtained because of clinical concern. Routine screening for clinically silent ischemic strokes was not performed. Postprocedural imaging obtained to detect an ischemic stroke could include any combination of a noncontrast computed tomography, computed tomography angiography, or magnetic resonance imaging. Only ischemic strokes in the territory of the treated vessel were included. An ischemic complication was considered symptomatic if the patient reported symptoms attributable to thromboembolism or demonstrated signs attributable to thromboembolism; this includes transient or resolving signs and symptoms.

Hemorrhagic complications were identified intraoperatively as contrast extravasation on DSA or on postprocedure imaging obtained due to clinical concern. Hemorrhagic complications occurring from the time of the procedure up until last follow-up were included. Hemorrhages were counted as symptomatic if the patient reported symptoms or demonstrated signs attributable to a hemorrhage. In contrast to ischemic complications, all vascular territories and arterial puncture sites were included.

Statistical Analysis

Statistical analysis was performed with SPSS 21.0 (IBM Corp., Armonk, New York, USA). In univariable analysis, variables were compared between groups by use of the Mann–Whitney U test for nonparametric numerical variables and χ^2 tests for categorical variables. Statistical significance was defined as $P < 0.05$.

RESULTS

Baseline and Aneurysms Characteristics

A total of 50 large and giant aneurysms (median age 61.5 years, female-to-male ratio was 2:1) were treated at the 3 institutions via PED. Current smoking and multiple aneurysms at other locations were present in 18% and 32% of patients, respectively. Incidental aneurysms were found in 36% of patients at the time of presentation, whereas minor (mRS 1–2) and major (mRS 3–5) neurologic deficits were present in 56% and 8% of patients, respectively. Aneurysms were primarily located along the ICA (62%), followed by the posterior circulation (30%). Aneurysms had fusiform (74%) or saccular (26%) morphology. Fusiform aneurysms had a median length of 27 mm and a median width of 20 mm. Saccular aneurysms had a median maximal diameter of 26 mm and a median neck size of 10.8 mm. None of the aneurysms had been previously treated (Table 1).

Treatment Outcome

PED alone was used for treating 78% of the aneurysms, whereas PED with adjunctive coiling was used for 22%. Aneurysms that underwent PED with adjunctive coiling were significantly larger than aneurysms that underwent PED placement alone (median maximal diameter 33 mm vs. 25 mm, $P = 0.01$). The median number of PEDs used was 2 (range 1–9).

The median duration of angiographic follow-up was 13 months (mean 20.4 months). At last follow-up, complete or near-complete occlusion (90%–100%) was achieved in 76.9% of aneurysms, whereas partial occlusion (<90%) was achieved in 23.1% (Figure 1). Complete or near-complete occlusion was achieved in