CASE REPORT

First US experience with Pipeline Flex with Shield Technology using aspirin as antiplatelet monotherapy

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SUMMARY

Flow diversion has revolutionised the treatment of intracranial aneurysms, and the Pipeline Embolization Device (PED) remains the only flow diverter (FD) approved in the USA. However, thromboembolic events remain an issue for FDs. Attempting to minimise these incidents, a newer PED has been developed with the use of covalent bonding of phosphorylcholine onto the Pipeline device that has been known as Shield Technology (PED Shield), which in vitro has demonstrated a significant reduction in material thrombogenicity. We report the first US experience of the PED Shield in the treatment of a ruptured fusiform aneurysm located in the right vertebral artery in an attempt to mitigate complications related to the use of dual-antiplatelet therapy and discuss our rationale for using the new FD, using aspirin only as the antiplatelet regimen.

BACKGROUND

Flow diversion has changed the treatment of intracranial aneurysms (IAs) resulting in durable aneurysm occlusion without endosaccular embolisation. The Pipeline Embolization Device (PED; ev3-Covidien, California, USA) remains the only Food and Drug Administration (FDA)-approved flow diverter (FD) and has demonstrated excellent outcomes over the past 5 years.^{1–3} A second generation, the Pipeline Flex Embolization Device (PED Flex) has been recently introduced with a redesigned delivery system to facilitate device deployment.^{4,5} However, thromboembolic events remain an issue for FDs due to its high metal content. To overcome this issue, a surface modification was introduced onto the PED Flex implant known as Shield Technology, which consists of a layer of phosphorylcholine covalently bound onto the bare metal device, reducing the tension surface and thrombogenicity. Herein, we report the initial experience with the PED Shield in the USA in the treatment of a ruptured fusiform vertebral artery (VA) aneurysm.

CASE PRESENTATION

A 48-year-old man presented to the hospital after sudden onset of severe neck pain and headache. A non-contrast head CT demonstrated a Fisher grade III subarachnoid haemorrhage (SAH, [figure 1A](#)) and a cerebral angiogram revealed a 7 mm fusiform aneurysm in the dominant right VA ([figure 1B,C](#)). An external ventricular drain was placed in the right frontal horn due to acute hydrocephalus and the patient was transferred to our centre for

treatment. On admission, the patient had a Hunt and Hess grade III with right ptosis and left sixth nerve palsy. After discussing treatment options, microsurgery was disfavoured due to location and fusiform nature of the lesion. Parent vessel sacrifice was considered not ideal given the dominance of the right VA and possible concomitant left VA dissection. We then opted for endovascular vessel reconstruction. Considering risks associated with dual-antiplatelet therapy in the setting of SAH and possible thromboembolic events with bare metal devices, we entertained the utilisation of PED Shield with full disclosure to patient family and consent for utilisation under FDA emergency use and institutional review board approval.

TREATMENT

The patient received a loading dose of aspirin (325 mg) 2 hours prior to the procedure. The initial angiogram and a 3-D reconstruction demonstrated the complex morphology of the aneurysm, which was located in the V4 segment of the right VA, measuring 8 mm×6 mm with a hypoplastic left VA ([figure 2A](#)). A 6-French guide catheter was used to provide stability for FD deployment and the PED Shield was delivered through a standard 0.027-inch microcatheter. Prior to FD deployment, a standard embolisation catheter was placed inside the aneurysm. We decided to use adjuvant coils to secure the aneurysm and prevent further haemorrhage. Coils were detached after deploying two FDs (3.5 mm×20 mm and 3.75 mm×20 mm) along the right VA to increase metal coverage over the aneurysmal segment ([figure 2B–G](#)). Final angiogram runs showed patency of right VA ([figure 2H–K](#)), without evidence of device thrombosis, and a cone-beam CT angiogram demonstrated wall apposition of the FDs ([figure 2L, M](#)). The patient was maintained only on aspirin (81 mg/day) and low-molecular-weight heparin as prophylaxis for deep vein thrombosis.

OUTCOME AND FOLLOW-UP

Postprocedure MRI revealed multiple hits in the diffusion-weighted imaging (DWI) sequence ([figure 3](#)) which are well described with PED utilisation.⁶ A cerebral angiogram was performed 24 hours postintervention, which demonstrated a patent right VA. During hospitalisation, the patient was newly diagnosed with metastatic cancer consistent with colorectal adenocarcinoma. At the ninth hospital day, a new MRI demonstrated no new DWI abnormalities and the patient continued to improve neurologically.

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Figure 1 Initial non-contrast head CT demonstrating a subarachnoid haemorrhage with a modified Fisher grade III (A). Initial cerebral angiogram in anteroposterior view (B) and lateral view (C) demonstrating a fusiform dissecting aneurysm in the right vertebral artery and a left hypoplastic vertebral artery.

At 10 days postintervention, a cerebral angiogram for FD patency surveillance revealed complete occlusion of the device, patent ipsilateral posterior inferior cerebellar artery filling via left VA collaterals and no evidence of distal vessel drop out to the basilar artery or its branches (figure 4A–E). A further MRI showed no new diffusion-restricting lesions on DWI or haemorrhage. At this point, the patient was tested for aspirin response (VerifyNow Aspirin, Accu-metrics, New York, USA), showing inadequate platelet reactivity (580 aspirin reaction units (ARU)). The patient was discharged at 16 days postprocedure, clinically stable with his left sixth nerve palsy, a modified Rankin Scale (mRS) of 3 and under palliative

Figure 2 Pipeline Flex Embolization Device with Shield Technology (PED Shield) deployment procedure with adjunctive coil embolisation. (A) 3-D reconstruction depicting a fusiform dissecting aneurysm in the right vertebral artery. (B) Right vertebral artery roadmap showing the placement of the PED Shield delivery system and a coil catheter in the dissecting segment. (C and D) Unsubtracted lateral views showing the PED Shield partially and completely deployed. (E) Unsubtracted lateral view showing contrast stasis in the dissecting segment of the fusiform aneurysm. (F) Roadmap showing the detachment of adjunctive coils in the dissecting segment. (G) Unsubtracted lateral view demonstrating the final deployment of the coils. (H–K) Final angiogram images demonstrating a right patent vertebral artery with a moderate coil packing of the dissecting segment of the fusiform aneurysm. (L and M) Cone-beam CT demonstrating good wall apposition of the PED Shield within the intracranial segment of the right vertebral artery.

Figure 3 Postprocedure diffusion-weighted imaging demonstrating an ischaemic lesion involving the genu of the left internal capsule.

chemotherapy. At 1 month follow-up, the patient was found with resolution of his cranial neuropathy and a mRS of 2.

DISCUSSION

For ruptured IAs, PED remains controversial due to potential deleterious effect of dual-antiplatelet therapy that could increase

the risk of aneurysm rebleeding, haemorrhagic complications and increased mortality. Although periprocedural complications have generally been considered high (5%–19%), those studies have indicated that ruptured aneurysms are not an absolute contraindication to FDs, especially if the aneurysm is secured with coils and in patients with favourable Hunt and Hess grade.^{7 8} Still, one of the major unanswered questions refers to the ideal timing for PED placement, with some authors suggesting to intervene in the acute phase whereas others have preferred to stage the procedure by coiling the aneurysm and deploying the PED at a later intervention.

IAs located in the posterior circulation, especially those with fusiform morphology, remain challenging to treat either by endovascular and microsurgical techniques, with high rates of morbidity and mortality.^{9–11} The experience with PED in this subset of lesions is limited with a few case series reported and ischaemic complications ranging from 0% to 71.4% of cases and mortality rates ranging from 0% to 28.6%.^{12–18} The inner surface of the PED Shield includes a phosphorylcholine coating, which is abundant on the surface of erythrocytes and attempts to reduce thrombogenicity.¹⁹ This technology has been used in implanted vascular devices for more than a decade and Shield Technology refers to a modified version, which creates a chemically bonded coating to the surface of the metallic mesh.

Based on the aforementioned information and an initial experience reported by Habboub (verbal communication at WLNC 2016, Shanghai, China), we decided to use the PED Shield with aspirin only on this high-risk patient. However, we observed thrombosis of the device at day 10 follow-up with no clinical consequence due to collateral flow via the left VA. Although PED thrombosis could be attributed to aspirin-only therapy, many other factors might have contributed such as (1) off-label use of the PED in the setting of SAH, (2) use of two PED Shield implants, which increased the risk of thrombogenicity as well as vessel manipulation, (3) vasospasm

Figure 4 (A) Cerebral angiogram, anteroposterior view, demonstrating a patent right vertebral artery immediately after the flow diversion assisted-coil embolisation of the aneurysm. (B) Follow-up angiogram at 24 hours postintervention demonstrating patency of the vertebral artery. (C–E) Follow-up angiogram at 10 days postintervention demonstrating complete obliteration of the intracranial segment of the right vertebral artery and evidence of good collateral flow.

window and the well-known proinflammatory state during the early days of SAH, (4) concomitant diagnosis of active malignancy, which promotes a steady prothrombotic state by releasing tumour procoagulants and indirectly, through activation of endothelium, leucocytes and platelets²⁰ and (5) borderline resistance to aspirin, which suggests an ineffective antiplatelet therapy, rather than failure of the monotherapy.

Limitations

Our experience with the PED Shield is limited by a single case study and cannot be generalised, but occurrence of thrombosis with PED Shield and aspirin-only therapy on this case, in spite of confounding factors, should serve as a warning to curb the enthusiasm of using this device with aspirin-only therapy in the setting of SAH. The safety and effectiveness of this new technology cannot be warranted with this single experience and further closely monitored clinical studies are required to elucidate the ideal antiplatelet regimen and duration as well as the proper patient selection.

CONCLUSION

Our experience with the PED Shield was premature and construct thrombosis was a consequence of multiple factors. Although we believe that the introduction of Shield Technology could potentially reduce thromboembolic complications, future well-controlled studies in ruptured and unruptured aneurysms are needed to guide the utilisation of this exciting new technology.

Learning points

- Flow diversion has quickly expanded the endovascular options for the treatment of intracranial aneurysms beyond large and giant internal carotid artery aneurysms, including ruptured lesions and aneurysms located in the posterior circulation as well as distal anterior circulation.
- The Pipeline Embolization Device with Shield Technology represents a new generation of flow diverters, which uses a modified phosphorylcholine coating to reduce its thrombogenicity, potentially reducing the rate of thromboembolic complications.
- Larger studies are required to determine the rate of thromboembolic events and the ideal regimen and duration of antiplatelet therapy.

Contributors RAH and PA-S were responsible for study concept and design. PA-S contributed to the acquisition of the data. All the authors were responsible for analysis and interpretation of the data. PA-S and LBCB contributed to the drafting of the manuscript. RAH and ES contributed to the critical revision of the manuscript for important intellectual content. PA-S and LB were responsible for administrative, technical and material support. RAH and ES contributed to study supervision.

Competing interests RAH is a consultant for Covidien, Stryker, Codman, MicroVention and scientific advisory board for Medina Medical and shareholder

for Blockade Medical. The other authors have no personal, financial or institutional interest in any of the drugs, materials or devices described in this article.

Patient consent Obtained.

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