CASE REPORT

Flow diversion in vasculitic intracranial aneurysms? Repair of giant complex cavernous carotid aneurysm in polyarteritis nodosa using Pipeline embolization devices: first reported case

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SUMMARY

Intracranial aneurysms in polyarteritis nodosa (PAN) are exceedingly rare lesions with unpredictable behavior that pose real challenges to microsurgical and endovascular interventions owing to their inflammatory nature. We introduce a safe and effective alternative for treating these aneurysms using Pipeline embolization devices (PEDs). A 20-year-old man presented with diplopia, headaches, chronic abdominal pain, and weight loss. Diagnostic evaluations confirmed PAN, including bilateral giant cavernous carotid aneurysms. Cyclophosphamide and steroids achieved significant and sustained clinical improvement, with a decision to follow the aneurysms serially. Seven years later the left unruptured aneurysm enlarged, causing a sudden severe headache and a cavernous sinus syndrome. Treatment of the symptomatic aneurysm was pursued using flow diversion (PED) and the internal carotid artery was successfully reconstructed with a total of four overlapping PEDs. At 6 months follow-up, complete exclusion of the aneurysm was demonstrated, with symptomatic recovery. This is the first description of using a flow-diverting technique in an inflammatory vasculitis. In this case, PEDs not only attained a definitive closure of the aneurysm but also reconstructed the damaged and fragile arterial segment affected with vasculitis.

BACKGROUND

Visceral aneurysms characterize polyarteritis nodosa (PAN) and are a diagnostic criterion for this prototypic systemic vasculitis.¹ Associated intracranial aneurysms (IAs) are exceedingly rare^{2–6} and their natural history remains unknown. Any operative intervention in this inflammatory vascular setting is challenging, and only a handful have been reported.^{3–6–9} We report the successful treatment of a PAN-associated complex and giant cavernous carotid aneurysm using Pipeline embolization devices (PEDs).

CASE PRESENTATION

History

A 20-year-old man presented to the emergency department with chronic headaches, progressive diplopia, and a 3-week history of epigastric pain, malaise, and 9 kg weight loss. On examination a left ophthalmoplegia, mononeuritis multiplex, knee arthritis, and a small desquamated rash on his inner thigh

and penis were noted. Blood tests demonstrated elevations in the erythrocyte sedimentation rate and C-reactive protein to 98 mm/h and 191 mg/L, respectively. Further comprehensive immunologic and infectious evaluations were normal or negative. Angiographic studies showed multiple intra-abdominal aneurysms involving bilateral renal arteries, liver parenchymal vessels, and the right and left hepatic arteries within the porta hepatis. A diagnosis of PAN was made. A brain MR angiogram (MRA) revealed bilateral large multilobulated cavernous carotid aneurysms (figure 1). Medical treatment was initiated, including intravenous pulse cyclophosphamide and corticosteroids, and the visceral aneurysms were treated endovascularly. Because of the limited treatment options and resolving symptoms related to the left carotid aneurysm, it was decided to follow this closely with clinical evaluations and serial MRI assessments. Seven years later the left carotid aneurysm became symptomatic with a sudden severe headache, blurred vision, left palpebral pseudoptosis, nausea and vomiting.

Examination

On examination a left-sided cavernous sinus syndrome was demonstrated by complete ophthalmoplegia, facial numbness and tingling along the territory of V₁ and V₂, Horner syndrome, and ipsilateral elevated intraocular pressure. Ophthalmologic evaluation documented a left optic neuropathy with decreased visual acuity but no papilledema or anisocoria. There was concern of acute subarachnoid hemorrhage (SAH) but a CT (figure 2) and lumbar puncture were negative.

Neuroimaging

MRA (figure 3) once again demonstrated bilateral, partially thrombosed, multilobulated fusiform aneurysms located at the cavernous segment of the internal carotid arteries without any evidence of a carotid-cavernous fistula. On the left symptomatic side the aneurysm had enlarged. Treatment options considered were microsurgery, carotid occlusion preceded by balloon test occlusion, and stent-assisted coiling. However, a flow-diverting technique was chosen to repair the symptomatic aneurysm using PEDs, preserving the left carotid artery and thus minimizing the potential additional stress on the contralateral side with risk of this aneurysm enlarging.

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Figure 1 Coronal MR angiogram at the initial presentation revealing large bilateral multilobulated aneurysms in both carotid cavernous segments.

PROCEDURE

The patient was started on aspirin 325 mg and clopidogrel 75 mg 7 days prior to the procedure. A 6 F Shuttle was used as a guide catheter. Heparin was administered to a target activated clotting time of 300 s. A 4.75×20 mm Pipeline embolization device (ev3, Irvine, California, USA) through a Marksman microcatheter was positioned across the smaller distal component of the aneurysm. A second telescoping 5×30 mm PED was deployed starting at the middle of the previous PED and intended to be ‘seated’ in the petrous carotid segment proximal to the aneurysm (figure 4). The distal overlapping segment,

Figure 3 Coronal MR angiogram 7 years from the initial presentation showing significant enlargement of both complex aneurysms, now almost greeting at the midline in a kissing-like fashion. The symptomatic left-sided intracranial aneurysm grew the most, and its distal lobular component extends medially towards the sella turcica.

however, shortened while re-accessing the device over the wire with the Marksman and became completely disengaged at its distal end (figure 5). The ‘gap’ between the two PEDs could not be bridged despite many attempts, so the second PED was pushed into the space of the aneurysm to lie free (figure 6). Next, maneuvers succeeded in re-entering the distal PED with the guidewire and deploying a third PED (4.75×30 mm) into position, acknowledging that the degree of overlap distally (figure 7) turned out to be less than anticipated. Final angiographic runs showed adequate contrast stagnation inside the

Figure 2 CT image showing clear cisterns without subarachnoid hemorrhage. The unruptured aneurysms show areas of thrombosis and calcification.

Figure 4 Lateral fluoroscopy showing placement of the first two Pipeline stents. The first extends distally to the terminal carotid region and the second, telescoping inside the first (arrowheads), ends proximally at the petrous segment of the carotid artery.

Figure 5 (A) Plain and (B) unsubtracted angiographic intraoperative anteroposterior views showing the disconnection between the two deployed Pipelines. The free ends are inside the aneurysm space (*←→*). The proximal Pipeline is still anchored to the petrous carotid (arrowheads).

aneurysm and patency of all hemispheric vessels. An immediate post-procedure CT head revealed SAH, made more conspicuous by the presence of contrast material intermixed with it. The SAH was concentrated around the left carotid aneurysm, which had undergone several ‘manipulations’ during the repair. While the patient remained asymptomatic, anti-vasospasm measures were implemented. Early repeat CT showed rapid resolution of the SAH at day 4 and surveillance CT angiography (CTA) showed appropriate initial thrombosis within the aneurysm. Promising clinical improvement ensued and the patient was discharged home in a stable condition. On follow-up CTA 45 days later (figure 8), the aneurysm appeared to remain active with worsening partial contrast filling, persisting severe headaches, and declining extraocular motor function. Symptomatic deterioration corresponded with the onset of aneurysm recanalization. Re-intervention was therefore deemed necessary in order to obtain a complete and definitive aneurysm occlusion, accelerate

parent vessel healing, and alleviate symptoms (especially in this lesion with unpredictable behavior). The patient was then brought in for placement of two more 4.75×35 mm PEDs to fortify the existing construct (figure 9). No intraoperative or postoperative complications occurred and the headaches and ophthalmoparesis slowly improved.

OUTCOME AND FOLLOW-UP

At 6-month follow-up, examination demonstrated symptomatic improvement with only slight persisting abducens paresis. The MRA (figure 10) showed complete exclusion of the aneurysm. The contralateral right cavernous carotid aneurysm remained asymptomatic and stable, but remains under close surveillance.

DISCUSSION

PAN was first described in 1866.¹⁰ Pathologic sections revealed nodule-forming vessel wall inflammations which were termed

Figure 6 Anteroposterior angiogram showing the second Pipeline resting free in the lumen of the aneurysm after being pushed in (arrowheads).

Figure 7 Lateral run showing the successful deployment of a third Pipeline telescoping into the distal device.

Figure 8 Sagittal CT angiogram 45 days after the procedure showing residual contrast filling. The overlap between the two Pipelines remains stable.

‘periarteritis nodosa’. The Chapel Hill Consensus¹¹ defines it as a necrotizing arteritis involving vessels of medium size, small size, or both; with or without glomerulonephritis or vasculitis in arterioles, capillaries, or venules; but lacking antineutrophil cytoplasmic antibodies. As a multisystem vasculitis it can affect almost any organ but typically prefers the skin, gastrointestinal tract, kidneys, heart, and peripheral nerves. Neurologic complications occur in up to 79% of patients,¹² with mononeuritis multiplex the most frequent.¹³ The involvement of the CNS is reported in 15–40% of cases,^{13 14} often occurring 2–3 years after the initial diagnosis,¹³ and is associated with worse outcomes. CNS manifestations include diffuse encephalopathies, focal neurodeficits, and seizures. Characteristic findings on neuroimaging

Figure 9 Sagittal CT angiogram depicting the final arrangement of the flow diverter composed of four ‘active’ Pipeline devices and one ‘inactive’—that is, being incorporated by the aneurysm (arrowhead).

Figure 10 Six-month follow-up coronal MR angiogram showing complete exclusion of the left aneurysm. The right cavernous carotid aneurysm remains unchanged and under close surveillance.

are cortical and subcortical infarctions,¹⁵ but SAH and intracerebral hemorrhage (ICH) are also found.¹⁶ The literature on cerebral angiographic findings in PAN is scarce; however, available descriptions show alternating segments of narrowing and widening of the intracranial vessels,¹⁷ arterial dissections with ‘pearl and string’ signs,⁶ and occlusion of smaller arteries.^{6 15}

The inflammatory reaction seen in histopathologic specimens of PAN consists of a segmental transmural necrotizing vasculitis which weakens the vessel wall and predisposes to aneurysm formation. While aneurysms in visceral vessels are common in PAN, IAs are exceptional, with only 19 reports in the literature. Aneurysmal lesions in PAN tend to be widespread, multiple, and small. Large (>1.5 cm) PAN-associated IAs, such as in this case, are extremely rare,^{2 9} and this report represents the only giant (>2.5 cm) IA in the literature. IAs most commonly present with intracranial hemorrhage (SAH or, less frequently, ICH).^{4 5 18 19} Ischemic strokes may occur, including retinal infarctions² and a lateral medullary syndrome.⁶ Akin to our case,^{2 5 7 9 20 21} an IA was an initial clinical manifestation triggering the diagnosis of PAN, two of which presented with compression-induced cranial nerve palsies,^{7 9} including one ophthalmoplegia⁹ with similar cavernous carotid IAs.

Our patient fulfilled the criteria for a diagnosis of PAN¹ with evidence of an abdominal aneurysm and IA at presentation. Moreover, signs and symptoms attributed to the IAs were the primary reason for seeking medical attention. An extensive investigation for other causes was negative. Bilateral giant cavernous carotid aneurysms in a young patient are uncommon, particularly without past medical history of chronic hypertension or other predisposing factors.

The aggressive anti-inflammatory regimen (steroids and immunosuppressive agents) diminished disease activity significantly and relieved symptoms related to the IAs. However, the patient did experience continued low-grade disease activity, as evidenced by intermittently elevated laboratory markers and cranial and abdominal discomfort that responded to adjustments in the anti-inflammatory regimen.

The medical management of aneurysms in PAN is the administration of immunosuppressive and anti-inflammatory agents.¹⁷ While the use of high-dose pulse cyclophosphamide may contribute to aneurysm regression,²² cases of IA rupture while under medical treatment are well documented and can result in fatality. Therefore, a more definitive operative intervention may be considered. In this regard, five cases have been reported, three using microsurgical techniques^{6–8} and two endovascular coiling.^{3–9} While obtaining therapeutic benefits, these procedures were invariably associated with postoperative complications, aneurysm recurrence, or incomplete aneurysm occlusion.

We had significant concerns regarding placement of flow-diverting stents in the context of an inflammatory vasculitis, and particularly given the lack of any previous reports. Alternatives were considered, including microsurgery, endovascular occlusion with or without bypass, and traditional stent coil modalities. To the best of our knowledge, this is the first report on the use of flow-diverting techniques in the repair of IAs in PAN. Our rationale for using a flow-diverting technique was predicated on the knowledge that, because the fibrinoid necrosis in PAN is known to cause destruction of the normal arterial wall structure,⁸ placement of overlapping PEDs will attain a definitive closure of the aneurysm and may also reconstruct this severely affected arterial segment, promoting healing and ultimately formation of a new intima. Additionally, we had already obtained significant experience and excellent results with PEDs in similar giant and complex aneurysms. In this case, the procedure achieved the desired result and demonstrated potential utility in addressing the challenge of IAs in inflammatory vascular disease.

Learning points

- Intracranial aneurysms, although uncommon, can occur in polyarteritis nodosa (PAN). Most of them are multiple and small, but large aneurysms like those reported here have been documented. Their unknown natural history makes it difficult to determine clearcut indications for definitive treatment. Detailed studies describing histopathological, immunohistochemical, ultrastructural, and angiographical features in cerebral PAN and associated aneurysms are called for—aimed not only at expanding our understanding of the disease but also at helping predict its behavior. Nonetheless, those aneurysms that are symptomatic, rupture, enlarge, or have aberrant morphologies should be considered for repair.
- Neurological complications in PAN occur late, commonly several years after diagnosis. Therefore, neuroimaging assessments are helpful in patients with long-standing disease or with CNS symptoms.
- We report the feasibility of safely and effectively eliminating an intracranial aneurysm in PAN using a flow-diverting technique, despite its complex morphology and inflammatory nature.

Contributors JS, TRM, and JMS contributed to the conception and design of the work. JMS drafted the manuscript. All authors revised the manuscript critically and made corrections. All authors approved the final version.

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