Occlusion of an Internal Carotid Artery Pseudoaneurysm After Gunshot Wound Using the Pipeline Embolization Device

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Running Title: PED for Traumatic Pseudoaneurysm

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ABSTRACT

Traumatic intracranial pseudoaneuryms are rare and have different presentations depending of its location and size. With a high rupture rate that leads to significant morbidity and considerable lethality, many treatments were proposed, aiming the reestablishment of adequate blood flow, avoidance of embolization and control of mass effect. We present the case of a 48-year-old male, victim of penetrating gunshot wound, who developed a late internal carotid artery pseudoaneurysm which was treated with the Pipeline Embolization Device. Immediate post-operative, six and twelve months angiography showed adequate device positioning and aneurysm resolution. The treatment with the Pipeline Embolization Device was a safe procedure without complications and allowed complete occlusion and a great outcome after 12 months of follow-up.

KEY WORDS: flow-diversion; Pipeline Embolization Device; traumatic pseudoaneurysm; internal carotid artery; gunshot wound

ABBREVIATIONS: PED= Pipeline Embolization Device; TPA= traumatic pseudoaneurysm; ICA=internal carotid artery; BCI=blunt carotid artery injury

Traumatic intracranial pseudoaneurysms are rare lesions corresponding to less than 1% of all aneurysms.[3] Due to its low prevalence, studies are limited by the few cases and different treatment modalities, especially if considered each center's individualities.

Vessel sacrifice and cerebral revascularization have been considered gold standard for many years. Treatment with anti-thrombotic therapy and anti-coagulants alone have been utilized.[20] However, both 60% chance of rupture before definitive treatment and a mortality rate of 31-54% may determine the necessity of a more aggressive and precocious treatment.[2,3,21]

Recently, with a greater development of endovascular techniques, many authors reported the management of pseudoaneurysms with coils and/or covered stents. The Pipeline Embolization Device (PED) has been widely used managing large wide-necked intracranial aneurysms of the internal carotid artery (ICA) from the petrous segment to the superior hypophyseal one. The off-label use of flow-diversion technology has been increasingly reported including occlusion of ruptured aneurysms, small aneurysms and blister aneurysms. Few reports demonstrated successful occlusion of pseudoaneurysms with flow-diverters.

We sought to report the use of a flow-diverter stent for treatment of a rare late and large traumatic pseudoaneurysm of the ICA due to a gunshot injury.

CASE REPORT

History and investigation

Male, 48-year-old, victim of gunshot wounds to the head, one that penetrated at the right hemiface with its trajectory through the ethmoid sinus and lodged near the left anterior clinoid process, and another one that did not penetrate the left occipital

bone. He was submitted to restorative facial surgery without complications**.** Through all of the time he scored 15 on the Glasgow Coma Scale, with no motor deficits, having only a left hemifacial hypoesthesia and transitory diplopia with partial visual loss. After five years, he had a worsening headache with change in its pattern. A digital subtraction angiogram was performed (Fig.1) and revealed a left internal carotid pseudoaneurysm superior to the petroclival ligament at the cavernous segment of the left ICA, measuring approximately 2.0 x 1.1 cm at the coronal view and 2.4 x 1.6 cm at the sagittal view, (Fig.2). After considering the location, size and shape, the endovascular treatment was chosen.

Operative technique

The procedure was done under general anesthesia with an intravenous bollus of heparin (10,000 UI) after 5 days using 100mg of aspirin and 75mg of clopidogrel. A Terumo 6Fr long introducer sheath was inserted into the right femoral artery and a guidewire, Neuron 0.70 delivery catheter, was placed at the intracranial portion of the left ICA under fluoroscopic guidance with a Siemens Artis Zee. The PED (5x25mm) was deployed with adequate positioning, covering all the pseudoaneurysm extension. A final angiogram was done showing preservation of the ICA branches and an adequate flow, with no evidence of distal thrombus. (Fig.3) An Angioseal 8Fr was used for femoral closure. The patient went to the intensive care unit for 24-hour observation, being discharged after 48 hours of the surgery.

Postoperative course

The use of aspirin and clopidogrel was kept for 6 months, followed by a control angiography that demonstrated a complete resolution of the pseudoaneurysm

with luminal reconstruction and adequate blood flow with anatomic preservation of the adjacent vessels. The clopidogrel was interrupted but the aspirin was kept indefinitely. The 12-month control had the same results. (Fig.4) The facial hypoesthesia and diplopia persisted but without additional symptoms.

DISCUSSION

The damage to all vessel layers where blood could be contained, allows the formation of a false wall of friable connective tissue, gaining the denomination of pseudoaneurysm or traumatic aneurysm. Differently from the regular aneurysms, the pseudoaneurysms typically don't have a neck, having a fusiform shape.[3,15,25] Its formation is independent of the trauma's severity.[23]

Several provocative factors are described such as atherosclerosis, infections, collagen disease, fibromuscular dysplasia, irradiation, Behçet's disease, but mostly after surgical repair and trauma.[20] The last one is more related to young males, because of a higher trauma incidence,[25] and in children.[2,9,15]

Blunt carotid artery injury (BCI) is responsible for 60% of the carotid pseudoaneurysms, penetrating trauma for 29% and iatrogenic for 11%.[20]

Internal carotid artery TPA have a general mortality of 30-50%,[28] penetrating trauma have 6.6-33% mortality and BCI appears in 0.08-0.38% with 20-40% mortality and neurological impairment in 40-80%.[20]

Skull base fractures are the origin of traumatic aneurysm especially at the cavernous sinus and para/supraclinoid segments of the ICA,[2,25] other areas are the tentorium board, sphenoid wing and the interhemispheric falx.[15,25]

High speed penetrating trauma produces a shock wave that leads to small vessels rupture and damages of the microvascular network, in addition, it carries bone

fragments into brain tissue elevating the chances of vascular disruption, which may originate pseudoaneurysms anywhere in its trajectory.[9,25] Twenty percent of these patients present multiple aneurysms.[5]

The symptoms may develop only after a variable period of time,[5,15] many times because of thrombotic events or bleeding (41-57%),[15] with its manifestation depending of the localization, shape and associated injuries.[10,14,20] Pseudoaneurysm should be suspected in head trauma patients who presented delayed neurological deterioration,[2,5,9,15,26] even in those with normal angiography at an initial investigation.[5] The evolution of the TPA is unpredictable, which might lead to fatal rupture.[15] Others manifestations described are massive epistaxis,[8,11,23,28] headaches with possible cluster migraine-like when located at the cavernous segment.[13]

Traditionally, surgical treatment for direct carotid repair presents a 0-22% mortality and post-surgical neurological disability of 0-21%.[20] Vessel ligation, by-pass[21] and graft are used.[20] Appropriate surgical repair reduces mortality from 41% to 18%.[5]

Non-surgical management of carotid lesions with anti-coagulants and anti-thrombotics alone presents a satisfactory result in only one third of the patients and 29% develops pseudoaneurysm, keeping the risk for embolic-stroke and rupture.[20]

The improvement of endovascular techniques makes it more attractive to treat traumatic aneurysms with branch preservation[3,6,7] specially in those where the location can challenge open surgery treatment,[1,27] but still faces resistance from some institutions.[18] Coils, stents, flow-divertion, Onyx and angioplasty are single-used or combined.[1,3,4,19,23] According to Martinaks et al.[17], the self-expanding stent was used in 35% of the cases, stenting and coiling in 20% and balloon expending stents in 5%. The self-expending covered stent was the most used, 54%.[17] These stents are

normally used in cardiac procedures and peripheral vessels, its lower flexibility makes it hard to navigate through tortuous vessels compromising its optimized positioning and risking a pseudoaneurysm damage leading to bleedings, dissections and a thrombus displacement.[28] It has the advantage of not requiring additional coiling.[1] There is only one commercialized model available for intracranial vessels, the Willis, of Chinese fabrication.[16] The treatment with stents are associated with a mortality of 0.9% and ischemic events of 3.5%, a much lower rate compared to the traditional surgery.[20]

A possible complication to covered stents is obliteration of small perforating arteries causing neurological deficits.[28] Thromboembolic events, in its majority, happen during stent positioning causing permanent or transitory symptoms.[27] The continuous extrinsic force made by the self-expending stents, makes it preferable than the balloon expanding.[27] There is a possibility of recanalization with the metallic stent even when coils are used.[27]

Another study with 17 patients showed 50% of cavity-dense coil packing rate with coil embolization and 42.9% with stent-assisted coil embolization, but 2 of the coil-treated patients had recanalization and had a second procedure with coils and stents having a successful result.[24] Coil exteriorization through nasal cavity with massive epistaxis was described after intracavernous pesudoaneurysms treatment.[3]

Factors related to good outcome with endovascular techniques are: non-acute, penetrating trauma, non-cervical and high-grade lesions.[12]

There's no consensus if heparin should be used with or without distal protection during stent placement and the ideal anti-coagulation and anti-platelet regimen.[27]

Pipeline is a flow-divisor that reduces the intra-aneurysm blood flow causing thrombosis and luminal reconstruction of the parent artery. It's formed by a bi-metallic design with optimized radial force and flexibility allowing conformity to tortuous arteries, being indicated in giant aneurysms with complex structure of the carotid territory. Satisfactory results were obtained in pseudoaneurysm, including in children.[3,19,23]

The follow-up has divergences in the literature. Angiographic study with computer tomography[16,18] and digital subtraction angiogram are used individually or combined.

CONCLUSION

The rarity of pseudoaneurysm caused by gunshot wound, the size, the location and widened indication spectrum of PED made it the ideal treatment modality to this case providing luminal reconstruction of the ICA and total obliteration of the TPA, without complications during and after surgery. Larger studies are wanted to assess PED as the new standard treatment for complex pseudoaneurysms of the carotid artery.

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FIGURE LEGENDS

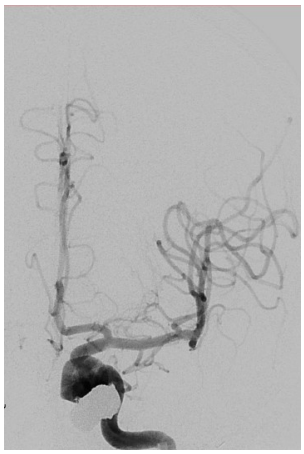
Figure 1. Digital substraction angiogram showing the pseudoaneurysm at the sagittal view of the left ICA study and a bullet fragment anterior to the artery.

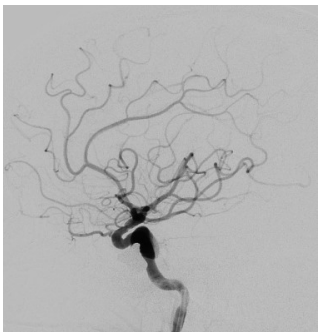
Figure 2. Left: Coronal view measures; right: Sagittal view measures.

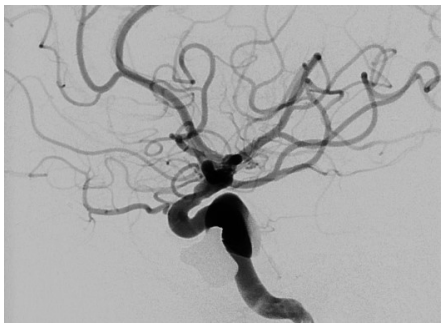
Figure 3. Immediate post-operative angiogram with blood flow preservation to the posterior branch and the anterior and middle cerebral arteries.

Figure 4. The 6-month (left) and the 12-month (right) control study show luminal reconstruction with obliteration of the pseudoaneurysm.

PRE OPERATIVE







POST OPERATIVE