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Emergency endovascular treatment of petrous carotid artery false aneurysm☆

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ABSTRACT

Introduction: The management of ruptured intracranial false aneurysms (IFAs) might be tricky as any kind of treatment modality, surgical or endovascular, is burdened with significant challenges. A case report of the endovascular treatment of IFA in emergency setting is presented to provide more understanding of its pathophysiology as well as of the best operative work-up for petrous carotid artery reconstruction.
Methods: Technical notes from a left sided skull base abscess, involving and eroding the carotid canal and petrous carotid artery (PCA) resulting in an IFA are shown and analyzed.
Results: Balloon-assisted low viscosity Onyx embolization seems an effective method for the emergency treatment of IFA. Indications, technical nuances, and peri- and post-procedural complications are thoroughly discussed. A flow chart for the management of IFA is also proposed.
Conclusions: The combination of parent artery balloon protection and low viscosity Onyx embolization can provide an effective occlusion of the IFA while maintaining parent artery patency. Normal distal filling of the parent artery, and optimal obliteration of the IFA are easily achievable.

Introduction

Intracranial false aneurysms (IFAs) are rare lesions, accounting for <1% off all intracranial aneurysms; almost any intracranial arterial compartment might be affected, nevertheless the majority of cases involve the petrous carotid artery (PCA). In the latter cases clinical presentation is usually characterized by otorrhagia, epistaxis and sudden sensory neural hearing loss; noteworthy the bleeding may be so massive to cause hemodynamic shock and progressive neurological deterioration [1–3]. Several potential causes leading to the development of IFA were so far described in the scientific literature, including traumatic (following blunt or penetrating brain traumas), infectious (osteomyelitic, mycotic- or arteritis-related artery degeneration), iatrogenic (following surgical or endovascular treatments), neoplastic (associated with any type of skull base tumor), genetic (i.e. related to Cystic Necrosis or Marfan syndrome) and degenerative (due to arteriosclerosis or fibro-muscular dysplasia) diseases [3–12].

Often called pulsating hematomas, IFAs share a common feature: in contrast to the physical structure of a true aneurysm, which has all anatomical layers (intima, media and adventitia), and independently from their specific nature, all IFAs lack a formal arterial wall. In fact, following its disruption blood extravasation is confined by the adventitia or the surrounding tissues only, and progressively undergoes fibrous organization to become the sac of a pseudoaneurysm. Historically, surgical intervention was the method of choice, but because the histopathological features of these lesions make them largely unsuitable for clipping, trapping or excision was often described as the only surgical option. However, due to the high rate of patency loss of the parent artery with standard surgical approaches, in more recent years treatment strategies have focused toward the rise of endovascular techniques, which became the mainstay on elective cases [8,13–16].

In cases of massive, life-threatening bleedings the best management of those lesions is still a matter of debate. We present a case report of the endovascular treatment of IFA in emergency setting and propose an interventional management regimen for petrous carotid artery reconstruction.

Case description and management

To provide the readers with a detailed description of the endovascular management of PCA IFA in the emergency setting an exemplificative case of a left sided skull base abscess, involving and

Abbreviations: IFA, intracranial false aneurysms; PCA, petrous carotid artery; BTO, balloon test occlusion; ACT, activated clotting time; AVMs, artero-venous malformations.

☆ Ethical Standards and Patient Consent: We declare that this manuscript does not contain clinical studies or patient data.

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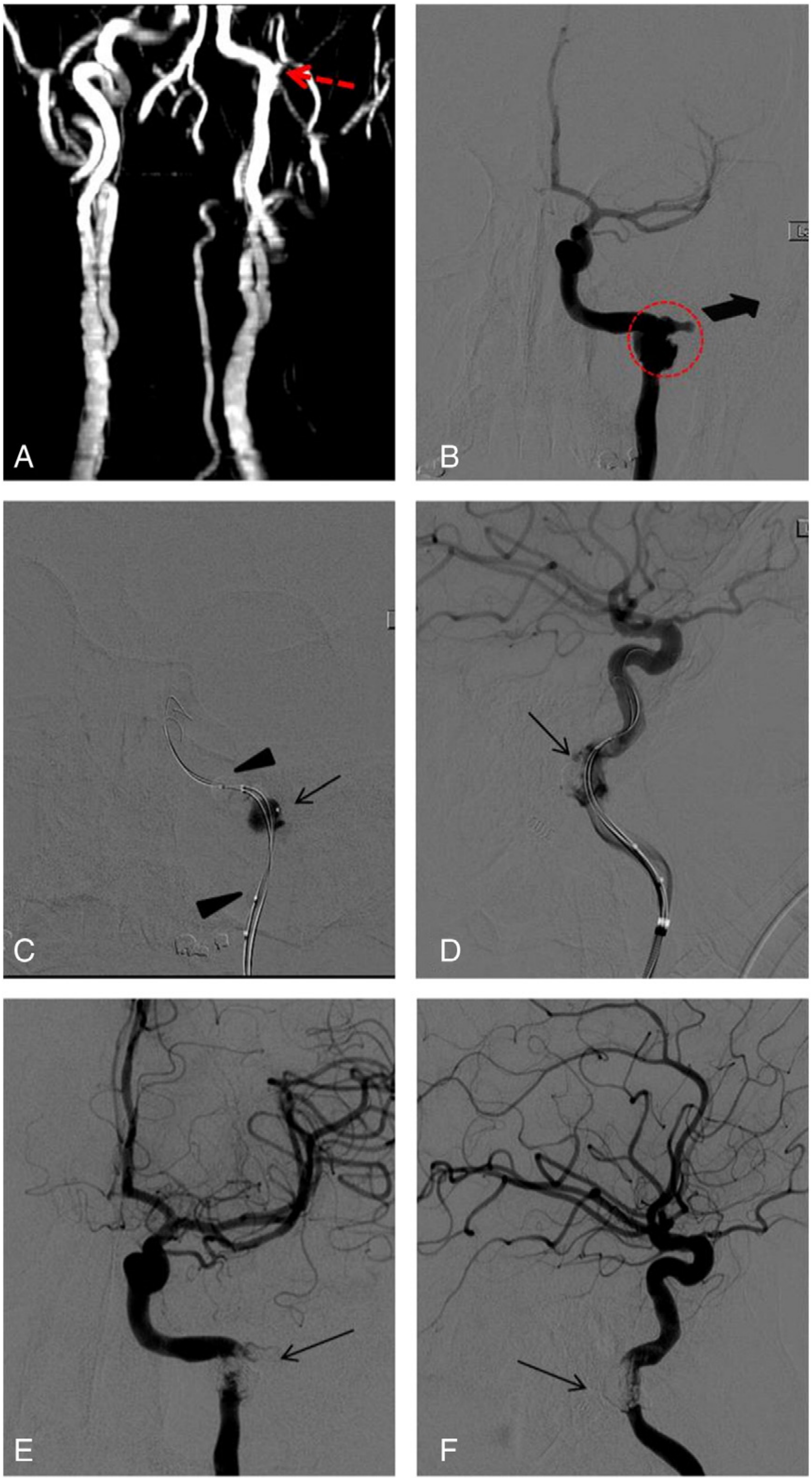

Fig. 1. MRA and DSA. A: Pre-operative MRA shows a large and irregular false aneurysm of the internal carotid artery at its entrance into the petrous bone (red dotted arrow). B: DSA, left ICA, antero-posterior view. The false aneurysm (red dotted circle), points postero-laterally towards the middle ear (thick arrows). C: DSA, left ICA, antero-posterior view. Seal test. Two hyper glide balloons (4 × 7 mm and 4 × 20 mm, arrowheads) were advanced across the false aneurysm (arrowhead). A small amount of contrast was injected trough an Echelon 10 microcatheter after balloon inflation. A good seal test, depicting no extravasation of the contrast along the left petrous ICA and no flow into and out of the lesion (thin arrow), was confirmed. D: DSA, left ICA, lateral view. Reperfusion with partial balloon deflation during Onyx embolization. E, F: DSA, left ICA, antero-posterior and lateral view respectively. The final follow-up angiography shows the 95% obliteration of the false aneurysm (thin arrow) with preservation of the parent artery.

eroding the carotid canal and resulting in a PCA IFA is briefly sketched. This will serve as the basis for further discussion covering treatment indications, technical nuances, as well as possible peri- and post-procedural complications.

Description of the endovascular procedure

The neuroradiologic work up of a 61-year-old man presenting with a massive left sided otorrhagia and subsequent hemorrhagic shock requiring reanimation and assisted ventilation is presented in Fig. 1A and B: the large and irregular PCA IFA responsible for the patient's critical clinical conditions is perfectly identified, along with its anatomical configuration and its relationship with the surrounding vascular, bone and neural structures.

Given the patient's hemodynamic instability a decision to attempt an endovascular treatment following the diagnostic stage of the DSA was made. The 5 F femoral sheath was exchanged for a 7 F shuttle sheath which was placed into the distal left ICA over an angled glide wire; no aneurysm neck could be identified and therefore, coil embolization with or without stenting, was not attempted. Moreover, a Balloon Test Occlusion (BTO), although mandatory in elective cases, could not be performed because of the patient's comatose status, therefore occlusion of the PCA was regarded as a treatment of last resort.

Several attempts were made to pass a covered stent across the lesion. These attempts were unsuccessful mainly because the stent can hardly if ever pass the 90° bend of the PCA junction. At this point a microcatheter was advanced into the IFA. Next, 4 × 7 mm and 4 × 20 mm hyperglide balloons (Micro Therapeutics, Irvine, CA, USA) were advanced across the IFA and inflated using cadence syringes to nominal volume. Low molecular weight heparin (5000 UI every 20 min) was intravenously administered, then a seal test was performed where the iodine contrast agent was injected through the microcatheter into the IFA. As shown in Fig. 1C the seal test confirmed that the balloons were occluding flow into and out of the IFA. The next step was the injection of Onyx-34 embolic agent (EV3 Inc.) through the microcatheter. Injection cycles were performed as follows: 5 min Onyx injection, 3 min balloon occlusion with no Onyx injection, followed by 2 min of partial balloon deflation to allow reperfusion. During the procedure a total of 1.3 cc of Onyx-34 was infused, achieving a 95% obliteration of the PCA IFA with normal distal and parent vasculature filling as shown in Fig. 1E and F. Furthermore, the details of each step are presented and explained in Fig. 2.

Post-operative course and follow Up

The patient was taken to the intensive care unit, where he eventually made an uneventful recovery returning to his neurological baseline without any evidence of focal deficits. No further bleeding occurred, and upon transsphenoidal biopsy of the abscess to detect the causative germ a specific antibiotic treatment was started. Follow up head CT scans were unremarkable. A 3-month Follow UP DSA study revealed the thrombosis of the internal carotid artery proximal to the lesion; despite that no changes in the patient's neurological status occurred.

Discussion

The treatment of PCA IFA is a critical task in the neurosurgical practice from both a microsurgical and endovascular point of view. On one hand, surgical clipping of IFA is extremely challenging, because a proper aneurysm neck does not exist and catastrophic bleeding or potential further damage of the lesion itself can occur during the clip placement [17,18]. On the other, in the last three decades the endovascular embolization has extremely changed the trend of cerebro-vascular disease management, but as further discussed one size doesn't fit all [8,14,19,20]. The endovascular armamentarium has advanced progressively so as, nowadays, it is considered to be the first line of defense against most complex and critical vascular pathologies. With specific regard for the treatment of IFA, or infectious aneurysms, endovascular procedures, including covered stent reconstruction, coil embolization, and parent vessel occlusion were progressively proposed and increasingly adopted to address the challenges related to the absence of a proper aneurysmal neck [3,13–16,18,21–26]. Nevertheless they are not always technically feasible [13,23].

Among all the endovascular tools nowadays available, Onyx, a liquid embolic agent, has showed to be a valuable treatment of saccular aneurysms, dural arteriovenous fistula, artero-venous malformations (AVMs), and as an adjuvant tool to decrease the vascular feeding of angioblastic tumors [10,11,16,17,20,27,28]. Onyx is an ethylenevinyl

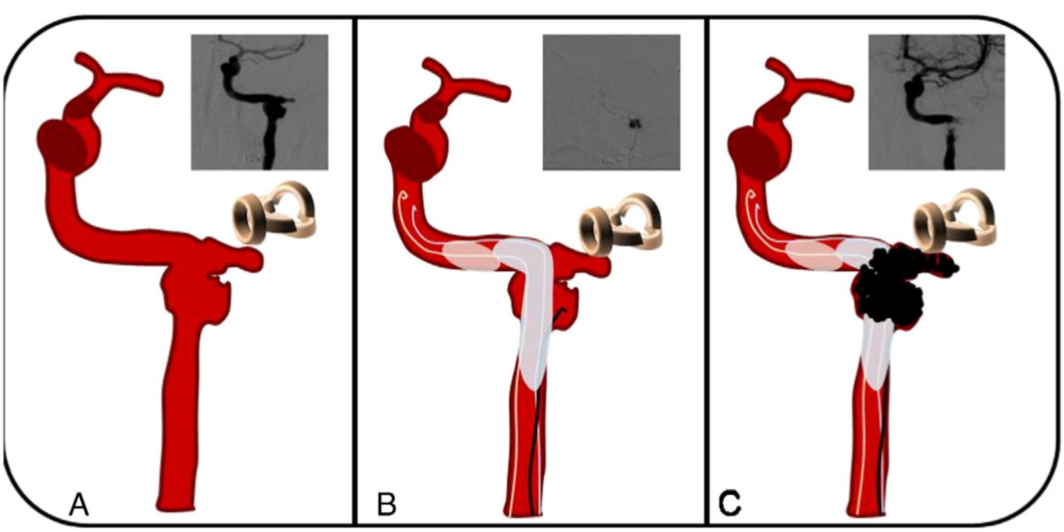

Fig. 2. Schematic drawing of the endovascular procedure. A: A large and irregular false aneurysm formation of the internal carotid artery at its entrance into the carotid canal at the petrous bone is depicted. The close relationship of the tympanic cavity and the semicircular canals to the false aneurysm is seen. B: A microcatheter was advanced into the false aneurysm. Two hyperglide balloons (4 × 7 mm and 4 × 20 mm) were then advanced across the false aneurysm and used to protect the parent vessel. C: Onyx-34 was slowly injected into the false aneurysm, using standard cycling parameters. No Onyx extravasation outside the lesion was seen, and normal distal and parent vasculature filling was preserved.

alcohol copolymer dissolved in an organic solvent, dimethyl sulfoxide, which diffuses away when the solution contacts blood, leading to precipitation of the polymer within the intravascular space. Onyx injection is widely coupled with the balloon assisted technique in order to selectively occlude the lesion, avoiding Onyx migration into the parent vessel. Beside the large application in the treatment of saccular wide-necked aneurysm, to avoid migration of the embolic agent into the parent vessel, this technique is finding a second-line indication also for aneurysmal re-canalization [16,25]. Onyx can also be associated with stent devices or coils in order to provide a more stable aneurysm occlusion. Onyx is supplied in three viscosities, 18, 34 and 500 with higher numbers corresponding to higher viscosities. Onyx 18 is used primarily for AVM embolization where deep nidal penetration is desired. Onyx 34 has been used to treat high flow fistulas or vessel sacrifice where distal embolization is to be avoided. Onyx 500 is for the treatment of wide necked intracranial aneurysms under Humanitarian use device (HUD) FDA approval. The HUD approval limits the application and accessibility of Onyx 500 for cases which fall outside its specific indications [16,26,28].

The use of Onyx in the treatment of IFA is still rarely reported: for instance it was used in two pediatric patients harboring IFA to sacrifice the parent artery, nevertheless both procedures were carried out in an elective manner [13,23]. The use of Onyx in an emergency setting is also becoming a reasonable treatment option for ruptured aneurysms (aortic arch), nevertheless there is still a lack of specific reports regarding its use for intracranial procedures [29,30]. The rationale for applying this technique however is basically the same: whenever endovascular or open repair cannot be considered safely feasible, the internal sealing of the aneurysm with Onyx might be employed as salvage strategy. Given the often acute clinical presentation of IFAs, this strategy should be considered in the decision making process meant to establish their most appropriate management.

To provide the readers with a useful management tool in Fig. 3 we propose a flow chart describing the possible treatment options for IFA and their selective indications. Whenever BTO cannot be performed every attempt must be made to preserve the parent artery blood flow; the morphology of the aneurysm and the conformational architecture of the parent artery are among the factors to evaluate to deem stent assisted coil embolization suitable or not (i.e. the exemplificative case reported perfectly shows that the placing of a covered stent was unsuccessful because of the 90° bend of the carotid–petrous ICA junction). As a result, repeated cycle of Onyx administration and balloon protection technique may be considered as a way out when the other common strategies fail to offer a safe and reasonable management of IFA.

In a salvage strategy, the indications for using Onyx 34 are identical to those recommended for intracranial aneurysm treatment with Onyx 500: the concerns regarding polymerization time and extravasation of low viscosity Onyx beyond the balloon occlusion or through the IFA lumen can be overshadowed by the limited treatment options. In this regard, Fig. 1 (E and F) nicely shows that Onyx 34 can actually perform in an almost identical manner as the higher viscosity Onyx 500, as it provided a satisfying exclusion of the IFA with preservation of the parent vessel.

It is also important to mention that the 3 month follow up DSA revealed a thrombosis of the internal carotid artery proximal to the lesion: without being misled by the fact that it never affected the patient's neurological status, this has to be considered as one of the commonest complications of such endovascular procedures especially in the emergency setting. In fact, the etiology of this phenomenon may be correlated to the underlying disease, as infectious emboli may have occluded the vessel, or to a late thrombotic effect of the Onyx injection. Even though the balloon assisted Onyx embolization may be a helpful and effective tool to provide a prompt safety treatment for ruptured false aneurysm, the potential risk of an unexpected late parent vessel thrombosis has to be taken into account. When feasible, a pre-operative evaluation of the capability of the patient to tolerate a vessel occlusion is advocated and a regular clinical and radiological follow up of these patients is always recommended.

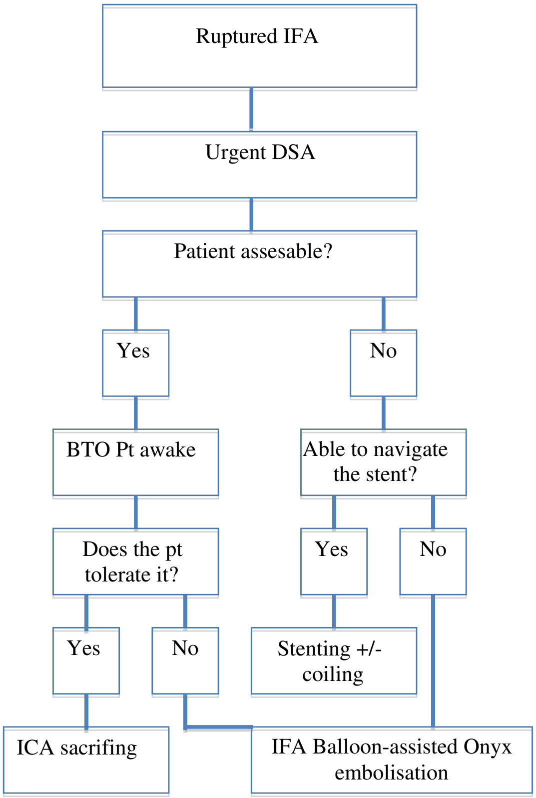

Fig. 3. Flow chart describing the decision making process in the treatment of IFA. *Abbreviations*: IFA: intracranial false aneurysm; DSA: digital subtraction angiography; BTO: balloon test occlusion; ICA: internal carotid artery.

Conclusion

Low viscosity Onyx embolization with parent artery balloon protection may represent a feasible and safe therapeutic option for the emergency treatment of ruptured IFA. However, further studies are warranted to assess the long term safety of this procedure and confirm its efficacy. Furthermore, a strict clinical and neuroradiologic follow-up of these patients is always deemed in order to rule out the possible related complications.

Disclaimer

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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