Original Paper

Provocative Testing Prior to Anterior Cerebral Artery Fusiform Aneurysm Embolization

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Abstract

We report 2 cases of parent artery occlusion (PAO) for anterior cerebral artery (ACA) fusiform aneurysm embolization after superselective provocative testing was performed to confirm distal territory viability. The first case involves a patient in the second decade of life who presented with subarachnoid hemorrhage and underwent PAO after a balloon test occlusion in the distal ACA revealed no neurophysiology changes. The second case involves another patient in the fourth decade of life who presented with an enlarging pseudoaneurysm and underwent PAO after a sodium amobarbital infusion in the distal ACA revealed no clinical change. Both patients tolerated PAO without clinical compromise. PAO after provocative testing may be a safe and effective strategy in the management of fusiform aneurysm treatment. **Key Messages:** Provocative testing with superselective balloon test occlusion and sodium amobarbital infusion are both viable options for clinical and physiological interrogation of brain tissue prior to parent vessel occlusion. Neurophysiological monitoring may be a useful surrogate for clinical examination after provocative testing, particularly if patients were treated under general anesthesia.

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Background

Surgical management of fusiform aneurysms is challenging as these lesions often incorporate essential parent vessels that supply eloquent brain tissue. Several treatment options can be considered, including microsurgical sacrifice with or without bypass [1], stent-assisted

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coiling, or flow diversion [2]. Vessel sacrifice with endovascular embolization may be a viable option [3], particularly if the territory at risk remains viable through collateral blood supply. Selective provocative testing of the target vessel may serve as a proxy to gauge the tolerability of vessel sacrifice. In this report, we present 2 methods, temporary balloon occlusion and sodium amobarbital challenge, to simulate permanent occlusion of the involved anterior cerebral artery (ACA) prior to parent artery occlusion (PAO) for the treatment of pseudoaneurysms. This presentation is unique in utilizing neurophysiological monitoring to evaluate collateral viability during provocative testing.

Case Presentation

Case 1

A patient in the second decade of life with a family history of intracranial aneurysms presented after developing acute onset of headache, nausea, and vomiting in the setting of interhemispheric subarachnoid hemorrhage. Catheter-based angiography revealed a large, right ACA segment 2 (A2) fusiform aneurysm measuring 2 cm (arrowheads, Fig. 1a, b). Under general anesthesia and neurophysiological monitoring, a triaxial system consisting of a 6-F Cook shuttle (Cook Medical, Bloomington, IN, USA), a 0.071-inch guide catheter (Benchmark, Penumbra, Alameda, CA, USA), and a Scepter XC micro-balloon (Microvention, Tustin, CA, USA) was advanced into the distal right internal carotid artery (ICA). The Scepter microballoon was then advanced over a 0.014-inch Synchro-2 micro wire (Stryker Neurovascular, Fremont, CA, USA) into the right A2 segment, distal to the aneurysm (arrows, Fig. 1c, d). The balloon was then gently inflated and a guide catheter run was performed to confirm distal occlusion. Neurophysiological monitoring, including somatosensory-evoked potentials (SSEP), EEG, and motor responses, were stable over a 15-min balloon inflation time. The balloon was then deflated and exchanged for an Echelon-10 micro-catheter and the dissecting aneurysm and parent vessel were then embolized with coils (Target coils, Stryker Neurovascular; arrowheads, Fig. 1e, f). There were no changes in neurophysiological monitoring throughout the procedure. The patient was extubated with intact neurological function on physical examination. At 1 year of follow-up, the patient remained clinically intact with persistent obliteration of the aneurysm on catheter-based angiography.

Case 2

A patient in the fourth decade of life with a history of soft palate rhabdomyosarcoma and glioblastoma multiforme status following resection, chemotherapy, and radiation therapy was found to have an enlarging right pericallosal artery pseudoaneurysm on surveillance MRI of the head. Catheter-based angiography confirmed a 5-mm pseudoaneurysm of the right pericallosal artery (arrowhead, Fig. 2a) on a background of diffuse ACA disease consistent with radiation-induced vasculopathy.

Under conscious sedation, a 0.071-inch guide catheter (Benchmark) was advanced over a Bernstein diagnostic catheter and guide wire into the petrous segment of the right ICA. Superselective angiography better revealed the right pericallosal pseudoaneurysm. Under roadmap guidance, an Echelon-10 micro-catheter over an 0.014-inch Synchro-2 micro wire was advanced to the distal ACA and placed in the proximal aspect of the pseudoaneurysm (arrowhead, Fig. 2b). From this position, 30 mg of intra-arterial sodium amobarbital (Valeant Pharmaceutical, Bridgewater, NJ, USA) was slowly infused followed by 10 ml of saline flush. After sodium amobarbital injection, the patient was serially examined and demonstrated normal language and motor function, including full strength in the left leg. After 15 min of clinical stability, the micro-catheter was flushed with DMSO and Onyx-34 was slowly infused until a cast was visualized under roadmap guidance in the pseudoaneurysm. Follow-up angiographic run confirmed occlusion of the pseudoaneurysm and the distal right pericallosal artery (arrowhead, Fig. 2c).

After the procedure, the patient had intact neurological function on physical examination. At 1 year of follow-up, the patient remained clinically intact with persistent obliteration of the aneurysm on catheter-based angiography.

(For legend see next page.)

Discussion

The management of fusiform aneurysms remains a surgical challenge as definitive treatment requires complete obliteration of the aneurysm, since any residual aneurysm has a high risk of recurrence and rerupture. Resultant compromise of the parent vessel is often unavoidable and perhaps even necessary as the underlying disease pathology typically extends to the parent vessel itself. Preservation of blood flow to normal tissue may be compromised and result in ischemic complications.

Endovascular treatments are preferred since a microsurgical approach may be associated with high morbidity, require complex vessel manipulation and bypass with the possible added technical requirement of two craniotomies to obtain control of the input and output vessels. Coil embolization has previously been shown to be an efficient means for achieving long-term aneurismal obliteration [4], but prior to terminal occlusion of the target vessel, provocative testing may be necessary to understand the likelihood of ischemic complication.

In the most intuitive approach, temporary balloon occlusion test transiently arrests blood supply to the areas that would be permanently affected following a vessel sacrifice. A systematic review of 13 studies showed that applying balloon test occlusion (BTO) as a provocative test prior to ICA occlusion reduces stroke and mortality from 26 and 12% to 13 and 3%, respectively [5]. Sensitivity and complication rate can be improved by combining hypotension with BTO [6]. BTO has been used in awake patients [7], thus allowing clinical testing during provocation. Such an approach may be technically challenging as general anesthesia and paralysis may be necessary to safely catheterize the aneurysm and target vessel. Alternative methods of evaluation, such as neurophysiological monitoring with EEG and SSEP, may be suitable surrogates for clinical examination. Transcranial Doppler (TCD) and SPECT have also been used previously in conjunction with BTO [8]; however, SPECT is not a real-time assay and TCD provides information on hemodynamic fluctuations rather than alterations of central nervous system function. Here, we report a case in which SSEP monitoring of 15 min after temporary balloon occlusion of the parenting vessel suggested no clinical sequelae after vessel sacrifice. It is possible that 15 min of BTO is an inadequate amount of time to sufficiently assay the viability of tissue supplied by the target vessel and that a longer BTO may be indicated. Typically, 15 min appears to be an adequate amount of time for extracranial carotid artery BTO [9]. Additionally, BTO is performed in patients on full dose anticoagulation to avoid thromboembolic complications. In our case, the concern with a longer BTO was the possibility of thrombus formation as the patient could not be anticoagulated in the setting of recently ruptured and unsecured aneurysm.

In certain cases, BTO is avoided as it might propagate dissection or cause thromboembolic complications [3] particularly in the background of a diseased parent vessel [10] or small caliber of the involved vessel [11]. Pharmacological provocative testing is an acceptable alternative, where sodium amobarbital, a short-acting barbiturate that inhibits cortical gray matter neurons via the gamma-aminobutyric acid A (GABA_A) receptor, is injected through a superselective catheter in the target vessel. GABA_A receptors are abundantly found in the gray matter cortex. Therefore, amobarbital suppresses cortical neurons, rather than white matter tracts that are devoid of GABA_A receptors. In contrast, using voltage-gated sodium

Fig. 1. a, b Catheter-based angiogram reveals a right A1 aneurysm and the A2 dissecting aneurysm in case 1 (arrowhead). Position of the microballoon (arrows) for balloon test occlusion in the coronal (**c**) and lateral (**d**) views. **e, f** Catheter-based angiogram after coil embolization confirms parent artery occlusion and aneurysm obliteration (arrowhead).

Fig. 2. **a** Catheter-based angiogram reveals a right distal pericallosal pseudoaneurysm in case 2 (arrowhead). **b** Position of the microcatheter in the distal A2 for superselective injection of sodium amobarbital (arrowhead). **c** Catheter-based angiogram after Onyx embolization confirms parent artery occlusion and aneurysm obliteration (arrowhead).

channel blockers, such as lidocaine, will affect signal transition in both gray matter and white matter [12]. With amobarbital provocative testing, the optimum concentration of the drug (25–125 mg) must be delivered in a volume small enough to prevent reflux and dissipation into more proximal vessels and hence to other cortical areas. In our second case, an infusion of sodium amobarbital in the distal parent vessel suggested no clinical sequelae after vessel sacrifice.

Our report presents 2 distinct approaches to evaluate the safety of PAO for the management of pseudoaneurysms, each tailored for the particular clinical scenario. A larger-scale case series or controlled trial is needed to better understand the generalizability of these approaches.

Disclosure Statement

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Author Contribution

Author contributions to the study and manuscript preparation include the following. Conception and design: A.P. Jadhav. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: P. Moshayedi and A.P. Jadhav. Critically revising the article: all authors. Reviewed submitted version of manuscript: P. Moshayedi and A.P. Jadhav. Approved the final version of the manuscript on behalf of all authors: A.P. Jadhav. Administrative/technical/material support: all authors. Study supervision: A.P. Jadhav.

References

- 1 Gelfenbeyn M, Natarajan SK, Sekhar LN: Large distal anterior cerebral artery aneurysm treated with resection and interposition graft: case report. *Neurosurgery* 2009;64:E1008–E1009; discussion E1009.
- 2 Ducruet AF, Crowley RW, Albuquerque FC, McDougall CG: Reconstructive endovascular treatment of a ruptured vertebral artery dissecting aneurysm using the Pipeline embolization device. *J Neurointerv Surg* 2013;5:e20.
- 3 Coley SC, Hodgson TJ, Jakubowski J: Coil embolization of giant serpentine aneurysms: report of two cases arising from the posterior cerebral artery. *Br J Neurosurg* 2002;16:43–47.
- 4 Higashida RT, Halbach VV, Cahan LD, Hieshima GB, Konishi Y: Detachable balloon embolization therapy of posterior circulation intracranial aneurysms. *J Neurosurg* 1989;71:512–519.
- 5 Linskey ME, Jungreis CA, Yonas H, Hirsch WL Jr, Sekhar LN, Horton JA, et al: Stroke risk after abrupt internal carotid artery sacrifice: accuracy of preoperative assessment with balloon test occlusion and stable xenon-enhanced CT. *AJNR Am J Neuroradiol* 1994;15:829–843.
- 6 Standard SC, Ahuja A, Guterman LR, Chavis TD, Gibbons KJ, Barth AP, et al: Balloon test occlusion of the internal carotid artery with hypotensive challenge. *AJNR Am J Neuroradiol* 1995;16:1453–1458.
- 7 van Rooij WJ, Sluzewski M, Beute GN: Endovascular treatment of giant serpentine aneurysms. *AJNR Am J Neuroradiol* 2008;29:1418–1419.
- 8 Jung YJ, Kim MS, Choi BY, Chang CH: Fusiform aneurysm on the basilar artery trunk treated with intra-aneurysmal embolization with parent vessel occlusion after complete preoperative occlusion test. *J Korean Neurosurg Soc* 2013;53:235–240.
- 9 Tarr RW, Jungreis CA, Horton JA, Pentheny S, Sekhar LN, Sen C, et al: Complications of preoperative balloon test occlusion of the internal carotid arteries: experience in 300 cases. *Skull Base Surg* 1991;1:240–244.
- 10 Fusco MR, Stapleton CJ, Griessenauer CJ, Thomas AJ, Ogilvy CS: Endovascular treatment of intracranial infectious aneurysms in eloquent cortex with super-selective provocative testing: case series and literature review. *Interv Neuroradiol* 2016;22:148–152.
- 11 Wang Q, Chen G, Gu Y, Song D: Provocative tests and parent artery occlusion in the endovascular treatment of distal middle cerebral artery pseudoaneurysms. *J Clin Neurosci* 2011;18:1741–1743.
- 12 Fitzsimmons BF, Marshall RS, Pile-Spellman J, Lazar RM: Neurobehavioral differences in superselective Wada testing with amobarbital versus lidocaine. *AJNR Am J Neuroradiol* 2003;24:1456–1460.