Treatment of carotid-cavernous fistulas using intraarterial balloon assistance: case series and technical note

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Object. Multiple approaches have been used to treat carotid-cavernous fistulas (CCFs). The transvenous approach has become a popular and effective route. Onyx is a valuable tool in today’s endovascular armamentarium. The authors describe the use of a balloon-assisted technique in the treatment of CCFs with Onyx and assess its feasibility, utility, and safety.

Methods. The authors searched their prospectively maintained database for CCFs embolized using Onyx with the assistance of a compliant balloon placed in the internal carotid artery (ICA).

Results. Five patients were treated between July 2009 and July 2011 at the authors’ institution. A balloon helped to identify the fistulous point, served as a buttress for coils, protected from inadvertent arterial embolizations, and prevented Onyx and coils from obscuring the ICA during the course of embolization. No balloon-related complications were noted in any of the 5 cases. All 5 fistulas were completely obliterated at the end of the procedure. Four patients had available clinical follow-ups, and all 4 showed reversal of nerve palsies.

Conclusions. Balloon-assisted Onyx embolization of CCFs offers a powerful combination that prevents inadvertent migration of the embolic material into the arterial system, facilitates visualization of the ICA, and serves as a buttress for coils deployed in the cavernous sinus through the fistulous point. Despite adding another layer of technical complexity, an intraarterial balloon can provide valuable assistance in the treatment of CCFs.

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Key Words • Onyx embolization • carotid-cavernous fistula • balloon assistance

Carotid-cavernous fistulas are abnormal connections between the internal, external, or both carotid arteries and the cavernous sinus. This shunting of blood can lead to ocular venous hypertension and orbital congestive symptoms. Multiple treatments have been tried over the years with variable success. The endovascular approach has demonstrated safety and durable efficacy in the treatment of CCFs. The use of a nondetachable balloon during Onyx embolization (ev3, Inc.) of CCFs has been reported in 2 recently published articles, but the utility and the safety of the technique have not been investigated. We present a series of 5 cases in which a direct or type A CCF was treated using a transvenous or transarterial approach with simultaneous protection of the ICA with a nondetachable compliant balloon. We describe this technique and assess its feasibility, safety, and utility.

Abbreviations used in this paper: CCF = carotid-cavernous fistula; ICA = internal carotid artery; IPS = inferior petrosal sinus; SOV = superior orbital vein.

Methods

We searched our prospectively maintained database for all patients with a CCF who underwent Onyx embolization with the simultaneous use of intraarterial balloons. All procedures were performed under general endotracheal anesthesia and neurophysiological monitoring using electroencephalography and somatosensory evoked potentials. Bilateral femoral access was obtained using a 7-Fr sheath on the arterial side and a 6-Fr sheath on the contralateral venous side. After placement of bilateral sheaths, patients were heparinized, and an activating clotting time was maintained at 2–2.5 times baseline. Standard cerebral angiography was performed, including bilateral internal and external carotid arteries as well as bilateral vertebral angiograms.

The fistula was demonstrated on the arterial run (Fig. 1) and the venous phase was used as a mask to identify the IPS. A 6-Fr guide catheter was placed at the jugular bulb, and the IPS was catheterized using an Echelon 10 (ev3, Inc.) as a conduit to the cavernous sinus. A veno-
gram was performed in all patients to ascertain that the microcatheter was positioned proximal to the origin of the SOV.

At this point, a Hyperglide balloon (ev3, Inc.) was navigated in the arterial side and was left in a position spanning the fistulous site. If the fistulous point was not identified on the ICA angiogram through the guide catheter, a standard microcatheter was advanced and positioned distally to the balloon. The balloon was subsequently inflated to decrease the high flow through the ICA and to allow for the identification of the fistulous point on serial microangiography runs (Fig. 2). Once the fistulous point was identified (Fig. 3), an attempt was made to access the cavernous sinus through the fistulous site. When this approach was unsuccessful, the microcatheter was removed from the arterial side, and access to the cavernous sinus was obtained through the IPS. Coils were deployed in the cavernous sinus transvenously through the IPS or transarterially through the fistulous point using the balloon as a buttress to prevent coil herniation into the ICA. Once coils were deployed, Onyx was carefully injected with the balloon inflated in the ICA (Fig. 4). The balloon was deflated 2 minutes after interruption of Onyx injection, allowing time for Onyx solidification. In cases in which there was still arteriovenous shunting (Fig. 5), the balloon was reinflated and the procedure was continued until no evidence of early venous drainage was identified from the arterial injection (Fig. 6). The microcatheters were removed, and a control angiogram was obtained and was compared with the initial run to rule out embolic events and confirm complete fistula obliteration.

Five patients with type A CCFs (4 women and 1 man), with a mean age of 49 years (range 23–77 years) were treated between August 2009 and September 2011 at our institution (Table 1). All CCFs were successfully embolized using ethylene vinyl alcohol copolymer (Onyx 18) and simultaneous balloon assistance. Two patients were treated transarterially using the balloon as a buttress for coil embolization. In one of these patients, the use of a balloon allowed the identification of the fistulous site as well. The other 3 patients were treated from the venous side with the simultaneous assistance of an intraarterial balloon that allowed the demarcation of the boundaries of the ICA and prevented accidental reflux of the embolic material during the course of embolization. The utility of balloon assistance for all 5 patients is summarized in Table 1.

All fistulas were occluded at the end of the procedure.
Preoperative and postoperative assessment of the intraocular pressure (IOP) was obtained. The IOP decreased immediately in all cases, and no rebound was seen. No worsening of the cranial neuropathies was seen.

No complications were associated with the use of a balloon. One patient with Ehler-Danlos syndrome developed a large retroperitoneal hematoma that required urgent surgical evacuation with no neurological consequence. Among the 5 treated patients, 4 underwent clinical follow-up at a mean time point of 6.5 months (range 1–14 months) (Table 2). All 4 patients had reversal of their nerve palsies at their respective follow-up visits. One patient had an available angiographic follow-up at 8 weeks that confirmed occlusion of the CCF.

### Discussion

Treatment of CCFs can be difficult. Different modalities have been described, including the transarterial approach that is ideal for CCFs with a single arteriovenous connection.6,9 Detachable balloons have been used to obliterate such fistulas but are currently not available in the US. Coil embolization through a transarterial route is a valuable treatment option for CCFs, especially in patients with large fistulous sites such as those that develop following the rupture of carotid cavernous aneurysms. This approach is, however, limited for CCFs with multiple arterial feeders given the difficulty and the risk of catheterizing small arterial feeders.

The transvenous approach, popularized by Debrun et al.,3 constitutes a versatile technique to access the cavernous sinus through different possible routes including the ipsilateral and contralateral IPSs, the facial and angular veins, or the SOV via a surgical cut-down or direct puncture.4 However, this approach is time consuming, and the cost incurred by deploying large numbers of coils to obliterate the fistula can be substantial. Additionally, coils have the potential to compartmentalize in different areas of the cavernous sinus, leaving untreated “pockets” in the sinus and making it difficult for retreatment later on.4,5 Instead, deployment of a few coils, either transarterially or transvenously, provides a framework for Onyx allowing for safer and better embolization of the fistula.6 Once access is obtained, the cavernous sinus can be embolized with coils in a distal-to-proximal fashion, starting usually at the SOV and packing the sinus progressively.

Arat et al.1 described for the first time the use of Onyx in the treatment of CCFs. In contrast to other liquid embolic agents, Onyx is nonadhesive and has unique solidification characteristics that allow precise delivery at the desired location and pace. Onyx also offers the advantage of filling all the intrinsic interstices of the cavernous sinus, making it an ideal agent for embolizing CCFs.

The concomitant use of a balloon has been described during treatment of dural arteriovenous fistulas.7 When embolization is performed through a transarterial route, a balloon can be inflated in the venous circulation to protect a sinus in close proximity to the fistulous site.7 Balloon assistance during embolization of CCFs was used by Zenteno et al.10 and Elhammady et al.5 to increase microcatheter...
Table 2: Etiology, presentation, and outcome of treated patients

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Etiology</th>
<th>Presentation</th>
<th>Follow-Up (mos)</th>
<th>Clinical Outcome</th>
</tr>
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<tr>
<td>1</td>
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<td>CN VI, bruit</td>
<td>5</td>
<td>CR</td>
</tr>
<tr>
<td>2</td>
<td>posttraumatic</td>
<td>HA, CN VI</td>
<td>6</td>
<td>CR</td>
</tr>
<tr>
<td>3</td>
<td>spontaneous</td>
<td>HA, CN VI</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>spontaneous</td>
<td>CN VI</td>
<td>1</td>
<td>CR</td>
</tr>
<tr>
<td>5</td>
<td>spontaneous</td>
<td>CN VI, bruit</td>
<td>14</td>
<td>CR</td>
</tr>
</tbody>
</table>

* CN VI = cranial nerve VI; CR = complete resolution; HA = headache; NA = not available.

purchase and avoid reflux of the embolic material into the arterial circulation. However, these authors did not use the balloon for identification of the fistulous site or demarcation of the ICA during embolization. The latter indication is a potentially key feature of balloon assistance, especially when liquid agents are used to obliterate the fistula. We routinely use the assistance of a conformal, highly compliant balloon such as the Hyperglide (ev3, Inc.) with the purpose of buttressing coils deployed in the cavernous sinus through the rent in the carotid artery wall. Additionally, when using Onyx through a transvenous route, a balloon can protect the ICA from inadvertent embolization into the intracranial circulation. We prefer an elongated conformal balloon (Hyperglide) rather than the highly conformal but shorter balloon (Hyperform, Inc.) that was used by Elhammady et al. In fact, the Hyperglide balloon covers a longer segment, which allows better identification of the carotid artery during the course of embolization.

Having a balloon inflated in the ICA with a trapped microcatheter can help localize the fistulous site, especially when high-flow lesions are approached transarterially. As Onyx injection progresses, it becomes difficult to visualize the boundaries of the carotid artery due to the progressive “encasement” within the Onyx cast. Having the balloon inflated will delimit the boundaries of the ICA while simultaneously preventing accidental Onyx reflux. Two minutes after the injection, the balloon is deflated, and distal branches are checked to rule out embolic accidents. Usually, heparin is avoided during embolization of arteriovenous fistulas or malformations to facilitate clotting. However, we routinely use heparin, targeting an active clotting time around 2.5 times the baseline to prevent thromboembolic events.

Having a balloon in the ICA may add another layer of complexity to these cases and introduces the potential for thromboembolic events. However, we believe that balloon assistance has an excellent safety-efficacy profile and should be given strong consideration in the treatment of CCFs.

Conclusions

Balloon-assisted treatment of CCFs is a useful technique to prevent inadvertent migration of the embolic material within the arterial compartment. Additionally, it facilitates the visualization of the fistulous point and demarcates the ICA.

Although no complications were noted with balloon assistance in this small series, the technique theoretically may increase the risk of thromboembolic phenomenon. Anticoagulation is mandatory when the balloon is inflated. More disseminated use of this technique will be necessary to establish its safety and efficacy. Balloon-assisted treatment of CCFs with Onyx appears to hold tremendous promise as a rapid and safe strategy for complete obliteration of these often challenging lesions.

Disclosure

Dr. Tjoumakaris is a consultant for Stryker, and Dr. Dumont is a consultant for ev3, Inc.

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

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