Curative Onyx embolization of tentorial dural arteriovenous fistulas

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Object. The authors conducted a study to review their experience with tentorial dural arteriovenous fistulas (DAVFs) treated with transarterial endovascular embolization in which Onyx was used.

Methods. The authors reviewed prospectively collected data in 9 patients with tentorial DAVFs treated with Onyx embolization between 2008 and 2011. Information reviewed included clinical presentation, angiographic features, treatment, and clinical and radiologically documented outcome. Clinical follow-up was available in every patient. Radiological follow-up studies were available in 8 of 9 patients (mean follow-up 4.6 months).

Results. Six of 9 patients had complete angiographic obliteration (in 5 this was confirmed by a follow-up angiogram obtained 3–6 months later), and 2 patients had near-complete obliteration (faint filling of the venous drainage in the late venous phase). One patient had partial obliteration and required surgical disconnection. In all patients with complete obliteration, transarterial embolization was performed through the posterior branch of the middle meningeal artery. There were no procedural complications, and no morbidity or mortality resulted from Onyx embolization.

Conclusions. Transarterial Onyx embolization is a valid, effective, and safe alternative to surgical disconnection in many patients with tentorial DAVFs. The presence of an adequate posterior branch of the middle meningeal artery is critical to achieve a microcatheter position distal enough to increase the likelihood of complete obliteration. (http://thejns.org/doi/abs/10.3171/2011.12.FOCUS11323)

Key Words • Onyx • tentorial dural arteriovenous fistula • fistula • embolization

Tentorial DAVFs are relatively uncommon, comprising only 4%–8.4% of all intracranial DAVFs.2,15,17 These lesions have typically demonstrated an aggressive natural history, with hemorrhage or progressive neurological deficits occurring in a reported 97% of cases.2,6 Several characteristics of tentorial DAVFs, including retrograde parenchymal venous drainage, formation of venous varices, and deep drainage through the galenic system, are responsible for their aggressive clinical behavior.4,5,13,16 While DAVFs involving a large dural venous sinus lend themselves to endovascular treatment with either transvenous or transarterial embolization, tentorial DAVFs have often necessitated surgical disconnection to achieve a permanent cure. Many tentorial DAVFs drain directly into subarachnoid veins, making transvenous access impossible.3,4,7,8,12

Abbreviations used in this paper: CTA = CT angiography; DAVFs = dural arteriovenous fistulas; DSA = digital subtraction angiography; MHT = meningohypophyseal trunk; MMA = middle meningeal artery; MRA = MR angiography; OA = occipital artery; PAA = posterior auricular artery; PMA = posterior meningeal artery; SCA = superior cerebellar artery; STA = superficial temporal artery.

The Onyx Liquid Embolic System (Covidien) was approved by the FDA in 2005 for the treatment of intracranial arteriovenous malformations but has been used off label for the treatment of DAVFs.1,11,14 The availability of Onyx has introduced a new endovascular option for tentorial DAVFs otherwise considered better suited for surgical therapy. In this study, we review our experience with 9 consecutive patients with tentorial DAVFs treated with transarterial Onyx embolization.

Methods

Institutional review board approval was received for this study. We reviewed a prospectively maintained database of patients with intracranial DAVFs treated at our institution between 2008 and 2011. Nine consecutive patients (mean age 55.8 years) with a tentorial DAVF underwent Onyx embolization and are the focus of this report. Information collected and analyzed included demographics, clinical presentation, radiological features, therapy, perioperative, and late complications.

After diagnostic DSA was performed, general anes-
the patient had extremely tortuous vessels and there was a faint, very delayed venous filling was considered of no clinical importance. Further MRI in this patient 1 year later did not suggest evidence of revascularization. Both patients are well and free of any symptoms 18 months (Case 3) and 13 months (Case 6) postembolization. Another patient underwent successful surgical disconnection of a lateral tentorial ("petrosal") DAVF a few weeks after a transarterial Onyx embolization attempt had failed to completely obliterate the fistula. Complete occlusion of the fistula was confirmed by immediate postoperative CTA, as well as MRA performed 6 months later. Clinical outcomes were excellent, with 89% of patients reporting complete resolution of initial presenting symptoms/signs. No complications occurred during or after treatment with Onyx.

Illustrative Case

Case 5

This 41-year-old man suffered a seizure and was found to have a small intraparenchymal occipital hemorrhage 2 months prior to evaluation at our institution (Fig. 1). Digital subtraction angiography revealed a small tentorial DAVF supplied by branches of the right OA and the posterior branch of the MMA, with retrograde cortical venous drainage. Using a coaxial technique, an Echelon 10 microcatheter was navigated over a Synchro microguidewire into the posterior branch of the MMA, and a wedge position was achieved. Under constant fluoroscopic roadmap guidance, Onyx 34 was slowly injected until it opacified the proximal portion of the draining vein. After confirming angiographic complete occlusion of the fistula, the microcatheter was uneventfully withdrawn. There were no complications, and the patient was discharged the following day. A 6-month follow-up angiogram demonstrated complete obliteration of the DAVF.

Discussion

We have demonstrated a high rate of complete obliteration and safety of Onyx embolization for tentorial DAVFs. Specifically, 89% of patients with a tentorial DAVF embolized with Onyx had total or near-total obliteration and no complications were exhibited during any of the endovascular procedures. Clinically, 89% of symptomatic patients experienced complete resolution of their symptoms, whereas those presenting with hemorrhage did not experience recurrent bleeds after a mean clinical follow-up time of 4.6 months.

Onyx is a mixture of ethylene vinyl alcohol dissolved in dimethylsulfoxide with tantalum powder added to make the mixture radiopaque. The dissolved polymer is delivered through a microcatheter, and once the polymer is in contact with an aqueous environment it starts to precipitate. Because its ability to disrupt blood flow is based on precipitation and not polymerization, the kinetics are more predictable than glue, such as N-butyl cyanoacrylate. Transarterial N-butyl cyanoacrylate embolization of DAVFs is highly operator dependent because...
TABLE 1: Summary of data in 9 patients with tentorial DAVFs treated with Onyx transarterial embolization

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Presentation</th>
<th>Cognard Grade</th>
<th>Feeding Artery</th>
<th>Embolization via Posterior Branch of MMA</th>
<th>Venous Drainage</th>
<th>Angiographic Outcome</th>
<th>Complication</th>
<th>Clinical Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40, M</td>
<td>pulsatile tinnitus, bruit</td>
<td>III</td>
<td>lt MMA, lt OA</td>
<td>yes</td>
<td>cortical venous</td>
<td>complete obliteration (6-mo FU)</td>
<td>none</td>
<td>persistent tinnitus</td>
</tr>
<tr>
<td>2</td>
<td>61, M</td>
<td>ICH</td>
<td>III</td>
<td>rt MMA, rt OA, rt PMA</td>
<td>yes</td>
<td>cortical venous (varix)</td>
<td>complete obliteration (6-mo FU)</td>
<td>none</td>
<td>resolution</td>
</tr>
<tr>
<td>3</td>
<td>73, M</td>
<td>ICH</td>
<td>III</td>
<td>rt OA, rt STA, rt PAA</td>
<td>no</td>
<td>cortical venous (varix)=superior sagittal sinus</td>
<td>near-total obliteration (1-mo FU)</td>
<td>none</td>
<td>resolution</td>
</tr>
<tr>
<td>4</td>
<td>68, F</td>
<td>incidental discovery</td>
<td>III</td>
<td>rt MMA</td>
<td>yes</td>
<td>basal vein of Rosenthal (varix)</td>
<td>partial obliteration (went on to have op disconnection, confirmed on MRA at 6 mos)</td>
<td>venous stasis inhibited transvenous attempt, op disconnection necessitated</td>
<td>resolution</td>
</tr>
<tr>
<td>5</td>
<td>41, M</td>
<td>ICH, seizure</td>
<td>III</td>
<td>rt MMA, rt OA</td>
<td>yes</td>
<td>cortical venous</td>
<td>complete obliteration (6-mo FU)</td>
<td>none</td>
<td>resolution</td>
</tr>
<tr>
<td>6</td>
<td>54, M</td>
<td>ICH, vision abnormalities</td>
<td>III</td>
<td>lt MMA</td>
<td>yes</td>
<td>cortical venous (varix)</td>
<td>near-total obliteration (6-mo FU)</td>
<td>none</td>
<td>resolution</td>
</tr>
<tr>
<td>7</td>
<td>72, M</td>
<td>speech arrest</td>
<td>III</td>
<td>lt MMA, lt SCA, lt PMA</td>
<td>yes</td>
<td>cortical venous (varix=along basal vein of Rosenthal)</td>
<td>complete obliteration (3-mo FU)</td>
<td>none</td>
<td>resolution</td>
</tr>
<tr>
<td>8</td>
<td>21, M</td>
<td>ICH</td>
<td>III</td>
<td>lt MMA, lt OA</td>
<td>yes</td>
<td>cortical venous (varix=transverse sinus)</td>
<td>complete obliteration (3-mo FU)</td>
<td>none</td>
<td>resolution</td>
</tr>
<tr>
<td>9</td>
<td>72, F</td>
<td>rt leg paresis, diplopia, &amp; ataxia</td>
<td>III</td>
<td>lt MHT, lt MMA</td>
<td>yes</td>
<td>via pial veins</td>
<td>complete obliteration</td>
<td>none</td>
<td>resolution of diplopia, improvement of paresis</td>
</tr>
</tbody>
</table>

* FU = follow-up; ICH = intracerebral hemorrhage.
the glue quickly polymerizes (unless a wedge position can be achieved), often leading to inadequate filling of the proximal draining vein. Complete filling of the proximal vein is a critical component for definitive endovascular cure of these lesions. Onyx represents a more controllable solution to treating DAVFs with direct cortical venous drainage from the arterial side. The unique features of Onyx make it ideally suited for the treatment of DAVFs with direct cortical venous drainage, and it has profoundly changed our practice for this specific type of DAVF, which until a few years ago was almost exclusively treated with open surgical exclusion at our institution. Because the Onyx permeates the actual fistula, it often refluxes into incoming additional small feeders, ensuring progressive slowing of incoming blood while the fistulous tract and the proximal portion of the draining vein are being obliterated. While the embolization progresses, it is important not to end the procedure as soon as the material is seen permeating the proximal draining vein. This embolizing material often coats the wall of the vessel before actually filling the entire lumen. Thus, angiographic opacification of the proximal vein with Onyx is not always synonymous with complete obliteration. In the final stages of the embolization, it is also critical to use a low frame rate and allow the angiogram to run well into the late venous phase to rule out small persistent and delayed filling of the fistula. One of the limitations of Onyx is the issue of reflux, because the material has a tendency to reflux alongside the microcatheter during injection. While the material is refluxing, care has to be taken to avoid migration of the material into dangerous anastomoses and/or retrograde filling of important branches (in the case of the posterior branch of the MMA, the petrous branch to the facial nerve). Microcatheter retrieval is usu-

**Fig. 1.** Studies obtained in a 41-year-old man who presented with a seizure. 

**A:** A small inferior occipital hemorrhage was found.  

**B:** Right external carotid artery digital subtraction angiogram, lateral projection, showing a DAVF (black arrows) fed by the posterior branch of the MMA and OA, with retrograde drainage through a vein that emerges from the insertion of the tentorium (arrowheads) to drain in a retrograde fashion through inferior temporal veins (not shown). 

**C:** Anteroposterior projection outlining the proximal venous drainage (arrowheads). 

**D:** Anteroposterior “road map” showing the catheter in the distal posterior meningeal branch and an Onyx cast of the proximal cortical vein. 

**E:** Unsubtracted right external carotid artery angiogram, lateral projection, showing the microcatheter (black arrow) in the posterior branch of the MMA with an Onyx cast in the venous nidus (arrowheads). 

**F:** Anteroposterior projection angiogram. 

**G and H:** Six-month follow-up lateral (G) and anteroposterior (H) projection angiograms revealing complete resolution of the fistula.
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ally not a major issue even in the setting of significant reflux because, in the external artery carotid system, a much higher traction can be safely applied than in the case of parenchymal vessels.

Other authors have observed similar rates of high angiographic obliteration when using Onyx for tentorial DAVFs.\textsuperscript{3,10} Unlike our own series, however, these previous studies reported relatively high rates of complications. These complications, reported in up to 24\% of treatments, included venous rupture, migration of the Onyx embolus, trigeminocardiac reflex in 10\% of patients, and tissue infarction due to Onyx reflux through anastomoses. Anatomical and technical considerations are key to avoiding perioperative complications. We found that the availability of a “sizeable” posterior branch of the MMA is critical to the success of Onyx embolization for tentorial DAVFs. The posterior branch of the MMA is a relatively straight vessel and is often enlarged when feeding a DAVF. These characteristics allow for distal catheterization adjacent to the point of the fistula, unlike other common feeders such as the OA, which is often excessively tortuous and makes distal catheterization difficult if not impossible. Distal catheterization almost in a wedge position allows for forward progression of the embolic material, limiting the reflux to a minimum. When embolizing from the posterior MMA branch, it is critical to avoid any reflux into the petrosal branch, which supplies the facial nerve.

Conclusions

We have found transarterial Onyx embolization to be effective and safe in the treatment of tentorial DAVFs. The presence of an adequate posterior branch of the MMA is critical to achieve a microcatheter position distal enough to increase the likelihood of complete obliteration.

Disclosure

Dr. Lanzino reports receiving an unrestricted education grant from ev3/Covidien.

Author contributions to the study and manuscript preparation include the following. Conception and design: Lanzino. Acquisition of data: Lanzino, Puffer, Daniels. Analysis and interpretation of data: all authors. Drafting the article: Puffer, Daniels. Critically revising the article: Lanzino, Daniels, Kalilmes, Cloft. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Lanzino. Study supervision: Lanzino.

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