**Onyx transarterial embolization of dural arteriovenous fistula for failed N-butyl cyanoacrylate treatment: case report**

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**Abstract**

**Objective:** To report efficacy of transarterial Onyx embolization of dural arteriovenous fistulas (DAVFs) previously treated with N-butyl cyanoacrylate (NBCA). Two cases are presented with special considerations given to the technical and anatomical aspects based on operative findings.

**Case Presentation:** Superior petrosal and tentorial DAVFs presented with tinnitus and cortical venous reflux, headache with decreased cognitive function respectively. The DAVFs were initially treated with multiple injections of NBCA ending in persistently remaining fistula, subsequently leading to recurrence. Transarterial Onyx embolization was performed, resulting in penetration of Onyx into the complex vascular network and draining veins, with retrograde filling of multiple feeding arteries. The affected sinuses was preserved.

**Conclusion:** With the potential of better penetration of Onyx, transarterial Onyx embolization may be capable of treating recurrent NBCA-treated DAVFs. Larger number of cases and longer follow-up are required to determine the efficacy and safety of transarterial Onyx embolization of DAVFs.

**Key Words**

DAVF, dural arteriovenous fistula, NBCA, Onyx, transarterial embolization

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(Received November 9, 2009 : Accepted November 25, 2009)

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**Introduction**

Total occlusion of dural arteriovenous fistulas (DAVFs) via transarterial embolization is difficult due to the rich anastomotic network of the dural/falcine plethora of feeding arteries, blood supply to cranial nerves, and extracranial to intracranial anastomoses. Incomplete occlusion of the fistulas will result in recanalization of the DAVF from the multiple collateral arteries constituting the dural blood supply. Transvenous occlusion or surgical skeletonization of true sinus or resection of the affected venous sinus has been reported effective in selected cases.12-13 However, these treatments can be hazardous when the venous sinus drains cortical or deep veins. When total occlusion of a DAVF is difficult, surgical or endovascular selective disconnection of cortical venous reflux to control the disease is reported effective in DAVFs with combined sinus drainage and cortical venous reflux.11

Onyx (ev3, Irvine, CA, USA) is a new liquid embolic agent with longer precipitation time enabling prolonged injection time, with potential of better penetration into a fistulous network. Previous reports have described initial successful transarterial Onyx embolization of DAVF as a primary treatment.12-13 In our report, we present successful Onyx DAVF embolization in recurrent DAVFs previously treated with N-butyl cyanoacrylate (NBCA). Focus is given on the technique and anatomical considerations of transarterial DAVF Onyx embolization based on intraprocedural findings.

**Case Presentation**

1. **Case 1**

A 41 year-old woman presented in May 2004 with an incidental right petrous DAVF discovered during workup for a head trauma. Neurological examination was normal except for pulsatile tinnitus, which she had been aware for several years. The patient initially underwent transarterial NBCA embolization from the right middle meningeal and occipital artery branches. Three embolizations were performed from the middle meningeal branches and one from the occipital artery branch, resulting in significant decrease of the shunt to
Fig. 1 Right common carotid artery angiogram in lateral view (A) show persistent right petrosal DAVF, supplied from C5 branch of the internal carotid artery, recurrent meningeal branch of the ophthalmic artery (black double arrow), artery of foramen rotundum (black arrow), middle meningeal artery (white double arrow), accessory meningeal artery (white arrow), and occipital artery. Venous drainage is to a superficial cortical vein with a venous ectasia in the right cerebellar hemisphere (white arrowheads), then to the lateral mesencephalic vein (black arrowheads), draining to the basal vein of Rosenthal. Note persistent trigeminal artery. Post Onyx embolization unsubtracted image in anteroposterior (B) and lateral (C) views demonstrate Onyx cast filling the vascular network of the fistula and the affected sinus. Mid-arterial phase of post-embolization right common carotid artery angiogram in lateral view (D) shows complete occlusion of DAVF.

the fistula. However, persistent filling of the DAVF remained (Fig. 1A) 18 months after the first embolization with feeders from right middle meningeal artery (white arrow), accessory meningeal artery (white double arrow), artery of foramen rotundum (black arrow), recurrent meningeal artery from the ophthalmic artery (black double arrow), occipital artery, anterior inferior cereberellar artery, and bilateral C5 branches of the internal carotid arteries. Venous drainage
was to a superficial cortical vein with a venous ectasia in the right cerebellar hemisphere (white arrowheads), then to the lateral mesencephalic vein (black arrowheads), which drained to the basal vein of Rosenthal. The patient underwent a second procedure in November 2005 using Onyx. Under general anesthesia, the right occipital artery transmastoid branch was catheterized with a 5Fr Envoy (Cordis, Miami Lakes, FL, USA) guiding catheter. A Marathon (ev3, Irvine, CA, USA) microcatheter was advanced close to the fistula site with the aid of Silverspeed 10 (ev3 Irvine, CA, USA) and Mizzen Soft (Boston Scientific, Fremont, CA, USA) microguidewires. The microcatheter was flushed first with 40 mg of lidocaine to prevent vasospasm, then 3 ml of normal saline, and then with 0.23 ml of dimethyl sulfoxide (DMSO) over 2 minutes, followed by 2.4 ml of Onyx 18 injection over 45 minutes. The Onyx was slowly and continuously injected with intermittent pauses from 20 to 45 seconds whenever reflux of Onyx was observed to the catheterized access vessel or when the Onyx started to penetrate into an unfavorable vessel (normal vessel, functional venous sinus, etc). Frequent interim angiograms of all potential circulations using a second diagnostic catheter were performed to monitor safe and
progressive Onyx deposition. Special attention was paid to avoid the Onyx refluxing or penetrating into vital vessels such as an internal carotid artery or a venous sinus through feeders and anastomoses. The Onyx penetrated the fistula to the venous sinus and could be controlled to permit reflux into the multiple feeding arteries, to assure total occlusion without sacrificing the sinus. The microcatheter was retrieved with gentle traction. Post-embolization unsubtracted skull image in anteroposterior and lateral views demonstrated the cast of Onyx obliterating multiple feeders and the affected sinus (Fig. 1B, C). Angiogram showed complete occlusion of the DAVF (Fig. 1D). No transient or permanent neurological or procedure related complications were encountered. Six-month follow up angiogram demonstrated stable occlusion of the DAVF.

2. Case 2

with decrease of the shunt to the DAVF, and improvement of
the exophthalmos and cognitive function each time. Workup
MRI for increasing headaches and cognitive decline in August
2005 showed evidence of increased cortical venous reflux and
venous hypertension that warranted another treatment. The
DAVF was supplied from bilateral middle meningeal,
occipital, posterior meningeal arteries, recurrent meningeal
artery from bilateral ophthalmic arteries, and left anterior
calcarine artery (Fig. 2A-D). There was supply from meningeal
branches of bilateral posterior cerebral arteries as well (Fig.
2A, C). Venous drainage was to the vein of Galen with reflux
of contrast to the posterior portion of the superior sagittal
sinus and the cortical veins. The most prominent recurrent
meningeal artery off the right ophthalmic artery (Fig. 2A
arrowheads) was embolized with NBCA, followed by
transarterial Onyx 18 embolization from two right middle
meningeal artery branches. A 5Fr Envoy guiding catheter was
selectively placed into the right internal maxillary artery and
another 5Fr Envoy guiding catheter was placed into the right
common carotid artery for control angiogram. A Marathon
micrcatheter and Silverspeed 10 microguidewire was
employed in the two Onyx embolizations. A total of 4.6 ml
Onyx was injected from 2 middle meningeal artery branches,
each injection taking 30 minutes. Both micrcatheters were
retrieved with gentle traction without incident. In November
2006, a second-stage procedure was performed. Two 5Fr
Envoy catheters were placed in bilateral common carotid
arteries. The right side was used for catheterization of the
fistula, and the other was used for intermc control angiogram.
A right middle meningeal artery feeder was catheterized
close to the fistula at the vein of Galen with a Marathon
micrcatheter and 0.008 Mirage (BALT, Montmorency,
France) microguidewire. Total of 3.0 ml Onyx was injected in
41 minutes. The Onyx was able to penetrate the vascular
network in the wall of the dilated vein of Galen and refluxed
to multiple feeding arteries. Notably, the Onyx also
penetrated to the contralateral nidal network in the dural wall
of the vein of Galen from the right middle meningeal artery
injections. The cast of Onyx almost represents the
configuration of the vein of Galen (Fig. 2E). The embolization
resulted in significant decrease in the arteriovenous shunt,
preserving the vein of Galen (Fig. 2F, G). The micrcatheter
was retrieved in 3 seconds with gentle traction. The patient
experienced transient severe headache after the first
procedure, which was well-controlled with dexamethasone.
The patient recovered from the headache and cognitive dysfunction
and remains stable. She is currently under observation for
signs for neurological decline, at which further intervention
will be considered.

Discussion

Until present, transarterial embolization of DAVF with
embolic materials such as NBCA, ethanol, coils, and particles
was largely unsatisfactory for extensive lesions due to
proximal feeding artery occlusion and subsequent
reestablishment of arterial blood supply through numerous
collateral vessels. Cure may be achieved in selected cases
if permanent embolic agents such as NBCA or ethanol can be
used effectively and safely. If NBCA can be injected under
flow control, transarterial embolization of DVF can be more
effective. However, Onyx, with its enhanced ability to
penetrate, may overcome this shortcoming.

Onyx liquid embolic system is an ethylene–vinyl alcohol
copolymer (EVOH) dissolved in DMSO, mixed with
tantalum. EVOH precipitates in aqueous condition with
dissolution of DMSO providing mechanical occlusion of the
vessel. The characteristic feature of Onyx is that it is a non
adhesive material that allows prolonged injection time. In the
brain arteriovenous malformation (AVM), this feature
enabled the Onyx to penetrate better into an AVM nidus and
regradrally occlude multiple arterial feeders.

There have been several reports of transarterial
embolization of DAVF using Onyx as the primary
treatment. All reported excellent occlusion of the fistula due
to improved penetration of the embolic material as well as
lesser arterial catheterizations. In this report, we present
successful treatment of recurrent DAVFs previously embolized
by NBCA using transarterial Onyx injection. Two conclusions
may be deduced from our experience. First, repeat treatment
of DAVFs previously treated by NBCA is feasible.
Incomplete occlusion of the fistulas almost always resulted in
recruitment of multiple collateral arteries constituting the
dural blood supply, leading to recurrence. In our cases,
recurrence resulted in enlargement of another arterial feeder
enabling access for retreatment. Second, Onyx may be a more
potent agent in transarterial DAVF embolization than NBCA.
Although NBCA embolization was effective in reducing the
arteriovenous shunts, it was to a lesser extent than that
achieved by Onyx. Our cases may be examples of showing the
efficiency of Onyx over NBCA. However, further studies are
necessary to conclude what the most effective treatment is for
DAVF.

For better penetration of the Onyx into the nidal network
and retrograde filling of the multiple feeding arteries, the tip
shunting of a DAVF may not be a collection of multiple single fistulas opening into a venous sinus. In case 2, the Onyx penetrated the nidal network of the dural covering of the vein of Galen, reaching to the contralateral surface before entering the vein of Galen. The configuration of the Onyx cast almost shows the outline of the vein of Galen. An illustrative example of this is shown in Fig. 3. After the majority of the fistula was occluded in a left transverse-sigmoid sinus DAVF with Onyx, a left occipital artery injection opacified the nidal network of the DAVF and retrogradely visualized the entire arterial feeder of the fistula. The injection shows occipital artery branches supplying the dural fistula, retrograde visualization of the nidal network and multiple feeders of middle and posterior meningeal arteries, and internal carotid artery C5 branches. Reflux of contrast through the nidal network reaches as far as the internal carotid and vertebro-basilar arteries. This nidal network was not seen in conventional angiogram and was only observed after closure of the majority of the fistula, thus opening up potential anastomosis. Carlson et al., in their report have indicated to the presence of such network, and we have angiographically demonstrated the existence of the network. These observations that some DAVFs possess a nidal network interconnecting multiple feeders may have important impacts on DAVF treatment. First, with better penetration ability of the Onyx, this type of DAVF may benefit most from transarterial Onyx embolization. Second, this shows the possibility that certain DAVFs can be treated transarterially without venous sinus sacrifice, as experienced in our cases. Third, this may expand the indication for endovascular DAVF treatment in such cases as curative venous sacrifice may not be an option due to absence of venous outflow restrictions, or cortical venous drainage. Forth, this nidal network may be a potential source of recanalization after incomplete transarterial or transvenous embolization.

To determine the exact indication for transarterial Onyx DAVF embolization, and its long-term effectiveness, further experience and study are necessary. For safe injection, anatomical analysis and assessment of the potential anastomosis and the supply to transcranial nerves is mandatory. The present technique of reflux and “plug” formation on the delivery catheter is still not optimal. Advances in delivery catheters with detachable tips, proximal control, or other forms to obtain control in forward delivery of Onyx are forthcoming, which will further add to its safety and reliability.
Conclusion

Transarterial Onyx embolization was effective in treating recurrent DAVFs previously treated by transarterial NBCA injection. Plug formation at the tip of the microcatheter and double catheter technique was applied in the embolization. With the potential of better penetration of the Onyx and from our observations that in certain DAVFs a nidal network is interconnecting with other feeding arteries, transarterial Onyx embolization may be a more effective treatment for DAVF than transarterial embolization with previously used embolic agents or certain transvenous embolizations. Larger number of cases and longer follow up are required to determine the efficacy and safety of transarterial Onyx embolization of DAVFs.

References