Combined Trans-Arterial Coil and Percutaneous Onyx Embolization for Treatment of an Extracranial High-Flow Arteriovenous Malformation

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ABSTRACT

Facial and scalp arteriovenous malformations (AVM) are a relatively uncommon clinical finding. An arteriovenous malformation is an abnormal connection between a feeding artery and a draining vein without an intervening capillary bed. This allows for the creation of a high flow low resistance circuit. We present a case of a young male treated for a high flow extracranial arteriovenous malformation of the forehead. The lesion was embolized using both metallic coils and ethylene-vinyl alcohol (Onyx; ev3, Irvine, CA). The embolization facilitated subsequent surgical removal of the devascularized mass. The current literature on optimal embolic agents and technical strategies for extra-cranial AVM treatment is fairly limited. This case report will present the method used at our institution.

The patient is a 14-year-old male referred to the multidisciplinary vascular malformations clinic for headaches and evaluation of a forehead mass. The mass was originally flat, but had progressively grown outward for a few years prior to presentation. The patient’s symptoms included headaches, nausea, and minor bleeding episodes. Physical exam was remarkable for an 8 x 4 cm (cranio-caudal x transverse) pulsatile, warm, protruding forehead mass. Ultrasound of the lesion revealed multiple high velocity low resistance superficial vascular channels consistent with the diagnosis of a high flow AVM. Subsequent magnetic resonance imaging/magnetic resonance angiography (MRI/MRA) was conducted to further characterize the feeding and draining vessels of the lesion to aid in treatment planning. Diagnostic carotid angiography revealed arterial contributors from the anterior and posterior division of the superficial temporal artery with multiple dominant draining veins. Combined transarterial coil and percutaneous Onyx embolization was performed until no further flow could be detected. There were no post-procedural complications and surgical excision was performed the following day. The patient is recovered well. Optimal embolic agents and technical strategies for pre-surgical embolization of high flow extracranial arteriovenous malformations have yet to be defined. Our institution achieved complete devascularization of an AVM utilizing a combination of transarterial coil embolization and percutaneous injection of Onyx.
A 14-year-old male was referred to the multidisciplinary vascular malformations clinic for headaches and evaluation of a forehead mass that had been present for several years. Per the patient and his family, the mass was originally a flat lesion, but over the past two years had grown outward with visible pulsations. The patient reported headaches every other day, sometimes severe, with associated nausea and vomiting. There had been 3 episodes of minor bleeding from the mass in the past few months, which were controlled with manual pressure. He also noted longstanding visual impairment in his left eye; however, he was able to see specific colors and shapes. Family history was noncontributory. The patient had no allergies and was not on any medications. Physical exam was remarkable for a slightly hyperpigmented 8 x 4 cm (cranio-caudal x transverse) pulsatile, warm, protruding forehead mass with an associated thrill (Figure 1).

Characterization of the lesion using ultrasound revealed multiple low resistance superficial vascular channels with associated turbulence and aliasing from high velocities. The findings were consistent with the diagnosis of a high-flow arteriovenous malformation (Figure 2). A magnetic resonance imaging/magnetic resonance angiography (MRI/MRA) was performed to identify the extent of the lesion as well as the location of the contributory arterial vasculature and draining veins for the nidus (Figure 3). This revealed a midline frontal scalp AVM with arterial feeders arising from the bilateral superficial temporal arteries (STA) as well as an arterial feeder to the left of midline from the region of the medial canthus. Venous drainage was primarily from an antero-inferior draining vein extending to the bilateral angular/facial veins. There was no detectable intracranial pathology.

The patient then underwent bilateral carotid angiography. The right external carotid artery was
selected and angiogram was performed demonstrating a tortuous and hypertrophied superficial temporal artery with an anterior branch supplying the midline arteriovenous malformation (Figure 4A). There also appeared to be some arterial contribution from the posterior branch of the STA. There were numerous draining veins including dominant anteriorly and posteriorly directed veins consistent with MRA results. The catheter was then used to select the left external carotid artery and angiography was performed which demonstrated a similarly tortuous and hy-

**Figure 4.** Digital subtraction angiography from right (A) and left (B) external carotid artery injections shows arterial supply to the AVM from the superficial temporal artery (solid arrow).

**Figure 5.** A. Fluoroscopic image from percutaneous access of the dominant anterior draining vein with Onyx injection. B. Fluoroscopic image from percutaneous access of the nidus with Onyx injection.
pertrophied STA (Figure 4B). No abnormal collaterals between the feeding arteries and ophthalmic arteries were noted.

A microcatheter was then used to super select the anterior divisions of the superficial temporal arteries bilaterally and coil embolization was performed to complete occlusion. All catheters and wires were then removed. Next under ultrasound guidance, the dominant anterior and posterior draining veins on the forehead were accessed with a 21-gauge needle (Figure 5A). The outflow veins were manually occluded and retrograde Onyx embolization was performed with intermittent ultrasonographic and fluoroscopic guidance. Subsequently the nidus of the mass was directly accessed and embolization repeated until no further flow was detected by ultrasound (Figure 5B).

Post-embolization fluoroscopic images showed excellent filling of the lesion with Onyx and cast formation (Figure 6). Ultrasound showed no remaining intra-lesional flow confirming devascularization. The patient was taken to surgery the following day for resection and reconstruction and discharged on post-operative day one with no complications. Patient is doing well as of May 2014 and will be seen at 1-year follow-up intervals.

**DISCUSSION**

An arteriovenous malformation (AVM) is an abnormal connection between a feeding artery and a draining vein without an intervening capillary bed. This allows for the creation of a high-flow low resistance circuit with transmission of arterial pressures into the venous system. Simple malformations are those with one or few contributing vessels, while complex lesions have multiple feeding arteries and draining veins. AVMs can be congenital, traumatic, or idiopathic, with the latter being most common. They can also present as part of syndromic conditions such as Osler-Weber-Rendu. AVMs can be asymptomatic; however, patients occasionally develop problematic clinical consequences beyond esthetic and social disturbances. Common patient complaints include headaches, pain, tissue overgrowth, and bleeding. Physical exam can demonstrate a discolored cutaneous mass with warmth, pulsatility, and palpable thrill. If the AVM is untreated, patients can go on to develop high output cardiac failure. While these lesions can be diagnosed clinically, diagnostic imaging techniques can be used to further assess and map the lesion for treatment planning.

Face and scalp AVMs are relatively uncommon. The different treatment strategies include transarterial embolization, transvenous embolization, direct percutaneous embolization, electrothrombosis, and surgical excision or ligation. Previously, surgical resection or ligation was the primary treatment; however, with the recent advancement of endovascular techniques, embolization is often the initial treatment of choice for these lesions. Recent developments in microcatheter design allow for the use of a variety of different embolic agents including particles, coils, liquid N-butyl cyanoacrylate (NBCA) and ethylene-vinyl alcohol copolymer (Onyx; ev3, Irvine, CA). The majority of the literature on the treatment of extra
and intracranial arterio-venous malformations focuses on the use of NBCA and Onyx. Onyx is ethylene-vinyl alcohol mixed with DMSO and micronized tantalum powder. The EVOH/tantalum mixture precipitates within the vessel lumen leading to occlusion. Purported advantages of Onyx include its non-adhesive nature allowing for longer injection times, ability to suspend and proceed with embolization as needed, and decreased incidence of catheter tip adhesion to the vessel wall. Disadvantages include DMSO-induced vasospasm and angiotoxicity leading to necrosis. NBCA is an adhesive agent that acts by rapid polymerization producing an exothermic reaction causing protein denaturation and inflammation, which leads to vessel thrombosis and fibrosis ultimately creating a hard cast. Advantages of NBCA include the ability to vary the polymerization rate by altering the NBCA and Ethiodol mixture ratios, while Onyx only comes in two formulations. In addition, NBCA makes a hard permanent cast of vessels, which has been reported to aid in surgical excision of the lesion. Disadvantages are that the use of NBCA requires expertise. Frequent catheter flushing with 5% dextrose is needed to prevent glue polymerization within the catheter lumen. The most commonly reported disadvantage of NBCA is increased frequency of catheter tip adhesion to the vessel wall. Lastly the polymerization can spread distally or reflux proximally, causing non-target vessel injury. Ultimately, the decision whether to use NBCA or Onyx continues to be user preference and familiarity. A randomized controlled trial conducted by Loh and Duckwiler showed no statistically significant difference between Onyx and NBCA in achieving AVM volume reduction of at least 50%. 

Several techniques have been described to help achieve maximum devascularization of AVMs. A transarterial approach with metallic coil embolization of arterial feeders can be used as an initial step to decrease flow to the nidus. Diagnostic angiography of extracranial AVMs is important prior to vessel occlusion to prevent non-target embolization of ophthalmic artery collaterals to reduce the risk of injury to the eye. There have also been reports of superficial skin necrosis from bilateral superficial temporal artery occlusion. When using liquid embolic agents such as NBCA or Onyx transarterially, reflux into proximal vessels can be problematic. Balloon inflation proximal to the catheter tip and plug and push methods can be used to minimize non-target embolization. Plug and push involves forming an Onyx plug proximally in the artery followed by advancement of the catheter tip distally prior to additional Onyx injection.

Percutaneous nidus and venous outflow puncture to directly inject embolic agent into the lesion is preferred by some authors. It can be an effective, safe, and time saving technique as compared to the transarterial route. Direct puncture minimizes retrograde reflux into arteries and also decreases the possibility of incomplete embolization, which can result in the recruitment of new collateral feeders to the nidus. Compression of the draining veins with liquid embolic agents is important to decrease complications arising from distal migration such as pulmonary embolism and occlusion of normal venous drainage. External band ligation, manual compression, and circular ring compression devices have been described. Using bands or compression devices helps reduce operator exposure to radiation. At our institution, we utilized multiple embolic agents and embolization techniques to achieve maximal pre-operative devascularization of an AVM. This case demonstrated transarterial coil embolization and percutaneous Onyx injection into both the nidus and draining veins as an adjunct to surgical removal.
LEARNING POINTS

- Arteriovenous malformations are abnormal connections between a feeding artery and a draining vein without an intervening capillary bed; physical exam can demonstrate a pigmented cutaneous mass with warmth and pulsatility.

- If AVMs are left untreated, patients can develop headaches, bleeding, and high output cardiac failure.

- Treatment strategies include transarterial embolization, transvenous embolization, direct percutaneous embolization, electrothrombosis, and surgical excision or ligation.

REFERENCES


