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Staged endovascular and open surgical approach for treatment of a giant left upper back arteriovenous malformation

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ABSTRACT

We present a case of a symptomatic, giant, left upper back arteriovenous malformation that was treated through a staged endovascular and open approach. Through a series of embolizations, followed by resection, we were able to preserve the limb and upper back neurovascular supply, demonstrating an approach to preserve sensation and function and improving quality of life. (J Vasc Surg Cases Innov Tech 2024;10:101528.)

Keywords: Arteriovenous malformation; Embolization; Hybrid vascular surgery; Resection

Arteriovenous malformations (AVMs) are high-flow congenital anomalies with a direct connection between an artery and a vein.[1,2] Peripheral AVMs, such as the one we describe, occur outside the central nervous system, either in the limbs or trunk. These malformations typically grow with age; however, accelerated growth can be stimulated by trauma, hormonal changes, infection, or spontaneous hemorrhage.[3,4] AVMs of the extremities can cause functional impairment related to sitting and sleeping and cosmetic distress, often in relation to the size of the deformity. The sequalae of unmanaged AVMs include venous hypertension, peripheral edema, inflammatory changes, and high-output heart failure.[5]

There is a paucity of population-based prevalence data on AVMs; however, hospital-based autopsy data have shown a range of 5 to 613 per 100,000 persons.[6] Nonoperative treatment such as monitoring, imaging, and pharmacotherapy can be considered. The operative management of this condition can be complex, because serial embolizations are often required to devascularize the nidus, followed by surgical resection, if indicated.[7] There have been novel approaches toward surgical management that have guided a more aggressive approach for complex AVMs, serving as a progressive blueprint for staged resection.[8] The following case details a patient who was treated with serial embolizations, followed by surgical resection. The patient provided written informed consent for the report of his case details and imaging studies.

CASE REPORT

A 25-year-old White man with no significant medical history presented to our vascular surgery clinic with a chief complaint of a 2-year history of a worsening left upper back AVM. The AVM began as a small nidus but grew considerably after a traumatic motor vehicle collision. The patient was not managed for any other health conditions and appeared otherwise healthy. His surgical history was significant for trial excision of the AVM, initially presumed to be a lipoma, by a general surgeon who aborted the procedure due to the complex vascular involvement. On physical examination, the patient endorsed pain when laying on his back and muscle aches but denied bleeding, bruising, or ulceration of the mass. The patient also denied left arm claudication, chest pain, and shortness of breath, resulting in a stage 2 Schobinger classification.[9]

The patient's initial computed tomography scan revealed a 5 × 18 × 14-cm AVM on the left upper back within the extrafascial fat planes of the left serratus anterior and trapezius muscles (Fig 1). On diagnostic angiography, the feeding artery arose from the left thyrocervical trunk and branches of the intercostal arteries, leading to a nidus of angiectatic blood vessels with early venous filling. A second diagnostic angiogram revealed the AVM had grown to 30 cm in diameter, with multiple arterial inflows from the axillary artery. At this time, the vascular surgeon confirmed the plan for staged embolization of the mass using Onyx 18 (Micro Therapeutics, Inc), followed by excision (Table). The risks of pain, bleeding, infection, wound healing difficulties, and nerve or vessel injury were explained to the patient, and consent was obtained.

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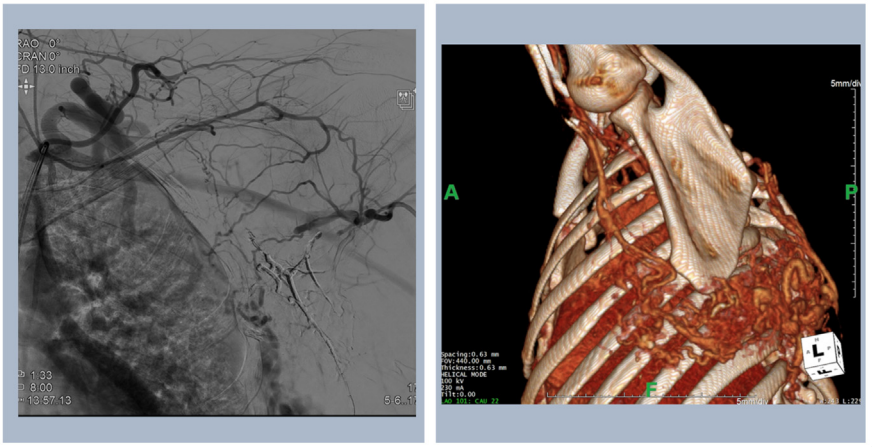

Fig 1. Diagnostic angiography (**Left**) and planning computed tomography reconstruction (**Right**).

Table. Chronological description of serial embolization and open resection procedures

Procedure date	Surgical approach	Vessels involved	Postoperative outcome
December 2018	Diagnostic angiogram to confirm plan for staged coil embolization using Onyx 18	None	Preparation for first embolization
January 2020	Selective catheterization from right femoral artery to left subclavian artery; deployment of embolic material through proximal costocervical trunk artery	Embolization of proximal medial costocervical trunk feeding branch	Significant postoperative pain during night 1 and sinus tachycardia; symptoms were managed with acetaminophen, ibuprofen, lidocaine patch, hydromorphone, and lorazepam
May 2020	Selective catheterization of proximal medial costocervical trunk artery	Embolization of distal lateral and medial costocervical trunk feeding branches	Uncomplicated discharge to home with 5 mg of oxycodone every 4 hours and acetaminophen 650 mg every 6 hours, as needed
July 2020	Selective microcatheterization of left T4 spinal radicular artery and left T6 spinal radicular artery	Embolization of left T4 spinal radicular artery and left T6 spinal radicular artery	Syncope, extreme pain ischemic in nature; transfer to SICU for pain management and monitoring of hemodynamic status; improved and transferred to main floor after 1 night stay in SICU
September 2020	Selective catheterization of left T5 spinal radicular artery	Embolization of left T5 spinal radicular artery	Uncomplicated discharge to home with 5 mg of oxycodone every 4 hours and acetaminophen 650 mg every 6 hours, as needed
February 2021	Selective catheterization of left T10 spinal radicular artery	Embolization of left T10 spinal radicular artery	Patient transferred to SICU for close monitoring of MAP with MAP goal of >85 mm Hg
May 2021	Circumferential dissection at the level of the ribs; AVM retracted posteromedially toward the pedicles and attached to paraspinous muscles	Complete resection of AVM in coordination with plastic surgery, neurosurgery, and vascular surgery	Discharge to home on postoperative day 3 with apixaban and pain management; Jackson-Pratt drain removal and wound check at 2 weeks postoperatively

AVM, Arteriovenous malformation; *MAP*, mean arterial pressure; *SICU*, surgical intensive care unit.

The vessels were systematically embolized from most distally to proximally with respect to the AVM. Success was marked by blockage of the feeding branches at each level. A stepwise approach was taken to allow time for vessel closure, limit excess pain, and decrease the likelihood of embolic events to the spinal vessels or lungs. For the first embolization, selective catheterization of the left subclavian artery was performed. Neurosurgery collaborated to deploy the embolic material through the

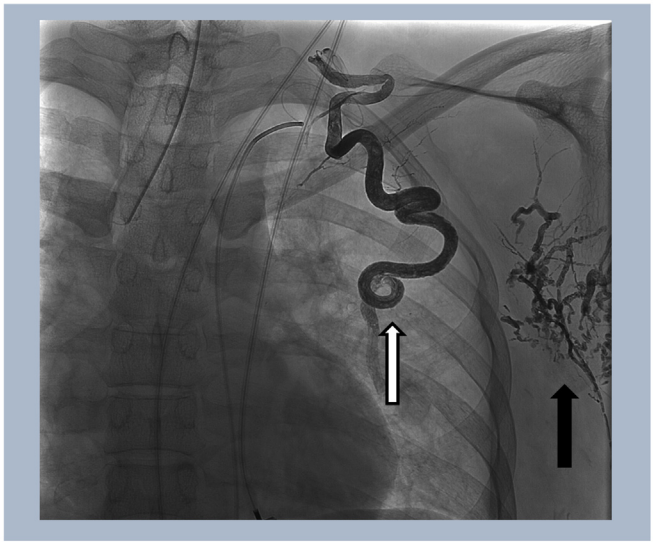

Fig 2. Angiogram demonstrating deployed embolic material in the proximal medial costocervical trunk feeding branch (embolization event 1; *white arrow*) and distal lateral costocervical trunk feeding branch (embolization event 2; *black arrow*).

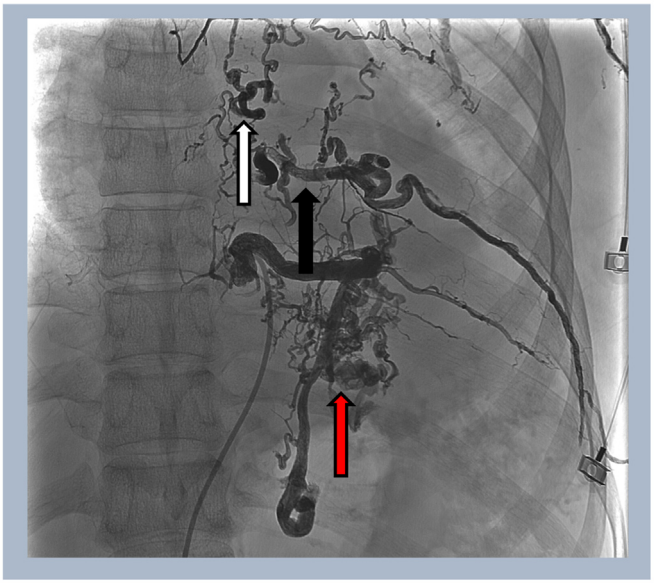

Fig 3. Angiogram demonstrating deployed embolic material in left T4 spinal radicular artery and left T6 spinal radicular artery (embolization event 3; *white arrow*), left T5 spinal radicular artery (embolization event 4; *black arrow*), and left T10 spinal radicular artery (embolization event 5; *red arrow*).

proximal costocervical trunk artery. Microinjection from this vessel cut off superficial drainage to the AVM. After the first embolization, two major branches to the malformation were embolized. In the second embolization, supraselective microcatheterization of the distal lateral and medial costocervical trunk via the left subclavian artery was performed. Onyx 18 was deployed. The second embolization procedure resulted in blocking the distal costocervical trunk from feeding the AVM (Fig 2). The first two embolization events were without significant sequelae; however, the third through fifth embolization events had hemodynamic concerns that required intensive care unit management secondary to radicular artery embolization between T5 and T10 (Fig 3). On completion of the embolizations, the number of feeding vessels was minimized for the open operation; however, the size of the AVM itself was the same as at the initial presentation. These procedures did not result in excessive scarring of the primary lesion.

With collaboration between plastic and vascular surgery, circumferential dissection was achieved to the level of the ribs, where the AVM was retracted posteromedially toward the paraspinous muscles. Once resected by the pedicle attachments, plastic surgery assisted in the closure with creation of myofascial flaps (Supplementary Video 1). Despite successful efforts at closing off feeding vessels, the open operation had an estimated blood loss of 5000 mL due to the highly vascular nature of the lesion. The patient's surgical intensive care unit course was complicated by a pulmonary embolism for which apixaban was started, and the patient was discharged on postoperative day 3. At the most recent follow-up at 2 years after surgery with the vascular clinic, the patient remains symptom free with complete resolution of the AVM and no recurrence (Fig 4).

DISCUSSION

Treatment of AVMs depends on their size, location, and symptoms. Nonsurgical management, typically reserved for asymptomatic lesions, includes clinical follow-up, imaging, and pharmacologic therapy.[2] Surgical techniques include endovascular embolization or open resection, or a combination. Although the recurrence rates of AVMs are reportedly lower after traditional surgical resection than after embolization alone, recent literature suggests a hybrid approach can lead to optimal functional and aesthetic outcomes.[10,11] A hybrid approach might serve as a novel alternative to resection after noninvasive imaging studies alone. The ability to take a staged approach with interval embolization has been previously shown to help with collateral formation, reduce ischemic events to surrounding structures, and, potentially, help with cosmetic results. Prior reports encourage scheduling excision within 48 hours of embolization; however, the our case presented a unique challenge given the massive size and complex vascular involvement.[12] As a result, this case required staged, serial embolization during a 13-month period before surgical excision.

Previous studies have demonstrated multiple techniques and modalities to help with embolization. This study demonstrates one of many accepted treatment techniques that can be used at scale with other applications such as ours. Our serial embolization was performed using Onyx 18, an ethylene vinyl alcohol copolymer, which is a nonadhesive polymer that precipitates vessel occlusion. These nonadhesive agents have a

Fig 4. Clinical images of the left upper back arteriovenous malformation (AVM) preoperatively (**Left**) and postoperatively (**Right**).

slower polymerization time and, therefore, allow for more controlled embolization.[2] This material is appropriate for high-flow malformations due to the lower rates of distal complication.[9] Other embolization formulations such as ethanol and cyanoacrylate were alternative options; however, Onyx 18 was selected because of operator familiarity. Also, Onyx 18 was chosen instead of Onyx 34 because its lower viscosity allows for more distal penetration of the lesion.[13] The risks of these agents include skin pigmentation and local ulceration; however, case consideration and judicious use of the embolization agent can minimize these potential complications. In the present case, transarterial access was used to achieve better visualization and control of embolic agent, although accessing the AVM directly has also been described.[2]

Once embolization is complete, curative surgical resection of the malformation can be pursued to decrease the likelihood of recurrence.[14] Incomplete resection can result in neovascularization and AVM growth. Additionally, this serves to debulk the region and flatten the appearance of the defect. Operative risks include blood loss and damage to nearby nervous structures. These risks can be mitigated by clamping large feeding vessels methodically and collaborating with surgical subspecialties. This interdisciplinary approach is critical when resecting peripheral AVMs that involve functionally salient structures such as tendons, nerves, or the spinal cord. Local flaps and microsurgical tissue transfer can maximize the functional and aesthetic outcome after the procedure.[11] In our group's experience, complex

peripheral AVMs should be electively managed at a tertiary center in collaboration with other surgical subspecialities to ensure the safest outcome. Our approach yielded a logical and progressive method that can serve as a guide toward management and successful intervention for an otherwise lifestyle-limiting and potentially limb-threatening vascular phenomenon.

CONCLUSIONS

Patients with giant AVMs can be good candidates for hybrid endovascular embolization, followed by open resection. A series of embolization procedures with subsequent multidisciplinary complete surgical resection, involving both neurosurgery and plastic surgery, during a 13-month period was an effective option for our patient, who presented with a symptomatic giant AVM.

DISCLOSURES

None.

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