SUBARACHNOID HEMORRHAGE DURING ARTERIOVENOUS MALFORMATION EMBOLIZATION AS A RESULT OF VESSEL WALL “SANDBLASTING”

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OBJECTIVE
Preoperative selective particulate embolization of arteriovenous malformations can make subsequent surgical resection of such lesions safer for the patient and easier for the surgeon. Nevertheless, embolization carries intrinsic risks, which include subarachnoid hemorrhage. We report two cases of subarachnoid hemorrhage during particulate embolization that we think was attributable to catheter positioning near a vessel curve and subsequent denudation of the vessel wall to the degree that hemorrhage was induced. © 1998 by Elsevier Science Inc.

KEY WORDS
Arteriovenous malformation; embolization; subarachnoid hemorrhage.

Embolization of cerebral arteriovenous malformations (AVM) is a useful preoperative adjunctive therapy. Reduction in AVM blood flow serves a number of purposes and provides numerous benefits to both the patient and surgeon. These include:

1. preoperative control of poorly accessible vessels
2. reduction in AVM turgor which makes manipulation of the lesion and surrounding brain less traumatic
3. gradual, stepwise alterations in AVM and surrounding parenchymal blood flow patterns that theoretically may reduce the incidence of postoperative cerebral breakthrough perfusion and subsequent hemorrhage
4. improved visualization of the arterial and venous architecture of the AVM as blood flow in superimposed vessels is slowed and eliminated, thus making AVM opacification less dense and more easily interpretable
5. reduction in AVM size to allow for radiotherapy in those lesions considered inoperable

As a result of embolization the patient hopefully is able to undergo a safer and faster surgical procedure with a minimum of blood loss.

Despite the many benefits of preoperative AVM embolization, there are intrinsic risks to the procedure that must be factored into the decision to perform such therapy. Our own review of 116 superselective AVM embolizations performed over a 3-year period using polyvinyl alcohol (PVA) particles revealed a 12% overall complication rate. These included a 0.9% incidence of significant groin hematoma, 1.7% incidence of vessel dissection, 6% incidence of permanent neurologic deficit, 0.9% incidence of temporary neurologic deficit, and 1.7% incidence of subarachnoid hemorrhage.

Two recent cases of subarachnoid hemorrhage during AVM embolization have demonstrated the specific danger of positioning the microcatheter near a vessel curve and performing prolonged particulate injections from this location. Such a technique likely slowly denudes the vessel wall as the particles “sandblast” the tissue. During a long procedure the vessel eventually leaks, leading to subarachnoid hemorrhage.

CASE REPORTS

CASE 1
A 29-year-old woman presented with an unruptured, high-flow, fistulous left frontal lobe arteriovenous malformation fed by branches of the anterior and middle cerebral arteries (Figure 1 A,B).
Two preoperative embolizations were performed before successful complete resection of the lesion. During the first embolization the microcatheter was positioned in a left orbitofrontal branch just proximal to an acute vessel curve. Prolonged embolization with PVA particles ranging in diameter from 300 to 1,000 microns was performed. Late in the embolization, extravasation of contrast into the subarachnoid space was visualized (Figure 1C). Before the extravasation, the catheter had not been repositioned and no other manipulations were performed to promote vessel rupture. The patient's heparin was immediately reversed and the vessel was sacrificed using platinum coils (Figure 1D). The patient was awake throughout the procedure, never reported headache, and suffered no ill effects from
(A, B) Right frontal lobe arteriovenous malformation. (C) CT scan demonstrating subarachnoid hemorrhage.
the rupture. An immediate post embolization head computed tomography (CT) revealed contrast and blood in the subarachnoid space (Figure 1E). The patient was followed overnight in the intensive care unit with no sequelae. Her embolization was completed 2 days later and the AVM was subsequently resected without difficulty.

**CASE 2**
A 23-year-old woman presented with seizures secondary to a large, high-flow, right frontal arteriovenous malformation (Figure 2A,B). A two-stage embolization using PVA was performed before complete, uncomplicated resection of the lesion. Embolization of one of the middle cerebral artery feeders was conducted with the catheter tip just proximal to an acute arterial curve. Late in the procedure extravasation of contrast was visualized. No catheter manipulations preceded the complication. Heparin was immediately reversed and the vessel was sacrificed using platinum coils. The patient suffered no neurologic sequelae, including no complaints of headache. Immediate post-procedure head CT scan demonstrated blood and contrast within the subarachnoid space (Figure 2C). The patient’s embolization was completed 2 days later and the AVM was subsequently resected without difficulty.

**DISCUSSION**
Embolization of arteriovenous malformations is a useful adjunct to operative resection. Our own review of 116 procedures over a 3-year period revealed a 12% overall complication rate with a 1.7% incidence of procedure-related subarachnoid hemorrhage. When using PVA we are generally mindful of embolizing with the catheter tip positioned near a vessel curve for fear of denuding the vessel wall with the particles and potentiating a subarachnoid hemorrhage. In these two cases, however, the catheter could technically not be positioned further along the vessel into a straight segment and we thought more proximal positioning was undesirable. Both cases involved prolonged particulate injections because of the rapid flow and fistulous nature of the lesions. We believe that the PVA slowly denuded the vessel wall until a small hole developed that permitted the extravasation of blood and contrast. Interestingly, neither patient, both of whom were awake and minimally sedated during their procedures, complained of headache nor suffered any immediate nor delayed neurologic sequelae. This course differs from patients who have had vessels perforated with catheters or guidewires. Such patients generally complain of headache and rapidly lose consciousness secondary to the hemorrhage and increase in intracranial pressure. The results of the two cases described above is likely testimony to the fact that extravasation from the “sandblasting” effect of PVA is secondary to a low-pressure leak that if rapidly addressed should cause minimal or no damage.

**CONCLUSION**
When using particulate embolization the interventionist must be mindful of catheter position and try not to inject particles immediately proximal to a vessel curve, especially if a large volume of material is going to be introduced from this location. We think such injections lead to a “sandblasting” of the vessel lining and the ultimate possibility of vessel perforation and subarachnoid hemorrhage. If extravasation does occur in such a situation it seems to take a benign course if addressed quickly.

**COMMENTARY**
Two cases of subarachnoid hemorrhage (SAH) during the embolization of a brain AVM with particles are reported. The authors explain the leak of blood into the SAH by the “sandblasting” effect of the particles injected repeatedly at the same place in a vessel curve. There is no evidence to support this hypothesis.

I do not believe that the technique of delivery of particles is as aggressive as the sandblasting of a monument being rejuvenated. They certainly used a Tracker catheter with a metallic guidewire, and they probably tried many times to advance the tip of the Tracker beyond the curve of the vessel. Therefore, they may have injured the wall of the vessel, which ruptured at the end of the embolization.

It is also well demonstrated that at the end of the embolization, the pressure builds up into the feeder, and a weak area of the wall may rupture.

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The most feared complication of a cerebral embolization procedure is iatrogenic hemorrhage. Those of us who perform particulate embolization of brain arteriovenous malformations routinely are well
When Allegheny Health, Education and Research Foundation’s financially strapped Philadelphia empire collapsed July 20, its hospitals weren’t the only entities affected.

The Pittsburgh-based organization declared bankruptcy the next day for eight of its nine Philadelphia hospitals, its physician practices—including 310 doctors in the eastern region and 225 in the west—and Allegheny University of the Health Sciences.

“This is a very hard time for all of us here,” said Emily Blumberg, MD, an associate professor of medicine at Allegheny University Hospitals, Hahnemann. “People are essentially in shock that this all could have happened, and everyone is very anxious about what the outcome might be.”

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