EDITORIAL

Arteriovenous malformations and embolization

Gregory J. Zipfel, MD

Departments of Neurological Surgery and Neurology, Washington University School of Medicine, St. Louis, Missouri

IN this issue of the *Journal of Neurosurgery*, Crowley and colleagues retrospectively reviewed a very large cohort of patients with arteriovenous malformations (AVMs; $n = 342$) treated using endovascular embolization.¹ The majority was treated in preparation for surgery or radiosurgery; only 2.3% were treated with the goal of endovascular cure. The primary objective of the study was to determine whether the rate of neurological morbidity was different in patients treated with Onyx versus those treated with *N*-butyl cyanoacrylate (NBCA). Other factors to potentially affect neurological outcome were also evaluated, including age, sex, Spetzler-Martin grade, number of embolized arteries, number of embolization sessions, and use of other embolic materials besides Onyx and NBCA. Unfortunately, angiographic outcome after endovascular embolization was not evaluated. The authors noted a permanent neurological morbidity rate of 9.6% and a mortality rate of 0.3%, rates that are similar to those reported by other high-volume cerebrovascular centers. Importantly, no difference in neurological morbidity was noted between patients treated with Onyx versus NBCA. Of the other evaluated factors, only number of embolization sessions was associated with increased risk of neurological morbidity.

Two other studies have directly examined the safety and efficacy of Onyx versus NBCA for endovascular embolization of cerebral AVMs. In the first study, Loh and Duckwiler² reported on a prospective, multicenter, industry-sponsored, randomized controlled trial in which 117 patients underwent presurgical endovascular embolization with the goal of reducing the AVM nidus by $\geq 50\%$. Of these 117 patients, 54 were treated with Onyx and 63 patients were treated with NBCA. Angiographic outcome was similar between the 2 groups, with 96% of Onyx cases and 85% of NBCA cases achieving $\geq 50\%$ AVM nidus reduction. No significant difference in the rate of serious adverse events for patients treated with Onyx versus NBCA was noted;

however, the study's sample size was modest and a trend for greater serious adverse events with Onyx versus NBCA was noted (9.3% vs 4.8%, respectively; $p = 0.47$).

In the second study, Lv et al.³ reported on a retrospective, single-institution, observational study in which 147 patients underwent 220 endovascular embolization procedures for treatment of cerebral AVMs. Complete AVM obliteration was achieved in nearly 20% of patients, while the remainder had residual AVMs that were either treated with radiosurgery or managed expectantly. The authors reported a complication rate of 3.2% per procedure and 4.8% per patient; no significant difference between Onyx and NBCA embolization was noted. Finally, as the authors discuss well in their paper, Morgan et al.⁴ indirectly compared the safety and efficacy of AVM embolization with Onyx versus older-generation embolysates by carefully examining patient outcome after AVM surgery in time periods before and after the introduction of Onyx. They found that surgical morbidity for higher-grade AVMs tended to be greater in the Onyx era as compared with the pre-Onyx era despite the increased use of embolization as a preoperative adjunct during the Onyx time period. From these data, Morgan and colleagues⁴ concluded that Onyx embolization is not superior to older generation embolysates and that the availability of Onyx may even embolden surgeons to attempt resection of higher-grade/higher-risk AVMs. However, because the neurological morbidity and angiographic outcome associated with Onyx versus older-generation embolysates were not directly compared in this study, it is difficult to draw definitive conclusions as to the safety and efficacy of one technique versus the other.

The present study is an important contribution to the growing literature regarding the safety and efficacy of Onyx versus older generation embolysates such as NBCA.¹ Crowley and colleagues are to be congratulated for this valuable contribution. Collectively, their results when combined with those of Loh and Duckwiler and Lv et al.

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strongly suggest that Onyx embolization carries very similar neurological risks as compared with NBCA embolization. What is not as well described is whether Onyx is more effective in reducing AVM nidus volume as compared with NBCA or other embolysates. The anecdotal experience at my own institution suggests that Onyx provides superior nidus penetration and extent of AVM volume reduction compared with older-generation embolysates. Unfortunately, the present study sheds little light on this issue, although the authors note that in general they are “able to achieve a greater degree of embolization with Onyx” as compared with older-generation embolysates. Therefore, future studies will be needed to objectively compare the angiographic outcome of Onyx versus NBCA embolization, which if proven superior would suggest that the balance of risk versus efficacy may ultimately favor the use of Onyx as the primary embolization technology for cerebral AVMs. The issue of angiographic efficacy will be especially important in cases in which embolization is being utilized as a curative procedure for cerebral AVMs rather than as a preoperative or preradiosurgical adjunct.

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References

1. Crowley RW, Ducruet AF, Kalani MYS, Kim LJ, Albuquerque FC, McDougall CG: Neurological morbidity and mortality associated with the endovascular treatment of cerebral arteriovenous malformations before and during the Onyx era. **J Neurosurg** [epub online ahead of print March 27, 2015. DOI: 10.3171/2015.2.JNS131368]
2. Loh Y, Duckwiler GR: A prospective, multicenter, randomized trial of the Onyx liquid embolic system and N-butyl cyanoacrylate embolization of cerebral arteriovenous malformations. **J Neurosurg** **113**:733–741, 2010
3. Lv X, Wu Z, Jiang C, Li Y, Yang X, Zhang Y, Zhang N: Complication risk of endovascular embolization for cerebral arteriovenous malformations. **Eur J Radiol** **80**:776–779, 2011
4. Morgan MK, Davidson AS, Koustais S, Simons M, Ritson EA: The failure of preoperative ethylene-vinyl alcohol copolymer embolization to improve outcomes in arteriovenous malformation management: case series. **J Neurosurg** **118**:969–977, 2013

Response

R. Webster Crowley, MD,¹ and
Cameron G. McDougall, MD, FRCS²

¹Division of Neurosurgery and Radiology, University of Virginia Medical Center, Charlottesville, Virginia; and ²Division of Neurological Surgery, Barrow Neurological Institute, St. Joseph's Hospital and Medical Center, Phoenix, Arizona

We would like to thank Dr. Zipfel for his thoughtful comments regarding our study. As Dr. Zipfel indicated, our study does not examine how effective the various embolysates are in reducing the volume of the AVM nidus. Although we agree that this would certainly be useful information, for this particular study we believe that a number of confounding variables would render such an analysis fairly meaningless. Perhaps the most significant of these is the fact that 79% of embolizations were performed prior to planned resection, where a successful embolization did not necessarily equate to good nidal penetration. In fact, for preoperative embolizations, it may be as effective to occlude a number of feeding arterial pedicles proximally along their courses as it would be to achieve a thorough nidal penetration, and could even conceivably carry fewer risks. Unlike curative embolization, in which the AVM is either cured or not, the success of embolization conducted for other reasons can be more nuanced. In these cases, it may be possible for an embolization to be “good enough,” a definition that would likely vary substantially for each AVM and probably for each surgeon. Therefore, analyzing our patient population for the percentage of embolization that is achieved would likely be fruitless. We share Dr. Zipfel's belief regarding the superiority of Onyx for nidal penetration, but this is based largely on anecdotal evidence for us as well. As Dr. Zipfel suggests, such an analysis would appear to be more appropriate for patients in whom the endovascular goal is cure, but only 2.3% of our patients were in this category, and therefore future studies would certainly be needed.