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Embolization of Brain Arteriovenous Malformations for Cure: Because We Could or Because We Should?

We read with great interest the series by Panagiotopoulos et al in this issue of the *American Journal of Neuroradiology*.[1] They reported the results of brain arteriovenous malformation (AVM) embolization by using ethylene-vinyl alcohol copolymer (Onyx; eV3, Irvine, Calif). In their series, 82 patients were embolized during 119 sessions. Angiographic "cure" (defined as no residual shunt surgery seen) was 24.4% initially, but dropped to 19.5% at follow-up, when 4 angiographic recurrences were seen. They reported an overall 11.3% rate of permanent disabling deficit or death. Additional treatment including open microsurgical resection and stereotactic radiosurgery has been performed in 63% of their patients, with others awaiting definitive treatment. We commend the authors on their thorough and honest analysis of their results. However, several concerns are evident regarding the overall role of embolization in the treatment of brain AVMs and the use of Onyx in particular.

The goal of treatment of brain AVMs should be complete obliteration of the nidus to prevent future hemorrhage. Currently, microsurgical resection, stereotactic radiosurgery, and endovascular embolization are used, often in combination, to achieve that goal. Any treatment plan should attempt to provide a high rate of cure with a low rate of complications. AVM embolization is now primarily performed with liquid embolic agents, Onyx and *n*-butyl cyanoacrylate (*n*-BCA; Trufill, Cordis, Miami Lakes, Fla). The handling characteristics of these materials are in many ways polar opposites. Onyx is injected in a slow fashion, with 30-minute injections not uncommon. This is in sharp contrast to *n*-BCA, for which the injection rarely takes longer than a minute. It is this slow injection of Onyx, with the potential for deeper nidal penetration, in conjunction with its cohesive but not adhesive nature, that is often described as advantageous over *n*-BCA[1-8] in both initial reports and several recent large series. As a result, many centers have changed their goal of embolization from adjunctive therapy before surgery or radiosurgery to primary curative attempts with embolization with Onyx.[2,3,5,7,8] However, although the overall cure rates in these series have varied, none have demonstrated cure for most of their patients (Table). In addition, the permanent disabling morbidity or mortality rates have been higher than those in several recent large series using predominantly or exclusively *n*-BCA,[9-12] which have ranged from 1.6% to 6.5%. Embolization for cure was not the primary aim in most patients treated in these series.

The issue here is not necessarily Onyx versus *n*-BCA. Both agents have their advantages and disadvantages, and we are better off having both of them available for our patients. The bigger issue is what the role of embolization should be in the management of brain AVMs. Although the promise of Onyx may be cure of AVMs with embolization alone, the current literature fails to show impressive cure rates when embolization is compared with treatment using surgery and radiosurgery. Moreover, the complication rates are at least as high, if not higher, than those of historic *n*-BCA series.

Summary of complication and cure rates in recent larger series with embolization predominantly or exclusively using Onyx

Series	No. of Patients	Permanent Morbidity and Mortality (%)	Cure by Embolization Alone (%)
Mounayer et al[3]	94	11 (11.7)	26 (28)*
Weber et al[5]	93	9 (9.7)	19 (20.4)
Katsaridis et al[7]	101	11 (10.9)	28 (27.7)*
Pierot et al[2]	48	6 (12.5)	2 (4.1)*
van Rooij et al[6]	44	3 (6.8)	7 (15.9)
Perez-Higueras et al[8]	45	8 (17.7)	10 (22.2)
Panagiotopoulos et al[1]	82	9 (11.3)	16 (19.5)

*Further endovascular treatment was planned in some patients.

Small AVMs may be deemed suitable for attempts at curative embolization. However, from past experience, we know that these lesions are also extremely well suited for microsurgical resection or stereotactic radiosurgery, both of which have low complication rates and very high cure rates. For small AVMs, surgery has a cure rate of almost 100% and a complication rate of 0%–15%, and radiosurgery has a cure rate of approximately 70% and a complication rate of ≤10%.[13] If a small AVM is treated by an embolization procedure that fails to cure, then the patient has been exposed to a risk (7%–18% according to data in Table 1) without any compensatory benefit. So is it worth exposing patients to this level of risk if the chance of cure is no better than 30%, or even as high as 50%? Is it wise to attempt endovascular cure when another procedure with similarly low risk and higher cure potential is available? An argument might be made that even without cure, embolization benefits the patient by making surgery or radiosurgery safer or more effective. However, to our knowledge, there is no evidence that this is the case for small AVMs, so this seems to be a hollow argument.

Until we can better predict which AVMs can be cured with embolization alone, perhaps we should be more careful about attempting endovascular cure. Above all, we should not let a "shiny new toy" with theoretic, albeit yet unrealized, advantages over the "old standby" cloud our judgment and treatment goals for these complex lesions.

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