



## Letters to the Editor

# Comparison of transarterial n-BCA and Onyx embolization of brain arteriovenous malformations: A single-center 18-year retrospective analysis

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## TO THE EDITOR

We read with great interest the recent article by Behzadi and colleagues entitled “Comparison of transarterial n-Butyl cyanoacrylate (n-BCA) and Onyx embolization of brain arteriovenous malformations: A single-center 18-year retrospective analysis”.<sup>2)</sup> We believe their principal finding of high safety when pursuing embolization using Onyx and n-BCA to be both encouraging and reflective of appropriate patient selection for standalone embolization treatment of brain arteriovenous malformations (AVMs). However, we would like to highlight an additional aspect of brain AVMs that relates to the present work.

Endovascular embolization for definitive AVM treatment is best performed in conjunction with other treatment modalities, either to facilitate microsurgical resection or to reduce the size of the AVM to influence response to radiosurgery.<sup>4)</sup> In these cases, the ultimate goal of treatment is radiographic obliteration of the AVM, which is best confirmed using catheter angiography.<sup>9)</sup> The authors appropriately note that “successful” embolization of AVMs may occur in the context of partial occlusion, occlusion of a ruptured portion of an AVM, or obliteration of an intranidal aneurysm when a definitive cure is not the objective.

When definitive treatment of brain AVMs is pursued, close follow-up surveillance imaging is warranted in order to identify potential recurrences before patients present with secondary hemorrhage, seizures, or other symptoms.<sup>5)</sup> In the adult population, recurrences are a rare entity, with current estimates suggesting that under 2% of AVMs with angiographically-confirmed cure will recur in adults.<sup>12)</sup> In children, recurrences can be far more problematic. Indeed, numerous studies suggest over 10% of AVMs recur following angiographic cure in children.<sup>3)6)8)</sup> Most pertinent to the

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present work of Behzadi and colleagues is the increased recurrence rate observed in young patients undergoing curative embolization, with one paper reporting a recurrence rate of over 70% in a cohort with highly-protocolized imaging follow-up and identifying embolization as a predictor of AVM recurrence.<sup>7)</sup>

There are two prevailing theories explaining AVM recurrences. The first theory was proposed by Pellettieri et al., and suggests that “hidden compartments” remain angiographically unfilled initially due to low flow in feeding vessels, but internal steal following treatment leads to dilation of the previously hidden region.<sup>10)</sup> The second theory relates to the broader view that developmentally-expressed molecules such as vascular endothelial growth factor (VEGF) drive recurrence due to reactive angiopathic processes subsequent to AVM treatment.<sup>11)</sup> The theory of increased angiogenesis is supported by an in-vivo study conducted by Akakin et al. where human AVM tissue that had been treated via microsurgery, embolization, or radiosurgery was grafted onto rat corneas. The authors then assessed gross microvessel count and VEGF staining in order to assess the degree of neoangiogenesis following treatment.<sup>1)</sup> In their study, it was observed that AVM tissue treated with embolization had higher microvessel counts and VEGF expression than AVM tissue treated with other modalities.<sup>1)</sup>

With clinical evidence for elevated recurrence and regrowth of AVMs following embolization, as well as proposed underlying mechanisms, we firmly believe that study surrounding embolization of AVMs should consider development of AVM recurrence or regrowth as a key endpoint. Recurrence is generally defined with respect to confirmed angiographic cure, but regrowth after partial treatment with embolization is another endpoint of clinical significance. In their present work, Behzadi et al. report that angiographic follow-up is available for 19 months ( $\pm 26$  months), which is adequate time to identify possible recurrence or regrowth.<sup>7,8)</sup> It would be valuable for the authors to review this data in the patients included in their study. Further, future study in embolization of brain AVMs should explore this vital

aspect of the disease, particularly when embolization is performed in younger patients.

**Keywords** AVM, Embolization, Imaging

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