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Endovascular Treatment of Cerebral Arteriovenous Malformations following Radiosurgery

Robert C. Dawson III¹

The article by Marks et al (1) in the current issue of this journal is both timely and thought-provoking. In its specifics, it reports a small series of six brain arteriovenous malformations (AVMs) that failed radiosurgery. These lesions were then embolized as a component of further therapy: three were excised, two were reirradiated, and one is being followed in expectation of cure from embolization. The authors are to be congratulated for these innovative efforts. While many will quibble over the flaws in this report, such as its small numbers, lack of randomization, short follow-up, and assorted other complaints, both valid and nitpicking, the true value of this paper lies in not its specifics, but in the questions it raises. Patients with partially treated AVMs abound. They should not be abandoned. They deserve consideration for further therapy, provided we can be inventive in our approaches and safe in its delivery. What queries does this communication raise?

The first is simple. How many reasonable ways can we combine therapies to treat brain AVMs, and what are the best sequences? Mathematically, counting surgery, radiosurgery, and embolization alone or in various combinations and sequences, I count 15. This excludes using any mode twice, so this calculation understates the matrix considerably. No therapy is also an option. By illustrating one possible extension of therapy the authors show the feasibility of exploring additional theoretical and practical alternative therapeutic regimens, for those patients who have reached a frustrating "non-endpoint." They make the case that once a patient has failed our current therapy, other avenues of treatment may remain open.

Historically, AVMs have caused great consternation for therapists. Although the first reported excision of a brain AVM by Pean in 1889 resulted in a satisfactory outcome, the subsequent sur-

gical reports by such luminaries as Cushing, Dandy, Olivercrona, Yasargil, Drake, Stein, and Spetzler serve to show persistent difficulties, as well as document the great technical and surgical improvements over time (2–20). Further advances in surgery and anesthesia will no doubt continue to lower morbidity and mortality for surgically accessible lesions.

The addition of embolotherapy was a great advance. Once employed in the therapy of AVMs, embolization techniques advanced rapidly in the late 1970s and early 1980s. Stein and Wolpert reported their experience with the combination of embolization and surgery (21). Kerber developed flow-directed techniques to deliver cyanoacrylate glues for curative and preoperative efforts (22). Bank, Kerber, Cromwell, Wolpert et al reported on the palliative effects of embolization without surgery (24, 24).

Radiosurgery developed along a parallel path, beginning with Leksell and progressing through the efforts of Steiner, Kjellberg et al, Betti, and others (25–29). Their cure rates for lesions smaller than 3.5 cm are impressive.

Since irradiation of lesions larger than 3.5 cm has not been nearly as effective, workers at the University of Pittsburgh investigated the utility of embolizing AVMs larger than 35 mm to a size amenable to this therapy (30). Their study, while limited because of their small numbers, showed utility to this regimen, and in various forms, is widely used. Further data from this institution, involving 56 patients currently pending publication, shows a 38% cure rate at 2 years, with no permanent sequelae from embolization. An additional 48% had an average reduction of 96% (Mathis JM, Horton JA, Vincent D, Dawson RC, Lunsford LD. Written communication, 1993). Based on Steiner's data, at least some of these should go on to cure by 3 years. Further refine-

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ments in technique and patient selection should improve these outcomes.

Currently, I am aware of centers of radiosurgery for residual lesions, surgery following radiotherapy, and other combinations of therapies. We applaud these endeavors.

Finally, a word of warning regarding embolization. Nearly any AVMs can be embolized. Many should not be. The embolization should be done only with clear goals and end points in mind. Are we setting out to cure the AVM? Lower operative morbidity? Decrease the steal phenomenon? Ameliorate headache? Any of these are potentially laudable goals. There should be a plan. At times I have questioned whether the angiographer's goals or plan were clear (ego aside). Granted goals may be altered, fall-back positions may be necessary, alternative plans developed, but at least, going in, there should *be* a plan. With complications and morbidity like we see from these procedures, we owe this to our patients.

The multidisciplinary approach to AVM therapy has resulted in a true spirit of cooperation between the clinical participants. It has brought forth a genuine appreciation between heretofore competitive disciplines for the unique talents of each specialty. Accordingly, it can and should serve as a model for further cooperative efforts between these and other specialties.

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