This article is one of a series published in the *Journal of Neurosurgery* and the *Journal of Neurosurgery: Pediatrics*.
See *Appendix* for a complete series listing.

J Neurosurg 116:7–8, 2012

Editorial

Role of radiosurgery for arteriovenous malformations

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The therapeutic approach to intracranial arteriovenous malformations (AVMs) has evolved in recent years following the development and refinement of endovascular techniques and radiosurgery. Over the past 3 decades, radiosurgery has become a valid therapeutic option for many patients with intracranial AVMs. Dosimetry, obliteration rates,[7] and early as well as late complications have been well characterized. In this 6-part series, the group from the University of Pittsburgh provides us with an update of their experience with radiosurgical treatment of AVMs in different situations.[1–6] How can we incorporate the information provided into our management of these challenging lesions?

Simplistically, AVMs can be divided into 3 main groups.[9] There are many options for "simple" AVMs (Spetzler-Martin Grade I and II AVMs). Surgery has been traditionally considered the main and most effective therapy for these "simple" AVMs because it removes the risk of bleeding with a very low surgical risk. However, stereotactic radiosurgery is being considered more and more as a valid therapeutic alternative to microsurgical excision, with the main downside being the risk of hemorrhage during the "latency period." In unruptured AVMs that have not hemorrhaged, this risk is very low, and the series from the Pittsburgh group suggests that results comparable to those obtained after microsurgical excision can be achieved in this subgroup of patients.[6] More recently, with the advent of newer embolization materials, even embolization has been proposed as a valid alternative to surgery for small AVMs,[8] although the overall complication rates and effectiveness of this approach are not clear when this strategy is used by less experienced surgeons. Ideally, patients should receive objective, unbiased information about the pros and cons of each treatment modality before a final recommendation is provided. A history of prior hemorrhage is by far the strongest predictor of future hemorrhages. Thus, in patients with ruptured small AVMs, I recommend microsurgical excision. Young patients with small, unruptured AVMs are provided with information about the risks and benefits of each alternative therapeutic treatment and usually are encouraged to make "an informed" choice based on the facts provided. Not surprisingly, most patients prefer to pursue radiosurgery. I am not sure that curative embolization is ready for "prime time" for this subgroup as the complication rates are not yet defined when this strategy is pursued routinely in patients with small, uncomplicated AVMs.

Therapeutic recommendations for Grade III AVMs involve considerations based on location, size, and rupture status. For ruptured superficial Grade III AVMs, microsurgical excision (usually preceded by preoperative embolization) is the treatment of choice. As shown by Kano and coworkers in this multipart series, radiosurgery is a good (and probably the best) option for most thalamic and brainstem AVMs with obliteration rates approaching 70% at 5 years.[4,5] However, the incidence of adverse radiation effects with Gamma Knife surgery in these locations is higher than that for AVMs of equal volume in other areas of the brain.

Despite all of the recent advances, treatment of most Grade IV and V AVMs remains challenging. This is especially true considering that often these large and complex AVMs are discovered incidentally or in patients with few symptoms. Staged radiosurgery has been an appealing option in some of these patients (especially in those without prior hemorrhage), but Kano and coworkers[1] suggest that the results with this strategy are dismal with very low obliteration rates. Despite their observation of very low obliteration rates, I have been favorably impressed by the response to staged radiosurgery in a small subgroup of very young patients, and I believe staged radiosurgery may have a role in the treatment of this very select group. Although widely practiced throughout the world, I don't think that the strategy of preradiosurgical embolization to reduce the size of the nidus followed by definitive radiosurgery is a valid one. In the past few years, I have been intrigued (as speculated by Kano and coworkers) by the possibility of performing proximal embolization after radiosurgery targeting in large and complex AVMs. In such cases, embolization would target large, accessible, and safe feeding vessels and any accessible large direct arteriovenous shunt. Theoretically, in such cases, proximal embolization could reduce flow through the nidus without altering venous outflow, which may lower the risk of hemorrhage in the latency phase and may "accelerate" the effects of radiosurgery by eliminating high-flow compartments. Whether or not this is a valid strategy remains to be demonstrated.

Appendix

This article is one of a series. The complete series is as follows.

Sheehan J: Editorial. Radiosurgery. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.6.JNS11844]

Bambakidis NC, Selman WR: Editorial. Stereotactic radiosurgery for arteriovenous malformations. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.6.JNS11842]

Lanzino G: Editorial. Role of radiosurgery for arteriovenous malformations. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.8.JNS11843]

Kondziolka D, Kano H, Lunsford LD: Response to editorials. Arteriovenous malformations and radiosurgery. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.8.JNS111498]

Kano H, Lunsford LD, Flickinger JC, Yang HC, Flannery TJ, Awan NR, et al: Stereotactic radiosurgery for arteriovenous malformations, Part 1: management of Spetzler-Martin Grade I and II arteriovenous malformations. Clinical article. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.9.JNS101740]

Kano H, Kondziolka D, Flickinger JC, Yang HC, Flannery TJ, Awan NR, et al: Stereotactic radiosurgery for arteriovenous malformations, Part 2: management of pediatric patients. Clinical article. **J Neurosurg Pediatr** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.9.PEDS10458]

Kano H, Kondziolka D, Flickinger JC, Yang HC, Flannery TJ, Awan NR, et al: Stereotactic radiosurgery for arteriovenous malformations, Part 3: outcome predictors and risks after repeat radiosurgery. Clinical article. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.9.JNS101741]

Kano H, Kondziolka D, Flickinger JC, Yang HC, Flannery TJ, Niranjan A, et al: Stereotactic radiosurgery for arteriovenous malformations, Part 4: management of basal ganglia and thalamus arteriovenous malformations. Clinical article. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.9.JNS11175]

Kano H, Kondziolka D, Flickinger JC, Yang HC, Flannery TJ, Niranjan A, et al: Stereotactic radiosurgery for arteriovenous malformations, Part 5: management of brainstem arteriovenous malformations. Clinical article. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.9.JNS11176]

Kano H, Kondziolka D, Flickinger JC, Park KJ, Parry PV, Yang HC, et al: Stereotactic radiosurgery for arteriovenous malformations, Part 6: multistaged volumetric management of large arteriovenous malformations. Clinical article. **J Neurosurg** [epub ahead of print November 11, 2011. DOI: 10.3171/2011.9.JNS11177]

Disclosure

Dr. Lanzino reports that his institution receives educational grants from ev3 and Synthes.

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Please include this information when citing this paper: published online November 11, 2011; DOI: 10.3171/2011.8.JNS11843.