

Angioarchitectural Predictors of Obliteration After Stereotactic Radiosurgery in Brain Arteriovenous Malformations

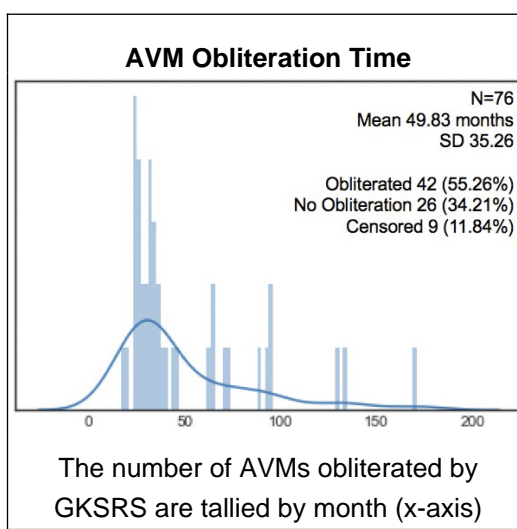
Evgeniya Tyrtova; Alexandria Marino; Isaac G Freedman BPhil, MPH; Samuel Aramis Cornelio Sommaruga MD; Branden John Cord MD, MS, PhD, BA; Ryan Matthew Hebert MD; Charles Christian Matouk BSc MD
 Yale University, Yale New Haven Hospital



Table 1. AVM Patients Demographics

	Obliteration	to Obliteration	P
N	42	26	
Demographics			
Age at First Treatment, yr	38.5 (SD 17.6)	38.7 (SD 17.2)	0.9648
Gender: Female	23 (54.8%)	9 (34.6%)	0.1068
Race/Ethnicity			0.1212
Caucasian	19 (45.2%)	15 (57.7%)	0.3264
Hispanic or Latino	9 (21.4%)	9 (34.6%)	0.2562
Black	10 (23.8%)	1 (3.8%)	0.0117
Other	2 (4.8%)	0	0.1598
Unknown	2 (4.8%)	1 (3.8%)	0.8577
Medical History			
Hypertension	10 (23.8%)	3 (11.5%)	0.1882
Diabetes Mellitus	2 (4.8%)	1 (3.8%)	0.8577
Dyslipidemia	6 (14.3%)	2 (7.7%)	0.3910
Smoking status			0.7410
Never smoked	26 (61.9%)	14 (53.8%)	0.5229
Current smoker	8 (19%)	7 (26.9%)	0.4688
Previous smoking	8 (19%)	5 (19.2%)	0.9854
Anticoagulant Therapy, Any	3 (7.1%)	5 (19.2%)	0.1799
Presenting Symptoms			
Asymptomatic	5 (11.9%)	4 (15.4%)	0.7210 **
Intracranial Hemorrhage	23 (54.8%)	6 (23.1%)	0.0076 **
Headache	24 (57.1%)	17 (65.4%)	0.4452
Seizure	8 (19%)	5 (19.2%)	0.9778
Focal Deficit	13 (31%)	17 (65.4%)	0.0071 **
AVM Characteristics			
AVM Volume, cm ³	17.2	10.9	0.4772
Laterality			
Left	17 (40.5%)	18 (69.2%)	0.0384 *
Right	21 (50%)	5 (19.2%)	0.0073 **
Midline	4 (9.5%)	3 (11.5%)	0.7989
Location			
Frontal lobe	11 (26.2%)	2 (7.7%)	0.0371 *
Parietal lobe	9 (21.4%)	8 (30.8%)	0.4099
Temporal lobe	10 (23.8%)	9 (34.6%)	0.3566
Occipital lobe	7 (16.7%)	4 (15.4%)	0.8905
Eloquent cortex	1 (2.4%)	5 (19.2%)	0.0104 *
Angioarchitectural Features			
Venous Characteristics			
Average Number of Draining Veins	1.7 (1-4)	1.6 (1-3)	0.6838
Deep Venous Drainage	25 (59.5%)	14 (53.8%)	0.6535
Superficial Venous Drainage	27 (64.3%)	20 (76.9%)	0.2688
Venous Ectasia/Varices	16 (38.1%)	9 (34.6%)	0.7760
Venous Stenosis/Obstruction	4 (9.5%)	7 (26.9%)	0.0894
Arterial Characteristics			
Average Number of Feeding Arteries	1.9 (1-4)	2.3 (1-7)	0.2444
Arterial Enlargement/Hypertrophy	13 (31%)	15 (57.7%)	0.0145 *
Flow-related/Intranidal Aneurysm	12 (28.6%)	7 (26.9%)	0.8649
Treatment Modality			
Radiosurgery Only	32 (76.2%)	18 (69.2%)	0.5435
Embolization + Radiosurgery	8 (19%)	8 (30.8%)	0.2957
Surgery + Radiosurgery	1 (2.4%)	0	0.3232
Surgery + Embolization + Radiosurgery	1 (2.4%)	0	0.3232
Total Maximum Radiation Dose, Gy	56.4	54.1	0.7473

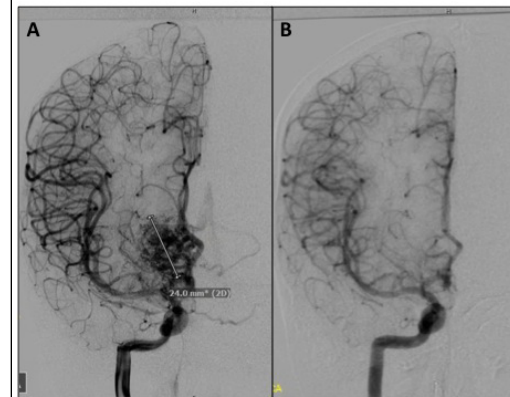
* P<0.05, **P<0.01, ***P<0.001



Results

Among 68 patients included in the analysis, 50 patients (73.5%) underwent SRS and 18 patients (26.5%) received SRS in conjunction with embolization and/or surgery. 42 patients (55.3%) achieved complete AVM obliteration. Among all AVM angioarchitectural features, arterial enlargement was found to be negatively associated with obliteration after SRS (P=0.0145). In addition, AVM location in the areas amenable to less constrained SRS planning (non-eloquent cortex (P=0.0104), right side(P=0.0073), frontal lobe (P=0.0371)), absence of focal deficit (P=0.0071) and presence of hemorrhage (P=0.0076) on presentation, and black race (P=0.0117) were positively correlated with AVM obliteration.

GKSRS Mediated Obliteration of AVM



A. Pre-GKSRS angiogram demonstrating AVM. B. Post-GKSRS angiogram demonstrating complete obliteration of AVM

Conclusions

AVM angioarchitectural features reflective of high flow as well as certain clinical factors influence AVM obliteration rates after SRS treatment, which has important implications in AVM treatment planning and prognostication.

Learning Objectives

- Discuss AVM epidemiology, presentation, available treatment modalities, and the use of stereotactic radiosurgery for AVM obliteration
- Appreciate the relationship between certain angioarchitectural features and complex AVM flow dynamics
- Recognize angioarchitectural features and clinical characteristics that are associated with AVM obliteration after SRS treatment

References

1. Starke RM, Yen CP, Ding D, et al. A practical grading scale for predicting outcome after radiosurgery for arteriovenous malformations: analysis of 1012 treated patients. *J Neurosurg.* 2013;119:981–987.
2. Starke RM, Kano H, Ding D, Lee JY, Mathieu D, Whitesell J, et al. Stereotactic radiosurgery for cerebral arteriovenous malformations: evaluation of long-term outcomes in a multicenter cohort. *J Neurosurg.* 2017;126:36–44.
3. Taeshineetanakul P, Krings T, Geibprasert S, Menezes R, Agid R, Terbrugge KG, Schwartz ML. Angioarchitecture determines obliteration rate after radiosurgery in brain arteriovenous malformations. *Neurosurgery.* 2012;71:1071–1078; discussion 1079.

Introduction

Brain arteriovenous malformation (AVM) is an uncommon vascular abnormality that can cause significant morbidity and mortality. Stereotactic radiosurgery (SRS) has been reported to be safe and effective treatment modality for brain AVMs, resulting in complete obliteration in 60-80% of cases. While it has been proposed that certain AVM flow-related characteristics can play a role in obliteration after SRS, very few studies have focused on AVM angioarchitectural features that correlate with flow. Our objective was to investigate the association between AVM angioarchitectural features and obliteration rates after SRS treatment.

Methods

A retrospective review of 150 patients who underwent SRS treatment for AVM obliteration between 2009-2017 was performed. All patients who were missing pre-treatment angiograms or had less than 36 months follow-up without complete obliteration of the AVM were excluded. Comprehensive clinical data collection and detailed investigation of AVM angioarchitectural features (arterial feeders, presence of arterial enlargement, patterns of venous drainage, presence of venous obstruction / ectasia / rerouting / pseudophlebitis, nidus morphology, and presence of flow-related/intranidal aneurysms) was completed. Parametric and non-parametric univariate analysis was performed as appropriate to investigate associations of AVM characteristics and obliteration.