Journal of Clinical Neuroscience 22 (2015) 357–362

Contents lists available at ScienceDirect

Journal of Clinical Neuroscience

journal homepage: www.elsevier.com/locate/jocn

Clinical Study

Predictors of functional outcome following treatment of posterior fossa arteriovenous malformations

Wuyang Yang [a], Joanna Y. Wang [a], Justin M. Caplan [a], Maria Braileanu [b], Hanbing Shang [a], Urvashi Upadhyay [c], Georgios A. Zenonos [d], Daniele Rigamonti [a], Geoffrey P. Colby [a], Alexander L. Coon [a], Rafael J. Tamargo [a], Judy Huang [a,*]

[a] Department of Neurosurgery, Johns Hopkins School of Medicine, Zayed Tower, Suite 6115F, 1800 Orleans Street, Baltimore, MD 21287, USA
[b] Georgetown University School of Medicine, Washington, DC, USA
[c] Department of Neurosurgery, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA
[d] Department of Neurosurgery, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

ARTICLE INFO

Article history:
Received 8 August 2014
Accepted 22 August 2014

Keywords:
Arteriovenous malformations
AVM obliteration
Functional outcome
Intracranial hemorrhage
Posterior fossa

ABSTRACT

Posterior fossa arteriovenous malformations (AVM) present particular therapeutic challenges. Studies aimed at clarifying risk of hemorrhage focus on obliteration rates, but few have addressed functional outcomes in these patients. In this study, we aim to explore the predictors of good functional outcome for posterior fossa AVM after treatment. A retrospective review of patients diagnosed with posterior fossa AVM at our institution from 1990 to 2013 was performed, and 61 patients met the inclusion criteria. Functional outcomes were assessed using the modified Rankin Scale (mRS), and mRS $\leqslant$1 was defined as good outcome. Within our cohort, 39 patients presented with hemorrhage (64.0%). Spetzler-Martin grades were I (n = 9, 14.8%), II (n = 20, 32.8%), III (n = 22, 36.1%), IV (n = 8, 13.1%), and V (n = 2, 3.3%). Patients were treated with surgery (n = 8), radiosurgery (n = 34), embolization (n = 2) or multimodal therapies (n = 8). Nine patients did not undergo treatment. Average follow-up was 41.9 months. Obliteration of AVM was confirmed in 44.3% of patients (n = 27). Forty-three patients (70.5%) achieved good functional outcomes (mRS $\leqslant$1). The absence of pre-treatment symptoms ($p < 0.01$) and AVM obliteration ($p = 0.04$) were predictive of good functional outcomes. In contrast, non-hemorrhagic presentation was not a significant predictor ($p = 0.60$). Asymptomatic presentation and AVM obliteration are associated with good functional outcomes in patients with posterior fossa AVM. Non-hemorrhagic presentation does not necessarily predict good functional outcome. Therefore treatment should not be considered only for those who present with hemorrhage. Posterior fossa AVM should be considered for definitive treatment in order to prevent future hemorrhages and subsequent poor functional outcomes.

1. Introduction

Posterior fossa arteriovenous malformations (AVM) comprise approximately 7–15% of all diagnosed AVM [1–3] and represent a distinct subgroup due to their unique therapeutic challenges and possibly more severe clinical course [3,4]. A majority (75%–92%) of lesions in this location present with hemorrhage [1,2,4–6], and they are also associated with a greater risk of recurrent bleeding and increased mortality rates [1,4,7–9]. Definitive treatment with a multimodality approach is generally recommended to eliminate the risk of hemorrhage [10,11]. To our knowledge, previous studies have focused on recommendations to prevent subsequent bleeding after treatment, and few studies have addressed functional outcomes in these patients. In this study, we examined functional outcomes following treatment of posterior fossa AVM and explored factors predictive of good functional outcomes.

2. Methods

A retrospective review of 602 patients diagnosed with cerebral AVM at the Johns Hopkins Medical Institutions from 1990–2013 was performed. All research protocols were approved by the Johns Hopkins Institutional Review Board for Human Research. Posterior fossa AVM were defined as AVM located in the cerebellum (vermis and hemisphere), brainstem, cerebellopontine angle, or infratentorial notch. Patients with both AVM and hereditary hemorrhagic telangiectasia, with inadequate data, or lost to follow-up were

* Corresponding author. Tel.: +1 410 502 5767; fax: +1 443 287 0683.
E-mail address: jhuang24@jhmi.edu (J. Huang).

http://dx.doi.org/10.1016/j.jocn.2014.08.007
0967-5868/

excluded from the study. A total of 77 patients were found to meet the inclusion criteria, but after application of exclusion criteria, our study cohort consisted of 61 patients.

Patient demographics and clinical and angiographic characteristics were collected for evaluation. Demographic factors included age at diagnosis, sex and race. AVM location categories included cerebellum, vermis, brainstem, complex (AVM with multiple territories) and others. Angiographic features included AVM location, dimensions on angiogram, deep venous drainage, eloquence, presence of associated aneurysms and drainage venous abnormalities (including venous varix and venous stenosis). Hemorrhagic presentation was limited to bleeding detected on head CT scan that could be attributable to the AVM.

Length of follow-up was defined as the duration from the date of first treatment to the date of last follow-up. For patients without any course of therapy, length of follow-up was defined as date of presentation to the date of last follow-up. Complete obliteration of the lesion was defined as angiographic or MRI confirmation of the absence of a residual lesion. With respect to our primary outcome measure, modified Rankin Scale (mRS) score was assessed at the last follow-up, with a good functional outcome defined as a mRS score of 0 or 1 (mRS $\leqslant$1). Secondary outcome measures included mortality, recurrent hemorrhages and lesion obliteration.

Patients were stratified into two groups based on mRS score at last follow-up (mRS $\leqslant$1 *versus* mRS >1). Fisher's exact test was used for analysis of categorical variables, and *t*-test or Wilcoxon rank-sum test was used for continuous variables. Statistically significant factors in univariate analysis were selected into a multivariate logistic regression model. Odds ratio (OR) is presented with a 95% confidence interval (CI). Statistical significance was defined as $p < 0.05$. Statistical analysis was performed using R Project for Statistical Computing.

3. Results

The average age for all patients was 44.0 years, and 32 (52.5%) patients were male. Of all patients who presented with bleeding (n = 41, 67.2%), 39 (63.9%) were from a hemorrhagic AVM. Two (3.3%) patients experienced aneurysmal subarachnoid hemorrhage (SAH) that were unrelated to their AVM. Seventeen patients (27.9%) presented with chronic headaches and two (3.3%) patients presented with seizure. Spetzler-Martin grading of all lesions were grade I (n = 9, 14.8%), II (n = 20, 32.8%), III (n = 22, 36.1%), IV (n = 8, 13.1%), and V (n = 2, 3.3%). Average size of all AVM was 2.3 cm. Twenty patients (32.8%) had associated aneurysms and 18 (29.5%) patients had associated venous abnormalities. Other detailed patient baseline characteristics are described in Table 1.

Table 1
Baseline patient characteristics

Parameters	All patients (N = 61)	Good outcome (mRS $\leqslant$1) (N = 43)	Poor outcome (mRS >1) (N = 18)	*p* value
Age, mean (SD)	44.0 (17.5)	45.3 (18.0)	40.9 (16.4)	0.36
Sex, male	32 (52.5)	23 (53.5)	9 (50.0)	>0.99
Race				0.43
White	38 (62.3)	28 (65.1)	10 (55.6)	
Black	21 (34.4)	13 (30.2)	8 (44.4)	
Hispanic	2 (3.3)	2 (4.7)	0 (00.0)	
Ruptured presentation	39 (63.9)	24 (55.8)	15 (83.3)	<0.05*
AVM mean size, cm (SD)	2.3 (1.3)	2.2 (1.2)	2.6 (1.5)	0.38
Deep drainage	35 (57.4)	23 (53.5)	12 (66.7)	0.40
Eloquence	34 (55.7)	21 (48.8)	13 (72.2)	0.16
Spetzler-Martin grade				0.07
I	9 (14.8)	8 (18.6)	1 (50.6)	
II	20 (32.8)	16 (37.2)	4 (22.2)	
III	22 (36.1)	15 (34.9)	7 (38.9)	
IV	8 (13.1)	4 (9.3)	4 (22.2)	
V	2 (3.3)	0 (0.0)	2 (11.1)	
Location				0.03*
Cerebellum hemisphere	30 (49.2)	24 (55.8)	6 (33.3)	
Vermian	10 (16.4)	8 (18.6)	2 (11.1)	
Brainstem	13 (21.3)	6 (14.0)	7 (38.9)	
Complex	4 (6.6)	1 (2.3)	3 (16.7)	
Other	4 (6.6)	4 (9.3)	0 (0.0)	
Associated aneurysms	20 (32.8)	15 (34.9)	5 (27.8)	0.77
Venous abnormality	18 (29.5)	10 (23.3)	8 (44.4)	0.13
Pretreatment mRS score				<0.01*
0	17 (27.9)	17 (39.5)	0 (0.0)	
1	30 (49.2)	23 (53.5)	7 (38.9)	
2	6 (9.8)	2 (4.7)	4 (22.2)	
3	3 (4.9)	1 (2.3)	2 (11.1)	
4	2 (3.3)	0 (0.0)	2 (11.1)	
5	2 (3.3)	0 (0.0)	2 (11.1)	
6	1 (1.6)	0 (0.0)	1 (50.6)	
Treatment				0.44
Surgery only	8 (13.1)	6 (14.0)	2 (11.1)	
Radiation only	34 (55.7)	25 (58.1)	9 (50.0)	
Embolization only	2 (3.3)	1 (2.3)	1 (50.6)	
Surgery + embolization	4 (6.6)	4 (9.3)	0 (0.0)	
Radiation + embolization	3 (4.9)	2 (4.6)	1 (50.6)	
Surgery + radiation + embolization	1 (1.6)	1 (2.3)	0 (0.0)	
Observation	9 (14.8)	4 (9.3)	5 (27.8)	
Follow-up, months, mean (SD)	41.9 (61.9)	36.0 (50.4)	55.9 (83.3)	0.35
Obliteration	27 (44.3)	24 (55.8)	3 (16.7)	<0.01*

Data are presented as number (%) unless otherwise specified.
AVM = arteriovenous malformation, mRS = modified Rankin Scale, SD = standard deviation.
* Statistically significant.