Rates of Re-hemorrhage, Risk Factors, and Outcomes of Previously Ruptured Arteriovenous Malformations (AVMs)

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Introduction

The annual hemorrhage rate of unruptured AVMs is well established. However, hemorrhage risk of a previously ruptured AVM is not well defined. In this study, we describe the rate of AVM re-hemorrhage as well as the risk factors and outcomes associated with AVM re-hemorrhage from an institutional cohort.

Methods

We retrospectively reviewed AVM patients from our institution seen from 1990-2015. Patients with hemorrhagic presentation were stratified into 1) patients with subsequent re-hemorrhage prior to treatment and 2) patients without re-hemorrhage. Patient demographic, clinical and angiographic data was compared across study groups. Cumulative and annual re-rupture rates were determined using Kaplan-Meier survival analysis.

Results

Of the 247 patients with hemorrhagic presentation, 29(11.7%) re-bled prior to treatment. There were no statistically significant differences between groups for age, gender, race, Spetzler-Martin grade, eloquence involvement, deep venous drainage, venous stenosis, AVM location, feeding artery aneurysms and intranidal aneurysms. AVM size was larger in the re-hemorrhage group (3.5cm+/-2.1 vs. 2.5cm+/-1.4,p=0.032). Multivariate analysis identified age(HR1.03[CI1.00-1.05],p=0.043), Hispanic race(HR5.94[CI1.34-26.45],p=0.019), AVM size(HR1.31[1.02-1.68],p=0.035) and venous stenosis(HR3.9[1.03-14.73],p=0.045) as risk factors for re-hemorrhage. Presence of a venous varix(HR0.04[CI0.00-0.37],p=0.005 and significant venous dilatation(HR0.27[0.09-0.80],p=0.018) decreased the risk of re-hemorrhage. The cumulative risk of rupture at 2, 4, 12, 26 and 52 weeks was 0.9%, 1.3%, 2%, 3.2% and 5.5% respectively. The annual rate of re-rupture decreased from 7.09%(year 1) to 2.89%(year 10). Outcomes (dichotomized as good((modified Rankin score (mRS) 0-2) or poor (mRS 3-6)) were significantly improved in the patients without re-hemorrhage(79.8%) compared to re-hemorrhage

Table 3. Univariable and Multivariable Cox Regression of Free of Rerupture after First Hemorrhage

Parameters	Univariable Analysis			Multivariable Analysis		
	HR	95% CI	*p Value*	HR	95% CI	*p Value*
Age at First Hemorrhage, per 1-year increase	1.02	[1.00, 1.04]	*0.107*	1.03	[1.00, 1.05]	*0.043* *
Gender (Male *versus* Female)	0.80	[0.36, 1.77]	*0.582*	0.77	[0.29, 2.06]	*0.602*
Race (*versus* White)						
Black	1.10	[0.42, 2.89]	*0.846*	0.43	[0.14, 1.33]	*0.143*
Hispanic	6.26	[1.56, 25.16]	*0.010* *	5.94	[1.34, 26.45]	*0.019* *
Asian	2.17	[0.48, 9.81]	*0.315*	2.22	[0.37, 13.21]	*0.382*
Others/Unknown†	-	-	-	-	-	-
AVM Size, per cm increase	0.91	[0.74, 1.11]	*0.342*	1.31	[1.02, 1.68]	*0.035* *
Deep Venous Drainage	0.71	[0.33, 1.51]	*0.371*	1.00	[0.42, 2.37]	*0.999*
Posterior Fossa Location	0.97	[0.33, 2.83]	*0.953*	0.79	[0.21, 2.98]	*0.728*
Associated Aneurysm	0.77	[0.29, 2.03]	*0.596*	0.84	[0.25, 2.83]	*0.778*
Venous Stenosis	1.59	[0.54, 4.67]	*0.398*	3.90	[1.03, 14.73]	*0.045* *
Venous Varix	0.09	[0.01, 0.73]	*0.024* *	0.04	[0.00, 0.37]	*0.005* *
Significant Venous Dilatation	0.34	[0.13, 0.87]	*0.024* *	0.27	[0.09, 0.80]	*0.018* *

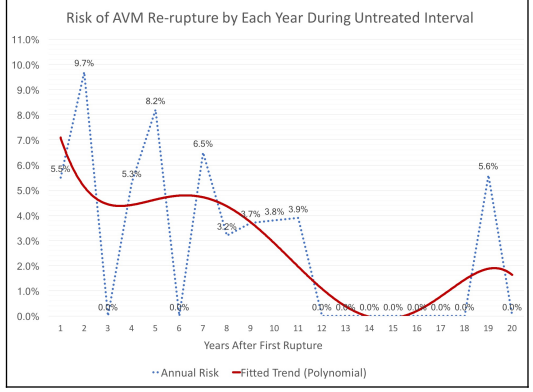
* Statistical significance ($p < 0.05$)
† Infinite value in upper limit of 95% CI
‡ Trend towards statistical significance ($p < 0.10$)

Table 4. Rate of Hemorrhage by Weeks and by Significant Variables

Selected Cohorts	Weekly Re-rupture Rates by Time in Weeks*					
	within 2	2 to 4	4 to 8	8 to 12	12 to 26	26 to 52
Overall	0.44%	0.23%	0.00%	0.15%	0.09%	0.09%
Risk Factors						
Venous Stenosis: Yes	1.60%	1.86%	0.00%	0.00%	0.00%	0.36%
Race: Hispanic	3.57%	0.00%	0.00%	0.00%	0.00%	0.51%
Size: > 3cm	0.00%	0.00%	0.00%	0.00%	0.12%	0.10%
Age: 18-60	0.35%	0.00%	0.00%	0.23%	0.07%	0.07%
Age: > 60	1.40%	1.52%	0.00%	0.00%	0.29%	0.00%
Protective Factors						
Venous Varix: Yes	0.00%	0.00%	0.00%	0.00%	0.00%	0.23%
Significant Venous Dilatation: Yes	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

* Estimated using predicted values in univariable Cox regression

Annual hemorrhage rate after ruptured presentation



Conclusions

The rate of re-rupture is low immediately following initial hemorrhage of an AVM, with increasing cumulative risk over time. Outcomes in patients are significantly improved if there is no re-hemorrhage. This study helps identify the rates and risk factors associated with AVM re-hemorrhage, such that timing of treatment of a ruptured AVM may be optimized.

Learning Objectives

By the conclusion of this session, participants should be able to:

1.Appreciate the risk of re-rupture after initial hemorrhage for AVMs

2.Identify critical risk factors that modify re-rupture risk in ruptured patients

3.Understand that rate of re-rupture is low immediately following initial hemorrhage and increases