

Delayed Hemorrhage Following Treatment of Brain Arteriovenous Malformations (AVMs)

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Introduction

The primary goal of brain AVM treatment is to reduce hemorrhagic risk. However, post-treatment hemorrhagic risk exists, and has been reported separately for different treatment modalities: annual rate of 1% after surgery, 10% after embolization, and 2-7% after radiosurgery. We aim to compare the risk of delayed hemorrhages across different treatment modalities in a single study cohort.

Methods

Our study included patients diagnosed with brain AVMs that were at Johns Hopkins Hospital and Johns Hopkins Bayview Medical Center between Jan 1st, 1990 and Dec 31st, 2013. All patients included in the study underwent some kind of intervention. Patients that were put on observation or conservative treatment were excluded. Patients with multiple AVMs or with hereditary hemorrhagic telangiectasia(HHT) were also excluded from this study. Delayed hemorrhage was defined as hemorrhage occurring at least 2 years after treatment. Proportion of delayed hemorrhage, Kaplan Meier analysis and patient-time statistics were used to assess hemorrhagic risks by treatment modality.

Results

A total of 420 patients were included after application of inclusion and exclusion criteria (Figure 1). Spetzler-Martin grades were: I(n=53,12.6%), II(n=152,36.2%), III(n=137,32.6%), IV(n=63,15.0%), V(n=15,3.6%). Twenty-three patients(5.5%) were found to have a total of 29 delayed hemorrhage events. Among these, three patients (13.0%) were previously confirmed to have no residual AVMs by angiography. Average interval between last treatment and delayed hemorrhage was 7.5 years, with the longest interval as 24.2 years. Proportions of delayed hemorrhages by treatment modalities(p<0.01) were: surgery +/embo(8.7%), radiosurgery +/embo(65.2%), embolization only(21.7%) and surgery + radiosurgery +/- embo (4.3%). Kaplan Meier curves (Figure 2) revealed difference of delayed hemorrhage event between treatment modalities, with embolization having the highest probability in having delayed hemorrhage event, and surgery +/- embo being the lowest (p < 0.01). Patient-times of delayed hemorrhages by treatment modalities were: surgery +/- embo (3.96/1000 patient-years), radiosurgery +/- embo (12.6/1000 patient-years), embolization only (36.6/1000 patientyears), and surgery + radiosurgery +/ - embo (17.1/1000 patient-years). Of note, there was no significant difference between surgery +/- embo and radiosurgery +/- embo cohort on a poisson-rate-test(p=0.14).



patients across all treatment modalities.



Figure 2b. Survival curve sparated by different treatment modalities.

Conclusions

Delayed hemorrhages may occur after AVM treatment, even after angiographic confirmation of obliteration. Surgery has the best control for delayed hemorrhage, while embolization only has the worst control. Control for delayed hemorrhage between radiosurgery and surgery was not found to be statistically different.

Learning Objectives

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

 Understand that there are risks of delayed hemorrhages (> 2 years post -treatment) after AVM treatment.

2) Understand the difference of delayed hemorrhagic risk control for different modalities.

3) Identify the fact that AVM may hemorrhage after angiographically confirmed obliteration.