

Hemorrhagic Risk of Intracranial Arteriovenous Malformations (AVMs) Treated With Embolization as the Single Modality

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Introduction

Embolization has been discussed as a feasible single modality treatment for intracranial arteriovenous malformations (AVMs). We sought to compare hemorrhagic risk between embolization and conservative management in a multivariate survival analysis.

Methods

Patients with intracranial AVMs evaluated at our institution from 1990-2013 were reviewed. Those recommended to undergo embolization without plans for other treatment modalities were included. Patients managed without any interventions were also included for comparison. Multivariate Cox regression analysis of hemorrhage-free survival was performed, with survival interval right-censored to date of last follow-up or date of salvage treatment.

Results

We identified 205 patients matching our inclusion criteria, with 160 patients in the non-interventional group and 45 in embolization group. Average age of all patients was 40.2 ± 19.5 years, with younger patients treated with embolization ($p=0.026$). Spetzler-Martin grades were: grade 1 (9.3%), grade 2 (30.2%), grade 3 (31.2%), grade 4 (14.1%), and grade 5 (15.1%). Hemorrhagic presentation occurred in 51 (31.9%) in conservative group and 13 (28.9%) in embolization group ($p=0.703$). Other baseline characteristics were similar between the two management groups. Between conservative management and embolization, thirty-three (20.6%) and 14 (31.1%) patients crossed-over to radiosurgery, respectively; whereas 2 (4.4%) and 9 (5.6%) patients crossed-over to surgery. During average follow-up period of 7.7 years, 30 patients (14.6%) suffered a recurrent hemorrhage. Multivariate Cox regression revealed older age ($p=0.031$) and hemorrhagic presentation ($p<0.001$) to be significantly associated with follow-up hemorrhage after accounting for treatment modality. Embolization had 1.9-fold hazard ratio of hemorrhage, although the association was not significant ($p=0.149$). However, in a subset analysis of unruptured AVMs, embolization was associated with 4-fold hazard ratio of hemorrhage compared to conservative management ($p=0.044$).

Conclusions

Older age and initial presentation with hemorrhage were associated with increased risk of hemorrhage during follow-up. Treatment of AVMs with embolization as the single modality may increase hemorrhagic risk compared with conservative management. Embolization as the only planned intervention has associated risk of hemorrhage, especially in unruptured AVMs.

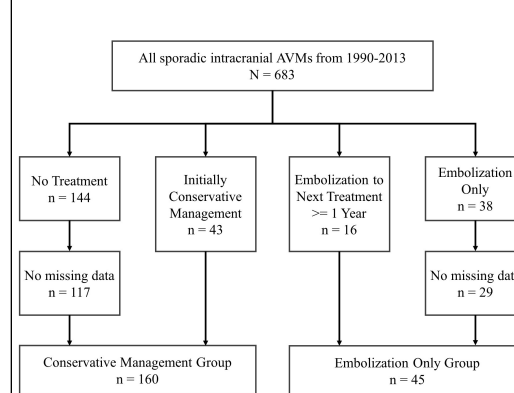
Learning Objectives

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

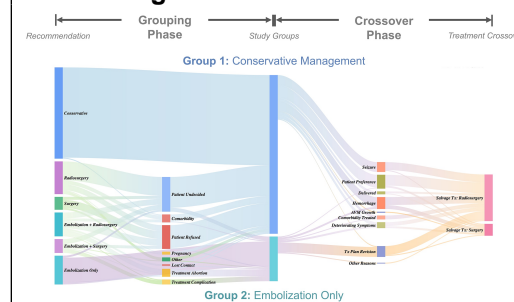
- 1) Understand the hemorrhagic risk associated with embolization or conservative management
- 2) Understand that embolization may increase hemorrhagic risk, especially in unruptured AVM patients
- 3) Understand that embolization without further planned interventions should be avoided

Patient Selection Flowchart

Figure 1. Flowchart for Study Cohort Selection



Sankey Plot of Patient Treatment Assignment and Cross-over



Kaplan-Meier Curve of Free of Hemorrhage Survival at Follow-up

