

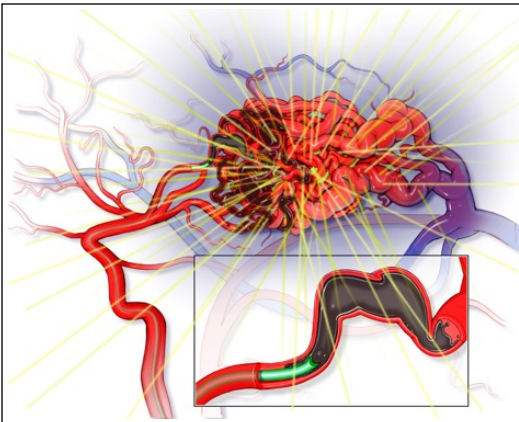
A Retrospective Analysis of Outcomes in Patients with Hemorrhagic Arteriovenous Malformations Treated with combination Endovascular Embolization and Gamma Knife Stereotactic Radiosurgery

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Introduction

In this study we report a retrospective case series examining outcomes of patients who presented with a hemorrhage secondary to a cerebral AVM who were not felt to be candidates for surgical resection. All patients were Spetzler-Martin Grade III or IV and were initially treated with varying degrees of endovascular embolization prior to Gamma Knife radiosurgery.



Methods

A retrospective analysis was performed on 16 patients who presented to our institution from 2010 to 2015 with Spetzler Martin grade 3-4 AVMs. Each of these patients was treated with combination endovascular embolization and gamma knife stereotactic radiosurgery. As a measure of clinical outcome, neurological function was measured using the modified Rankin Scale (mRS). The nidus was measured and compared before and after treatment. We evaluated for clinical or radiographic evidence of re-hemorrhage, stroke within the AVM territory, or radiation necrosis.

Table 1

Age	Gender	AVM location	Dominance	Spetzler-Martin grade	Associated aneurysms
10	M	Temporal	Dominant	3	Yes
15	F	Thalamic	Non-dominant	3	No
18	M	Thalamic	Dominant	4	Yes
24	M	Thalamic	Dominant	3	No
27	F	Thalamic	Non-dominant	3	Yes
36	M	Parietal	Dominant	4	Yes
36	M	Basal ganglia	Dominant	4	Yes
47	F	Frontal	Dominant	3	No
51	M	Parietal	Dominant	3	Yes
52	M	Parietal	Non-dominant	3	No
55	M	Thalamic	Non-dominant	3	No
56	F	Frontal	Non-dominant	4	Yes
65	M	Cerebellar	Dominant	3	Yes
66	M	Cerebellar	Non-dominant	3	Yes
70	F	Frontal	Non-dominant	3	Yes
70	M	Basal ganglia	Non-dominant	3	Yes

Cohort Characteristics

Table 2

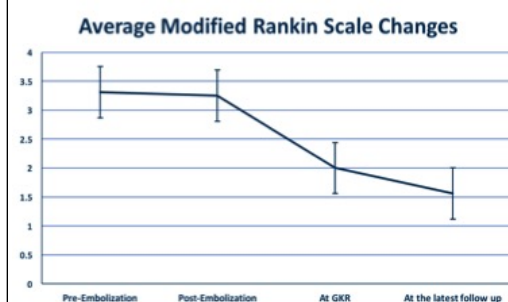
AVM Location	Dominance	mRS at initial presentation	mRS at time of embolization	mRS at time of gamma knife	mRS at last follow up
Temporal	Dominant	2	2	0	0
Thalamic	Non-dominant	2	2	1	1
Thalamic	Dominant	4	3	1	1
Thalamic	Dominant	3	3	3	3
Thalamic	Non-dominant	5	5	3	3
Parietal	Dominant	4	4	2	2
Basal ganglia	Dominant	3	3	2	2
Frontal	Dominant	2	2	2	1
Parietal	Dominant	5	5	4	2
Parietal	Non-dominant	1	1	1	0
Thalamic	Non-dominant	5	5	3	1
Frontal	Non-dominant	5	5	2	2
Cerebellar	Dominant	4	4	1	1
Cerebellar	Non-dominant	3	3	3	3
Frontal	Non-dominant	1	1	1	0
Basal ganglia	Non-dominant	4	4	3	2

mRS Scores

Results

There was no subsequent re-hemorrhage in any patient with a mean follow-up period of 45 months. There was significant improvement in the mRS score in all, but 1 patient who remained stable. The one patient noted to have a stable mRS score from first presentation to last follow up was also noted to have complete obliteration of the AVM.

There were no patients with worsening of mRS score. At last known follow-up 81.25% had an mRS less than 2. 57% of the patients had complete obliteration of the nidus

Chart 1


Change in mRS scores over time

Table 3

AVM Location	Dominance	Largest diameter before treatment (mm)	Largest diameter after treatment (mm)	Lesion volume before treatment (ml)	Lesion volume after treatment (ml)	Gamma Knife Dose
Temporal	Dominant	11.35	0	0.438	0	20
Thalamic	Non-dominant	24.85	0	3.012	0	18
Thalamic	Dominant	32.5	N/A	14.619	N/A	20
Thalamic	Dominant	19.3	0	1.584	0	18
Thalamic	Non-dominant	20.65	0	2.081	0	18
Parietal	Dominant	18.25	0	4.642	0	18
Basal ganglia	Dominant	30.7	15.75	5.917	1.646	20
Frontal	Dominant	17.65	0	0.985	0	20
Parietal	Dominant	39.95	16.5	12.459	1.129	18
Parietal	Non-dominant	19.25	N/A	2.636	N/A	20
Thalamic	Non-dominant	24.15	11.25	6.425	0.210	20
Frontal	Non-dominant	53.7	40.7	27.990	18.991	18
Cerebellar	Dominant	16.35	0	1.195	0	18
Cerebellar	Non-dominant	11.7	0	0.405	0	22
Frontal	Non-dominant	29.25	23.05	7.087	4.453	18
Basal ganglia	Non-dominant	6.4	5.2	0.056	0.046	19

Gamma Knife Dosage with Nidus size before and after treatment

Conclusions

The combination therapy of targeted endovascular embolization and gamma knife stereotactic radiosurgery is a safe and effective option for treating ruptured grade 3 and 4 brain AVMs who are not felt to be surgical candidates. In our Series, 57% of our patients were cured of their AVM and protected permanently against re-hemorrhage with no incidence of re-hemorrhage or worsening of clinical outcome.

Learning Objectives

Understand the treatment options for ruptured brain AVMs. Understand the clinical and radiographic outcomes obtained after treatment of ruptured brain AVMs with combination stereotactic radiosurgery and endovascular embolization.