



Full length article

## Validity assessment of grading scales predicting complications from embolization of cerebral arteriovenous malformations



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### ABSTRACT

**Objective:** Endovascular embolization, though initially approved as an adjunctive therapy for surgical excision of cerebral arteriovenous malformations (AVMs), has found extensive use in the management of these lesions. A number of systems have been proposed to stratify AVMs by the procedural risk of embolization, including the Buffalo score and AVM Neuroendovascular grade. An external validity assessment of these systems has not been performed.

**Patients and methods:** A retrospective review of all patients who underwent embolization of cerebral AVMs at a single institution, between 2010 and 2016, was performed. Data including patient demographics, AVM characteristics, procedural details, complications, and outcomes were collected.

**Results:** Fifty-five embolization procedures in 39 patients (median age 53.1 years) were identified. Ten (25.6%) patients underwent more than 1 embolization procedure. A triaxial catheter system for support was used in 48 (87.3%) of the embolization procedures and a detachable tip microcatheter was used in 28 (50.9%). Complete obliteration of the AVM was achieved in 10.9% of the cases. There was one (2.6%) mortality unrelated to the procedure. Three minor (5.5%) and 2 major (3.6%) clinical complications occurred. Neither Spetzler-Martin grade, Buffalo score, or AVM Neuroendovascular grade correlated with complications.

**Conclusion:** Neither Buffalo score nor AVM Neuroendovascular grade predicted complications from embolization in the present study. Given the relative infrequency of complications, the number of factors that may influence AVM treatment, recent advancements in endovascular technologies, and the subjectivity inherent in these grading systems, the relative utility of risk stratification scales in the embolization of AVMs remains largely unknown.

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## 1. Introduction

The recent Randomized Trial of Unruptured Brain Arteriovenous Malformations (ARUBA) has spurred significant debate amongst neurointerventionalists regarding the precise role of invasive procedures for the treatment of cerebral arteriovenous malformations (AVMs). It found that the risk of stroke and death was nearly three-fold more in patients presenting with unruptured AVMs who were treated via intervention *and* medical management as compared with medical management alone [1]. One of these invasive pro-

cedures, endovascular embolization, is commonly performed as an adjunct to surgical resection. In select cases it is used for cure, palliation, or for volume reduction in larger AVMs, prior to stereotactic radiosurgery [2]. The liquid embolic agent, ethylene-vinyl alcohol copolymer (Onyx; Covidien – Ev3, Irvine, CA), has recently gained favor for these indications. While the Spetzler-Martin grading scale accurately predicts the risk of peri- and postoperative complications following microsurgical resection [3], the system is less applicable to embolization [4]. Recently 2 grading scales, the Buffalo score [5] and the AVM Neuroendovascular grade [6], have been proposed (Table 1) to specifically predict the risk of clinical complications associated with embolization. The purpose of the present study was to perform an external validity assessment of these systems.

**Abbreviations:** ARUBA, randomized trial of unruptured brain arteriovenous malformations; AVMs, arteriovenous malformations; mRS, modified Rankin scale.

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**Table 1**  
AVM Grading Scales.

Grading Scales	Assigned Points
<b>Spetzler-Martin Scale [10]</b>	
<i>Size of AVM</i>	
Less than 3 cm	1
3–6 cm	2
Greater than 6 cm	3
<i>Location of AVM</i>	
Noneloquent brain region	0
Eloquent brain region	1
<i>Venous Drainage</i>	
Superficial	0
Deep	1
<b>Buffalo Score [5]</b>	
<i>Number of Arterial Feeders</i>	
1–2	1
3–4	2
5 or more	3
<i>Diameter of Arterial Feeders</i>	
Majority greater than 1 mm	0
Majority less than or equal to 1 mm	1
<i>Location of AVM</i>	
Noneloquent brain region	0
Eloquent brain region	1
<b>AVM Neuroendovascular Grade [6]</b>	
<i>Number of Arterial Feeders</i>	
1–2	1
3–5	2
6 or more	3
<i>Location of AVM</i>	
Noneloquent brain region	0
Eloquent brain region	1
<i>Arteriovenous Fistulous Component</i>	
1–2	0
3–5	1

## 2. Materials and methods

### 2.1. Data collection

After Institutional Review Board (IRB) approval, a retrospective review of AVM embolizations performed at a major tertiary referral center in the United States between 2010 and 2016 was preformed. Patient demographics and angio-architectural characteristics of the AVM were collected. Procedural details including the use of coaxial or triaxial catheter systems and the use of detachable tip microcatheters were recorded. Angiographic outcome was assessed using digital subtraction angiography. Incidence of both peri- and post-procedural clinical and technical complications were recorded in similar fashion. Clinical complications were classified as either major or minor. Major complications were defined as complications resulting in severe permanent neurological deficits with a change of greater than 2 points on the mRS when compared to the pre-procedure score. All others were classified as minor. The use of multimodality treatments such as surgical resection and/or radiotherapy was noted. Baseline clinical condition and functional outcome was assessed using the modified Rankin Scale (mRS).

### 2.2. Embolization procedure

All patients underwent general anesthesia followed by standard femoral arterial access. A guide catheter was generally positioned into the intracranial carotid or vertebral artery and the patient was heparinized throughout the procedure with a goal activated clotting time (ACT) of 250. Most commonly, a distal access catheter and microcatheter were used to obtain distal access to the arterial pedicles of the AVM (triaxial catheter support). Onyx-18 was prepared according to manufacturers instructions and was deployed in a slow pulsatile manner under fluoroscopic guidance. Generally, a

plug was formed around the catheter tip and then forward propulsion of the Onyx was used to obliterate the AVM (We have not found the creation of an initial plug with Onyx 34 embolization to be beneficial and have primarily used Onyx 18). Onyx embolization usually ceased when either the portion of the AVM visible from a particular pedicle was obliterated, the Onyx could not be manipulated to the AVM, the Onyx began to reflux significantly past the microcatheter tip, or the Onyx began to egress into normal parenchyma. Microcatheters were carefully removed by very slow and constant withdrawal. Pharmacologic provocation was not routinely utilized.

### 2.3. Statistical analysis

The statistical software, SPSS 21.0 (IBM Corp., Armonk, NY), was employed to perform all relevant analyses. The Fisher's exact test was performed for categorical variables. The Mann-Whitney *U* test was performed for non-parametric numerical variables. Statistical significance was defined by a *p* value less than 0.05.

## 3. Results

### 3.1. Patient demographics and arteriovenous malformation characteristics

Fifty-five embolization procedures were performed between 2010 and 2016. A total of 39 patients with 39 AVMs were included in the analysis. Ten (25.6%) patients underwent more than 1 embolization procedure. Nineteen (48.7%) of the patients were male, while 51.3% were female. The median age of these patients was 53.1 at the time of embolization. Fifteen (38.5%) of the patients presented with a headache, while fourteen (35.9%) presented with a focal neurological deficit, including sudden onset of weakness, blurred vision, or aphasia. Twenty-one (53.8%) patients presented with a hemorrhage. Twenty-seven patients (69.2%) had an mRS of 0–2 prior to embolization, with the remaining patients having an mRS of 3 or greater (Table 2).

All patients (100%) underwent embolization with the liquid embolic agent Onyx at a median of 76 days (range 0–591 days) from presentation. Patients with ruptured lesions underwent embolization at a median of 7 days from presentation. The majority of AVMs (60%) had an initial diameter of less than 3 cm. Thirteen (33.3%) of the AVMs were located in the frontal lobe. Fifteen (38.5%) of the AVMs were located in eloquent brain regions. The middle cerebral artery (MCA) (22; 56.4%) and anterior cerebral artery (14; 35.9%) territories most frequently contributed to the AVM. Greater than half (53.8%) of AVMs were found to be diffuse. The median number of arterial feeders was 2 (range 1–8). Deep perforating feeders were visualized in 4 (7.3%) of embolization procedures. In 29 (52.6%) of the embolization procedures, a single draining vein was visualized. A score of 1, 2 or 3 according to the Spetzler Martin grade, Buffalo score, and the AVM Neurovascular grade score was assigned in 94.5%, 90.9%, and 92.8% of procedures, respectively (Table 2).

### 3.2. Procedural details, complications, and outcome

A triaxial system utilizing a distal access catheter was used in 48 (87.3%) of procedures. A detachable tip micro-catheter was used in 28 (50.9%). Pre-embolization radiosurgery was performed in 2 (3.6%) cases, with a one-time dose of 1800 cGy delivered in each. In 10.9% of the cases the AVM was completely obliterated solely with embolization. Venous penetration of the embolic material was seen in 14 procedures (25.5%). This was not associated with an increase in complications. Eight (14.5%) complications were noted including 3 (5.5%) technical complications which consisted of distal fracture of the microcatheter. Five (9.1%) clinical complications were observed, which included 3 minor (asymptomatic

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