Target Embolization of Associated Aneurysms in Ruptured Arteriovenous Malformations

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■ OBJECTIVES: **The purpose of this study was to examine the safety and efficacy of target embolization of aneurysms associated with ruptured brain arteriovenous malformations (BAVMs).**

■ METHODS: **Ruptured BAVM patients who underwent endovascular treatment at our institution from January 2011 to December 2015 were retrospectively reviewed. Patients were divided into aneurysm (AN) and non-aneurysm (non-AN) groups on the basis of the existence of BAVM-associated aneurysms or not. Demographics, angiographic characteristics, complications, and clinical outcomes were compared between 2 groups. Complication risk factors were analyzed for all objects. Patient outcomes were assessed with modified Rankin Scale (mRS).**

■ RESULTS: **A total of 129 (male = 53) patients were included. In 31 (24.0%) patients, 33 aneurysms were observed, including 16 intranidal and 17 flow-related aneurysms. Of the 166 sessions of embolization performed, there were 13 (10.1% of patients, 7.8% per session) complications in all, including 2 hemorrhagic, 8 transient ischemic, and 3 permanent ischemic types. There was no statistical difference in terms of complication incidence rate between groups. A total of 12 patients (9.3% of patients, 3.3% per person-year) experienced postoperative hemorrhage during follow-up (mean = 3.4 years). The yearly postoperative hemorrhage incidence rate was 3.4% in the non-AN group and 2.0% in AN group. Excellent or good outcomes (mRS ≤ 2) were observed in 103 (91.2%) patients. Unfavorable outcomes (mRS ≥ 3) as a direct result of embolization remained in no patients.**

■ CONCLUSIONS: **Target embolization of aneurysms associated with ruptured BAVMs could significantly decrease postoperative rehemorrhage without increasing complications.**

INTRODUCTION

Intracranial hemorrhage (ICH) secondary to brain arteriovenous malformations (BAVMs) carries significant morbidity and mortality.[1,2] Initial hemorrhage presentation is the most important indicator for subsequent hemorrhage for BAVM patients. The overall yearly hemorrhage risk of ruptured BAVMs ranges from 2.55%–17.8%, higher than that (2.1%–4.12%) of unruptured BAVMs.[3-6] Aneurysms associated with BAVMs portend a high risk of hemorrhage or rehemorrhage. The risk of hemorrhage in BAVM patients with associated aneurysms was reported to be 7% per year, which is higher than the 3% risk of hemorrhage for patients without aneurysms.[3,7,8] Studies have proved that target embolization of associated aneurysms may decrease the hemorrhage rate and improve clinical outcome for unruptured BAVMs.[9] However, for ruptured BAVMs, whether target embolization of associated aneurysms will be safe and efficient is not well known. In order to evaluate the safety and efficacy of target embolization, we compared the complication incidence rate and rehemorrhage incidence rate between ruptured BAVMs with and without associated aneurysms.

Key words
- Associated aneurysm
- Complication
- Rehemorrhage
- Ruptured brain arteriovenous malformations
- Target embolization

Abbreviations and Acronyms
AN: Aneurysm
BAVM: Brain arteriovenous malformation
ICH: Intracranial hemorrhage
mRS: Modified Rankin Scale
NBCA: N-butyl cyanoacrylate
NPPB: Normal perfusion pressure breakthrough
S-M: Spetzler-Martin grade

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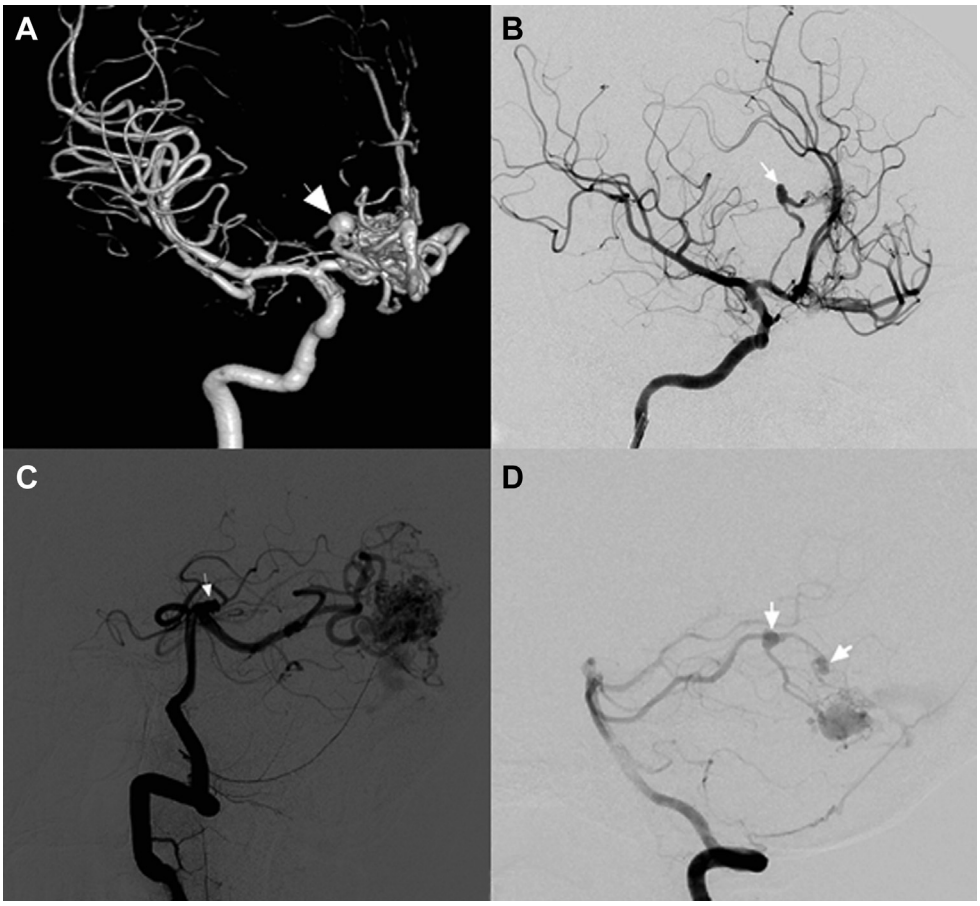

Figure 1. Aneurysms associated with brain arteriovenous malformations. (**A**) 3-dimensional view of right internal carotid artery angiography shows an intranidal aneurysm (*arrowhead*). (**B**) Anteroposterior view of right internal carotid artery angiography shows flow-related aneurysm at vessels supplying the nidus (*arrow*). (**C**) Anteroposterior view of right vertebral artery shows flow-related aneurysm at the origin of an artery (right posterior cerebral artery) supplying blood to the nidus (*arrow*). (**D**) Lateral view of left vertebral carotid artery shows multiple flow-related aneurysms at vessels supplying the nidus (*arrows*). The aneurysm in (**A**) is intranidal aneurysm. The aneurysms in "**B**, **C**, and **D**" are proximal aneurysms.

MATERIALS AND METHODS

Patients

This study was approved by the ethics committee of Beijing Tiantan Hospital. All patients signed informed consent. A series of 336 consecutive BAVM patients from January 2011 to December 2015 at Beijng Tiantan Hospital were retrospectively reviewed. Patients who presented with intracerebral hemorrhage (ICH) caused by BAVM or associated aneurysms and underwent endovascular embolization were included. Patients who underwent surgery resection before or after embolization were excluded.

ICH is defined as sudden onset of headache, seizure, focal deficit, or a combination of these features, with signs of fresh bleeding on computed tomography. Subjects were divided into aneurysm (AN) and nonaneurysm (non-AN) groups on the basis of the existence of BAVM-associated aneurysms or not. We compared demographics, angiographic characteristics, complications, and rehemorrhage incidence rates within the follow-up period and clinical outcomes between the 2 groups.

Brain aneurysms associated with BAVMs were divided into 2 large subgroups: intranidal aneurysms and flow-related aneurysms (Figure 1). Intranidal aneurysms were located within or in the immediate vicinity of the nidus of BAVM. Flow-related aneurysms include aneurysms of vessels supplying the AVMs and aneurysms of the circle of Willis origin of an artery supplying blood to the nidus.[8]

Management of Patients

Patients come to our hospital in acute or delayed fashion after ICH. In acutely ruptured AVMs, we will perform angiography except when surgery is needed for management of hydrocephalus and mass effect. If there are aneurysms associated with AVMs and they could be identified as the likely source of bleeding, the