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Endovascular Treatment of Intracranial AVM

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ABSTRACT

Summary : Since 1983, we have experienced endovascular treatment of intracranial AVMs.[2)3)] Superselective catheterization of feeding artery, embolization or feeding artery occlusion of the cerebral AVMs have been performed for 73 cases in 134 sessions. Endovascular treatment of intracranial AVMs such as embolization or feeding artery occlusion have been performed for 57 cases of AVMs in 95 sessions. In each time, endovascular approach was performed for two to five feeding arteries, so more than 300 feeding arteries were catheterized by microcatheters or balloon catheters. In this report, we present our experiences of endovascular treatment of intracranial AVMs and discuss embolic materials and the role of endovascular treatment of intracranial. AVMs. (**Kor J Cerebrovascular Disease 1:82-7, 1999**)

KEY WORDS : Intravascular neurosurgery · Interventional neuroradiology · Endovascular treatment · AVM · Embolization · Embolic material.

Introduction

Endovascular treatment of intracranial arteriovenous malformations (AVMs) has been experienced for almost 30 years by interventional neururadiologists or endovascular neurosurgeons. In 1960, Luessenhop et al reported the first intravascular cerebral treatment when he embolized an AVM by injecting silastic beads into the arteries of the neck.[5)] The era of selective endovascular therapy began in 1974 when Serbinenko treated a variety of neurovascular lesions using a detachable balloon technique.[7)] The development of a calibrated-leak balloon catheter by Kerber allowed the first direct embolization of AVMs through the introduction of a rapidly solidifying polymer.[4)] Since then endovascular treatment of intracranial AVMs has been refined with improvements in fluoroscopic equipment, catheters, embolic agents, angiographic techniques, and understanding of neurovascular anatomy. These developments have improved not only patients' survival but also their quality of life. Now further progress demands further improvements in all of these things.

Since 1983, we have experienced endovascular treatment of intracranial AVMs.[2)3)] Superselective catheterization of feeding artery, embolization or feeding artery occlusion of the cerebral AVMs have been performed for 73 cases in 134 sessions. Endovascular treatment of intracranial AVMs such as embolization or feeding artery occlusion have been performed for 57 cases of AVMs in 95 sessions. In each session, endovascular approach was performed for two to five feeding arteries. In this report, we present our experiences of endovascular treatment of intracranial AVMs and discuss embolic materials and the role of endovascular treatment of intracranial. AVMs.

Materials and Methods

From 1983 to 1999, endovascular treatment of intracranial AVM was carried out 134 times for 73 cases. In each time, endovascular approach was performed for two

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to five feeding arteries, so more than 300 feeding arteries were catheterized by a microcatheter or a balloon catheter. In those procedures, embolization or feeding artery occlusion have been performed 95 times for 57 cases, and the other procedures have been performed as a provocative test or superselective catheterization before surgical treatment or embolization. The age of the patients varied from 2 to 62 years, mean age was 32 years old, and there were 45 males and 28 females. Initial symptom was intracranial bleeding in 29 cases, epileptic seizure or neurological symptom in 22 cases and headache or incidental findings in 22 cases. The site of the AVM was located in the cerebral hemisphere in 52 cases, deep region such as basal ganglia or thalamus in 9 cases, cerebellum in 10 cases, and brain stem such as mid brain, pons or medulla in 2 cases. The size of AVM was large (more than 6 cm) in 16 cases, medium (3-6 cm) in 35 cases and small (less than 3 cm) in 22 cases. The nidus of the AVM was located at an eloquent area in 50 cases among 73 cases of the AVM.

In almost all cases, the endovascular technique was performed from a transfemoral approach under local anesthesia with consciousness, and with DSA control using the road map function. In initial some cases, transcarotid or transbrachial approach was applied. In some selective cases, procedure was performed under general anesthesia. The patient was usually heparinized and ACT monitoring was used. For initial 14 patients, a micro-balloon catheter was used for endovascular treatment of AVMs. After 1988, over-the-wire microcatheters such as Tracker catheter, Transit catheter, or flow-guided microcatheters such as Magic catheter began to be available for clinical cases, then these catheters were routinely used for endovascular procedure.

A 6 French sheath is positioned in the groin and a 6 French guiding catheter is located in the involved cervical artery such as internal carotid artery or vertebral artery. We used over-the-wire microcatheters or flow-guided microcatheters to selectively catheterize AVM arterial feeding vessels as near to the nidus as possible, and to perform superselective angiography and superselective Amytal testing as a provocative test.

As we already described, endovascular treatment such as embolization or feeding artery occlusion have been performed 95 times for 57 cases. As embolic materials, we used Ethylene-vinyl alcohol copolymer (EVAL) mixture,[8] Methyl and butyl methacrylate, and dimethylaminoethyl methacrylate copolymer (Eudragit-E) mixture,[9] Polyvinyl alcohol (PVA) particle, silk suture and coils. The embolic materials was decided to select for use each time for some reasons. It depended on the quality of embolic materials, easy handling, availability of it, and benefit and risk of embolization.

A staged embolization was performed in most large or giant AVMs. The time between embolization is approximately 1 to 2 weeks, if there are no technical or clinical complications.

Results

Endovascular treatment of intracranial AVMs such as embolization or feeding artery occlusion have been performed for 57 cases of AVMs in 95 sessions. As an embolic material, we prefer to use EVAL or Eudragit-E instead of Cyanoacrylates as a liquid embolic material. EVAL or EVAL combined with some solid materials such as PVA particle or silk suture were used in 33 times out of 95 sessions. Eudragit-E or Eudragit-E combined with some solid materials such as PVA particle or coils were used in 18 times out of 95 sessions. As a solid material, PVA particles, coils or silk suture were used in 33 times out of 95 sessions. Detachable balloons were used in 12 times out of 95 sessions as a material for feeding artery occlusion.

As an embolic material, detachable balloons were used in first 12 times. Then EVAL began to be available for use, so EVAL was the choice for liquid embolic material. Several years later, the supply of EVAL stopped. Then, Eudragit-E was followed the choice of liquid embolic material. The solid embolic material such as PVA particle, coils or silk suture has been used for selected cases which was suitable for them.

The size of AVM before endovascular treatment was large (more than 6 cm) in 12 cases, medium (3-6 cm) in 30 cases and small (less than 3 cm) in 15 cases. After endovascular treatment, the size of AVM was large (more than 6 cm) in 1 case, medium (3-6 cm) in 9 cases and small (less than 3 cm) in 47 cases. According to this result, the effect of embolization which decreased the size of AVM was prominent. However, complete occlusion after endovascular treatment was performed in only two cases which means 7% of the cases of embolization and

the size of these cases were both small.

The complication occurred in 17 times out of 134 sessions, however, serious complication which required emergency operation or resulted major neurological deficit occurred in 5 cases. The complication occurred more in the cases of high grade of Spetzler Martin Grade and the AVM located in infratentorial region or fed by perforating arteries. There was no mortality related to endovascular treatment.

After the endovascular treatment performed in 57 cases of AVM, surgical extirpation was done in 30 cases, radiosurgery such as proton-beam irradiation or gamma-knife surgery was performed in 21 cases and no additional treatment in 5 cases. In one case, After embolization of AVM, surgical extirpation was tried but it was not completed, then followed by proton-beam radiosurgery.

Representative Case

Case 1 :

This 42 years old male suffered from sudden onset of severe headache. He admitted to our affiliated hospital and diagnosed as subarachnoid hemorrhage. Right carotid angiography revealed cerebral aneurysms located at right middle cerebral artery and internal carotid artery, and medium sized cerebral AVM which located right frontal lobe and fed by branches of middle cerebral artery. Cerebral aneurysms were clipped and he was transferred to our hospital three months later. Head CT scan on admission revealed medium sized cerebral AVM located at right frontal lobe (Fig. 1). Right carotid angiogram before embolization showed the nidus of AVM fed by branches of right middle cerebral artery (Fig. 2). Embolization of the AVM was performed using EVAL via over-the-wire microcatheter which catheterized into the branch of right middle cerebral artery just proximal to the nidus after superselective Amytal testing. Digital subtraction angiogram during embolization showed the contrast material only distributed in the nidus (Fig. 3). After embolization from two feeding arteries using EVAL, right carotid angiogram showed the nidus of AVM was almost disappeared (Fig. 4). During and after embolization, he

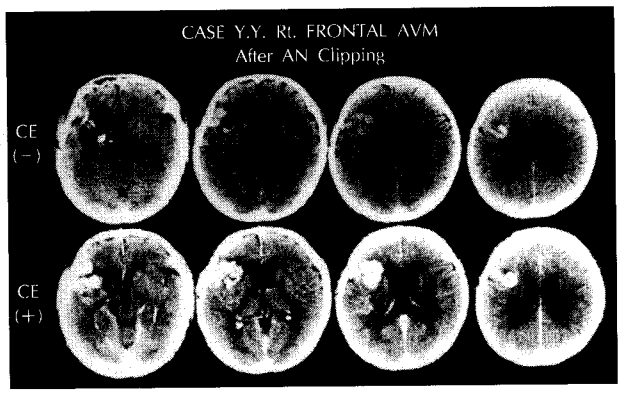

Fig. 1. Head CT scan before embolization of the case 1. Without (upper row) and with (lower row) contrast enhancement.

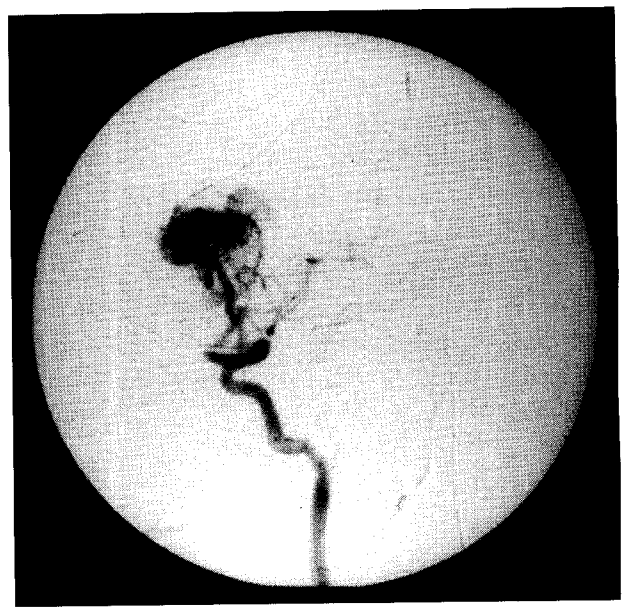

Fig. 2. Lateral view of the right carotid angiogram before embolization of the case 1 showed the nidus of AVM feeded by branches of right middle cerebral.

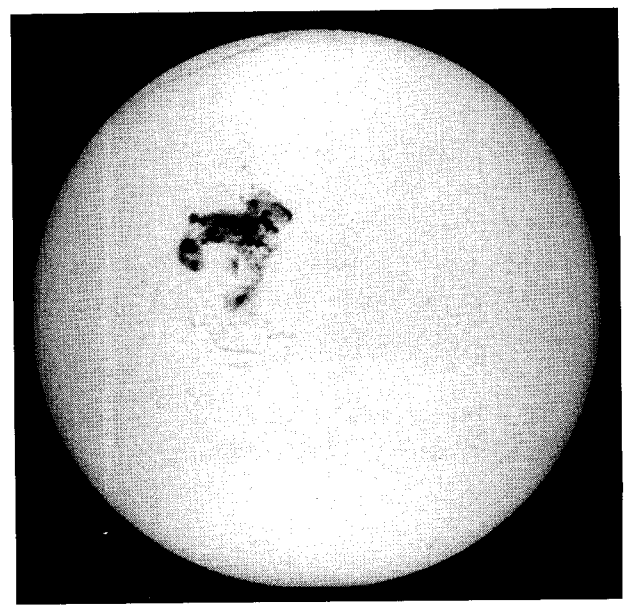

Fig. 3. Lateral view of the digital subtraction angiogram during embolization of the case 1 showed the contrast material only distributed in the nidus.

did not show any neurological deficit. Two weeks later, total removal of AVM was performed without any difficulty. He discharged one month after operation with no neurological deficit. Head CT scan after removal of AVM revealed surgical defect and clips located at right frontal lobe (Fig. 5). Right carotid angiogram before and after embolization after total removal of AVM were shown in Fig. 6.

Case 2 :

This 40 years old male was admitted due to epileptic attack. Head CT and MRI suspected medium sized cerebral AVM located in the medial part of the left parietal lobe. Left carotid angiography revealed AVM fed by the branches of left anterior cerebral artery (Fig. 7). He desired AVM to be treated, so he was transferred to our hospital. Embolization of the AVM was performed using Eudragit-E combined with coils via over-the-wire microcatheter which catheterized into the branch of left anterior

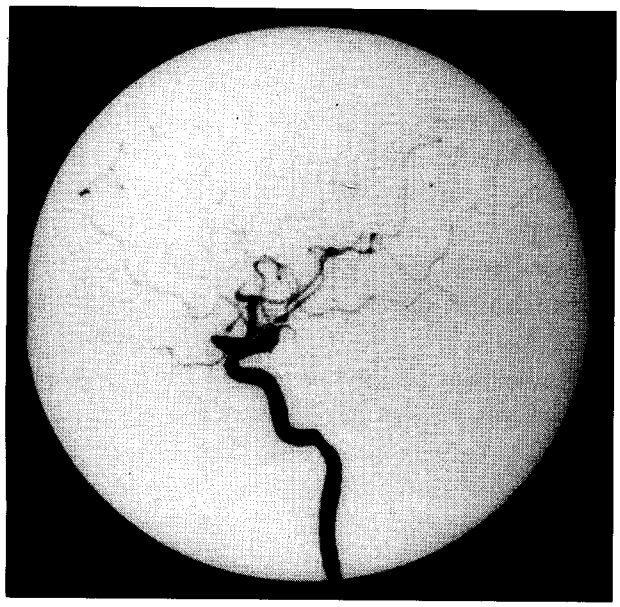

Fig. 4. Lateral view of the right carotid angiogram after embolization of the case 1 showed the nidus of AVM was almost disappeared

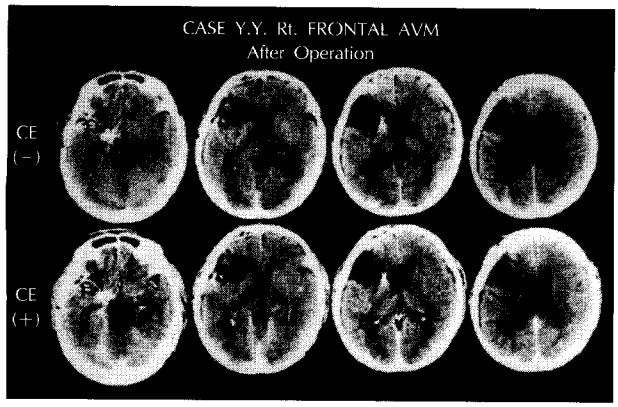

Fig. 5. Head CT scan after removal of AVM of the case 1 revealed surgical defect and clips located at right frontal.

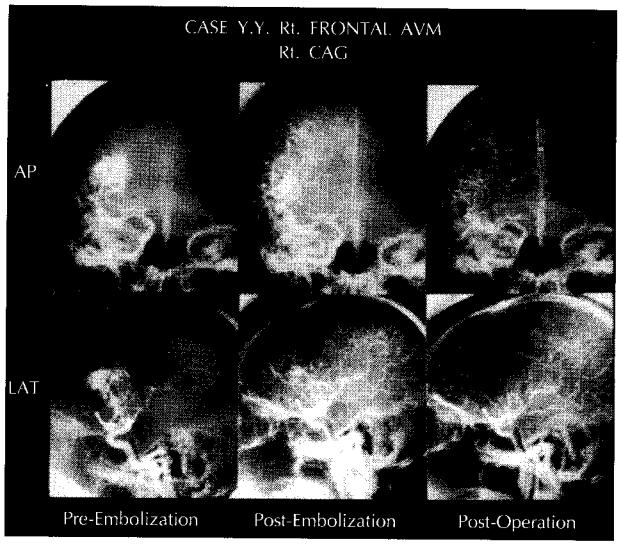

Fig. 6. Right carotid angiogram before (left) and after (center) embolization, and after total removal of AVM (right) of the case 1. A-P views (upper row) and lateral vies (lower row).

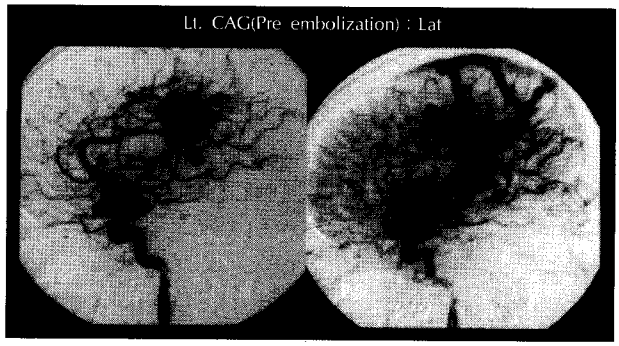

Fig. 7. Lateral view of the left carotid angiogram of the case 2 revealed AVM feeded by the branches of left anterior cerebral artery.

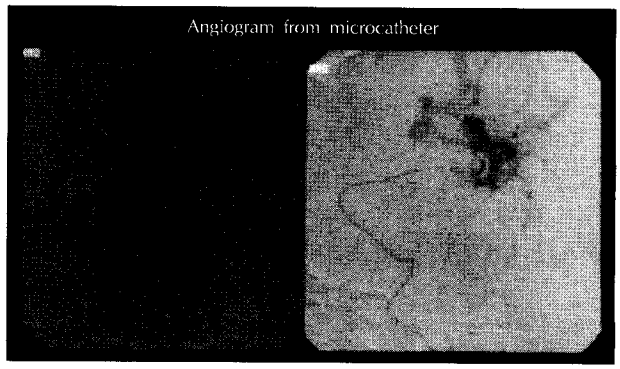

Fig. 8. Lateral view of the superselective angiogram just before embolization of the case 2 showed only nidus and draining veins of the AVM.

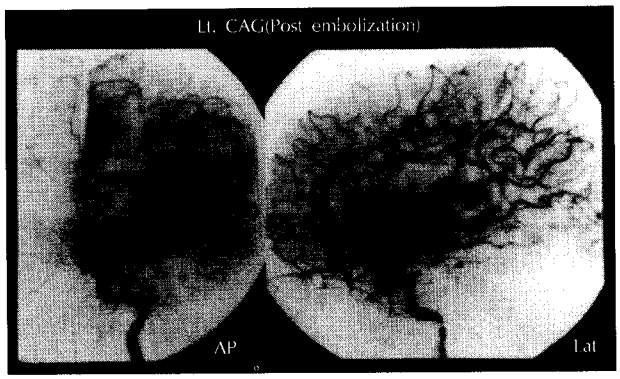

Fig. 9. A-P (left) and lateral (right) view of the left carotid angiogram after embolization of the case 2 showed the nidus of AVM was almost disappeared.

cerebral artery just proximal to the nidus after superselective Amytal testing. Superselective angiogram before embolization showed only nidus and draining veins of the AVM (Fig. 8). After embolization from two feeding arteries using Eudragit-E, left carotid angiogram showed the nidus of AVM was almost disappeared (Fig. 9). During and after embolization, he did not show any neurological deficit. Two months later, proton-beam radiosurgery for residual AVM was performed.

Discussion

The goal of embolization of the AVM is to selectively obliterate the nidus while preserving the blood supply to surrounding normal tissues. That is accomplished with fluoroscopic equipment which can visualize the materials in the body, low-profile soft microcatheters which allow superselective catheterization into the brain, and embolic materials. In Luessenhop et al.'s report,[5] the patient's neck was directly punctured, and the embolic agent was injected from the site via the carotid artery, which was remote from the target. Now the procedure has been refined so that in almost all cases, the microcatheter is navigated to the brain through the femoral artery under fluoroscopic control. In order to preserve normal tissue, the microcatheter is advanced as close to the lesion as possible. Only then is the embolic material injected through the microcatheter into the targeted lesion.

Embolic materials available now make up four groups; liquids, particles, coils and balloons.[6] Liquid materials are used commonly in the treatment of AVMs. Some authors believe the ideal embolic material would be liquid. Because injection through the microcatheter is easy if the viscosity is low enough, the agent will penetrate deeply into the lesions to be permanently occluded. However, there is a possibility that liquids can pass through the lesion and cause complications by occluding the venous system, especially if the lesion has significant arteriovenous shunting or includes a fistula.

Particulate materials are commonly used for preoperative embolization of AVMs. Particle embolization refers to the mechanical blockage of a vessel with individual particles of uniform sizes and shapes which largely determine their occlusive properties. The large particles tend to lodge more proximally, which is safer. However, the effect of large-particle emboli tends to be temporary and less effective, because the smaller vascular bed distal to the embolization, which forms a collateral pathway, is not occluded.

No single embolic material can be used in all circumstances. The choice of embolic material depends on anatomy and size of the target vessel, the type and position of the catheter, the desired duration of occlusion (e.g. permanent or temporary), and the specific purpose of embolization.

As an embolic material, we prefer to use EVAL or Eudragit-E instead of Cyanoacrylates as a liquid embolic material.

Cyanoacrylates are the most common currently used liquid embolic material. In the past Isobutyl-2-cyanoacrylate (IBCA) had been used. N-Butyl-2-cyanoacrylate (NBCA) has taken the place of IBCA, because of question of mutagenicity from IBCA. NBCA is a vinyl monomer of the alkyl-2-cyanoacrylates which was developed as a tissue adhesive. When it is injected into vessels through microcatheters, it polymerizes on contact with blood which is ionic solution. It then becomes solid and occludes vessels. NBCA is an effective embolic material, and it is able to permeate far distally to reach very small vessels, and it embolic occlusive effect is permanent. However, extensive training and experiences are required for their use because adhesiveness may inadvertently bind catheters to vessel walls.

EVAL and Eudragit-E are also liquid embolic material. EVAL dissolved in dimethyl sulfoxide (DMSO), and Eudragit-E dissolved in ethanol. Upon contact with blood, DMSO or ethanol rapidly diffuses into the circulation, and an EVAL or an Eudragit-E elastic soft sponge is formed. These spongy materials reach to the nidus and oc-

clude it. These materials do not adhere the catheters and are very easy to handle.

Embolization of brain AVM is undertaken to facilitate surgical removal or stereotactic radiation therapy, but also as a primary treatment. As for our experiences, the role of endovascular treatment of AVM was preoperative embolization in early period. Then, the role of endovascular treatment of AVM shifted to the enbolization before stereotactic radiation therapy. The goal of embolization before stereotactic radiation therapy is to decrease the target size, bringing the AVM size to a level that improves the efficacy of total obliteration by radiosurgery, to eradicate dangerous element such as aneurysms that increase the propensity for hemorrhage.

Complete AVM obliteration by embolization alone is not so frequently achieved and about 10% of reported cases.[1] These AVM are usualy small and a few feeding arteries. From our results, complete AVM obliteration by embolization alone is achieved only 7% of the cases.

Conclusion

We present our experiences of endovascular treatment of intracranial AVMs and discuss the embolic materials and the role of endovascular treatment of intracranial. AVMs. Endovascular treatment of intracranial AVMs is effective for presurgical or preradiosurgical treatment. However, the risk of endovascular treatment of intracranial AVMs is not negligible. So the indication of the treatment should be determined very carefully and endovascular treatment of intracranial AVMs must be performed by experienced endovascular neurosurgeons or interventional neuroradiologists.

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