Endovascular Surgery for Intracranial Aneurysm

Histopathological Analysis after Embolization Using Balloon or Coil

Y. KONISHI, E. SATO*, M. SHIMADA*, K. HINO, M. FUJITSUKA, I. SAITO

Kyorin University School of Medicine. Dept. of Neurosurgery,

* Inagi Municipal Hospital, Dept. of Neurosurgery, Shinkawa, Mitaka-shi, Tokyo; Japan

Summary

Recently, endovascular surgery became common approach for management of intracranial aneurysms. Though its efficacy, this approach is still new and under development. Here, we report our clinical experience in patients treated with two methods – balloon or Guglielmi detachable coil.

In addition, to understand better the mechanisms underlying postoperative complications, we studied them in histopathological specimens of patients and in a model of experimental aneurysm. From our data we conclude that choice of appropriate therapeutic method should respect specific conditions of patients as well as of facility.

Careful postoperative studies including examination of intravascular surface by endovascular scope examination would be useful for prediction of possible complications.

Introduction

The endovascular treatments of intracranial aneurysms were mainly performed by endovascular balloon embolization until 1991 when Guglielmi detachable coil (GDC) became available for the management of this disease.

Both of these methods, balloon as well as GDC, have been frequently used also for embolization of parent vessels. As a result, an accumulation of experience resulted in their broad applicability. Recently, in Europe and United State, endovascular approach have become the method of first choice for management of intracranial aneurysms, and is also increasing in the other world.

In our country, the number of institutions using this approach is rising, though neck clipping still remains a method of the first choice.

Our indication of endovascular approach depends on the localization of lesion: aneurysms in the cavernous internal carotid artery, top of the basilar artery and dissection of the vertebral artery are treated by coiling; aneurysms of ICPC, Acom and VA-PICA aneurysms are treated by clipping or coil. Finally, MCA, AC distal and the other aneurysms are treated mainly by clipping. In addition individual patient's conditions, such as advanced age, heart disease, serious subarachnoid hemorrhage and others, which should be carefully examined play a crucial role in choosing of appropriate method before making decision about therapy indications.

Here are some drawbacks of balloon and

Figure 1 Right upper: left VAG showed unruptured BA aneurysm and post embolization angiograms. Right lower: 1 year 3 months after embolization in MRA and skull X-P. These showed compaction of the coils. Left CT showed a bleeding from the aneurysm 1 year 5 months after embolization.

coil: balloon - 1. Inapplicability for a arteriosclerotic vessels, 2. difficult detention in aneurysm, 3. time required for replacement of contrast medium by HEMA, 4. unclear long-term follow-up results; coil - 1. inapplicability for arteriosclerotic vessels, 2. thrombogenesis, 3. weak embolization power, 4. compaction, 5. unclear long-term follow-up results, 6. wide neck of an aneurysms, 7. large aneurysms, 8. Impossible correspondence during bleeding.

Methods/Results

In the period between February 1994 and October 2002, 16 cases of intracranial aneurysms were treated by balloon embolization. In the two patients rupture occurred during procedures or in a few day after operation. In another one patient transient neurological deficit occurred.

Endovascular treatment by coil was applied in 137 cases with the results as follows: Fourteen cases - incomplete or impossible; seven cases - compaction, (two cases - ruptured, five cases - unruptured, one case - permanent cerebral infarction; two cases - ruptured during manipulations (one case - IDC, one case - guide wire).

Here we present two representable cases showing complications.

Case 1

56-years-old woman with unruptured aneurysm of the internal carotid artery was treated by balloon embolization. Though post-operative angiography showed complete obliteration of the aneurysm, on the third postoperative day the patient suddenly became unconscious and died. Pathological examination

Figure 2 Histological findings showed pathological examination was not able to reveal clearly the source of bleeding but showed the presence of newly formed embolus, reaching neck of aneurysm. It was mixed with another embolus formed more formally with coil. The emboli were incompletely covered by endothelium.

showed a little balloon displacement, which produced consequent gap especially in the proximal part of aneurysm, as well as a new embolus formation. Balloon movement seemed to be caused by fast bloodstream flow due to stenosis in the parent artery distal to the aneurysm.

Case 2

70-years-old woman with hypertension. She had an unruptured BA top aneurysm, which was treated by 90% coil embolization. The patient was followed-up ambulatory with blood pressure control, but angiography and MRI were impossible due to the patient's serious lumbago.

Skull X-ray revealed changes in the coil's shape, and MRA confirmed coil compaction later.

As informed consent for a radical further treatment was not obtained from patient's family, conservative therapy had to be applied. Two months later the patient suddenly became unconscious and died. Pathological examination was not able to reveal clearly the source of bleeding but showed the presence of newly formed embolus, reaching neck of aneurysm. It was mixed with another embolus formed more formally with coil.

The emboli were incompletely covered by endothelium (figures 1,2).

In the both two cases with rupture complication shown above, one of balloon and one of coil treatment, especially two important factors seem to play a role: incomplete membrane formation in aneurysmal neck, and fast bloodstream flow between embolus materials and the aneurysmal inner wall.

To understand better the mechanisms under-

Figure 3 Carotid angiograms the swine aneurysm model after embolization. Right side (upper: right carotid artery lower: left carotid artery) were 2 weeks after embolization angiograms. Right aneurysms showed compaction.

lying these complications we prepared a model of experimental aneurysm using cervical arteries of the swine. Two weeks later angiography showed that a partial obliteration was caused by coil compaction on the right, and a complete obliteration was showed on the left side (figures 3,4).

We removed these aneurysms for high-resolution microscopy analysis. Intra-aneurysmal surface was covered by neointimal layer, which was easy to be torn.

But, in contrast, in the portion with a complete blood component covering the coil were hard and difficult to be torn.

From these results we conclude that intraluminal surface is changed between one and two weeks after embolization. Nevertheless different blood stream flows are engaged in this

process. In addition, in the portion with complete obliteration the surface was fully covered by blood components.

This stage before inner membrane is formed should be important for prediction of coil compaction. Therefore, we think that examination of vascular wall condition by endoscopes may be useful for clinical settlement (figures 3,4).

Discussion

Endovascular therapy for intracerebral aneurysms has grown over the last few years that have made aneurysm occlusion safer and more effective.

The advance of new equipments will continue to be applied to aneurysms. Feureberg reported 28 residual aneurysmal neck after clip-

Figure 4 Hi-resolution microscopy findings; Upper; the surface of aneurysm covered intimal layer with coil. Lower; the surface of aneurysms non-covered with intimal layer with coil.

ping and found a rebleeding rate of 0.38~0.79% per year during the observation time (4~13 years)⁴. The other side, natural history of neck remnant in 71 cases treated by coil embolization has been reported. Mean follow-up period was 17.3 months. There was a 17% recanalization in small aneurysms with small neck. In contrast, an 87% recanalization was found in small aneurysms with large neck. Large giant aneurysms were recanalized in 87-90%. Data mentioned above show that there are still limitations for this new approach, and that basic experiments are essential for better clinical applications as well as for development of new coils^{1,2,3,5,7}.

Recently, new type coils are developing and used clinically, and protein-coated coil, and hydrogel coil and intravenously with factor XIII

using after coiling for aneurysm were experimental studied and clinically tried^{6,8}.

Conclusion

- It can't be easily decided whether clipping or coiling is the method of first choice. Conditions of each facility as well as of each patient should be carefully analyzed before the decision is made.

- Coil embolization is still a method under development and, therefore, unreasonable application resulting in complication, especially bleeding, should be avoided. Instead, more bravery embolizations are sometimes recommended.

- Many experiments and clinical research have to be done to develop a safe and complete methodology.

References

- 1 Deburan G, Fox A et Al: detachable balloon and calibrated leak balloon techniques in the treatment of cerebral vascular lesions. *J Neurosurg* 49: 635-649, 1978.
- 2 Gugliemi G, Vinenuela F, Sepetla I: Electrothrombosis of saccular aneurysms via endovascular approach. Part 1: Electrochemical basis, technique, and experimental results. *J Neurosurg* 75: 1-7, 1991.
- 3 Gugliemi G, Vinenuela F et AL: Electrothrombosis of saccular aneurysms via endovascular approach. Part 2: preliminary clinical experience. *J Neurosurg* 75: 8-14, 1991.
- 4 Feuerberg I, Lindquist C et Al: Natural history of post-operative aneurysm rests. *J. Neurosurg*: 66: 30-34, 1987.
- 5 McDougall CG, Hallbach VV Al: Cause and management of aneurysmal hemorrhage occurring during embolization with Gugliemi detachable coils. *J Neurosurg* 89: 87-92, 1998.
- 6 Hayakawa M, Murayama Y et Al: Natural history of the neck remnant of a cerebral aneurysm treated with the Guglielmi detachable coil system. *J Neurosurg* 93: 561-568, 2000.
- 7 Horowitz MB, Levy E et Al: Endovascular therapy for intracranial aneurysms: A historical and Present status review. *Surg Neurol* 57: 147-159, 2002.
- 8 Keno H, Konishi Y et Al: Histological investigation of endothelial cell proliferation on the coil surface after endovascular treated using factor XIII. *Interventional Neuroradiology* 7: 29-33, 2001.

Yoshifumi Konishi MD
Kyorin University School of Medicine
Dept. of Neurosurgery
Tokio -Japan