Clinical and Angiographic Results after Treatment with Combined Clipping and Wrapping Technique for Intracranial Aneurysm

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INTRODUCTION

Clipping the aneurysmal neck is generally considered as the treatment of choice for intracerebral aneurysms. Recently, coiling the intra-aneurysm space has come into the spotlight as a more non-invasive treatment. However, when clipping or coiling is impossible, neurosurgeons have to decide on another treatment such as wrapping or aneurysm neck remodeling. Many authors had reported the efficacy of the wrapping technique, and the rebleeding and regrowth rates in wrapped aneurysms. There have been numerous materials for wrapping have been used to reinforce the aneurysmal sac including muslin gauze, Surgicel, muscle, biobond adhesive and histoacryl adhesive, etc. The aim of this study was to share the results and efficacy of surgical wrapping or wrapping after the partial clipping of the aneurysmal sac with temporalis muscle in angiographic and clinical follow-up.

MATERIALS AND METHODS

Patient information

The study group was obtained from patients who were operated for ruptured or unruptured intracranial aneurysms in our hospital between February 2002 and December 2006. Patient data were analyzed retrospectively from hospital records, operating records and neuroimaging studies. Follow-up study data were obtained through outpatient records and telephone interview. These included...
| Patient number | Sex/Age | Study | Follow-up period (mon) | Presentation (Fisher grade) | Location | Shape | Operation | Complication | Angiographic follow-up | Initial GCS | Discharge GOS | Last GOS |
|---------------|---------|-------|------------------------|-----------------------------|----------|-------|-----------|--------------|------------------------|-------------|---------------|----------|
| 1             | F 56    | Angio | 25                     | SAH (3)                     | Rl. MCA  | Bleb, to M2 | Partial clip & wrap | ICH, ipsilateral | No change             | 14          | 5             | 5        |
| 2             | F 61    | Angio | 16                     | Headache                    | Li. MCA  | Bleb, severe AS | Wrap & clip | Infarction | No change             | 15          | 4             | 4        |
| 3             | F 64    | Angio | 32                     | Incidental (multiple sac) – BA rupture | Ri. AChOA | Bleb, to AChOA | Partial clip & wrap | N–S | No change             | 14          | 5             | 5        |
| 4             | F 50    | Angio | 21                     | Incidental (multiple sac) – AcA rupture | Ri. MCA  | Broad neck | Partial clip & wrap | N–S | No change             | 15          | 5             | 5        |
| 5             | F 63    | Angio | 12                     | Incidental (multiple sac) – PcomA rupture | Ri. MCA  | Fusiform | Wrap & clip | N–S | No change             | 15          | 5             | 5        |
| 6             | F 53    | Angio | 11                     | SAH (3)                     | Li. MCA  | Broad neck | Partial clip & wrap | N–S | Decrease             | 15          | 5             | 5        |
| 7             | F 40    | Angio | 8                      | Incidental (multiple sac) – Li. PcomA rupture | Ri. MCA  | Broad neck | Partial clip & wrap | N–S | No change             | 14          | 5             | 5        |
| 8             | M 65    | Angio | 28                     | Seizure                     | Ri. MCA  | Broad neck with AS | Wrap & clip | ICH, contralateral | No change             | 15          | 5             | 5        |
| 9             | F 67    | Angio | 24                     | SAH (3)                     | Ri. MCA  | Giant, bleb to M2 | Partial clip & wrap | N–S | Decrease             | 13          | 5             | 5        |
| 10            | M 45    | CTA   | 15                     | SAH (4)                     | Li. MCA  | Broad neck | Partial clip & wrap | N–S | No change             | 13          | 5             | 5        |
| 11            | M 45    | CTA   | 14                     | Incidental (multiple sac) – Li. MCA rupture | Ri. MCA  | Broad neck with AS | Partial clip & wrap | N–S | No change             | 15          | 5             | 5        |
| 12            | M 61    | CTA   | 44                     | SAH (2)                     | Ri. MCA  | Broad neck | Partial clip & wrap | N–S | No change             | 15          | 5             | 5        |
| 13            | M 40    | MRA   | 18                     | SAH (3)                     | Ri. PICA | Bleb, to PICA | Partial clip & wrap | N–S | Decrease             | 13          | 4             | 5        |
| 14            | F 67    | CTA   | 12                     | SAH (3)                     | Ri. PcomA | Bleb, to PcomA | Partial clip & wrap | N–S | No change             | 14          | 5             | 5        |
| 15            | F 63    | Angio | 26                     | Headache                    | Ri. MCA  | Broad neck | Wrap & clip | EDH, contralateral | No change             | 15          | 5             | 5        |
| 16            | F 29    | Angio | 13                     | SAH (4)                     | Ri. MCA  | Broad neck | Partial clip & wrap | N–S | Decrease             | 10          | 3             | 2        |
| 17            | F 62    | CTA   | 25                     | Headache                    | Li. MCA  | Broad neck | Partial clip & wrap | Optic neuropathy | No change             | 15          | 5             | 5        |
| 18            | M 41    | CTA   | 11                     | SAH (2)                     | AcomA    | Bleb, to A2 | Partial clip & wrap | N–S | No change             | 15          | 5             | 5        |
| 19            | F 65    | Angio | 14                     | Dizziness                   | Ri. MCA  | Board neck, bifurcation sac | Partial clip & wrap | N–S | No change             | 15          | 5             | 5        |
| 20            | F 47    | Angio | 8                      | Dizziness                   | Ri. MCA  | Broad neck | Wrap & clip | N–S | No change             | 15          | 5             | 5        |
| 21            | F 46    | Angio | 12                     | SAH (3)                     | Ri. MCA  | Bleb, to M2 | Partial clip & wrap | N–S | Decrease             | 13          | 5             | 5        |

angio: 4-vessel angiography; CTA: computed tomographic angiography; MRA: magnetic resonance angiography; SAH: subarachnoid hemorrhage; ICH: intracerebral hemorrhage; BA: basilar artery; MCA: middle cerebral artery; AcomA: anterior communicating artery; PcomA: posterior communicating artery; AChOA: anterior choroidal artery; PICA: posterior inferior cerebellar artery; AS: atherosclerosis; N–S: no specific complication.
clinical presentation, neuroimaging finding, location and shape of aneurysm sac, reason for wrapping, operation technique, complication after surgery, GOS by hospital records, last GOS by out-patient records, and telephone interview.

Thirty-eight patients were treated by wrapping or wrapping after partial clipping using the temporalis muscle and aneurysm clip(s). All patients were studied using four-vessel angiography prior to surgery. The non-angiographic follow-up group and follow-up loss group were excluded, and 21 patients remained. Follow-up angiographic studies included conventional angiography, computed tomographic angiography (CTA), magnetic resonance angiography (MRA).

Surgical technique

Prior to operation, we planned to treat the aneurysm using wrapping when the aneurysm sac had a broad neck or fusiform shape, or was associated with severe atherosclerosis. We also decided on wrapping when it appeared that direct clipping was impossible to preserve the adjacent artery, such as our case of an anterior choroidal artery aneurysm, because multiple clips to secure a broad-based or fusiform aneurysm can cause luminal stenosis, followed by cerebral hypoxia or infarction. Also, in some aneurysm cases with severe atherosclerosis, clipping had the possibility of sliding and leave-out.

For many years, gauze, adhesive or muscle was used as wrapping material. At our institution in 1998, a case of granuloma and infection occurred after wrapping using muslin gauze and the patient had a poor outcome. Since then, we have used the temporalis muscle as a wrapping material.

We obtained fingernail-sized amount of temporalis muscle and smoothened it out until the muscle became thin and broad without a hump. Then, an incision of the fanned muscle was made to make a Y-shaped wrapping muscle. If there were any perforators or branching arteries around the aneurysmal sac, we made wrapping material with more than three-divisions to avoid vessel or brain injury. The aneurysmal sac was wrapped using a microforcep. After covering the aneurysmal sac with multi-divided muscle, each divided muscle was clipped together to enhance the power of the covering (wrap and clip technique or clip-reinforced wrapping technique). Transcranial doppler was used before and after clipping to confirm adequate blood flow velocity. If there was no abnormality in blood flow and complete wrapping was confirmed, remnant muscle distal to the clip was cut away.

If there was a definite weak or ruptured point and direct complete clipping was impossible, partial clipping was intentionally done to avoid bleeding or rebleeding. Since then, we have used the same wrapping technique described above (clip-wrap technique).

RESULTS

Between February 2002 and December 2006, 201 cases underwent craniotomy and clipping or wrapping of the aneurysm sac and 71 cases underwent endovascular embolization of the aneurysm sac at our hospital. Among these, 21 cases (7.7%) were chosen for our study. The mean age was 53 years (range 29-67). Ten patients had ruptured aneurysms and 20 cases were located in the anterior circulation. The mean GCS at admission was 14.2 (Table 1, 2). Aneurysm shapes were broad neck form (14 cases), fusiform (1 case), bleb to adjacent vessel (6 cases) (Table 3).

Five patients were treated by clipping of wrapped temporalis muscle, and the clip-wrap technique was used in 16 patients. In the subarachnoid hemorrhage (SAH) group, the clip-wrap technique was used in all patients, and in the non-SAH group, clip-wrap technique was used in 6 patients (55%). Postoperative complications were intracerebral hemorrhage not related to aneurysm rebleeding (3 cases), intracerebral infarction (1 case) and optic neuropathy (1 case). Hemorrhagic complications included small contusion hemorrhage on operation site (1 case) and opposite

| Location                        | Number |
|---------------------------------|--------|
| Middle cerebral artery          | 17     |
| Anterior communicating artery   | 1      |
| Internal carotid artery         | 1      |
| Posterior communicating artery  | 1      |
| Posterior inferior cerebellar artery | 1    |

| Reason                                      | Number |
|---------------------------------------------|--------|
| Broad neck                                  | 7      |
| Unpreservable of adjacent artery by clipping| 6      |
| Incomplete clipping                         | 4      |
| Fusiform shape                              | 1      |
| Atherosclerosis with broad neck             | 3      |

| GOS | At discharge | Last Fu |
|-----|--------------|---------|
| 5   | 18           | 19      |
| 4   | 2            | 1       |
| 3   | 1            |         |
| 2   | –            | 1       |
| 1   | –            |         |

Fu: Follow-up
site (1 case), and epidural hematoma located in the opposite site (1 case). One patient with a ruptured aneurysm experienced a small contralateral cerebral infarction after the 8th postoperative day. We thought this lesion was a result of vasospasm. One patient with an unruptured aneurysm showed optic nerve injury on the operative side due to external compression of the eyeball by the frontal scalp flap during the operation. This patient has had visual difficulty until now, about 4 years. There were no cases with infection or abscess associated with the wrapped temporalis muscle.

Outcome was classified according to the GOS. The mean GOS at discharge was 4.8 and 20 patients were grade four or five. One patient whose initial GCS was 10 had a final GOS of 3. The mean final GOS was 4.8, the same GOS as at discharge (Table 4).

The mean period between initial angiography and last angiography was 18.5 months (range 8-44). There were no cases where aneurysm size increased on follow-up angiography. Five cases showed reduced size on follow-up angiography, and no patient experienced bleeding or rebleeding.

Case study

Case 1
A 56-year-old woman presented with severe headache. CT showed SAH of Fisher grade 3. She had no neurologic deficit on admission. Initial 4-vessel angiography revealed a right middle cerebral artery (MCA) aneurysm that had a broad neck and bleb formation to both M2 branches (Fig. 1A). In the postoperative CT, the patient had small contusive hemorrhage on the right frontal lobe, caused by traction. However, the patient recovered without any sequela. Follow-up angiography after 25 months showed no change in aneurysm size or shape (Fig. 1B).

Case 2
A 63-year-old woman with a history of a ruptured posterior communicating artery (PcomA) aneurysm secured by clipping 10 years earlier. Initial 4-vessel angiography showed a fusiform shaped right MCA aneurysm (Fig. 2A). She underwent an operation by wrapping technique, and was discharged without complication. Follow-up angiography after 12 months showed no change in aneurysm size or shape (Fig. 2B).

Case 3
A 63-year-old woman presented with severe headache. Initial 4-vessel angiography showed multiple aneurysms, including a right MCA aneurysm with broad neck (Fig. 3A), two PcomA aneurysms (one : contralateral side), an anterior choroidal artery aneurysm, two internal carotid artery (ICA) bifurcation aneurysms, and a proximal basilar artery aneurysm. Coiling was scheduled for the ICA bifurcation and bailar artery aneurysms and open surgery was done for the remnant anterior circulation aneurysms. Clip-reinforced wrapping technique (wrap and clip technique) was applied to the right MCA bifurcation aneurysm. Postoperative CT showed contralateral epidural hematoma. Follow-up angiography after 26 months showed no change in aneurysm size or shape (Fig. 3B). She has had no complications or neurologic deficits until now.
DISCUSSION

Clipping the aneurysmal neck is generally considered as the treatment of choice for intracerebral aneurysms. Recently, endovascular treatment of aneurysms is increasingly accepted as an alternative form of treatment for intracerebral aneurysms. However, the size of the neck, the shape of the aneurysm sac and adjacent vessel of aneurysm are important factors in successful clipping or embolization. In some patients, surgical clipping or endovascular occlusion is technically impossible. In such cases, it is necessary to protect against aneurysmal rupture by reinforcement using external wrapping with an available material or by trapping after bypass surgery. We selected the temporalis muscle as a wrapping material in this study. In some cases, partial clipping before wrapping was done on the weak or ruptured point. If there was room for partial clipping, we chose the clip-wrap technique intentionally. We considered this method to be more protective than the wrapping only method. In the premicroscopic era of neurosurgery, wrapped aneurysms had a significantly higher risk of intraoperative complication or rebleeding, because surgical exposure of the aneurysmal neck was more difficult with the naked eye. With the development of microsurgical equipment and techniques, neurosurgeons now able to illuminate and magnify the operative field much better. It is now easy to expose the aneurysm neck without adjacent vessel or brain injury. As a result, safer and perfective wrapping of the aneurysm sac is possible without sacrificing an adjacent vessel. However, neurosurgeon must always be concerned about the possibility of rebleeding.

Several early studies have described the wrapping technique and clinical/angiographic outcomes. After the introduction of microsurgical technology, these studies showed that the rebleeding rate of wrapped aneurysms was generally low, but these studies suggested that the wrapping technique was still less effective than clipping in preventing early rebleeding. Todd et al. reported that their early rebleeding rate (within the first 6 months) was 8.6%, and their late rate of rebleeding was 1.5% per year. Another study using biobond and histoacryl with gauze showed that the total rebleeding rate was about 10.5% (4/38).

In our study, 21 wrapped aneurysms have had no evidence of rebleeding and the outcomes have been generally as good as grade four or five GOS. Our result has a relatively higher protection rate than the rate we thought initially and that other reports have presented. We now think that the clip-reinforcement technique has a more protective effect on cerebral aneurysms than the simple wrapping technique.

Several studies showed that the wrapping technique was as effective as clip ligation to aneurysm treatment on long-term follow up. A number of materials have been used to treat aneurysms: muslin gauze, surgicel, muscle, biobond adhesive, and histoacryl adhesive. In an early study, a high rebleeding rate was reported when biobond was used as a coating agent. In an other study, it was reported that biobond induced chronic inflammatory changes, necrosis of the media and fibrosis in a rat model. Muslin gauze is regarded as an effective material by inducing fibrosis which reinforces the aneurysm sac, and possibly inducing intraluminal thrombosis. On the other hand, it has caused foreign body reaction such as infection or granuloma. It can also cause cranial nerve injury, especially to the optic or oculomotor nerve in anterior circulation and brain edema, which causes chronic headache or mental deterioration. In our study, a case of ipsilateral optic neuropathy developed after wrapping an unruptured MCA aneurysm. This complication was not associated with wrapping procedure itself, but resulted from external compression of the eyeball by the frontal scalp flap during the operation. Also, there was no granulomatous formation in this case. Our study is a retrospective analysis of wrapped aneurysms using the temporalis muscle. Because autologous tissue is less inflammatory than a foreign body as gauze or adhesive agent, no infectious complications such as granuloma was seen in our study.

Previous studies have shown that about 80% cases had reduced or unchanged aneurysm sac size on follow-up angiogram after wrapped operation. In our study, there was no increase in size of aneurysm on follow-up angiographic finding in any of patients. Furthermore, there was no change in aneurysm size in 16 patients, and 5 cases showed a reduction in size. Our wrap-and-clip technique or clip reinforcement wrapping technique using temporalis can be a favored method in unclippable aneurysm cases. In earlier studies, there was a degeneration and resorption of the wrapped temporalis muscle, and resulted in late rebleeding. However, such cases have not been found in our hospital yet. Our study, however, has several limitations, such as short-term follow-up period in small number of patients and the fact that this technique requires multiple clips for complete wrapping.

CONCLUSION

Although technically more demanding, our wrapping technique using temporalis muscle and aneurysm clip(s) for intracranial aneurysms is considered as a safe way to protect against rebleeding or regrowth of aneurysm, thus can be considered as an alternative modality for the treatment of
intracranial aneurysms with low rate of postoperative complications.

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