Clinical Analysis of Recurrent Subarachnoid Hemorrhage after Neck Clipping Surgery

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Abstract

The clinical features of recurrent subarachnoid hemorrhage (SAH) after neck clipping surgery were investigated in a series of 1436 consecutive patients treated between 1980 and 1994, and seven patients treated prior to 1980. Recurrent SAH occurred within 1 month in seven patients and between 1.5 and 20 years in 20 patients (mean interval 9.2 years) from the first surgery. The patients were aged from 31 to 76 years (mean 49.8 years) at the first SAH. There were 19 females and eight males. Recurrent SAH occurred at the same site as the prior aneurysms in 12 cases, at an infundibular dilatation in three cases, *de novo* aneurysms in nine cases, untreated multiple aneurysms in two cases, and unknown in one case. The main causes for early recurrent SAH were incomplete clipping or untreated multiple aneurysms, whereas late recurrent SAH was due to *de novo* aneurysms, untreated multiple aneurysms, or regrowth aneurysm at the prior site. The outcomes of late recurrent SAH were good in eight cases, moderate disability in two, severe disability in three, and dead in seven, whereas most cases of early recurrent SAH resulted in poor outcome. Immediate postoperative angiography is desirable in cases with incomplete clipping, because early recurrent SAH resulted in poor outcomes. *De novo* or regrowth aneurysms caused late recurrent SAH, so follow-up angiography is strongly recommended for young patients, even if complete clipping was achieved.

Key words: intracranial aneurysm, neck clipping, recurrent subarachnoid hemorrhage

Introduction

Various cases of recurrent intracranial aneurysm with subarachnoid hemorrhage (SAH) occurring after neck clipping surgery have been reported based on operative findings, angiograms, and histological observations.^{2-5,7-9,15,16,18)} Recurrent aneurysms after neck clipping have been classified into early recurrence within 1 month and late recurrence at over 1 year.⁴⁾ An early series of 70 cases included six of early recurrence and five of late recurrence, reported in 1967.⁵⁾ Advanced microsurgical techniques²²⁾ have improved the efficacy of neck clipping, but recurrence of aneurysms with SAH is still observed.

This retrospective study evaluates the clinical features of early and late recurrent SAH after previous clipping procedures and discusses the causes of recurrence to identify preventive measures against aneurysmal rebleeding.

Materials and Methods

Twenty of 1436 patients with ruptured intracranial aneurysms treated by neck clipping procedures in Gifu University Hospital and affiliated hospitals from January 1980 to December 1994 suffered recurrent SAH after neck clipping surgery. An additional seven patients were identified who were treated before 1980. Their clinical records were reviewed for age, sex, radiological findings, surgical details, and other general clinical data. Postoperative angio-

grams and/or intraoperative findings were used to classify the extent of aneurysm obliteration by clipping into complete clipping, aneurysm totally obliterated without residual neck; and incomplete clipping, aneurysm obliterated with a small residual neck. The origin of the recurrent SAH was identified based on intraoperative findings, radiological images, and/or histological observation. The final outcome was also assessed at discharge. The timing of recurrent SAH was divided into two groups; early recurrent SAH within 1 month and late recurrent SAH at over 1 year after surgery.

Results

There were 19 females and eight males aged from 31 to 76 years (mean 49.8 years) at the first episode of SAH. There were seven cases of early recurrent SAH, three males and four females aged 34 to 76 years (mean 56 years), and 20 cases of late recurrent SAH, five males and 15 females aged 31 to 73 years (mean 47.6 years).

Early recurrent SAH: The seven cases of early recurrent SAH occurred between 6 and 22 days after initial neck clipping with Sugita permanent clips (mean interval 11.9 days) (Table 1). The recurrent SAH occurred at the previously treated aneurysm in five cases, and at previously untreated multiple aneurysms in two cases. The initial ruptured aneurysms had a mean size of 5.6 mm, but the recurrent aneurysm consisting of organized clot and granulation at the same site was enlarged in two cases. Clipping of the aneurysm was evaluated as incomplete in five cases which occurred at the same

site. One (Case 3) of the five incomplete clipping cases developed bleeding from an aneurysm at the anterior wall of the internal carotid artery. Two patients with multiple aneurysms with completely clipped ruptured aneurysms presented with recurrent SAH from untreated aneurysms. Both patients had received anticoagulant therapy to prevent vasospasm. All patients but one suffered from recurrent SAH during their hospitalization. The final outcome of the early recurrent SAH group was five deaths and two survivors in a vegetative state.

Late recurrent SAH: The 20 cases of late recurrent SAH occurred between 1.5 and 20 years (mean 9.2 years) after surgery (Table 2). Recurrence was located at the same sites as the previous aneurysm in seven cases, at an aneurysm developed from non-treated infundibular dilatation in three, and at a newly developed aneurysm (including two cases of mirror imaging) in nine cases. The origin of the recurrent SAH in one patient could not be identified, because the patient died soon after admission. Two patients (Cases 8 and 24) with multiple aneurysms on initial admission developed another new ruptured aneurysm at a quite different site. The initial ruptured aneurysms measured 6.5 mm on average and the newly developed aneurysms measured 7.4 mm. Complete clipping was achieved in 13 ruptured aneurysms, but four developed SAH from the same aneurysms. Seven ruptured aneurysms were incompletely clipped, and three caused recurrent SAH. Seven cases of recurrent SAH were clipped by Heifetz clips, three of which bled from the same site. The other 13 cases were treated with Sugita clips, four of which bled from the same site.

Table 1 Patients with early recurrent subarachnoid hemorrhage after neck clipping surgery

Case No.	Age/ Sex	First admission				Interval (day)	Second admission		
		Site	Size (mm)	Clipping	Outcome		Site	Size (mm)	Outcome
1	34/M	BA	6	incomplete	H	6	BA	—	dead
2	50/F	lt ICA	4	incomplete	H	7	lt ICA	14	vegetative
		lt MCA*	5	complete					
3	68/F	lt ICA	5	incomplete	H	8	lt ICA	—	dead
4	55/M	ACoA	6	incomplete	H	12	ACoA	8	dead
5	71/F	lt MCA	10	complete	H	12	BA	12	dead
		BA*	—	none					
6	38/M	ACoA	5	incomplete	good	16	ACoA	5	vegetative
7	76/F	lt PICA	3	complete	H	22	—	—	dead
		lt ICA***	11	none					
		lt MCA*	6	none					
		rt ICA***	18	none					

*Unruptured aneurysm, **fusiform aneurysm. ACoA: anterior communicating artery, BA: basilar artery, H: hospitalization, ICA: internal carotid artery, MCA: middle cerebral artery, PICA: posterior inferior cerebellar artery, —: data not given.

Table 2 Patients with late recurrent subarachnoid hemorrhage after neck clipping surgery

Case No.	Age/ Sex	First admission				Interval (year)	Second admission		
		Site	Size (mm)	Clipping	Outcome		Site	Size (mm)	Outcome
8	65/F	lt IC-PCoA rt MCA*	3 5	complete complete	good	1.5	ACoA	4	SD
9	50/F	lt IC-PCoA	—	complete	good	3	lt MCA	8	good
10	44/M	ACoA	4	incomplete	good	3	ACoA	13	good
11	73/F	ACoA	—	complete	good	5	BA	5	dead
12	45/F	ACoA	4	complete	good	7	BA	6	dead
13	61/F	lt IC-PCoA	10	incomplete	good	7	rt IC-PCoA lt IC-PCoA*	9 4	good
14	44/F	rt IC-PCoA	5	complete	good	7	rt IC-PCoA	3	good
15	43/M	ACoA	11	incomplete	good	8	ACoA	11	dead
16	51/F	ACoA	6	incomplete	good	8	lt IC-PCoA ACoA*	6 6	good
17	33/M	ACoA	—	incomplete	good	8	ACoA	15	dead
18	36/F	rt IC-PCoA	8	complete	MD	9	rt ACA	8	MD
19	66/F	ACoA	6	complete	good	9	lt IC-PCoA rt MCA*	8 6	SD
20	35/F	rt IC-PCoA lt ID*	9 2	complete none	good	9	lt IC-PCoA	8	good
21	31/F	lt MCA	6	incomplete	good	10	rt MCA	4	good
22	48/F	lt IC-PCoA	3	complete	good	12	—	—	dead
23	41/M	ACoA	—	complete	good	13	ACoA	7	MD
24	60/F	lt ACA rt MCA*	6 6	incomplete complete	good	14	BA	10	dead
25	43/M	lt MCA	8	complete	good	14	lt MCA	—	dead
26	42/F	ACoA	8	complete	good	16	lt MCA lt VA-PICA*	5 3	good
27	41/F	rt IC-PCoA	—	complete	good	20	rt IC-PCoA	4	SD

*Unruptured aneurysm. ACA: anterior cerebral artery, ACoA: anterior communicating artery, BA: basilar artery, IC-PCoA: internal carotid-posterior communicating artery, ID: infundibular dilatation, MCA: middle cerebral artery, MD: moderate disability, SD: severe disability, VA-PICA: vertebral artery-posterior inferior cerebellar artery, —: data not given.

The clinical outcome of late recurrent SAH was good in eight patients, moderate disability in two, severe disability in three, and death in seven. The outcome at the first SAH was good in all except for one case of moderate disability.

Causes for recurrent SAH: The causes for recurrent SAH are summarized in Table 3. Early recurrent SAH was caused by incomplete clipping in four patients, specifically uncontrollable premature rupture in Case 1, a blind neck in Case 2, and anatomical complexity with a broad neck in Case 4 and with immature berry aneurysm in Case 3. A slipped clip was responsible in one patient (Case 6). Rupture of untreated aneurysms was responsible in two patients (Cases 5 and 7) with multiple aneurysms.

Late recurrent SAH was caused by *de novo* aneurysms in nine patients (Cases 8, 9, 11–13, 18, 21, 24, and 26), although the initially treated aneurysms remained uneventful. Enlargement of previous infundibular dilatation was recognized in three

Table 3 Causes of recurrent subarachnoid hemorrhage after neck clipping surgery

Cause	Early recurrence	
	(n = 7)	(n = 20)
Incomplete clipping	4	2
Slipped clip	1	1
Untreated remaining aneurysms	2	0
<i>De novo</i> aneurysms	0	9
Developmental aneurysms from infundibular dilatation	0	3
Regrowth aneurysms from completely clipped site	0	4
Unknown	0	1

patients (Cases 16, 19, and 20). Recurrent SAH occurred at the residual neck of partially clipped aneurysms in two patients (Cases 10 and 17). A slipped Heifetz clip was responsible in one patient

Fig. 1 Case 25. *left:* Left carotid angiogram after the first operation showing total obliteration of the left middle cerebral artery aneurysm. In this case, a Heifetz clip was successfully applied to the neck and a supplementary Weck clip was placed close to the Heifetz clip to prevent it from sliding. Heifetz and Weck clips (arrow). *center:* Left carotid angiogram, early phase, 14 years after the first surgery and just before the second operation revealing occlusion of the superior trunk of the left middle cerebral artery proximal to the clips. *right:* Left carotid angiogram, late phase, showing delayed opacification of the superior trunk of the left middle cerebral artery.

Fig. 2 Case 25. *left:* Intraoperative photograph showing a regrowth aneurysm at the left middle cerebral artery. The previous clips (arrow), maintaining the original interval between them, were located on the fundus of the regrowth aneurysm and indicated that the Heifetz clip had been precisely applied on the neck without sliding. A part of mural thrombus is translucently visible through the aneurysmal wall (arrowhead). *right:* Intraoperative photograph after excision of the aneurysm showing a broad neck and mural thrombus (arrow) located at the orifice of the aneurysm which might have obliterated the parent artery. The new aneurysm developed at the same site as the previous aneurysm, so it was suggested that the previous aneurysm had been clipped completely and was silent as a dormant aneurysm for a long time, but finally had enlarged again with the clips on its fundus.

(Case 15). New aneurysms developed at the previous site despite complete clipping in four patients (Cases

14, 23, 25, and 27). A representative case of newly developed aneurysm (Case 25) is shown in Figs. 1 and

2. Although these cases were considered as complete clipping by intraoperative observation and postoperative angiography, they might be regrowth aneurysms at the repaired aneurysmal neck.

Discussion

The site of rebleeding is important when considering the causes of recurrent SAH after neck clipping surgery. In general, recurrent SAH from another site, not associated with the initial ruptured aneurysm, implies bleeding from a *de novo* aneurysm¹²⁾ not detected by the initial angiography, rupture of untreated multiple aneurysms^{14,17)} or an aneurysm developing from a previous infundibular dilatation.^{13,20)} Rebleeding from the same site after initial clipping may be due to failure of the clip, such as breaking or slipping,^{3,19)} fragility of the parent artery adjacent to the aneurysmal neck,⁷⁾ vessel injury due to repeated temporary clipping,^{1,6,11,21)} residual neck and dome due to incomplete clipping,^{2,5,8,15,18)} or continuous hemodynamic stress causing on aneurysm at a flow dividing area.⁹⁾

In our series, early recurrent SAH had two main causes. Firstly, incomplete clipping was caused by uncontrollable premature rupture requiring repeated clipping at the neck, or anatomical difficulties prevented perfect clip placement on the neck. New aneurysms occurring at the same site as those previously clipped had quite different shapes and dimensions. In addition, the new aneurysm was a pseudoaneurysm consisting of organized clot and granulation. A new aneurysm might be initiated by hemorrhage that becomes organized rapidly.¹⁰⁾ Secondly, unruptured multiple aneurysms were ruptured under anticoagulant therapy. One-stage operation is desirable in the cases of aneurysms at more favorable sites and, if this is impossible, consecutive operations with early timing would achieve better results.¹⁷⁾

Late recurrent SAH was caused by three factors in our series. Firstly, bleeding may occur from another site as *de novo* aneurysms or developmental aneurysms from infundibular dilatations. Secondly, rebleeding may occur from the same site where the previous ruptured aneurysm was clipped incompletely. Thirdly, bleeding was from the previously completely clipped site. The conditions at the parent artery adjacent to the clipped neck, where hemodynamic stress⁹⁾ had caused the initial aneurysm, may be an important factor. Loss of normal structure such as thinning and weakening has been observed in a previous report of recurrent aneurysms.⁷⁾ In addition, hidden neck, too broad neck, thrombosed sac, and premature or danger of

rupture and branching from the sac have caused difficulties in clipping.⁵⁾ Under such conditions, even apparently complete aneurysmal neck clipping according to intraoperative and postoperative angiographical inspection will allow residual neck to persist microscopically, which will undergo continuous hemodynamic stress resulting in potential enlargement and rupture.⁴⁾ Therefore, the cause may have been a dormant aneurysm which was apparently completely cured.

Most patients with early recurrent SAH suffered the second bleeding within 22 days postoperatively and had a worse outcome. Ideally, all patients who undergo clipping surgery should be examined by postoperative angiography as soon as possible to prevent the second bleeding. However, the condition of some patients will be too poor to manipulate in the early postoperative period. Therefore, we suggest that patients with marked degeneration of the parent artery found at intraoperative inspection or requiring repeated clipping with premature rupture should receive immediate postoperative angiography. A new aneurysm which originates from the initial aneurysm with a different shape indicates the formation of a pseudoaneurysm. Furthermore, such intraoperative observations mandate careful manipulation of the aneurysm and reinforcement with some material even if clipping appears satisfactory. Successful clipping without intraoperative problems prevented recurrence in a previous series.⁴⁾ In our series, even completely clipped aneurysms could rebleed in the late stage. The interval until late recurrence of SAH ranged from 1.5 to 20 years (mean 9.2 years). Therefore, long follow-up should be continued and, if symptoms are observed, magnetic resonance or conventional angiography should be attempted. New aneurysms or enlargement of the previous aneurysm may indicate reoperation. The indications for reoperation after incomplete clipping include body clipping, slipped clip, and enlargement of residual aneurysm.¹⁸⁾ We agree with these indications and consider that clipped aneurysms can recur at any time.

Intraoperative inspection to observe the aneurysm and parent artery adjacent to the aneurysmal neck, and to check the accuracy of neck clipping is the most reliable way to predict possible recurrence of SAH after aneurysmal clipping. If the possibility of recurrence is suspected, additional reinforcement following neck clipping and early postoperative angiography should be performed to prevent early rebleeding which has a poor prognosis. Follow-up angiography is recommended for young patients, even if complete clipping has been achieved.

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Commentary

This article summarizes experience with recurrent hemorrhage in a very large number of aneurysm patients gathered in one center over a 15 year period. The total number of late recurrent bleeds (which does not include other possible hemorrhages in patients who may have died suddenly without reaching hospital, or moved to another district) is rather small at 20 in 1436 consecutive patients. However, they form a very interesting and important group, particularly those who bled from a new source.

In three cases a previously noted infundibulum developed into a true aneurysm and ruptured, with a delay to hemorrhage of 8, 9, and 9 years. The time course of enlargement is of course unknown, and they may have enlarged quite soon after the original admission. It would have been interesting to know how many others in the total series of 1436 also had an infundibulum noted in addition to their ruptured aneurysm and have not (so far) had later problems. These cases emphasize the importance of following such infundibula indefinitely, with repeated imaging studies at intervals. One patient among our own cases had bled from a posterior inferior cerebellar artery aneurysm and undergone surgery; 5 years later she was studied with helical CT scans and three-dimensional reconstruction,¹⁾ and found to have developed a 1 cm right carotid artery aneurysm. Review of the original angiogram showed an infundibulum there which had not been noted previously, and the new aneurysm was clipped prophylactically.

Also of great interest are the nine patients with recurrent hemorrhage from new aneurysms. The actual number of new aneurysms may, of course, be much greater, for the reasons noted above and also be-

cause others may have developed but still be asymptomatic.

These cases support the authors' suggestion of the need for careful observation at surgery for completeness of clipping, and for postoperative angiograms if there is any doubt. Long follow-up, with further investigation if new symptoms develop, is also a valid recommendation. The recent availability of investigations that are safer and less invasive than angiography, i.e. magnetic resonance angiography (if one can be certain of the safety of any aneurysm clips present) or 3D CTA, has altered the picture. I would go further, and recommend that all patients should be investigated periodically with one of these techniques, to look for new aneurysms at the site of previous surgery or elsewhere. The natural history of new aneurysm formation, or of infundibula, is essentially unknown, and can only be elucidated if all patients are studied in this way.

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For a long time, we have believed that aneurysm clipping is an established and reliable technique with long-term efficacy. However, there have recently been a number of reports which illustrate enlargement of previously clipped aneurysms and formation of de novo aneurysms. As far as I know, there is no angiographical follow-up study reporting the long-term efficacy of aneurysm clipping in a large series of patients. At present, interventional neuroradiologists are making efforts to obtain follow-up data in order to verify the long-term effectiveness of coil embolization treatment. Neurosurgeons may also have to investigate not only clinical status, but also angiographical follow-up results in their patients. I agree with the conclusion of Dr. Yamakawa et al. that follow-up angiography is recommended especially for young patients, even if complete clipping was achieved.

Early postoperative recurrent SAH is a disastrous problem in aneurysm treatment. As the authors mentioned, the main cause of this complication is incomplete clipping. Another unforgettable cause is misjudgment of the lesion responsible for SAH in multiple aneurysm cases. Among the seven patients with early

recurrent SAH reported here, two patients with multiple aneurysms had rupture of untreated aneurysms within 3 weeks after initial surgery. I wonder whether a previously intact aneurysm will rupture during such a short postoperative period, even with the use of hypertensive and/or anticoagulant therapy to prevent vasospasm. When we have some doubt concerning the ruptured site in multiple aneurysms, it is recommended that all aneurysms should be explored in the same operation.

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The authors reviewed 27 cases of recurrent subarachnoid hemorrhage (SAH) after neck clipping. Their results showed early recurrence within 1 month (26%) was due to incomplete clipping (15%) or untreated multiple aneurysms, whereas late recurrence (74%) resulted from de novo aneurysms (33%), "regrowth aneurysm" from completely clipped site (15%), aneurysms from infundibular dilatation (11%), or untreated aneurysms.

I agree with their opinion about early recurrent SAH in that patients with markedly degenerated parent artery or those with aneurysms having required repeated clipping should receive immediate postoperative angiography. The problem is late recurrent SAH due to de novo aneurysms or "regrowth aneurysms." The authors suggested that follow-up angiography is strongly recommended for young patients, even if complete clipping has been achieved. Although postoperative long term follow-up is essential, repeated evaluation by conventional angiography cannot be generally accepted until it is proved beneficial to large number of patients whose aneurysms were "completely" clipped. Use of artifact-free aneurysmal clips, and 3D-CT-A or MRA may be helpful for that purpose.

"Regrowth aneurysm" as referred in this article may be due to some incomplete clipping unrecognizable to the surgeons or true regrowth from the arterial wall near the neck. However, they are very interesting with regard to intravascular procedures. Since complete intraaneurysmal embolization does not always imply eliminating fragile wall of or around the aneurysm, recurrent SAH due to "regrowth" might increase in the future with increasing experience of the procedure.

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