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The Microsurgical Anterior Interhemispheric Approach Suitably Applied to Ruptured Aneurysms of the Anterior Communicating Artery in the Acute Stage

By

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With 4 Figures

Summary

From 1973 to 1980, 177 cases with ruptured aneurysms of the anterior communicating artery (Aco) have been operated on using various microsurgical procedures. Since 1974, 136 cases were directly operated on using the microsurgical anterior interhemispheric (AIH) approach; a modification of Lougheed's approach.

The overall mortality was 5%. The early operations, within 1 week of onset of subarachnoid haemorrhage had a 3% mortality in grade 1 and 2 patients; a 16% mortality in grade 3 and 4 and a 25% mortality in grade 5 patients. The rate of cases in which the patient was independent following surgery was 92% in grade 1 and 2 patients, 47% in grade 3 and 4, and 25% in grade 5 in the same group.

The AIH approach for severe cases in the acute stage has the following benefits;

1. The retraction pressure on the brain in the AIH approach is half as much as that in Yaşargil's approach. The aneurysms can be operated on with less retraction of the brain and thus without damaging the brain, olfactory nerves, bridging veins, hypothalamic arteries and other perforating arteries.
2. Various types of aneurysms, whatever their position, especially those located high and in a posterior direction, can be easily clipped.
3. Adequate removal of clots can be achieved from the interhemispheric fissure, the chiasmatic and the prepontine cisterns and the frontal lobe.
4. Interarterial anastomosis between both anterior cerebral arteries can be applied if necessary to allow easy clipping of unusual aneurysms.
5. Temporary occlusion of A_1's and A_2's and external decompression can be easily done if necessary.

Keywords: Anterior communication artery aneurysm; Anterior interhemispheric approach; Early operation; Vasospasm.

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Introduction

Prior to the introduction of microsurgery into the surgical treatment of anterior communicating arterial (Aco) aneurysms, the direct approach to the Aco aneurysm was extremely difficult because any of the surgical approaches performed under the naked eye frequently involved compression of the brain, resulting in damage to the frontal lobes and sometimes resulting in functional damage of the frontal lobes.

Since I actively began early surgery for ruptured Aco aneurysms in 1973, I have compared the advantages of various kinds of operative approaches, such as the interhemispheric approach developed by Lougheed[9], the frontobasal lateral approach by Yaşargil[19] and/or the subfrontal approach, using a microsurgical technique. As a result, it has been clarified that the anterior interhemispheric approach, modified from Lougheed's original method, following a bifrontal or a hemifrontal craniotomy, is superior to other approaches on several points and most suitable in treating ruptured Aco aneurysms in the acute stage[5]. Since 1974, the microsurgical anterior interhemispheric approach has been applied almost constantly in treating ruptured Aco aneurysms.

In this paper, the author describes the operative technique for this approach, the operative results of early surgery, and the reasons for the advantages of this approach.

Materials and Methods

From 1973 to 1980, 177 cases with ruptured Aco aneurysms underwent microsurgical neck clipping of the aneurysms by the author.

Since 1974, following the establishment of my microsurgical technique using the anterior interhemispheric approach for Aco aneurysms, 136 cases have been operated on using the same technique. The operative mortality of this group was 5%. In this series, the advantages of this approach, comparisons of the operative results of this approach with those of other approaches, and/or the correlation between the extent of removal of the subarachnoid clot and the incidence of postoperative vasospasm in the acute stage patients were analysed in detail.

1. Operative Technique for the Anterior Interhemispheric Approach (AIH)

The patient is placed supine with a horizontal position of the head. A bilateral or unilateral frontal craniotomy is commonly used following suitable skin incisions, in a bifrontal, a hemifrontal, or a mid-frontal fashion. Frontal craniotomy on both sides is most suitable in severe cases in the acute stage. Following craniotomy and the W-shaped incision on the dura, the incised dura is reversed anteriorly. After coagulation or ligation of the superior sagittal sinus at its most anterior

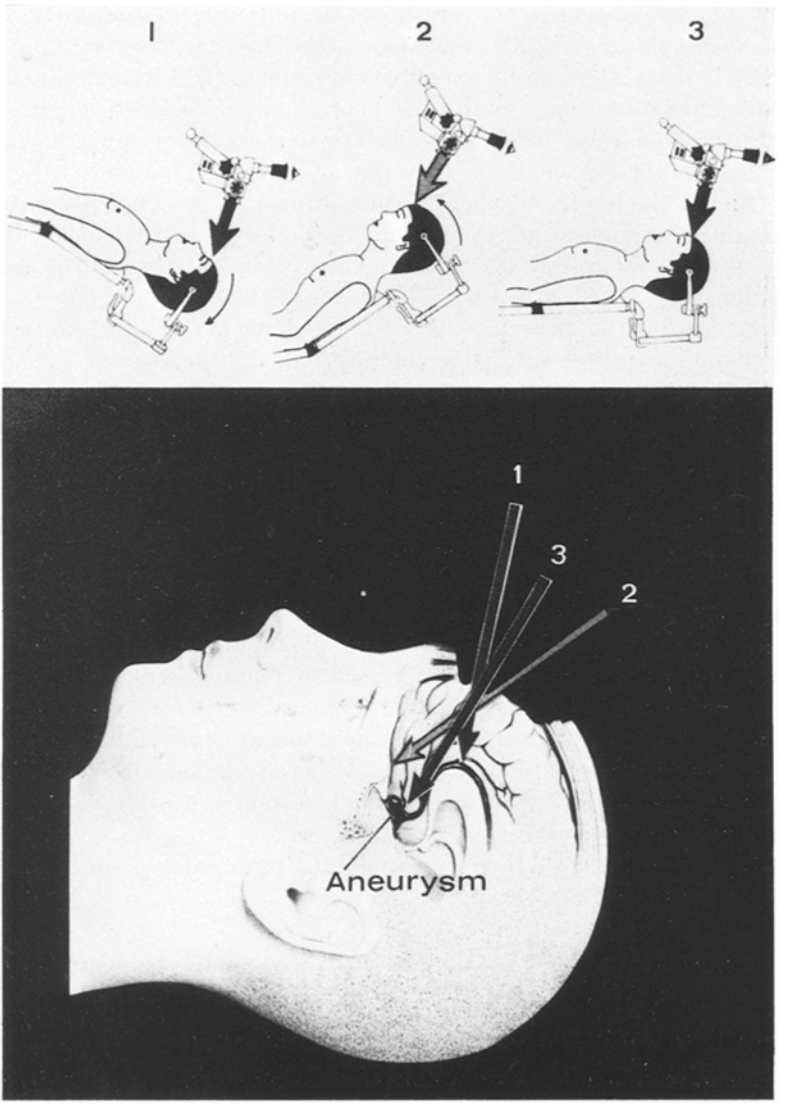


Fig. 1. Anterior interhemispheric approach and intra-operative changes of the head-position. *1* Head-down: To approach the knee portion of the corpus callosum for preparating a narrow space in the interhemispheric fissure. *2* Head-up: To approach directly towards the planum sphenoidale without dissecting the whole way alongside both pericallosal arteries. *3* Head-horizontal: To approach the anterior communicating complex and its aneurysm

part, the falx should be cut off toward the anterior, inferiorly. During this manipulation a skillful technique is required to preserve bridging veins. If there is severe subarachnoid haemorrhage (SAH) and/or acute ventricular dilatation, continuous ventricular drainage through the right frontal horn should be performed to decrease the brain volume. As a result, brain damage from brain retraction can be minimized.

Firstly the interhemispheric fissure just above the knee portion of the anterior cerebral arteries should be slightly prepared until both callosomarginal arteries meet, with a vertex-down position of the head to allow easy dissection of the fissure (Fig. 1).

Secondly, after elevating the head, dissection of the interhemispheric fissure progresses anteriorly, inferiorly toward the planum sphenoidale. The whole space alongside both pericallosal arteries and the corpus callosum should not be opened. On reaching the planum sphenoidale after dissecting the narrow space above both pericallosal arteries, the patient's head position is returned to horizontal for dissection of the suprachiasmatic cistern, the anterior part of the pericallosal cistern towards the Aco-complex.

After evacuating the intra-cisternal and the intracerebral clot near the aneurysm, the aneurysmal dome and neck should be carefully dissected to complete occlusion of the aneurysmal neck. Temporary clips on the parent arteries are not usually required.

If necessary, the clot in the prepontine cisterns can also be evacuated over the chiasma, beside the pituitary stalk, and through a space between the anterior and the posterior clinoid processes. The operative opening of approximately 0.8 to 1.0 cm in width is enough to approach the aneurysm.

In cases of severe SAH or a swollen brain, bifrontal decompression is usually performed after complete haemostasis.

2. *Reasons for Applying the Anterior Interhemispheric Approach to Aco Aneurysms*

a) Direction and distribution of Aco aneurysms.

The direction and the distribution of the aneurysms were analysed during operation. Aneurysms arising anteriorly to the Aco were detected in 40% of cases. Of these, aneurysms with an anterior superior lateral direction were seen in 30%, anterior superior direction in 6%, and anterior inferior direction 3%. In contrast, the incidence of aneurysms with a posterior direction was 61%, including a posterior superior direction in 42%, a posterior inferior direction in 16%, and a posterior superior lateral direction 3%.

In the case of aneurysms in which the direction is towards the

posterior, [especially for aneurysms arising in a posterior superior direction and positioned high in the interhemispheric fissure], this operative approach, which does not require removal of the rectus gyrus and extreme retraction of the frontal lobe, may be much better than the frontobasal lateral approach (FBL).

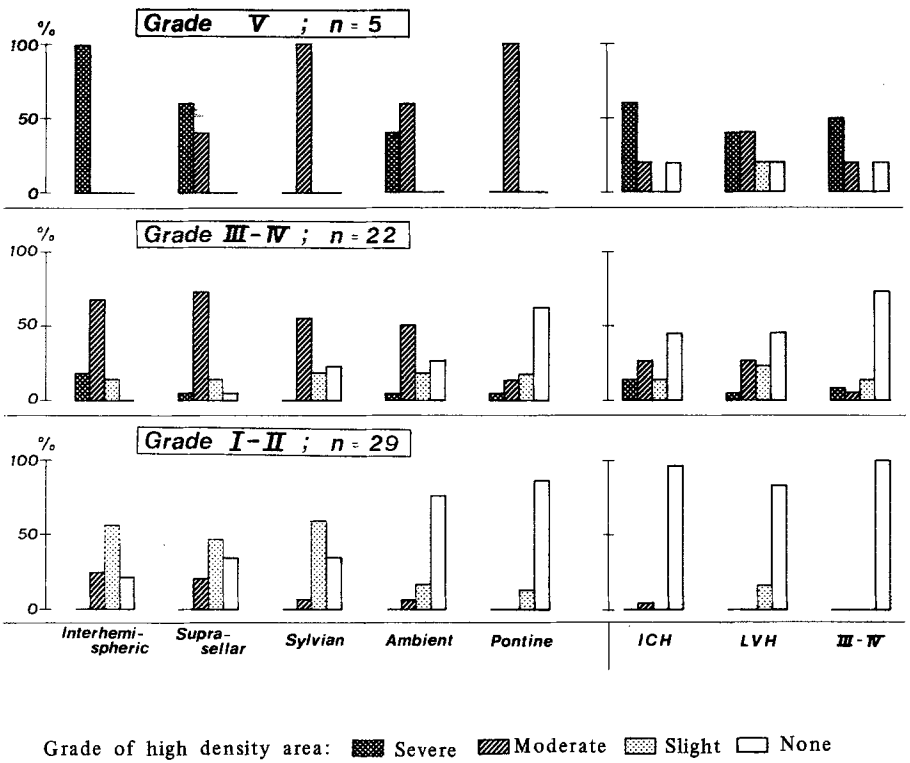


Fig. 2. Correlation between clinical grading and location and grade of high density areas in CT's examined within 3 days of SAH. *ICH* intracerebral haematoma, *LVH* haematoma in the lateral ventricle, *III-IV* haematoma in the IIIrd or IVth ventricle

b) Distribution of subarachnoid and intracerebral clots.

The distribution of the subarachnoid and intracerebral haematoma was analysed by CT examination within 3 days of the onset of, haemorrhage to help assess the clinical grading.

As shown in Fig. 2, severe subarachnoid clots in the interhemispheric fissure and the chiasmatic cisterns, and clots in the frontal lobe are most frequently recognised in cases with grades 3, 4 and 5.

In treating ruptured aneurysms of the anterior communicating artery in the acute stage, it is important that the clots in the frontal lobe and in the cisterns surrounding the Aco complex should be evacuated. Furthermore, the clot in the prepontine cistern can also be evacuated above the chiasma and through the space between the anterior and posterior clinoid processes. This operative approach is readily available to evacuate such clots.

c) Differences in the retraction pressures on the frontal lobe between the anterior interhemispheric approach and the frontobasal lateral approach.

To compare the differences in the retraction pressure on the brain between both approaches, intraoperative measurements of the retraction pressure on the frontal lobe were performed by a platetype pressure sensor under the brain spatula in chronic cases, aged between 65 and 70 without noticeable brain atrophy.

Using the FBL approach, the retraction pressure was 20–30 cm H_2O but with the AIH approach it was below 10 cm H_2O.

When approaching ruptured Aco aneurysms in the acute stage and located deeper in the brain, additional damage from severe brain swelling and softening or other brain damage were often encountered. Therefore, a slight increase in the retraction pressure can easily cause extremely extensive damage to the brain during surgery in the acute stage. For the same reason, meticulous evacuation of the subarachnoid clot involving considerable compression of the brain and unfavourable damage to perforating arteries would not be so suitable in the early operation[5].

d) Application of interarterial anastomosis between both distal anterior cerebral arteries (ACA).

The present technique of inter-distal ACA, developed by Ito[6] in 1975, is the side-to-side anastomosis between both pericallosal arteries at the knee portion of the corpus callosum. Following this anastomosis, one side of A_1 or A_2 can be sacrificed to allow easy clipping. This new technique has extended the indication for direct clipping of big or giant aneurysms. The anastomotic procedure can be done only by using the anterior interhemispheric approach.

e) Other advantages.

Both olfactory nerves, the hypothalamic and other perforating arteries can usually be well-preserved. If necessary, temporal occlusion

of the parent arteries, both A_1's and A_2's, can be easily performed. Furthermore, where external decompression in the bifrontal area is necessary cisternal and ventricular drainage can be performed in the acute stage.

3. Operative Results

During the 6 years since 1974, all the 136 cases with a ruptured Aco aneurysm were microsurgically clipped using the AIH approach and in 18 cases using the FBL approach.

a) Comparison of the operative results in using the anterior interhemispheric approach (AIH) and the frontobasal lateral approach (FBL).

The operative mortality was 5% in the 136 cases where the AIH was used, and 11% in the 18 cases where the FBL was used. The overall mortality rate was 6%. The mortality rate in the cases with the AIH approach was less than half in the cases with the FBL approach (Table 1).

Table 1. *Summary of the Operative Results Using the Anterior Interhemispheric (AIH), the Fronto-Basal Lateral (FBL) and the Bilateral Subfrontal Approaches in 177 Cases with Ruptured Anterior Communicating Artery Aneurysms (1973-Dec. 1980)*

Year	Operative procedure							
	AIH		FBL		Subfrontal		Total	
	No.	Death (%)	No.	Death (%)	No.	Death (%)	No.	Death (%)
1973	9		1 0 2 (20)	4	2 (50)	23	4 (17)	
1974 ~ 1980. 12	136	7 (5)	18	2 (11)	0	—	154	9 (6)
Total	145	7 (5)	28	4 (14)	4	2 (50)	177	13 (7)

b) Correlation between the operative timing and the operative results in 136 cases with the AIH approach.

Seventy cases (52% of the 136 cases) were operated on within 1 week of SAH. Deaths within 2 months postoperatively occurred in 6 cases, representing 9%. Out of the 70 cases, 28 (21% of the AIH cases) were

Table 2. *Operative Results in 136 Cases with Ruptured Anterior Communicating Artery Aneurysms Operated on Using the AIH Approach Only (1974-Dec. 1980)*

a) *Operating timing and operative results*

Interval from onset to operation	No.	%	Death No.	Death %
within 24 hours	28	21	4*	14
2-3 days	17	12	0	—
4-7	25	18	2**	8
8-14	28	21	1***	4
15-20	12	9	0	—
more than 21	26	19	0	—
Total	136	100	7	5

Deaths caused by:

* Meningitis in 1 Grade 4 patient, pulmonary infarction in 1 Grade 4, severe brain damage in 1 Grade 5 and severe vasospasm in 1 Grade 5.

** Renal failure in 1 Grade 2 and pneumonia in 1 Grade 4.

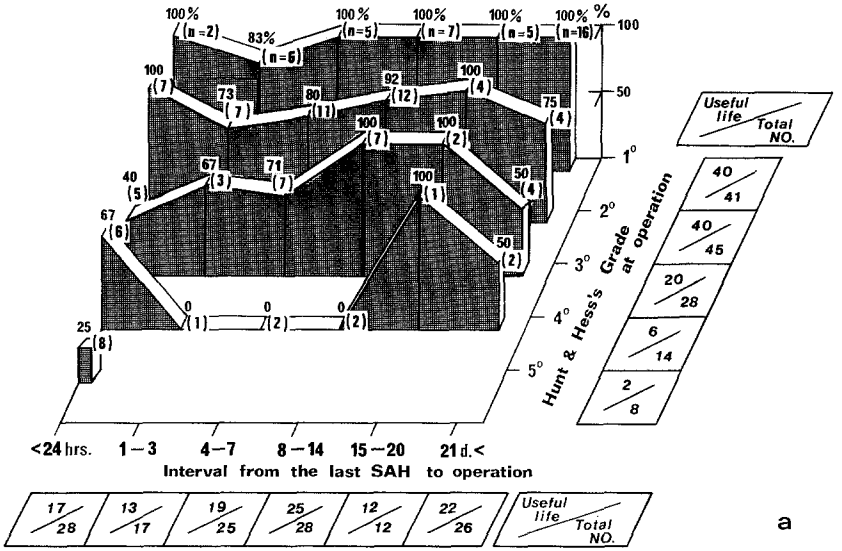
*** Intracerebral haematoma by invasion of a clip into the brain in 1 Grade 2.

b) *Clinical grades at operation and operative results*

Grade (Hunt and Hess)	Total No.	Follow-up results (2 mon.) Good No.	Good %	Fair No.	Fair %	Poor No.	Poor %	Died No.	Died %
I	41	40	98	1	2	0	—	0	—
II	45	40	89	3	7	0	—	2	4
III	28	20	71	3	11	5	18	0	—
IV	14	6	43	2	14	3	21	3	21
V	8	2	25	1	13	3	38	2	25
Total	136	108	79	10	7	11	8	7	5

operated on within 3 days, with no deaths and 25 cases (18% of the 136) were operated on during a period of 4 to 7 days after SAH, with 2 deaths, giving a mortality rate of 8% (Table 2 a).

In the other 66 cases, in which the direct operation was performed after 1 week of SAH, there was only one death; a mortality rate of 2% (Table 2 a).



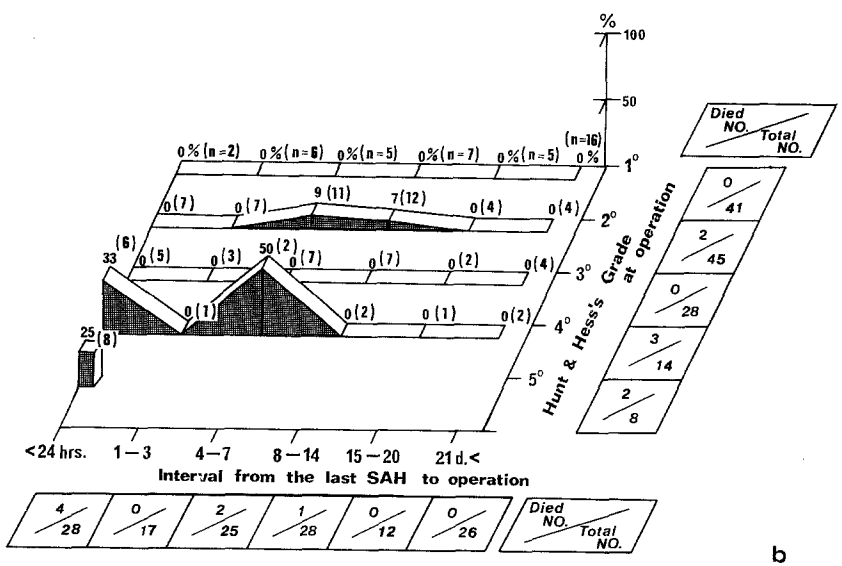


Fig. 3. Interrelationships between the operative timing, the grade at operation and the surgical results in 136 cases (up to the postoperative 2 months). a) Cases with full recovery and independence. Total No. = 108 (79.4% of 136 cases). b) Cases with death. Total No. = 7 (5.1% of 136 cases)

c) Correlation between the grading at operation and the operative results.

In 41 cases with grade 1 and 28 cases with grade 3 there were no deaths. Two of 45 cases with grades 2 or 3 and 14 cases with grade 4, and 2 of 8 cases with grade 5 died postoperatively (Table 2 b).

The causes of death included 1 fatal case of severe brain damage due to severe subarachnoid haemorrhage and 1 occurrence of diffuse brain ischaemia due to postoperative vasospasm in the grade 5 patients; 1 case of postoperative meningitis, 1 case of pulmonary infarction and 1 of pneumonia in the grade 4 patients. In the grade 2 patients there was patient 1 with renal failure and 1 with postoperative intracerebral bleeding due to invasion of the clip-head into the frontal lobe.

Accordingly, in cases with grades 1, 2 and 3, and even in cases with grade 4, there would be no or at least fewer deaths due to operation if certain accidents or complications did not occur postoperatively.

d) Interrelationships between the operative timing, the grades at operation and the surgical results.

Direct operations at any time resulted in a high incidence of cases with a full recovery and an independence rate of 93% as an average in grade 1 and 2 patients.

However, in the group of grade 3 patients, good results were obtained in 40% of the cases operated on within 24 hours of SAH, in 67% of those operated on between day 1 and day 3 and in 71% of those operated on between day 4 and day 7. The morbidity was higher in cases with early surgery than in those with delayed surgery in this group (Fig. 3 a, b).

In contrast earlier operations resulted in relatively good outcomes in cases with grade 4 and 5. Out of 6 cases with grade 4, with operations within 24 hours of SAH, 2 died. All of the other 4 surviving cases had outcomes leading to a full recovery or independence. However, in 2 cases operated on during the period from day 4 to 7, 1 died and 1 had a poor result. In an additional 8 cases with grade 5 undergoing an emergency operation within 24 hours of onset, 2 cases died and 2 cases had good outcomes (Fig. 3 a, b).

e) The limitations of suitable evacuation of subarachnoid clots to prevent postoperative vasospasm in severe cases in grade 3, 4 and 5.

As shown in Fig. 4, all of 16 severe cases which underwent emergency operations were divided into 3 groups according to the

method of clot evacuation as follows: (A) represents the localised evacuation of the clot only from an interhemispheric fissure, a chiasmatic cistern and/or a prepontine cistern by the AIH approach. (B) represents the extensive evacuation of the clot from an interhemispheric fissure, a chiasmatic cistern, a unilateral sylvian fissure and a prepontine cistern by the AIH and the unilateral transsylvian ap-

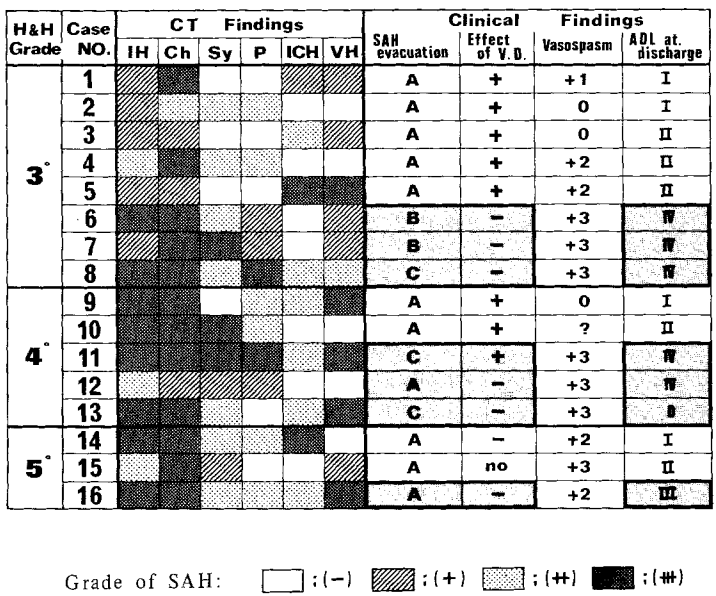


Fig. 4. Grade of subarachnoid haemorrhage (SAH), mode of removal of subarachnoid clots and operative results in severe cases operated on within 3 days of SAH. Mode of clot evacuation: *A* localised, *B* extensive, *C* super-extensive. Grade of vasospasm + 1 localized, slight, + 2 moderate, + 3 severe and diffuse. VD = ventricular drainage

proach (TS). (C) represents the extremely extensive evacuation of the the clot from the interhemispheric and both sylvian fissures, interpeduncular and prepontine cisterns by the AIH and bilateral TS's.

Seven cases with grade 4 and 5, (except Case 12), had almost the same distribution and grade of subarachnoid haemorrhage.

Out of the 5 cases with grade 4 and 5 in group A, vasospasm was not visualized in 1 case; it was moderate in 2, severe in 1, and unknown in 1. Four cases of this group had good outcomes. Two cases with grade 4 in group C had severe vasospasm, with 1 becoming bed-ridden and 1 dying as a result.

In 8 cases with grade 3, all 5 cases in group A had moderate, slight or no vasospasm, which resulted in a good outcome. The other 3 cases in group B or C became worse following severe vasospasm.

Brain swelling or oedema was intraoperatively detected in 8 cases. Of these, all 4 in which extensive clot evacuation was performed became worse following severe vasospasm after the operation. By contrast 2 of the 4 cases in which a limited evacuation of the clot was performed had good results.

Furthermore, in 8 cases which did not reveal marked brain oedema, only one case which underwent extremely extensive evacuation of a clot resulted in a poor outcome following severe vasospasm.

The results described above suggest that the considerable compression of the brain necessary to extensively evacuate the clot from the many cisterns would result in additional severe damage to a brain which has already been damaged.

Discussion

There is no doubt that the principal problems concerning the treatment of ruptured cerebral aneurysms exist in the possibility of a rebleeding, the secondary damage of the brain due to an acute rise in the intracranial pressure caused by an intracerebral haematoma, a coagulated subarachnoid clot and an acute hydrocephalus, an acute circulatory disturbance and ischaemic dysfunction due to vasospasm following SAH.

Many reports have described that in cases with grades 1 or 2 and operations whatever the timing, resulted in a high recovery rate of more than 90%[13,18,20] and a mortality rate as low as 0-3%[13,18,20]. In cases of grade 3 to 5, operated on within 1 week of SAH, the postoperative results showed a good recovery in 40-60% and mortality in 15-25%[3,5,8,13].

In contrast, grades 3 to 5 patients had a high mortality rate of 80-100% when surgery was not performed in the short period after SAH[8,18]. Therefore, the most important surgical problem concern the treatment of severely ill patients—grade 3, 4 or 5—in the acute stage.

From our data, it would seem that an early operation is superior to a delayed operation for the severe cases with grades 4 or 5 to enhance their chance of survival and to generally predict an improvement in their condition.

In severe cases having ischaemia of hyperaemic lesions with global regulatory dysfunction of circulation[1,2,4,15], brain swelling[17] and/or hypertensive intracranial pressure[11] are frequently present. Therefore

the surgical procedure which requires less compression and less invasion of the brain should be employed.

At present, the microsurgical frontobasal lateral approach developed by Yaşargil[19] is widely applied to aneurysms of anterior communicating artery. There is no doubt that this approach is simple and effective for neck clipping of Aco aneurysms in mild cases or patients in a chronic state[20]. This approach has, however, the following weak points in severe cases at the acute stage;

1. Aneurysms with a posterior direction are more frequent than those with an anterior direction. For approaching such aneurysms with a posterior direction, strong retraction of the base of the frontal lobe and sucking out the rectus gyrus are commonly required. These manipulations could bring about a worsening of the damaged brain in severe cases.

2. Frequently the CT results reveal significant amounts of clot in the interhemispheric fissure, the suprasellar cistern and the frontal lobe. The FBL approach does not allow an easy evacuation of the clots in these locations. The interhemispheric approach, which was reported by Lougheed[9], solved these weak points of the FBL. The original approach in Lougheed's method was relatively difficult technically and caused additional damage to the brain because of the necessary preparation of the entire space alongside both pericallosal arteries from the knee portion of corpus callosum to the Aco-complex[10].

In 1973, I modified the anterior interhemispheric (AIH) approach so that the whole space of the interhemispheric fissure is no longer prepared alongside both pericallosal arteries up to Aco complex, but is directly dissected downwards and anteriorly to the chiasmatic cistern for approaching an Aco aneurysm[5].

By this AIH approach, the width of the operating field is approximately 0.8 to 1.0 cm and the retraction pressure to the brain by the spatula is less than half of that in the FBL approach. In our series of patients operated on in the acute by using the AIH approach, the operative mortality in 32 patients with grades 3, 4 and 5 was 16%, which is significantly superior to that of other authors using other approaching procedures[3,8,13].

In the operative results of early surgery by other surgeons with larger patient series, Saito *et al.*[13] described a 20% mortality in patients with grades 3, 4 and 5 (using the FBL approach). Ljunggren, *et al.*[8] had a 24% mortality in grades 1, 2 and 3 patients using the same approach, and Hori *et al.*[3] also had a 24% mortality in grades 3 and 4 patients using Suzuki's[3] approach, (which is in routine use), of temporary occlusion of a unilateral A_1 or both A_1's following both subfrontal

approaches, then approaching through the interhemispheric space to the aneurysm under the naked eye.

Recently, early surgery, removing the subarachnoid clot as soon as possible, has been proposed to prevent postoperative vasospasm[4,7,14,16], because coagulated subarachnoid clot frequently causes a delayed vasospasm. From our experience, also the early removal of subarachnoid clot within 48 hours can decrease the rate of severe vasospasm resulting in neurological deficits[12]. In severe cases with a swollen brain, however, extensive evacuation of a clot would involve much additional trauma to the damaged brain. In analysing my operative results in the severe cases by using various modes of clot evacuation, the extensive evacuation of a clot resulted in marked vasospasm and poor outcomes when apparent brain swelling could be detected intraoperatively; but the relatively localised removal of a clot with less compression and less trauma to the brain brought about minimal vasospasm and a relatively good outcome.

Before 1973, prior to the provision of early surgery, we have had many clinical experiences in which frequent repeated rebleeding occurred in the short period after the first bleeding and there was a progressive deterioration of intracranial pathology resulting in death or deterioration of the patient's condition in all of the severe cases. It is concluded that only emergency surgery, with suitable removal of subarachnoid and intracerebral haematoma, external decompression, and/or cisternal and ventricular drainage, prior to the appearance of symptoms of brain stem dysfunction, can ensure a better chance of survival and a good recovery in severely ill patients.

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