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Surgical Treatment of Anterior Communicating Artery Aneurysms

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Direct Microsurgical intracranial approach is a standard technic for the treatment of ruptured intracranial aneurysms. Nevertheless aneurysms of the anterior communicating artery present particular difficulties because of their critical location, their various projections, the serious circulatory disturbances that may follow their rupture or vasospasm, the prevalence of local vascular anomalies, and their tendency for fatal recurrent hemorrhage. The authors analyzed 102 cases of anterior communicating artery aneurysms, surgically treated at Yonsei University Hospital in the Department of Neurosurgery from 1971 through August 1981. The operative mortality of the microsurgical pterional approach was 4.8% and the morbidity was 5.9% as compared to a mortality of 16.7% and a morbidity of 44.4% seen before the advent of microsurgery.

Key Words: Cerebral aneurysms, Anterior communicating artery aneurysms, Microsurgery, Pterional approach

The anterior communicating artery is the most common site of intracranial aneurysm and accounts for 30% of the aneurysms with a single bleeding episode (Locksley, 1966; Yasargil *et al.*, (1975). Conservative management of the anterior communicating artery aneurysm showed a high mortality of 44.5% as reported by Logue (1956), while McKissock *et al.* (1965) reported 52% and Graf (1971), 68%. In 1933, Dott reported the first operative success in a ruptured anterior communicating artery aneurysm with the use of muscle wrapping. In 1936, Tönnis reported the same procedure by the transcallosal route. Dott performed proximal occlusion of the anterior cerebral artery in 1941 (Dott, 1969), which was further developed by Logue (1956). Many subsequent reports (Pool, 1961, 1962; Lougheed, 1968; Tindall *et al.*, 1970; Hockley, 1975) on surgical treatment of the anterior communicating artery aneurysm appeared, but the mortality rate remained high until the 60s

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(Skultety and Nishioka, 1966; Logue *et al.*, 1968). Moreover, McKissock *et al.* (1965) challenged the value of surgical treatment for anterior communicating artery aneurysm. Reports from the cooperative study of Skultety and Nishioka (1966) revealed a high mortality rate (35%), and Graf and Nibbelink (1974) reported similar results (34% mortality) in their cooperative study.

The introduction of the operating microscope with refined instruments and technics has produced remarkable results, such as the report of a 3% mortality rate obtained by Krayenbühl *et al.* (1972) in 95 patients with anterior communicating artery aneurysms by the direct approach. In addition, the reports of Yasargil *et al.* showed a 1.5% mortality rate in 203 cases of anterior communicating artery aneurysm (1975) and a 2.2% mortality in a subsequent report of 274 cases (1978). Thus, the microsurgical approach has become the standard procedure for the treatment of anterior communicating artery aneurysms.

The authors analyzed 102 cases of the anterior communicating artery aneurysms (35.1%) among the 291 cases of intracranial aneurysms surgically treated in the Department of Neurosurgery, Yonsei University Hospital from 1971 through August 1981.

MATERIALS AND METHODS

The analysis was based on the medical records of 102 cases of anterior communicating artery aneurysms which were treated surgically. Among the 102 cases, 84 cases were operated by the microsurgical frontobasal pterional approach. The analysis was based mainly upon the personal experience of the senior author (K.C.L.) with 84 consecutive cases of microsurgical pterional approach, which was started from 1975 at Yonsei University Hospital in the Department of Neurosurgery. Aneurysms on the proximal A-1 segment and on the distal anterior cerebral artery were not included. The age and sex distribution, symptoms and signs, cerebral angiographic findings, brain CT scan findings, preoperative treatments, surgical treatment and results, and complications of the surgery in the 102 cases of surgically treated anterior communicating artery aneurysms were reviewed and analyzed. Since the medical records were not satisfactory for some aspects of the study, the surgical subnote (with sketches of the operative findings, brief summaries of the patient's condition and operative procedures), have been prepared only since 1975 when the microsurgery was started, were invaluable for the analysis. Therefore, the surgical results and the technical aspects of surgery for the 84 microsurgically treated cases were emphasized in this report of 102 cases.

RESULTS

Age and Sex distribution

The anterior communicating artery aneurysms ruptured most frequently in the 5th decade (37.2%), followed by 6th (24.5%), 4th (20.1%), 7th (10.8%), and 3rd (6.9%) in decreasing order of frequency. The youngest patient was 24 years of age and the oldest was 69.

There were 60 male patients (58.5%), and 42 female patients (41.2%) (Table 1).

Symptoms and Signs

Headache, vomiting, transient loss of consciousness, and stiff neck were the chief presenting symptoms and signs. Hypertension (above 140/90 mmHg) was noted in 46.1% of the patients at the time of admission. Among these patients, 26 (55.3%) showed blood pressure over 170/110 mmHg and 3 (6.3%) were above 200 mmHg. Impaired consciousness was noted

Table 1. Age and sex distribution of ACoA aneurysms

Age (yrs)	Cases		Sex	
	No.	%	M	F
20-29	7	6.9	2	3
30-39	21	20.6	13	6
40-49	38	37.2	27	11
50-59	25	24.5	11	14
60-69	11	10.8	5	6
Total	102	100	60	42

ACoA: Anterior communicating artery

Table 2. Symptoms and signs of ACoA aneurysm

Symptoms and signs	Cases (%)
Headache	98.6
Neck stiffness	95.1
Brief unconsciousness	83.4
Vomiting	81.8
Hypertension	46.1
Impaired consciousness	34.4
Motor weakness	19.2
Seizure	6.3
Visual disturbance	
Dim vision	2.9
Field defect	1.9
Blindness	0.9
Abducens palsy	0.9
Fundus	
Hemorrhage	17.6
Papilledema	3.9
Optic atrophy	2.9
Microaneurysm	0.9

ACoA: Anterior communicating artery

in 34.4% and motor weakness and seizure were noted in 19.2% and 6.3% respectively. Giant (more than 25 mm) or large (12-25 mm) aneurysms produced eye symptoms and field defects similar to pituitary tumors. One patient with a giant aneurysm had total blindness of one eye. Funduscopic examination showed hemorrhage in 17.5% and a microaneurysm was noted in one case. A case with a giant aneurysm complicated by hydrocephalus showed a gait disturbance (Table 2).

Cerebral angiographic findings

The aneurysm was fed by the left anterior cerebral artery in 55.9% and by the right in 33.3%, and from both sides in 10.8%. The projection of the aneurysm was the prechiasmatic direction in 43 cases (42.2%) and the interhemispheric direction in 39 cases (38.2%). Angiographic vasospasm was noted in 46 cases (45.1%). Multiple aneurysms were noted in 9 cases (8.8%) with associated aneurysms of the middle cerebral artery in four cases, the posterior communicating artery in three cases, and the internal carotid artery in two cases. Among these nine multiple aneurysms, the anterior communicating artery aneurysm bled in 8 cases while the posterior communicating artery was the bleeding source in one case. Three cases (2.9%) of giant aneurysm and 8 cases of large aneurysm were seen (Table 3).

Table 3. Angiographic findings of ACoA aneurysms

Findings	Cases (No. / %)	
ACA filling aneurysm		
Right dominant	34	33.3
Left dominant	57	55.9
No dominance	11	10.8
Projection		
Prechiasmatic	43	42.2
Interhemispheric	39	38.2
Vasospasm	46	45.0
Large aneurysm (12-25mm)	8	7.8
Giant aneurysm (> 25mm)	3	2.9
Multiple aneurysm	9	8.8

ACoA: Anterior communicating artery
ACA : Anterior cerebral artery

Brain CT scan findings

After the introduction of the CT scan in this

hospital, 55 surgically treated anterior communicating artery aneurysm patients were evaluated with CT scans. Findings such as location and extent of the subarachnoid hemorrhage, intracerebral hematoma and intraventricular hemorrhage, changes in ventricular size, occurrence of cerebral edema and/or cerebral infarction, and contrast enhancement of the aneurysmal sac were evaluated. The subarachnoid hemorrhage was noted in 26 cases (47.3%) which was located in the suprasellar cistern (16 cases), interhemispheric fissure (15 cases), Sylvian cistern (11 cases), interpeduncular cistern (8 cases), ambient cistern (5 cases), and quadrigeminal cistern (4 cases) in order of frequency. Hydrocephalus was noted in 24 cases (43.7%), but only one case required preoperative ventriculoperitoneal shunt. Cerebral infarction was noted in 15 cases (27.3%) and all these cases had symptoms and signs of cerebral vasospasm. Five cases of intracerebral hematoma were noted. When the diameter of the aneurysm was larger than 10 mm, the aneurysm appeared as a small enhancing lesion. The size of the giant aneurysm was measured more precisely with the CT scan than with the angiogram, because of the presence of intramural thrombus (Table 4).

Table 4. CT scan findings of 55 ACoA aneurysms

Findings	Cases (%)
Subarachnoid hemorrhage	26 (47.3)
Suprasellar	16
Interhemispheric	15
Sylvian	11
Interpeduncular	8
Ambient	5
Quadrigeminal	4
Hydrocephalus	24 (43.7)
Infarction	15 (27.3)
Intracerebral hematoma	9 (16.4)
Enhancing mass (aneurysm)	7 (12.7)
Intraventricular hemorrhage	5 (9.1)

ACoA: Anterior communicating artery

Preoperative treatments

Preoperative observations and treatments were started as soon as the diagnosis of the subarachnoid hemorrhage due to aneurysmal rupture was made. For the early detection of neurological deterioration preoperative evaluations included regular neurologic examinations, checking the blood pressure, daily grading of the Botterell's classification, measurement of the precise intake and output, and periodic checking of the electrolytes, hematocrit, serum albumin and total protein. These evaluations were used to maintain a good status of the patient by correcting any electrolyte imbalance, anemia and/or hypoalbuminemia, and also, to prevent blood volume contracture and negative nitrogen balance in confined patients.

Prevention of recurrent bleeding was tried with meticulous control of the blood pressure and administering antifibrinolytic agents. Antihypertensive drugs were used to reduce the blood presure about 20 to 30%. Epsilon aminocaproic acid (EACA) was given 24 grams per day by oral or intravenous route. Absolute bed rest in a semidarkened room and quiet surroundings were maintained to prevent any external stimuli while minor tranquilizers were used as needed. Laxatives were used to soften the stool and catheterization of the urinary bladder was done when there was a voiding difficulty to prevent elevation of the blood pressure.

Dexamethasone was used to relieve cerebral edema and intracranial hypertension. When the intracranial pressure was threateningly high enough to produce herniations, Mannitol and loop diuretics were used liberally.

The most serious problem in the preoperative period was cerebral vasospasm. Sundt regimen (Sundt et al., 1973) was used in the past but was without much benefit, and recently new efforts

were made to improve the cerebral perfusion and oxygenation. When clinical deterioration occurred, a brain CT scan and lumbar puncture were done immediately to rule out recurrent bleeding. As soon as recurrent bleeding was excluded, vigorous management of the ischemic symptoms was started; such as the transfusion of whole blood or albumin and infusion of low molecular weight dextran; to improve microcirculation. The blood pressure was elevated 10 to 20 mmHg from the control level to improve perfusion in the ischemic area. Oxygen inhalation was done to prevent cerebral hypoxia. When the mental state deteriorated, endotracheal intubation and artificial ventilation with a volume respirator were done to maintain the arterial oxygen tension above 100 torr and the carbon dioxide tension around 30 torr. Often the patients responded to these vigorous efforts with reversal of the ischemic symptoms, but the response was not so good in poor grade patients. Prevention of pulmonary complications and early detection and treatment of fluid and electrolyte imbalance were stressed; although they may not prevent vasospasm, at least they would not aggravate the spasm. The average period of preoperative management was about 2 to 4 weeks (Table 5, Table 6). The frequency of the rupture of the aneurysm is summarized in Table 7. Sixty eight patients (66.7%) were operated on with a single bleeding episode while seven patients (6.9%) had recurrent bleeding during the preoperative period.

Table 5. Clinical grade of ACoA aneurysm patients

Time of assesment	Grade				
	I	II	III	IV	V
Admission	31	25	17	10	1
Operation	36	23	20	5	

ACoA: Anterior communicating artery

Table 6. Preoperative grade and microsurgical timing

Grade*	Interval from last bleed to op. (wk)						Total
	1	2	3	4	5	5	
I	1	9	14	7	3	2	36
II		9	7	5			23+
III		3	6	7		4	20
IV		1		1	2	1	5
Total	1	22	27	20	5	7	82\84+

* Botterell's grade

\+ Two aneurysms were unruptured.
(Patient's grade was rated according to the coexisting ruptured aneurysm)

Table 7. Frequency of rupture

Time	Frequency				
	0*	1	2	3	4
Admission	2	73	20	6	1
Operation	2	68	23	8	1

* Unruptured aneurysm

Surgical treatment

During the pre-microsurgery era, carotid artery ligation, A-1 clipping, muscle wrapping, and neck clipping were done in several cases. Those cases were excluded and the following descriptions are based on the microsurgical operation.

1) Pterional approach:

All cases of microsurgery were carried out with the low frontobasal pterional approach. The patient was placed in the supine position with the head elevated, rotated 30 degrees, and tilted 15 degrees contralaterally while the neck was extended 20 degrees. The head was stabilized by the Mayfield skull clamp. The pterional approach as described by Yasargil (Yasargil and Fox, 1975; Yasargil *et al.*, 1975) was done. The side of the dominant feeding artery of the aneurysm was the side of the operative approach. After the scalp incision, 40 to 60 grams of Mannitol was infused intravenously to induce a slack brain. Hypotension of about 90 mmHg

(systolic pressure) was maintained after the dural incision with Halothane and with Arfonad or Nitroprusside. Operating microscope and the self retaining brain retractors were introduced after the dural incision.

2) Drainage of the cerebrospinal fluid:

Cerebrospinal fluid was removed from the Sylvian, chiasmatic, and carotid cisterns. If the drainage was insufficient, the Liliequist membrane was opended between the optic nerve and carotid artery. Cases complicated by hydrocephalus were managed with anterior third ventriculostomy by opening a hole in the lamina terminalis. Only one case required preoperative ventriculoperitoneal shunt due to hydrocephalic symptoms. Dramatic relaxation of the brain was obtained by opening the Sylvian fissure along the medial border of the Sylvian vein after Mannitol infusion and drainage of the cerebrospinal fluid. Tangential approach to the chiasmal area was achieved by only a 1 to 2 cm elevation of the frontal lobe with light pressure.

3) Gyrus rectus resection:

Microdissection of the arachnoid membrane was done and the optic nerve and the internal carotid artery were identified. Before the exposure and dissection of the aneurysm, A-1 and 1-2 segments of both sides and its major branches such as Heubner's arteries, frontopolar, and fronto-orbital branches were dissected and visualized. During the dissection, the systolic blood pressure was maintained at around 80 mmHg and the mean arterial pressure at 70 mmHg. Subsequent procedures varied depending upon the projection of the aneurysm fundus. In cases of interhemispheric projection, both A-1 segments were visualized by opening the suprachiasmatic and lamina terminalis cisterns. But the contralateral A-1 segments could not be visualized in suprachiasmatic projections with this technic, and the gyrus rectus resection medial to the olfactory tract with opening of the interhemispheric arachnoid membrane was done (VanderArk *et al.*, 1974; Yasargil *et al.*, 1975). In most of these cases, the size of the gyrus rectus resection was less than 1 cm. Also, in occasional cases of marked looping of the A-1 segment, the terminal portion of the A-1 was identified after gyrus rectus resection, rather than following the tortous loop. The Heubner's arteries, which take origin from the superior lateral side at the junction of the A-1 and A-2 segments, wre carefully preserved. The fronto-orbital artery arises from the A-2 segment distal to Heubner's artery and crosses the lower margin of the gyrus rectus, which is an useful landmark to find the A-2 segment. The fronto-orbital artery, especially on the right side, could be divided without producing deficits but the hypothalamic perforating arteries, which run posterosuperiorly from the anterior communicating artery, had to be preserved.

4) Clipping:

It was not in all cases that the aneurysm and complex surrounding vessels could be identified and exposed, rather it was seldom that the aneurysm presented with the ideal, easily definable neck. But every effort was made to dissect the neck of the aneurysm with microdissectors, microscissors, and bipolar forceps. Heifetz clips were used, but it was not until after 1978 that several shapes and sizes of the clips were prepared beforehand and selected according to the shape of aneurysm at the time of operation. Clipping was done after complete dissection of the aneurysm neck at an angle that would not produce kinking of or encroach on the surrounding vessels. The systolic arterial pressure was maintained at around 70 mmHg and the mean arterial pressure was not allowed to exceed 60 mmHg. The patency of the surrounding vessels were confirmed again after the clip-

ping, and the fundus of the aneurysm was aspirated with a 24 G needle and/or punctured with the tip of bipolar forceps to assure complete clipping. A few drops of ethyl 2-cyanoacrylate was applied on the clip and the aneurysm to prevent slipping of the clip (Drake and Allock, 1973; Diaz *et al.*, 1978). The operation field was bathed in a 4% papaverine solution before the coating to alleviate the traumatic vasospasm induced by surgical manipulation.

5) Enforcement (Coating):

It was not always possible to clip the neck, though the aneurysm and its neck were dissected and the major arteries identified. Only coating was possible when the base of the aneurysm was very broad or when clipping of the neck caused kinking of or encroached on the major important arteries. Coating of the aneurysm was also used in cases such as; dissection of severe adhesions around the aneurysm risked premature rupture, incomplete clipping, and partial tearing of the aneurysmal neck. The optic nerve and surrounding arteries were protected with small pieces of Gelfoam and/or Surgicel (oxidized cellulose) before coating with ethyl 2-cyano-acrylate. Localized thinning, small evaginations, and preaneurysmal states (Sekhar and Heros, 1981) were observed in more than half of the cases, which were coated before proceeding to dissection of the aneurysms.

6) Giant aneurysm, and Unruptured aneurysms:

The authors treated a case of giant aneurysm microsurgically. The fundus of the aneurysm was opened after bilateral temporary A-1 clipping to remove the intramural thrombus, and the aneurysm was clipped with two long Heifetz clips. Five cases among the 7 cases of microsurgically treated large anterior communicating artery aneurysms were clipped at the neck. The fundus of the aneurysm was opened in one of these cases to decompress the intramural thrombus. A small amount of premature bleeding was noted during the dissection of one large aneurysm, which was managed by coating over the gauze wrapped aneurysm after temporary clipping of the dominant A-1. Another large aneurysm was treated by 'tandem clipping' (Drake, 1979) with a fenestrated Drake clip and a long Heifetz clip after temporary clipping of the dominant A-1. Two cases of unruptured aneurysms were treated by clipping and coating.

7) Temporary clipping:

Nineteen cases of temporary clipping were performed during surgery of the anterior communicating artery aneurysms. In nine cases, clipping was done on the dominant A-1 during the aneurysm dissection. Eight cases were premature rupture cases. Elective temporary clipping was done in the other 2 cases to prevent premature bleeding during dissection of the giant and large aneurysms.

8) Premature rupture:

Nine cases of premature rupture were experienced. Seven cases of rupture occurred during dissection of the aneurysm, and two during neck clipping. Of these cases, one was treated with A-1 clipping. Temporary clipping was used in the other 8 cases. In five cases, the bleeding was controlled by temporary clipping of the aneurysm neck or by repositioning the clip to stop the bleeding. In 2 other cases, the leaking site was covered with a piece of Gelfoam after A-1 temporary clipping and the aneurysm was coated

Table 8. Microsurgical procedures

Procedures	No.	%
Neck clipping (with or without reinforcement)	69	82.1
Reinforcement only	13	15.5
A-1 clipping	2	2.4
	84	100.0

Table 9. Microsurgical timing and results

Interval (wks)	No of Cases	Results				
		Excel.	Good	Fair	Poor	Dead
1	1	1				
2	22	10	4	5	2	1
3	27	15	9	1	1	1
4	20	9	4	3	2	2
5	5	2	1	2		
5	7	2	3	2		
Total	82+	39	21	13	5	4

+ Two aneurysms were unruptured.

Table 10. Preoperative grade and microsurgical results

Grade*	Cases	Results				
		Excel.	Good	Fair	Poor	Dead
I	36	27	4	3	2	
II	23	11	9	1	1	1
III	20	2	9	5	1	3
IV	5			4	1	
Total	84	40	22	13	5	4

* Botterell's grade

Table 11. Surgical results by year

Year of surgery	Surgical outcome					
	Excel.	Good	Fair	Poor	Dead	Total
1971-4*	5	2	4	4	3	18
1975	3	1	1	1		6
1976	4	3	2			9
1977	5	3	2	2	1	13
1978	3	2	3	1		9
1979	10	5	3		2	20
1980	9	6	2	1	1	19
1981+	6	2				8
1975-81	40	22	13	5	4	84
Total	45	24	17	9	7	102

* Before the microsurgery.

+ Up to August.

with ethyl 2-cyano-acrylate. In the remaining case, bilateral A-1 and A-2 temporary clippings were done and the neck of the aneurysm was clipped.

Table 8 summarizes the surgical treatment of anterior communicating artery aneurysms. After the introduction of microsurgery, aneurysmal neck clipping was the definitive treatment in 69 cases (82.1%)

Results and Complications

Table 9 and 10 summarize the results of the operation with respect to surgical timing and patient's grade at the time of operation. The postoperative condition of the patients was classified as follow;

Excellent: Capable of working without symptoms or signs

Good: Capable of working with minimal symptoms or signs

Fair: Capable of self care with minor deficits

Poor: Unconscious with major neurological deficits

Sixty nine cases (82.1%) were operated on within 2 to 4 weeks from the last bleeding. The best surgical results were seen in cases operated on within 3 weeks from the last bleeding. Patients in Botterell's grades I and II had good results in 86.1% and 86.9% respectively while patients in grade III had the good results in only 55%. Table 11 represents surgical results by years. The high mortality (16.7%) and morbidity (44.4%) of the pre-microsurgical period cannot be compared with the results following microsurgery, since major factors such as surgical instruments, methods, and techniques, as well as surgical timing are quite different in two eras.

Microsurgical mortality and morbidity of the anterior communicating artery aneurysm were 4.8% and 5.9% respectively. Three patients in grade III and one in grade II expired. One patient was found to have a huge amount of

bifrontal epidural hematoma postoperatively and and emergency operation was done to remove the hematoma with the patient comatose. The patient died on the 6th postoperative day. The other 3 patients expired due to postoperative vasospasm. One of them had a premature rupture during surgery, and vasospasm. One of them had a premature rupture during surgery and clipping was done after temporary clipping of the dominant anterior cerebral artery. This patient was alert without any neurological deficit until the third postoperative day but progressively deteriorated after that. A brain CT scan showed massive bilateral cerebral infarction and the patient died on the 8th postoperative day. The other patient was in a stuporous state after the operation, and a postoperative angiogram showed complete clipping of the aneurgsm with diffuse cerebral vasospasm. In spite of treatment, the patient lapsed into a coma and died from bilateral pneumonia and sepsis on the 66th postoperative day. Another patient had progressive deterioration of mental state and showed signs of hypothalamic failure such as hypothermia and nonketotic hyperglycemic hyperosmolar coma (NHHC). This patient died from vasospasm with hypothalamic failure. Surgical results in the giant anterior communicating artery aneurysm case were good with some improvement of the visual field defect. The results of seven cases of large aneurysms were as follows: two excellent, five good, one fair, and one death. This patient died from vasospasm and the mortality rate in premature rupture cases was 11.1%.

Table 12. Postoperative complications

Complications	Cases
Postoperative vasospasm	14
Intracranial hematoma	
Epidural hematoma	2
Chronic subdural hematoma	1
Intracerebral hematoma	1
Subdural hygroma	1
Wound infection	2
Pneumonia	4
GI bleeding	1
SIADH	3
NHHC	4

SIADH: Syndrome of inappropriate ADH secretion
NHHC : Nonketotic hyperglycemic hyperosmolar coma

Postoperative complications are summarized in Table 12. Postoperative vasospasm was noted in 14 cases. Three of the 14 patients died and the others had the following results: six good, five fair, and one poor. Sudden change in intracranial pressure dynamics might have caused accumulation of the intracranial hematomas. One case of intracerebral hematoma may have been a sequela of ischemic brain damage caused by retraction. Severe electolyte imbalances were noted in 7 cases postoperatively; 4 cases of NHHC and 3 cases of syndrome of inappropriate ADH secretion (SIADH). The NHHC cases were noted in the patients with postoperative vasospasm, and two of these patients died. The other complications did not differ significantly from complications of other brain surgery.

DISCUSSION

After the introduction of microsurgery in aneurysm operations, the direct intracranial approach developed as a definitive and safe procedure. Anterior communicating artery aneurysms presented particular difficulties because of their critical location, prevalence of local vascular anomalies (Dunker and Harris, 1976; Purlmutter and Rhoton, 1976; Rhoton *et al.*, 1979), serious circulatory disturbances of the perforating vessels, ambiguous localization of

these aneurysms even after angiography, and their tendency for fatal recurrent hemorrhage (Pool, 1962; Sengupta *et al.*, 1975). The incidence of anterior communicating artery aneurysms in the authors' aneurysm series is 35.1%, which is somewhat higher than other reports (Locksley, 1966; Yasargil *et al.*, 1975).

As in other intracranial aneurysm surgery, the major factors that influence the outcome are: age of the patient, blood pressure, recurrent bleeding, occurrence of vasospasm, preoperative grade of the patient, surgical timing, and pre-and post-operative care. Among these factors only the surgical timing and the perioperative care are at the discretion of the surgeon.

Major aims in the preoperative treatment of anterior communicating artery aneurysms are prevention of recurrent bleeding, prevention and treatment of the cerebral edema and intracranial hypertension, and treatment of cerebral vasospasm (Krayenbühl *et al.*, 1972; Pool, 1972; Peerless, 1979). Recurrent bleeding and cerebral edema can be effectively prevented in most cases with antihypertensive agents and other conservative measures. Therefore, the problem of vasospasm is the most serious. Recent reports present ischemic events and the increasing incidence of hydrocephalus as major complications of antifibrinolytic agents (Park, 1979; Wilkins, 1981), but these were not problems in our cases.

The reported incidence of cerebral vasospasm varies from 30 to 60% with different authors (Heros *et al.*, 1976; Sundt et al., 1977; Kwak *et al.*, 1979). Niizuma *et al.*(1979) reported angiographic vasospasm in 20% of anterior communicating artery aneurysms. Kwak *et al.* (1979) stressed that the incidence increased to 59.1% when angiography was done 10 to 17 days after bleeding, that is, during the period of increasing vasospasm. Drake and Allock (1973) reported that the incidence of angiographic vasospasm varied from 14% to 80% according to the patient's condition. The incidence of angiographic vasospasm in the authors' series was 45.1%, which may be related to the timing of angiography. Innumerable reports on the etiology, pathophysiology, and treatment of vasospasm have appeared (Lougheed, 1968; Zervas *et al.*, 1973; Heros *et al.*, 1976; Sundt *et al.*, 1977; Peerless, 1979; Gionnotta and Frazee, 1980) without a definite single solution. Two programs generally accepted in the treatment of vasospasm are; the use of beta-adrenergic stimulants, phosphodiesterase inhibitors, and vascular smooth muscle relaxants (Sundt *et al.*, 1973; Zervas *et al.*, 1973; Heros *et al.*, 1976), and physiologic measures to improve cerebral perfusion and oxygenation with blood volume expansion and induced hypertension (Gionnotta and Frazee, 1980; Wilkins, 1981). The authors used both regimens and are more interested in the latter.

Another report worthy of note is that by Hart (1981) which showed that 90% of seizure attacks occurred at the time of bleeding. The author contended that it is a non-epileptic release phenomenon due to the sudden increase of pressure and that anticonvulsants have no effect in such cases. This should be considered when administering lots of medications to patients during the preoperative period.

It is well known that surgical timing influenced the results of operation (Krayenbühl *et al.*, 1972; Yasargil and Fox, 1975; Hori and Suzuki, 1979-a; Peerless, 1979; Suzuki *et al.*, 1979-a; Wilkins, 1981). Lougheed (1968) reported a threshold increase of mortality in patients operated on within one week after the last bleeding as compared with patients operated on at a later period. Krayenbühl *et al* (1972) reported a mortality rate of 12% in patients operated on with microsurgery within 1 week after bleeding. As long as rebleeding can be

prevented in the period of vasospasm. Most authors agreed that good results are more often achieved in patients operated on 2 to 3 weeks after bleeding (Pool, 1972; Yasargil *et al.*, (1975, 1978). The authors operated 2 to 4 weeks after the last bleeding in 82.1%, and 86.9% of them had good results. Hori and Suzuki (1979-b) proposed early operation as they reported that the operative mortality in patients operated on during the 3rd to 7th day period after the last bleeding was 24.1% and that this was the worst period for operation. They noted good results in patients operated on within 3 days from the last bleeding and this was possible by draining ventricular fluid for pressure reduction and by preventing postoperative vasospasm by washing out clots in the basal cisterns. They reported a mortality of 7.7% with patients operated on the first day, 11.5% on the second day, and 30.8% on the third day. Thus they recommended an early operation of within two days from the last bleeding.

The importance of the patient's condition at the time of operation cannot be overemphasized (Yasargil *et al.*, 1975; Suzuki *et al.*, 1979-b). The authors experienced a 1.7% mortality and a 5.1% morbidity in 59 patients in Botterell's grade I and II.

Hypotensive anesthesia induced with Halothane, Nitroprusside, and Arfonad is an essential part of the operation. Drake (1979) maintained the mean arterial pressure at 40 mmHg, and Krayenbühl *et al.* (1972), and Yasargil *et al.* (1975) induced hypotensive anesthesia with Arfonad. The authors used hypotensive anesthesia at a systolic pressure level of below 70 mmHg and a mean arterial pressure of around 60 mmHg during dissection and clipping of the aneurysm. After clipping, the blood pressure was returned to the normal level. Removal of CSF from the basal cistern and intravenous Mannitol dripping replaced cumbersome spianl drainage. Mannitol was infused during the period of normotension, when the renal blood flow was adequate, for a maximal effect. Circulatory disturbance of CSF, caused by arachnoid adhesions following hemorrhage, was relieved by opening the Liliequist membrane and lamina terminalis when needed. Only 4 cases (4.8%) required a ventriculoperitoneal shunt in the authors' series, which was much less than Yasargil's report (1975) of 13.1%.

Surgical approaches in anterior communicating artery aneurysms are: subfrontal approach of Dott (1933), transcallosal approach of Tönnis (1936), interhemispheric subfrontal approach of Pool (1961, 1972), unilateral frontal lobe wedge resection of French (French *et al.*, 1962, 1966), gyrus rectus resection of VanderArk and Kempe (1974), and pterional approach of Yasargil (1975). It is of interest that Alksne and Smith (1980) tried stereotaxic iron acrylic occlusion for anterior communicating artery aneurysms.

Most of the anterior communicating artery aneurysms are located at the junction of dominant A-1 and anterior communicating artery, projecting contralaterally, along the course of the flow of the dominant anterior cerebral artery (Sekhar and Heros, 1981). Yasargil *et al.* (1975) reported that the interhemispheric projection (80%) was much more prevalent than the prechiasmatic projection (16.8%); while VanderArk and Kempe (1970) reported a prevalence of prechiasmatic projection (70.5%). In the authors' series, prechiasmatic projection was seen in 42.2%. The direction of projection in giant and large aneurysms was usually upward, which is the same as VanderArk and Kempe's report (1974). Although VanderArk and Kempe used the gyrus rectus resection only for prechiasmatic projections, the authors used the technique of gyrus rectus

resection regardless of the direction of projection. The subpial dissection provided a safe means to reach the aneurysm even in cases of adhesion of the aneurysm to the cortex, since it exerts relatively little direct mechanical trauma to the aneurysms.

The operating microscope has become an essential tool for the surgical treatment of intracranial aneurysm. Since the report of Krayenbühl *et al.* (1972), mortality rates of 5 to 10% have been reported in microsurgical aneurysm surgery (Yasargil *et al.*, 1975; Hori and Suzuki, 1979-b; Suzuki *et al.*, 1979-b). The mortality rate and morbidity rate in the authors' series was 4.8% and 5.9% respectively. Before the introduction of the operating microscope, the surgical mortality in aneurysms was high. According to Graf and Nibbelink (1974), the operative mortality for 149 patients with anterior communicating artery aneurysms was 34%, and many other studies (McKissock *et al.*, 1965; Lougheed, 1968; Graf and Nibbelink, 1974; French and Ortiz-Suarez, 1974) showed mortality rates of 30 to 40%. Although, without the aid of a microscope, Norlen (1968) lowered the operative mortality to 1.6% in patients operated on at 3 weeks after the last hemorrhage and Hori and Suzuki (1979-b) reported a mortality rate of 9.6% in their 346 patients, microsurgery is essential for lowering the mortality rate to single digits. The advantages of the microscope fulfills the goals in aneurysm surgery, which are: adequate exposure and illumination of the magnified area, minimal retraction on the brain, accurate definition of the anatomical configuration of the aneurysm and surrounding vessels, and obliteration of the aneurysm without compromising neighboring vessels (Pool, 1962; Logue *et al.*, 1968; Krayenbühl *et al.*, 1972).

Yasargil *et al.* (1975) reported local vascular anomalies in some of his 203 cases of anterior communicating artery aneurysm as follows: nine aplasias of A-1 segment, 4 duplications of A-1s, 1 single A-1, 12 triple A-2s, and 21 duplications of anterior cerebral artery. The authors experienced one triple A-2 segments and one duplication of the anterior communicating artery in 84 microsurgical cases.

It is this authors' policy, after experiencing nine cases of premature rupture, to dissect the A-1 and A-2 segments on both sides for temporary clipping before dissecting the aneurysm itself.

Takaku *et al.* (1979) reported that about 60% of the severe electrolyte imbalances following aneurysm rupture occurred in anterior communicating artery aneurysms, and that hypothalamic damage was confirmed by autopsy in these patients. The authors' experiences are similar to this report in that NHHC was seen in patients with severe vasospasm and the prognosis was poor in these patients, while SIADH cases were relatively mild and less frequent than in the preoperative period.

It is the authors' experience that the best surgical results can be obtained by intensive pre- and post-operative care and by microsurgery 2 to 4 weeks after the last hemorrhage, when the risk of vaso spasm is least.

CONCLUSION

Clinical analysis of surgery on anterior communicating artery aneurysms provided the following results:

1. The anterior communicating artery aneurysms ruptured most frequently in the 5th decade (37.2%), and 81.7% of the patients were in their 30s to 50s. Anterior communicating artery aneurysms were more common in men than women (60:42).
2. Presenting symptoms and signs of rupture of the anterior communicating artery

aneurysms were headache (98.6%), stiff neck (95.1%), brief lapse of consciousness (83.4%), vomiting (81.8%), hypertension (41.6%), and impaired state of consciousness (34.3%).

3. The prechiasmatic projection of the anterior communicating artery was slightly more frequent than the interhemispheric projection (43:39) in this series. The aneurysms were fed by the left anterior cerebral artery in 55.9% and by the right in 33.3%. Angiographic vasospasm was noted in 45.1% and the incidence of multiple aneurysms was 8.8%.
4. Brain CT scan showed subrachnoid hemorrhage in 47.3%, hydrocephalus in 43.7%, and cerebral infarction in 27.3%. When the diameter of the aneurysm was larger than 10 mm, the aneurysm appeared as a small enhancing lesion. The actual size of the giant aneurysm was measured more precisely with the CT scan than by the angiogram.
5. Patients in Botterell's grades I and II occupied 70.2% of the microsurgically treated cases. The majority of cases (82.1%) were operated on during the second to fourth weeks after the last bleeding.
6. All of the 84 microsurgically treated cases were operated by the pterional approach and the gyrus rectus resection was frequently performed. Clipping of the aneurysmal neck was possible in 82.1% of the series.
7. Fourteen cases of postoperative vasospasm, 4 cases of intracranial hematoma, and 7 cases of serious electrolyte imbalance were the major postoperative complications. Four patients died of these major complications.
8. Operative mortality of the microsurgical pterional approach was 4.8% and the morbidity was 5.9%. The mortality rate in nine premature rupture cases was 11.1%. Among the 18 cases who were operated on before 1975 without the aid of the microscope, the mortality rate was 16.7%, and the morbidity was 44.4%.

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