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Surgery of Intact Intracranial Aneurysm

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The authors have reviewed and analyzed 105 cases of unruptured cerebral aneurysms in 94 patients from the medical records of 407 patients who had aneurysm surgery consecutively since the advent of microsurgery at the Department of Neurosurgery of Yonsei University. This study was done to define the clinical characteristics of intact intracranial aneurysms and to determine the principles of their management. There was no surgical mortality among 75 cases of intact intracranial aneurysms in 68 patients. Two cases of morbidity were not directly related to the surgery of intact aneurysms. As a result of the analysis of the cases, it was concluded that all symptomatic aneurysms should be treated immediately after the diagnosis, because they tend to be large in size and prone to rupture. If asymptomatic multiple unruptured aneurysms are accessible during surgery for a ruptured aneurysm, they should be treated at the same time. The decision for the treatment of unruptured aneurysms located opposite to ruptured ones or detected incidentally, should be made at the surgeon's discretion. The authors' belief is that intact intracranial aneurysms should be corrected regardless of their size when detected in young patients, in hypertensive patients, or in patients with such high flow lesions as arteriovenous malformation.

Key Words: Aneurysm, intracranial, intact, surgery.

Despite modern progress in the management of ruptured cerebral aneurysms and excellent surgical results, 67% of patients with ruptured aneurysms die or become disabled after initial subarachnoid hemorrhage (SAH) (Kassell and Drake, 1982). One of the explanations is that only a small proportion of the patients with SAH receive surgery.

Measures to improve management outcome include early recognition of warning leaks, prompt and accurate diagnosis of SAH, early referral of patients with such hemorrhage to specialized centers, prevention of rebleeding and vasospasm, treatment of vasospasm, and application of improved operative techniques. One approach which has been suggested for preventing rebleeding and vasospasm is early operation (Ljunggren *et al.*, 1981; Mizukami *et al.*, 1982). Another possibility is treating cerebral aneurysms before they rupture. Unruptured aneurysms are becoming an increasingly important neurosurgical problem as a result of recent innovations in diagnostic technology. Nevertheless, management policy for unruptured cerebral aneurysms has not been agreed upon among neurosurgeons. A number of reports (Jain, 1974; Moyes, 1971; Salazar, 1980) show that surgical correction of unruptured cerebral aneurysms protects the patient from the hazard of bleeding, and carries a combined mortality and morbidity rate less than the risk of rupture in one year.

Reviewed in this report are the experiences resulting from the surgical treatment of 75 unruptured cerebral aneurysms in 68 patients, and recommendations for the most appropriate management of unruptured aneurysms.

CLINICAL MATERIAL AND RESULTS

A retrospective review of aneurysm cases treated by the authors at the Yonsei University Hospital in Seoul, Korea, provided the case material for this report. From a total of 509 aneurysm operations performed by the authors during the past eleven years, 105 unruptured cerebral aneurysms were found in 94 patients. Among these unruptured aneurysms, 75 aneurysms in 68 patients were surgically treated. Clinical analysis was made for age and sex distribu-

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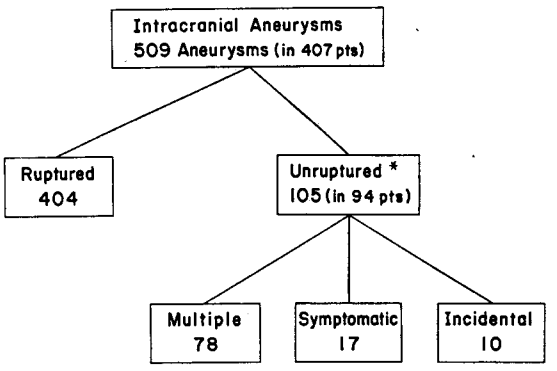

Fig. 1. Incidence of unruptured aneurysms.

tion, location and size of the aneurysms, presenting symptoms, methods of surgical treatment, and results of the treatment. Unruptured aneurysms were categorized into symptomatic aneurysms, multiple aneurysms, and incidental aneurysms (Fig. 1).

Seventeen symptomatic aneurysms were found in 15 patients, whose ages ranged from 25 to 60. Ptosis was the most frequent presenting symptom, followed by visual field defect, decreased visual acuity, headache, and seizure in decreasing order. The size of the aneurysm was much larger in symptomatic aneurysm patients. Fourteen aneurysms were larger than 7 mm, five of which were giant aneurysms (Table 1).

Multiple aneurysms were found in 71 patients who had 78 additional unruptured aneurysms. Slight female preponderance was noted in sex distribution of multiple aneurysm patients. Bilateral aneurysms were observed in 18 cases. The internal carotid artery-posterior communicating artery junction (11 cases) was the most frequent location of bilateral aneurysms, followed by the middle cerebral artery (5 cases) and the anterior communicating artery (2 cases). Size of the aneurysm was smaller than 7 mm in 70 out of 78 aneurysms. Microaneurysms of less than 3 mm size were found in 37 cases and 19 of them were so-called junctional dilatation lesions (Table 2). A separate operation was performed in 8 cases to clip the unruptured aneurysm located opposite to the ruptured aneurysm.

Ten intact aneurysms were detected incidentally in eight patients during the investigation for disease other than aneurysmal SAH. The diseases that required angiography in this group were arteriovenous malformation (three patients), meningioma (two patients), and one each of craniopharyngioma, pituitary tumor and carbon monoxide poisoning (Table 3).

Surgery was done for 75 unruptured aneurysms in 68 patients. Carotid ligation was the only available treatment for two patients who had internal carotid artery aneurysms within the cavernous sinus, and two other patients who had giant aneurysms at the bifurcation of the internal carotid artery. The remaining

Table 1. Symptomatic unruptured aneurysms

Age	: 25-60
Sex	: Male 7, Female 8
Location	: PCOM 7, ACOM 5, ICA 3, ACA 1, SCA 1
Size	: Giant 5, Medium 9, Small 3
Symptoms	: Ptosis 7, Field cut 3, Poor vision 2, Headache 2, Seizure 1

PCOM : Internal carotid-posterior communicating artery
ACOM : Anterior communicating artery
ICA : Internal carotid artery
ACA : Anterior cerebral artery
SCA : Superior cerebellar artery

Table 2. Multiple unruptured aneurysms

Age	: 28-65
Sex	: Male 31, Female 40
Location	: PCOM 26, ICA 20, MCA 18, ACOM 8, ACA 4, Basilar 1, Vertebral 1
Size	: Medium 8, Small 33, Micro 37
Bilateral	: PCOM 11, MCA 5, ACOM 2

PCOM : Internal carotid-posterior communicating artery
ICA : Internal carotid artery
MCA : Middle cerebral artery
ACOM : Anterior communicating artery
ACA : Anterior cerebral artery

Table 3. Incidentally found unruptured aneurysms

Age	: 15-66	
Sex	: Male 6, Female 2	
Location	: PCOM 5, ICA 2, MCA 1, PCA 1, SCA 1	
Disease	: Arteriovenous malformation	3
	Meningioma	2
	Pituitary tumor	1
	Craniopharyngioma	1
	Carbon monoxide poisoning	1

PCOM : Internal carotid-posterior communicating artery
ICA : Internal carotid artery
MCA : Middle cerebral artery
PCA : Posterior cerebral artery
SCA : Superior cerebellar artery

Table 4. Operative management of unruptured aneurysms

	Multiple	Symptomatic	Incidental	Total
Clipping	23	9	2	34
Reinforcing	31	3	3	37
Carotid ligation		4		4
Total	54	16	5	75

Table 5. Operative results of unruptured aneurysms*

	Good	Fair	Poor
Multiple	46	5	2
Symptomatic	15	2	
Incidental	5		
Total	66	7	2

* Duration of follow up: Six months to 10 years.
Good : Returned to work without deficit.
Fair : Capable of self-care with minor neurological deficits.
Poor : Unconscious patient with major neurological deficits.

71 aneurysms were treated by intracranial procedures, that is, 34 clippings and 37 reinforcements. The reinforcement procedures were done for the microaneurysm (smaller than 3 mm in size) where clipping was not possible. Operative managements for unruptured aneurysms are summarized in Table 4.

There was no operative mortality, but morbidity occurred in two cases (2.9%), both of which were due to complications of the SAH from other lesions. One patient had a massive intracerebral hematoma from rupture of an aneurysm and was operated on within 24 hours after bleeding. Two aneurysms, one of which was unruptured, on the middle cerebral artery of the same side were clipped and the hematoma was evacuated. Ischemic neurological deficits developed in this patient from postoperative vasospasm, complicated by massive upper GI bleeding. Another patient who had SAH from Moya-Moya disease had an ischemic fixed deficit and hydrocephalus. An unruptured basilar bifurcation aneurysm was incidentally found in this patient, and was clipped by the pterional approach. Except for these two cases, morbidity of which was from other origins, there was no mortality or morbidity for the operations directed only for unruptured aneurysms. The duration of follow up after the operation ranged from six months to ten years with a mean of four years (Table 5). No recurrent bleeding was observed in these patients during the follow-up period.

DISCUSSION

Recent reports indicated an overall prevalence rate of at least 5% of population for intracranial aneurysms (Dell, 1982; Phillips *et al.*, 1980). Accepted yearly incidence of SAH from ruptured aneurysms is 11 per 100,000 in the age corrected population, which exceeds the incidence of primary brain tumor (Drake, 1978; Parkarinen, 1967). Epidemiological surveys by Kassel and Drake (1982) regarding aneurysms emphasized the fact that 36% of patients with ruptured aneurysms died or were disabled from the initial insult, but 64% of the patients had the chance for treatment. About half the treated patients will eventually die or be disabled from rebleeding, vasospasm, and complications of managements. This leaves only 32% of the patients as functional survivors. This also means that one in every 14,000 of the population will die or be disabled every year from the rupture of the cerebral aneurysms. This 60 to 70% mortality and morbidity rate clearly demonstrates the necessity of improvement in the management of patients with SAH.

Over the past 30 years, operative mortality and morbidity for intracranial aneurysms have decreased dramatically (Mullan *et al.*, 1978; Post *et al.*, 1977; Sundt and Whisnant, 1978). However, the overall results of management for aneurysmal SAH has improved minimally. This discrepancy can be explained by the fact that many patients die or are disabled by vasospasm or rebleeding during the waiting period before the operation and only a small proportion of the patients have surgical treatment. Under this traditional treatment, less than one in three patients has surgery, and less than one third of all patients return to their premorbid state (Kassell and Torner, 1983). One approach for improving management outcome is the early operation (Ljunggren *et al.*, 1981; Mizukami *et al.*, 1982; Suzuki *et al.*, 1979). The early operation affords maximum protection against rebleeding and provides the possibility of preventing vasospasm by removing the clot in the basal cisterns. After clipping of the aneurysm, the arterial pressure can be elevated to reverse ischemic deficits from vasospasm. There may also be the psychological and economical advantages to a shorter hospitalization period.

There is still room for improving the overall management outcome in cerebral aneurysm patients. A ruptured aneurysm was once an unruptured

aneurysm. An unruptured aneurysm is not a benign lesion, especially because the growth rate and risk of rupture is entirely unpredictable. If unruptured aneurysms could be screened by further development of diagnostic technology, the ideal treatment plan for an intracranial aneurysm should be clipping the aneurysm before it bursts. Samson *et al.* (1977) classified the unruptured intracranial aneurysms into symptomatic aneurysms, multiple aneurysms in cases of SAH, and incidental aneurysms found during angiographic investigation for other disease. Locksley (1966) reported that the incidence of multiple aneurysm is about 20%, while that of symptomatic aneurysms and intact incidental aneurysm are 10% and 1%, respectively. Recently, unruptured cerebral aneurysms have been recognized more frequently because of the current advances in noninvasive diagnostic procedures, including high resolution computed tomography, digital subtraction angiography, and magnetic resonance imaging. With future enhancements in existing technology, this trend in improved diagnosis is expected to accelerate.

Locksley (1966) reported that 28% of symptomatic unruptured aneurysm patients subsequently died of SAH and an additional 16% were disabled by other effects of their intracranial aneurysms. Heiskanen (1981) reviewed 61 multiple aneurysm patients, with whom only the ruptured aneurysm had been clipped and found a risk of 21% rebleeding and 12% mortality. Drake and Girvin (1976) learned that 17% of their patients at risk bled from a previously unruptured aneurysm. Jane reported that the natural history of an unruptured asymptomatic aneurysm is similar to that of untreated ruptured aneurysm in a patient who survived for six months – a hemorrhage rate of 3 to 4% per year (Dell, 1982). Nonetheless, cumulative risk of asymptomatic unruptured aneurysms is of considerable significance, especially among younger patients. Dell (1982) projected a lifetime 16% risk of SAH for a 20-year-old patient harboring an unruptured aneurysm. This risk decreases to 5% for individuals aged 60 years. Moyes' (1971) analysis on multiple and incidental aneurysms revealed that 27.6% of the patients showed evidence of enlargment of untreated aneurysms or recurrent hemorrhage or both, and half of the recurrent bleeding was fatal. Weibers *et al.* (1981) reported that eight of the his 65 unruptured aneurysm patients subsequently bled and seven of eight died as a result of intracranial hemorrhage. Because half of the ruptures occurred within two and a half months of diagnosis in these patients, he concluded that symptomatic aneurysms larger than 1 cm should be operated on as soon as possible.

Recent reports indicate that the size of the aneurysm is the major risk factor of rupture (Kassell and Torner, 1983; Weibers *et al.*, 1981). Winn *et al.* (1983) contended that the presence of hypertension also increased the risk of hemorrhage. Kassell's Cooperative Aneurysm Study (1983) showed the average maximal diameter of the ruptured aneurysm was 8.2±3.9 mm and the median diameter was 7.0 mm. Seventy-one per cent of the sacs were smaller than 10 mm and 13% were less than 5 mm in diameter. Kassell stressed, based on these findings, that operations should be considered for unruptured aneurysms larger than 5 mm. Weibers *et al.* (1981), on the other hand, reported that unruptured intracranial saccular aneurysms smaller than 1 cm in diameter have a very low probability of subsequent rupture, and questioned the necessity of operation for unruptured aneurysms smaller than 1 cm in size. However, Weibers' cases were a selected group of patients not considered for surgery for some reason, and probably do not represent the population with unruptured aneurysms. It should be pointed out that the pathophysiology and the risk of rupture of an aneurysm is the same, regardless of the time of diagnosis. This is the reason why we should not differentiate ruptured aneurysms from unruptured aneurysms when calculating the risk of rupture.

Surgical risk of unruptured aneurysms reported by Drake and Girvin (1976) was 3%. There was no surgical death in their last 40 cases. Jain (1974), Mount and Brisman (1974), Salazar (1980), and Wirth *et al.* (1983), who had no surgical mortality in their series advocated the surgical obliteration of unruptured cerebral aneurysms. The development of neuroanesthesia and microsurgical techniques has made surgical treatment safer in most patients with asymptomatic unruptured intracranial aneurysms. There still is disagreement among neurosurgeons as to what size of unruptured aneurysms should be operated on. However, smaller aneurysms are those most amenable to complete surgical exposure and uncomplicated clip obliteration. As the aneurysm increases in size, there are increasing chances of anatomical complexity and distortion of surrounding normal anatomy, which increase the incidence of operative complications. This was confirmed by Wirth (23) in his report of multicenter retrospective review for surgical treatment of incidental aneurysms. The operative morbidity was 2.3% for aneurysms less than 5 mm in diameter, 6.8% with those 6 to 15 mm in diameter, and 14% with those 16 to 24 mm in diameter.

Most authorities agree that unruptured symptomatic aneurysms should be corrected promptly

because they tend to be large in size and prone to rupture. Multiple aneurysms that are accessible from the same craniotomy as used for ruptured aneurysms, should be clipped at the time of surgery for ruptured ones. The decision for surgery of intact incidental aneurysms and multiple aneurysms located opposite to the ruptured aneurysm is dependent upon the discretion of operating surgeon. It is well known that the size of an aneurysm on an angiogram may not be the actual size of the aneurysm, which is experienced by the neurosurgeons during the operation. Furthermore, the thickness of wall of the aneurysm cannot be estimated on the angiogram. The risk of rupture of an unruptured aneurysm is best estimated by visual inspection of the aneurysm under a surgical microscope. No neurosurgeon would leave untreated the thin walled unruptured cerebral aneurysm, through which the blood stream could be seen under the surgical microscope. Careful inspection has been made by the authors of the major cerebral arteries in the basal cisterns in all intracranial surgery performed by the pterional approach. This inspection has increased the detection and treatment of small sized unruptured cerebral aneurysms which were not visualized or which have been overlooked on the angiograms. It is the authors' belief that unruptured intracranial aneurysms should be corrected regardless of size, if possible, especially when detected in young patients, in hypertensive patients, and in patients with such high flow lesions as arteriovenous malformation.

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