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One-Year Outcome in Early Aneurysm Surgery: a 14 Years Experience

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Summary

In a consecutive series of 1150 patients with cerebral aneurysms diagnosed in our department by angiography or autopsy between the years 1977–1990, 1007 patients underwent definitive operative treatment of their aneurysms mainly by early surgery. More than half (55%) were operated on during the first three days after subarachnoid haemorrhage (SAH), and more than three quarters (77%) during the first week. The surgical mortality at 30 days was 9%; at one-yearfollow-up 13% had died. The total management mortality was 22%. The 618 patients presenting in Hunt and Hess Grades I–II had a 4% mortality, and 90% had an independent life at follow-up; 270 Grade III patients hat a 19% mortality and 68% were independent. There were 99 patients operated on in Grades IV–V with a 46% mortality and 30% were independent. Age of the patient and size of the aneurysm were strongly related to outcome; however, many of the giant aneurysms were operated on as an emergency because of large intracerebral haematomas. Best results were obtained in the anterior communicating artery (ACA) area; the lowest rate of useful recoveries was in the vertebro-basilar artery (VBA) area (71%). Early surgery did not prevent delayed ischaemic deficits.

During the first 72 hours patients in Grades I–III can be operated on safely with good results. The results in Grades IV–V are poor, and we suggest that only cases with large haematomas or considerable hydrocephalus or those improving should be operated on in the first days after SAH, with limited hopes of functional recovery.

Keywords: Cerebral aneurysm; timing of surgery; subarachnoid haemorrhage; early surgery; outcome.

Introduction

During the last fifteen years early surgery to prevent rebleeding has gradually been accepted as a possible alternative for the timing of aneurysm surgery in many institutions[2, 3, 6–8, 11, 13–17, 19–30]. The emergency evacuation of life-threatening haematomas and the treatment of acute hydrocephalus can save some additional patients[24, 26]. Prevention of vasospasm and better possibilities for the treatment of other complications of the bleeding and operation have also been attributed to early aneurysm surgery[2, 8, 20, 21, 29, 30]. However, still many doubts exist whether there is any real difference in the results between early and late surgery, and there is not yet a consensus regarding the timing of aneurysm surgery[2, 3, 6, 13–15, 19–30].

Over the years the definitions of acute and early surgery have changed. Surgery during the first seven to ten days following subarachnoid haemorrhage (SAH) was initially considered dangerous and called "early aneurysm surgery" (EAS)[2, 3, 6–11, 15–17, 20, 22, 24–27, 29, 30]. Nowadays only cases operated on during the first 48 to 72 hours (or even 24 hours) are accepted into the group of EAS[2, 3, 6, 7, 12–14, 17, 20, 21, 25–27, 29, 30]. The term "acute aneurysm surgery" (AAS) has been introduced[21]. In this article, surgery during days 0–1 after SAH is called AAS, surgery during days 2–3 EAS, surgery in the days "4–6 intermediate aneurysm surgery" (IAS), and surgery 7 or more days after SAH "late aneurysm surgery" (LAS)[30].

We present our results using a policy of AAS and EAS with a follow-up of all the patients. Our catchment area in Eastern Finland with a very stable population is well suited for epidemiological and long-term follow-up studies[5, 18, 24, 26]. All patients with aneurysms are presented in order to evaluate different timing policies and surgical results. One-year outcome has been chosen to show the late complications of SAH and surgery.

Patients and Methods

Admission Policy

Kuopio University Hospital has the only neurosurgical unit in Eastern Finland (catchment population 870,000). All patients surviving the initial bleed with an aneurysm suspected or diagnosed are referred to us. Thirty-one per cent of the patients operated on for aneurysmal SAH were referred directly to us.

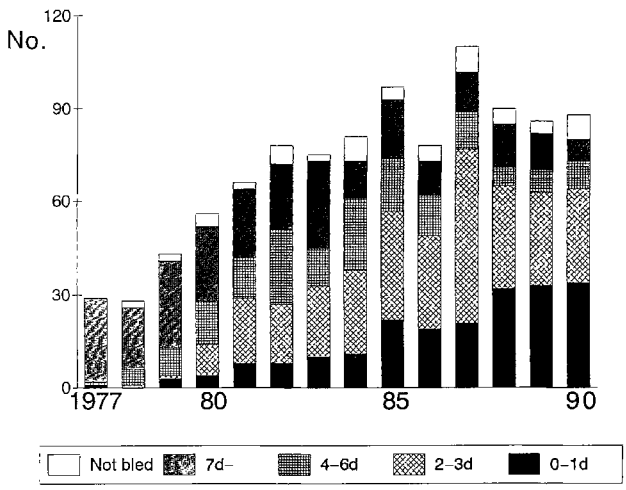

Fig. 1. Timing of cerebral aneurysm surgery in 1007 patients treated during a 14-year-period. 0 = day of subarachnoid haemorrhage

A total of 1445 patients with cerebrovascular malformations were treated from January 1977 to December 1990. Of these, 120 had a cerebral or dural arteriovenous malformation (AVM), 92 had a SAH of unknown origin despite four vessel angiography, and 82 elderly and/or moribund patients had a primary SAH[18] but incomplete studies (only computed tomography (CT) but no angiographic studies or autopsy). The majortity, 1150 patients, had a diagnosed cerebral aneurysm with (1077) or without (73) SAH.

Inclusion Criteria, Treatment Policy, Analysis of Data

The records and x-rays of all patients with cerebrovascular malformations were reviewed, and 1150 patients with cerebral aneurysm were scrutinized. Excluded were 123 patients without any kind of surgical treatment, 12 patients in poor condition receiving only ventriculostomy as a treatment for acute hydrocephalus, and 8 patients with huge arteriosclerotic vertebrobasilar aneurysms treated by shunting procedures. Most of these 143 patients died, and the total management mortality in the 1150 patients admitted was 22% at one year. Two patients with spontaneous ICH and incidental aneurysm were included in the nonbleeding aneurysm group, as they were erroneously operated on as aneurysm cases with haematomas, as was one patient operated on for traumatic middle cerebral artery aneurysm with haematoma. Of a total of 1150 patients with aneurysms, 1007 patients had definitive operative treatment for their presenting aneurysm, and form the series of this report.

Timing of Surgery

The timing of surgery has changed during the study period, with a careful start of the early surgery in the late 70's (Fig. 1). The aim of the timing has been to perform the operation at the latest 24 hours after admission in conscious patients (Grades I–III). Significant haematomas have even been evacuated acutely in a few patients with both pupils dilated; the offending aneurysm has been ligated at the same time[24]. Severe acute hydrocephalus has also been considered as an indication for emergency surgery with treatment of the aneurysm at the same time.

Diagnostic Procedures

Since 1980 the diagnosis of SAH was confirmed by CT examination. Pre-operative CT findings were classified according to Fisher[4]. Angiographic studies were tailored according to the findings in the CT scans. Four vessel angiography was performed only in cases where no aneurysm was found in carotid angiograms, or where a posterior circulation aneurysm was suspected on the CT. Bilateral carotid and at least one vertebral angiogram were performed in 161 patients (16%).

Pre-operative spasm in angiograms was classified in three Grades: local, local severe with two vessels involved, and severe with more than 2 vessels involved. The size of the aneurysm was measured in angiograms or CT scans: the largest diameter of the aneurysm in any direction was defined as the aneurysm size. In 24 cases, the angiograms were not available and the aneurysms were classified according to radiological, clinical, and operative notes as small (0–6 mm), medium (7–14 mm), large (15–24 mm), and giant (25 mm and more).

Pre-operatively the patients were graded according to Hunt and Hess, and patients in Grade 1A (4 cases) were included in Grade I[9–11]. No correction of Grades with associated diseases was done[9–11].

Surgery

The majority of the operations was performed by two neurosurgeons (MV 413 cases, JH 482, AT 91, ML 17, and others 4 cases).

Operations were performed under balanced anaesthesia; patients received mannitol and were hyperventilated. Controlled hypotension (systolic blood pressure below 90 mm Hg for more than 30 min) was frequently used early in the series, but most cases were operated on during the last years under normotension (693 patients).

A pterional approach was used for most supratentorial aneurysms[28]. Anterior communicating aneurysms were usually approached from the side of the dominant anterior cerebral artery (A 1) segment. Pericallosal aneurysms were operated on through a frontal paramedian craniotomy, as were a few anterior communicating aneurysms. Basilar artery aneurysms were approached mainly pterionally, except in cases with the aneurysmal neck below the level of the dorsum sellae, or basilar bifurcation aneurysms in posterior or anterior direction, which were operated on subtemporally as were a few cases of posterior cerebral artery aneurysms. Vertebral aneurysms were operated on through a lateral (posterior inferior cerebellar artery = PICA origin) or medial (PICA distal) suboccipital craniotomy[28]. Local papaverin or lidocaine was used to treat vasospasm due to manipulation. In many cases, an attempt was made to remove subarachnoid blood even outside the operative area. In case of a tight brain, the frontal horn was cannulated or the lamina terminalis or the interpeduncular cisterns were opened.

All aneurysms were operated on using microsurgical methods and clipped with Heifetz (in 1970's), Sugita or Aesculap clips. If feasible, the aneurysm was opened and/or coagulated. In 972 cases, the aneurysm received definitive treatment in the first operation. Thirty-one patients had their symptomatic aneurysm operated on after pre-operative shunting[6] or ventriculostomy[25]. In four cases, the symptomatic aneurysm was operated on at a second operation, i.e., a false aneurysm was operated on in the first operation. Multiple aneurysms were all ligated at one session if technically feasible, otherwise two months later.

Since 1984, control angiograms were done infrequently. Since 1980, all patients had at least one postoperative CT scan. Fluid

accumulations and hydrocephalus were initially treated by external drainage or lumbar punctures and, if persistent, by a shunting operation.

Hypervolemic therapy with plasma expanders was used in three-fourths of the cases. Corticoids and prophylactic anticonvulsants were routinely used. Intravenous nimodipine treatment was introduced as routine in 1988 (232 cases). Two-thirds of the patients had prolonged bedrest of at least three days postoperatively, usually until ten days post SAH. Prophylactic anticoagulation with warfarin was used in 658 patients.

Follow-up Study

All survivors came for at least two outpatient visits two and twelve months postoperatively. The patients have been under the scrutiny of the department all these years. The final analysis and the long-term follow-up study were done in 1990–91 (JH). The outcomes of all 1007 patients were determined by telephone calls, questionnaires or clinical records. In the case of late death, the relatives, clinical records, statistical offices, and autopsy records were consulted for the cause of death. All the records were available for analysis, and no patient was lost from follow-up. Outcome was assessed at discharge from hospital, two and twelve months after operation and at the last follow-up point using the Glasgow Outcome Scale (GOS)[12]. Good recovery (GR) and moderate disability (MD) were classified as useful recovery = favorable result, as these patients are independent.

Statistical Analysis

Differences between groups were analysed by the chi-square test or by the Mann-Whitney's U test when appropriate. The results of the multivariate analyses are presented in a separate report (Niskanen *et al.*).

Results

Admission and Pre-Operative State, Delays and Rebleedings

The total number of patients and the number of patients operated on acutely or early, increased yearly, remaining rather stable during the last years (Fig. 1). The outcomes of the patients were rather similar in different years, in spite of various treatment modalities (Fig. 2). The basic data related to timing of surgery are shown in Table 1 and the pre-operative medical condition in Table 2. Significant delays (no contact with physicians, patient sent home, or wrong diagnosis for at least one day) in the diagnosis of SAH were observed in 26% of the cases. The majority of the delays was caused by the patients or their relatives (55%). Forty-three patients (4.5%) had a pre-operative time longer than one week, i.e., planned delayed surgery for different reasons. Seventy-four patients had rebleeds: 37 had a fatal rebleed before surgery, and 37 survived rebleeding(s) to have a subsequent operation.

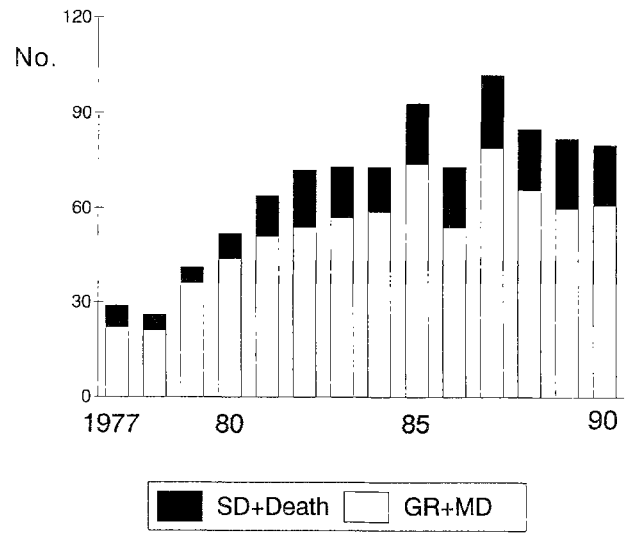

Fig. 2. Outcome (Glasgow Outcome Scale) [12] at one-year follow-up in 1007 patients with cerebral aneurysm surgery treated during a 14-year-period. *GR* = Good recovery, *MD* = moderate disability, *SD* = severe disability. *GR* + *MD* = Useful recovery

Mortality

The results can be seen in Tables 3–7 and Figs. 2–6. The surgical mortality at 30 days was 9%. There were 108 (11%) deaths during the first two months, all of them related to SAH or surgery. During the first year, 23 additional patients died: 10 deaths were related to SAH or surgery, one was due to rupture of another aneurysm, and 12 deaths were caused by other diseases. Deaths from all causes are included in the mortality rates. At the last follow-up 1 to 13 years postoperatively (mean 5 years), a total of 191 patients had died. Fifty-four of these deaths were caused by diseases other than SAH.

Pre-Operative Grade and Outcome

Outcome and mortality were directly related to pre-operative Grades (Table 3). Of the 99 patients (10%) who were in poor condition (Grade IV or V) before operation, only 30 (30%) made a useful recovery (Table 3). Overall, 79% of the patients had a favorable outcome (good recovery or moderate disability in GOS), and 13% of patients were dead at one year. Of patients with Grade III or better, 84% had a favorable outcome. Good recovery at one year was observed in 75% of 696 patients with Grade III or better without pre-operative neurological deficits, and in 50% of 211 patients with deficits.

Table 1. *Baseline Characteristics in 1007 Patients with Cerebral Aneurysms Operated on at Different Time Intervals After SAH*

Variable No. of patients	Timing of surgery (days post SAH)						
	0–1 d 207	2–3 d 317	4–6 d 165	7–10 d 130	11 + d 128	Not bled 60	Total 1007
Mean Hunt Hess Grade	3.0[1]	2.4	2.3	2.2	1.8	0.2	2.2
Mean age	47.8	47.8	47.9	48.5	51.2	50.5	48.5
Females %	40.6	48.9	47.9	46.9	48.4	50.0	46.8
Delay %	14.5	14.5	32.1	41.5	53.9	10.0	25.6
Cardiac disease %	13.5	17.4	15.8	19.2	21.1	20.0	17.2
Hypertension %	26.1	26.2	29.7	37.7	39.8	36.7	30.6
Multiple aneurysms %	22.2	23.0	21.3	24.6	21.9	23.3	22.0
Multiple bleeds %	29.0[1]	15.8	17.6	15.4	17.2	0	18.0
Pre-operative spasm %	8.7	3.2	18.2	27.7	34.4	0	13.7
Severe bleed in CT %	80.2[2]	68.5[2]	41.2	22.3	7.8	5.0	48.9
Severe intraventricular bleeding %	11.6	4.4	7.9	4.6	0.8	0	5.8
Intracerebral bleeding (> 25 mm)	44.4[1]	13.9	17.0	12.3	11.0	5.0	19.6
Subdural haematoma	1.4	1.3	0.6	1.5	0	0	1.0
Severe pre-operative hydrocephalus	9.2[3]	9.8[3]	3.6	5.4	1.6	3.3	6.7
Large (15–24 mm) aneurysms %	17.4	13.6	13.3	14.6	9.4	20.0	14.3
Giant (25 mm+) aneurysms %	7.7	1.6	4.2	1.5	5.5	26.7	5.3
Mean aneurysm size	12.2	9.8	10.7	9.6	10.7	18.4	11.0
Carotid artery aneurysm %	17.9	24.0	17.6	23.1	25.8	40.0[4]	22.7
Middle cerebral artery aneurysm %	46.4[5]	28.1	35.2	34.6	35.9	28.3	34.9
Anterior cerebral artery aneurysm %	30.9	42.6	41.8	30.8	32.8	23.3	36.1
Vertebrobasilar artery aneurysm %	4.8	5.4	5.5	11.5	5.5	8.3	6.3

[1] $p < 0{,}001$ 0-1 d vs. other groups of bleeding aneurysms.
[2] $p < 0{,}001$ 0-1 d and 2-3 d vs. other groups of bleeding aneurysms.
[3] $p < 0{,}001$ 0-1 d and 2-3 d vs. all other groups combined.
[4] $p < 0{,}001$ Not bled vs. other groups combined.
[5] $p < 0{,}001$ 0-1 d vs. all other groups combined.

Table 2. *Pre-Operative Medical Condition in 1007 Patients with Cerebral Aneurysm*

Disease	Per cent
Cardiac disease	17.2
Hypertension	30.6
Severe symptomatic atherosclerosis	3.7
Carotid or vertebral occlusion	1.1
Chronic renal disease	2.6
Chronic liver disease	1.4
Alcoholism	7.8
Chronic pulmonary disease	6.3
Rheumatoid arthritis	4.0
Diabetes mellitus	2.7
Coagulopathy	0.9
SAH or ICH years ago	7.1

There was a 21% mortality among all the patients operated on during the days 0–1, but most deaths were in patients with poor Grades and intracranial haematomas operated on as emergencies. The rather high total mortality of 10% in cases operated on later than seven days is due to the high number of Grade III–IV cases in this group (85 patients with 22% mortality; Table 3). However, there were no differences in the outcome of patients in Grades I and II whatever the timing of aneurysm surgery. Grade III patients made a useful recovery in 82% of cases when operated on during days 0–1, with less satisfactory results in subsequent days (Table 3).

The outcome was poor in Grades IV and V patients (Table 3). Of the 99 patients in Grade IV or V, 70 had significant haematomas. Sixty-three of these 70 were operated on acutely. Sixteen of the 29 patients in Grades IV–V without haematomas had acute operations. Nine of 70 patients with haematomas and in Grade IV–V made a good recovery, only one of the 29 without haematoma made a good recovery. The mortality was nearly half (49 and 45%) in both groups.

Table 3. *One-Year-Outcome (Glasgow Outcome Scale[12]) Following Different Timing of Surgery in Different Pre-Operative Grades (Hunt-Hess) in 1007 Patients with Cerebral Aneurysms*

		Timing of surgery (days post SAH)													
	0-1 d		2-3 d		4-6 d		7-10 d		> 11 d		Not bled		Total		
HH	GOS	N	%	N	%	N	%	N	%	N	%	N	%	N	%
0	GR											46	81	46	81
	MD											9	16	9	16
	SD											1	2	1	2
	Dead											1	2	1	2
1	GR	7	100	19	100	16	89	30	91	58	83			130	88
	MD					1	6	2	6	6	9			9	6
	SD							1	3	3	4			4	3
	Dead					1	6			3	4			4	3
2	GR	51	74	144	79	77	83	41	82	17	85			330	80
	MD	11	16	21	12	4	4	4	8	2	10			42	10
	SD	3	4	9	5	5	5	1	2					18	4
	Dead	4	6	8	4	7	8	4	8	1	5			24	6
3	GR	25	38	48	48	17	38	18	44	14	39			122	42
	MD	29	44	19	19	13	29	6	15	8	22	1	50	76	26
	SD	4	6	9	9	7	16	7	17	9	25	1	50	37	13
	Dead	8	12	24	24	8	18	10	24	5	14			55	19
4	GR	8	17					1	17					9	12
	MD	9	20	4	31	3	33	1	17					17	22
	SD	8	17	5	39	2	22			2	100			17	22
	Dead	21	46	4	31	4	44	4	67			1	100	34	44
5	GR	1	5											1	5
	MD	2	11	1	33									3	14
	SD	4	21	1	33									5	23
	Dead	12	63	1	33									13	59
Total	GR	92	44	211	67	110	67	90	69	89	70	46	77	638	63.4
	MD	51	25	45	14	21	13	13	10	16	13	10	17	156	15.5
	SD	19	9	24	8	14	9	9	7	14	11	2	3	82	8.1
	Dead	45	22	37	12	20	12	18	14	9	7	2	3	131	13.0

GR = Good recovery, MD = moderate disability, SD = severe disability, HH = Hunter-Hess, GOS = Glasgow outcome scale.

Age and Sex, Aneurysm Site and Size

A strong relationship between age and outcome was seen except in the patients without bleeding, where no relationship was seen (Fig. 3). There was no relationship beween sex and outcome.

The timing of operative treatment of aneurysms at different sites was equally distributed, with one-third of the patients with vertebrobasilar and carotid aneurysms and over 40% of the patients with anterior cerebral or middle cerebral aneurysms operated on during the first two days (Fig. 4). The lowest mortality among different aneurysm sites was seen in the patients with anterior communicating and pericllosal aneurysms, or carotid bifurcation aneurysms. The outcome was least satisfactory in VBA aneurysms, with 71% useful recoveries (Fig. 4).

Small and giant aneurysms had the highest mortality rates in acute and early surgery. Generally, however, with increasing size results became worse (Fig. 5). Giant aneurysm patients operated on during the first two days were in poorer condition (half of the patients had significant haematomas) as compared to other patients with smaller aneurysms operated on in the same time period (Table 1).

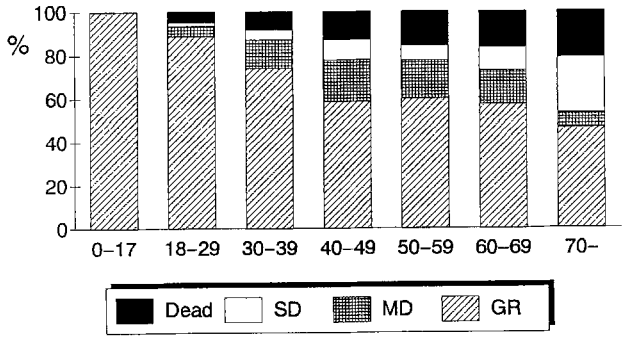

Fig. 3. Outcome (Glasgow Outcome Scale) [12] at one year related to age in 1007 patients with cerebral aneurysm surgery treated during a 14-year-period. *GR* = Good recovery, *MD* = moderate disability, *SD* = severe disability

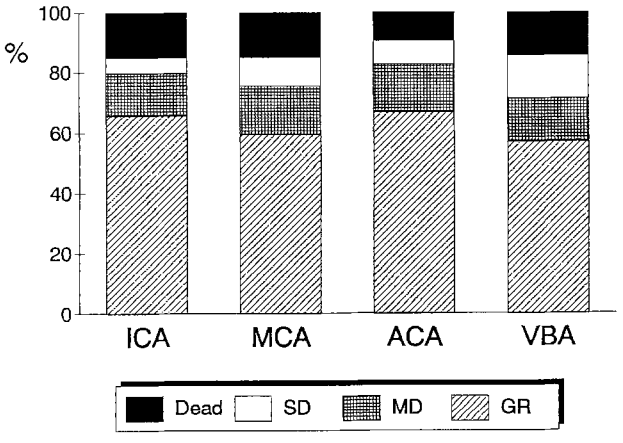

Fig. 4. Outcome (Glasgow Outcome Scale) [12] at one year related to the location of the symptomatic aneurysm in 1007 patients with cerebral aneurysm surgery treated during a 14-year-period. *GR* = Good recovery, *MD* = moderate disability, *SD* = severe disability. *ICA* = Internal carotid artery, *MCA* = middle cerebral artery, *ACA* = anterior cerebral artery, *VBA* = vertebro basilar artery

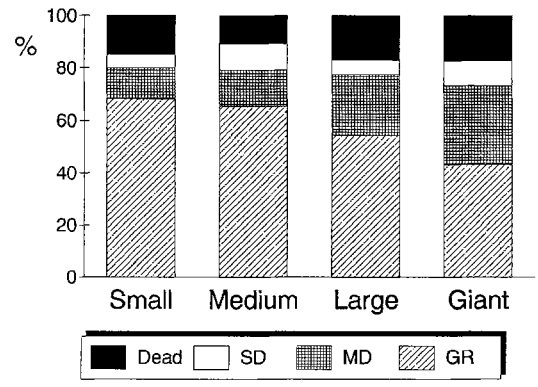

Fig. 5. Outcome (Glasgow Outcome Scale) [12] at one year related to the size of the symptomatic aneurysm in 1007 patients with cerebral aneurysm surgery treated during a 14-year-period. *GR* = Good recovery, *MD* = moderate disability, *SD* = severe disability

Peri- und Postoperative Complications

Complications caused one or more re-operations in 186 cases: inadequate clipping of the aneurysm in 11, postoperative haematomas in 17, bone flap removal in 13, and postoperative shunting or ventriculostomy in 116 cases. Tracheostomy was performed in 29 patients.

Temporary vessel occlusion was used mainly in very difficult or desperate situations (altogether 62 cases) for short time periods, usually below five minutes. The results in these cases can be seen in Table 4. Mortality rate in patients with peri-operative ruptures was 17% (Table 4).

In a total of 71 patients a significant vessel was occluded, or occlusion was strongly suspected, at some stage of the operation. Twenty-six out of these 71 cases had angiographic verification, in 15 cases a trapping

Table 4. *Outcome (Glasgow Outcome Scale[12]) in 62 Patients with Aneurysm Surgery and Temporary Vessel Ligation, as Related to Timing of Surgery*

Outcome	0-1 d	2-3 d	4-6 d	7-10 d	11 d+	Not bled	Total
Good recovery	3	9	7	3	5	1	25
Moderate disability	2	4	0	2	1	3	12
Severe disability	1	5	2	0	3	0	11
Dead	5	5	2	1	1	0	14
Total	11	23	11	6	10	4	62

procedure was used and six cases were intentional carotid occlusions. In 24 cases a major vessel ligation was suspected on the basis of clinical or CT findings. In the acute surgery group 13 of 33 died, in the early surgery group 10 of 24 cases died. Only one death and one severe disability were observed in 16 patients with late surgery. Thrombosis of an afferent or efferent vessel for unknown (probably manipulative) reasons occurred in three patients with acute surgery; two died. Seven cases of thrombosis in the late surgery group all had good recoveries. Significant postoperative haematomas occurred in 32 cases, with nine deaths and fifteen useful recoveries (Table 5).

Sixty-two patients improved immediately after the operation, most of them had their large haematomas removed or hydrocephalus relieved. Postoperatively 146 patients were worse. Of these 146, 30% died and 51 made a useful recovery. Of these 146 cases, one-fifth had temporary vessel ligation, one-half peri-operative aneurysm rupture, and one-third a major vessel ligated or thrombosed. Eleven additional patients had postoperative haematomas. No obvious reason for deterioration was seen in 44 out of these 146 cases. Thirty-seven (84%) of these 44 cases were in Grades III–V, and they were least frequent in acute or late surgery. Of these 44 cases seven died. The main cause of death was brain infarction due to spasm in four, infection in one case, and unknown in two cases despite autopsy.

Half of the patients had no delayed ischaemia (Table 6). Reversible symptoms were more common in patients operated on early. Of the 872 survivors at one year 104 (12%) had moderate or severe disability due to ischaemia. Thirty-five patients (3.5%) had postoperative delayed ischaemia as the main cause of death. Nimodipine treatment had no significant influence on the outcome in this series.

Epilepsy was seen in 136 (15%) of the 899 patients surviving two months or more. Nonruptured aneurysms were most often associated with epilepsy (27%). Two per cent of the eyes had diminished vision. One

Table 5. *Peri-Operative Complications (%) in 1007 Patients Operated on for Cerebral Aneurysms, as Related to Timing of Surgery*

Complication	Timing of surgery (days post SAH)						
	0-1 d	2-3 d	4-6 d	7-10 d	11+ d	Not bled	Total
Verified or suspected ligation of a major vessel	8.2	6.3	9.1	3.8	5.5	15.0	7.2
Aneurysm rupture before aneurysm dissection	2.9	2.8	3.9	5.4	3.9		3.2
Aneurysm rupture during aneurysm dissection	10.2	8.2	12.7[1])	6.9	5.5	5.0	8.6
Aneurysm rupture during clipping	14.0[2])	10.4	9.1	6.2	6.3	1.7	9.3
Afferent vessel thrombosis		0.6	2.4	0.8			0.7
Efferent vessel thrombosis	0.5	0.3	0.6		0.8		0.4
Postoperative epidural haematoma		0.3				0.8	0.2
Postoperative subdural haematoma	1.4	1.3	2.4	3.1			1.5
Postoperative intracerebral haematoma	2.4	1.3	1.8		4.7	1.7	1.9

[1] $p < 0{,}05$ 4-6 d vs. all other groups combined.
[2] $p < 0{,}01$ 0-1 d vs. all other groups combined.

Table 6. *Severity of Post-Operative Delayed Ischaemia (%) in 1007 Patients Operated on for Cerebral Aneurysm, as Related to Timing of Surgery*

SPASM	Timing of surgery (days post SAH)						
	0-1 d	2-3 d	4-6 d	7-10 d	11+ d	Not bled	Total
No	49.3	50.5	47.9	53.1	61.7	100.0	54.5
Mild	30.0	26.2	30.3	16.9	14.1		23.3
Medium	10.1	11.0	9.1	15.4	16.4		11.1
Severe	6.3	8.2	9.1	10.0	7.0		7.5
Fatal	4.3	4.1	3.6	4.6	0.8		3.5

per cent of the patients had double vision. At one-year follow-up 11% of the patients had some residual hemiparesis, and 6% showed a psycho-organic syndrome. These complications of SAH or surgery were combined in 36 patients.

Medical Complications

Postoperative medical complications are presented in Table 7. Thirty per cent of the patients with sepsis or pneumonia died. Mortality among patients with meningitis or wound infection was 16%. One patient died due to a brain abscess caused by wound infection. Thirteen of 22 pulmonary embolisms were fatal. Five of nine patients with postoperative myocardial infarction died. Gastrointestinal bleeding resulted in 12 fatalities out of 23.

Discussion

The timing of surgery had little influence on the outcome, which was dominated by the pre-operative Grade[2, 3, 6–11, 13–17, 19–30]. Pre-operative Grade was of major importance in the patients operated on acutely, in patients operated on later postoperative ischaemia played an important role in the outcome. The patients in Grades I–II made in more than 80% of cases good recoveries, irrespective of timing. Grade III patients had a rather more favorable outcome when operated on acutely, after that the outcomes were worse with 18–24% fatalities. The severity of SAH, assessed in Grades, depends, however, on the time of assessment. The pathophysiology behind the symptoms and also the surgical risks are different and not easy to compare[3, 6–11, 13–15, 20, 21, 23, 27]. Patients with persistent high Grades (IV and V) without haematomas or hydrocephalus should not be operated on during days 3–7, where 7 of 12 died. Operative mortality is diminished in the second week; however, many of these patients die with or without surgery. Patients in Grade V without space occupying lesions seldom benefit from operative treatment.

The more complicated outcome in patients operated on between days 3 and 7 may represent selection bias[8, 20, 21]. Patients in poor condition or with difficult aneurysms tend to be operated on later. In this series, however, vertebrobasilar and giant aneurysms were operated on in accord with an acute or early surgical policy (Table 1). Forty-four patients were worse after operation for reasons unknown to us. These patients might

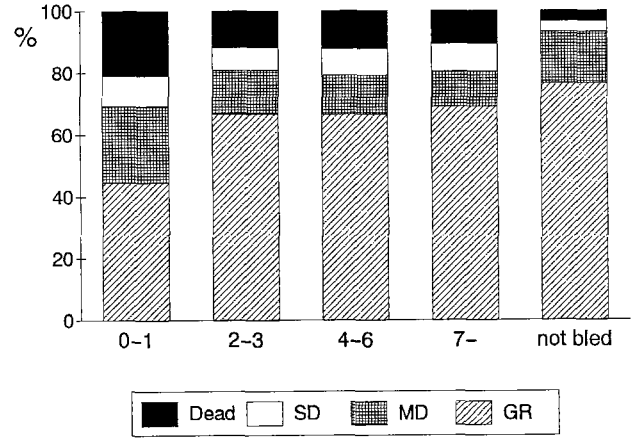

Fig. 6. Outcome (Glasgow Outcome Scale) [12] at one year related to the timing of surgery in 1007 patients with cerebral aneurysm surgery treated during a 14-year-period. *GR* = Good recovery, *MD* = moderate disability, *SD* = severe disability

Table 7. *Post-Operative Medial Complications (%) in 1007 Patients Operated on for Cerebral Aneurysm, as Related to Timing of Surgery*

Complication	Timing of surgery (days post SAH)						
	0-1 d	2-3 d	4-6 d	7-10 d	11+ d	Not bled	Total
Sepsis or pneumonia	20.8[1])	15.8	13.3	13.8	10.2	5.0	14.8
Meningitis (bacterial or aseptic)	8.2	8.8	5.5	4.6	4.7	1.7	6.7
Wound infection	2.4	2.2	2.4	6.2	3.1		2.8
Venous thrombosis	1.9	2.5	6.7	9.2	8.6	6.7	5.0
Pulmonary embolism	4.3[2])	1.3	1.2	4.6		1.7	2.2
Myocardial infarction	0.5	1.3		2.3	0.8		0.9
Gastrointestinal bleeding	4.3[2])	1.9	1.2	2.3	2.3		2.3

[1] $p < 0{,}01$ 0-1 d vs. all other groups combined.
[2] $p < 0{,}05$ 0-1 d vs. all other groups combined.

represent inaccurately estimated timing or other factors which are unknown to us.

There was no difference in the outcome between the sexes[13–15]. Male dominance in Finnish aneurysm series has been shown earlier[5, 18, 30]. Age and accompanying diseases had a marked influence on the outcome. Our patients were sick in spite of their rather young age, with many cardiovascular diseases which are common in this area and also represent a problem in the late deaths during the long-term follow-ups (Tables 1 and 2)[13–15]. Number of medical complications is high in patients operated on acutely – this is due to the high number of poor Grade patients and the need for more intensive monitoring.

Pre-operative angiographic spasm was rare and occurred mainly in patients with delayed admission. Post-operative delayed ischaemia was, in addition to poor pre-operative Grade and ligation of a major vessel, one of the leading causes of poor results (Table 3)[13–15]. Early surgery did not prevent ischaemia[2, 3, 23, 30]. We feel that removal of cisternal blood is not possible to the extent needed to prevent vasospasm[20–24, 25–30]. Different treatment modalities had very little influence on the one-year outcome (Fig. 2). We could not find a significant positive effect of nimodipine[30].

With growing experience most of the aneurysms can be managed early and even acutely[20, 21, 24, 28, 30]. Large and giant aneurysms in all locations and vertebrobasilar aneurysms of all sizes remain, even with present methods of surgery, operative challenges. Due to the high number of associated haematomas, large and giant middle cerebral artery aneurysms often must be treated acutely[24]. Patients with small aneurysms operated on during the first week fared better than patients with large aneurysms; later, aneurysm size was of minor importance [13–15].

Acute and early surgery differ technically from delayed surgery by the presence of disturbed surgical anatomy and a soft swollen brain. Aneurysm dissection may be easier in early surgery in the absence of adhesions[13–15, 20, 21]. Peri-operative rupture of anterior circulation aneurysms had very little influence on outcome, but in this series temporary ligation or inadvertent ligation of a main vessel during acute, early or intermediate surgery was often catastrophic (Tables 4 and 5)[3, 7, 13–15].

Seven per cent of the patients had rebleedings before surgery, half of them ending fatally. Twenty-four of the 37 fatal rebleedings were in patients presenting in Grades II–III, and they could have been saved with acute surgery – an improvement of two per cent in management mortality. Based on the incidence figures of primary SAH in our region (19.4/100,000, population 870,000) we operated on half of the patients with aneurysmal SAH in our region. Ten years earlier, a study from the same region showed that only 20% had operative treatment with a late surgical policy[5]. No increase in the number of patients with ruptured aneurysms has been observed during the recent years in spite of better diagnosis (CT available in all referring hospitals; Figs. 1 and 2). Significant delays in admission were seen in 26%[13–15]. As more than half of these delays were caused by the patients and relatives themselves, public education regarding the symptoms of SAH is needed.

The overall outcome is rather similar to the co-operative study, with 63.5% good recoveries[13, 14]. The criteria for inclusion in the series were different, as this series contains only surgical cases, and patients with multiple bleeds and emergency surgery are included. Deaths from all causes should be included even in surgical series. True mortality figures are better seen at one year[29]. Between discharge from the hospital and one-year follow-up, mortality increased in this series by four per cent, from 9% to 13%. Management mortality gives an idea about the quality of treatment, but may reveal more about admission policy[27]. The only reliable data on the effectiveness of treatment policies are incidence-related management results of SAH in the area.

Conclusions

Acute and early surgery is safe in patients presenting in Grades I–II. During the first 72 hours patients in Grade III can also be operated on safely with good results. The results in Grades IV–V are poor, and we suggest that only patients who are improving or who have large haematomas or considerable hydrocephalus and are below the age of seventy should be operated on acutely. In the case of delayed admission or other complications, and depending on the severity of SAH, patients in high Grades can be operated on, but with limited expectation of functional recovery.

Acute and early aneurysm surgery is a heavy burden for the neurosurgeon because of the high mortality and complication rate of acutely ill patients. Despite improvements in surgical technique we are far from achieving ideal results. Early recognition and surgery before rupture are urgently needed. Even now there are no means to detect aneurysms before they rupture,

excluding multiple ones and a few incidental cases. We must accept the patients with fresh severe bleeding and its consequences, and select the patients who benefit from surgery.

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