THE INCIDENCE of subarachnoid hemorrhage (SAH) varies widely, according to earlier studies, from 4 to 23.9/100,000/year, with the highest rates in Middle-Finland in Iceland and the Estonian USSR, and 8.7/100,000/year. Many of the epidemiological studies include data on the prognosis of SAH, and it is generally accepted that the fatality rate is highest during the first days and weeks after bleeding. Later on the probability of survival is much higher but for many years the annual risk of rebleeding in patients without aneurysms found by bilateral carotid angiography. Patients with intracranial arterial spasm or arteriovenous malformations revealed by angiography. Patients with intracranial arterial spasm without visualization of aneurysms were also included, as well as a few patients with normal angiograms. When no angiograms were performed, the clinical diagnosis of SAH was made applying the criteria of Pakarinen. The aim of these criteria is to exclude patients with primary intracerebral hemorrhage with secondary
rupture into the subarachnoid space. Excluded were:
1. Patients over 50 years of age
   a) Patients who died of the initial hemorrhage
   b) Patients who survived the initial hemorrhage but were left with severe neurological defects
   c) Hypertensive patients with an initial coma of duration longer than 24 hours
2. Patients under 50 years of age
   a) Hypertensive patients who died of the initial hemorrhage
   b) Normotensive patients with severe neurological defects who died of the initial hemorrhage
   c) Hypertensive patients who survived the initial hemorrhage but were left with severe neurological defects.

Acute clinical deterioration, most often an acute increase in the severity of headache and/or disturbed consciousness, was considered as rebleeding. In most patients this was confirmed by CSF examination and/or autopsy. When confirmation was lacking the symptoms may also have been due to severe arterial spasm.

Death was considered to be due to the first bleeding if the patient died within 6 hours from onset of the symptoms or if the patient was unconscious from the onset to death within 48 hours.

Results

During the years 1976–78 a total of 146 patients suffered SAH. Six of the patients had a recurrence with the first SAH predating the study period. These patients are not included in the incidence calculations. The age and sex distributions of the patients are shown in the table.

SAH was confirmed by angiography and/or autopsy in 70% of all cases, and in 88% of those younger than 60 years. Because patients older than 60 years were not operated on they did not have angiograms. Of these patients the cause was confirmed in 37% by autopsy. The proportion of angiograms and/or autopsy was highest in the younger age groups (fig. 2).

The incidence rate of SAH in Middle-Finland during 1976–78 was 19.4/100,000/year, 19.6 for women and 19.2 for men. The incidence increased with increasing age almost linearly from 1.6/100,000/year at the age of 10–19 years to 49.6/100,000/year at the age of over 70 years (fig. 3).

During the first 3 months after the first bleeding 71 of the 146 patients (49%) died. Half of the deaths occurred on the first day, 70% of these within 6 hours after the bleeding (fig. 4). Among all deaths during the first 3 months 68% took place during the 1st week, 12% during the 2nd, and 4% during the 3rd week. The subsequent weekly fatality rate averaged 1.6%. The fatality rate varied between 44% and 65% in different

<table>
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<tr>
<th>Table</th>
<th>Age and Sex Distribution of the Present Series. Rebleeds in Brackets</th>
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<tbody>
<tr>
<td></td>
<td>10-19</td>
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<tr>
<td>Men</td>
<td>(N = 70)</td>
</tr>
<tr>
<td>Women</td>
<td>(N = 76)</td>
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<td>Total</td>
<td>146</td>
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age groups. There was no difference in fatality rate between men and women, nor had age any notable influence on this rate. In 41 (58%), death ensued after the first bleeding while it was due to a recurrence in 27 (38%). Twenty-one of the rebleedings were confirmed by CSF examination or autopsy. Other causes of death were massive brain infarction and pulmonary complications of a prolonged coma.

Among the 94 patients younger than 60 years, 62 (66%) had angiograms. Bilateral carotid angiograms were obtained in 52 patients and a unilateral carotid angiogram in 10. The angiograms were obtained during the first 10 days after bleeding in 78% of cases. Fifty (81%) of the 62 patients had an intracranial arterial aneurysm, and one had an arteriovenous malformation. Five patients had severe intracranial arterial spasm, one had signs of hydrocephalus, and 2 had occlusion of internal carotid or pericallosal artery. Three patients had normal angiograms. Vertebral angiograms were not obtained.

The main reasons why 32 of the patients in this age group did not have angiography were: death within 48 hours (24 patients), and prolonged coma with fatal termination (4 patients).

The angiograms revealed a total of 62 arterial aneurysms. The most common locations were: middle cerebral artery (31), anterior communicating artery (13), and carotid syphon (10). Eight patients had multiple aneurysms.

An autopsy was performed on 56 (79%) of the 71 deceased patients and in 52 one or several aneurysms were found. Six of the patients had multiple (2 to 3) aneurysms. The most common locations were: middle cerebral artery (29), anterior communicating artery (12), basilar artery (6), and posterior communicating artery (4). An infratentorial location was found in 10 (16% of all aneurysms).

The basic management of all patients consisted of bed rest, analgesics, and, when required, antiemetics and sedation. In case of extremely high blood pressure (diastolic over 120 mm Hg) clonidine hydrochloride was administered. Antifibrinolytic therapy was not used, dexamethasone was given to only a few critically ill patients. If the patient was not eligible for surgical treatment, bed rest was continued for at least 3 weeks, most often for 4 weeks, after which the patient was mobilized.

Neurosurgical treatment was carried out at the Department of Neurosurgery, University of Helsinki. Of the 50 patients younger than 60 years with an aneurysm on the angiogram, 29 were believed to be eligible for surgical ligation of the aneurysm, and 20 patients were operated on, 8 to 25 days (median 15
days) after the first bleeding. Six of the 29 patients eligible for surgical treatment died of a recurrence before surgery, 8 to 20 days after the first bleeding (median 12 days). Two patients refused to have surgery, and in one patient the operation was limited to explorative craniotomy, owing to inoperability of the aneurysm.

Twenty-one of the patients were considered inoperable after angiographic evaluation. The most common cause was an aneurysm having no neck to be clipped (12 patients), and in 4 too much time had passed since the initial bleeding.

**Discussion**

The results of the present study support earlier studies, indicating that the incidence of SAH is higher in Finland than in other countries. The results of the present study are shown in figure 5, together with those 4 studies in which identical diagnostic criteria have been applied. The incidence of SAH in Middle-Finland increased with increasing age almost linearly, having its maximum in the oldest age group. This finding is similar to the Espoo-Kauniainen study and the results from the Mayo Clinic. Other studies show the maximum incidence at the age of 50-59 years. The possibility of over-diagnosing older people in the present study as having SAH on clinical criteria alone seems unlikely. Of the 19 patients older than 60 years who were autopsied and proven to have a ruptured intracranial aneurysm, a total of 14 (74%) had died during the first day after the bleeding, and if not autopsied, had been excluded as having intracerebral hemorrhage. In addition, of the 8 autopsied patients neurologically examined before death, 6 had hemiplegia; if they had survived, they would also have been excluded as intracerebral hemorrhage. During the compilation of the present study, numerous patients dying during the first days or surviving with severe neurological defects were excluded because of lack of angiographic or autopsy verification of the cause of possible SAH. Thus the real incidence of SAH in Middle-Finland must be even higher than that obtained, perhaps in the order of 22-24/100,000/year.

The early prognosis was in agreement with other studies. In all studies, most deaths occur during the first week, and, in particular, in the first few days after initial bleeding. On average, 40% to 65% of the patients die within one to 3 months after the hemorrhage. The present study revealed no trend in the fatality rate related to the age of the patient.

Theoretically, every patient suffering SAH is a candidate for surgical treatment. Unfortunately, 25% of the patients die within one day after bleeding, often before reaching the hospital. In addition, fatal recurrences occur frequently during the first 3 weeks. In the present study, 20% of the survivors after the first day were lost because of a fatal recurrence.

During the last 10 years attempts have been made to improve the prognosis of SAH in patients during the first critical days and weeks. Prevention of recurrences by antifibrinolytic therapy has been one of the main interests. The results, however, have been contradictory, and the most recent reports on both epsilon-aminocaproic acid and tranexamic acid give little support for therapeutic benefits of these drugs. The electrocardiographic abnormalities after SAH, their prognostic significance, and probable association with autonomic nervous system overactivity have suggested the use of adrenergic blocking drugs. The clinical results have, however, been meager. Corticosteroids are not effective in treatment of brain edema following SAH. Thus, there is at the moment no effective means to prevent recurrence before angiograms and surgery. Bed rest and symptomatic treatment remain the treatment of choice.

The principal aim of surgery is to prevent fatal recurrences from aneurysms, which threaten the victims of SAH during their lifetime as 1.5% to 3.5% of them annually have rebleedings. Neurosurgeons have had a more active attitude about evacuation of intracerebral hematomas secondary to SAH. Opinions have fluctuated regarding the optimum timing of surgery, and it seems still to be an unresolved problem. It is now customary to advise surgery 1 to 3 weeks after bleeding. Operation performed many weeks later is effective in preventing late recurrences.

In addition to survival and a reasonably good general condition the patient must have an aneurysm fit for surgery. All series contain a number of patients who do not have an aneurysm, no matter how extensive the angiography. In the present
study this percentage was 18. This may be partly explained by the failure to do vertebral angiograms. After the completion of this study vertebral angiograms now are performed on patients younger than 45 years.

A point that has been raised is whether there is an upper age limit for patients eligible for surgery. The custom followed in Finland has been that only patients younger than 60 years are offered surgery. This practice is partly dictated by the shortage of beds in the neurosurgical departments; and the fact that older patients are believed to have higher surgical risk.

Only one-fifth of the whole series, 33% of those surviving for 2 weeks, were deemed suitable for surgical treatment, and only 20 patients, 14% of the total series and 23% of those who survived for 2 weeks, had surgery. Six of the candidates for surgery were lost due to a fatal rebleed.

The endeavor to increase the number of patients with SAH who can be afforded the benefits of neurosurgical treatment may be related to different expedients. First, the timing of the operation must be earlier than in the present study, in which one-fifth of the patients assessed to be eligible for surgery had a fatal rebleed while waiting for surgery, i.e., 8 to 20 days after the first bleeding. The addition of vertebral angiography in the examination of the patients will reveal additional treatable aneurysms. An important possibility is to include patients older than 60 in the group of candidates for neurosurgery. The question of an age limit has been a subject of discussion in the literature, and opinions are divergent. Some studies show that older patients can tolerate neurosurgical treatment. The present series contains 52 patients (36% of the total) 60 years or older. One-third of these succumbed during the first week, but many survivors were in good health and eligible for angiographic examination, and possibly for neurosurgical treatment. As Horrocks and Knox put it: “are those over 59 in some way intrinsically of less value than younger patients?” If in the future these patients are admitted into the group eligible for neurosurgery, then 40% of the SAH patients could benefit from surgical treatment of their aneurysms.

Acknowledgements

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SUMMARY Sixty-five male gerbils, divided into 3 groups, were used in this study, in which focal cerebral blood flow, taken as a measure of edema, was compared to the corresponding focal cerebral blood flow using the hydrogen washout technique. Extracranial unilateral or bilateral carotid ligation was performed and one hour later the animal was sacrificed. When focal blood flow was less than 20 ml/100 g/min, edema developed and increased with progressive ischemia, reaching maximal values at 5-7 ml/100 g/min. In the zero flow situation there was no edema. Pretreatment of the other 2 groups with indomethacin or dexamethasone, did not prevent edema formation at flows of 20-12 ml/100 g/min, but considerably reduced the edema previously noted at low flows (5-7 ml/100 g/min). The drugs did not affect the decreased flow in the ischemic area. We conclude that prostaglandins, released by membrane disruption, are involved in the development of ischemic edema.

EXPERIMENTAL WORK suggests that "ischemic brain edema" has cytotoxic and vasogenic features. The early accumulation of water is presumed to be intracellular, and, if the ischemia progresses, a vasogenic component develops with increasing permeability of the blood-brain barrier. The reasons for these changes are still not clear. It may be that 2 separate pathophysiological effects are progressing simultaneously, or they may be sequential aspects of the same basic mechanism, the degree of one component depending on the severity of the other. Following damage to cell membranes, Wolf has emphasized the release of prostaglandins. Yamamoto and Pickard have shown that prostaglandins are highly vasoactive and their precursor, arachidonic acid, has been shown to produce edema. It might be presumed, therefore, that increasing ischemia eventually leads to cell membrane breakdown and release of vasoactive substances which, in turn, aggravate the situation and increase the amount of edema produced.

We described in a previous paper, an experimental stroke model in the gerbil in which we studied the relationship between the focal cerebral blood flow (rCBF) and brain edema as judged by brain specific gravity. The Mongolian gerbil, because of the incompleteness of the circle of Willis, has been extensively used to study the histological changes associated with ischemia, edema formation, changes in the blood-brain barrier and focal cerebral blood flow which developed following extracranial carotid ligation. Our initial studies showed that edema developed when the regional blood flow was less than 20 ml/100 g/min and increased with increasing ischemia to a maximum at blood flows around 7 ml/100 g/min. Blood flows less than this were associated with little or no change in the brain's specific gravity. To discover if the prostaglandins, or their precursors, are involved in the post-ischemic edema formation, we repeated our studies having pretreated the animals with indomethacin, a well known inhibitor of prostaglandin synthesis. Another approach to the same problem would be to "stabilize" the cell membrane, as well as prevent the action of these vasoactive substances; in another part of this same experiment, the animals have been pretreated with dexamethasone.
Subarachnoid hemorrhage in middle-Finland: incidence, early prognosis and indications for neurosurgical treatment.
R Fogelholm

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