PAPERS AND ORIGINALS

Intracranial aneurysms: analysis of results of microneurosurgery

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Summary

Subarachnoid haemorrhage from intracranial aneurysms has a poor prognosis. Operative management of intracranial aneurysms was once considered ineffective. The first 100 cases treated by microsurgery were analysed to see whether mortality and morbidity were reduced. Modern surgical techniques halved the total mortality but the morbidity was unaltered. Results can be improved by delaying surgery seven days and by treating any hypertension before surgery.

Introduction

Subarachnoid haemorrhage due to rupture of an intracranial "berry" aneurysm has an immediate mortality of 43%. Pakarinen's[1] study of patients managed conservatively showed that 35% of the survivors would be expected to die of a recurrence within a year, and 51% would be dead in five years, the remaining survivors dying at 3·3% a year thereafter. The mortality is greater after recurrent haemorrhage—64% in the first recurrence and 86% in the second. Total disability occurs in 11% of survivors and partial disability in 19%. These statistics are similar to those found in an English population by Crawford and Sarner.[2]

Subarachnoid haemorrhage occurs at the most productive phase of life, in young and middle-aged adults who leave a heavy burden of dependants. Considerable funds are presently chanelled into investigation, surgery, and rehabilitation of survivors: Is this worth while?

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Before the introduction of microsurgery with the operating microscope and microinstruments direct operative management of intracranial aneurysms did not significantly improve the overall mortality and morbidity.[3-5] We analysed the first 100 cases of intracranial aneurysms treated by microneurosurgical methods at Oxford. These patients presented for surgery between January 1972 and January 1974. Follow-up has continued in all but one case, and we report here the results six months after operation, which give a good indication of the final result.

Patients and methods

Fifty-six patients were women and 44 men. The mean age was 46 years (range 18-81). Most presented with an acute subarachnoid haemorrhage (97 patients) while three patients were found to have unruptured intracranial aneurysms on investigation for epilepsy; one also had a history of recurrent headache and a transient hemiparesis. Some of the patients had been referred to the department of neurosurgery from within the hospital after emergency admission, but most of the patients had been referred from peripheral hospitals within the region. The diagnosis of subarachnoid haemorrhage was based on the history and physical findings and confirmed by lumbar puncture.

All patients underwent bilateral carotid angiography soon after admission. Vertebral artery studies were done when there was clinical evidence of a vertebrobasilar lesion or when carotid studies failed to show an aneurysm in a patient under 50 years of age. The distribution of intracranial aneurysms is shown in table I.

Patients were graded according to the Botterell[6] classification: grade I—conscious, alert, and orientated, with or without meningism; grade II—drowsy, without significant neurological deficit; grade III—drowsy with neurological deficit; grade IV—major neurological deficit; grade V—moribund. This grading and the age of the patients is given in table II. During the period studied patients were operated on as soon as possible after the lesion was recognised unless the patient was graded IV or V, when surgery was deferred until the patient improved. The presence of spasm on the preoperative angiogram did not delay the surgery if the patient was graded I. All the operations were carried out by one of two surgeons. The procedure of choice was craniotomy and obliteration of the aneurysm by the application of a clip or reinforcement of its wall with cotton wool and cyanoacrylate glue if clipping was not technically feasible. Most patients (81%) had a check angiogram usually on the second or third day after operation, either to show the placement of the clip or to investigate a deteriorating neurological state.

TABLE I—*Sites of aneurysms*

Sites of aneurysms	No of patients
Intracranial carotid artery	10
Posterior communicating artery	21
Anterior cerebral-anterior communicating artery complex	24
Middle cerebral artery	21
Vertebrobasilar artery	3
Peripheral branches of the anterior cerebral artery	1
Multiple sites	20
Total	100

TABLE II—*Grade and age of patients*

Botterell grade:	I	II	III
No of patients	65	17	18
Mean (±SD) age	46±13·7	48±11·7	50±9·6

Results

The surgical results were analysed, taking the patient's recovery of function as an end point. A good result implied that the patient was working full-time at his normal occupation; a fair result meant that he could not resume his original occupation because of some residual neurological deficit, although all such patients returned to a modified or part-time occupation; and a poor result meant that the patient still needed help in daily life. If there was doubt about a patient's classification, the poorer result was chosen. At six months the results were good in 64 patients, fair in 12, and poor in nine; 15 patients had died.

Thus 76% of these patients achieved a good or fair result from surgery when assessed at six months. Two of the patients with a poor result needed help in daily life only because of impaired visual acuity due to vitreous haemorrhages occurring at the original subarachnoid haemorrhage. None of these patients has had a further subarachnoid haemorrhage.

Of the 15 patients who died one who had previously suffered a myocardial infarct had a cardiac arrest during surgery, two had a fatal pulmonary embolus, two died of intracranial arterial thrombosis remote from the site of surgery; and nine died of postoperative cerebral vasospasm. One died from a misplaced aneurysm clip, which occluded the internal carotid artery. One patient who died from a pulmonary embolus did have severe generalised vasospasm, which contributed to his death.

A hypotensive anaesthetic technique employing sodium nitroprusside was used in 49 cases and a hypothermic technique with intermittent brachycephalic occlusion in 31 cases. In the remaining 20 cases other methods of hypotension with or without hypothermia were used. There was no difference in the result obtained in the hypotensive and the hypothermic groups. Because of convenience, and because it means a less complicated procedure for the patient, hypotension induced by sodium nitroprusside has become the usual technique in this department.

The surgical results obtained appear to be related to several factors: the presence of systemic hypertension; the interval between subarachnoid haemorrhage and surgery; and cerebral vascular spasm.

SYSTEMIC HYPERTENSION

Systemic hypertension was presumed when a patient had a history of hypertension or when the blood pressure after admission was consistently above 160/95 mm Hg. This presumption was reinforced in most cases by clinical evidence: left ventricular hypertrophy and electrocardiographic or radiological evidence suggestive of systemic hypertension. The surgical results obtained in treated and untreated hypertensive patients were analysed and are shown in table III.

TABLE III—*Results of treatment according to blood pressure level*

Patients	Good	Fair	Poor	Died	Total
Normotensive	49	12	4	9	74
Treated hypertensive	5	1			6
Untreated hypertensive	9		5	6	20

Although the numbers are small, it seems that those patients with untreated systemic hypertension at the time of surgery had a poor result or died (11 out of 20), while those hypertensive patients who were treated at the time of surgery all had a good or fair result. Furthermore, of the nine patients with a normal blood pressure at rest in the ward who died four had left ventricular hypertrophy at necropsy and one had polycystic kidneys, these findings suggesting pre-existing systemic hypertension.

INTERVAL BETWEEN SUBARACHNOID HAEMORRHAGE AND SURGERY

Although early surgery is desirable after subarachnoid haemorrhage to avoid a second haemorrhage, it has been associated with poor results. Table IV sets out the results related to the interval between subarachnoid haemorrhage and surgery. In our series 58% of patients were operated on in the first week and 22% in the second week. When surgery was carried out in the first week after subarachnoid haemorrhage the mortality was 22%. When surgery was carried out in the second week the mortality fell to 5%, and when the interval between subarachnoid haemorrhage and surgery was greater than two weeks there were no deaths. Patients who were operated on in the second week had a higher incidence of poor results (23%) than those who underwent operation in the first week (7%). This group may have included patients who, had they been operated on in the first week, would have died and a further group of patients whose operation had been delayed by their poor neurological condition.

Of the 35 patients in grade I who were operated on in the first week five died. Of the 14 patients in this grade operated on in the second week after the bleed none died. Indeed the only death in this series, other than in the first week, occurred in a grade III patient operated on in the second week. The surgical mortality seems to be high in the first seven days after the bleed, irrespective of the condition of the patient.

TABLE IV—*Interval between subarachnoid haemorrhage and surgery and results*

	0-7 days	8-15 days	>15 days	No subarachniod haemorrhage
Good	35	14	13	2
Fair	6	2	4	0
Poor	4	5	0	0
Died	13	1	0	1
Total	58	22	17	3

SPASM

Postoperative cerebral vasospasm was recognised by radiological criteria by the reporting radiologist. The distribution of cerebral vasospasm is set out in table V. Local vasospasm was defined as radiographic narrowing of one vessel usually only over a short segment and usually related to the site of the aneurysm; generalised vasospasm was defined as narrowing of more than one main intracranial vessel. The presence of vasospasm on the preoperative angiograms did not relate to the presence of postoperative vasospasm or the clinical result.

Most of our patients developed either local or generalised vasospasm after operation. The development of generalised postoperative cerebral vasospasm correlated with a poor outcome from surgery and, indeed, caused the death of nine of the patients and probably contributed to the death of another. Postoperative vasospasm was unrelated to the type of anaesthetic used; in both the hypothermic group and the hypotensive group the incidence was similar, implying that the potent vasodilating action of sodium nitroprusside does not protect against the development of vasospasm in the doses used.

TABLE V—*Distribution of postoperative cerebral vasospasm and results*

	No vasospasm	Local vasospasm	Generalised vasospasm	No angiogram
Good	19	25	7	13
Fair	1	3	5	3
Poor	2	3	4	0
Died	3	1	9	2
Total	25	32	25	18

Discussion

After a series of careful studies of the results of surgery of intracranial aneurysms in 1960-5 McKissock *et al*[3-5] concluded that surgery was of little overall benefit compared with conservative management. They also stated that patients who survived six months after an initial subarachnoid haemorrhage had little risk of recurrence. Both these points are arguments in favour of conservative management of these patients. Pakarinen,[1] however, in his total population study of the citizens of Helsinki could not agree with their finding of a low recurrence rate six months after subarachnoid haemorrhage: Pakarinen showed that patients treated conservatively, even if they survived one year after subarachnoid haemorrhage, still had a mortality from recurrent haemorrhage of 25% when assessed at five years. He also found recurrences occurring up to 21 years after the initial subarachnoid haemorrhage.

Conservative management becomes less attractive in the light of this information, particularly when obliterating an intracranial aneurysm by direct surgery will prevent a recurrent haemorrhage from that aneurysm. The long-term advantages of direct surgery of intracranial aneurysms are clear, but the effectiveness of surgery must be compared with that of conservative management in terms of mortality within the first six months.

The series of McKissock *et al* has the unique virtue of providing a control series of patients treated conservatively but who were also suitable for surgery. When assessed at six months they had a mortality of 37%.

Surgical results depend especially on how long after the bleed the operation is performed. Unless this information is provided with the results then assessment of the effect of surgery may be difficult. For example, the apparent mortality in our series is 15%. If the four patients who bled waiting for surgery are added, then the "true mortality" is 19%. Alternatively, knowing from Pakarinen's series that 5% of patients die each week in the first five weeks and that 22% of the patients in our series were operated on in the second week and 20% after that, then from theoretical considerations about four patients should be expected to die before surgery. Therefore the "true mortality" in our series is about 19%. In the only other large published series of microneurosurgery for intracranial aneurysms Krayenbuhl *et al*[7] reported a mortality of only 5·6%. But 48% of their patients were operated on after the 14th day and only 24% in the first week after the bleed. Assessing their "true mortality" by referring to Pakarinen's figures brings their mortality to a similar level to that of our series, which was about half that of the control series of McKissock *et al.*

Morbidity is more difficult to assess, there being no well defined end-point. McKissock *et al* classified their patients as being at full work, partially disabled, and totally disabled, whereas Krayenbuhl *et al*[7] had good and poor groups. When doubt existed in our assessment of patients the poorer category was chosen. The McKissock *et al* control series when assessed at six months showed that 10% were partially disabled and 5% totally disabled. Comparison is difficult; allowing for variations in assessment there would seem to be little difference in outcome between the control series, our series, and the series of Krayenbuhl *et al* (12% poor results).

Hypertensive patients pose a particular problem. If untreated at the time of surgery they seem to do badly: 11 out of 20 untreated hypertensive patients had a poor result or died. Although the numbers are small, our results suggest that hypertensive patients might do better if treated before surgery. Experience of further cases (unpublished data) reinforces the view that bringing the blood pressure under control in the interval between subarachnoid haemorrhage and surgery improves the results of surgery.

Cerebral vasospasm remains a major problem for which no treatment is effective once it occurs. It is common but affects the outcome of surgery little unless it is generalised, when it often results in death or disability.

Further improvement in the results will depend on better control of the blood pressure, careful timing of surgery, prevention of rebleeding, and control of vasospasm.

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References

1 Pakarinen, S, *Acta Neurologica Scandinavica*, 1967, **43**, suppl No 29.
2 Crawford, M D, and Sarner, M, *Lancet*, 1965, **2**, 1254.
3 McKissock, W, Richardson, A, and Walsh, L, *Lancet*, 1965, **1**, 873.
4 McKissock, W, Richardson, A, and Walsh, L, *Lancet*, 1960, **1**, 1203.
5 McKissock, W, Richardson, A, and Walsh, L, *Lancet*, 1962, **2**, 417.
6 Botterell, E H, *et al*, *Journal of Neurosurgery*, 1956, **13**, 1.
7 Krayenbuhl, H A, *et al*, *Journal of Neurosurgery*, 1972, **37**, 678.

Diagnostic and therapeutic assessment by telephone electrocardiographic monitoring of ambulatory patients

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Summary

The electrocardiograms of ambulatory patients have been monitored over the telephone by staff of the intensive cardiac care unit using equipment in the unit. Telephone monitoring is a useful way of diagnosing transient symptomatic arrhythmias and a reliable aid in supervising the patient's rhythm at the beginning or end of treatment. The doctor has direct contact with the patient at the time of his symptoms so that he can reassure or instruct him. This system costs relatively little in manpower and equipment and permits relatively long periods of follow-up. It is effective, however, only in symptomatic cases in which the rate or rhythm disturbances last long enough to be transmitted. Also important are the negative findings when the patient complains of symptoms and abnormal findings during routine telephone transmissions. Accurate detection of transient ischaemic changes seems to be less reliable, and further technical improvements are required.

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