Aneurysms of the Vertebrobasilar System*

Surgical Intervention in 19 Cases

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Aneurysms of the vertebral, basilar, cerebellar, and posterior cerebral arteries have received scant attention in neurosurgical writing. They are usually dismissed as “aneurysms in other sites” in published reviews and in reports of large series of intracranial aneurysms. Yet some of these papers indicated the considerable case with which examples of fatal aneurysms of the vertebrobasilar system, managed conservatively or surgically, can be accumulated.

Recently, an increasing literature, consisting chiefly of sporadic reports of successful surgical treatment, draws attention to the importance of these aneurysms. Of particular interest is the clinical and surgical assessment of the problem by Dimsdale and Logue. Drake collected the literature on the subject to 1960. Since that time other writers have reported successful surgery and have advocated more frequent use of vertebral angiography in the investigation of subarachnoid haemorrhage as a result of their optimism regarding the possibility of surgical attack upon aneurysms on these vessels.

It may be suspected, however, that the present literature is considerably biased because successful operations tend to be reported, and unsuccessful ones do not. Thus it is questionable whether such figures as those produced by Drake, obtained by summation of published cases, present a valid picture of the mortality and morbidity which may attend surgical endeavour in this field.

The present paper reports a series of 19 patients with aneurysms of the vertebrobasilar system treated by operation over the past 6 years. The series includes all examples of aneurysm in these sites from a personal experience with over 250 craniotomies for aneurysm in the same period.

Basis of Diagnosis

In 18 of the 19 cases in this series, the aneurysm was the cause of the patient’s illness. In 16 cases subarachnoid haemorrhage from the aneurysm in question was the presenting factor. In 2 others (Cases 1 and 13), the patient was seen because of pressure of the aneurysm on surrounding structures, although in Case 13 earlier haemorrhage from the aneurysm may have occurred. The patient (Case 14) in whom the aneurysm was not the cause of illness suffered a spontaneous intracerebral haemorrhage wrongly believed to have been caused by a fusiform aneurysm of the basilar artery, which was explored and found not to have bled.

Three patients (Cases 4, 12 and 13) were operated upon without prior angiographic demonstration of the lesion. In all other cases the aneurysm was demonstrated by deliberate vertebral angiography, although in Case 1 partial filling of a posterior cerebral aneurysm in a carotid angiogram indicated the desirability of this procedure.

Selection for Surgery

One difficulty in the assessment of the results in any reported series of aneurysms, and of the policy upon which such results are based, is appreciation of factors influencing selection of patients in any particular surgical unit.

In the Brisbane Hospital policy in the management of intracranial aneurysms has
been directed to early attack on all aneurysms which angiography shows to be accessible surgically and operable technically.

In lucid patients without major neurological deficit, the 5th day after haemorrhage is chosen as the day for operation, although limited flexibility is allowed when this particular day is inconvenient. In more seriously ill patients, operation may be delayed longer if the patient's condition is stable and expected to improve. Such improvement is interpreted as a sign of relaxation of vascular spasm, and thus of danger of renewed haemorrhage, and operation follows as soon as possible. The date of operation may be advanced, sometimes to the category of "immediate surgery", when progressive deterioration indicates impending disaster from a space-occupying haematoma, or repeated and frequent haemorrhages appear to demand early intervention for their arrest.

The operation preferred is definitive clipping or ligation of the neck of the aneurysm whenever possible, with trapping of an aneurysm on an expendable (or relatively expendable) vessel, or occlusion of both aneurysm and vessel, as a second choice.

The Department of Neurology and Neurosurgery from which this series is reported is part of a major general public hospital receiving acute and unselected admissions in a capital city. Special admission to a specialist department is not a necessary prelude to neurosurgical consultation or investigation. However, some patients from smaller outlying communities in the State of Queensland must be flown 1,000 miles or more to neurosurgical aid. Thus some selection, geographically determined, of relatively fit patients occurs, while time taken in communication and transport may delay operation beyond the day selected according to the policy stated above.

Most of the patients diagnosed as suffering from subarachoid haemorrhage are referred for neurosurgical opinion. All of these patients are submitted to early angiography except those aged over a flexible chronological limit of 60 years, those in whom associated disease or disability outweighs aneurysm as a threat to longevity, and those who are moribund without suggestion of a space-occupying haematoma.

All but 2 of the aneurysms of the vertebrobasilar system demonstrated radiologically have been attacked surgically. The exceptions were an aneurysm of the posterior cerebral artery discovered as an incidental finding during angiography in a patient with early dementia, and an aneurysm of the basilar bifurcation which bled again, fatally, too soon after angiography for surgery to be possible.

Thus both the policy and the practice followed in this series are at least as radical as any advocated by the protagonists of more active surgical attack upon vertebrobasilar aneurysms.

Case Reports

Since so many of these patients exhibited features of particular interest, all cases are reported. For convenience, the aneurysms have been divided into 4 groups according to site, chronological order being observed in each group.

A summary of the clinical features is given in Table 1.

Group A. Aneurysms of the Posterior Cerebral Artery—4 Cases.

Case 1. P.H., a 21-year-old fitter and turner, suffered a minor head injury on Dec. 13, 1957 without loss of consciousness. Four days later profound paralysis of his left limbs developed suddenly, and his right upper eyelid drooped. The cerebrospinal fluid was normal. A right parietal burr hole, made on suspicion of complication of the head injury, disclosed no abnormality. On Jan. 13, 1958, he was transferred 700 miles to our care.

Examination. The patient was alert and normotensive. The only neurological abnormality was severe left hemiplegia, maximal in the arm. Function of the 3rd nerve was normal.

Right carotid angiography showed a large fusiform aneurysm on the right posterior cerebral artery which filled poorly. Vertebral angiography confirmed this finding (Fig. 1a).

Operation was performed, under induced hypothermia, by a posterior subtemporal approach. The tentorium was divided to improve access. The aneurysm was fusiform, and embedded firmly for more than half its circumference in the lateral aspect of the cerebral peduncle. Excision of the aneurysm was decided upon and a clip
was placed across the posterior cerebral artery distal to the aneurysm. The clip stuck in the applicator forceps, and the aneurysm was avulsed when these were withdrawn. The proximal end of the posterior cerebral artery was caught eventually and clipped as it lashed about in the interpeduncular cistern, but in this process the oculomotor nerve was injured.

Course. Five years later, the patient still has left hemiplegia and left hemianopia, with incomplete recovery of the right 3rd nerve. However, he has married since operation, has 2 children, and works full time as an insurance assessor.

**Case 2.** W.H., a 47-year-old male hairdresser, vomited and collapsed with loss of consciousness while doing morning exercises on Aug. 29, 1960. He was admitted next day complaining of headache and stiffness of the neck.

**Examination.** The patient was conscious. He

<table>
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<tr>
<th>Case</th>
<th>Patient &amp; Date of Admission</th>
<th>Age and Sex</th>
<th>Blood Pressure</th>
<th>Side</th>
<th>Vertebral Angiogram</th>
<th>No. of Bleedings</th>
<th>Interval Last Bleeding to Operation</th>
<th>Operation</th>
<th>Complication</th>
<th>Result</th>
<th>Deficit</th>
<th>Employment</th>
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<td>1</td>
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<td>M</td>
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<td>R</td>
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<td>Hemiplegia, hemianopia, 3rd nerve</td>
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<td>M</td>
<td>140/90</td>
<td>R</td>
<td>Yes</td>
<td>1</td>
<td>7 weeks</td>
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<td>Motor atrophy, mental impairment</td>
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<td>230/110</td>
<td>R</td>
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<td>1</td>
<td>6 days</td>
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<td>170/100</td>
<td>L</td>
<td>Yes</td>
<td>3</td>
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<td>1</td>
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<td>Other aneurysms</td>
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<tr>
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<td>M</td>
<td>190/110</td>
<td>R</td>
<td>Yes</td>
<td>1</td>
<td>5 days</td>
<td>Clip &amp; trap</td>
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<td>F</td>
<td>120/90</td>
<td>L</td>
<td>Yes</td>
<td>1</td>
<td>5 days</td>
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<td>3rd nerve, mental dulling</td>
<td>Subsequent death</td>
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<td>165/110</td>
<td>L</td>
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<td>L</td>
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<td>1</td>
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<td>Clipping</td>
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was normotensive and severe stiffness of the neck was the only clinical abnormality. The cerebrospinal fluid was heavily blood-stained at a pressure of 120 mm.

Bilateral carotid angiograms were normal. Vertebral angiography demonstrated a saccular aneurysm on a branch of the left posterior cerebral artery, which disappeared distally into a small arteriovenous malformation (Fig. 1b).

Operation. On the 4th day after the haemorrhage, the aneurysm was approached subtemporally after division of the tentorial edge. A small branch of the left posterior cerebral artery, arising almost at the origin of that vessel, ran parallel and inferior to it around the peduncle. Between the left 3rd and 4th cranial nerves, a saccular aneurysm with blood clot on its fundus hung from this small arterial branch. A small vessel from the fundus of the aneurysm disappeared under the 3rd nerve. The arteriovenous malformation consisted of small-calibre vessels in the ambient cistern, without evidence of haemorrhage. The neck of the aneurysm was clipped, sparing its parent vessel.

Course. There was an immediate and complete paralysis of the left oculomotor nerve. The patient resumed his previous occupation, with gradual recovery of the lesion of the 3rd nerve.

Case 3. G.A., a 34-year-old housewife, was well until 5 weeks before admission when she arose one morning and complained of sudden pain in the head and neck. She was admitted to a country hospital suffering from “lethargy, drowsiness, nocturnal delirium and inability to concentrate” until July 8, 1961, when she was transferred 200 miles to this hospital for psychiatric assessment.

Examination. The patient was conscious, but very drowsy, and disoriented in time and place. Blood pressure was normal. There was slight stiffness of the neck. The optic fundi showed consecutive optic atrophy, and visual acuity was too poor for counting of fingers. Both pupils were dilated widely and the left eye showed divergent strabismus. All tendon reflexes were hyperactive; the plantar responses were normal. Sufficient cooperation could not be obtained for formal testing of cerebellar function.

Bilateral carotid angiography showed an aneurysm projecting downwards from the anterior communicating artery, but no evidence that this had bled. There was also evidence of hydrocephalus. Vertebral angiography demonstrated bilateral almost symmetrical aneurysms of the posterior cerebral artery (Fig. 1c). Ventriculography revealed bilateral symmetrical hydrocephalus caused by ambient cisternal obstruction.

Operation. Craniotomy by right temporal osteoplastic flap, under induced hypothermia, was undertaken on July 20, 1961, 7 weeks after the presumed haemorrhage. The temporal pole was amputated and the tentorium was divided to improve access.

The right aneurysm was saccular and passed downward and laterally to perforate the right oculomotor nerve which bifurcated into a larger medial and smaller lateral bundle to surround the neck of the aneurysm. The arachnoid mater in the area was stained yellow, while the aneurysm showed a fundal defect from which firm clot protruded. The lateral portion of the bifurcated nerve was divided to expose the neck of the aneurysm which was then clipped.

The left aneurysm was exposed next and was of fusiform type. Since the left posterior communicating artery appeared normal in size, the aneurysm was trapped by clipping the left posterior cerebral artery proximally near its origin,
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and distally just before the posterior choroidal artery.

Course. The patient was at first stuporose, but consciousness was restored by the 4th postoperative day. There was a right hemiparesis and a curious tremor of the left limbs of red nucleus type. Thereafter the patient's condition deteriorated, and on Aug. 23, 1961 ventriculography was repeated. The ventricular pressure was 210 mm., while the films showed communicating hydrocephalus as before. Spinopelitoneostomy on Aug. 31, 1961 established normal pressure, and thereafter improvement occurred steadily.

Five months later, memory and physical activity had improved sufficiently for discharge to her home from a convalescent hospital, and vision in the right eye had recovered to 6/6, while that in her left eye was less than 6/60.

Case 4. S.G., a housewife aged 29 years, suffered a sudden severe headache and vomited. She lost consciousness, and recovered to find that her right eye had closed.

Examination. The patient was confused, with stiff neck, complete right oculomotor palsy, and arterial hypertension (250/140).

Right carotid angiography demonstrated a saccular aneurysm on the internal carotid artery at the level of the posterior communicating artery (which did not fill), and a second aneurysm at the first bifurcation of the right middle cerebral artery.

Operation. On the 6th day after haemorrhage, Nov. 13, 1962, hypothermia was induced and a right frontotemporal osteoplastic flap was cut for the purpose of clipping the aneurysm of the internal carotid artery. The sylvian fissure was dissected first to secure the aneurysm of the middle cerebral artery against accident during retraction—it had not bled and its neck was clipped. The aneurysm of the internal carotid artery then was exposed and found to be intact. Behind it the basal cisterns were filled with clot which was cleared to expose an unexpected aneurysm, about 2 cm. in diameter, on the anterior surface of the right cerebral peduncle, in close relation to the right posterior cerebral artery (Fig. 1d). Arterial hypotension was induced but the aneurysm remained tense from contained clot which protruded through a small rent on its antero-inferior surface. The posterior cerebral artery was therefore held proximal to the aneurysm, which was excised to provide access. The neck of the aneurysm was too wide for clipping and was trapped by occlusion of the posterior cerebral artery proximal and distal to it, leaving an apparently adequate right posterior communicating artery in continuity with the distal posterior cerebral artery.

An attempt then was made to clip the neck of the aneurysm of the internal carotid artery. The neck split and the rent extended into the carotid artery which required occlusion below and across the origin of the posterior communicating artery to control haemorrhage.

Course. The patient regained consciousness at stuporose level, but exhibited profound left hemiplegia. Gradual and progressive deterioration, despite continued hypothermia, ended in death 48 hours later.

Autopsy. The chief findings were gross infarction of the whole right cerebral hemisphere and extensive haemorrhages of the brain stem.

Group B. Aneurysms of the Basilar Bifurcation—7 Cases.

Case 5. A.W., a 53-year-old labourer, suffered a moderately severe attack of headache and stiffness of the neck. One week later he had an exacerbation of bilateral temporal and occipital headache, with persistent nausea and vomiting. The cerebrospinal fluid obtained by lumbar puncture was heavily blood-stained. Two weeks later he had a further haemorrhage resulting in coma from which he recovered with left facial twitching, narrowing of the left palpebral fissure, and right hemiplegia, all of which receded rapidly. On the following day, Feb. 14, 1959, he was transferred 300 miles to this hospital.

Examination. He was conscious but very drowsy and disoriented, with stiffness of the neck, but there were no localizing signs. A previously mild diabetes mellitus had exacerbated and required some days for adequate control. Blood pressure was elevated (170/100).

Bilateral carotid angiography demonstrated a small rounded aneurysm on the medial aspect of the right internal carotid artery, but the appearance of this suggested its innocence. Vertebral angiography showed an irregularly shaped aneurysm, measuring 1.5 cm. in its largest diameter, passing upwards and to the left from the basilar bifurcation (Fig. 3a).

Operation. Under induced hypothermia, on the 10th day after haemorrhage, the aneurysm was approached subtemporally from the right side. The aneurysm was cleared of adherent blood clot, and was found to have taken up the basilar bifurcation in its neck so that both posterior cerebral arteries arose directly from it. The fundus was grossly atheromatous. Since no way could be found of occluding the sac or clipping the neck, the aneurysm was wrapped in muscle and gauze.

Course. Consciousness was regained soon after operation, and the only apparent deficit was a partial lesion of the right 3rd nerve. During the night there was sudden deterioration with left hemiplegia which progressed to decerebrate coma, and in this state the patient remained until his death on the 5th day after operation.

Permission for autopsy was refused.
Case 6. G.R., a housewife aged 42 years, complained of sudden onset of severe throbbing pain in the back of the neck and shoulders, followed by vomiting. Later, a right-sided headache had developed.

Examination. The patient was conscious and alert. She had a stiff neck, and was normotensive. A diagnosis of subarachnoid haemorrhage was confirmed by lumbar puncture.

Bilateral carotid angiography demonstrated an aneurysm at the bifurcation of the left internal carotid artery (Fig. 2b). Vertebral angiography showed an aneurysm at the bifurcation of the basilar artery (Fig. 2c). There was no radiological evidence as to which one had bled.

Operation. A left frontotemporal osteoplastic flap was cut on the 4th day after the haemorrhage. The aneurysm of the internal carotid artery showed no evidence of recent haemorrhage. Its neck was occluded with a clip. The basilar aneurysm was then approached by division of the left posterior communicating artery. A silver clip was placed across the neck of this aneurysm which was surrounded by blood clot.

Course. The patient regained consciousness, but had a lesion of the left oculomotor nerve and right hemiplegia. On the next day, the level of consciousness slowly deteriorated. The wound was reopened and a haematoma was evacuated from the left frontal lobe. Some improvement occurred then but was not maintained. Death occurred on the 2nd day after operation.

Permission for autopsy was not granted.

Case 7. H.S., a 43-year-old electrician, awoke with severe pain behind the right eye, and vomited. Stiffness of the neck and diplopia developed. The cerebrospinal fluid was blood-stained, and he was transferred 700 miles to our care on Nov. 23, 1960.

Examination. He was fully conscious and alert, with blood pressure 190/110. The sole neurological abnormality was an incomplete right oculomotor palsy.

Bilateral carotid angiography showed marked tortuosity of the carotid vessels. Vertebral angiography demonstrated a saccular aneurysm arising from the basilar bifurcation and extending upward and to the right (Fig. 2d).

Operation. Under induced hypothermia on the 5th day after the onset of the illness the aneurysm was approached by the right subtemporal route. It arose by a broad neck from the summit of the bifurcation and the proximal portion of the right posterior cerebral artery. A clip was placed diagonally across the neck of the aneurysm and the origin of the right posterior cerebral artery, and further clips occluded the fundus.

Course. Full consciousness was regained rapidly. There was a complete right oculomotor palsy, and a transient left hemiplegia. Visual fields were full.

Case 8. J.F., a 56-year-old company director, had suffered severe headaches for 3 months before the onset of a sudden headache associated with vomiting and culminating in coma, on Nov. 2, 1961.

Examination. He was conscious but confused, with severe stiffness of the neck but no localizing signs. Blood pressure was normal.

Bilateral carotid angiograms demonstrated a small rounded aneurysm at the origin of the right anterior choroidal artery, but there was no evi-
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dence that it had bled. Vertebral angiography revealed an aneurysm, 1.2 cm. in length, passing upward, backward, and to the left from the basilar bifurcation (Fig. 2e).

Operation. On the 5th day after haemorrhage, under induced hypothermia, the aneurysm was approached subtemporally from the right. The neck of the aneurysm was clipped after a short period of brisk haemorrhage when the fundus was delivered from the interpeduncular recess.

Course. Recovery of consciousness was slow, and a right oculomotor palsy was present. Eight days after operation his level of consciousness deteriorated. Repeated right carotid angiography showed subdural avascularity and swelling of the temporal lobe. The wound was reopened to evacuate a subdural haematoma and to excise the infarcted temporal pole. Steady improvement occurred then. Ventriculography in the 6th week showed a dilated ventricular system, but no obstruction, and ventricular pressure was less than 200 mm.

Three months later the patient was much more alert and active, though still severely handicapped.

Case 9. R.G., a customs officer aged 36 years, suffered severe occipital headache after exercise. He appeared shocked and his neck was stiff. The cerebrospinal fluid was heavily blood-stained. Nine days later he was transferred 1500 miles to this hospital on Dec. 5, 1961. His father and his paternal grandfather had died of cerebral vascular accidents when aged 44 years and 42 years respectively.

Examination. He was fully conscious, mildly hypertensive (165/110), with stiffness of the neck but with no localizing neurological signs.

Bilateral carotid angiograms showed no aneurysm, but the right carotid system showed evidence of spasm. Right carotid angiography was therefore repeated after an interval, the appearances being normal at that time. A vertebral angiogram showed an aneurysm, 1.5 cm. long, extending upward and backward from the basilar bifurcation (Fig. 2f).

Operation. On the 16th day after haemorrhage, under induced hypothermia, the aneurysm was approached subtemporally from the right. It was binocular, with thin-walled blisters on each loculus, and there was an atheromatous plaque on the basilar artery just below the neck of the aneurysm. Arterial hypotension was induced and an attempt was made to mobilize the fundus which adhered to the left peduncle. The aneurysm split from fundus to neck adjacent to the atheromatous plaque. The basilar artery was occluded proximally temporarily while oblique clips were placed across the neck of the aneurysm and the origin of the left posterior cerebral artery.

Spontaneous respiration ceased during this period, but recovered when induced hypotension reverted to normal.

Course. Consciousness was not regained, although purposive response of all limbs soon could be elicited. Thereafter the patient deteriorated steadily and died 5 days after operation.

Autopsy. The clips occluded the neck of the aneurysm and the origin of the left posterior cerebral artery. The right posterior cerebral artery was patent at its origin and throughout its course. There was infarction of the territories of the right middle and both posterior cerebral arteries, with gross swelling and haemorrhage of the brain stem.

Case 10. J.G., a 32-year-old railway porter, suffered a sudden severe occipital headache on June 26, 1962 and had to lie down. He then had a severe fit of coughing, his headache worsened, his neck became stiff, and he became drowsy. Over the next 8 hours he lapsed slowly into semicoma.

Examination. The patient was unconscious, responding purposively to painful stimuli. There was a right external strabismus and both plantar reflexes were extensor. Blood pressure was 130/90. On lumbar puncture the cerebrospinal fluid was heavily blood-stained at a pressure of over 400 mm.

Bilateral carotid angiograms showed no abnormality. A vertebral angiogram revealed an aneurysm, 1.4 cm. in diameter, passing up and back from the basilar bifurcation (Fig. 2g).

His clinical state improved gradually but deteriorated again at the end of the 2nd day to recover again on the 3rd day.

Operation. On the 3rd day after the onset of the illness, under induced hypothermia, subtemporal approach to the aneurysm was undertaken from the right side. The pontine cistern was full of blood clot. The aneurysm was adherent to the right posterior cerebral artery, which was divided proximal to the posterior communicating artery to permit mobilization of the aneurysm, which then ruptured. The neck of the aneurysm and the origin of the right posterior cerebral artery were occluded with a clip.

Course. Full consciousness and normal body temperature were not regained. Hypothermia persisted spontaneously at levels ranging from 29° to 32°C. At times the patient would obey command, and purposive response was good with the right limbs but poor with the left. Death occurred after 10 days.

Autopsy. The brain was swollen and congested, with infarction of the right hemisphere. The right thalamus was softened grossly and there were major haemorrhages in the midbrain and pons, especially on the right, with softening and early liquefaction. The right posterior cerebral and superior cerebellar arteries were thrombosed, and
several posterior perforating arteries were caught by the clip. All other vessels were patent.

There were extensive haemorrhages into the mucosa of the alimentary canal and into the kidneys, thought to be secondary to hypothermia.

Case 11. V.M., a housewife aged 52 years, suffered from chronic pyelonephritis, hypertension and malaria, and was receiving hypotensive therapy when a sudden severe occipital headache developed on Jan. 29, 1963. Twelve hours later she collapsed and was unconscious for 10 minutes, but recovered fully. Three days later she suffered a further severe headache with stiffness of the neck. The cerebrospinal fluid obtained by lumbar puncture was heavily blood-stained and she was transferred 170 miles to this hospital on Feb. 2, 1963.

Examination. The only abnormalities found were stiffness of the neck, palsy of the left lateral rectus muscle, and hypertension (160/100).

Bilateral carotid angiograms were normal. Vertebral angiography showed an aneurysm at the basilar bifurcation, projecting directly backward (Fig. 2h).

Several further episodes suggesting renewed haemorrhage occurred, but none was severe.

Operation. Seven days after the last major haemorrhage, hypothermia was induced and the aneurysm was approached subtemporally from the right. The basilar artery was occluded temporarily while the aneurysm was dissected. It arose from a broad base which, together with the origin of the right posterior cerebral artery, was occluded from the basilar circulation by a silver clip placed obliquely. Since portion of the aneurysmal neck still opened into the posterior cerebral artery, this vessel was occluded again just distal to the aneurysm.

Course. The patient remained almost fully comatose with fixed dilatation of the right pupil until death on the 4th postoperative day.

Autopsy. Chief findings were infarction in the territories of the right middle and posterior cerebral arteries, and of both superior cerebellar arteries. The upper brain stem was disorganized and partly liquefied, and the end of the basilar artery contained antemortem thrombus.

Group C. Aneurysms of the Basilar Trunk—3 Cases.

Case 12. M.N., a 44-year-old housewife, a known hypertensive, suffered an unusually severe headache of sudden onset which forced her to retire to bed. She lost consciousness 48 hours later. A diagnosis of subarachnoid haemorrhage was confirmed by lumbar puncture on Dec. 26, 1938.

Examination. The patient was drowsy and confused, with stiff neck and hypertension (200/140).

Intermittent myoclonic jerking of the right arm and leg suggested lateralization. Both plantar responses were extensor.

Bilateral carotid angiography demonstrated no aneurysm but slight midline shift to the right and elevation of the left sylvian fissure.

Two days later, right hemiparesis became apparent, and on the 3rd day she was drowsier with enlargement of the left pupil. On the 4th day, she was stuporose and left oculomotor palsy was complete.

Repeated left carotid angiography showed increase in the previous abnormalities. Vertebral angiography was not performed.

Operation. A left temporal osteoplastic flap was cut on the 5th day after the 2nd haemorrhage. The left temporal lobe showed subarachnoid blood-staining, and was elevated to allow inspection of the tentorial margin and posterior communicating artery. A profuse gush of blood-stained cerebrospinal fluid was followed by copious haemorrhage and apnoea. The tentorial margin was cut, the posterior communicating artery was divided and a vascular orifice, source of profuse haemorrhage immediately below the posterior cerebral artery, was occluded by a clip. The blood pressure had been rising steeply since respiratory arrest despite adequate artificial ventilation, and death occurred on the operating table.

Autopsy. The clip was found to be occluding the neck of an aneurysm arising from the basilar artery between the posterior cerebral and superior cerebellar arteries (Fig. 3a). No other significant lesion was seen.

Case 13. L.B., a 57-year-old housewife, in 1949 had suffered a serious illness regarded as a cerebral vascular accident. On June 24, 1959 she presented
A history of left-sided headache, constant stiffness of the neck, recurrent left facial neuralgia, and numbness of the right arm and leg, which collapsed readily, over a period of years. Articles dropped readily from the left hand, control of which was poor, while speech and balance were deteriorating. Headache was paroxysmal and had become increasingly violent during the previous 3 months.

Examination. The patient exhibited stiffness of the neck, left facial hypoesthesia, left spinothalamic sensory loss, signs of the right posterior column, bilateral cerebellar incoordination, maximal on the left, and bilateral pyramidal signs, maximal on the right.

Ventriculography showed bilaterally symmetrical hydrocephalus of moderate degree, without apparent obstruction or displacement. The 4th ventricle appeared normal but, in retrospect, filling at this level was not good.

The patient became unconscious 72 hours later.

Operation. Decompression of the posterior fossa was performed. It was apparent immediately that there was a large tumour anterior to the lower part of the medulla oblongata. It had the appearance of an aneurysm, and aspiration confirmed that it contained blood. It measured 3 cm. in diameter.

The aneurysm was mobilized to determine the vessel of origin, and free haemorrhage occurred. Clips were applied to the left and to the right vertebral artery before the origin of the aneurysm from the lower end of the basilar artery was identified (Fig. 3b). It proved impossible to control haemorrhage except by occlusion of the lower end of the basilar artery.

Apnoea occurred with the onset of haemorrhage, and the patient died on the operating table.

Case 14. D.T., a grazier aged 36 years, known to be hypertensive, had suffered severe headaches for some time. On Feb. 25, 1963 he experienced a particularly severe and sudden headache, and the next morning was found drowsy, confused and ataxic, with slurred speech. He was taken to a hospital where his condition deteriorated. He was transferred 200 miles to this hospital.

Examination. The patient was semicomatose with brisk and purposeful response to painful stimuli. Stiffness of the neck, right oculomotor palsy, left hemiplegia, and hypertension were the dominant findings.

Immediate right carotid angiography showed an avascular space-occupying lesion of the temporal lobe, presumed to be haematoma.

The next morning the patient had improved to a level of muttering when annoyed. Vertebral angiography demonstrated a grossly tortuous basilar artery with a fusiform aneurysm of its upper part including the bifurcation (Fig. 3c).

That evening a further haemorrhage occurred, producing sudden loss of consciousness, decerebrate rigidity, periodic respiration, and apparent impending death. However, his condition stabilized, and urgent operation was undertaken.

Operation. Hypothermia was induced, a right temporal flap was cut, the tentorium was divided, and the basilar artery was inspected. The aneurysm was fusiform, thick-walled and intact. The right 3rd nerve was crushed by the right posterior cerebral artery. A large haematoma was found deep in the substance of the right temporal lobe. It had ruptured into the temporal horn, but was separated from the basilar artery by intact brain. The haematoma was evacuated, and haemostasis was established. The aneurysm was not further disturbed.

Course. Recovery of consciousness was slow, complicated by hyperthermia and respiratory irregularity. Six months later the lesion of the 3rd nerve is recovering, the hemiplegia is improving, and, despite left hemianopia, he is able to read efficiently.

Group D. Vertebral Aneurysms—5 Cases.

Case 15. M.D., a 42-year-old housewife, was found lying on the ground unconscious on Oct. 16, 1962. She recovered consciousness but was drowsy, vomited repeatedly, and had a stiff neck.

Examination. The patient, when admitted, was stuporous, with severe stiffness of the neck and a left abducens palsy. There were no other localizing neurological signs. Blood pressure was normal.

Urgent ventriculography was performed on the day of admission because of deteriorating consciousness. The films showed moderate ventricular dilatation, with complete obstruction at the level of a filling defect in the lower part of the 4th ventricle.

Operation. An immediate decompression of the posterior fossa revealed soft blood clot in the cisterna magna and lower end of the 4th ventricle. The clot was removed together with the choroid plexus of the 4th ventricle, but no cause of haemorrhage was found.

Course. The patient was conscious, complaining of severe headache and stiffness of the neck.

The next day, bilateral carotid angiograms showed no abnormality, but vertebral angiography revealed an aneurysm, 1 cm. long, passing upwards and medially from the left vertebral artery about 2 cm. from its termination in the basilar artery (Fig. 4a).

2nd Operation. On the 5th day after the haemorrhage, the previous decompression was reopened. The aneurysm was identified readily. As separation of its fundus from the facial and auditory nerves was attempted, the aneurysm ruptured, and apnoea occurred. The left vertebral artery
was clipped above and below the aneurysm to trap it. The proximal clip was distal to the posterior inferior cerebellar artery. In this process, the left 6th, 7th and 8th nerves were injured. Tarsorrhaphy was performed.

Course. Consciousness was regained quickly. The only apparent defects were left facial and ab ductus palsy.

Over the next month, the patient became stuporous gradually with complaint of severe headache and vomiting. Repeated ventriculography demonstrated obstructive hydrocephalus with no escape of air from the 4th ventricle. A phenolsulphonephthalein test confirmed the presence of noncommunicating hydrocephalus. One month after the operation for aneurysm, ventriculopereoneuroscopy was performed on Nov. 20, 1959.

Melaena occurred 6 days later, followed by further heavy gastrointestinal haemorrhage the next day. Bleeding continued intermittently during that day, so that in the early morning of Nov. 28, 1959 partial gastrectomy was done for a large chronic duodenal ulcer in the first part of the duodenum.

The patient improved steadily to full consciousness, but on Dec. 10, 1959 she complained again of headache and nausea, and the suboccipital decompression appeared tense. The ventricles were tapped with temporary relief, but return of symptoms indicated obstruction of the ventriculopereoneuroscopy, which was explored and replaced on Dec. 14, 1959. This failed to relieve the intraventricular pressure. Lumbar puncture indicated that the hydrocephalus was now of communicating type, and on Dec. 22, 1959 spinoperitoneoscopy was performed, with gratifying improvement for 8 days.

On Dec. 25, 1959 the patient's condition deteriorated steadily. Lumbar puncture indicated the presence of meningitis which was treated energetically, but on the next day melaena recurred and was repeated until death on Dec. 28, 1959, 10 weeks after admission.

Autopsy. Postbasal meningitis and softening of the left half of the medulla posterior to the olive were found. All vessels were patent except the trapped segment of the left vertebral artery.

Case 16. R.B., a farmer's wife aged 42 years, collapsed with severe headache on Oct. 21, 1959.

Examination. The patient was drowsy and irritable and exhibited stiffness of the neck and photophobia. She was moderately hypertensive (170/90). The cerebrospinal fluid obtained by lumbar puncture was heavily blood-stained.

Bilateral carotid angiograms demonstrated two aneurysms—one on the right internal carotid artery at the level of the posterior communicating artery, and one on the right middle cerebral artery (Fig. 4b).

Operation. On the 3rd day after the haemorrhage, both aneurysms were clipped without difficulty through a right frontal osteoplastic flap. There was no definite evidence that either had bled.

Course. The patient was well, without neurological deficit, until the 4th day, when she deteriorated suddenly, becoming stuporous with tachycardia, hypotension, constricted pupils and rising temperature. Severe stiffness of the neck returned.

Vertebral angiography showed an aneurysm on the right vertebral artery at the level of the posterior inferior cerebellar artery (Fig. 4c).

2nd Operation. On the 4th day after the 2nd haemorrhage a right suboccipital decompression was performed, and the aneurysm was exposed. The facial and auditory nerves crossed the upper pole, and the glossopharyngeal, vagus and accessory nerves crossed the lower pole of a sac which expanded the junction of the vertebral and the posterior inferior cerebellar arteries (the latter
arising from the aneurysm). As the aneurysm was dissected from these nerves, rupture occurred. Haemorrhage was arrested by clipping of these vessels as they entered or left the aneurysm.

Course. The patient was slowly regaining consciousness when sudden collapse and death occurred 1 hour postoperatively.

Permission for autopsy was refused.

Case 17. M.O., a 31-year-old housewife, was found semiconscious on the floor, moaning, sweating and restless. She recovered consciousness but complained of severe headache, stiffness of the neck and photophobia. On lumbar puncture the cerebrospinal fluid was heavily blood-stained. She was flown 1000 miles to this hospital, 4 days later, on Sept. 22, 1962.

Examination. The patient was fully conscious, and complained only of giddiness and headache. There were no abnormal neurological signs except for stiffness of the neck, and blood pressure was normal.

Left carotid angiography showed a small aneurysm on the medial side of the internal carotid artery. An attempt at right carotid angiography was not successful.

Two days later a progressive right facial palsy developed. An attempt at right vertebral angiography failed, but left vertebral angiography demonstrated a bilocular aneurysm at the level of the posterior inferior cerebellar artery (Fig. 4d). Because of increasing headache and confusion, ventriculography was performed, and high ventricular pressure and mild hydrocephalus with poor filling of the 4th ventricle were demonstrated.

Operation. On the 15th day after the initial haemorrhage a full decompression of the posterior fossa was performed. The aneurysm, together with a large false sac (thus the bilocularity) was found and mobilized. The hypoglossal and spinal accessory nerves crossed the origin of the aneurysm and were divided. The vertebral artery was clipped above and below the aneurysm, and a clip was applied to the posterior inferior cerebellar artery which arose from it.

Course. There was early giddiness, ataxia and dysphagia, but these improved steadily. Four weeks later, minimal ataxia and hypoglossal palsy were the only abnormalities detected.

Case 18. J.W., a 40-year-old farmer, suffered severe headache on June 29, 1963 which persisted for several days. Ten days later there was an episode of transient loss of consciousness. The cerebrospinal fluid was blood-stained and he was transferred 500 miles to this hospital on July 17, 1963.

Examination. The patient was drowsy, confused, and rambling. Vision in each eye was poor (less than 6/60) and retinoscopy revealed extensive bilateral subhyaloid haemorrhages. His neck was stiff but there were no localizing signs. Blood pressure was normal.

Bilateral carotid angiograms on July 17, 1963 showed severe spasm of the right internal carotid and anterior cerebral arteries. Repeated carotid angiography 4 days later showed more severe and widespread spasm, which was unchanged when this study was repeated again on July 29, 1963. Vertebral angiography, on the same day, showed marked spasm which prevented satisfactory filling.

Repeated bilateral vertebral angiography on Aug. 7, 1963 demonstrated an aneurysm, 1.4 cm. long, arising from the right vertebral artery near the origin of the posterior inferior cerebellar artery, and extending upwards (Fig. 4e). Throughout this period the patient exhibited a fluctuating state of headache, confusion and stiffness of the neck.

Operation. Four weeks after the 2nd haemorrhage, a decompression of the right posterior fossa was performed. The aneurysm was found, covered by old blood clot and arising by a broad neck immediately opposite the posterior inferior cerebellar origin. To obtain access, the latter vessel was divided distal to its posterior spinal branch, and the hypoglossal and spinal accessory nerves were severed. The fundus of the aneurysm was excised, and its neck was occluded by three clips.

Course. The early postoperative period was difficult, with severe dysphagia and hoarseness, but improvement occurred steadily. At the time of discharge from hospital visual acuity was improving, but still poor.

Case 19. P.P., a housewife aged 46 years, suffered sudden severe pain around the left orbital region, felt dizzy and collapsed on July 30, 1963. The pain spread gradually to become a left-sided headache, and she vomited. For some years there was a history of an irritating cough and of intermittent paraesthesia in the left arm and occasionally in the right arm.

Examination. The patient was conscious, with stiff neck and normal blood pressure. There were no objective localizing signs. The cerebrospinal fluid was heavily stained with blood.

Bilateral carotid angiograms were normal, but bilateral vertebral angiography showed an aneurysm passing upwards and curving medially from the left vertebral artery at the level of its posterior inferior cerebellar branch (Fig. 4f).

Operation. On the 4th day, the aneurysm was exposed through a decompression of the left posterior fossa. Its fundus was adherent to the medulla, and showed a small posterior rent plugged by clot. The sac was mobilized and its neck was clipped without difficulty after the division of some spinal accessory fibres.
Course. Recovery was uneventful, and the patient was discharged home on the 12th postoperative day.

Comment

Several anatomical, pathological, radiological, and clinical features warrant special comment.

1. Anatomical Considerations.

(a) The 3rd cranial nerve. The special vulnerability of the oculomotor nerve to lesions of the posterior cerebral artery is well known. Of particular interest in the present series is the relation of this nerve to the aneurysms in Cases 2 and 3 (Fig. 5).

In Case 2, the aneurysm arose from an anomalous branch of the posterior cerebral artery, and from its fundus a small vessel disappeared into the oculomotor nerve. Occlusion of the aneurysm, and of its neck, resulted postoperatively in a complete oculomotor palsy.

In Case 3, the right-sided aneurysm perforated the 3rd nerve which bifurcated about its neck. Clearly the aneurysm was on a vessel similar to that in Case 2, but arising directly from the posterior cerebral artery. The red nucleus tremor that developed postoperatively may well represent the known termination of this vessel in the region of the nucleus rubra.

(b) Multiple vascular anomalies. The frequency of multiple vascular anomalies in this series is noteworthy.

Aneurysms of the vertebrobasilar system in 19 cases were associated with: (i) aneurysms of the carotid system in 7 patients (Cases 3–6, 8, 16 and 17); (ii) symmetrical aneurysm on the other posterior cerebral artery in Case 3; and (iii) arteriovenous malformation and an anomalous vessel in Case 2.

This experience emphasizes the need for careful assessment of any abnormality demonstrated by angiography to determine whether it is the lesion responsible for the patient’s illness. Error in this regard is demonstrated by Cases 4 and 14, and by 2 patients, not included in this series, who had been submitted to surgery for aneurysms of the carotid system (one on the anterior communicating artery and one at the origin of the ophthalmic artery), but who died later from recurrent haemorrhage from unsuspected basilar aneurysms—a salutary experience apparently shared by McKissock and Walsh.

(c) Site. Twenty aneurysms were found in 19 patients. These 19 cases represent approximately 7 per cent of the author’s cases of aneurysm treated surgically. Of these 20 aneurysms of the vertebrobasilar system, 10 occurred on the basilar artery itself, while the other 10 were equally divided between the posterior cerebral and vertebral arteries. Of those aneurysms not on the basilar artery itself, 5 were on the left and 5 were on the right.

2. Pathological Considerations.

(a) Type of aneurysm. Of these 20 aneurysms, 17 were saccular, and 3 (Cases 1, 3 and 14) were fusiform in type. All of the saccular aneurysms had bled at some time, but none of the fusiform aneurysms had been the source of haemorrhage. Two of the 3 fusiform aneurysms (Cases 3 and 14) were incidental findings, while the 3rd (Case 1) had produced disability by compression of the cerebral peduncle. One saccular aneurysm (Case 13) presented finally as a space-

![Fig. 5. Oculomotor nerve. (a) Case 2. Sketch of the upper end of the basilar artery. The left posterior cerebral artery bifurcates in anomalous fashion at its origin. An aneurysm arises from the lower branch, which terminates in an arteriovenous malformation. From the fundus of the aneurysm a vessel which disappears under the left oculomotor nerve (L) which crosses the reduplicated superior cerebellar artery.](image)
occupying lesion, but the previous history suggests earlier haemorrhage.

(b) Hydrocephalus. Hydrocephalus of clinical importance was found in 4 patients. In Case 13 it was ascribed to the obstructive effect of an aneurysm acting as a space-occupying tumour in the posterior fossa, requiring excision of the aneurysm for its relief. In Case 3 there was ambient cisternal obstruction by haemorrhage, which required surgical relief. The cause of hydrocephalus in Case 8 was not determined, and resolution was spontaneous. In Case 15 hydrocephalus was at first acute because of obstruction of the 4th ventricle, and required urgent decompression; later it was subacute as a result of subarachnoidal obstruction, which necessitated surgical by-pass.

(c) Associated vascular disease. Of the 19 patients, 10 were relatively normotensive (blood pressure 150/90 or under) and 9 were hypertensive (blood pressure 165/110 or over). Of the 9 hypertensive patients, 7 had aneurysms of the basilar artery, and 1 each had a posterior cerebral and a vertebral aneurysm. Of the normotensive group, only 3 had aneurysms of the basilar artery.

3. Radiological Considerations.

Our general policy with respect to angiography in patients suffering subarachnoid haemorrhage is to perform bilateral carotid angiograms first, except when the clinical features suggest specifically an aneurysm of the verteobasilar system, in which case vertebral angiography is given priority.

Should no aneurysm be demonstrated in the carotid systems, vertebral angiography is performed except in patients of advanced age or in the presence of gross vascular disease, which in itself would prohibit this type of surgery.

If an aneurysm is demonstrated by carotid angiography, an attempt is made to assess whether it has been the cause of the subarachnoid haemorrhage according to the following criteria: (i) Relation of site of aneurysm demonstrated radiologically to neurological localizing signs if present. (ii) Appearance of the aneurysm. Small round “blisters” are regarded as innocent until no other aneurysm has been found, while irregular contour of the sac, partial filling defect in the sac, or the presence of secondary loculi are taken as suggestive of accident to the aneurysm. (iii). The presence of spasm in neighbouring vessels is regarded as confirmatory evidence of recent haemorrhage from an observed aneurysm, while its absence is held to be a reason for suspecting that this aneurysm has not bled except when no other aneurysm can be demonstrated. (iv) Local displacement of vessels suggesting haematoma in relation to the aneurysm demonstrated is regarded as evidence that haemorrhage has occurred from it.

When there is no such clinical or radiological evidence that the particular aneurysm of the carotid system demonstrated has bled, vertebral angiography is performed in recognition of the possibility of multiple aneurysms.

Should no aneurysm be demonstrated in either carotid or vertebral angiograms, search is made for radiological signs of local arterial spasm which might suggest the presence and location of an aneurysm and prevent its filling, or local displacement of vessels which might suggest the possible site of a nonfilling aneurysm. When the clinical picture is strongly suggestive of aneurysm as the source from which haemorrhage has occurred, and especially in relatively young patients, angiography is repeated at an interval to study again such suspected sites.

However, only in the current year have both vertebral arteries been studied routinely whenever vertebral angiography for aneurysm is indicated upon the above basis.

(a) Complications of angiography. In no case in this series was there any significant complication of carotid or vertebral angiography, although the policy was to undertake angiography at the first opportunity.

(b) Spasm. Many patients showed radiological evidence of spasm of the vessel from which the aneurysm arose. In our experience of ruptured aneurysms of the carotid system, radiological evidence of basilar spasm is quite common, and would correlate well with
instances in which there were severe and prolonged disturbances of consciousness. Of particular interest here is the reverse phenomenon of widespread spasm in the carotid system after rupture of vertebrobasilar aneurysms (Cases 9 and 18), whose site may be as remote as the vertebral artery (Case 18). The advisability, on occasion, of repeated examination is well exemplified by Case 18.


(a) Age incidence. The average age in this series of 19 patients was 41 years with extremes of 21 and 57 years. This is younger than the series reported by Dimsdale and Logue where 6 patients treated surgically had a mean age of 49 years, while that in the medically treated group was 52 years. In the present series 8 patients were aged 40 years or less. In this group, 3 patients had aneurysms of the basilar artery and 5 had aneurysms of the posterior cerebral or vertebral arteries. Four patients were hypertensive and 4 were normotensive. Eleven patients were older than 41 years, 7 having aneurysms of the basilar artery and 4 having posterior cerebral or vertebral aneurysms. In this group, 5 were hypertensive and 6 normotensive.

(b) Sex incidence. There were 9 males and 10 females in this series. In the aneurysms of the basilar bifurcation, males predominated 5:2 while in the vertebral aneurysms the female: male ratio was 4:1.

(c) Presenting picture. Few of these patients presented localizing signs suggesting vertebrobasilar lesions, but particular reference should be made to 2 clinical features.

(i) Oculomotor palsy. Oculomotor palsy in association with subarachnoid haemorrhage is regarded as strong presumptive evidence of an aneurysm of the internal carotid artery at the level of the posterior communicating artery. In Cases 4, 7, 10 and 12 this combination was caused by a posterior cerebral or upper basilar aneurysm, and in Case 4 failure to recognize this was the first step to disaster. In Case 1 an aneurysm of the posterior cerebral artery produced temporary oculomotor palsy without haemorrhage, while in Case 14 haemorrhage plus oculomotor palsy was unrelated to a basilar aneurysm.

(ii) Medullary localizing signs. In Case 13 the aneurysm acted as a tumour and was interpreted as such on the clinical picture. In Case 19, pain of the left ophthamlic division and paraesthesia of the left arm corresponded well to the site of the fundus of the aneurysm while chronic irritating cough might be interpreted as related to the juxtaposition of the vagus nerve to the neck of the aneurysm.

Mortality and Morbidity

Of 19 patients, 10 died. This figure may be analysed in relation to various features.

(a) Age. Excluding the 2 patients who had not bled recently (Cases 1 and 13), the average age of survivors is 48 years, and of those that died, 41 years. In this series age apparently is unrelated to the outcome.

(b) Sex. Six males survived and 3 died. Three females survived and 7 died. This is despite the male predominance both in the most lethal site of aneurysm, on the basilar artery itself (M:F = 6:4), and in the incidence of hypertension (M:F = 5:4).

(c) Associated hypertension. Of the 9 patients with hypertension 7 died; 1 of the survivors had not bled from his aneurysm which was not disturbed surgically (Case 14). It should be recorded that 1 of these deaths was caused by major error of surgical judgment (Case 4 — see below).

Only 3 of the 10 normotensive patients died and 1 of these deaths (Case 14) resulted from a complication of a secondary operation, relatively unrelated to the aneurysmal surgery. It is worth emphasizing that 7 of the 10 basilar aneurysms were found in hypertensive patients.

(d) Number of haemorrhages from aneurysm. It has been suggested by Dimsdale and Logue that recurrent haemorrhage from vertebrobasilar aneurysms may be tolerated well by the patient. Yet even in their experience the frequency of haemorrhage was generally greater in those who survived operation (and, in all cases, after it) than in those who succumbed during medical treatment.
Mortality in relation to number of haemorrhages in this series is indicated in Table 2.

(c) Site of aneurysm. The site of the aneurysm in relation to the outcome of operation is listed in Table 3. Again it may be noted that 1 death from aneurysm of the posterior cerebral artery was the result of an error in judgment (Case 4), and 1 from vertebral aneurysm to a complication of incidental surgery (Case 5).

Some observations regarding the various sites may be pertinent.

Aneurysms of the posterior cerebral artery. There appears to be no reason why aneurysms in this site should not be treated upon the same basis as other aneurysms of the circle of Willis.

Aneurysms of the basilar bifurcation. Despite the suspected high natural mortality of these lesions, it is clear from the present results that aneurysms at the basilar bifurcation are not inviting surgically. It has been suggested that aneurysms on the basilar artery tend to lie free in the subarachnoid space, and thus to be relatively easy of access. Our experience has not been so fortunate, for all aneurysms in this group projected upward between the perforating arteries, or backward where accessibility was poor. An aneurysm at this site projecting forward with an accessible neck would render operative treatment more feasible.

It appears that division of the posterior communicating artery as a routine method of access, as advised by Gillingham, is unwise, since this may limit the variety of procedures available to the surgeon when the aneurysm is seen. Effort should be made to spare this anastomotic vessel until it is sure that it will not be needed.

Aneurysms of the basilar trunk. Our present experience with these aneurysms is too small for useful comment.

Vertebral aneurysms. The observations of previous authors regarding the accessibility and operability of these lesions are supported. Correct positioning for operation is of major importance. The head-high lateral position, with head rotated downward away from the site of the aneurysm, has provided ideal access. Division of the vertebral arteries and the posterior inferior cerebellar arteries unilaterally has proved acceptable in relation to prevention of fatal haemorrhage in these cases.

(f) Timing and type of surgery. While many of the figures are too small except to indicate trends, the following analysis suggests that the same factors influence surgical mortality of patients with aneurysms of the vertebrobasilar system as in those with aneurysms at other sites. The interval from last haemorrhage to operation is given in Table 4, and type of operation is listed in Table 5.

(g) Morbidity. The morbidity in survivors, in some cases attributable to the aneurysm, in others to the operation, is recorded in the case notes and given in Table 1. It will be noted that 2 patients (Cases 7 and 8) with aneurysm of the basilar bifurcation were severely incapacitated, and 1 of these (Case 8) has since died.

The profound mental changes in these...

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### TABLE 2

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### TABLE 3

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<td>Site</td>
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### TABLE 4

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<th>Interval from last haemorrhage to operation</th>
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patients are of particular interest in view of the frequency of amnesia and emotional lability in patients who suffer basilar arterial insufficiency or vascular accidents of the brain stem. It would appear unnecessary to invoke concomitant inflexibility of carotid arterial supply to explain the occurrence of these "cerebral" symptoms.

**Discussion**

1. *The Deaths.* Several deaths deserve particular discussion. In Case 4 subarachnoid haemorrhage and right oculomotor palsy were presenting factors, and carotid angiography supported a well-founded clinical diagnosis of illness as a result of aneurysm of the internal carotid artery at the level of the posterior communicating artery. At operation, undertaken with the fixed purpose of clipping this aneurysm, a ruptured aneurysm of the posterior cerebral artery was found, excised and trapped. The surgeon then attacked the uncomplicated aneurysm of the internal carotid artery despite the fact that such an attack would endanger the posterior communicating artery on which he was already reliant. Unnecessary disaster resulted. The surgeon who deals with aneurysm must maintain flexibility of thought even when the plan of surgery appears as predetermined in this case.

Case 15 survived apparently successful initial surgery of the aneurysm, and a difficult postoperative period which included partial gastrectomy for bleeding duodenal ulcer, before disaster occurred in the management of secondary hydrocephalus. An ill-advised spinoperitoneostomy into the peritoneal cavity only 3 weeks after gastrectomy resulted in fatal meningitis. This death may well have been avoided by the establishment of a ventriculo-atrial shunt, but this technique was not in use in this hospital at that time (1959).

Case 12, one of the earliest in the series, underwent operation without prior vertebral angiography. An aneurysm on the basilar artery was found and clipped despite torrential haemorrhage, but immediate respiratory arrest could not be corrected despite prolonged ventilation. Had it been appreciated that the clip was as well placed as autopsy demonstrated, and was not occluding the basilar artery as was assumed at operation, attempts at resuscitation might have been more optimistic and enthusiastic. The mode of death appears comparable to that seen in sudden death from spontaneous rupture of an aneurysm, and may have been caused by profound basilar spasm.

Case 18 harboured an aneurysm which even with the benefit of prior angiography would almost certainly have proved inoperable.

Case 5 bled again despite muscle wrapping, which is obviously an inferior procedure, although the possibility exists of recurrent haemorrhage even after trapping of the aneurysm, as may have happened in Case 16.

2. *The Effect of Increasing Experience.* It may be noted that Table 1, because of the listing of cases in groups according to anatomical site, obscures the over-all chronological order. Correction of this order indicates that the first 6 patients were treated prior to January 1960 and the remaining 13 since that date. The first 6 patients included 2 in whom the aneurysm had not been demonstrated pre-operatively, 1 that bled again after muscle wrapping, and Case 15 discussed above.

The results on a chronological basis are:

<table>
<thead>
<tr>
<th>Period</th>
<th>Cases</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to January 1960</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Since January 1960</td>
<td>13</td>
<td>5</td>
</tr>
</tbody>
</table>
Aneurysms of Vertebrobasilar System

For comparison, 189 craniotomies for aneurysm at all sites have been carried out in this Department since January 1960, upon the same policy of radical and early surgery. In these 189 craniotomies, 66 deaths have occurred. This mortality rate of 35 per cent is comparable to that reported by McKissock et al. (151 definitive craniotomies, 57 deaths).

It can be concluded that since January 1960, our mortality rate for surgical attack upon aneurysms of the vertebrobasilar system is similar to that in craniotomy for aneurysm at all sites.

Summary

Nineteen successive operative cases of aneurysm of the vertebrobasilar system were distributed as follows: 4 posterior cerebral, 7 basilar bifurcation, 3 basilar trunk, and 5 vertebral.

Anatomical, pathological and clinical features of these lesions are discussed, with particular reference to associated vascular abnormalities and to involvement of the oculomotor nerve.

A mortality rate of 10 out of 19 is analysed in relation to site, clinical and pathological features, and nature of operation, and is compared with the mortality rate of craniotomy for aneurysm in general.

The indications for vertebral angiography in subarachnoid haemorrhage are considered, and a policy of surgical management of aneurysms of the vertebrobasilar system is presented.

Addendum

Since this paper was submitted for publication another patient has undergone operation for a basilar aneurysm.

A normotensive 26-year-old woman suffered her 3rd subarachnoid haemorrhage from a saccular aneurysm, 1 cm. in diameter, arising from the anterior surface of the basilar artery, just below its bifurcation. She had right oculomotor paresis and left homonymous hemianopia. On Feb. 6, 1964 the neck of the aneurysm was clipped by the sub-temporal route and a haematoma of the temporal lobe was removed. Some days later a spino-fallopioperitoneal shunt was established to relieve communicating hydrocephalus. The patient returned to full activity.

This case illustrates several points made in the main text: the youth of some patients with basilar aneurysms, the frequency of oculomotor lesion as a presenting sign and of recurrent haemorrhages, and the likelihood of hydrocephalus as a complication. The greater technical operability of aneurysms that project forward from the basilar artery and the influence of increasing surgical experience on the outcome of operation are also shown.

References