Surgical Management of Subarachnoid Haemorrhage

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The diagnosis of spontaneous subarachnoid haemorrhage is based on a high degree of clinical suspicion, with confirmation by lumbar puncture findings of xanthochromia with blood staining. Such diagnosis simply indicates that blood has entered the subarachnoid space from rupture of a pathological vessel; the exact nature and situation of the lesion, and the presence or absence of a complicating haematoma are not revealed by clinical examination alone. Precise diagnosis requires angiography with satisfactory visualisation of the cerebral vessels. This investigation, which has a low morbidity rate, must be carried out at the right time. The first determining factor is the patient's clinical state. Unremitting coma usually has such a poor prognosis that the investigation can be withheld until the patient's condition improves. Medical measures should be taken to combat respiratory embarrassment, fluid depletion or electrolyte imbalance and to reduce raised intracranial pressure. Complicating disorders of poor prognosis, such as recent cardiac infarction or very advanced age may also defer angiography. However, the most common situation is of a satisfactory or improving level of consciousness in cases of subarachnoid haemorrhage with or without localising signs.

In the absence of any clear clinical clues, the patient must be managed on a presumptive diagnosis of intracranial aneurysm, the causative lesion in 60 per cent of cases of subarachnoid haemorrhage as compared with 20 per cent with a primary cerebral or cerebellar haemorrhage, 5 per cent with an angioma, and 15 per cent with no demonstrable lesion.

One must await a satisfactory and stable conscious level as the prognosis for surgical treatment depends on this. However, if the patient later deteriorates, the high surgical risk becomes acceptable, as the risk for the unoperated case is so great.

Finally, the risk of recurrent haemorrhage from an aneurysm increases markedly from the sixth day onwards; therefore, the presence of such a lesion and a surgical decision should be determined prior to this time. In severe cases a compromise between the various risks has to be accepted.
REQUIREMENTS OF ANGIOGRAPHY
Adequate delineation of sufficient of the intracranial vessels is required to demonstrate or exclude the responsible or potentially responsible lesion, or to demonstrate multiple pathologies. In most centres, visualisation of both carotid and vertebral systems is the accepted routine. General anaesthesia is usually employed. More limited investigation is only justified by uncommon circumstances such as a deteriorating course with clear localising signs of a lesion requiring immediate surgery.

The surgeon requires the angiogram to demonstrate the lesion and its precise situation and anatomical relationships. Additional views may be necessary to decide on accessibility or operability. It must also demonstrate or exclude associated or unrelated pathology such as abnormal vessel constriction or vascular occlusion, or a space-occupying haematoma.

After an accurate clinical appraisal of the patient and his immediate post-ictal course, and a detailed assessment of the primary lesion and any associated pathology, management of the individual lesions can be considered.

ANEURYSMS
The object of surgical treatment is to prevent recurrent haemorrhage with minimum mortality and morbidity risks. Certain general approaches should be considered since the precise surgical detail is of less importance.

*Neck occlusion* represents the most elective and most certain method. A metal clip or ligature is applied to the muscular neck of the lesion to occlude it completely, thus excluding the lesion from the circulation (Scoville, 1966).

*Wall reinforcement* techniques are designed to strengthen the sac and require its complete dissection. The aneurysm wall and its vessel of origin are then completely invested in muslin, gauze, acrylic, compound adhesives or similar substances. Total coverage is essential but this poses obvious problems. However, if the neck is unsuitable for occlusion or if adjoining vessels might be compromised, such investment may be the procedure of choice (Dutton, 1956; Selverstone, 1963).

*Intramural thrombosis* requires the insertion of a foreign material to produce a solid thrombus within the aneurysm. Mammalian hairs have been inserted, using a pressure gun, copper needles have been introduced stereotactically, colloid iron has been held magnetically in the aneurysm and intra-arterial balloons have been used for neck occlusion. These methods are not widely used but may have a place in selected difficult cases (Gallagher, 1964; Mullan et al., 1965).

*Proximal ligation* has been applied to the cervical carotid artery in aneurysms arising from the internal carotid artery, to the anterior cerebral artery in
aneurysms arising from the anterior cerebral/anterior communicating complex, and to the vertebral artery in lesions of the basilar/vertebral axis. The method can only be applied in the paired artery situation where collateral circulation is available and is designed to reduce tension in the lesion and allow natural healing (Tindall and Odom, 1969; McKissock et al., 1960).

Surgical Problems
1. Recognised Difficulties

(a) Access to the lesion without causing additional brain damage. Very few lesions are inaccessible but the approach to the more superficial aneurysm, i.e. middle cerebral, is easier than to those deeply placed or related to vital structures such as terminal basilar aneurysms.

(b) Feasibility of safely neutralising the lesion will depend on the situation of the lesion, its size, shape, direction and local anatomical relationships such as proximity to vital perforating arteries.

(c) Cerebral vasoconstriction. Spontaneous changes in cerebral autoregulation can occur, the precise mechanism being unclear. Such changes may be aggravated or precipitated by surgery and may lead to hemispherical or brain-stem infarction which account for most of the surgical mortality and morbidity. At present, the changes are unpredictable and untreatable and are most common from the sixth to the tenth post-ictal days, but may occur at any time and may persist for days or weeks. If such vascular changes are seen on the diagnostic angiogram, surgery is usually delayed. Undue delay, however, carries an increased risk of recurrent haemorrhage in the waiting period.

2. Less-recognised Difficulties

The difficult path that has to be trodden in the surgical management of these lesions has led to a multiplicity of methods, refinements of technique and much speculation on the timing of treatment. The natural history of these lesions is becoming more clearly defined, and prognostic factors are emerging (Richardson et al., 1964, 1966; Alvord et al., 1972), but the multiplicity of treatments and surgical regimes and the obvious problems of selection of cases make valid comparisons difficult. The comparison of selected surgical results with the global natural history is clearly invalid but multiple controlled treatment trials are not more acceptable.

The controlled trials conducted in our Department since 1958 comparing surgery with bedrest and/or hypotensive therapy allow some general conclusions to be drawn. In the cases of internal carotid aneurysms we demonstrated the superiority of cervical carotid ligation over bedrest. The surgical mortality of 11 per cent, compared with 37 per cent in untreated cases, was
overshadowed by a morbidity rate of 15 per cent due to ischaemic complications. No strictly comparable figures are available for the results of direct surgical intervention. By contrast, we demonstrated the global superiority, particularly in males, of craniotomy and direct surgery in middle cerebral aneurysms. The position with aneurysms of the anterior cerebral complex was less clear and careful case selection is still required (McKissock et al., 1965).

Multiple aneurysms still pose many difficult problems but our general policy can be stated as follows—

1. If the responsible lesion can be definitely identified it is treated.
2. If there are two lesions suitable for one surgical approach then this operation is performed.
3. If widely distributed lesions are present with no indication of causality, no surgery is performed.

Careful clinical, and particularly angiographic, evaluation helps to reduce the size of Group 3.

Finally, mention must be made of vertebro-basilar lesions which are very uncommon; few series of analysable size exist, so the results of surgery must await further evaluation.

ANGIOMATOUS MALFORMATION
Such lesions are more common in patients of 20 to 40 years, sometimes with a history of epilepsy. As has been stated, the risk of recurrent haemorrhage and death is much less than with aneurysms and thus, once the diagnosis is established, the same degree of surgical urgency does not exist. As excision of the lesion is the aim, adequate angiography is essential to demonstrate the details of feeding arteries and draining veins. Situation, size and complexity of vasculature are the important factors if surgery is not to prove fatal or result in a severe neurological deficit. Using modern surgical techniques a high percentage of these lesions can be excised with a mortality of 5 per cent or less. In massive or inaccessible lesions, operations designed to ligate some of the contributing arteries are of limited value. The usefulness of radiotherapy or other techniques designed to produce an endoarteritis have not been proven. Occasionally, a large angioma may require partial resection to gain access to an accompanying intracerebral haematoma.

INTRACEREBRAL AND CEREBELLAR HAEMORRHAGE
These lesions pose differing diagnostic and surgical problems and require brief separate discussion.
Surgical enthusiasm in relation to intracerebral haematomas has been variable. Our own controlled trials showed no global superiority for urgent surgery when compared with non-surgical methods but certain guide lines emerge from the study (Richardson, 1969a).

1. Unremitting coma from the onset carries such a poor prognosis that surgery is rarely helpful.
2. Spontaneous recovery from a severe neurological deficit occurs in about 20 per cent of cases.
3. Deterioration from a reasonable level of consciousness can be due to medical causes rather than from increasing cerebral compression. Supervention of chest infection or retention of pulmonary secretions is common; dehydration or electrolyte disturbance may arise quite rapidly. Such deterioration requires energetic medical measures rather than emergency surgery.
4. Surgery is rarely life saving, its major role being to limit disability or increase the rate or extent of neurological recovery. Surgery, therefore, has a limited place in management, but should be considered if—
   (i) The haematoma is large and accessible.
   (ii) A significant neurological deficit persists unaltered after 10 to 12 days.
   (iii) The patient’s level of consciousness is stable and any complicating medical problems have been adequately managed.
   (iv) There is no absolute contra-indication to anaesthesia.

This global management approach has reduced the total mortality to 20 per cent compared to past mortality rates of 38 per cent for similar cases treated entirely non-surgically and 55 per cent for cases treated entirely surgically. It is realised and accepted that retrospective comparisons even in a trial structure, lack full validity; nevertheless, the results suggest that the combined regime may be advantageous.

Haemorrhage into the cerebellar hemispheres, with a reasonable time of survival, is uncommon and difficult to recognise (Richardson, 1972). Classical presentations with cerebellar symptoms and signs are rare, more common being rapid obtundation with apparent hemiplegia and conjugate gaze paralysis associated with respiratory irregularity. These haemorrhages are suspected at angiography if there is ventricular dilatation with no supratentorial lesion. Further studies may be required to confirm the diagnosis and thereafter urgent surgery is usually required. The prognosis depends very much on the level of consciousness at the time of treatment; coma carries a very poor prognosis, whereas a good outcome is likely if the patient is still accessible.
UNEXPLAINED HAEMORRHAGE

Finally, we must consider the 15 per cent of cases who, on angiography, have no demonstrable causal or associated lesion. As this group is defined by radiology alone it is heterogeneous—some cases are later shown to harbour aneurysms not previously visualised; other cases have small angiomas, virtually destroyed by the haemorrhage, or may have a small intracerebral haematoma below demonstrable size. These three possibilities account for approximately 10 per cent of these cases. Though the cause of haemorrhage remains obscure in most of them there is no doubt that this group of unexplained cases has a good prognosis. In a recent review of 650 cases of this type, only 37 were known to be dead—a late mortality of 6 per cent for a follow-up period of up to ten years (Richardson, 1969b).

SUMMARY

Subarachnoid haemorrhage demands careful and detailed investigation, the most likely lesion being an aneurysm with its high risk of early and fatal recurrent haemorrhage. Urgency of investigation varies inversely with the patient’s level of consciousness and general condition. Younger patients in good clinical condition should be investigated at once, whereas advanced age and/or poor neurological or medical condition dictate some delay. During such waiting periods energetic medical treatment must not be overlooked. While there are still limits on surgical applicability and capability in managing the lesions, rational decisions can be taken only after adequate investigation with the patient in the best clinical condition attainable.

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