CURRENT SURVEY

Carotid endarterectomy in cerebral vascular disease

W. REX MORRIS*

B.A., M.D.(N.Z.)

Formerly Registrar, Department of Neurology, Guy's Hospital, London, S.E.1

Summary

1. The role of surgery in carotid artery disease is discussed for both transient ischaemic attacks and for completed strokes.

2. It is emphasized that surgery is essentially prophylactic and therefore best undertaken before a stroke has occurred, but it may still be of value after an infarct.

It is now over 12 years since the first successful operation was performed (Eastcott, Pickering & Rob, 1954). Much is known about the indications for surgery and two carefully controlled trials now in progress, the Joint Study (Lyons, 1965; Fields, 1966) and one in Detroit (Bauer *et al.*, 1966) may well reach definitive conclusions.

Clinical and pathological classification and the scope of surgery

The clinician divides cerebrovascular disease into three categories, the stage of transient ischaemic attacks, the stage of progressing stroke and the stage of completed stroke. The division is sometimes hard to apply and transient attacks may occur after a completed stroke. Only the first and third stages will be considered here. In general these clinical stages may be associated with disease of small blood vessels or of large vessels either inside the skull or in the neck. Sometimes more than one type of vessel is involved. Moreover, extracranial disease, especially at the carotid bifurcation, is quite common, occurring in many people without brain disease, and it may not necessarily be the cause of symptoms in those who have them. Furthermore, whereas a carotid stenosis is operable, carotid occlusion which has been present for more than 1 or 2 days may not be correctable and the cir-

culation is unlikely to be restored after 2 weeks and only then with additional hazards. In a series at Guy's Hospital the circulation appeared to have been restored for certain in only three of twenty-nine occluded arteries. The feasibility of surgery is clearly limited. Its advisability must be considered separately for the different stages of the disease.

Surgery in transient ischaemic attacks

Definition

These attacks are characterized by a brief focal disturbance of neurological function due to an inadequate blood supply to part of the brain or retina. If there is a residual deficit the patient has suffered a completed stroke. Most transient attacks last less than half an hour. The maximum duration is a matter of opinion. Acheson & Hutchinson (1964) consider anything lasting over an hour to be a completed stroke, but some allow up to 24 or even 72 hr. Bauer *et al.* (1966) introduce the term reversible ischaemic neurological defect (RIND) for episodes which leave only a minor deficit after a day or two and which resolve completely within 2 or 3 weeks. Jennett (1967) uses the term 'prolonged temporary stroke' for an episode lasting longer than an hour but not more than a week.

Incidence

The true incidence of transient ischaemic attacks is unknown, our information coming either from patients who seek advice for them or from the histories of stroke victims. Baker, Schwartz & Rose (1966) found that 14% of 1498 patients seen for the first time with 'focal stroke' had transient attacks and the same percentage of patients with cerebral infarctions had a history of them. However, in the Joint Study (Lyons, 1965) 74% of patients with a neurological deficit had a history of transient ischaemic attacks.

* Present address: Newcastle Regional Hospital Board, Benfield Road, Newcastle-upon-Tyne.

Natural history

Before advising treatment for transient ischaemic attacks, we must consider their natural history. Some have claimed that of those who get them about four-fifths will get strokes. Siekert and his colleagues (Siekert, Millikan & Whisnant, 1961; Siekert, Whisnant & Millikan, 1963) concluded that 40–50% will get strokes if they are not treated. However, the studies of Baker *et al.* (1962, 1966) and Acheson & Hutchinson (1964) suggest that a third or less will be disabled and attacks tend to cease with the passage of time. Marshall (1964) decided that there is no way of telling who is going to have a stroke or how soon it will occur, although patients with carotid artery disease tend to have fewer warning attacks spread over a shorter period than do those with vertebrobasilar disease. This makes investigation and treatment urgent, for there is a substantial risk of a stroke occurring. Moreover the attacks are unpleasant and merit treatment on their own account, a point often overlooked. The choice lies between anticoagulants and operation. With the former, besides the risk of bleeding the lesion persists and it may itself be dangerous. Moreover symptoms may continue.

Investigation

For surgical treatment angiography is essential and pictures should be taken of the intracranial circulation as well. These may show some other lesion such as an aneurysm or neoplasm as in one patient in this series who had a secondary deposit and whose transient attacks might have been focal epilepsy despite a carotid plaque and a positive carotid compression test (see Bull, 1960). The lesion may be in an unusual place, another patient having a common carotid stenosis instead of the usual lesion at the bifurcation. There may be occlusion within the skull (Bladin & Doyle, 1966), or the intracranial circulation may be anomalous. (A third patient had not only bilateral internal carotid stenoses in the neck but also occlusions of the anterior and middle cerebral arteries at their origins so that his brain was supplied via the posterior communicating and posterior cerebral arteries.) It is well to examine the other vessels as well, for one or both carotids may be occluded or stenosed.

Unfortunately angiography has its hazards, especially in patients with cerebral vascular disease and if the technique is faulty. The complication rate, however, can be very small indeed, only 0.3% in deBakey's unit (Bruetman *et al.*, 1963). Arch angiograms are preferred by many but these too have their risks and opacification may be poor and small lesions missed (Cronqvist,

1966). Two patients, one with an occluded artery, the other with gross bilateral disease, had strokes within 3 days of angiography.

Once investigations have been completed, operation should not be long delayed. In several patients (in the completed stroke group), the artery became occluded between radiography and operation. Another developed a complete occlusion during angiography. A sluggish circulation (Bladin & Doyle, 1966) may indicate that occlusion is imminent, whilst a funnel-shaped block (Dye, 1967) suggests that it is recent. It is wise, therefore, for the neurologist to consult with the vascular surgeon from the beginning so that arteriography is done only on suitable patients and operation can follow without delay.

Indications for operation

Some surgeons operate only on what they call a significant lesion. The reduction of the lumen as shown on the radiograph is measured. Some consider a 30% reduction significant, others require 50%. The concept of the significant lesion arises from the view that stenoses reduce blood flow. It has, however, been conclusively shown, for example by Brice, Dowsett & Lowe (1964), that the lumen has to be reduced by about 90% for the flow to be much diminished. It is now generally believed that embolization from plaques causes most transient attacks in the carotid territory (Gunning *et al.*, 1964). This is apparently commoner with higher degrees of stenosis according to Murphey & Maccubin (1965), but it can also occur with smaller lesions. Moreover, plaques often look smaller on the radiograph than they really are. Two patients illustrate this point. Despite minor arteriographic changes they were considered suitable for operation. One, who developed transient attacks after a mild completed stroke, was found to have a large plaque at operation. The other, who was also having transient attacks, had a solitary plaque, but it was ulcerated. Ehrenfeld, Hoyt & Wylie (1966) also operate on patients with small lesions if there is evidence of embolization. No one has reported the progress of patients with transient attacks who have not been operated on because their lesions seemed too small.

Operative dangers

There are two grave dangers in carotid endarterectomy: the discharge of emboli from the operation site, leading to retinal and cerebral infarction, and the infarction of the brain itself due to inadequate perfusion during operation. Unfortunately two of our patients had retinal infarcts post-operatively and another developed slight weakness of the hand.

Results of surgery

Good results have been published for transient attacks. Rob (1965) reported on 380 patients with carotid artery disease; 67% were symptom free, 21% were improved and 12% unchanged, worse or dead. deBakey *et al.* (1965) reported that of 496 patients with carotid or vertebro-basilar disease, 88% were asymptomatic and 8% worse or dead. These figures must be compared with the stroke rate of about 30% in untreated patients.

Post-operative anticoagulants and arteriography

At one time many authorities recommended post-operative anticoagulants, but the consensus of opinion is no longer in favour of this. Should further attacks arise in the same or in another territory the question can be reviewed.

Post-operative arteriography is unnecessary from the patient's point of view. However, Bladin & Doyle (1966) point out that back-bleeding, our criterion of operative success, does not necessarily mean restoration of flow, especially if there is an intracranial block. They also show that months or years after operation, silent occlusions may occur.

Conclusions

Some patients who later suffer strokes have premonitory transient ischaemic attacks. Although only about a third of patients with these attacks later have strokes, arteriography should be carried out promptly and if a plaque capable of giving rise to emboli is shown, it should be removed as soon as possible. Operation is a good method of treating transient ischaemic attacks and a good way of preventing strokes.

Surgery for completed stroke

Here the role of surgery is much less certain than it is for the transient ischaemic attack. The probable cause of the stroke must be borne in mind. It may be due to an embolus from a stenosis or occlusion or it may be due to inadequate blood flow. Angiography is again necessary but it may also lead to deterioration. In considering surgery in this group, the time that has elapsed since the stroke occurred is relevant. There are therefore two sub-groups, those with acute strokes and those seen a week or two later, the so-called stable stroke group.

Surgery in the acute stroke

In the past operations have been performed on patients with global hemiplegia. In rare occasions striking improvement has ensued and it may well be that operation has benefited these

patients. On the other hand, patients with strokes may improve suddenly and strikingly with only supportive treatment; usually they improve gradually after surgery, just as they do without it, and the credit perhaps belongs as much to the physiotherapist as to the vascular surgeon. Once brain tissue has been infarcted, there is little point in restoring its blood supply; it will not recover. However, there is some evidence that some nerve cells may not die but merely cease to function because of ischaemia and may recover if their blood supply is improved, a point emphasized by deBakey (1963), and there may well be some merit in surgery if there is a recent occlusion or a tight stenosis. The argument is less valid if a plaque merely narrows the lumen insufficiently to reduce flow and if it has already given rise to a massive cerebral embolus. Moreover, when the survival of part of the brain is precarious, the manipulation involved in vascular surgery may tip the balance in favour of infarction. There is an additional serious danger. Post-operative cerebral haemorrhage has been reported when the blood supply is restored to recently infarcted brain. Fields (1966) and others have shown that patients with impaired consciousness do badly. For these reasons many prefer to postpone operation for 1-2 weeks after an acute stroke.

Surgery in the stable stroke

Here, too, the value of operation is a matter of opinion. The figures for survival after stroke are generally for unselected stroke victims not subjected to angiography. These unselected series are sometimes compared with highly selected operative series, to the considerable advantage of the latter. The controlled trial of Bauer *et al.* (1966) shows little advantage to date for surgery in this group but the trial is still continuing. It is important to remember that some patients have serial infarcts or continue to deteriorate. Twelve patients in this series, presenting with a completed stroke, if investigated earlier, might perhaps have escaped further episodes, with or without irreversible arterial occlusion. In these patients there seems to be room for individual judgment as Marshall (1966) points out. It is surely wise, if a patient has made a good recovery, to remove a source of further emboli and safeguard his cerebral circulation from the risk of subsequent occlusion. Some patients, indeed, feel better after operation, as did one lady at Guy's, and this improvement may be genuine. Unfortunately these patients may also be worse after operation, either temporarily or permanently, as occurred in some of these patients.

Conclusions

Although it is uncertain whether operation can aid recovery from a stroke, it is probably of value in preventing further infarction.

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