Carotid endarterectomy: recommendations for management of transient ischaemic attack and ischaemic stroke

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Although carotid surgery was first performed in the early 1950s, the benefit of surgery has only recently been convincingly established by two large international multicentre randomised trials. The collaborators in the European carotid surgery trial and the North American symptomatic carotid endarterectomy trial have published data showing the value of carotid endarterectomy in patients with severe stenosis (70-99% linear reduction in diameter) who have had recent cerebrovascular symptoms in the carotid artery territory.[1,2] In both studies the risk of ischaemic stroke over two or three years after surgery was reduced by 75% (table I). The risk of perioperative severe stroke or death was 3·7% in the European trial and 2·1% in the North American trial. Allowing for the initial surgical risk, the patients allocated to surgery started to do better than patients in the non-surgical group after about 10 months in the European trial or six months in the North American trial.

The European trial also showed that endarterectomy had no significant benefit in patients with mild carotid stenosis (less than 30%), mainly because of a low event rate in this group. The North American trial did not include patients with mild stenosis. The value of carotid endarterectomy in symptomatic patients with moderate stenosis of 30-69% is still uncertain and both studies are continuing to randomise patients with this degree of stenosis. There is no evidence that asymptomatic patients with severe stenosis should be operated on, although other trials are examining this problem.

Selection of patients

Symptoms—All patients with transient ischaemic attacks or minor ischaemic strokes should be considered as potential candidates for carotid endarterectomy if they have had appropriate carotid territory symptoms within the previous six months. Patients who have had a major carotid ischaemic stroke may also be considered if they make a good recovery within six months and stand to lose useful function from a further stroke in the same territory. A careful clinical history is required to decide whether the symptoms are compatible with an event in the carotid artery territory and to prevent inappropriate angiography or surgery. These decisions are not always straightforward and the assessment should preferably be undertaken by a neurologist or physician with a special interest in cerebrovascular disease. Symptoms which may suggest a carotid origin include amaurosis fugax, retinal infarction, dysphasia, hemiparesis, hemisensory loss, constructional dyspraxia, and spatial disorientation. Patients with isolated dizziness or blackouts and symptoms that can definitely be attributed to the vertebrobasilar circulation are not likely to be appropriate for endarterectomy. Asymptomatic patients may not benefit from surgery and should be considered for carotid endarterectomy only if they are thought to be at considerable risk of stroke from other planned major surgery, although no clear data on this group are available on which to base this advice.

Fitness for surgery—Patients considered for carotid endarterectomy should be fit for surgery, but there are no firm criteria for making this decision. Age is no definite barrier. The carotid surgery trials included patients up to, and even over, the age of 80. Elderly patients should therefore be investigated for carotid stenosis if they are reasonably fit. Recent myocardial infarction and unstable angina are definite contraindications to surgery. Poorly controlled hypertension is a relative contraindication (systolic pressures >160 mm Hg were associated with adverse surgical outcome in the European trial).

Routine investigation—Screening investigations for vascular risk factors and other causes of stroke are essential before carotid endarterectomy. Minimum investigations should include full blood count; measurement of erythrocyte sedimentation rate, biochemical variables and blood sugar and cholesterol concentrations; serology for syphilis; electrocardiography; and chest radiography. In selected patients echocardiography may be necessary to exclude a cardiac source of embolism. Cranial computer tomography is helpful in patients with transient ischaemic attacks to exclude the occasional patients whose symptoms are due to an intracranial lesion and to detect asymptomatic infarcts. Patients who have had a completed stroke should ideally have computer tomography within two weeks of the stroke to establish that the symptoms were ischaemic rather than haemorrhagic, to exclude other intracranial disease, and to confirm the site of the infarct, if visible, within the appropriate carotid territory. Magnetic resonance imaging is an alternative investigation which is more sensitive to the presence of old haemorrhage.

TABLE I—*Balance of risks and benefits of endarterectomy in patients with severe carotid stenosis. Values are percentages unless stated otherwise*

	European carotid surgery trial (n=778)	North American symptomatic carotid endarterectomy trial (n=659)
Non-surgical group:		
No of patients	323	331
Rate of stroke in non-surgical group at end of study*	21·9	27·6
Surgical group:		
No of patients	455	328
One month postoperative mortality and stroke rate*	7·5	5·8
One month rate of disabling stroke or death	3·7	2·1
Rate of stroke at end of study* (excluding surgical risks)	5·8	6·8
Rate of stroke at end of study* (including surgical risks)	12·3	12·6
No (%) of strokes prevented by surgery*	9·6†	15·0‡

* Strokes lasting more than seven days in European carotid surgery trial or any stroke in North American symptomatic carotid endarterectomy trial. End of study=three years in European trial and two years in North American trial.
† SD=3·3, $p<0·01$. ‡ SE=3·8, $p<0·001$.

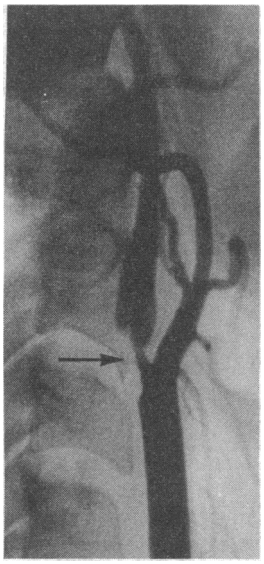

FIG 1—*Angiogram showing severe internal carotid stenosis (arrow) in 53 year old woman presenting with transient episodes of left hemiparesis. No bruit was present*

Non-invasive vascular imaging—In patients who are candidates for surgery, non-invasive screening for carotid stenosis is highly desirable to ensure that patients who do not have significant stenosis are not exposed to the risks of arteriography.[3] Duplex ultrasonography with Doppler analysis of peak systolic frequency is currently the recommended technique. In appropriate hands this is very reliable, but it is operator dependent and each unit should initially validate its results against angiography.[4] When reliable ultrasonography is available, intra-arterial angiography can be limited to patients with moderate or severe stenosis. Patients with apparent occlusion on Doppler imaging should also have angiography to exclude very severe stenosis (pseudo-occlusion). If ultrasonography is not available, intravenous digital subtraction angiography is an alternative non-invasive screening technique which, in good hands, provides reliable information about the carotid bifurcation but is less pleasant for the patient and may result in systemic contrast reactions.[5] Magnetic resonance angiography may provide a further alternative in the future.

Angiography—Bilateral selective intra-arterial carotid angiography with at least two views of the symptomatic carotid bifurcation is required to confirm the results of non-invasive screening and determine the degree of stenosis accurately. Adequate views of the carotid syphon and intracranial circulation are also required on the side of any bifurcation stenosis to exclude more severe inaccessible distal stenosis or an intracranial aneurysm, which are both relative contraindications to carotid endarterectomy. Because of the risks of carotid angiography and the expertise required to obtain good views of the whole of the carotid circulation, angiography should be limited to centres with considerable experience of cerebral angiography.[6]

The technique used to measure the degree of stenosis may be important. The European carotid surgery trial used the ratio of the smallest visible residual lumen to the estimated maximum diameter of the carotid bulb, had it been normal. The North American trial used the ratio of the residual luminal diameter at the point of greatest stenosis to the diameter of the normal carotid artery beyond the bulb. The second technique is more reproducible, but equally arbitrary and results in a percentage degree of stenosis which is less severe than that determined by the European trial's method.

Medical treatment

All patients should receive the best possible treatment of risk factors, including advice against smoking, treatment of hypertension, control of hyperlipidaemia, and antiplatelet therapy, usually with aspirin. Both carotid surgery trials showed increased benefit from best medical treatment plus surgery compared with best medical treatment alone. It is important that careful medical control of risk factors is maintained after surgery. Aspirin should be started as soon as possible before surgery and continued indefinitely afterwards.[7] The optimum dose of aspirin remains uncertain, but 300 mg daily has been shown to be effective after transient ischaemic attack.[8] The dose can be reduced to 75-150 mg daily if intolerance is a problem.

TABLE II—*Approximate estimates of incidence of transient ischaemic attacks and minor or major non-disabling strokes and need for carotid endarterectomy**

	Annual no of patients in health district (population 200 000)	Annual No of patients in United Kingdom
All transient ischaemic attacks and non-disabling strokes (all ages)	168	48 000
No of patients under 75 years	108	32 000
No with symptoms of carotid distribution	86	25 600
No with relevant carotid stenosis >70%	18	5 600
No with relevant carotid stenosis >50%	34	10 000
No with relevant carotid stenosis >30%	50	14 600

* Based on an estimated incidence of transient ischaemic attacks of 0·42/1000/year[11] and assuming that an equal number of minor strokes are considered for carotid endarterectomy. (In the European carotid surgery trial 52% of patients had completed stroke and 48% had transient symptoms.) The number with carotid stenosis of differing degrees is estimated from Hankey and Warlow.[1]

Summary and recommendations

1 Two recent large international multicentre randomised trials have established the benefit of carotid endarterectomy in preventing stroke in patients with severe carotid stenosis (70-99% reduction in diameter) who have had recent cerebrovascular symptoms in the carotid artery territory

2 All reasonably fit patients, irrespective of age, with transient ischaemic attacks, amaurosis fugax, minor ischaemic strokes, or major ischaemic strokes in the carotid artery territory who have made a good recovery within six months should be investigated for carotid stenosis as well as other risk factors

3 Reliable non-invasive screening for carotid stenosis with Doppler and duplex ultrasonography is desirable. Carotid stenosis or occlusion should be confirmed in appropriate patients by carotid angiography

4 Selection of appropriate patients for angiography and carotid endarterectomy requires careful clinical assessment, preferably by a neurologist or physician with a special interest in cerebrovascular disease, to confirm that the symptoms are compatible with ischaemia of carotid artery territory

5 Candidates for carotid endarterectomy with stroke should have computed tomography within two weeks of the event or magnetic resonance imaging to exclude intracranial haemorrhage or other intracranial disease as a cause of the stroke.

6 All patients should be investigated and treated for other vascular risk factors. Aspirin should be started as soon as possible and continued after carotid endarterectomy

7 Symptomatic patients with severe carotid stenosis who are fit for surgery should be referred to a surgeon with experience of endarterectomy

8 Surgeons performing carotid endarterectomy should audit their results with the aim of maintaining a low complication rate

9 Patients with mild stenosis (<30%) should not normally be referred for surgery. The benefits remain uncertain in patients with moderate carotid stenosis (30-70%), and these patients should, if possible, be randomised within the ongoing carotid surgery trials

10 Between 5000 and 10 000 patients in the United Kingdom might benefit from carotid endarterectomy every year, saving 500-1000 strokes. In recent years only about 1500 carotid endarterectomy operations have been carried out a year

11 Districts should consider setting up non-invasive ultrasonography screening services for detecting carotid stenosis. Each unit should validate its results against angiography. Resources will be needed to provide a comprehensive cerebrovascular screening service, cerebral angiography, and carotid endarterectomy

12 Research should continue into the indications for carotid endarterectomy, improving the safety of the operation, and alternatives to endarterectomy such as percutaneous transluminal angioplasty

Surgical referral

Appropriate patients with a history of symptoms that are clearly attributable to severe ipsilateral carotid stenosis of 70% or more should be referred to a surgeon with an interest in carotid endarterectomy. The value of carotid endarterectomy falls as surgical risk rises and largely disappears if the risk of stroke during surgery is 10% or higher. Only experienced surgeons should

carry out carotid endarterectomy and should aim for a rate of death or severe stroke during surgery of less than 5%. Surgeons should have their results independently audited regularly with the aim of maintaining a low complication rate.

Patients with stenosis of less than 30% should not be referred for surgery. Patients with moderate degrees of stenosis (30-69%) should be considered for randomisation within the carotid surgery trials, unless surgery is thought to be definitely indicated or contraindicated in an individual case. These trials should determine whether surgery is beneficial in this group.

Potential numbers

Carotid endarterectomy has not been a popular operation in the United Kingdom, and in 1984 only 1500 operations were performed in Great Britain and Ireland.[9] Similar figures have been reported for 1989.[10] About 24 000 patients present to a general practitioner with a transient ischaemic attack every year and about 2 800 of these will have severe carotid stenosis appropriate for carotid endarterectomy. There are probably an equal number of patients with minor or non-disabling major ischaemic strokes associated with carotid stenosis who could benefit from carotid surgery (table II). The potential requirement for over 5000 carotid endarterectomies would prevent about 500 major strokes each year.[12] If future studies show a benefit for surgery in patients with 50% stenosis then 10 000 operations would be required with 1000 strokes prevented. If these estimates are correct the number of carotid endarterectomies performed should be increased significantly. Around 30 000 patients in the United Kingdom or about 100 patients in an average health district (population 200 000) would need to be screened for carotid stenosis every year if the benefits of carotid endarterectomy are to be offered to all eligible patients.

Implications

Increasing the number of patients receiving carotid endarterectomy has implications for several aspects of health care.

Primary care—Many patients with transient ischaemic attack never consult a doctor and many general practitioners and even hospital doctors do not refer patients with transient ischaemic attacks or strokes for appropriate investigation. Both the public and the medical profession need to be educated about the benefits of investigation and carotid endarterectomy.

Non-invasive investigation—Each district should provide a non-invasive screening service for carotid stenosis. This requires investment in Duplex ultrasonography equipment as well as funding for ultrasound technicians, radiologists, training, and audit.

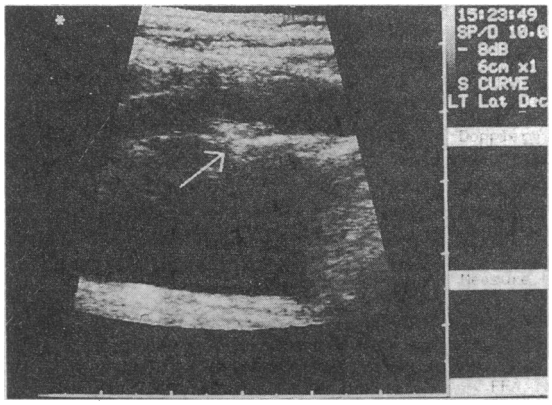

FIG 2—*B mode ultrasound image from a duplex scan showing an echodense atheromatous plaque in the carotid artery (above the arrow) causing about 50% stenosis*

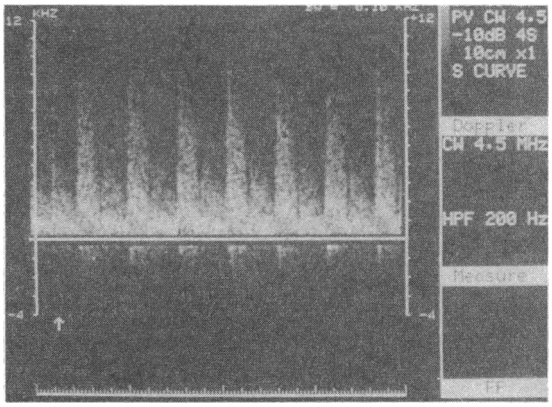

FIG 3—*Doppler signal in 35 year old woman with amaurosis fugax showing a very high peak systolic frequency from symptomatic internal carotid artery consistent with severe stenosis. The atheroma was echolucent and no abnormality was seen on B mode imaging, but angiography confirmed a tight stenosis*

Radiology—If ultrasonography is not available the number of carotid angiograms required will increase with implications for radiology departments, radiologists, and bed occupancy. There will also be an increase in computer tomography before surgery.

Vascular surgery—There are about 130 vascular surgeons in the United Kingdom, but only 25 do more than 20 carotid endarterectomies a year. A few neurosurgeons also perform the operation. Since experience and interest are important factors in obtaining good surgical results, carotid endarterectomy should continue to be performed in a limited number of centres, which should be designated within each region. More surgeons and anaesthetists with an interest in carotid endarterectomy will be required and appropriate training will need to be determined. The costs of increased operating time and bed occupancy should be partly compensated for by a decrease in bed occupancy by patients who have had a stroke.

Neurology—Neurologists or other physicians with an interest in stroke will need to spend more time assessing patients with transient ischaemic attacks and stroke. Consideration of carotid endarterectomy is only one aspect of improving the management of these patients. Each district should set up a cerebrovascular disease service to facilitate this process.

Costs—No accurate figures are available to calculate the total costs of carotid surgery or the potential financial benefits in terms of strokes saved. The European carotid surgery trial results suggest that 10% of the population operated on will benefit by not having a major stroke that would otherwise have occurred over the next three years. If carotid endarterectomy costs the NHS £2000 the cost of a stroke saved can be estimated at £20 000, but this does not include the costs of screening a much larger number of patients who will not require carotid endarterectomy.

Future studies

Continued randomisation within European and American trials is essential to determine whether surgery is beneficial in patients with moderate stenosis. Research should also continue on the indications for carotid surgery in asymptomatic patients. Further studies are required into the medical, surgical, and anaesthetic factors associated with increased risk from carotid endarterectomy. Less invasive alternatives to surgery, such as better antiplatelet agents and percutaneous transluminal angioplasty, should also be investigated.

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meeting of the Association of British Neurologists in April 1992. We thank Professor Charles Warlow for his helpful comments.

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Quality of life measures in health care. I: Applications and issues in assessment

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Summary

Many clinicians remain unsure of the relevance of measuring quality of life to their clinical practice. In health economics quality of life measures have become the standard means of assessing the results of health care interventions and, more controversially, the means of prioritising funding; but they have many other applications. This article—the first of three on measuring quality of life—reviews the instruments available and their application in screening programmes, audit, health care research, and clinical trials. Using the appropriate instrument is essential if outcome measures are to be valid and clinically meaningful.

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Interest in measuring quality of life in relation to health care has increased in recent years.[1,2] The purpose is to provide more accurate assessments of individuals' or populations' health and of the benefits and harm that may result from health care. The term quality of life misleadingly suggests an abstract and philosophical approach, but most approaches used in medical contexts do not attempt to include more general notions such as life satisfaction or living standards and tend rather to concentrate on aspects of personal experience that might be related to health and health care. Some of the commonly used synonyms for quality of life more accurately convey the content and purpose of measures—health related quality of life, subjective health status, functional status. This is the first of three papers intended to review measurement issues surrounding the use of the growing number of questionnaires and interview based instruments designed to assess health related quality of life.

Alternative applications

Quality of life measures can be used in many ways in health care (box 1). For example, quality of life instruments have been shown to be better than conventional rheumatological measures as predictors of long term outcomes in rheumatoid arthritis in terms of both morbidity and mortality.[3,4] They can therefore be used to identify patients needing particular attention. They may also be used to screen for psychosocial problems; to monitor patients' progress, particularly in relation to the management of chronic illness; or to determine choice of treatment.

Several studies have shown that clinicians' and patients' judgments of quality of life differ substantially and systematic assessment may improve health professionals' judgments.[5,6] Clinicians seem to find the information from quality of life measures useful and informative but trials have found that the additional information does not greatly alter clinical decisions or short term changes in health status.[7,8] These disappointing results may arise either because the quality of life data are inappropriate to clinical decision making or, more likely, because the information is not fed back to clinicians in the most useful format or at the right time.

Quality of life measures used for screening need to be evaluated in terms of sensitivity (false negative results) and specificity (false positive results). Instruments whose value has been proved for screening should not be assumed to be effective for other purposes—for example, as outcome measures in trials or in evaluation studies. A recent conference on applications of quality of life instruments in routine patient care concluded that, in the United States at least, many practitioners have a mixture of enthusiasm for their potential relevance to clinical practice and unresolved doubts.[9]

POPULATION APPLICATIONS

Quality of life instruments can also be used in surveys of the health of district or general practice populations. Such instruments can assess subjective aspects of health problems not addressed by conventional epidemiological measures.[10] Here too, however, it is not yet clear how useful quality of life information will prove in assessing health needs.[11]

In more formal studies of health service research quality of life assessments provide an important

Box 1: Applications of quality of life measures

- Screening and monitoring for psychosocial problems in individual patient care
- Population surveys of perceived health problems
- Medical audit
- Outcome measures in health services or evaluation research
- Clinical trials
- Cost-utility analyses