



Management of Patients with Stroke

II: Management of Carotid Stenosis and Carotid Endarterectomy

**A National Clinical Guideline
recommended for use**

in

Scotland

by the

**Scottish Intercollegiate
Guidelines Network**

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S I G N

Getting validated guidelines into local practice

This guideline was issued in May 1997 and will be reviewed in 1999 or earlier if required. Comments are invited to assist the review process. All correspondence and requests for further information regarding the guideline should be sent to:

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The definitions of the types of evidence and the grading of recommendations used in this guideline originate from the US Agency for Health Care Policy and Research⁽¹⁾ and are set out in the following tables.

Level	Type of Evidence
Ia	Evidence obtained from meta-analysis of randomised controlled trials.
Ib	Evidence obtained from at least one randomised controlled trial.
IIa	Evidence obtained from at least one well-designed controlled study without randomisation.
IIb	Evidence obtained from at least one other type of well-designed quasi-experimental study.
III	Evidence obtained from well-designed non-experimental descriptive studies, such as comparative studies, correlation studies and case studies.
IV	Evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities.

Grade	Recommendation
A (Evidence Levels Ia, Ib)	Required - at least one randomised controlled trial as part of the body of literature of overall good quality and consistency addressing specific recommendation.
B (Evidence Levels IIa, IIb, III)	Required - availability of well conducted clinical studies but no randomised clinical trials on the topic of recommendation.
C (Evidence level IV)	Required - evidence obtained from expert committee reports or opinions and/or clinical experiences of respected authorities. Indicates absence of directly applicable clinical studies of good quality.

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Summary of Recommendations

For which patients is carotid endarterectomy considered worthwhile?

Grade

Patients who have had a TIA or ischaemic stroke during the last six months and are found to have **severe stenosis** of the proximal internal carotid artery on the side appropriate to the symptoms should be considered for carotid endarterectomy in order to reduce their future risk of stroke

A

Patients with only **mild to moderate carotid stenosis** should not be subjected to carotid endarterectomy

A

These patients should be made aware of the likely symptoms of carotid territory TIAs and stroke and advised to report any future events to their doctor, who should then refer them for further evaluation

A

Those responsible for **health education** should ensure that the public are aware of the symptoms of TIAs and stroke and encourage those with symptoms to consult their doctors promptly.

C

Has the patient really had a carotid artery event?

Patients with **suspected TIAs** should have access to a specialist opinion within two weeks of referral—earlier if possible—for comprehensive assessment

C

❖ to assess their suitability for carotid surgery

❖ to initiate other secondary preventative measures, e.g.

– **antiplatelet drugs**

A

– **anticoagulants** (in patients with cerebral ischaemic events and atrial fibrillation)

A

– modification of other vascular risk factors (e.g. hypertension)

A

Has the patient a relevant severe carotid stenosis?

Patients who may be suitable for carotid endarterectomy should have rapid access to accurate **non-invasive imaging** of the carotid arteries

B

The decision to perform non-invasive imaging in a patient with a recent TIA or ischaemic stroke should *not* depend on whether the clinician detects a cervical bruit

B

Is the patient likely to benefit from carotid surgery?

Grade

A general practitioner who suspects a patient has had a TIA or stroke should refer promptly to a specialist who has the training, expertise and facilities to assess the patient fully in order to determine the **balance of risk** for future stroke versus perioperative complications

C

A **CT brain scan** should be performed prior to carotid angiography (if not already done as part of the initial assessment)

C

Has the patient really got an operable carotid stenosis?

Conventional angiography (including intra-arterial digital subtraction angiography) should usually be performed prior to surgery

B

Carotid angiography should be supervised by an experienced operator, with steps taken to **minimise risks**

C

Patients should only undergo angiography if they fulfill all the following criteria:

B

- ❖ One or more carotid distribution TIAs or non-disabling ischaemic strokes in the previous few months
- ❖ Vascular risk factors are under control and the patient on antithrombotic drugs
- ❖ Duplex sonography shows severe carotid bifurcation disease in the symptomatic artery
- ❖ The patient is fit for surgery and prepared to accept the early risk of angiography and surgery for long term benefit

The **degree of stenosis** should be **measured**, rather than simply estimated

B

The **Common Carotid** method of measurement is recommended

C

Carotid endarterectomy

For patients undergoing carotid surgery, **surgery should be performed as soon possible after the ischaemic event** to maximise its effectiveness

A

A thorough **assessment of risk** of stroke and of the patient's general medical condition should be carried out prior to surgery

C

Carotid surgery should be carried out or directly supervised by surgeons who have received **specialist training** in carotid endarterectomy

C

Grade

Surgery should only be performed in or in collaboration with **centres with the necessary neurological and neuro-radiological skills**, performing a minimum number of operations (e.g. 50) per year **C**

Anaesthesia for carotid endarterectomy should be carried out by an anaesthetist with a vascular interest, training and experience in such cases **C**

Antiplatelet drugs should be continued throughout the perioperative period and the patient should be heparinised during the procedure **C**

Monitoring: Electrocardiogram, oxygen saturation and blood pressure should be carefully monitored in the perioperative period, with postoperative monitoring of blood pressure and neurological condition undertaken in a high dependency unit **C**

If a **perioperative stroke** is suspected a Duplex scan should be carried out immediately and the neck re-opened if occlusion of the internal carotid artery is confirmed or suspected. In an established perioperative stroke, a CT brain scan should be performed **C**

Carotid angioplasty

Carotid angioplasty should only be undertaken in the context of randomised controlled trials **C**

1 Introduction

1.1 SIGN has developed a series of guidelines to assist in the delivery of good quality clinical care following an acute stroke. The guidelines are presented in four parts, of which this is the second:

I Assessment, investigation, immediate management, and strategies for secondary prevention

II Management of carotid stenosis and carotid endarterectomy

III Identification and management of dysphagia

IV Prevention and management of complications, rehabilitation and discharge planning.

1.2 **Carotid endarterectomy** is a surgical procedure which involves removing the thickened lining of the proximal part of the internal carotid artery (ICA), which carries arterial blood to the eye and brain. The main aim of the procedure is to reduce the future risk of ischaemic stroke or retinal infarction in patients with atheromatous narrowing of the proximal internal carotid artery.

In both symptomatic and asymptomatic patients with severe ICA stenosis, carotid endarterectomy can prevent stroke but this benefit has to be balanced against the risk of stroke as a consequence of surgery, the risk of the other complications of surgery and the cost of surgery, as well as the risk and cost of investigations to select suitable patients.

1.3 **The need for this guideline**

Carotid surgery is only effective in selected patients and if performed with a low rate of complications. There are many tens of thousands of people with carotid stenosis in Scotland but relatively few of these would benefit from surgery. Further, whilst there are many surgeons who could perform the procedure, relatively few are able to demonstrate that they could operate with an acceptably low risk of complications to make the surgery worthwhile.

1.4 **Aims of this guideline**

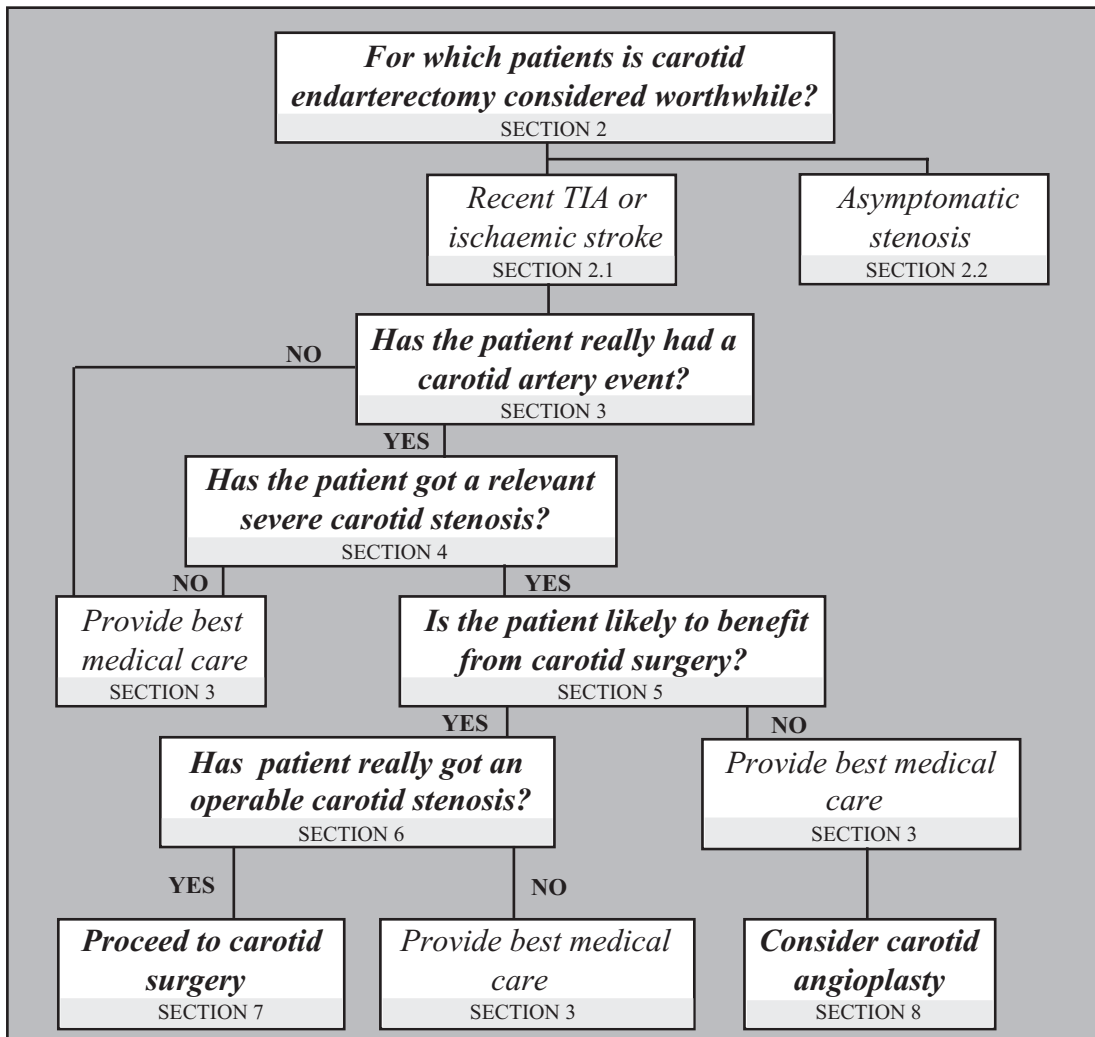
The major aim of this national guideline is to assist individual clinicians, hospital departments, hospitals and purchasers of health care to produce local protocols for:

- (i) the identification of patients who might benefit most from carotid endarterectomy
- (ii) the cost-effective investigation of patients who might benefit from surgery
- (iii) ensuring that suitable patients are offered carotid surgery with an acceptable level of complications
- (iv) ensuring that patients who have little to gain from surgery are not subjected to unnecessary procedures which may cause them harm and waste scarce resources.

1.5 Structure of the guideline

The major steps in identifying patients who might benefit from carotid endarterectomy are summarised in figure 1. This guideline is structured around each major step in the decision-making process.

Figure 1



2 For which patients is carotid endarterectomy considered worthwhile?

It is essential that safe surgery is offered to patients who have the most to gain (i.e. those at highest risk of ischaemic stroke in the territory of the symptomatic artery on medical treatment alone) and who are most likely to survive to enjoy that gain for a number of years. Any benefit from carotid endarterectomy will depend upon the balance between the combined imaging and surgical risk of perioperative death and stroke, and the risk of events with best medical treatment alone.

2.1 Patients with recent transient ischaemic attack or ischaemic stroke

Patients with stenosis of the internal carotid artery most often come to medical attention because they have had a transient ischaemic attack (TIA)—symptoms lasting less than 24 hours—or an ischaemic stroke—symptoms lasting longer than 24 hours. Such patients are referred to as having *symptomatic* carotid stenosis as long as those symptoms were attributable to ischaemia in that part of the brain or retina supplied by the stenosed vessel.

Endarterectomy of *severe* ICA stenosis almost completely abolishes the risk of ischaemic stroke ipsilateral to the operated artery over the subsequent few years.^(2,3,4,5) In symptomatic patients with severe carotid stenosis the combined angiographic and surgical risk of stroke may be 10%, so that if the unoperated risk of stroke is 20% after two years, and if successful surgery reduces this risk of stroke to zero, then doing 10 operations would cause one stroke, avoid two, and the net gain would be one stroke avoided.

Patients who have had a TIA or ischaemic stroke during the last six months and are found to have severe stenosis of the proximal internal carotid artery on the side appropriate to the symptoms should be considered for carotid endarterectomy in order to reduce their future risk of stroke

Grade A, level Ib ^(2, 3, 4)

Note: Evidence published to date demonstrates that symptomatic patients with >70% stenosis are likely to benefit from reduced risk of stroke following carotid endarterectomy. Subsequent analyses recently reported in abstract form⁽⁵⁾ indicate that this benefit applies only to patients with stenoses >80% but confirmation of this from the North American trial⁽³⁾ is awaited.

It is not clear whether moderate stenosis patients should undergo *serial* carotid Doppler studies in case the stenosis develops and becomes severe. If the patient has had no recent symptoms (within 6 months) the advantage of surgery at this stage is much less than it is for severe, recently symptomatic stenosis.

Patients with only mild (<30%) to moderate (<70%) carotid stenosis – see note at end of page 3 – should not be subjected to carotid endarterectomy

Grade A, level Ib ^(2, 3, 4, 5, 6)

Perhaps, as many as half the people who have transient ischaemic attacks in the population do not report their symptoms to their doctor and therefore cannot benefit from any measures aimed at reducing their risk of further strokes and other vascular events. This failure to present may often be due to the person's lack of awareness of the importance of what might appear to be transient and trivial symptoms.

Patients with known mild to moderate carotid stenosis should be made aware of the likely symptoms of carotid territory TIAs and stroke and advised to report any future such events to their doctor, who should then refer them for further evaluation *Grade A, based on extrapolation from level Ib evidence*^(2, 3, 4, 5, 6)

Those responsible for health education should ensure that the public are made aware of the symptoms of TIAs and stroke and encourage those with symptoms to consult their doctors promptly *Grade C, level IV*

2.2 Asymptomatic patients

Patients with asymptomatic carotid stenoses may come to medical attention:

- ❖ when a carotid bruit is heard or Duplex examination undertaken
 - during routine screening or examination of healthy people
 - during the investigation of patients with non-cerebral symptoms, particularly if they are presenting with vascular disease below the neck (angina, claudication etc.)
 - when patients are being worked up for major surgery below the neck
- ❖ when bilateral carotid angiography is carried out in patients with unilateral carotid symptoms.

Two studies have provided some information about the effectiveness of carotid endarterectomy in asymptomatic patients.^(7, 8) The overall risk of stroke in those randomised to no-surgery was so low (11.0% at 5 years) that even the considerable

relative reduction in risk in those randomised to surgery preceded by angiography (to 5.1% at 5 years) conferred a mere 5.9% absolute benefit. In other words, about 85 patients must be operated on to prevent one having a stroke in the next year. Further RCTs to evaluate surgery in asymptomatic patients are in progress.

2.3 **Setting priorities in health care**

Providers of carotid endarterectomy have to decide which patients should be operated on, given the limited number of vascular surgeons with experience in carotid surgery in Scotland. Should patients with asymptomatic disease be given priority, given the limited benefits of surgery, over other patients with symptomatic vascular disease?

Purchasers of healthcare need to make a strategic decision about whether carotid endarterectomy represents a worthwhile and cost effective method of stroke prevention in patients with recent TIAs or ischaemic stroke and in those found incidentally to have carotid stenosis without symptoms related to it. A study performed in Newcastle estimated the cost, excluding that of preoperative investigations for those not proceeding onto surgery, as being £3,200 in 1992. This figure is based on a mean length of stay in hospital of 13.5 days, including stays in high dependency and/or intensive care units. If and when stays shorten, complications diminish and outcomes improve, this cost should decrease.

Apart from taking into account the costs of the procedures and the absolute numbers of strokes prevented, the cost effectiveness of alternative methods of stroke prevention such as treatment of moderate hypertension should also be considered.

3 Has the patient really had a carotid artery event?

- 3.1 The clinical diagnosis of stroke is reasonably reliable but diagnosis of TIAs is more difficult. The diagnosis of TIAs depends almost entirely on the correct interpretation of a full and accurate description of the patient's symptoms and general health. The sooner patients are seen after the event the more likely one is to obtain a detailed and accurate account of their symptoms.

The clinical distinction of carotid territory TIAs and those in other vascular territories is even less reliable but is important if one is trying to identify those patients with symptomatic rather than asymptomatic carotid stenosis. However, even in patients with definite carotid territory TIAs and ischaemic strokes, a carotid stenosis may be an incidental finding or simply a marker of more widespread vascular disease (e.g. in those with an alternative source of embolism).

3.2 Early assessment is important

The risk of stroke is highest soon after the TIA or stroke.^(9, 10) The benefits of secondary prevention in general, and carotid endarterectomy in particular, will be greatest during this early period. The longer the interval between the TIA or stroke and the initiation of treatment, the more strokes will have occurred and the less effective the treatment.

Patients with suspected TIAs should have access to specialist opinion within two weeks of referral—earlier if possible—and necessary investigation and carotid surgery within a month of the specialist assessment

Grade C, level IV

The aim in operating earlier is to prevent more strokes occurring, but this must be balanced against the uncertainty about the safety and effectiveness of carotid endarterectomy within days of an acute ischaemic stroke.

3.3 Access to specialist assessment

Current waiting times for general neurological clinics in Scotland are long. Direct referral to radiologists or to vascular surgeons for investigation might be seen as one way of avoiding delays and enhancing the efficacy of surgery. However, this may lead to inappropriate and perhaps risky investigations and surgery being carried out on patients who are unlikely to benefit.

Patients should have access to a comprehensive assessment

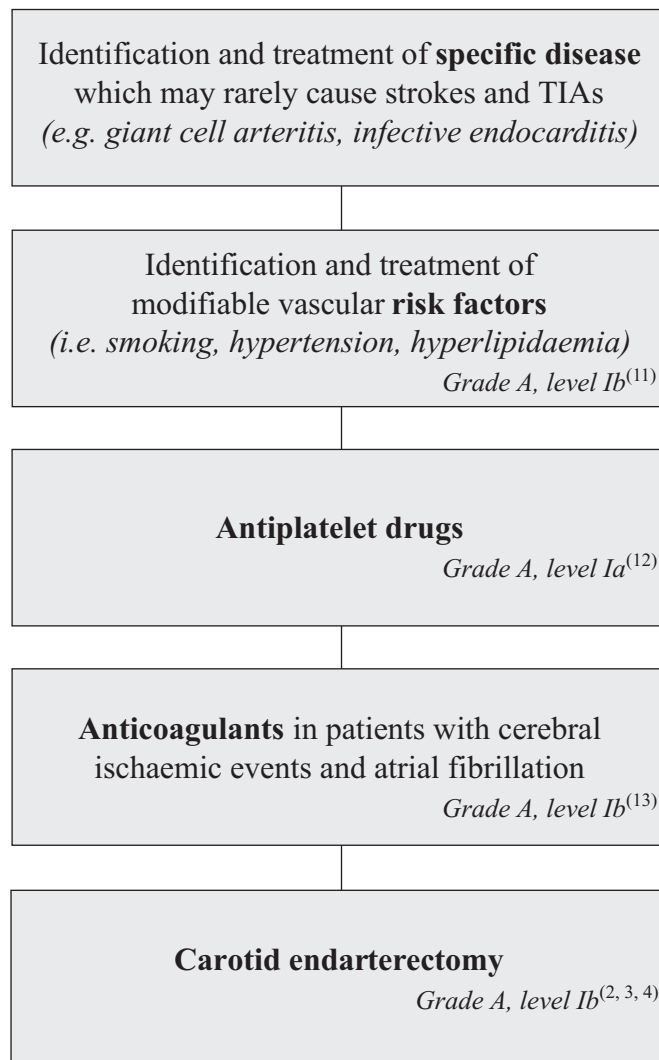
- ***to assess their suitability for carotid surgery***
- ***to initiate other secondary preventative measures which should then be continued in the primary health care system***

(see figure 2 and Part I of the SIGN stroke guidelines)

Grade C, level IV

Figure 2

A strategy for secondary prevention



4 Has the patient a relevant severe carotid stenosis?

- 4.1 There are no symptoms or signs which reliably indicate whether a patient has a severe carotid stenosis. Cervical bruits may be present with quite mild internal carotid disease and are often absent in very severe stenoses. Indeed, cervical bruits can be heard over a normal internal carotid artery if there is disease in the common carotid, external carotid, an occlusion on the opposite side or non-atheromatous distortion of the vessels.

Carotid angiography involving injection of contrast carries important risks of stroke and other complications and should not therefore be used as a first-line investigation⁽¹⁴⁾ (see section 6).

4.2 Non-invasive imaging

Patients who may be suitable for carotid endarterectomy should have rapid access to accurate, non-invasive imaging of the carotid arteries

The decision to perform non-invasive imaging in a patient with a recent TIA or ischaemic stroke should not depend on whether the clinician detects a cervical bruit

Grade B, level III⁽¹⁴⁾

- 4.3 Non-invasive imaging will usually mean carotid duplex. Alternative techniques include magnetic resonance angiography (MRA). It is essential that the method selected is accurate enough to ensure that patients with normal carotid arteries or only mild or moderate stenosis (who would not benefit from carotid endarterectomy) are not subjected to the risks of conventional angiography or surgery and also that patients with severe carotid disease are not missed.

Recommended minimum standards for the provision of a non-invasive imaging service are noted at Annex 1

Grade C, level IV

- 4.4 Where non-invasive imaging shows that the patient is unlikely to have severe carotid stenosis they should be offered medical therapy aimed at minimising future risk of vascular events. (See figure 2 in section 3 and the SIGN Guideline on Management of Stroke Part I: Assessment, investigation, immediate management and strategies for secondary prevention.)

- 4.5 Information about the presence or absence of carotid stenosis and whether it is severe or not may also be helpful in deciding how aggressively to treat hypertension. In patients where there is doubt about the diagnosis of stroke or TIA it may help decide whether long term antiplatelet drugs would be helpful.

5 Is the patient likely to benefit from carotid surgery?

Comprehensive assessment should include some assessment of whether the individual patient is at high (or low) risk of perioperative complications and whether they are likely to survive to be at high (or low) risk of ipsilateral ischaemic stroke without surgery. The balance of these risks will determine the value of surgery in the individual patient.

5.1 Risk factors for future stroke

The degree of stenosis is an important indicator of future stroke risk. Other factors—including an ulcerated plaque surface, the number of TIAs, the presence of residual neurological signs, and occurrence of cerebral rather than only ocular attacks—have been shown in preliminary studies to indicate a greater risk of future stroke.^(15, 16)

5.2 Risk factors for perioperative complications

Patients with serious medical conditions such as unstable angina or uncontrolled heart failure, disabling chronic airways disease or advanced malignancy, as well as the frail elderly, are likely to have increased risks associated with surgery and have less chance of surviving long enough to gain benefit from surgery—i.e. they *may* be put at high initial risk without long term benefit. Similarly, there are groups of individuals who, even in the presence of severe carotid stenosis, have a relatively low risk of stroke which *may* not justify the early risks of carotid angiography and surgery. These include those without recent symptoms, those with only ocular symptoms and perhaps those with a TIA or ischaemic stroke due to small vessel disease albeit within the territory of the carotid artery.

5.3 Referral

Given the complexity of the problem and the fact that most general practitioners will see relatively few patients with TIAs and strokes, GPs are unlikely to have the experience, time or the facilities to accurately diagnose and investigate possible TIAs to identify those patients who have most to gain from carotid endarterectomy.

A general practitioner who suspects a patient has had a TIA or stroke should refer promptly to a hospital specialist who has the training, expertise and facilities to assess the patient fully

Grade C, level IV

5.4 CT brain scanning

Occasionally structural brain lesions such as tumours and subdural haematomas may mimic TIAs or ischaemic strokes. Even if a patient with such attacks has a severe carotid stenosis they are unlikely to benefit from carotid surgery.

A CT brain scan should be performed prior to carotid angiography (if not already done) *Grade C, level IV*

Most patients with acute stroke will have undergone CT brain scanning as part of their initial assessment (*see SIGN Guideline on Management of Stroke Part I: Assessment, investigation, immediate management and strategies for secondary prevention*).

5.5 Carotid endarterectomy in specific situations

5.5.1 Co-existing severe symptomatic coronary disease

Recent myocardial infarction or current unstable angina are thought to increase the risk of perioperative cardiac complications. If coronary artery bypass surgery is deemed necessary for *symptomatic* coronary heart disease it is unclear whether this should be done:

- (1) **before** carotid endarterectomy
(and risk a stroke during the procedure);
- (2) **after** carotid endarterectomy
(and risk cardiac complications during carotid endarterectomy); or
- (3) **at the same time** under the same general anaesthetic.^(17, 18, 19)

The risk of the last option may be unacceptable, although a small quasi-randomised trial suggests otherwise.⁽²⁰⁾ Which of the first two options to choose depends on the individual patient and close collaboration between neurologists, cardiologists and surgeons: there is no clear guidance from randomised trials.

5.5.2 Bilateral symptomatic severe carotid stenoses

If a patient has symptoms referable to *both* severely stenosed ICAs, requiring bilateral carotid endarterectomy, it is probably safer to do the operations a few weeks apart rather than under the same anaesthetic. This is due partly to the dangers of bilateral hypoglossal or vagal nerve damage (*see section 7*).

6 Has the patient really got an operable carotid stenosis?

6.1 Carotid angiography

Trials evaluating carotid endarterectomy in symptomatic patients used conventional carotid angiography to indicate the severity of carotid disease and thus to define in which patients the risk of surgery is worth taking. Compared with conventional selective catheter angiography, intra-arterial digital subtraction angiography (intra-arterial DSA) is quicker, less contrast is used, and the images are easier to manipulate and store, but the spatial resolution is lower.

6.2 Non-invasive imaging

With improvements in other non-invasive imaging techniques it is likely that conventional angiography will become necessary only in a minority of patients where, even after non-invasive techniques, there is uncertainty about the degree of stenosis, whether the artery is actually occluded or whether more distal disease in the carotid circulation means there may be less benefit from carotid surgery. Some surgeons already operate routinely on the basis of ultrasonography alone, although the safety and effectiveness of this policy has not been formally demonstrated and it cannot therefore be recommended.^(21, 22) Several specialist centres have published results which demonstrate that non-invasive imaging can provide accurate data about the degree of stenosis in the majority of patients but it is uncertain how these would generalise to less specialised centres.^(23, 24, 25)

Conventional angiography (including intra-arterial DSA) should be performed prior to surgery unless:

(1) Other techniques such as the combination of Duplex and MRA have been shown locally to correlate extremely well with conventional or intra-arterial DSA

or (2) There are technical reasons which make conventional angiography impossible or particularly risky (e.g. severe peripheral vascular disease, allergies to intravenous contrast)

Grade B, level III

6.3 Criteria for performing angiography

In making a judgement about whether to operate without prior angiography, it is important to be aware of the false positive and negative rates for identification of severe carotid stenosis, the effect of the delay due to angiography on the patient's risk of stroke and the risk of angiography itself.

Conventional carotid angiography should only be performed with a view to selecting patients for carotid endarterectomy if the following criteria are fulfilled:

- (1) The patient has had one or more carotid distribution TIAs or non-disabling ischaemic strokes in the previous few months (except in local circumstances where it has been decided that the benefits of carotid endarterectomy in asymptomatic patients are worthwhile)***
- (2) Vascular risk factors are under control and the patient is on anti-thrombotic drugs***
- (3) Duplex sonography shows severe carotid bifurcation disease in the symptomatic artery***
- (4) The patient is prepared to accept the early risk and inconvenience of angiography and surgery for long term benefit. The guideline development group acknowledges that there are considerable difficulties in communicating this information to patients, which will depend on the individual patient's condition and circumstances***
- (5) The patient is fit for surgery: no recent myocardial infarction; controlled angina; no cardiac failure; controlled hypertension; reasonable lung function; and biologically not too aged (although the patient's chronological age should not be a factor)***
- (6) The institution has an experienced cerebral angiography team with a low complication rate, preferably kept under prospective and independent audit (see section 9)***
- (7) The institution has access to an experienced surgical and anaesthetic team with a low surgical complication rate, also kept under prospective and independent audit (see section 9)***

Grade B, level III

(There is level Ib evidence for entry criteria from the large RCTs of carotid surgery)

6.4 Minimising the risks of angiography

Carotid angiography carries an important risk of precipitating an ischaemic stroke, acute ischaemia of the lower limb and serious allergic reactions to the contrast. The size of these risks depends on the types of patients undergoing the procedure and are higher in patients with definite arterial disease.^(27, 28) Complication rates of up to 10% have been reported. It seems likely that the risk of some of the complications will depend upon the radiologist's skill and technique.

<p><i>Recommended practice to minimise risks of carotid angiography is noted in Annex 2</i></p>	<p><i>Grade C, level IV</i></p>
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The recommendations in Annex 2 refer to intra-arterial DSA with selective contrast injection into the common carotid artery via the femoral route using the Seldinger technique. Contrast injection into the aortic arch is performed in some radiology departments where there is less experience with selective common carotid injections but this may produce less satisfactory images due to overlap of arteries (even with multiple projections). Intravenous DSA is not acceptable. Neither intravenous DSA nor aortic arch intra-arterial DSA have been shown to be any safer than selective carotid intra-arterial DSA.⁽²⁸⁾

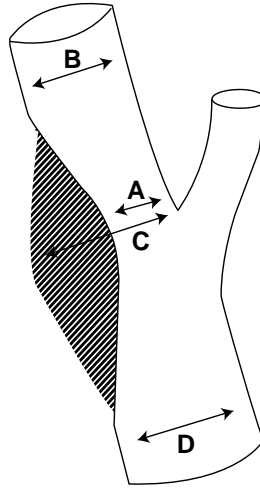
6.5 Degree of stenosis

The three accepted methods of measuring the degree of stenosis are illustrated in figure 3. Standardisation on one of these methods would facilitate audit and comparison between centres. The common carotid artery method (CC) has been shown to provide a reproducible measure of the degree of stenosis which can be related to the measurements used in randomised trials of carotid endarterectomy.⁽²⁹⁾

<p><i>The degree of stenosis should be measured rather than simply estimated</i></p>	<p><i>Grade B, level III⁽²⁹⁾</i></p>
<p><i>Standardisation on the Common Carotid method is recommended</i></p>	<p><i>Grade C, level IV</i></p>

Figure 3

Picture of bifurcation with different denominators illustrated



ECST method: $\frac{C-A}{C} \times 100\% \text{ stenosis}$

NASCET method: $\frac{B-A}{B} \times 100\% \text{ stenosis}$

CC method: $\frac{D-A}{D} \times 100\% \text{ stenosis}$

$$\text{NASCET \% stenosis} = \frac{(\text{ECST or CC stenosis \%} - 40)}{0.6}$$

ECST	European Carotid Surgery Trial
NASCET	North American Symptomatic Carotid Endarterectomy Trial
CC	Common Carotid

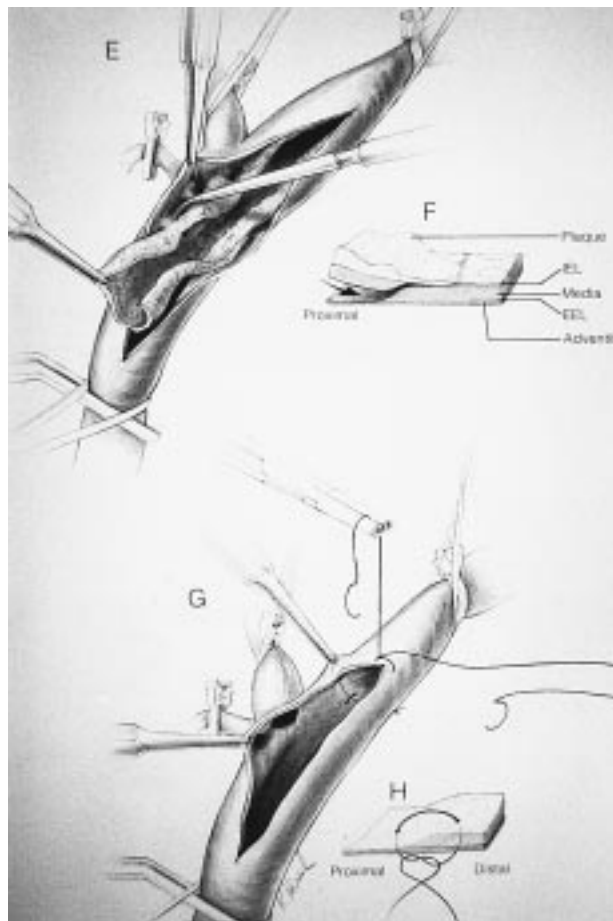
7 Carotid endarterectomy

7.1 The operation

Carotid endarterectomy is usually performed under general rather than local anaesthesia. The carotid bifurcation in the neck is exposed, then gently mobilised and slings are placed around the internal, external and common carotid arteries. After applying clamps to the three arteries, if possible away from any atheromatous plaque, the bifurcation is opened through a vertical incision, the entire stenotic lesion cored out, the distal intimal margin secured, the arteriotomy closed and the clamps released to restore blood flow to the brain. The skin incision is then closed (*figure 4*).

This is the operation at its simplest: it should take only about an hour and a half.

*Figure 4**



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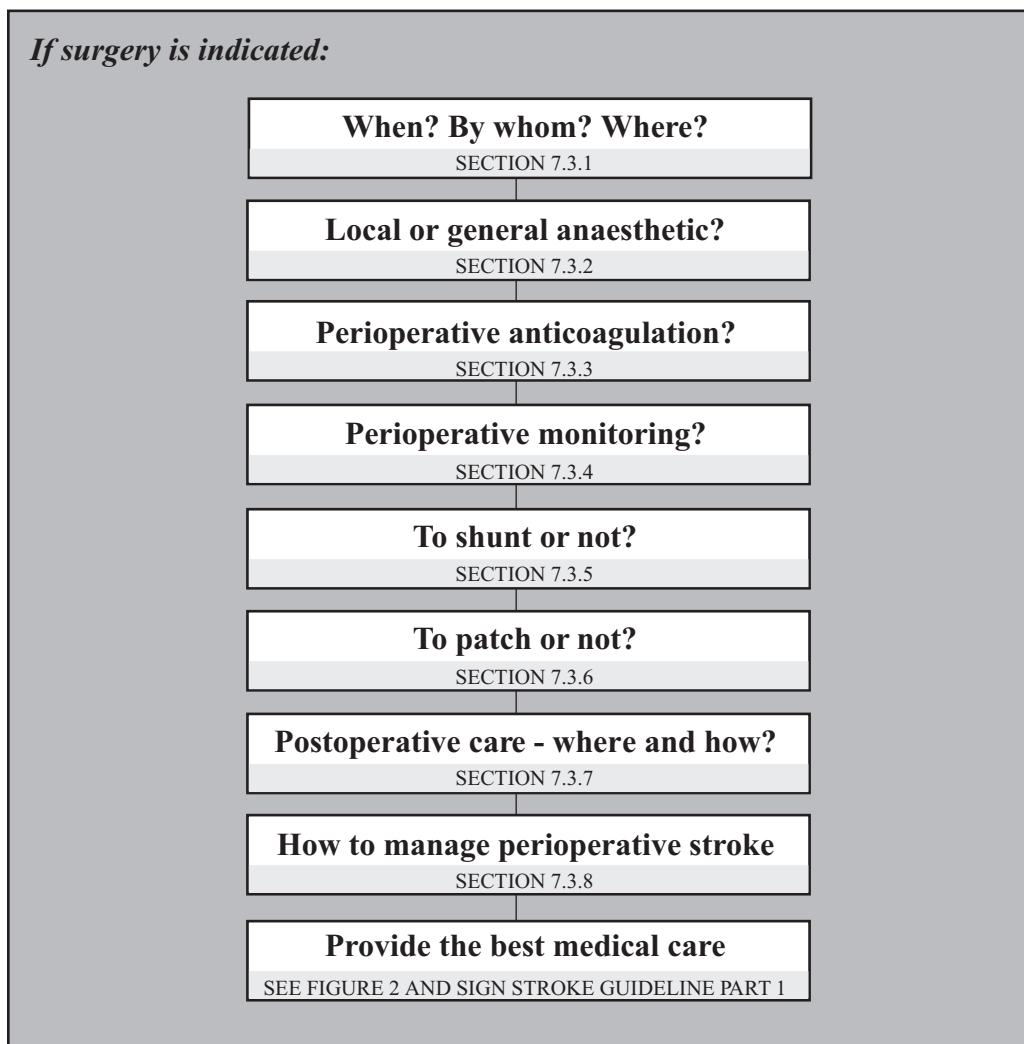
7.2 Complications of carotid endarterectomy

The operation has a large number of possible complications (*see Annex 3*), which occur with varying frequency. The risk of perioperative stroke (ischaemic or haemorrhagic) should be <7% in order for patients to be likely to benefit from surgery (*see section 2.1*). Death occurs in 1-2% of patients undergoing endarterectomy, but there are wide variations between centres.⁽³⁰⁾

7.3 Practical issues concerning surgery

Having made the decision that carotid endarterectomy is worthwhile and feasible in an individual patient, several further questions must be addressed. See figure 5 below.

Figure 5



7.3.1 When, where and by whom should surgery be carried out?

There is limited evidence to support carotid surgery in patients who have not had symptoms referable to carotid stenosis in the previous six months.^(2, 3)

For patients undergoing carotid surgery, surgery should be performed as soon as possible after the ischaemic event to maximise its effectiveness

Grade A, level Ib^(2, 3)

Note that the safety and effectiveness of carotid endarterectomy has not been established in patients who have had an ischaemic stroke within a few days.

The effectiveness of carotid endarterectomy depends upon the safety of the operation and the risk of stroke in the unoperated patient. It is therefore important that patients with a high enough risk of future stroke are selected and that surgery is performed with a low enough complication rate to make it worthwhile.

Patients should have a thorough assessment of their risk of stroke and their general medical condition prior to surgery

Grade C, level IV

If the perioperative stroke risk is too high then any benefit of surgery will be lost. Although surgical and anaesthetic skill must be important, the risk of surgery is not necessarily related to the number of operations done. It would be useful to know that a particular surgeon can perform the carotid endarterectomy with a low risk of complications. Unfortunately this is difficult to quantify accurately, particularly when the risk of surgical stroke is so low and when most surgeons operate on a relatively small number of patients every year.

Carotid surgery should be carried out or directly supervised by surgeons who have received specialist training in carotid endarterectomy

Carotid surgery should only be performed in or in collaboration with centres with the necessary neurological (see sections 3 & 5) and neuroradiological (see sections 4 & 6) skills

Centres should be discouraged from performing carotid endarterectomy if they perform fewer than an agreed minimum number of operations (e.g. 50) per year and should debate the minimum number of operations that each surgeon should undertake per annum. Such numbers, although arbitrary, would ensure that a reasonably precise estimate of performance could be made

Grade C, level IV

7.3.2 Local or general anaesthesia

A systematic review of the small randomised trials comparing the two techniques provided no definite evidence that either was superior.⁽³¹⁾ In the UK most surgeons operate under general anaesthetic and this is usually preferred where there are technical difficulties such as a high bifurcation. Operating under local anaesthetic has the advantage that patients are able to alert the surgeon to new focal symptoms which might be due to focal cerebral ischaemia. This might reduce the need for other types of intra-operative monitoring (*see section 7.3.4*).

Anaesthesia for carotid endarterectomy, whether performed under local or general, should be carried out by an anaesthetist with a vascular interest, training and experience in such cases *Grade C, level IV*

7.3.3 Perioperative antiplatelet and anticoagulant therapy

There have been no randomised trials to test the effectiveness of perioperative antithrombotic treatment. Most surgeons continue any antiplatelet treatment through the perioperative period and heparinise patients during the procedure.

Patients should continue on antiplatelet drugs throughout the perioperative period and should be heparinised during the procedure *Grade C, level IV*

7.3.4 Perioperative monitoring

There is widespread agreement amongst surgeons that controlling systemic blood pressure before, during, and after surgery is crucial to avoid hypotension—which will make any cerebral ischaemia worse—and hypertension—which may cause cerebral oedema or even intracerebral haemorrhage.

Electrocardiogram, oxygen saturation and blood pressure should be carefully monitored in the perioperative period, the latter ideally using an arterial line *Grade C, level IV*

Early warning of cerebral ischaemia may be provided by intraoperative monitoring of:

- ❖ EEG and sensory evoked potentials
- ❖ regional cerebral blood flow or middle cerebral artery (MCA) blood flow
- ❖ emboli detected with transcranial Doppler of the MCA
- ❖ the neurological state of patients if operated under local anaesthesia.

However, this may be too late for a quickly inserted shunt (*see below*) or abandoned operation to ameliorate the consequences of cerebral ischaemia. Ischaemia may anyway not be reversible if it is actually due to embolism rather than low flow.

No firm recommendations can be given concerning the optimal method of perioperative monitoring.

❖ *Perioperative Imaging*

On rare occasions the internal carotid artery (ICA) occludes immediately, or a few days after surgery, as a result of thrombosis or dissection. This does not necessarily cause stroke if the collateral supply to the brain is sufficient.

Both thrombosis and dissection are thought to be due to poor operative technique, particularly if the distal intimal flap has been left unsecured or there is a ridge of tissue due to faulty suturing. Therefore, before closing the skin some surgeons make considerable efforts to check the endarterectomy site with conventional ultrasonography, angiography, angioscopy or intravascular ultrasound imaging and—if necessary—reopen the artery to improve the anatomical result.

Whether this has much effect on the surgical or stroke risk is unknown.

7.3.5 **To shunt or not?**

Only two randomised trials have been done, both too small to be conclusive.^(32, 33) As a result it is not possible to make a recommendation on the routine use of shunts.

7.3.6 **To patch or not?**

Some surgeons now routinely insert a patch of vein or synthetic material when closing the artery to enlarge the lumen and, as a result, perhaps to reduce the risk of re-stenosis and, more importantly, of stroke.⁽³⁴⁾ A meta-analysis of the few randomised trials has shown a possible reduction in re-stenosis and fewer perioperative arterial occlusions in the patched group but, not surprisingly, there were so few strokes that any effect on their risk was quite uncertain.⁽³⁵⁾ It is not possible to make any firm recommendation regarding this issue.

7.3.7 **Postoperative care**

Caring for patients in a surgical high dependency unit in the immediate postoperative period facilitates careful monitoring of their physical condition and especially blood pressure.

Patients should be monitored in a high dependency unit in the immediate postoperative period to allow careful monitoring of blood pressure (see section 7.3.4) and neurological condition
Grade C, level IV

7.3.8 Perioperative stroke

If cerebral ischaemia has not already been suspected by intraoperative monitoring, the first clue that a patient has had an intraoperative stroke is delay or failure to awaken from anaesthesia. It is vital to determine—within minutes if possible—whether the cause is thrombosis at the operation site, which is amenable to correction.

If a perioperative stroke is suspected a Duplex scan should be carried out immediately and the neck re-opened if ICA occlusion is confirmed or suspected

Grade C, level IV

Passage of a Fogarty catheter, restoration of flow and correction of any technical fault which caused the thrombosis can, in some circumstances, be followed by complete neurological recovery. If the investigations show that the operated ICA is still patent then the next question to answer is whether the stroke is due to intracerebral haemorrhage.

In an established perioperative stroke a CT brain scan should be performed

Further management is as for spontaneous stroke

Grade C, level IV

8 Carotid angioplasty

- 8.1 Since endarterectomy of a severe symptomatic carotid stenosis more or less abolishes the risk of ipsilateral ischaemic stroke, other methods to remove the lesion might, in theory, have the same effect. Percutaneous transluminal balloon angioplasty is one such potential method.⁽³⁶⁾
- 8.2 The procedure is currently being evaluated in the Carotid and Vertebral Artery Transluminal Angioplasty Study (CAVATAS). It is not yet clear how risky the procedure is.^(37, 38)

Carotid angioplasty should only be undertaken in the context of randomised controlled trials

Grade C, level IV

9 Recommendations for audit

- 9.1 Several areas are recommended for ongoing audit in hospitals which are involved in the assessment of patients for surgery or in the actual provision of surgery itself. This process would be facilitated by the hospital keeping a register of patients undergoing carotid angiography and endarterectomy.
- 9.2 The following should be recorded to assist audit:
- (a) Whether each patient was **symptomatic** or **asymptomatic**.
 - (b) **Interval between the patient's presentation to their GP with symptoms and various aspects of management**, e.g. delay from initial presentation to:
 - Initial assessment by a specialist
 - Non-invasive imaging
 - Angiography
 - Surgery.
 - (c) **Completeness and accuracy of clinical assessment**. This might include details of the assessments performed to identify vascular risk factors. Ideally some system of peer review of at least a sample of cases might ensure consistent application of diagnostic criteria for TIAs and strokes.
 - (d) **Accuracy of the assessment of severity of carotid stenosis** by carotid duplex compared with conventional angiography, magnetic resonance angiography or spiral CT, depending upon which imaging technique is used.
 - (e) **Reliability of the angiographic assessment of the degree of carotid stenosis**. This might involve a measure of the interrater reliability of the measurement of the degree of carotid stenosis by at least two experienced radiologists blinded to each others findings.
 - (f) **Complications attributable to carotid angiography**. These should be monitored by somebody other than the radiologists performing the procedures. A register of who is performing the angiography should be maintained.
 - (g) **Complications attributable to carotid endarterectomy**, including perioperative stroke and death. These should be monitored by somebody other than the surgeons performing the procedures. A register of who is performing the surgery should be maintained.

10 Implementation of the national guideline through local protocols

- 10.1 It is expected that this guideline will be adopted after local discussion involving clinical staff and provider and purchaser management. The first step should be for the purchasers and providers of hospital services to meet to decide which, if any, part of the preoperative and operative management of patients with carotid endarterectomy should be provided locally and which should be purchased from a specialist centre. This decision will depend upon the local needs, existing hospital services and whether the guidelines could be met by the local services.
- 10.2 Local arrangements will then be made for the derivation of specific local protocols to implement the national guideline in individual hospitals, units and practices. These might include:
- ❖ A protocol for GPs and hospital practitioners to guide the initial assessment of patients with stroke and TIA and in particular to whom such patients should be referred.
 - ❖ Identification of individuals within the hospital who will be responsible for providing:
 - (a) The clinical assessment of patients with carotid stenosis
 - (b) The non-invasive imaging of carotid disease
 - (c) Carotid angiography
 - (d) Carotid endarterectomy
 - (e) On-going information regarding the quality of these services.

The staff groups who require to be involved in development of and familiar with protocols derived from this national guideline are set out in Annex 4.

10.3 **Statement of Intent**

This guideline is designed to provide information to assist decision-making. It is not intended to be construed or to serve as a standard of medical care. Standards of medical care are determined on the basis of all clinical data available for an individual case and are subject to change as scientific knowledge and technology advance and patterns evolve.

- ❖ These parameters of practice should be considered recommendations only. Adherence to them will not ensure a successful outcome in every case, nor should they be construed as including all proper methods of care or excluding other acceptable methods of care aimed at the same results.
- ❖ The ultimate judgement regarding a particular clinical procedure or treatment plan must be made by the doctor in light of the clinical data presented by the patient and the diagnostic and treatment options available.
- ❖ Significant departures from the national guideline as expressed in the local protocol should be fully documented and the reasons for the differences explained.
- ❖ Significant departures from the local protocol should be fully documented in the patient's case notes at the time the relevant decision is taken.
- ❖ A background paper on the legal implications of guidelines prepared by Dr Pamela Abernethy of Simpson & Marwick W.S. is available from the SIGN secretariat.

10.4 **Dissemination**

The guideline will be sent to:

- ❖ Named practitioners in each of the relevant staff groups throughout Scotland.
- ❖ Chief Executives and Clinical Directors in Trust and other hospitals in Scotland.
- ❖ Board General Managers and Directors of Public Health and other chief professional officers in each Health Board.
- ❖ Chairmen of Area Clinical Audit Committees and of Area Medical and other professional Advisory Committees.
- ❖ Local Medical Committees
- ❖ Relevant education and training bodies
- ❖ Selected others

11 Development of the guideline

11.1 Responsible bodies

The series of SIGN stroke guidelines has been developed under the chairmanship of Dr Margaret Roberts through the Royal College of Physicians and Surgeons of Glasgow acting on behalf of the Scottish Intercollegiate Guidelines Network (SIGN); and these have been accepted by SIGN as the Scottish National Guidelines from which local protocols should be derived.

11.2 Carotid Endarterectomy Guideline Development Group

Name	Location	Discipline
Dr Martin Dennis (<i>Chairman</i>)	Edinburgh	Stroke Medicine
Mr George Welch	Glasgow	Vascular Surgery
Dr Joanna Wardlaw	Edinburgh	Neuroradiology
Dr Donald Grosset	Glasgow	Neurology
Dr Peter Rothwell	Edinburgh/Oxford	Neurology
Mr Neil Craig	Glasgow	Health Economics

Declarations of interests are held by the SIGN Secretariat.

11.3 Development process

The Development Group met on three occasions between December 1995 and April 1996. Successive drafts were developed by synthesis of the literature, correspondence and full discussion. The draft recommendations were discussed at two conferences held in Glasgow and Edinburgh, attended by 350 health care professionals, patients and representatives of Chest, Heart & Stroke, Scotland.

The guideline was submitted in draft form to the following external referees: Dr Martin Brown, Neurologist, St George's Hospital, London; Dr Philip Cotton, General Practitioner, Glasgow; Mr Jetmund Engeset, Vascular Surgeon, Aberdeen Royal Infirmary; Professor David Mendelow, Neurosurgeon, Newcastle General Hospital; Dr Andrew Molyneux, Neuroradiologist, Radcliffe Infirmary, Oxford; Dr Olive Robb, Neuroradiologist, Aberdeen Royal Infirmary; and Professor James Weir, Radiologist, Aberdeen Royal Infirmary.

The following also responded to invitations to comment on successive drafts: Dr Ann Bisset, Senior Registrar in Public Health, Grampian; Dr Aileen Keel, Senior Medical Officer, Scottish Office; Dr Eric Baijal, Director of Public Health, Fife; and Dr Norman Waugh, Director, Scottish Health Purchasing Information Centre.

11.4 **SIGN Editorial Board**

The guideline was reviewed before publication by the SIGN Editorial Board.

Professor James Petrie	Royal College of Physicians of Edinburgh Chairman of SIGN
Dr Doreen Campbell	CRAG secretariat, Scottish Office
Dr Patricia Donald	Royal College of General Practitioners
Dr Jeremy Grimshaw	Health Services Research Unit University of Aberdeen
Mr Douglas Harper	Royal College of Surgeons of Edinburgh
Dr Grahame Howard	Royal College of Radiologists Vice Chairman of SIGN

11.5 **Systematic literature review**

The SIGN Editorial Board recognises that the systematic review undertaken for this pilot edition does not fully meet the requirements of the methodology now prescribed by SIGN and this will be addressed in the first review of the guideline (*see section 12.1*).

12 Review of the guideline and recommendations for research

12.1 Review

The Royal College of Physicians and Surgeons of Glasgow, on behalf of SIGN, will have continuing responsibility for the review and updating of the guideline. The guideline will be formally reviewed in 1999; amendments will be disseminated as required at that time or, exceptionally, at any other time when significant amendment becomes necessary.

12.2 Recommendations for further research

Research into the role of carotid surgery in acute stroke will facilitate the updating of this guideline. Evaluation, including cost-effectiveness assessment, of the following aspects is particularly recommended:

- ❖ **The role of carotid endarterectomy in asymptomatic patients**
- ❖ **The role of transluminal carotid angioplasty**
- ❖ **Preoperative imaging**
 - What is the optimum preoperative imaging strategy to ensure that the correct patients are selected?
 - The accuracy and reliability of Duplex vs. angiography
- ❖ **Patient selection**
 - How to identify patients at high and low risk of surgery
- ❖ **Surgical technique:**
 - To shunt or not
 - Local vs. general anaesthetic
 - To patch or not
- ❖ **The development of appropriate information to inform patient choices** (with the involvement of patient groups).

References

- 1 US Department of Health and Human Services, Agency for Health Care Policy and Research. Acute Pain Management: operative or medical procedures and trauma. Rockville (MD), The Agency; 1993. Clinical Practice Guideline No 1. (AHCPR Pub 92-0023): 107.
- 2 European Carotid Surgery Trialists' Collaborative Group. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70-99%) or with mild (0-29%) carotid stenosis. *Lancet* 1991; 337: 1235-1243.
- 3 North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 1991; 325: 445-453.
- 4 Mayberg MR, Wilson E, Yatsu F, Weiss DG, Messina L, Hershey LA, et al. Carotid endarterectomy and prevention of cerebral ischaemia in symptomatic carotid stenosis. . Veterans Affairs Cooperative Studies Program 309 Trialist Group *JAMA* 1991; 266: 3289-3294.
- 5 European Carotid Surgery Trialists' Collaborative Group. The European Carotid Surgery Trial: final results. *Cerebrovasc Dis* 1996; 6 (suppl 2): S2.
- 6 European Carotid Surgery Trialists' Collaborative Group. Endarterectomy for moderate symptomatic carotid stenosis: interim results from the MRC European Carotid Surgery Trial. *Lancet* 1996; 347: 1591-1595.
- 7 Executive Committee of the Asymptomatic Carotid Atherosclerosis Study. Endarterectomy for asymptomatic carotid artery stenosis. *JAMA* 1995; 273: 1421-1428.
- 8 Hobson RW, Weiss DG, Fields WS, Goldstone J, Moore WS, Towne JB et al. Efficacy of carotid endarterectomy for asymptomatic carotid stenosis. The Veterans Affairs Cooperative Study Group. *N Engl J Med* 1993; 328: 221-7.
- 9 Dennis M, Bamford J, Sandercock P, Warlow C. Prognosis of transient ischaemic attacks in the Oxfordshire Community Stroke Project. *Stroke* 1990; 21: 848-853.
- 10 Burn J, Dennis M, Bamford J, Sandercock P, Wade D, Warlow C. Long-term risk of recurrent stroke after a first-ever stroke. The Oxfordshire Community Stroke Project. *Stroke* 1994; 25: 333-337.
- 11 PATS Collaborative Group. Post stroke antihypertensive treatment study - A preliminary result. *Chinese Medical Journal* 1995; 108(9): 710-717.
- 12 Antiplatelet Trialists' Collaboration. Collaborative overview of randomised trials of antiplatelet therapy I: prevention of death, myocardial infarction, and stroke by prolonged antiplatelet therapy in various categories of patients. *BMJ* 1994; 308: 81-106.
- 13 European Atrial Fibrillation Trial Study Group. Secondary Prevention in non-rheumatic atrial fibrillation after transient ischaemic attack or minor stroke. *Lancet* 1993; 342: 1255-62.
- 14 Hankey GJ, Warlow CP. Cost-effectiveness investigation of patients with suspected transient ischaemic attacks. *J Neurol Neurosurg Psychiatry* 1992; 55: 171-176.
- 15 Hankey GJ, Slattery JM, Warlow CP. Transient ischaemic attacks: which patients are at high (and low) risk of serious vascular events? *J Neurol Neurosurg Psychiatry* 1992; 55: 640-652.
- 16 Hankey GJ, Slattery JM, Warlow CP. Can the long term outcome of individual patients with transient ischaemic attacks be predicted accurately? *J Neurol Neurosurg Psychiatry* 1993; 56: 752-9.

- 17 Graor RA, Hertzner NR. Management of coexistent carotid artery and coronary artery disease. *Stroke* 1988; 19: 1441-1443.
- 18 Davenport RJ, Dennis M, Sandercock PA, Warlow CP, Starkey IR, Ruckley CV et al. How should a patient presenting with unstable angina and a recent stroke be managed? *BMJ* 1995; 310: 1449-1452
- 19 Akins CW. The case for concomitant carotid and coronary artery surgery. *Br Heart J* 1995; 74: 97-98.
- 20 Hertzner NR, Loop FD, Beven EG, O'Hara PJ, & Krajewski LP. Surgical staging for simultaneous coronary and carotid disease: A study including prospective randomisation. *J Vasc Surg* 1989; 9: 455-463.
- 21 Strandness DE jr. Angiography before carotid endarterectomy - no. *Arch Neurol* 1995; 52: 832-833.
- 22 Eliasziw M, Rankin RN, Fox AJ, Haynes RB, Barnett HJ Accuracy and prognostic consequences of ultrasonography in identifying severe carotid artery stenosis. North American Symptomatic Carotid Endarterectomy Trial (NASCET) Group. *Stroke* 1995; 26: 1747-1752.
- 23 Patel MR, Kuntz KM, Klufas RA, Kim D, Kramer J, Polak JF, et al. Preoperative assessment of the carotid bifurcation. Can magnetic resonance angiography and duplex ultrasonography replace contrast arteriography? *Stroke* 1995; 26: 1753-1758.
- 24 Riles TS, Eidelman EM, Litt AW, Pinto RS, Oldford F, Schwartzberg GWST. Comparison of magnetic resonance angiography, conventional angiography and duplex scanning. *Stroke* 1992; 23: 341-346.
- 25 Young GR, Humphrey PR, Shaw MD, Nixon TE and Smith ET. Comparison of magnetic resonance angiography, duplex ultrasound and digital subtraction angiography in assessment of extracranial internal carotid artery stenosis. *J Neurol Neurosurg Psychiatry* 1994; 57: 1466-1478.
- 26 Levi CR, Mitchell A, Fitt G, Donnan GA. The accuracy of magnetic resonance angiography in the assessment of extracranial carotid artery occlusive disease. *Cerebrovasc Dis* 1996; 6: 231-236.
- 27 Davies KN, Humphrey PR. Complications of cerebral angiography in patients with symptomatic carotid territory ischaemia screened by carotid ultrasound. *J Neurol Neurosurg Psychiatry* 1993; 56: 967-972.
- 28 Hankey GJ, Warlow CP, Sellar RJ. Cerebral angiographic risk in mild cerebro-vascular disease. *Stroke* 1990; 21: 209-222.
- 29 Rothwell PM, Warlow CP. Making sense of the measurement of carotid stenosis. *Cerebrovasc Dis* 1996; 6: 54-58.
- 30 Rothwell PM, Slattery J, Warlow CP. A systematic comparison of the risks of stroke and death due to carotid endarterectomy for symptomatic and asymptomatic stenosis. *Stroke* 1996; 27: 266-269.
- 31 Tangkanakul C, Counsell C, Warlow C. Carotid endarterectomy performed under local anaesthetic compared to general anaesthetic: a systematic review of the evidence. *Cerebrovasc Dis* 1996; 6 (Suppl 2): 2
- 32 Gumerlock MK, Neuwelt EA. Carotid endarterectomy: To shunt or not to shunt. *Stroke* 1988; 19: 1485-1490.

- 33 Sandmann W, Willeke F, Kolvenbach R, Benecke R, Godehardt E. To shunt or not to shunt: the definite answer with a randomised study. In F.J. Veith editor. Current critical problems in vascular surgery 5. St Louis: Quality Medical Publishing, 1993; 434-440.
- 34 Awad IA, Little JR. Patch angioplasty in carotid endarterectomy: advantages, concerns and controversies. Stroke 1989; 20: 417-422.
- 35 C, Salinas R, Warlow CP, Naylor AR. The role of routine patch angioplasty in carotid endarterectomy: a systematic review of the randomised controlled trials. In: Warlow C, Van Gijn J, Sandercock P editors. Stroke module of the Cochrane Database of Systematic Reviews, issue 3. London: BMJ Publishing, 1996.
- 36 Brown MM. Balloon angioplasty for cerebrovascular disease. Neurological Research 1992; 14 (2 Suppl): 159-163.
- 37 Brown MM, Butler P, Gibbs J, Swash M, Waterston J. Feasibility of percutaneous transluminal angioplasty for carotid artery stenosis. Journal of Neurol Neurosurg Psychiatry 1990; 53: 238-243.
- 38 Porta M, Munari LM, Belloni G, Moschini L, Bonaldi G. Percutaneous angioplasty of atherosclerotic carotid arteries. Cerebrovasc Dis, 1991; 1: 265-272.

Annex 1

Recommended minimum standards for non-invasive imaging

Those providing a non-invasive imaging service should:

- ❖ **Have specific training in carotid duplex** and develop the skill as a special interest to maintain their expertise
- ❖ **Have regular access to the results of conventional angiography or other imaging modalities** (e.g. MRA, spiral CT) **in those patients they have investigated by carotid duplex.** These should be interpreted by a radiologist experienced in carotid imaging and a regular audit of the accuracy of carotid duplex undertaken
- ❖ **Have easy access to colour flow Doppler.** This makes the important differentiation of severe stenosis from complete occlusion more reliable and is less likely to miss tight stenoses
- ❖ **Maintain their experience by performing at least 15 investigations per month,** accepting that this is an arbitrary figure
- ❖ **Be aware of the pitfalls in the use of colour Doppler of the carotid arteries and know when the results are likely to be unreliable**

Grade C, level IV

Annex 2

Recommended practice to minimise risks of carotid angiography

- (1) **Angiography should be performed by, or under supervision of, an experienced operator.** Only persons with extensive angiography experience, especially of head and neck arteries should perform the procedure—i.e. a consultant or supervised senior trainee. Operators should maintain their experience by performing cerebral angiography regularly (perhaps five procedures per month).
- (2) **Non-ionic contrast media should be used:** 3-4ml of 300 strength is usually adequate. Care must be taken to remove all air bubbles from tubing and syringe.
- (3) **Biplanar or ideally triplanar views** should be obtained including a lateral and 45° oblique view to the side of the lesion. The proximal common carotid and distal internal carotid siphon should be included in the films.
- (4) **Late views are important if there is difficulty distinguishing occlusion from extreme ICA stenosis,** when contrast may eventually be seen to pass up to the head. The value of angiography of the contralateral ICA if asymptomatic, vertebral arteries, or aortic arch is not proven and increases the risk of the whole procedure. However, many vascular surgeons do seem to want this extra information. A suggested compromise is at least to have Duplex sonography or MRA of the asymptomatic ICA. Angiography should be timed so that any necessary surgery can be scheduled within two weeks.
- (5) **The smallest possible catheter with the thinnest tip should be used.** This will usually be about 5F size, as 4F often lacks sufficient torque control in elderly hypertensive patients. The smaller catheters minimise the size of the puncture hole in the femoral artery—reducing local bruising and complications and the time required to press on the groin after the procedure (most of the patients are on aspirin so the smaller the puncture the better)—and trauma to the aortic arch and neck vessels.
- (6) **Patients should be well-hydrated.** Fasting is probably not necessary prior to angiography as long as the patient avoids a heavy meal. All medication should be continued, including aspirin, except for oral anticoagulants which should be stopped and heparin cover provided if necessary. Patients should empty their bladder immediately before the procedure. Consider withholding diuretics until after the procedure to avoid dehydration and the need to micturate during the procedure.

Grade C, level IV continued →

(7) Foot pulses should be checked and recorded before the procedure and monitored after the procedure. Many patients have co-existent peripheral vascular disease so it can be difficult to know whether an acute arterial occlusion has occurred unless this is done.

(8) Blood pressure and groin site should be monitored after the procedure.

Grade C, level IV

Annex 3

Possible complications of carotid endarterectomy

- ❖ **Ischaemic stroke** (almost always ipsilateral to the operated artery) due to:
 - embolism from the operation site during or after surgery
 - carotid dissection
 - perioperative carotid occlusion
 - low cerebral blood flow during surgery
 - post-operative systemic hypotension
- ❖ **Haemorrhagic stroke** (almost always ipsilateral to the operated artery) due to:
 - perioperative hypertension
 - post-endarterectomy cerebral hyperperfusion
- ❖ **Death** due to:
 - stroke
 - myocardial infarction
 - pulmonary embolism
 - rupture of arterial operation site
- ❖ **Myocardial infarction**
- ❖ **Local complications**
 - nerve injury (vagal, hypoglossal, marginal mandibular branch of facial, spinal accessory, greater auricular, transverse cervical nerves)
 - wound infection
 - neck haematoma
 - aneurysmal dilatation at operation site
 - patch disruption and haemorrhage
- ❖ **Other**
 - deep venous thrombosis and pulmonary embolism
 - trans-hemispheric cerebral oedema
 - headache, focal motor seizures
 - facial (parotid) pain
 - pain at vein donor site after vein patch angioplasty

Annex 4

Staff groups who require to be involved in development and implementation of local protocols derived from this national guideline

- ❖ General Practitioners
- ❖ Physicians and neurologists
- ❖ Vascular surgeons and neurosurgeons
- ❖ Radiologists
- ❖ Anaesthetists
- ❖ Nursing staff in hospital and community
- ❖ Area audit committees
- ❖ Deans and Postgraduate Deans of University Faculties of Medicine in Scotland and other relevant professional educational bodies.

Management of Carotid Stenosis and Carotid Endarterectomy

A Quick Reference Guide

Derived from the National Clinical Guideline recommended for use in Scotland
by the Scottish Intercollegiate Guidelines Network (SIGN)

A **B** **C** refers to **grade of recommendation**

