The current status of carotid endarterectomy—part 1

Carotid endarterectomy is a surgical procedure in which an atherosclerotic plaque is removed from the carotid artery to avoid future stroke. A small proportion of patients will have adverse effects from surgery and need emergency blood-pressure management to avoid intracranial haemorrhage. This paradoxical risk of operation-related stroke leads to continuing controversy about this procedure. Large randomised trials have shown good evidence of benefit in symptomatic patients. However, despite the benefits of swift treatment, patients in the UK are still likely to have significant delay to treatment.

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The rationale underlying carotid endarterectomy is simple; removal of an atherosclerotic plaque from the internal carotid artery removes a source of thromboembolism and so reduces the long-term risk of stroke. However, in the 50 years since its introduction,[1] carotid endarterectomy has remained one of the most enduringly controversial and scientifically scrutinised procedures. Part 1 of this review deals with the current status of carotid endarterectomy in symptomatic patients. Part 2, looking at evidence in asymptomatic patients and how endarterectomy compares with stenting will be published in the next issue of GM.

Box 1: Preferred techniques for carotid endarterectomy

1. Routine patching is preferable to routine primary closure
2. Patch type (vein or prosthetic) does not influence outcome
3. Long-term outcomes after eversion endarterectomy are no different to traditional endarterectomy, provided the arteriotomy is patched
4. Routine shunting is preferable to routine never shunting[2]
5. No consensus exists on whether routine versus selective patching and shunting is preferable

What does the operation entail?

The operation is done under either locoregional or general anaesthesia. The GALA trial, with 3526 randomised patients,[2] was published in December 2008 and showed that neither anaesthetic strategy conferred significant benefit over the other in terms of reducing the peri-operative risk. Accordingly, surgeons may use their preferred method of anaesthesia. The carotid bifurcation is exposed by an anterior sternomastoid incision or a shorter transverse crease incision, and the patient is given systemic heparin. The actual endarterectomy procedure is performed in one of two ways.

Traditional endarterectomy involves a longitudinal incision across the stenosis. A Watson-Cheyne dissector is placed across the endarterectomy plane in the common carotid artery and the overlying intima and media are transected. Endarterectomy then continues up into the internal carotid artery, transecting the plaque in the external carotid artery. Distally, the intima either feathers and separates naturally or requires careful transection and tacking down.

The arteriotomy is usually closed with a venous or prosthetic patch. The alternative is eversion endarterectomy, in which the internal carotid artery is transected at its origin and the tube of plaque is expelled by everting the overlying media and adventitia. Afterwards, the internal carotid artery can be shortened as necessary before being reattached to the endarterectomised bifurcation. Many randomised trials have evaluated many technical aspects of carotid endarterectomy; the available evidence is summarised in box 1.[3]

Most patients are discharged home on the second day after surgery. 1–2% of patients will be readmitted as an emergency case with severe hypertension and seizures, perhaps with onset of a new neurological deficit. If these patients are admitted to medical units, informing their vascular surgeon as soon as possible is essential. These patients require aggressive control of blood pressure to prevent progression to intracranial haemorrhage.[4] Otherwise, most patients are seen only once in the outpatient department before being discharged with the recommendation to return if recurrent symptoms develop. This advice is

given because after successful carotid endarterectomy, the likelihood of returning with recurrent symptoms and a significant restenosis is very small.

Why is the operation so controversial?

Simply because of the paradox wherein this operation that aims to prevent stroke in the long term is responsible for a small but significant number of strokes in the short term. A sobering fact is that about 2 million carotid endarterectomies have been done since 1954, and (by conservative estimates) approximately 100,000 patients will have died or had a stroke in the first 30 days after surgery as a direct consequence. Additionally, concerns by neurologists about the appropriate selection of patients led to the sequence of large scale randomised controlled trials that became the foundation for establishing evidence-based practice in this field.

The symptomatic trials

Three trials; the European Carotid Surgery Trial (ECST), the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the Veterans Affairs Study were most influential in guiding practice.[5–7] The Carotid Endarterectomy Trialists Collaboration (CETC) combined the data from these three studies, having reassessed all pre-randomisation angiograms using the measurement method from NASCET.[8–10] Awareness of exactly which measurement method is used is essential, otherwise considerable confusion can occur over the definition of 50% or 70% stenosis thresholds.[11]

NASCET	ECST
30%	65%
40%	70%
50%	75%
60%	80%
70%	85%
80%	90%
90%	95%

Table 1: Correlation between measurements of carotid stenoses in ECST and NASCET[12]

The measurement method from ECST compared the residual luminal diameter against a guestimate of the diameter of the carotid bulb (figure 1). The NASCET measurement method compares the residual luminal diameter against the diameter of the normal internal carotid artery above the stenosis. Table 1 summarises how the two measurement systems compare. For example, a 50% stenosis as defined in the NASCET study is broadly equivalent to a 75% stenosis as defined in ECST.

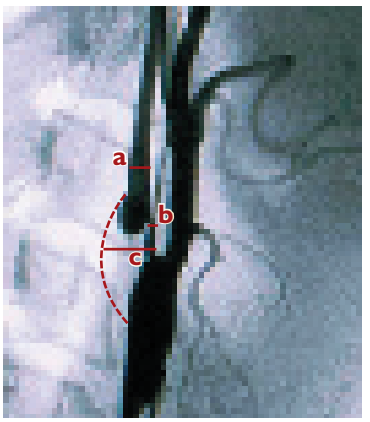

Figure 1: Intra-arterial digital subtraction angiogram showing severe stenosis at the origin of the internal carotid artery
The NASCET measurement method compares the diameter of normal internal carotid artery above the stenosis (a) against the residual luminal diameter (b). The ECST method of measuring stenosis compares the residual luminal diameter (b) against a guestimate of the diameter of the carotid bulb (c). Reproduced with permission from Walker & Naylor, and Elsevier.[11]

The CETC database consists of more than 6000 randomised patients and it is now the definitive reference source that should be cited instead of the constituent studies. Table 2 summarises the principle outcomes for any stroke within 5 years including the perioperative risk.

	Number of patients	30-day risk of stroke or death	5-year risk of stroke or death with surgery	5-year risk of stroke or death with best medical treatment	Absolute risk reduction	Relative risk reduction	Number needed to treat	Strokes prevented per 1000 procedures at 5 years
<30%	1746	..	18·36%	15·71%	−2·6%	no benefit	no benefit	0
30–49%	1429	6·7%	22·80%	25·45%	2·6%	10%	38	26
50–69%	1549	8·4%	20·00%	27·77%	7·8%	28%	13	78
70–99%	1095	6·2%	17·13%	32·71%	15·6%	48%	6	156
String sign*	262	5·4%	22·40%	22·40%	−0·1%	no benefit	no benefit	0

Table 2: 5-year risk of any stroke after carotid endarterectomy including stroke within 30 days of procedure or death by extent of stenosis[8–10]
Data are derived from CETC with all pre-randomisation angiograms reassessed according to NASCET method. *The string sign is also known as near occlusion.

As can be seen in table 2, carotid endarterectomy conferred small, but clinially significant benefit in patients with 50–69% stenoses, with maximum benefit observed in patients with 70–99% stenoses.

The confusion regarding stenosis thresholds is important,[10] because some centres recommend intervention in 50–99% stenoses, while others use a threshold for intervention of 70% stenosis. These differences in practice are simply due to the method of measurement. A recent audit of practice in the UK highlighted considerable variation and many health-care professionals did not know whether their unit used NASCET or ECST measurement criteria.[11] Do you know which method is used in your centre?

Patients at high risk of stroke

Each of the major trials (including CETC) has undertaken important subgroup analyses to try to determine who gains maximum benefit from carotid endarterectomy.[13] These subgroups can be broadly categorised by their clinical or imaging features (box 2). These groups should not be used to exclude patients from intervention, but rather to identify those patients at very high risk who should be treated swiftly. So, for example, an 80-year-old male who has a hemispheric transient ischaemic attack within 2 weeks of presentation and has a 90% stenosis with a contralateral occlusion treated with best medical therapy has a greatly increased risk of stroke compared with a 70-year-old female who had one episode of amaurosis fugax 5 months previously and has a unilateral 60% stenosis. The male patient would clearly benefit from urgent referral and surgery; however, this rarely happens.

Three groups of patients are worthy of specific mention. First, CETC has shown that patients with near occlusion (otherwise known as the string sign) do not seem to benefit from surgery.[7] These patients have a tiny residual lumen with no distal opening out of the vessel into a normal caliber internal carotid artery. Ultrasound, shows very low systolic velocities and loss of the diastolic waveform. These features can occasionally be difficult to differentiate from a critical stenosis which opens out into a normal vessel (ie, operable) and imaging to confirm the diagnosis is therefore sensible if any doubt exists. The remaining two key issues to be considered are the effect on patients of delay to treatment and the benefit conferred by carotid endarterectomy in elderly patients.

Delay to treatment

The UK does not have a good track record for expeditiously investigating and treating patients with transient ischaemic attacks and minor stroke.[14] In the 1997 UK audit of carotid endarterectomy, the median delay from onset of symptoms to surgery was 189 days.[15] In the 2004 Royal College of Physicians' Sentinel audit,[16] only 50% of patients with transient ischaemic attack had undergone a duplex ultrasound examination within 12 weeks, and in a 2006 survey of practice in 11 centres

Box 2: Features predicting high risk of stroke in patients on best medical therapy

Clinical features

- Male versus female gender
- Increasing age (especially 75 years and older)
- Hemispheric versus ocular symptoms
- Cortical versus lacunar stroke
- Recurrent symptoms for more than 6 months
- Increasing medical comorbidity
- Symptoms in the past 2 weeks

Imaging features

- Irregular versus smooth plaques
- Increasing stenosis but not near occlusion
- Contralateral occlusion
- Concurrent intracranial disease
- No recruitment of intracranial collaterals

	7 days	28 days	3 months
Transient ischaemic attack (n=87)	8·0% (2·3–13·7%)	11·5% (4·8–18·2%)	17·3% (9·3–25·3%)
Minor stroke	11·5% (4·8–11·2%)	15·0% (7·5–22·5%)	18.5% (10·3–26·7%)

Table 3: Cumulative risk of stroke after presenting with a transient ischaemic attack or minor stroke in a population-based study[20]
Data are proportion (95% CI).

in the Netherlands, only 24% of patients presenting with a transient ischaemic attack or minor stroke and a 70–99% stenosis underwent carotid endarterectomy within 6 months.[17] In the interim Royal College of Physicians' Vascular Society audit of UK carotid endarterectomy practice released in 2007, the delay from referral to surgery had fallen to 45 days.[18] However, emerging data suggest that these delays are still unacceptable and that the cohort of patients at highest risk—those who might have most to gain from carotid endarterectomy—are not being investigated and treated in time.

One enlightening natural history study was conducted by Coull and colleagues[19] who reported the cumulative risks of stroke in patients presenting with a transient ischaemic attack or minor stroke (table 3). This was a population-based study that was not subject to the inherent biases associated with those that recruit patients from emergency or outpatient departments. It was able to capture events happening in the first few days after presentation. The 7-day and 28-day risks of stroke were much higher than is traditionally taught in medical schools (ie, 1–2% at 7 days, 2–4% at 30 days).

Further evidence of the need for expedited intervention comes from CETC, in the form of a subgroup analysis correlating benefit from carotid endarterectomy against delays to surgery. Table 4 presents data from CETC in the form of the absolute risk reduction in stroke conferred by carotid endarterectomy at 5 years stratified for the time from presentation to randomisation.[7] On average, surgery was performed one week after randomisation. Table 4 shows unequivocally that the longer surgery is delayed the less the long-term benefit, to the extent that any delay beyond 12 weeks in patients with 50–99% stenoses (ie, 70–99% measured in ECST) prevents only eight ipsilateral strokes per 1000 surgeries at 5 years.

Physicians, have just as vital a role as your surgical colleagues in fast tracking patients with transient ischaemic attacks or minor strokes. The Government recently recommended a 48-hour target for surgery,[20] but achieving this is going to require a paradigm shift in attitudes and prioritisation of resources.

Finally, carotid endarterectomy has traditionally been deferred for 6–8 weeks in patients presenting with stroke to minimise the risks of haemorrhagic transformation. This policy is clearly at odds with the evidence and is the subject of much contemporary debate. Two recent reviews suggest that patients who present with minor stroke and who have rapid recovery or neurological plateau can undergo expedited carotid endarterectomy without an excessive increase in risk.[21,22]

Ageism

The second key issue is the relationship between age and benefit from carotid endartectomy. Previously, many physicians believed that elderly patients gained little long-term benefit from this surgery, primarily because risks from the procedure were thought to be increased. In a subgroup analysis from NASCET,[23] this was shown to be completely untrue (figure 2). Elderly patients (ie, those older than 75 years) gained more benefit from carotid endarterectomy than did any other age-group, a finding that is consistent across all stenosis subgroups. Accordingly, no patient should be denied access to this treatment simply on the basis of age.

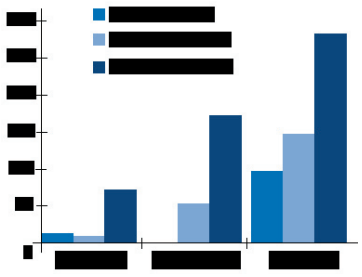

Figure 2: Number of strokes prevented per 1000 carotid endarterectomies stratified by age and extent of stenosis

	Less than 2 weeks	2–4 weeks	4–12 weeks	More than 12 weeks
Absolute risk reduction at 5 years	18·5%	9·8%	5·5%	0·8%
Number needed to treat	5	10	18	125
Strokes prevented per 1000 procedures	185	98	55	8

Table 4: Effect of different periods of delay to carotid endarterectomy on 5-year prevention of ipsilateral stroke in patients with 50–99% stenosis as measured in NASCET[8–10]
Data were derived from a reanalysis of CETC. Delay refers to time from randomisation to carotid endarterectomy. In the constituent studies, the average time from randomisation to surgery was about 7 days (Personal communication, PM Rothwell)

Part 2 of this article will appear in the next issue of GM.

I have no conflict of interest.

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