General or local anaesthesia for carotid endarterectomy?

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Key points
Carotid endarterectomy (CEA) is performed to reduce the risk of a future fatal or disabling stroke. The risk of major stroke is greatest in the first few days after a transient ischaemic attack (TIA) or minor stroke. Therefore, the potential benefit is greater if CEA is performed within 2 weeks of TIA or minor stroke. The results of CEA are improving though surgical and anaesthetic techniques vary between centres. Recent large trials and systematic reviews have shown that the type of anaesthesia does not affect outcome.

Stroke is the most common cause of adult neurological disability in the developed world. It is the third leading cause of death in the UK. The incidence in England and Wales is >130 000 each year. Costs to the NHS and to society were estimated at approximately £7 billion in 2005; both incidence and costs are predicted to increase as the population ages. Carotid endarterectomy (CEA) is performed as a preventative procedure to prevent disabling or fatal stroke in patients with significant carotid stenosis. These patients may have been asymptomatic or have already suffered a transient ischaemic attack (TIA) or minor stroke. The aim of this article is to discuss some recent trends and changes in the perioperative management of patients presenting for carotid surgery.

Large randomized prospective studies in the 1990s showed that CEA improves outcomes of symptomatic patients with >70% carotid stenosis, compared with the best medical management (reduction in arterial pressure, antiplatelet drugs, statins or diet to reduce serum cholesterol, stopping smoking, and reducing alcohol intake). The Asymptomatic Carotid Surgery Trial subsequently demonstrated that CEA improves outcome in those with carotid stenosis >60% but no symptoms, though the absolute risk reduction is lower than that in symptomatic patients and is better for younger patients (<75 yr).

It has long been known that a TIA or minor stroke increases the risk of a subsequent major stroke, causing death or significant disability. However, it has recently become clear that the risk of fatal or disabling stroke is exceedingly high in the first few days after minor stroke or TIA. The risk is 10–20% within a month, and the highest risk is within 72 h after TIA or minor stroke. In addition, the greatest benefits from CEA are gained if it is performed within 2 weeks of the last symptom. This target has now been incorporated into recent NICE guidelines and has led to important changes to UK practice with an imperative that CEA should be performed within 2 weeks of neurological symptoms and within 48 h if possible.

Because there are risks associated with CEA, patients only benefit from CEA when perioperative risks are low and medium-term survival (2 yr or more) is good, so all possible attempts should be made to minimize risks. The major complications of CEA are intra- and postoperative stroke, myocardial infarction (MI), and death; their combined 30 day incidence should be <5% in centres performing surgery. Any co-morbidities, such as ischaemic heart disease, hypertension, diabetes, and chronic obstructive pulmonary disease, should be optimized appropriately before surgery but the imperative to perform CEA urgently poses increased challenges for the medical, surgical, and anaesthetic teams as the time for optimization of co-morbidities is reduced. Furthermore, arterial pressure is actually more labile in the 2 weeks after a stroke, so is potentially more difficult to control. Studies in these areas are ongoing but recent reviews have emphasized the need for control of arterial pressure before, during, and after CEA.

Surgery and monitoring
CEA involves exposure and cross-clamping of the carotid artery above and below the area of stenosis. The area of atheroma within the artery is removed usually via a longitudinal incision and the defect closed by primary closure or using a patch angioplasty (synthetic or autologous vein graft). Using a patch reduces the risk of re-stenosis. Throughout the period of cross-clamping, cerebral blood flow (CBF) is reduced, depending on the degree of collateral flow via the circle of Willis. Ipsilateral CBF can be improved by deploying a temporary artificial shunt from below to above the
Transcranial Doppler
A Doppler probe is placed on the petrous temporal bone allowing measurement of middle cerebral artery flow
Monitors both flow and emboli, used inter- and postoperative period
Operator-dependent
Placement is near the surgical site
Acoustic window not found in 10–20% of patients

Stump pressure
The stump pressure distal to the carotid clamp reflects the perfusion pressure around the circle of Willis
Specific measure of cerebral ischaemia
Non-sensitive measure of cerebral ischaemia
Cannot identify emboli

EEG
EEG is affected by cerebral ischaemia. Raw and processed (spectral array) data can be used
Measurement only reflects cortical and not deeper structure
Difficult to interpret
GA can alter the signal
Cannot identify emboli

Somatosensory evoked potentials
EEG is recorded after a stimulus, thus reflects the cortex and deeper structure activity
Maybe useful if baseline EEG is abnormal
GA can alter the signal
Thought to be no more sensitive or specific compared with EEG
Cannot identify emboli

Near-infrared spectroscopy (NIRS)
NIRS measures arterial venous and capillary oxygenation producing a regional cerebral oxygenation (rSO₂) value
High negative predictive value for cerebral ischaemia
Poor positive predictive value
Frontal lobe sensors
Interference from non-cerebral blood flow and light
Cannot identify emboli

Cross-clamps. There are potential risks associated with a shunt, including particulate or bubble embolization, arterial wall dissection kinking, or thrombosis, and different surgeons adopt different approaches. Some always insert a shunt, on the basis that the benefits of shunting outweigh the risks and that these risks decrease with experience and technical expertise. Other surgeons only insert a shunt when cerebral perfusion is found to be inadequate without a shunt. Eversion CEA is an alternative surgical technique, during which the internal carotid artery is transected obliquely at its origin, everted to remove the plaque, and then re-implanted onto the common carotid artery. Eversion CEA is technically quicker and is used to avoid the need for both shunting and patch angioplasty. However, large trials have shown similar outcomes after both conventional and eversion CEA, so surgical opinions vary. ⁹

**Monitoring**

Almost all practitioners agree that there is a need to monitor CBF during CEA, particularly during the period of arterial cross-clamping. It is also agreed that the ‘gold standard’ in cerebral monitoring is to keep the patient awake during surgery so that sensory, motor, and higher mental functions can be assessed continuously. Any symptoms from reduced CBF or embolization are immediately apparent and this is one of the major benefits of performing surgery under local or regional anaesthesia (RA). Several other monitors of cerebral perfusion are available including transcranial Doppler (which also detects the occurrence of microemboli), stump pressure measurement, EEG, somatosensory evoked potentials, and near-infrared spectroscopy (Table 1). These electromechanical monitors are often used to determine the need for a temporary shunt, though their reliability in this regard varies. ⁹

**General considerations for anaesthesia**

The main aims of anaesthesia are to maintain airway control, oxygenation, and cardiovascular stability in a pain-free patient, while providing good operating conditions for surgery and allowing cerebral monitoring. Cardiovascular instability is very common during CEA because of several factors: arterial pressure autoregulation is impaired after a stroke and baroreceptor sensitivity is reduced owing to carotid atherosclerosis, the effects of carotid surgery, anaesthesia [general anaesthesia (GA) and RA], old age, diabetes, and antihypertensive medications. ⁸ Cardiovascular instability (especially hypotension or hypertension) can cause stroke or precipitate myocardial ischaemia or heart failure, though it is now accepted that the majority of perioperative strokes are caused by thrombo-embolism. Nevertheless, invasive arterial pressure monitoring is indicated and should be instituted before surgery. It is recommended to maintain arterial pressure below 170 mm Hg and ideally within 20% of the patient’s baseline during surgery, though there is little definitive evidence to substantiate this. Untreated postoperative hypertension can predispose to wound haematoma formation because of venous or suture line bleeding, which is
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Table 2 | Perceived advantages and disadvantages of GA and RA for CEA

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>General anaesthesia</td>
<td>Lack of direct neurological monitoring during surgery</td>
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<tr>
<td>Immobility</td>
<td>Intraoperative hypotension</td>
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<tr>
<td>Potential for neuroprotection</td>
<td>Postoperative hypertension</td>
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<tr>
<td>Controlled ventilation and CO₂</td>
<td>Increased rate of shunt use</td>
</tr>
<tr>
<td>Attenuated stress response</td>
<td>Delayed recovery from GA may mask postoperative neurological complications</td>
</tr>
<tr>
<td>Regional anaesthesia</td>
<td>Risks associated with sitting blocks (deep cervical plexus blockade)</td>
</tr>
<tr>
<td>Allows direct real-time neurological monitoring</td>
<td>Patient stress/pain causing increased risk of myocardial ischaemia</td>
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<tr>
<td>Avoids the risks of airway intervention</td>
<td>Restricted access to airway during surgery</td>
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<tr>
<td>Reduced shunt rate</td>
<td>Requires co-operative patient, able to lie flat</td>
</tr>
<tr>
<td>Reduced hospital stay</td>
<td>Risk of requirement to convert to GA during surgery</td>
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<tr>
<td>Allows arterial closure at ‘normal’ arterial pressure: may reduce risk of postoperative haematoma</td>
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exacerbated by the need to administer antiplatelet and anticoagulant drugs during surgery. Cerebral hyperperfusion syndrome (CHS) is an extreme form of cardiovascular instability which occurs in 1% of patients undergoing CEA, typically 2–7 days after surgery. Patients usually present with a hypertensive encephalopathy, that is, severe headache, variable neurological deficits, seizures, and marked hypertension. The aetiology is probably an ischaemia–reperfusion injury with impaired cerebral autoregulation in areas of the brain which were previously under-perfused. CHS can lead to cerebral oedema and cerebral haemorrhage. Mortality after intercerebral haemorrhage in these patients is up to 67%. Cerebral oedema can be reduced by aggressive arterial pressure control. Close monitoring of arterial pressure is imperative in the early postoperative period and hypertension should be treated promptly. The incidence of perioperative thrombo-embolism is reduced by the use of antiplatelet and anticoagulation drugs. All patients should be taking aspirin before surgery and increasingly patients are prescribed additional antiplatelet cover such as clopidogrel. Heparin (usually 5000 IU i.v.) is administered just before carotid artery cross-clamping.

Regional anaesthesia

RA can be provided using local infiltration, superficial and/or deep cervical plexus blockade, with or without ultrasound guidance. CEA can be performed under cervical epidural anaesthesia, but this is not common practice in the UK because of the technical difficulties involved and the high frequency of complications, for example, hypotension or high blocks. The major advantage of performing CEA under RA is the ability to assess the patient’s cerebral function clinically, without the need for additional monitoring devices, and cerebral arterial pressure autoregulation is relatively preserved. This allows the surgeon to use shunting in selected patients only. Other advantages include avoidance of some adverse consequences of GA (e.g. sore throat, fatigue, nausea, and vomiting) and early detection of myocardial ischaemia, and potentially fewer cardiorespiratory complications. The typical arterial pressure profile under RA is that mild hypertension occurs during the period of cross-clamping with mild hypotension after release of the clamp. This pattern is seen as advantageous as surgery is performed with the artery at normal or slightly high arterial pressure.

Disadvantages of RA include the risk of complications related to the block itself (inadequate anaesthesia, subarachnoid/epidural/intravascular injection, haematoma, phrenic nerve palsy) and possible patient discomfort (claustrophobia, over-heating, full bladder). Access to the airway is restricted, which may be a problem if conversion to GA is required during the procedure (69/1773 patients required conversion from RA to GA in the GALA trial). The patient must be cooperative and able to lie flat and still; many anaesthetists administer sedatives (e.g. midazolam or low doses of propofol or remifentanil) and there is a risk of excessive sedation. RA for CEA should be performed by a team with expertise in the area who are adept at avoiding and dealing with these challenges.

General anaesthesia

The main perceived advantages of GA over RA are that airway control can be assured, oxygenation maintained more easily, and arterial CO₂ tensions adjusted (Table 2). GA agents (inhalational and i.v.) also have theoretical neuroprotective effects, though there is little evidence for clinical benefit in CEA. There are also insufficient data to suggest that any single anaesthetic technique is superior. Anaesthesia can be maintained using inhalational or i.v. agents. Both potentially can impair cerebral autoregulation (both to pressure and to CO₂) at concentrations >1 MAC. Newer agents (isoflurane, sevoflurane, and desflurane) have less effect on cerebral autoregulation and no important effect if concentrations are kept below 1 MAC. Nitrous oxide should arguably be avoided because of the risk of air embolism and increased cerebral metabolic rate. The majority of anaesthetists maintain airway control using tracheal intubation but some use a laryngeal mask airway.
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Table 3 Summary of recent literature comparing GA and RA for carotid endarterectomy

<table>
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<tr>
<th>Study/Review</th>
<th>Patients</th>
<th>Primary outcome</th>
<th>Secondary outcome</th>
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<tr>
<td>Cochrane review (2004)</td>
<td>3526 (GA=1753, RA=1773)</td>
<td>Stroke, MI, or death 30 days after surgery (GA=4.8%, RA=4.5%)</td>
<td>Quality of life, length of hospital stay</td>
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<tr>
<td>GALA (2008)</td>
<td>1753, 1773</td>
<td>Meta-analysis showed that the odds of 30 day stroke or death were similar (OR 0.88 (95% CI 0.64–1.23))</td>
<td>RA associated with a significant reduction in postoperative neurological complications</td>
</tr>
<tr>
<td>Updated systematic review (2008)</td>
<td>4335 operations</td>
<td>Meta-analysis including the GALA trial concluded that there was no evidence of a reduction in the odds of operative stroke with RA but that many randomized studies were too small and further data are required.</td>
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Normocarbia should be maintained by artificial ventilation to prevent adverse effects on cerebral CBF.

The main disadvantage of CEA under GA is the need to use indirect methods of neurological monitoring. Other disadvantages include the increased likelihood of intraoperative hypotension and postoperative hypertension, with the need for vasoactive medication. Most patients undergoing CEA have cardiovascular disease so a careful and smooth anaesthetic technique is essential. If excessive volumes of i.v. fluids are administered, bladder catheterization may be required. Pain from an over distended bladder or irritation from a urinary catheter can cause discomfort and postoperative hypertension. It is also advantageous to close the artery at a normal arterial pressure to limit the risk of postoperative haemorrhage or haematoma formation. This is potentially more likely if intraoperative hypotension has not been treated.

The usual complications of GA are also present, ranging from the potential for major airway problems to ‘minor’ complications including headache and sore throat. More importantly, the residual effects of GA in the early postoperative period can mask the symptoms or signs of neurological complications from surgery. For example, these usually present initially as non-distinct sedation, confusion, or agitation, rather than gross motor deficits and could be wrongly attributed to the effects of anaesthesia.

General or regional anaesthesia?

Anaesthetists and surgeons have debated the relative benefits of GA or RA for CEA for many years, with opinions polarized (Table 3). A Cochrane review published in 2004 examined data from 26 non-randomized and seven randomized studies and concluded that there was a potential benefit from RA but the evidence was insufficient to make firm conclusions.7

In an attempt to answer this question, the GALA trial recruited over 3500 patients from 95 centres between 2001 and 2007, randomized to undergo CEA under GA or RA. The study had a pragmatic design, with the surgical and anaesthetic techniques (GA and RA) chosen according to individual’s practice. In an attempt to answer this question, the GALA trial recruited over 3500 patients from 95 centres between 2001 and 2007, randomized to undergo CEA under GA or RA. The study had a pragmatic design, with the surgical and anaesthetic techniques (GA and RA) chosen according to individual’s practice. Shunts were used in those undergoing RA only when awake testing indicated the need. The primary outcome by intention to treat was the proportion of patients with stroke, MI, or death between randomization and 30 days after surgery; secondary outcomes included stroke, MI, death at 1 yr, quality of life, and length of hospital stay.12 Postoperative evaluations were made by a stroke physician or neurologist at 1 month after surgery, blinded to anaesthetic technique.

The combined primary outcome incidence was almost identical in the two groups: 4.8% in the GA group and 4.5% in the RA group. There were also no significant differences in the secondary outcomes, although there was a non-significant (P = 0.094) lower rate of stroke and MI at 1 yr in the RA group. An updated meta-analysis including the GALA trial concluded that there was no evidence of a reduction in the odds of operative stroke with RA but that many randomized studies were too small and further data are required.13 However, RA is associated with a significant reduction in postoperative wound haemorrhage. A subsequent analysis of costs suggested a benefit for RA techniques; this figure could be higher if local avoided the need the more complex monitoring and physician pathways to avoid/reduced HDU/ICU admission.14 Should we therefore conclude that anaesthetic technique (GA or RA) has no effect on major outcomes?

The GALA trial attracted a great deal of attention from vascular surgeons and anaesthetists, perhaps partly because of the firm and opposing opinions in this area, including some criticisms. Undoubtedly, one of the factors involved in the lack of difference between the groups was that the incidence of the primary outcome was lower than anticipated and lower than in previous large trials. Planned recruitment was 5000 (with an anticipated reduction in the RA group from 7.5% to 5%) and the trial was stopped early (due to funding running out). However, the type of GA or RA was not standardized or recorded, and both conventional and evisceration CEA...
were not allocated, although numbers in each arm were similar. Other possible problems include the unrecorded preoperative use of statins in both groups, highly varied practices regarding intraoperative shunt usage (the type of shunts used was also not recorded), possible effects of the lack of binding of surgeons and anaesthetists, and cross-over of patients between groups. 4.4% of the patients allocated to RA had complications requiring cancellation of surgery or conversion to GA. It has been suggested that anaesthetic techniques (including arterial pressure management) changed during the study period and that surgeons and anaesthetists may have avoided randomizing the highest risk patients perceived as unsuitable for either GA or RA.

The GALA trial was a considerable undertaking on the part of the investigators. In some respects, the results are disappointing in that they perhaps raise more questions than answers, particularly in aspects of surgical practice such as the practice of routine or selective shunting. Further evaluations (e.g. longer term follow-up) are expected. However, it should be emphasized that most strokes related to surgery are related to thrombo-embolism rather than hypo- or hypertension and the majority of these are caused by an inadvertent technical surgical error. Whether surgery is performed under RA or GA could only affect these factors to a limited degree, especially within the context of a pragmatic study. Overall, however, the reduced morbidity and mortality in the GALA trial compared with previous data is encouraging.

On the current evidence, it is clear to the authors that major perioperative outcomes after CEA are similar between RA and GA. This does not mean that anaesthetic technique is unimportant, because GA or RA performed well (or badly) contribute to good (or bad) outcome. Nevertheless, the main factors in producing good results are preoperative evaluation, case selection and optimization, and the experience expertise and close attention of the anaesthetic, surgical, and perioperative care team.

Conclusions

Anaesthesia for CEA is challenging and practice is changing. Anaesthetic technique should be determined by the anaesthetist, surgeon, and patient, depending on individual skills and preferences, local facilities and expertise, and patient co-morbidities and preferences. Local practice should continue to be audited against international standards. The conduct of perioperative care is more important than the type of anaesthesia used.

Declaration of interest

None declared.

References


Please see multiple choice questions 37–40.