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[Intervention Review]

Local versus general anaesthesia for carotid endarterectomy

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ABSTRACT

Background

Carotid endarterectomy may significantly reduce the risk of stroke in people with recently symptomatic, severe carotid artery stenosis. However, there are significant perioperative risks that may be reduced by performing the operation under local rather than general anaesthetic. This is an update of a Cochrane Review first published in 1996, and previously updated in 2004 and 2008.

Objectives

To determine whether carotid endarterectomy under local anaesthetic: (1) reduces the risk of perioperative stroke and death compared with general anaesthetic; (2) reduces the complication rate (other than stroke) following carotid endarterectomy; and (3) is acceptable to patients and surgeons.

Search methods

We searched the Cochrane Stroke Group Trials Register (September 2013), MEDLINE (1966 to September 2013), EMBASE (1980 to September 2013) and Index to Scientific and Technical Proceedings (ISTP) (1980 to September 2013). We also handsearched relevant journals, and searched the reference lists of articles identified.

Selection criteria

Randomised trials comparing the use of local anaesthetic to general anaesthetic for carotid endarterectomy were considered for inclusion.

Data collection and analysis

Three review authors independently assessed trial quality and extracted data. We calculated a pooled Peto odds ratio (OR) and corresponding 95% confidence interval (CI) for the following outcomes that occurred within 30 days of surgery: stroke, death, stroke or death, myocardial infarction, local haemorrhage, cranial nerve injuries, and shunted arteries.

Main results

We included 14 randomised trials involving 4596 operations, of which 3526 were from the single largest trial (GALA). In general, reporting of methodology in the included studies was poor. All studies were unable to blind patients and surgical teams to randomised treatment allocation and for most studies the blinding of outcome assessors was unclear. There was no statistically significant difference in the incidence of stroke within 30 days of surgery between the local anaesthesia group and the general anaesthesia group. The incidence of strokes in the local anaesthesia group was 3.2% compared to 3.5% in the general anaesthesia group (Peto OR 0.92, 95% CI 0.67 to 1.28). There was no statistically significant difference in the proportion of patients who had a stroke or died within 30 days of surgery. In the local anaesthesia group 3.6% of patients had a stroke or died compared to 4.2% of patients in the general anaesthesia group (Peto OR 0.85, 95% CI 0.63 to 1.16). There was a non-significant trend towards lower operative mortality with local anaesthetic. In the local anaesthesia group

0.9% of patients died within 30 days of surgery compared to 1.5% of patients in the general anaesthesia group (Peto OR 0.62, 95% CI 0.36 to 1.07). However, neither the GALA trial or the pooled analysis were adequately powered to reliably detect an effect on mortality.

Authors' conclusions

The proportion of patients who had a stroke or died within 30 days of surgery did not differ significantly between the two types of anaesthetic techniques used during carotid endarterectomy. This systematic review provides evidence to suggest that patients and surgeons can choose either anaesthetic technique, depending on the clinical situation and their own preferences.

PLAIN LANGUAGE SUMMARY

Local versus general anaesthesia for carotid endarterectomy

About 20% of strokes result from narrowing of the carotid artery, which is the main artery supplying blood to the brain. Blood clots can form at the point of narrowing. If a blood clot breaks off into the bloodstream, it can be carried into the brain, block the blood supply there and cause a stroke. A surgical operation known as carotid endarterectomy removes the inner lining and blood clot in the carotid artery and can lower the risk of stroke. However, even with very careful surgery, approximately one in 20 patients will suffer a stroke caused by the operation itself. The use of local anaesthesia rather than general anaesthesia might lower the risk of a stroke happening during or after surgery. This review includes 14 randomised trials, involving 4596 operations, comparing the use of local anaesthetic to general anaesthetic for carotid endarterectomy. There was no statistically significant difference between the anaesthetic techniques in the percentage of patients who had a stroke or died within 30 days of surgery. This systematic review provides evidence to suggest that patients and surgeons can choose either anaesthetic technique, depending on the clinical situation and their own preferences.

BACKGROUND

Description of the condition

Around 20% of patients presenting with transient ischaemic attack or non-disabling ischaemic stroke have a significant stenosis with unstable atheromatous plaque at or around the bifurcation of the ipsilateral carotid artery. This plaque gives rise to the embolus. Carotid endarterectomy is an operation to remove this stenosis together with unstable plaque and, therefore, decrease the risk of stroke.

Description of the intervention

Carotid endarterectomy has been shown in large, well-conducted randomised controlled trials (RCTs) to reduce the risk of stroke in patients with recently symptomatic, severe (greater than 70%) internal carotid artery stenosis (ECST 1991; NASCET 1991). In a pooled analysis of data from these RCTs of endarterectomy versus medical treatment, surgery was of marginal benefit in terms of the five-year risk of ipsilateral ischaemic stroke in those with 50% to 69% stenosis, and was highly beneficial in those with 70% stenosis or greater without near occlusion (Rothwell 2003; Rerkasem 2011). These benefits were seen despite the significant perioperative risks associated with carotid endarterectomy. The risk of stroke or death within 30 days of the operation was between 5% and 7% in the trials. If the risk of perioperative stroke could be reduced, the benefits from carotid endarterectomy would be greater. Thus it is important to make the operation as safe as possible.

Some perioperative strokes occur during the operative procedure and may relate to reduced blood flow during carotid artery clamping. If the onset of such strokes could be recognised early, it may be possible to reverse the ischaemia by placing a shunt across the clamped artery, thereby increasing blood flow. In patients operated on under general anaesthetic, the development of a new stroke is only recognised after recovery from the anaesthetic. In order to minimise the operative risk of stroke, several different approaches to shunting have been adopted when the procedure is performed under general anaesthetic: namely the placement of a shunt in all patients (Javid 1979; Thompson 1979; Gumerlock 1988); the placement of a shunt in some patients thought to be at risk of an operative stroke (Ricotta 1983; Sundt 1986; Buche 1988; Schweiger 1988; Steiger 1989); or avoiding a shunt altogether (Prioleau 1977; Ott 1980; Reddy 1987). The avoidance of a shunt is based on the fact that only a small minority of patients do not tolerate arterial clamping without a shunt. Shunting may be associated with risks such as intimal damage promoting early postoperative thrombosis and late restenosis, which cause stroke. Thus, to many people, the selective method appears to be the most appropriate because it implies that only those patients who are at risk of having a stroke during carotid clamping are exposed to the risks of shunt placement. However, there is little consensus about the best way of identifying those patients who are at risk of stroke during the procedure. Several methods have been used to identify patients at risk of stroke including preoperative assessment (e.g. a history of recent stroke or occlusion of the contralateral artery), and a variety of techniques designed to directly or indirectly monitor cerebral blood flow during surgery. Techniques for monitoring blood flow during surgery include electroencephalographic monitoring, somatosensory evoked potential monitoring, transcranial Doppler monitoring, and measurement of the internal carotid artery back pressure (Rerkasem 2010). However, these methods are not reliable

for detecting intraoperative stroke (Bass 1989; Gnanadev 1989; Kresowik 1991; Kears 1992).

How the intervention might work

Performing carotid endarterectomy in awake patients under local anaesthetic offers the advantage of accurate assessment of the clinical state of the patient during surgery and during the early postoperative period (Benjamin 1993). Any neurological change, either during test clamping or during surgery itself, can be detected early and therefore allow more appropriate use of selective shunting in these patients. In addition, the cardiac and pulmonary morbidity of general anaesthetic may be avoided (Corson 1987; Becquemin 1991). There is also the suggestion that operation under local anaesthetic may be associated with an overall shorter hospital stay, and lower costs (Godin 1989; McCarthy 2001; Gurer 2003).

However, carotid endarterectomy under local anaesthetic may be associated with certain problems. The operation may be technically more difficult, which may increase the risk of a poor result from surgery. Patients may also undergo undue stress and pain during the operation, which may result in an increased risk of myocardial ischaemia. Finally, some surgeons may find performing the operation under local anaesthetic stressful. It is also possible that there may be certain advantages to operating under general anaesthetic. For example, there is some evidence that general anaesthetics reduce cerebral metabolic rate and may have a neuroprotective effect in the presence of ischaemia (Wells 1963; Michenfelder 1975; Markowitz 1984).

Why it is important to do this review

Carotid surgery is one of the most common types of vascular surgery. To date, there is no clear evidence that carotid endarterectomy performed under local anaesthesia is associated with reduced mortality. This issue is particularly important in older patients who comprise the majority of patients who need this type of surgery. The only reliable way to assess the relative risks and benefits of carotid endarterectomy under local anaesthetic versus general anaesthetic is by direct comparison in RCTs. We therefore undertook a systematic review of all such trials. This systematic review is an update of a Cochrane Review first published in 1996 and previously updated in 2004 and 2008 (Tangkanakul 1996; Rerkasem 2004; Rerkasem 2008).

OBJECTIVES

To determine whether carotid endarterectomy under local anaesthetic: (1) reduces the risk of perioperative stroke and death compared with general anaesthetic; (2) reduces the complication rate (other than stroke) following carotid endarterectomy; and (3) is acceptable to patients and surgeons.

METHODS

Criteria for considering studies for this review

Types of studies

All randomised and quasi-randomised trials that compared local with general anaesthetic for carotid endarterectomy and that measured clinically relevant outcomes were eligible for inclusion.

Types of participants

We considered trials that included any type of patient undergoing unilateral or bilateral carotid endarterectomy to be eligible for inclusion, whether the initial indication was symptomatic or asymptomatic carotid disease.

Types of interventions

We sought to identify all trials comparing carotid endarterectomy under general anaesthetic of any type with carotid endarterectomy under local anaesthetic of any type, including both epidural and skin or deep infiltration.

Types of outcome measures

Primary outcomes

The primary outcome was the proportion of patients who had a stroke of any kind (i.e. fatal or non-fatal, contralateral or ipsilateral or brainstem, haemorrhage or infarction) within 30 days of surgery, and during long-term follow-up.

Secondary outcomes

Secondary outcomes included the following.

1. Stroke ipsilateral to the operated artery within 30 days of operation and during long-term follow-up.
2. Deaths from all causes within 30 days of surgery. We tried to classify each death as stroke-related, related to other vascular disease (cardiac disease, pulmonary embolism, haemorrhage or other vascular disease) or non-vascular.
3. The proportion of patients who had a stroke or died within 30 days of surgery.
4. Any myocardial infarction (fatal or non-fatal) within 30 days of surgery.
5. Other significant complications related to surgery (e.g. local haemorrhage from the artery or neck wound, pulmonary complications including pneumonia, pulmonary embolism, atelectasis, prolonged intubation and pulmonary oedema, and cranial nerve palsies).
6. The numbers of participants with raised or lower blood pressure (hypertension or hypotension) during or after surgery.
7. The percentage of participants in whom a shunt was used during surgery.
8. The total duration of hospital and intensive care unit stay.
9. The overall satisfaction and preference of participants with each type of procedure. We hoped this would indirectly assess outcomes such as pain and anxiety during and after the procedure.
10. The overall satisfaction and preference of surgeons.
11. The feasibility of carrying out carotid endarterectomy under local anaesthetic. This was assessed by calculating the percentage of participants allocated to have the surgery under local anaesthetic but who had crossed over to general anaesthetic. We tried to divide further into those patients who had their choice of anaesthetic changed before the procedure was started and those who converted from local to general anaesthesia once the procedure had started.

Search methods for identification of studies

See the 'Specialized register' section in the [Cochrane Stroke Group](#) module. No language restriction was used in the searches and we arranged for translation of all possibly relevant non-English language publications.

Electronic searches

We searched the Cochrane Stroke Group Trials Register in September 2013. In addition we searched the following electronic bibliographic databases from inception to 30 September 2013: the Cochrane Central Register of Controlled Trials (CENTRAL, *The Cochrane Library* 2013 Issue 8, [Appendix 1](#)), MEDLINE (Ovid, [Appendix 2](#)), and EMBASE (Ovid, [Appendix 3](#)). We developed the search strategies with the help of the Cochrane Stroke Group Trials Search Co-ordinator.

We also systematically searched the conference proceedings database Index to Scientific and Technical Proceedings (ISTP) (BIDS) (1980 to September 2013) using the terms 'carotid' and 'trial or random*'.

Searching other resources

1. We handsearched the following journals:
 - a. *Annals of Surgery* (1981 to September 2013);
 - b. *Annals of Vascular Surgery* (1995 to September 2013);
 - c. *Vascular* (previously *Cardiovascular Surgery*) (1995 to September 2013);
 - d. *European Journal of Vascular and Endovascular Surgery* (previously *European Journal of Vascular Surgery*) (1988 to September 2013);
 - e. *Journal of Vascular Surgery* (1995 to September 2013); and
 - f. *Stroke* (1995 to September 2013).
2. We reviewed the reference lists of all relevant studies.
3. For a previous version of the review we advertised the review in *Vascular News*, a newspaper for European vascular specialists (August 2001) and handsearched the following journals:
 - a. *British Journal of Surgery* (1985 to 2002);
 - b. *International Journal of Angiology* (1995 to 2002);
 - c. *Journal of Cardiovascular Surgery* (1995 to 2002);
 - d. *Neurology* (1995 to 2002);
 - e. *Neurosurgery* (1995 to 2002);
 - f. *Surgical Neurology* (1995 to 2002); and
 - g. *World Journal of Surgery* (1978 to 2002).

Data collection and analysis

Three authors (TV, WC, KR) independently collected data, including details of methods, participants, setting, context, interventions, outcomes, results, publications and investigators. We performed meta-analysis using RevMan 5.2 ([RevMan 2012](#)).

Selection of studies

Three authors (TV, WC, KR) independently read the titles and abstracts of the records obtained from the searches and excluded obviously irrelevant studies. We obtained the full-text articles of potentially relevant studies and the same authors independently selected studies for inclusion based on the predefined criteria. We resolved any disagreements through discussion.

Data extraction and management

We extracted details of the method of randomisation, the blinding of outcome assessments, losses to follow-up, cross-overs and exclusions after randomisation from the publications. We also compared patient characteristics (age, sex, vascular risk factors, and indication for surgery) and details of the operation (type of cerebral monitoring, use of carotid patching, use of shunts, use of perioperative antiplatelet therapy) between the treatment groups in each trial. Also, although asymptomatic patients were included in some studies, the data were not available in sufficient detail to allow separate analysis of the outcomes of carotid endarterectomy in symptomatic and asymptomatic patients. However, it is unlikely that the relative effect of local versus general anaesthesia will vary qualitatively with symptom status.

Assessment of risk of bias in included studies

Three authors (TV WC KR) independently assessed the methodological quality of the included trials using the Cochrane risk of bias tool (Higgins 2011). We resolved disagreements in the methodological assessment by reaching consensus through discussion. If an item was assessed as unclear, we contacted trialists for clarification and to request missing information.

Measures of treatment effect

We estimated treatment effect for the following outcomes within 30 days of surgery: stroke, death, stroke or death, myocardial infarction, local haemorrhage, cranial nerve injuries, and shunted arteries. Peto odds ratios (OR) and corresponding 95% confidence intervals were calculated for each outcome.

Unit of analysis issues

An event is the onset of an adverse outcome. We extracted the outcome events reported for each study. Some studies included patients who had bilateral operations, but only reported the number of patients, and not arteries, in each group. However, since bilateral carotid endarterectomy was unusual, we used the number of patients as the number of operations in such studies. Where possible we used the number of patients, not the number of arteries in the analysis.

Dealing with missing data

When data were missing, we contacted the corresponding author or a co-author to request missing information. When missing data could not be obtained, we analysed only the available data.

Assessment of heterogeneity

We assessed heterogeneity between study results using the I^2 statistic (Higgins 2003). This measure describes the percentage of total variation across studies due to heterogeneity rather than chance. An I^2 value over 75% was considered to indicate a high level of heterogeneity.

The I^2 statistic may be interpreted as follows:

- 0% to 40%: might not be important;
- 30% to 60%: may represent moderate heterogeneity;
- 50% to 90%: may represent substantial heterogeneity; and
- 75% to 100%: considerable heterogeneity.

Assessment of reporting biases

In an effort to minimize the impact of reporting biases we sought to identify all relevant trials, including unpublished studies, by searching not only MEDLINE and EMBASE, but also the Cochrane Stroke Group Trials Register. In addition, we handsearched relevant journals and reviewed the reference lists of all relevant studies. In the previous version of this review we advertised the review in *Vascular News*, a newspaper for European vascular specialists. We did not impose any language restriction in the searches and we arranged translation of all relevant non-English language papers. Given a sufficient number of studies, publication bias was to be assessed by constructing funnel plots.

Data synthesis

We calculated proportional risk reductions based on a weighted estimate of the odds ratio using the Peto method (APT 1994). We calculated a pooled Peto OR and 95% CI for the following outcomes that occurred within 30 days of surgery: stroke, death, stroke or death, myocardial infarction, local haemorrhage, cranial nerve injuries, and shunted arteries.

Subgroup analysis and investigation of heterogeneity

Where there was considerable heterogeneity, we investigated the explanation for such interactions.

Sensitivity analysis

When the decisions for the process undertaken in this systematic review were arbitrary or unclear, we applied sensitivity analyses. For example, both fixed-effect and random-effects meta-analyses were performed to evaluate the consistency of the results, or pooled estimates of all studies' results compared with the results with studies of poorer quality excluded.

RESULTS

Description of studies

Results of the search

For this review we updated our previous searches of the Cochrane Stroke Group Trials Register, MEDLINE, EMBASE and ISTP. We also searched CENTRAL. We reviewed a total of 2392 references from the searches and obtained the full paper copy of 43 trial reports. We identified 14 RCTs.

Included studies

We included 14 RCTs, involving 4596 operations, which compared local and general anaesthetic for carotid endarterectomy. Most studies were small except the GALA trial, which reported on 3526 operations (GALA 2008). All studies were published in English except four, which were translated from French (Pluskwa 1989), German (Binder 1999), Serbian (Sindelic 2004), and Czech (Mrozek 2007) into English. There were two reports from one trial (McCarthy 2004). Initially the first report was published in 2002 with 67 participants and then, in 2004, another article was published including data from another hospital with a total of 176 participants (McCarthy 2004).

Since publication of the previous version of this review (Rerkasem 2008), we identified five new studies that appeared to meet the inclusion criteria (Mrozek 2007; Ebner 2008; Luchetti 2008; Mazul-

Sunko 2010; Moritz 2010). Two studies were published in 2008, but they were not included in the previous version due to delayed publication (Ebner 2008; Luchetti 2008). One Czech paper was published in 2007, but this was missed because the journal was not included in MEDLINE or EMBASE (Mrozek 2007). This paper was retrieved from the Cochrane Stroke Group Trials Register. Another article was published in 2010 and was retrieved from the Cochrane Stroke Group Trials Register (Mazul-Sunko 2010). One trial was subsequently excluded (Ebner 2008), leaving four new studies for inclusion in the review (Luchetti 2008; Mrozek 2007; Moritz 2010; Mazul-Sunko 2010). We found no ongoing studies.

Thirteen studies used a cervical block and one study (Pluskwa 1989) used an epidural block to provide local anaesthesia. All studies used standard medication in the general anaesthetic group. Ten trials reported the indication for shunting (Forssell 1989; Binder 1999; Sbarigia 1999; McCarthy 2004; Kasprzak 2006; Mrozek 2007; Luchetti 2008; GALA 2008; Moritz 2010; Mazul-Sunko 2010). One trial used intraluminal shunting in all patients (Binder 1999). One trial aimed to follow patients up to one year (GALA 2008). Four trials indicated the period of follow-up as follows: 30 postoperative days (Sbarigia 1999; Kasprzak 2006), two postoperative days (Binder 1999), and the time of hospital discharge (Forssell 1989). In the

other trials, the period of follow-up was not stated but appeared to be up to the time of hospital discharge.

In most studies important outcomes were not assessed. Only the GALA trial determined whether the strokes were ipsilateral to the operated artery (GALA 2008). However, most strokes will have been ipsilateral. The GALA trial was the only study that reported the cause of death and the severity of stroke in terms of disability (GALA 2008). Patient satisfaction was formally assessed in only one trial (McCarthy 2004). Surgeon satisfaction was not formally assessed.

Excluded studies

We excluded one trial because the randomised allocation was based on the rotation of the two anaesthetists who could perform cervical plexus block (Ebner 2008).

Risk of bias in included studies

One of the 14 RCTs was published as an abstract (Gimenez 2004). For this study, only data from the abstract and oral presentation were available. In general, reporting of methodology was poor. The overall results of the risk of bias analysis are summarized in Figure 1.

Figure 1. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.

| | Random sequence generation (selection bias) | Allocation concealment (selection bias) | Blinding of participants and personnel (performance bias) | Blinding of outcome assessment (detection bias) | Incomplete outcome data (attrition bias) | Selective reporting (reporting bias) | Other bias |
|------------------|---|---|---|---|--|--------------------------------------|------------|
| Binder 1999 | + | - | - | - | - | + | - |
| Forssell 1989 | ? | - | - | - | - | - | - |
| GALA 2008 | + | + | - | + | + | + | + |
| Gimenez 2004 | ? | - | - | - | - | - | - |
| Kasprzak 2006 | + | - | - | + | + | + | - |
| Luchetti 2008 | + | - | - | - | - | - | - |
| Mazul-Sunko 2010 | ? | - | - | - | - | + | - |
| McCarthy 2004 | ? | - | - | - | - | - | - |
| Moritz 2010 | + | - | - | - | + | - | - |
| Mrozek 2007 | - | - | - | - | - | + | - |
| Pluskwa 1989 | + | - | - | - | - | - | - |
| Prough 1989 | ? | - | - | - | - | - | - |
| Sbarigia 1999 | + | - | - | - | + | - | - |
| Sindelic 2004 | + | - | - | - | + | - | - |

Allocation

In all studies, allocation by randomisation was reported. However, only six papers indicated the method of randomisation. This included block randomisation ([Binder 1999](#); [GALA 2008](#)), computer randomisation ([Kasprzak 2006](#); [Luchetti 2008](#); [Moritz 2010](#)), and date of birth ([Mrozek 2007](#)). The methods used for randomisation in the remaining trials were unclear.

Blinding

All studies were unable to blind patients and surgical teams to randomised treatment allocation. In most trials, the blinding of outcome assessment was unclear. In three trials outcomes were assessed by neurologists who were blind to the type of anaesthesia used ([Sbarigia 1999](#); [Kasprzak 2006](#); [GALA 2008](#)).

Incomplete outcome data

Most studies did not report how incomplete outcome data was handled. However, six studies did report this information ([Sbarigia 1999](#); [McCarthy 2004](#); [Sindelic 2004](#); [Kasprzak 2006](#); [GALA 2008](#); [Moritz 2010](#)). In six studies, some patients who were randomised to have surgery under local anaesthesia actually had surgery under general anaesthesia ([Forsell 1989](#); [Binder 1999](#); [Sbarigia 1999](#); [Kasprzak 2006](#); [GALA 2008](#); [Moritz 2010](#)). Apart from two RCTs ([GALA 2008](#); [Moritz 2010](#)), the reasons for the change were usually unclear, and these patients were excluded from the analysis in five trial reports ([Forsell 1989](#); [Binder 1999](#); [Sbarigia 1999](#); [GALA 2008](#); [Moritz 2010](#)). In one trial ([Forsell 1989](#)), 11 (11%) patients underwent staged bilateral endarterectomies and were randomised twice. Some of these patients may have had one operation under general anaesthesia and the other under local anaesthesia.

Selective reporting

Most studies did not indicate prespecified outcomes or report all prespecified outcomes. Only six studies reported all expected outcomes that were prespecified ([Binder 1999](#); [GALA 2008](#); [Kasprzak 2006](#); [Mazul-Sunko 2010](#); [Moritz 2010](#); [Mrozek 2007](#)).

Other potential sources of bias

Regarding allocation concealment, two trials used sequentially numbered sealed envelopes but it was not stated if these were opaque ([Forsell 1989](#); [Sbarigia 1999](#)). The [GALA 2008](#) study utilised central allocation, while in 11 trials the method of concealment of allocation was unclear.

We were able to assess other bias, including measurement bias and funding bias in one study ([GALA 2008](#)).

Only the GALA trial clearly reported on the major differences in baseline prognostic factors between the two groups of patients ([GALA 2008](#)), although some studies provided limited data. Only four trials commented on the use of patching: two trials used a selective patch approach ([Sbarigia 1999](#); [Kasprzak 2006](#)), one used patching in all patients ([Binder 1999](#)) and one study used various patching approaches ([GALA 2008](#)). Only the GALA trial reported on perioperative antiplatelet therapy ([GALA 2008](#)).

Effects of interventions

We included data from 14 randomised trials (4596 operations) in this review. We only assessed outcomes within 30 days of surgery, because none of the included studies reported long-term results.

Any stroke within 30 days of operation

There were 149 reported strokes of any type within 30 days of surgery. There was no statistically significant difference in the incidence of stroke between the local anaesthesia group and the general anaesthesia group. The incidence of strokes in the local anaesthesia group was 3.2% compared to 3.5% in the general anaesthesia group (Peto OR 0.92, 95% CI 0.67 to 1.28, [Analysis 1.1](#)). Only the GALA trial data allowed a comparison between ipsilateral and contralateral stroke ([GALA 2008](#)), and reported the rate of ipsilateral stroke as 57/1771 (3.2%) in local anaesthesia and 54/1752 (3.1%) in general anaesthesia.

Death within 30 days of operation

There were 52 deaths: 16 due to coronary artery diseases, 27 due to stroke and 9 due to other causes. There were 20 deaths (0.9%) in the local anaesthesia group compared to 32 deaths in the general anaesthesia group (1.5%). There was no statistically significant difference in death rates (Peto OR 0.62, 95% CI 0.36 to 1.07, [Analysis 1.2](#)).

Stroke or death within 30 days of operation

The rate of stroke or death in the local anaesthesia group was 3.6% compared with 4.2% in the general anaesthesia group. There was no statistically significant difference in the rate of stroke or death (Peto OR 0.85, 95% CI 0.63 to 1.16, [Analysis 1.3](#)).

Myocardial infarction within 30 days of operation

Twenty-three patients suffered a myocardial infarction within 30 days of surgery. Fourteen patients (0.6%) in the local anaesthesia group had a myocardial infarction compared with nine patients (0.4%) in the general anaesthesia group. There was no statistically significant difference between the groups in the rate of myocardial infarction (Peto OR 1.53, 95% CI 0.67 to 3.47, [Analysis 1.4](#)). The 95% CI was wide.

Other operative complications

Local haemorrhage

Five studies reported the rate of haemorrhage from the wound. There were 314 haemorrhages. Haemorrhage was reported in 7.7% of patients in the local anaesthesia group compared with 8.1% of patients in the general anaesthesia group. There was no statistically significant difference between the groups (Peto OR 0.95, 95% CI 0.75 to 1.19, [Analysis 1.5](#)). There was no indication of the severity of these bleeds.

Cranial nerve injuries

Four trials reported cranial nerve palsies. Eleven per cent of patients in the local anaesthesia group had cranial nerve injuries compared with 9.7% of general anaesthesia patients. There was no statistically significant difference between the groups (Peto OR 1.17, 95% CI 0.95 to 1.44, [Analysis 1.6](#)).

Pulmonary complications

One trial reported on pulmonary complications ([Kasprzak 2006](#)), and found no statistically significant difference in the rate of pneumonia under local anaesthesia compared with general anaesthesia. The GALA trial reported on pulmonary embolism as an outcome and reported no events in either treatment group ([GALA 2008](#)).

Blood pressure

Twelve trials recorded blood pressure during and after surgery. However, the studies did not consistently report the number of patients with significant hypotension or hypertension or mean arterial pressure during and after surgery. Furthermore, the definitions of hypertension and hypotension varied between trials. We have therefore simply described the results.

Six reported that blood pressure dropped in the general anaesthesia group after induction of anaesthesia ([Forssell 1989](#); [Pluskwa 1989](#); [Prough 1989](#); [McCarthy 2004](#); [Sindelic 2004](#); [GALA 2008](#)). In one trial, more patients in the general anaesthesia group had significant hypotension during or after surgery compared with the local anaesthesia group (25% versus 7%) ([Forssell 1989](#)). However, this was not confirmed in another trial ([Pluskwa 1989](#)). The GALA trial reported on the manipulation of blood pressure ([GALA 2008](#)). More general anaesthesia than local anaesthesia patients had their blood pressure manipulated up (43% compared with 17%), and more local anaesthesia patients had their blood pressure manipulated down or not manipulated at all (74% compared with 41%) during or after surgery. The difference in blood pressure manipulation between the two trial arms was statistically significant ([GALA 2008](#)).

Five trials showed that blood pressure tended to increase during clamping of the carotid artery in the local anaesthesia group compared with the general anaesthesia group ([Forssell 1989](#); [Pluskwa 1989](#); [Prough 1989](#); [Gimenez 2004](#); [Luchetti 2008](#)) but this was not found in another trial ([McCarthy 2004](#)). In two trials, there were significantly more patients with hypertension in the local anaesthesia group during surgery than in the general anaesthesia group ([Forssell 1989](#): 36% versus 0%; [Pluskwa 1989](#): 80% versus 20%). Three trials reported that during surgery the mean arterial pressure in the local anaesthesia group was higher than in the general anaesthesia group ([Mrozek 2007](#); [Luchetti 2008](#); [Moritz 2010](#)). Two studies suggested that hypotension was more common in the postoperative period with local anaesthesia than with general anaesthesia ([Pluskwa 1989](#); [Prough 1989](#)). Two trials found that patients operated on under general anaesthesia had more postoperative (within day one) hypertension than those operated on under local anaesthesia ([Gimenez 2004](#); [Kasprzak 2006](#)).

Shunting

Eight studies reported the number of arteries shunted. The use of local anaesthetic was associated with significantly fewer shunts than general anaesthetic. Fifteen per cent of patients in the local anaesthesia group had their arteries shunted compared with 42% of patients in the general anaesthesia group. As there was significant heterogeneity between studies ($I^2 = 91\%$), we used the random-effects model to pool the results (OR 0.24, 95% CI 0.08 to 0.73, [Analysis 1.7](#)).

Hospital stay

The duration of hospital stay was reported in three trials ([Binder 1999](#); [McCarthy 2004](#); [GALA 2008](#)). The average time in hospital was not significantly different between the local and general anaesthesia groups.

Patient satisfaction

Patient satisfaction was formally assessed in one study ([McCarthy 2004](#)). There was no statistically significant difference in satisfaction between anaesthetic techniques. In [Forssell 1989](#), of the three patients who had repeat carotid endarterectomies (having had a local anaesthetic for the first operation) none refused repeat randomisation ([Forssell 1989](#)). [Forssell 1989](#) reported that one patient in the local anaesthesia group became extremely agitated during the procedure. Another trial evaluated patient satisfaction by a questionnaire ([Binder 1999](#)). They found that both types of anaesthesia were equally acceptable but the publication did not describe the questionnaire in detail. All patients preferred the same type of anaesthesia if they needed a second operation, except one patient in the local anaesthesia group (total 27 patients) who wished to have general anaesthesia for any further surgery. [Mrozek 2007](#) asked patients about any unpleasant sensations after surgery and during the postoperative period. A minimum amount of unpleasant sensation was reported for both types of anaesthetic after surgery and during the postoperative period ([Mrozek 2007](#)).

Surgeon satisfaction

The satisfaction or preference of the surgeon was not assessed in any of the trials.

Feasibility of performing operation under local anaesthetic

One trial recorded the number of patients randomised to have surgery under local anaesthesia, but who had surgery under general anaesthesia ([Forssell 1989](#)). Eight patients crossed over from local to general anaesthesia whilst none switched from general to local anaesthesia. The most common reasons for cross-over were that the patient changed his or her consent or that the patient had unstable cardiac disease. Seven out of eight patients had their anaesthetic changed before the procedure was started. In another trial, six patients were switched from local to general anaesthesia due to severe agitation (three patients), insufficient anaesthesia under local anaesthesia (two patients), and intravascular injection during application of local anaesthetic agent (one patient) ([Kasprzak 2006](#)). Three out of six patients had their anaesthetic changed before the procedure was started. No general anaesthesia cases were switched to local anaesthesia in this study ([Kasprzak 2006](#)). In the GALA trial, 167 patients were crossed over before initiation of anaesthesia: 75 patients crossed over from local to general anaesthesia whilst 92 switched from general to local anaesthesia ([GALA 2008](#)). Patients allocated to general anaesthesia were more likely to cross over due to a medical decision, whereas patients allocated local anaesthesia were more likely to cross over due to the patient's preference. Sixty-nine out of 1771 (3.9%) local anaesthesia patients were switched to general anaesthesia after initiation of anaesthesia, 17 before and 52 after the start of surgery. In one trial, two patients switched from local to general anaesthesia ([Moritz 2010](#)) and in another trial, no patients switched from local anaesthesia to general anaesthesia ([Mrozek 2007](#)).

DISCUSSION

Summary of main results

We identified 14 studies comparing adverse outcomes for carotid endarterectomy performed under local anaesthesia with adverse outcomes for carotid endarterectomy performed under general anaesthesia. Meta-analysis of the randomised studies showed that there was no statistically significant difference between the anaesthesia groups in the proportion of patients who had a stroke, or died or a myocardial infarction within 30 days of surgery.

Overall completeness and applicability of evidence

The pooled analyses showed no statistically differences in the rate of stroke or death between the two types of anaesthetic technique used during carotid endarterectomy. There was a non-significant trend towards lower operative mortality with local anaesthesia (Peto OR 0.62, 95% CI 0.36 to 1.07), but neither the [GALA 2008](#) study nor the pooled analysis were adequately powered to reliably detect an effect on mortality. It is unlikely that a sufficiently large (about 20,000 patients) randomised trial will be performed in the foreseeable future to confirm or refute this possible effect on mortality.

Twelve trials recorded blood pressure during and after surgery, but these data were difficult to interpret. It is interesting to note that two studies suggested that hypotension was more common in the postoperative period with local anaesthesia ([Pluskwa 1989](#); [Prough 1989](#)). This is may be due to the high rate of blood pressure being manipulated down, but we could not find any hard evidence to support this at the present time.

The choice of anaesthetic technique will therefore depend on the clinical situation and the preferences of individual patients and their surgeon. In some patients the operation may be technically more difficult under local anaesthesia (e.g. in patients with short, wide necks). Some patients, perhaps as many as 10%, will refuse to have the operation under local anaesthesia ([Forsell 1989](#)), and some surgeons may feel more comfortable performing the operation under general anaesthesia.

[GALA 2008](#) was also designed to determine whether the type of anaesthesia influenced the cost of endarterectomy. These data showed that the expected costs of carotid endarterectomy under local anaesthesia are less than those under general anaesthesia (mean difference GBP 178) ([Gomes 2010](#)). This difference was mainly due to the longer length of stay in an intensive care unit and the use of consumables such as shunts and patches. A post hoc subgroup analysis (40 patients) from the [GALA 2008](#) study investigated the influence of local versus general anaesthesia on postoperative neurocognitive function. This study showed that local anaesthesia beneficially influenced early postoperative neurocognitive functions. [Mazul-Sunko 2010](#) found shunting to be the only parameter associated with neurocognitive decline on the first day after carotid endarterectomy. Local anaesthesia was hypothesised to offer an indirect benefit due to the reduced rate of shunting ([Mazul-Sunko 2010](#)). However, given the small size of these studies, early postoperative neurocognitive function requires further investigation ([Weber 2009](#)).

Quality of the evidence

There were significant problems in the quality of the randomised trials. The method used for allocation concealment was inadequately reported in most of the included studies. The duration of follow-up was short in all included studies. It was also unclear in most of the studies whether the outcomes had been assessed blind to treatment allocation. It is well known that studies that have neurologists as assessors are associated with higher stroke and death rates ([Rothwell 1996](#); [Rerkasem 2009](#)). Only two studies reported that they had neurologists as blinded assessors ([Kasprzak 2006](#); [GALA 2008](#)). At least five of the trials excluded some randomised patients from the analysis, especially patients who crossed over anaesthetic type ([Forsell 1989](#); [Binder 1999](#); [Sbarigia 1999](#); [GALA 2008](#); [Moritz 2010](#)). If excluded patients differed from those patients who remained in the analysis, the results may be biased.

Potential biases in the review process

Many studies reported the number of arteries rather than the number of patients. Also, it was not clear how many of the strokes were ipsilateral, and how many were disabling. Few trials assessed patients' or surgeons' satisfaction or preference, or the duration of intensive care and overall hospital stay.

There was marked heterogeneity between studies in the use of shunts with both types of anaesthesia. This in part may be reflected by the different policies in shunting between studies. For example, in the [Binder 1999](#) study all patients were shunted irrespective of treatment allocation. All patients in the local anaesthetic group were shunted despite the fact that surgeons preferred local anaesthetic due to the low rate of shunting. Apart from this trial, the remaining seven RCTs in the pooled analysis used selective shunting. For six RCTs, although the indication of shunting in the local anaesthesia group was not markedly different, the indication for shunting in the general anaesthesia group varied considerably. One study used stump pressure measurement and clinical judgment ([Forsell 1989](#)), while another study used a mix of transcranial Doppler, stump pressure measurement, EEG, and clinical judgment ([GALA 2008](#)). Although another two studies used somatosensory evoked potentials, the indication was not identical ([Kasprzak 2006](#); [Moritz 2010](#)). One trial carried out shunting routinely, but the actual rate of shunting was 82% because of expected technical difficulties with shunt insertion in 18% of the cases in the general anaesthetic group ([Mazul-Sunko 2010](#)). The remaining three RCTs did not report the indication for shunting in the general anaesthesia group ([Sbarigia 1999](#); [Mrozek 2007](#); [Moritz 2010](#)). All of these differences may explain the considerable heterogeneity in the use of shunts.

Agreements and disagreements with other studies or reviews

It is also interesting to note that in our previous review, the non-randomised studies showed consistently lower risks of operative stroke and death when carotid endarterectomy was done under local anaesthesia ([Rerkasem 2008](#)). With the addition of [GALA 2008](#) study the meta-analyses show that these apparent differences were probably due to biases in the non-randomised comparisons, illustrating the importance of adequately powered randomised controlled trials ([Collins 2001](#)).

AUTHORS' CONCLUSIONS

Implications for practice

The proportion of patients who had a stroke or died within 30 days of surgery did not differ significantly between the two types of anaesthetic techniques used during carotid endarterectomy. This systematic review provides evidence to suggest that patients and surgeons can choose either anaesthetic technique, depending on the clinical situation and their own preferences.

Implications for research

There was a non-significant trend towards lower operative mortality with local anaesthesia. However, our pooled analysis was not adequately powered to reliably detect an effect on mortality. More randomised controlled trials comparing local anaesthesia with general anaesthesia are needed to assess the potential beneficial effect on mortality.

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Ongoing trials

If anyone is aware of any randomised trials that we have omitted please contact Professor Kittipan Rerkasem.

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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies [ordered by study ID]

Binder 1999

| | |
|---------------|--|
| Methods | RCT Block randomisation Blinding: unclear C: unclear Cross-over: yes, but number excluded during trial was unclear Losses to FU: none |
| Participants | Austria 1999 46 patients (46 operations) Age mean: 73 years (LA), 68 years (GA) Sex: unclear Comparability: unclear Indications for surgery: TIA, stroke, incidental diagnosis of carotid stenosis |
| Interventions | LA: superficial and deep block with bupivacaine GA: thiopental, vecuronium, fentanyl Patching: all cases Antiplatelet Rx: unclear Indication for shunting: all patients |
| Outcomes | Death, any stroke, TIA, myocardial infarction, time in hospital since surgery, bleeding, mean arterial blood pressure, shunted arteries |
| Notes | FU: 48 hours Ex: recent neurological deficit < 4 weeks, redo operation, recent myocardial infarction(< 2 months), ASA score ≥ 4, and any factor precluding randomisation such as pulmonary disease or refusal to participate in the study |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Low risk | Quote: "46 Patienten nach Aufklärung und Unterzeichnung einer Einverständniserklärung in die Studie aufgenommen und prospektiv randomisiert untersucht" |
| Allocation concealment (selection bias) | High risk | Not reported |

Binder 1999 (Continued)

| | | |
|---|-----------|---|
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | Low risk | All the study's prespecified outcomes of interest were reported |
| Other bias | High risk | Not reported |

Forssell 1989

| | |
|---------------|---|
| Methods | RCT C: unclear Blinding: unclear Sequentially numbered envelope Cross-overs: 8 LA performed under exclusions during trial: 8 cross-overs Losses to FU: none |
| Participants | Sweden 1985 to 1987 100 patients, 111 operations Age (mean): 66 years (LA), 63 years (GA) Male: 71% (LA), 64% (GA) Comparability: groups similar for vascular risk factors Indication for surgery: not reported |
| Interventions | LA: cervical block and skin infiltration with bupivacaine and mepivacaine or adrenaline GA: thiopental, isoflurane and bupivacaine or adrenaline skin infiltration Patching: not reported Antiplatelet Rx: not reported Indication for shunting: LA: neurological symptoms during/or after 1 minute test clamp; GA: stump pressure < 25 mmHg in TIA, stump pressure < 50 mmHg in vertebrobasilar insufficiency, always if previous stroke |
| Outcomes | Death, any stroke, myocardial infarction, wound haematoma, blood pressure, shunted arteries |
| Notes | FU: hospital stay Ex: consent refused, allergy to LA, ongoing heparin infusion, serious chronic cerebral insufficiency, uneasy during previous LA, randomisation miss, anxiety, simultaneous aortic repair, emergent operation |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Unclear risk | Quote: "The remaining patients were randomised on 111 occasions into two groups, which were comparable (Table 2)" |

Forssell 1989 (Continued)

| | | |
|---|-----------|---|
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | High risk | No prespecified outcomes were reported. |
| Other bias | High risk | Not reported |

GALA 2008

| | |
|---------------|--|
| Methods | <p>RCT</p> <p>C: central trial office allocate and concealment</p> <p>Blinding: single blinding - independent assessor</p> <p>Block randomisation</p> <p>Cross-overs: 92/1751 (5.3%) GA patients and 75/1771 (4.2%) LA patients went to theatre, but received the opposite treatment allocation to that allocated at randomisation</p> <p>Losses to FU: 3/3523 (0.09%)</p> |
| Participants | <p>Multicentre RCT conducted mainly in Europe (95 centres), in 24 countries 2003 to 2008</p> <p>3526 operations</p> <p>Age (mean): 69 years (LA), 70 years (GA)</p> <p>Male: 71% (LA), 70% (GA)</p> <p>Comparability: groups similar for vascular risk factors</p> <p>Indication for surgery: all patients with symptomatic or asymptomatic carotid stenosis for whom surgery was advised</p> <p>The reasons for using shunt varied in both the LA and GA groups depending on the practice of each trial site</p> <p>These reasons included: used routinely, drop velocity on TCD, unable to use TCD, contralateral occlusion or near occlusion, low stump pressure, contralateral carotid stenosis, recent stroke, unusual or damaged vein or arteries in head or neck, EEG or evoked potential change, blood pressure drop, falling brain oxygen level, operation converted to vein bypass and unknown</p> |
| Interventions | LA versus GA |
| Outcomes | <p>Primary outcome: proportion of patients alive, stroke free (including retinal infarction) and without myocardial infarction 30 days post-surgery</p> <p>Secondary outcomes: proportion alive and stroke free at 1 year and in the longer term, a comparison of health-related quality of life at 30 days and any surgical adverse events, re-operation and re-admission rates, the relative cost of the 2 methods of anaesthesia, length of stay and intensive and high dependency bed occupancy</p> |
| Notes | FU: perioperative period (30 days after operation) and 1 year follow up |

Local versus general anaesthesia for carotid endarterectomy (Review)

GALA 2008 (Continued)

Ex: a simultaneous bilateral carotid endarterectomy or carotid endarterectomy combined with another operative procedure such as coronary artery bypass surgery

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Low risk | Central computerised randomisation |
| Allocation concealment (selection bias) | Low risk | Quote: "the office randomised patients to surgery under either general or local anaesthesia, stratified by centre and with balanced blocks of variable size, ensuring that allocation was completely concealed before the decision to randomise a patient and after baseline data were received" |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Quote: "we could not blind patients or the surgical team to randomised treatment allocation" |
| Blinding of outcome assessment (detection bias) All outcomes | Low risk | Quote: "However, the independent stroke physician or neurologist who saw patients 1 month after surgery was unaware of the type of anaesthesia that the patients had received, although this blinding could be broken by the patient or by looking at hospital notes" |
| Incomplete outcome data (attrition bias) All outcomes | Low risk | Quote in Figure 1: "21 incomplete follow-up, 1 no follow-up at all, 1 no post-surgery form, 19 no physician follow-up at one month five of these had patient follow-up at 1 year" |
| Selective reporting (reporting bias) | Low risk | All data were analysed and reported as predefined |
| Other bias | Low risk | <p>Measurement bias: Quote: "a neurologist (CPW), unaware of treatment allocation, then prepared a summary for every patient that, depending on the outcome, was audited by an independent neurologist (PMR) or cardiologist (APB), who were also unaware of treatment allocation"</p> <p>Quote: "Data were analysed by the trial statistician (SCI) and reviewed annually in strict confidence by the Data Monitoring Committee. Everyone else involved in the study was unaware of the treatment allocation until the database was locked"</p> <p>Funding bias: Quote: "The funding source had no role in the study design, data collection, data analysis, data interpretation or writing of the report"</p> |

Gimenez 2004

| | |
|--------------|---|
| Methods | RCT C: unclear Blinding: unclear Cross-over: unclear Exclusion during trial: unclear Losses to FU: unclear |
| Participants | Spain 1999 to 2001 |

Local versus general anaesthesia for carotid endarterectomy (Review)

Gimenez 2004 (Continued)

93 patients and 93 operations
Age: not indicated
Male proportion: unclear
Comparability: not reported
Indication for surgery: not reported

| | |
|---------------|--|
| Interventions | LA: not reported GA: not reported Patching and antiplatelet Rx: not reported Indication for shunting: reported |
| Outcomes | Blood pressure |
| Notes | FU: probably hospital discharge Ex: not reported Data were extracted only from abstract and we could not contact the authors of this publication |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | Unclear risk | Quote: "In a prospective randomised study between 1999 and 2001, 93 patients underwent carotid endarterectomy, 47 under GA and 46 under LRA" |
| Allocation concealment (selection bias) | High risk | Not reported (only abstract available) |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported (only abstract available) |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported (only abstract available) |
| Selective reporting (reporting bias) | High risk | No prespecified outcomes were reported |
| Other bias | High risk | Not reported (only abstract available) |

Kasprzak 2006

| | |
|--------------|---|
| Methods | RCT C: unclear Blinding: independent neurologist Cross-over: 6 patients change from LA to GA Exclusion during trial: none Losses to FU: none |
| Participants | Germany 2006 186 patients, 186 operations Age (mean): 69 years (LA), 69 years (GA) |

Local versus general anaesthesia for carotid endarterectomy (Review)

Kasprzak 2006 (Continued)

Male: 67% (LA), 61% (GA)
Comparability: group similar for vascular risk factors
Indication for surgery: asymptomatic carotid stenosis > 80% or symptomatic carotid stenosis > 70%

| | |
|---------------|--|
| Interventions | LA: superficial and deep cervical plexus block by 0.5% bupivacaine + 1% prilocaine GA: fentanyl, etomidate, vecuronium, isoflurane Patching and antiplatelet: not reported Indication for shunting: LA: motor deficit, aphasia and loss of consciousness during carotid artery clamping; GA: decrease > 30% of amplitude in the baseline somatosensory evoked potential |
| Outcomes | Death, stroke, myocardial infarction, cranial nerve injury, blood pressure, shunting |
| Notes | FU: possibly hospital stay Ex: not meeting inclusion criteria, refused to participate, recalled consent, temporarily not operable, pilot study and other reason |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Low risk | Quote: "randomized by computer random list for one type of anesthesia" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | Low risk | Quote: "a neurological evaluation by a neurologist and a routine postoperative CT scan were done on day b2 or 3 after surgery. The neurologist was not informed about the type of anesthesia" |
| Incomplete outcome data (attrition bias) All outcomes | Low risk | Quote in Figure 1: "received allocated treatment n = 95 analysed n = 95" |
| Selective reporting (reporting bias) | Low risk | All the study's prespecified outcomes of interest were reported |
| Other bias | High risk | Not reported |

Luchetti 2008

| | |
|--------------|--|
| Methods | RCT C: unclear Blinding: unclear Cross-over: unclear Exclusion during trial: unclear Losses to FU: unclear |
| Participants | Italy 2008 28 patients, 28 operations Age/male: unclear, but publication indicated that demographic data and baseline haemodynamic values are comparable |

Local versus general anaesthesia for carotid endarterectomy (Review)

Luchetti 2008 (Continued)

Indication for surgery: unclear

| | |
|---------------|--|
| Interventions | LA: superficial cervical plexus block by 0.5% ropivacaine 30 cc GA: superficial cervical plexus block with continuous infusion of remifentanyl, propofol with intubation and mechanical ventilation Patching and antiplatelet: not reported Indication for shunting: LA: following carotid clamping, change in mental evaluation defined as agitation, confusion, contralateral weakness, seizure, unresponsiveness |
| Outcomes | Hemodynamic stability (mean arterial pressure), death, neurological deficit, cardiopulmonary complication |
| Notes | |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Low risk | Quote: "They were randomly assigned by means of a computer-generated random number table to receive 1 of 2 anaesthesia techniques" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | High risk | Not all prespecified outcomes were reported, namely time to recovery of consciousness, perioperative complications such as nausea, vomiting, sweating, and grade on pain perception and comfort |
| Other bias | High risk | Not reported |

Mazul-Sunko 2010

| | |
|--------------|---|
| Methods | RCT C: unclear Blinding: unclear Cross-over: unclear Exclusion during trial: unclear Losses to FU: unclear |
| Participants | Croatia 2010 57 patients, 57 operations Mean age: 66.2 years (LA); 66 years (GA) Percentage of male: 89.6% (LA) and 85.7% (GA) |

Local versus general anaesthesia for carotid endarterectomy (Review)

Mazul-Sunko 2010 (Continued)

Demographic data and baseline data are comparable
Indication for surgery: carotid stenosis 70% or more

| | |
|---------------|--|
| Interventions | <p>LA: superficial cervical plexus block by levobupivacaine (1.5 mg/kg) and supplemental infiltration by surgeons with 1% lidocaine</p> <p>GA: etomidate in a dosage of 0.2 mg/kg and fentanyl (3 microgram/kg) for induction, vecuronium (0.08 mg/kg) for paralysis, maintain with isoflurane 0.7 to 1.2 MAC in a mixture of oxygen and nitrous oxide 50%:50%. Reversal with neostigmine (2.5 mg) and atropine (1 mg)</p> <p>Indication for shunting: LA: following carotid clamping, neurological deficit. GA : routine shunting was used except when technical difficulties</p> |
|---------------|--|

| | |
|----------|--|
| Outcomes | Stroke, death, myocardial infarction, shunting |
|----------|--|

Notes

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | Unclear risk | Quote: "Elective carotid CEA were prospectively randomised to received either general or regional anaesthesia" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | Low risk | All prespecified outcomes were reported |
| Other bias | High risk | Not reported |

McCarthy 2004

| | |
|--------------|--|
| Methods | <p>RCT</p> <p>C: unclear</p> <p>Blinding: not reported</p> <p>Cross-over: not reported</p> <p>Exclusion during trial: none</p> <p>Losses to FU: none</p> |
| Participants | <p>UK 2004</p> <p>176 patients and 176 operations</p> <p>Age (mean): 71 years (LA), 72 years (GA)</p> <p>Male: 61% (LA), 68% (GA)</p> |

Local versus general anaesthesia for carotid endarterectomy (Review)

McCarthy 2004 (Continued)

Comparability: groups similar for vascular risk factors
Indication for surgery: not reported

| | |
|---------------|--|
| Interventions | LA: not reported GA: not reported Patching: not reported Antiplatelet Rx: not reported Indication for shunting: not reported |
| Outcomes | Stroke, TIA, myocardial infarction, wound complication |
| Notes | FU: probably in-hospital stay Ex: not reported |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | Unclear risk | Quote:"The CEA-EQ questionnaire was administered to 176 CEA patients, prospectively randomised to either GA or LA in two hospitals, the Royal United Hospital Bath and The General Infirmary, Leeds" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | High risk | No prespecified outcomes were reported |
| Other bias | High risk | Not reported |

Moritz 2010

| | |
|--------------|---|
| Methods | RCT Computer random Blinding: not reported Cross-over: 2 patients crossed over from LA to GA but these 2 patients were excluded from study Exclusion during trial: 6 (2 withdrawal of consent, 4 incomplete data) Losses to FU: not report |
| Participants | Germany 2010 96 patients, 96 operations Age (mean): of all participants, 69 years Male: 68.8% (LA), 70.8% (GA) Comparability for vascular risk factors, preoperative symptom, ASA classification |

Local versus general anaesthesia for carotid endarterectomy (Review)

Moritz 2010 (Continued)

Indication for surgery: symptomatic 70% to 99%, asymptomatic 80% to 99%

| | |
|---------------|---|
| Interventions | <p>LA: superficial + deep cervical block by 1% prilocaine</p> <p>GA: fentanyl, propofol, rocuronium and anaesthesia maintain by inspired sevoflurane, bolus fentanyl</p> <p>Patching: not reported</p> <p>Antiplatelet Rx: not reported</p> <p>Indication for shunting for LA group was any neurological deterioration like speech abnormality, hemiparesis, or impaired consciousness</p> <p>The indication for shunting in the GA group was N20/P25 amplitude of the somatosensory evoked potential decreased to or below 30% of the baseline value</p> |
| Outcomes | Stroke, myocardial infarction, cardiopulmonary data (blood pressure, heart rate), comparison neuromonitoring various method i.e. stump pressure, transcranial Doppler, near-infrared spectroscopy, somatosensory evoked potentials |
| Notes | |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Low risk | Quote: "All patients were randomised to either sevoflurane/fentanyl anaesthesia (GA = general anaesthesia) or regional anaesthesia (RAI) using a computerized system" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | Low risk | Quote: "a total of 106 patients were randomised to the sevoflurane/ fentanyl (n=53) and regional (n=53) anaesthesia groups. Four patients were excluded because of withdrawal of consent (2 in each group), 2 patients because of conversion to general anaesthesia, and 4 patients because of incomplete data acquisition (3 in GA and 1 in RA). Thus, the final analysis was conducted in 96 patients (GA: n=48; RA: n=48)" |
| Selective reporting (reporting bias) | High risk | All prespecified outcome were reported |
| Other bias | High risk | Not reported |

Mrozek 2007

| | |
|---------|---|
| Methods | <p>RCT</p> <p>C: unclear</p> <p>Blinding: not reported</p> <p>Cross-over: no crossovers from LA to GA</p> <p>Exclusion during trial: not report</p> |
|---------|---|

Local versus general anaesthesia for carotid endarterectomy (Review)

Mrozek 2007 (Continued)

Losses to FU: not report

| | |
|---------------|---|
| Participants | Olomouc 2007 80 patients, 80 operations Age (mean): 67 years (LA), 67 years (GA) Male: 55% (LA), 87.5% (GA) Comparability for vascular risk factors: not reported Indication for surgery: not reported |
| Interventions | LA: superficial + deep cervical block by 0.5% bupivacaine under neurostimulator GA: intravenous etomidate, thiopental, atracurium, midazolam, fentanyl and atracurium Patching: not reported Antiplatelet Rx: not reported Indication for shunting in LA group was loss of consciousness and loss of motor function following carotid clamping Indication for shunting in GA group: not reported |
| Outcomes | Hemodynamic parameter (blood pressure, pulse rate) death, stroke, myocardial infarction, patients' subjective feeling |

Notes

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | High risk | Quote: "the patients were randomised into two groups according to the first six digits of their date of birth (YYMMDD): odds to CB and even to GA" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | Low risk | All prespecified outcomes were reported |
| Other bias | High risk | Not reported |

Pluskwa 1989

| | |
|---------|--|
| Methods | RCT C: random number list Blinding: unclear Cross-overs: none |
|---------|--|

Local versus general anaesthesia for carotid endarterectomy (Review)

Pluskwa 1989 (Continued)

Exclusions during trial: none
Losses to FU: none

| | |
|---------------|--|
| Participants | France 1989 20 patients, 20 operations Age (mean): 66 years (LA), 63 years (GA) Male: 90% (LA), 70% (GA) Comparability: groups similar for vascular risk factors Indication for surgery: not reported |
| Interventions | LA: epidural (C7-T1) by bupivacaine and fentanyl GA: flunitrazepam, fentanyl, vecuronium Patching: not reported Antiplatelet Rx: not reported Indication for shunting: not reported |
| Outcomes | Death, any stroke, myocardial infarction, blood pressure |
| Notes | FU: probably hospital discharge Ex: bleeding risk, on anticoagulants |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | Low risk | Quote: "La veille de l'intervention. ces patients ont ete repartis en deux groupes par tirage au sort a partir d'une serie de nombres au hasard" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | High risk | Not all prespecified outcomes were reported, namely heart rate |
| Other bias | High risk | Not reported |

Prough 1989

| | |
|---------|--|
| Methods | RCT C: unclear Blinding: unclear Cross-overs: none Exclusions during trial: none |
|---------|--|

Prough 1989 (Continued)

Losses to FU: none

| | |
|---------------|--|
| Participants | USA 1989 23 patients, 23 operations Age (mean): 67 years (LA), 61 years (GA) Male: 69% (LA), 40% (GA) Comparability: groups similar for preoperative physical status Indication for surgery: not reported |
| Interventions | LA: superficial cervical block GA: thiopental, pancuronium, isoflurane Patching and antiplatelet Rx: not reported Indication for shunting: not reported |
| Outcomes | Death, any stroke, myocardial infarction, blood pressure |
| Notes | FU: probable hospital discharge Ex: 5 patients refused GA so not randomised |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|---|
| Random sequence generation (selection bias) | Unclear risk | Quote: "Patients who consented to either form of anaesthesia were randomised to received regional or general anaesthesia" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | High risk | Not reported |
| Selective reporting (reporting bias) | High risk | Not all prespecified outcomes were reported, namely intraoperative and post-operative intravenous fluid administration and urine output |
| Other bias | High risk | Not reported |

Sbarigia 1999

| | |
|---------|--|
| Methods | RCT Randomisation: casual number C: unclear Blinding: assessor (neurologist) Cross-overs: 2 exclusions during trials Losses to FU: 18 |
|---------|--|

Sbarigia 1999 (Continued)

| | |
|---------------|---|
| Participants | Italy 1995 to 1998 107 patients, 107 operations Age (mean): 69.0 years (LA), 70.4 years (GA) Males: 87.3% (LA), 88.5% (GA) Comparability: groups similar for vascular risk factors Indication for surgery: TIA, asymptomatic carotid stenosis > 70%, stroke |
| Interventions | LA: superficial and deep cervical block with bupivacaine GA: alfentanil + propofol or sodium thiopental + fentanyl + isoflurane or vecuronium + nitrous oxide Patching: LA 36.4%, GA 23.1% Antiplatelet Rx: not reported Indication for shunting: LA: neurological test (toy-squeaker squeezing test); GA: not reported |
| Outcomes | Death, any stroke, myocardial infarction, TIA, bleeding, cranial nerve injuries, shunted arteries |
| Notes | FU: 30 days Ex: clinical signs of congestive heart disease, severe valvular heart disease, unstable angina, left bundle branch block (by ECG) |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | Low risk | Quote: "randomization by means of causal numbers" |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | Low risk | 2 cross from LA to GA, no drop outs Quote: "two patients were excluded after randomisation and the operations were done under GA"; "in both cases, the anaesthesiologist considered the infiltration of LA to be dangerous" |
| Selective reporting (reporting bias) | High risk | No prespecified outcome was available |
| Other bias | High risk | Not reported |

Sindelic 2004

| | |
|--------------|---|
| Methods | RCT Randomisation, concealment and blinding of assessor: unclear Cross-over: unclear Losses to FU: unclear |
| Participants | Serbia |

Local versus general anaesthesia for carotid endarterectomy (Review)

Sindelic 2004 (Continued)

50 patients, 50 operations
Mean age: 64.4 years (GA), 65.9 years (LA)
Comparability of 2 groups in vascular risk factors
Indication for surgery: unclear
Males: 56% (GA), 52% (LA)

| | |
|---------------|---|
| Interventions | LA: superficial and deep cervical plexus block: superficial block was done with 15 cc 0.5% bupivacaine and 5 cc 2% lidocaine injection along posterior border of sternocleidomastoid muscle Deep cervical block was performed with 3 injection techniques for blockages of C2, C3 and C4 segment GA: thiopental + fentanyl + rocuronium Patching and antiplatelet Rx and indication for shunting: not reported |
| Outcomes | Blood pressure |
| Notes | FU and Ex: unclear |

Risk of bias

| Bias | Authors' judgement | Support for judgement |
|---|--------------------|--|
| Random sequence generation (selection bias) | Low risk | Quote: "Bolesnici su randomizirani u jednu od dve grupe, shodno anestezioloskim postupcima koji ce se sprovedi u toku operaciji: grupe opste anestezije (OA) i grupe regionalne anezije (RA)." |
| Allocation concealment (selection bias) | High risk | Not reported |
| Blinding of participants and personnel (performance bias) All outcomes | High risk | Patients and surgeons were not blinded to treatment group |
| Blinding of outcome assessment (detection bias) All outcomes | High risk | Not reported |
| Incomplete outcome data (attrition bias) All outcomes | Low risk | No patients lost |
| Selective reporting (reporting bias) | High risk | Selected to report parameters only at T2 time which is the only one that is significant but not pre-specified Quote: "Zbog znacajna medjugrupna u grupi OA postoji vremenu T2 i znacajna razlika u tom vremenu (OA vs RA, $p < 0.01$)" |
| Other bias | High risk | Not reported |

ASA: American Society of Anaesthesiologists

C: concealment of allocation

CABG: coronary artery bypass grafting

CT: computerised tomography

EEG: electroencephalography

Ex: exclusion criteria

FU: follow up

GA: general anaesthetic

ICA: internal carotid artery

ICU: intensive care unit

IHD: ischaemic heart disease

Local versus general anaesthesia for carotid endarterectomy (Review)

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LA: local anaesthetic
MCA: middle cerebral artery
RCT: randomised controlled trial
Rx: therapy
TCD: transcranial doppler
TIA: transient ischaemic attack

Characteristics of excluded studies [ordered by study ID]

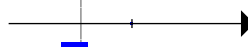


| Study | Reason for exclusion |
|----------------------------|--|
| Ebner 2008 | Randomised allocation was based on the rotation of two anaesthetists who could perform cervical plexus block |

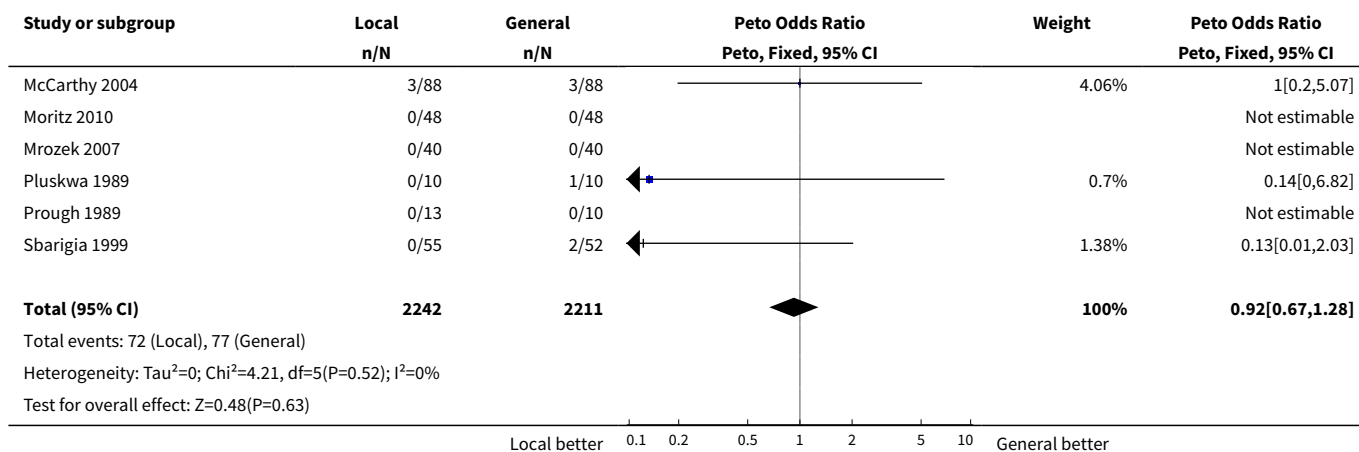
DATA AND ANALYSES

Comparison 1. Local versus general anaesthetic: randomised trials

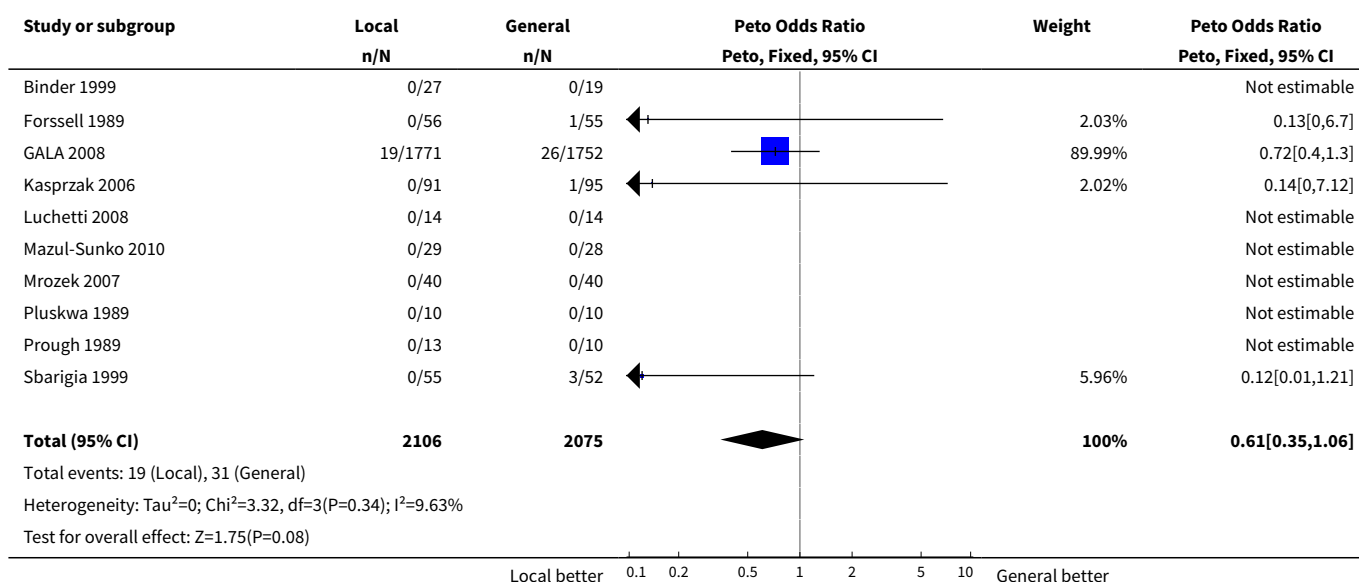
| Outcome or subgroup title | No. of studies | No. of participants | Statistical method | Effect size |
|---|----------------|---------------------|---------------------------------------|-------------------|
| 1 Any stroke within 30 days of operation | 12 | 4453 | Peto Odds Ratio (Peto, Fixed, 95% CI) | 0.92 [0.67, 1.28] |
| 2 Death within 30 days of operation | 10 | 4181 | Peto Odds Ratio (Peto, Fixed, 95% CI) | 0.61 [0.35, 1.06] |
| 3 Stroke or death within 30 days of operation | 10 | 4181 | Peto Odds Ratio (Peto, Fixed, 95% CI) | 0.85 [0.62, 1.16] |
| 4 Myocardial infarction within 30 days of operation | 11 | 4357 | Peto Odds Ratio (Peto, Fixed, 95% CI) | 1.53 [0.67, 3.47] |
| 5 Local haemorrhage | 5 | 3976 | Peto Odds Ratio (Peto, Fixed, 95% CI) | 0.95 [0.75, 1.19] |
| 6 Cranial nerve injuries | 4 | 3865 | Peto Odds Ratio (Peto, Fixed, 95% CI) | 1.17 [0.95, 1.44] |
| 7 Arteries shunted | 8 | 4133 | Odds Ratio (M-H, Random, 95% CI) | 0.24 [0.08, 0.73] |

Analysis 1.1. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 1 Any stroke within 30 days of operation.

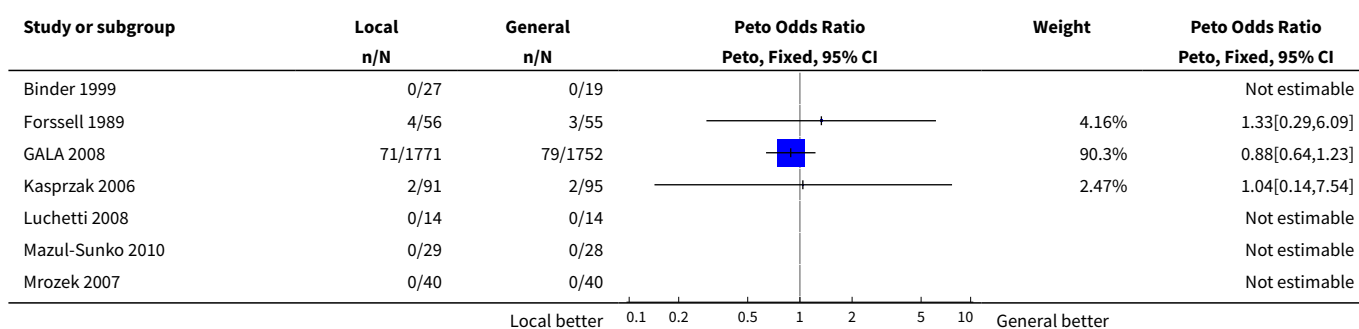
| Study or subgroup | Local n/N | General n/N | Peto Odds Ratio Peto, Fixed, 95% CI | Weight | Peto Odds Ratio Peto, Fixed, 95% CI |
|-------------------|--------------|----------------|--|--------|--|
| Binder 1999 | 0/27 | 0/19 | | | Not estimable |
| Forssell 1989 | 4/56 | 2/55 |  | 3.99% | 1.97[0.38,10.15] |
| GALA 2008 | 63/1771 | 68/1752 |  | 87.82% | 0.91[0.64,1.3] |
| Kasprzak 2006 | 2/91 | 1/95 |  | 2.06% | 2.05[0.21,19.96] |
| Luchetti 2008 | 0/14 | 0/14 | | | Not estimable |
| Mazul-Sunko 2010 | 0/29 | 0/28 | | | Not estimable |
| | | | Local better 0.1 0.2 0.5 1 2 5 10 General better | | |

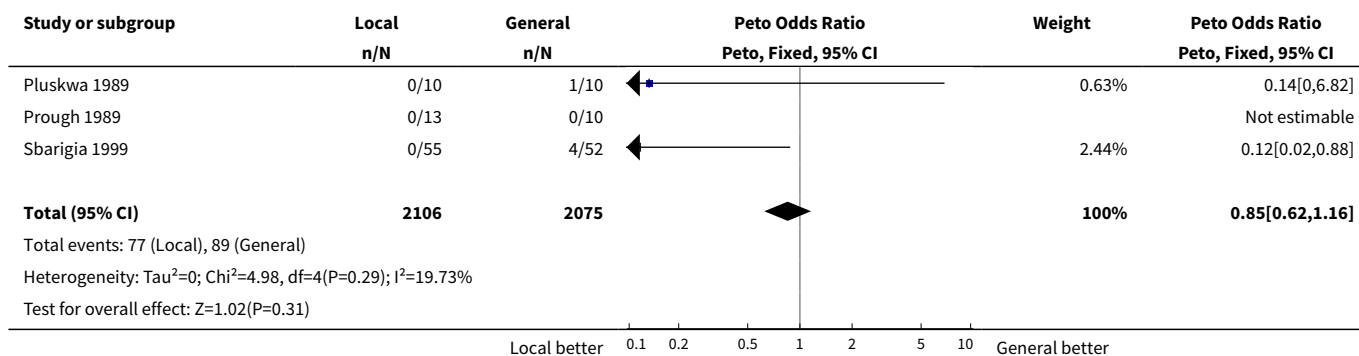


Analysis 1.2. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 2 Death within 30 days of operation.

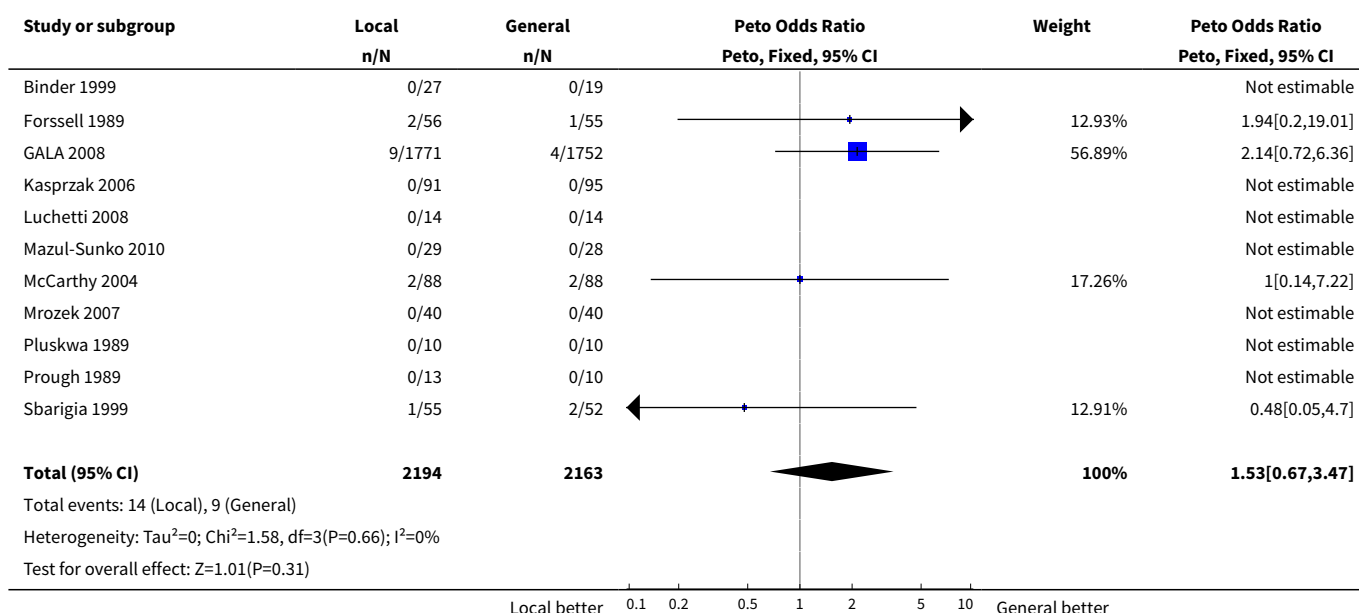


Analysis 1.3. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 3 Stroke or death within 30 days of operation.

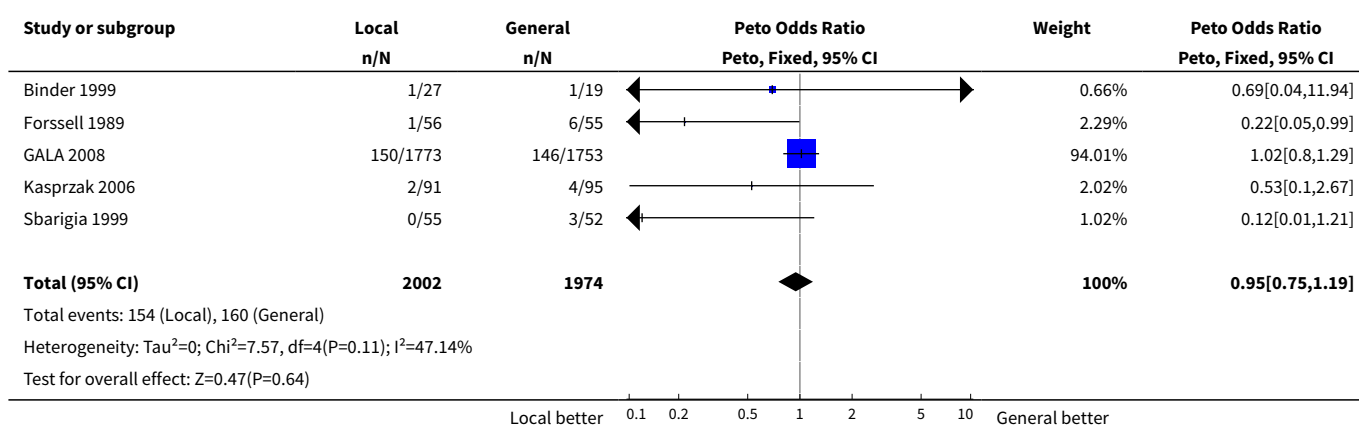




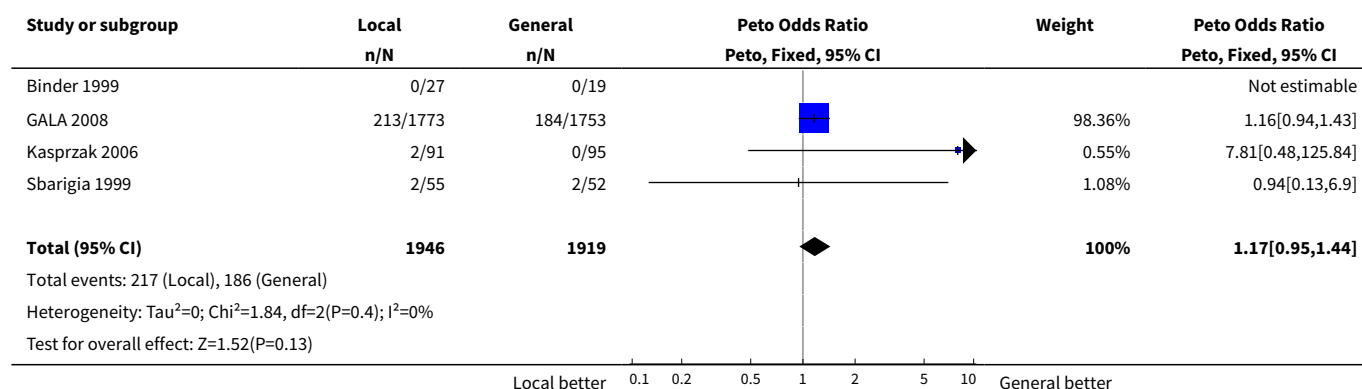
Analysis 1.4. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 4 Myocardial infarction within 30 days of operation.



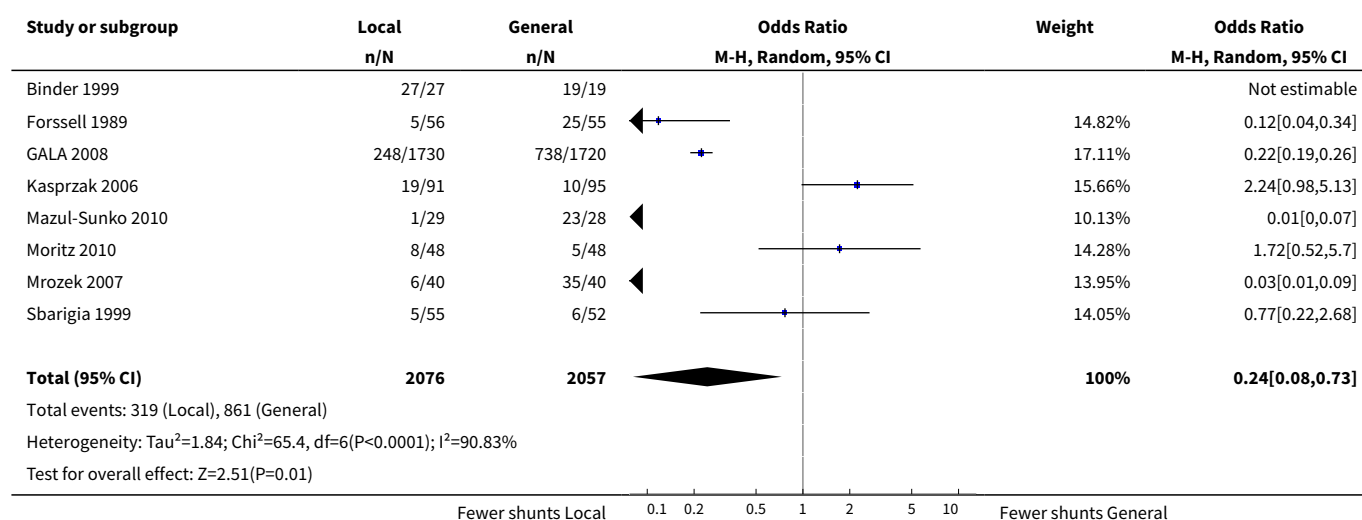
Analysis 1.5. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 5 Local haemorrhage.



Analysis 1.6. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 6 Cranial nerve injuries.



Analysis 1.7. Comparison 1 Local versus general anaesthetic: randomised trials, Outcome 7 Arteries shunted.



APPENDICES

Appendix 1. Cochrane Central Register of Controlled Trials (CENTRAL) search strategy

```
#1 [mh ^"endarterectomy, carotid"]
#2 [mh "carotid arteries"/SU]
#3 [mh "carotid artery diseases"/SU]
#4 [mh "carotid arteries"]
#5 [mh "carotid artery diseases"]
#6 carotid:ti,ab
#7 #4 or #5 or #6
#8 [mh ^endarterectomy]
#9 (endarterectom* or surg*):ti,ab
#10 #8 or #9
#11 #7 and #10
#12 #1 or #2 or #3 or #11
```

#13 [mh anesthesia]
 #14 [mh anesthetics]
 #15 (anesthe* or anaesthe*):ti,ab
 #16 [mh ^"cervical plexus"]
 #17 (cervical NEXT block):ti,ab
 #18 (bupivacaine or lidocaine or lignocaine or prilocaine or ropivacaine or mepivacaine or alfentanil or propofol or fentanyl or ketamine or midazolam or sevoflurane or desflurane or etomidate or isoflurane):ti,ab
 #19 #13 or #14 or #15 or #16 or #17 or #18
 #20 #12 and #19

Appendix 2. MEDLINE search strategy (OVID)

1 Endarterectomy, carotid/
 2 exp carotid arteries/su
 3 exp carotid artery diseases/su
 4 exp carotid arteries/
 5 exp carotid artery diseases/
 6 carotid.tw.
 7 4 or 5 or 6
 8 endarterectomy/
 9 (endarterectom\$ or surg\$).tw.
 10 8 or 9
 11 7 and 10
 12 1 or 2 or 3 or 11
 13 exp anesthesia/
 14 exp anesthetics/
 15 (anesthe\$ or anaesthe\$).tw.
 16 cervical plexus/
 17 cervical block.tw.
 18 (bupivacaine or lidocaine or lignocaine or prilocaine or ropivacaine or mepivacaine or alfentanil or propofol or fentanyl or ketamine or midazolam or sevoflurane or desflurane or etomidate or isoflurane).tw.
 19 or/13-18
 20 12 and 19
 21 exp animals/ not humans.sh
 22. 20 not 21.

Appendix 3. EMBASE search strategy (OVID)

1. carotid artery surgery/ or carotid endarterectomy/
 2. exp carotid artery/su [Surgery]
 3. exp carotid artery disease/su [Surgery]
 4. exp carotid artery/
 5. exp carotid artery disease/
 6. carotid.tw.
 7. 4 or 5 or 6
 8. endarterectomy/
 9. (endarterectom\$ or surg\$).tw.
 10. 8 or 9
 11. 7 and 10
 12. 1 or 2 or 3 or 11
 13. exp anesthesia/
 14. exp anesthetic agent/
 15. exp local anesthetic agent/
 16. (anesthe\$ or anaesthe\$).tw.
 17. cervical plexus/
 18. cervical block.tw.
 19. (bupivacaine or lidocaine or lignocaine or prilocaine or ropivacaine or mepivacaine or alfentanil or propofol or fentanyl or ketamine or midazolam or sevoflurane or desflurane or etomidate or isoflurane).tw.
 20. 13 or 14 or 15 or 16 or 17 or 18 or 19
 21. 12 and 20
 22. Randomized Controlled Trial/
 23. Randomization/
 24. Controlled Study/

25. control group/
26. clinical trial/ or phase 1 clinical trial/ or phase 2 clinical trial/ or phase 3 clinical trial/ or phase 4 clinical trial/ or controlled clinical trial/
27. Double Blind Procedure/
28. Single Blind Procedure/ or triple blind procedure/
29. drug comparison/ or drug dose comparison/
30. "types of study"/
31. random\$.tw.
32. (controlled adj5 (trial\$ or stud\$)).tw.
33. (clinical\$ adj5 trial\$).tw.
34. ((control or treatment or experiment\$ or intervention) adj5 (group\$ or subject\$ or patient\$)).tw.
35. (quasi-random\$ or quasi random\$ or pseudo-random\$ or pseudo random\$).tw.
36. ((control or experiment\$ or conservative) adj5 (treatment or therapy or procedure or manage\$)).tw.
37. ((singl\$ or doubl\$ or tripl\$ or trebl\$) adj5 (blind\$ or mask\$)).tw.
38. versus.tw.
39. (assign\$ or allocat\$).tw.
40. controls.tw.
41. trial.ti. or (RCT or RCTs).tw.
42. or/22-41
43. 21 and 42
44. (exp animals/ or exp invertebrate/ or animal experiment/ or animal model/ or animal tissue/ or animal cell/ or nonhuman/) not (human/ or normal human/ or human cell/)
45. 43 not 44

WHAT'S NEW

| Date | Event | Description |
|-------------------|--|---|
| 30 September 2013 | New search has been performed | The searches have been updated to September 2013. We have identified four new randomised trials. The total number of included trials is now 14 randomised trials of 4596 operations. However, the four new trials did not have any stroke or death events in the perioperative period, so the results for these outcomes have not changed |
| 30 September 2013 | New citation required but conclusions have not changed | New first author. Conclusions unchanged |

HISTORY

Review first published: Issue 1, 1996

| Date | Event | Description |
|------------------|-------------------------------|---|
| 30 November 2008 | New search has been performed | The searches have been updated and completed to November 2008. In the year since the searches were last completed in 2007, we have identified one new randomised trial. This most recent study is the biggest trial (3526 operations) in this systematic review. The total number of included trials is now 10 randomised trials of 4335 operations. The non-randomised studies, which are prone to bias and which were previously included in the review, have now been removed from this version. |
| 30 November 2008 | New search has been performed | The searches have been completed to November 2008. In the three years since the previous version of this Cochrane Review was published, there have been three new randomised trials; the |

| Date | Event | Description |
|---------------|--|---|
| | | total number of included trials is now ten randomised trials involving 4335 operations. |
| 6 August 2008 | New citation required but conclusions have not changed | There has been a change of authorship. |
| 15 April 2008 | Amended | Converted to new review format. |

CONTRIBUTIONS OF AUTHORS

Tanat Vaniyapong, Wilaiwan Chongruksut, Kittipan Rerkasem: designed the protocol, performed searches, selected studies for inclusion or exclusion, extracted data and updated the review.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- Faculty of Medicine, Chiang Mai University, Thailand.
- Center for Applied Science, Research Institute of Health Sciences, Chiang Mai University, Chiang Mai, Thailand.

External sources

- The Thailand Research Fund, Thailand.
- Stroke Prevention Research Unit, Nuffield Department of Clinical Neurosciences, University of Oxford, England, UK.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The non-randomised studies, which are prone to bias and which were previously included in the review, have been removed.

INDEX TERMS

Medical Subject Headings (MeSH)

*Anesthesia, General; *Anesthesia, Local; Endarterectomy, Carotid [*adverse effects] [methods]; Incidence; Myocardial Infarction [epidemiology] [etiology]; Randomized Controlled Trials as Topic; Stroke [epidemiology] [*etiology]

MeSH check words

Humans