Carotid endarterectomy under local anaesthesia

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Carotid endarterectomy has been widely used for the surgical treatment of carotid stenosis, and may be performed under either general or local anaesthesia. This article examines the relative merits of both techniques for carotid endarterectomy, and describes the local anaesthetic technique used by the authors for this procedure.

Carotid stenosis is caused by atherosclerotic plaques that develop at the carotid bifurcation, resulting in narrowing of the artery. Embolization of atheromatous material or thrombotic occlusion of the vessel can occur, resulting in transient ischaemic attacks, amorausis fugax or cerebral infarction. The risk of such events is greatest in patients who are already symptomatic and in those with greater degrees of stenosis of the artery.

The medical management of patients with carotid stenosis includes control of coexistent hypertension and diabetes mellitus as well as advice on giving up smoking. Patients should also be started on aspirin unless contraindications exist (160–300 mg for 2–4 weeks followed by 75 mg daily thereafter).

CEA is now recognized as the treatment of choice in symptomatic patients who have a high degree of stenosis of the internal carotid artery (>70%) (North American Symptomatic Carotid Endarterectomy Trial Collaborators, 1991; European Carotid Surgery Trialists' Collaborative Group, 1998). It is also recommended in patients with less severe narrowing of the vessel in whom medical treatment has failed, or in those where irregular or ulcerated lesions are noted (Wittgen and Brewster, 1997).

In asymptomatic patients who have a high degree of stenosis the picture is less clear. In these patients surgery offers improved outcome only in centres that have very low perioperative morbidity and mortality rates (<3%), and in patients who represent a very low anaesthetic risk (Executive Committee for the Asymptomatic Carotid Atherosclerosis Study, 1995).

GENERAL ANAESTHESIA

Advantages

Most anaesthetic agents reduce the cerebral metabolic rate, which may offer some degree of cerebral protection during the period of carotid cross-clamping. The benefits of this, however, may be restricted by the loss of cerebral autoregulation associated with volatile anaesthetic agents. Furthermore, most intraoperative neurological events are now believed to be embolic rather than ischaemic in nature, so the benefits of reduced cerebral metabolic rate may have been overestimated in the past (Riles et al, 1994).

Many feel that general anaesthesia provides better operating conditions and improved surgical access, especially in patients with a high carotid bifurcation. It is also argued that it is less stressful than a regional procedure, which may benefit the patient with unstable angina and limited cardiovascular reserve.

Disadvantages

Cardiac complications are the primary cause of perioperative morbidity and mortality associated with CEA. Atherosclerosis is a systemic disease and patients with carotid stenosis have a high incidence of ischaemic heart disease. Anaesthetists usually aim to keep the mean arterial pressure 20% above the normal value for the patient to ensure adequate cerebral perfusion pressure during the period of carotid cross-clamping. General anaesthesia in these patients is associated with labile blood pressure, and the use of inotropes to maintain an elevated mean arterial pressure has been shown to increase the cardiovascular perioperative morbidity (Boysen et al, 1972). This is presumably due to drug-induced increases in myocardial workload.

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Clinical assessment of neurological function is lost under general anaesthesia. Jugular venous oxygen saturation, transcranial doppler-derived middle cerebral artery blood flow velocities, stump pressure measurements and continuous electroencephalogram monitoring are commonly used to assess cerebral blood flow and function during cross-clamping (*Figure 1*). These techniques all require skilled interpretation, and when used in the awake patient both false-positive and false-negative results have been observed (Benjamin et al, 1993).

Under general anaesthesia the use of shunts is based on stump pressure measurements and they are used more commonly than in the awake patient. This is of concern because of the potential for thrombus formation, embolization of atheromatous material, intimal dissection, increased cross-clamp time and the increased incidence of postoperative carotid artery stenosis that may result.

LOCAL ANAESTHESIA

Advantages

The overwhelming advantage of performing CEA under local anaesthesia is that it allows awake cerebral function monitoring during the period of cross-clamping. Cerebral ischaemia may present as loss of consciousness, seizures, confusion, dysarthria or a reduction in contralateral motor strength, and may be easily detected clinically. This is done by maintaining verbal contact with the patient and asking them to squeeze a squeaky toy held in the opposite hand and to move their toes (*Figure 2*). If the patient becomes symptomatic during the initial trial period of cross-clamping, a shunt is inserted and a decision made to proceed. In this situation elevation of the mean arterial pressure may also be beneficial.

When the procedure is performed under local anaesthesia the blood pressure is generally well maintained and is often noted to rise by 20 mmHg during the period of cross-clamping. This suggests that some cerebral autoregulation is preserved, which may reduce ischaemic episodes.

Local anaesthesia offers both improved cardiovascular stability and the ability to monitor the patient for chest pain. Meta-analysis of non-randomized trials has shown that local anaesthesia is associated with lower cardiorespiratory complications in the perioperative period (Tangkanakul et al, 1997). Further randomized trials are required, however, to establish this conclusively.

Local anaesthesia also offers potential financial advantages as intensive care is rarely required and the overall hospital stay is reduced (Godin et al, 1989). In our experience local anaesthesia is well tolerated and this is supported by the results of a number of large clinical audits. In one series of 128 consecutive patients, over 90% said that they would have the same type of anaesthesia for future CEA (Davies et al, 1990).

Disadvantages

The main disadvantages of local anaesthesia stem from complications of the technique itself, and are discussed in detail below. The procedure normally takes 1–2 hours and anxiety and physical discomfort caused by lying still for this length of time are potential problems.

Clearly not all patients are suitable for surgery under local anaesthesia, and in a minority general anaesthesia may be more appropriate. This may be due to psychological reasons, difficult neck anatomy (e.g. very obese) or simply because of patient refusal to undergo a procedure under local anaesthesia.

Figure 1. Selection of monitoring used to assess neurological function in the anaesthetized patient during carotid endarterectomy: transcranial doppler, near infrared spectroscopy and jugular venous oxygen saturation — various manufacturers, total cost about £100 000.

Figure 2. 'Cerebral function monitor' as used in the awake patient — Woolworth's 99p.

APPLIED ANATOMY

The cervical plexus is formed from the upper four cervical nerves, although only C2, 3 and 4 have sensory components. The nerves pass laterally along the corresponding transverse process immediately posterior to the vertebral artery and vein. At the tip of the transverse process they divide into ascending and descending branches that form a series of loops before uniting to form deep and superficial branches.

The deep branches form the deep cervical plexus. This is entirely motor in function and supplies the muscles of the neck. The superficial branches form the superficial cervical plexus, branches of which emerge from behind the midpoint of the posterior border of the sternocleidomastoid. They are entirely sensory in nature and supply the skin and subcutaneous tissues of the neck and posterior aspect of the head.

Sensory supply to the side of the neck may also receive variable contributions from the trigeminal nerve over the angle of the jaw and the opposite cervical plexus close to the midline. Similarly structures within the carotid sheath may receive innervation from the glossopharyngeal and vagus nerves. Because of this, cervical plexus block may need to be supplemented by local infiltration to achieve complete surgical anaesthesia.

LOCAL ANAESTHESIA

We perform CEA under a combination of deep and superficial cervical plexus blocks together with local infiltration. The procedure can be adequately performed under local infiltration, but we favour a combined approach to ensure a high success rate and thereby avoid the difficulties associated with conversion to general anaesthesia in a patient with an open neck wound.

Before performing the regional anaesthesia it is important to establish full monitoring and to secure venous access. In our practice we place a 14 G venous cannula and a 20 G arterial line on the same side as the surgery. This leaves the opposite arm free to assess the effects of arterial cross-clamping.

Patient comfort and positioning

Before performing the block ensure that the patient does not have a full bladder. Unless catheterized, intravenous fluid should also be restricted during the procedure. (In practice we usually use 300–500 ml of normal saline.)

The patient is placed supine with a break in the table to produce slight flexion at the knees and the legs are supported with a pillow behind the knees. In theatre we arrange a plastic drape to allow the patient some vision and to avoid claustrophobia (*Figure 3*). Patients often complain of feeling very hot under the drapes and we have found a fan useful in adding to patient comfort. The head is turned slightly to the opposite side and asking the patient to turn their head to the opposite side against slight resistance identifies the posterior border of the sternocleidomastoid (*Figure 4*). The position of other surface landmarks, including the mastoid process, cricoid cartilage and external jugular vein, should also be noted.

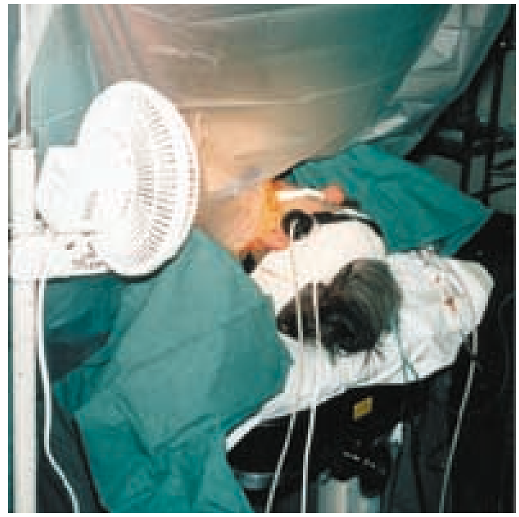

Figure 3. Patient position during surgery.

Before performing the block it is our practice to give 25–50 μg fentanyl and 1–2 mg midazolam. This adds to patient comfort and at this dose its short duration of action ensures that it does not interfere with neurological assessment of the patient during cross-clamping.

The patient should be fully informed of what they may experience during the procedure.

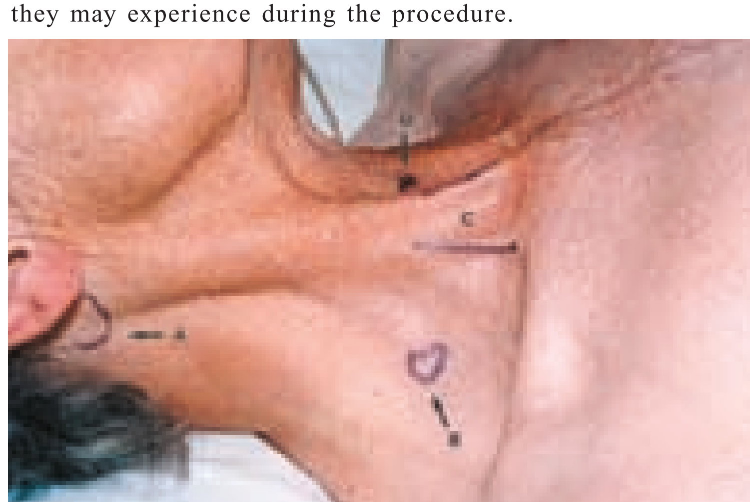

Figure 4. Surface anatomy for local anaesthetic technique. A= mastoid process, B= transverse process of C6, C= sternocleidomastoid with anterior and posterior borders highlighted, D= cricoid cartilage.

They should be told that they may retain deep touch sensation and that they may feel some discomfort on initial dissection of the carotid sheath and deeper layers. If this is not done it may be interpreted as failure of the technique, leading to unnecessary anxiety and distress. Reassurance must be given that if they experience pain at any time during the procedure this can be corrected easily by further local infiltration by the surgeon. We find it useful to describe the local anaesthetic technique as a combined approach, with the anaesthetist performing the first part and the surgeon performing the last part.

Figure 5. Deep cervical plexus block. In this picture the injection is being made at the level of C2. Note the slightly caudal direction of the needle to avoid intrathecal/epidural injection.

Figure 6. Superficial cervical plexus block.

Figure 7. Local infiltration along the anterior border of sternocleidomastoid.

Choice of local anaesthetic

We favour a high-volume, low-concentration technique for this procedure. We use 30 ml of 0.5% bupivacaine with 1 in 200 000 adrenaline diluted with 30 ml of 0.9% normal saline. This produces a final solution of 60 ml 0.25% bupivacaine with 1 in 400 000 adrenaline. Any supplemental infiltration by the surgeon is performed using 1% lignocaine. A solution of 1–2 ml 1% lignocaine is also applied to the carotid bifurcation to block the cardiovascular changes, which might otherwise result from pressure on the carotid sinus during dissection.

Deep cervical plexus block

A deep cervical plexus block entails paravertebral injections of C2, 3 and 4. To locate their position a line is drawn from the tip of the mastoid process to the tip of the transverse process of C6 (this lies at the level of the cricoid cartilage and is usually palpable). A parallel line drawn 1cm behind this line overlies the tips of the upper cervical transverse processes. The tip of the transverse process of C2 lies 1.5–2.0 cm (approximately one finger's breadth) below the mastoid process. The transverse processes of C3 and C4 lie in turn 1.5 cm below the one above. A further landmark is that C4 lies at the level of the upper border of the thyroid cartilage.

Three separate injections are now made at each of the above sites using a 21G needle. This is introduced in a medial and slightly caudal direction, keeping the angle of injection perpendicular to the skin in all planes (*Figure 5*). It is important to direct the needle in a slightly caudal direction to avoid intrathecal or epidural injection. The needle is advanced until bone is encountered or until paraesthesia is elicited. If bone is encountered the needle is withdrawn and angled slightly laterally until the tip lies on the lateral point of the transverse process. After careful aspiration, 5 ml of local anaesthetic is injected slowly at each site.

During injection it is important to perform repeated aspiration and to maintain verbal contact with the patient, as the nerve lies very close to both the vertebral artery and vein at this point. In our practice we have found that good results can be achieved by slightly more superficial injections that reduce the risk of intravascular injection.

As the branches of the deep cervical plexus supply only motor function, the procedure may be performed equally well if the deep cervical plexus block is omitted entirely. Residual motor tone may slightly restrict surgical access but the risk of complications is reduced.

Superficial cervical plexus block

The branches of the superficial cervical plexus emerge from behind the midpoint of sternocleidomastoid and pass in three groups upwards, medially and downwards. A 23 G needle is introduced behind the midpoint of the muscle to a depth of 1–2 cm until a 'pop' is felt when the needle pierces the investing layer of deep cervical fascia. Then 20 ml of local anaesthetic solution is introduced using a fan-like motion (*Figure 6*).

Local infiltration

Finally local anaesthetic is infiltrated along the anterior border of sternocleidomastoid from the mastoid process to the jugular notch. A weal of local anaesthetic is raised at the midpoint of the muscle and 20 ml of local anaesthetic is infiltrated along its entire length using a 3.5 inch 22G Yale spinal needle (*Figure 7*). It is important that both extremes of the wound are adequately infiltrated, especially in the area of the jugular notch as this is where a drain is often sited.

COMPLICATIONS

In performing a cervical plexus block, local anaesthetic is injected close to a number of vascular and neural structures creating the potential for serious complications. A thorough understanding of the anatomy involved is required for a reliable and safe technique. *Table 1* lists the complications associated with cervical plexus block.

Intravascular/intra-arterial injection

The vertebral artery and vein lie anterior to the cervical nerves at the point where the injections for the deep cervical plexus block are made. As little as 1–2 ml of local anaesthetic injected intra-arterially at this point may cause neurological symptoms, so injection should be made very slowly, repeated negative aspirations should be performed and verbal contact maintained throughout to detect early signs of CNS toxicity.

Local anaesthetic toxicity

Local anaesthetic toxicity arising from absolute overdosage is unlikely when using the volumes and concentrations of bupivacaine described above. The addition of adrenaline further limits the systemic uptake of local anaesthetic, but this remains a potential risk that must be considered, especially in frail elderly patients.

Subarachnoid/epidural injections

It is essential that the needle is angled caudally when performing the deep cervical plexus block to avoid the danger of epidural or intrathecal injection. By doing this the needle will strike the tip of the transverse process below, rather than passing medially into the intervertebral foramen.

Phrenic nerve block

Hemidiaphragmatic paralysis has been shown to occur in more than 60% of patients undergoing CEA under cervical plexus block (Castresana et al, 1994), although changes in arterial blood gases have not been shown to be clinically significant. Patients may complain of a 'heavy' sensation in their chest and reassurance and supplemental oxygen is all that is required.

Recurrent laryngeal and vagus nerve block

Studies have shown the incidence of recurrent laryngeal or vagus nerve block to be as high as 55% (Castresana et al, 1993). It presents as transient hoarseness and apart from the need to alert the surgeon to this before surgery, it is a harmless complication.

Facial nerve block

An ipsilateral facial nerve block may occasionally occur. This may cause confusion at the

TABLE 1.
Complications of cervical plexus block

Intra-arterial injection
Intravascular injection
Local anaesthetic toxicity
Intrathecal injection
Epidural injections
Phrenic nerve block
Recurrent laryngeal nerve block
Vagus nerve block
Horner's syndrome
Ipsilateral facial nerve block
Cardiovascular instability
Failure of block

time of cross-clamping or in the recovery area but it can be easily distinguished from a vascular complication as it occurs on the same side as the surgery.

Horner's syndrome

Injection anterior to the transverse process deposits local anaesthetic onto the middle cervical sympathetic ganglion, and presents with injected conjunctiva, ptosis or a blocked nose.

Cardiovascular instability

Elevation of systolic blood pressure is often noted during arterial cross-clamping but this rarely requires treatment.

Hypotension occurs much less frequently than in patients undergoing surgery under general anaesthesia and can usually be treated by fluids and vasoactive drugs. For this reason it is our practice to have atropine and ephedrine readily available.

Surgical stimulation or retraction of the vagus may cause bradycardia and we have recently seen a case of asystole in such circumstances. This settled with removal of the stimulus and intravenous atropine and ephedrine.

Failure of block

Our experience reflects that of others — that complete failure of the block is very unusual. In one series of over 600 patients undergoing CEA under cervical plexus block, only 1.1% of patients were converted to general anaesthesia (Shah et al, 1994). We have found that most patients can be managed with supplemental local anaesthesia or modest increments of fentanyl or midazolam, and conversion to general anaesthesia is rarely necessary. We believe that light sedation and modest increments of analgesia may be preferable in this situation, as it avoids the need for tracheal intubation and the cardiovascular changes associated with general anaesthesia that have been discussed above.

CONCLUSION

Local anaesthesia in the form of cervical plexus block is a safe and convenient technique for carotid anaesthesia that is finding increased popularity. Our own experience is supported by a meta-analysis of non-randomized trials, which suggests improved perioperative cardiorespiratory morbidity in association with local anaesthesia. Large scale randomized trials are still needed, however, to support this opinion. HM

KEY POINTS

- Carotid endarterectomy is recommended for the treatment of patients with symptomatic stenosis of the internal carotid artery of greater than 70%.
- Surgery should be offered to asymptomatic patients with similar degrees of stenosis only if they represent a very low anaesthetic risk and in centres with very low perioperative morbidity and mortality rates.
- Local anaesthesia offers a safe alternative to general anaesthesia with low failure rates and high patient compliance.
- Local anaesthesia allows neurological assessment of the awake patient during cross-clamping.
- Meta-analysis of non-randomized trials has shown that local anaesthesia is associated with lower cardiorespiratory complications.
- Large scale randomized trials are required to conclusively establish the benefits of local anaesthesia for this procedure.

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