Regional anaesthesia for carotid endarterectomy: an audit over 10 years

M. Hakl1 *, P. Michalek2 3, P. Ševčik1, J. Pavlíková1 and M. Stern2

1Department of Anaesthesiology and Intensive Care, St Ann’s Teaching Hospital in Brno, Pekářská 53, 656 91 Brno, The Czech Republic. 2Department of Anaesthesia and Intensive Care, Na Homolce Hospital, Roentgenova 2, 150 30 Prague, The Czech Republic. 3Department of Anaesthetics, Antrim Area Hospital, 45 Bush Road, Antrim, BT41 2RL, UK

*Corresponding author. E-mail: marek.hakl@fnusa.cz

Background. The aim of this retrospective study was to compare the failure rates and the frequency of anaesthesia-related complications of two different methods of regional anaesthesia used for carotid endarterectomy—cervical epidural (CE) anaesthesia and cervical plexus block (CPB).

Methods. The study included 1828 carotid endarterectomies performed in 1455 patients between 1996 and 2006. A combination of deep and superficial CPB was used for 1166 procedures, whereas in 662 cases surgery was performed under CE anaesthesia.

Results. The failure rate of CPB was 3% compared with 6.9% for CE anaesthesia ($P<0.0001$). The reasons for failure of the anaesthetic techniques were (1) technical failure, (2) insufficient analgesia, (3) non-compliant patients, and (4) anaesthetic complications. The incidence of complications resulting from CE anaesthesia was significantly higher than with CPB: life-threatening complications—2% compared with 0.3% ($P<0.0001$); other anaesthesia-related complications 5.7 vs 4.7%. Serious complications included inadvertent injection into the subarachnoid space or vertebral artery. The frequency of shunt insertion, perioperative stroke, and death from any cause was similar in both groups of patients.

Conclusions. Both methods of regional anaesthesia are acceptable for carotid artery surgery. CPB is associated with a significantly lower frequency of anaesthesia-related complications and should therefore be considered the anaesthetic of choice. CE anaesthesia should not be performed except in extenuating circumstances such as variant anatomy or the requirement for more extensive surgery.


Keywords: anaesthetic techniques, epidural; anaesthetic techniques, regional; complications; surgery, endarterectomy

Accepted for publication: May 4, 2007

Carotid artery surgery can be performed under either general or regional anaesthesia,1 2 the latter commonly being cervical plexus blockade (CPB). Superficial plexus blockade is reported to be as effective as the combined superficial and deep CPB with a potentially lower risk of complications.3 4 Some surgeons use only local anaesthetic infiltration. Cervical epidural (CE) anaesthesia is an alternative option for carotid endarterectomy but seems rarely to be selected as the technique of choice.5–7 A number of retrospective and prospective studies have compared the frequency of both perioperative and postoperative complications in patients who have had carotid endarterectomy under general or regional anaesthesia.8–11 Results from some studies have shown that regional anaesthetic techniques are associated with better circulatory stability and lower morbidity and mortality rates,8–10 but the robustness of the statistical data in these studies has been questioned. The GALA trial (General vs Local Anaesthesia for Carotid Endarterectomy—www.galatrial.com) was set up to clarify this issue, and is currently in progress.

The aim of our study was to compare the failure rate and the frequency of anaesthesia-related complications associated with the two regional anaesthetic techniques CPB and CE anaesthesia. We hoped that this would
identify the technique with the lowest complication rate. We also aimed to identify any specific groups of patients that might benefit from each technique.

Methods

Ethical approval was obtained from both institutions involved in this study. The requirement for patient consent was waived because of the retrospective design of this study.

The primary data source for this retrospective study was a computer database, case notes including anaesthetic records, were also reviewed. Regional anaesthesia, was chosen in 52.9% of a total of 3455 carotid endarterectomies performed from January 1996 to January 2006 in two major teaching hospitals in this period. A total of 1455 patients had 1828 carotid artery procedures under regional anaesthesia during the study period.

The choice of regional anaesthesia depended on several factors, for example the individual preference of an anaesthetist or surgeon, the extent of the procedure, and local anatomy at the site of surgery. In 662 cases (36.2%), the surgery was performed under CE anaesthesia while 1166 procedures (63.8%) were performed under CPB.

During the study period, regional anaesthesia for carotid endarterectomy was performed by a total of eight anaesthetists (five of consultant grade and three of SpR grade). All patients were premedicated orally with benzodiazepine (1 mg of flunitrazepam or 7.5–10 mg of midazolam) on the evening prior to surgery.

CE anaesthesia was performed with the patient sitting. The epidural space was entered at C6–7 or C7–T1 using a midline approach. The epidural space was identified using the ‘hanging drop’ technique. An epidural catheter was inserted to a depth of 4–5 cm. The correct placement of the catheter was verified by aspiration followed by the administration of a test dose of 5 ml of a mixture consisting of 16 ml of bupivacaine 0.5% and 4 ml (20 µg) of sufentanil. After about 5 min, the initial dose was supplemented according to the patient’s body weight up to a total amount of 15 ml of the analgesic mixture. This amount was sufficient for sensory blockade between C2 and T4–6 without the motor blockade of intercostals. Another dose of 5–10 ml of the same mixture was usually administered after 90 min.

Deep cervical block was performed with the patient in the supine position with the head turned slightly away from the side of surgery. A 22 gauge insulated needle was used with a peripheral nerve stimulator (Stimpulex HNS, BBraun AG, Melsungen, Germany). The puncture site was located approximately 3 cm below the mastoid process at the posterior edge of the sternocleidomastoid muscle. Digital compression was performed at this point. The needle was then inserted between two fingers in a medial and slightly dorsal direction. The needle was perpendicular to the skin in all directions. The stimulating current was initially 3.0 mA. When the twitches of deep anterior cervical muscles were seen, the current was gradually decreased to a level of 0.3–0.5 mA. A dose of 14–18 ml of bupivacaine 0.5% (or levo-bupivacaine 0.5%) was injected following careful aspiration.

The intersection of the sternocleidomastoid muscle and external jugular vein served as an anatomical landmark for the superficial CPB. The needle was inserted approximately 1 cm cranially to this point perpendicular to the skin. Local anaesthetic (4–5 ml) was injected at this point followed by s.c. infiltration close behind the lateral edge of the sternocleidomastoid muscle. A dose of a 4–5 ml of local anaesthetic was injected in both cranial and caudal directions.

Five-lead ECG monitoring was used during surgery. Leads II and V5 were displayed and multi-lead ST-segment monitoring was used throughout the operation. SpO2 was monitored and arterial blood pressure was measured either non-invasively or invasively using a radial artery cannula. The patient’s level of consciousness was monitored by means of verbal contact and the motor function of the contralateral arm was monitored using a rubber whistling toy placed in the patient’s hand. A carotid shunt was inserted if the patient’s neurological status deteriorated after carotid clamping.

The ‘Epidural Scoring Scale for Arm Movements—ESSAM’ score12 was used for an assessment of motor block associated with CE anaesthesia (Table 1). Rises in systemic blood pressure were treated with antihypertensive drugs if the systolic blood pressure increased over 180 mm Hg or if the signs of acute heart decompensation were present (dyspnoea, ECG ST-segment changes, chest discomfort/pain). After the surgery, the patient was transferred to the intensive care unit (ICU) or high dependency unit (HDU) where they stayed for at least 24 h depending on their clinical state.

We examined a number of outcomes as described by Pandit and colleagues.13

(1) Conversion to general anaesthesia related to regional anaesthesia technique
(a) Failure of regional anaesthesia. The reasons for this included technical failure and lack of patient compliance (because of insufficient analgesia, prolonged surgery, stress, anxiety, or musculoskeletal pain).
(b) Occurrence of a life-threatening complication arising as a result of block placement, which led to

<table>
<thead>
<tr>
<th>Grade</th>
<th>Movement hand grip (C8–T1)</th>
<th>Wrist flexion (C7–C8)</th>
<th>Elbow flexion (C5–C6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>1</td>
<td>–</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

Hakl et al.
either conversion to general anaesthetic or abandonment of the surgery.

(2) Severe anaesthesia-related complications occurring after block placement but before commencement of surgery.

(a) Neurological—the injection of local anaesthetic mixture into the subarachnoid space or into vertebral artery (or into another artery supplying the brain) and seizures due to local anaesthetic toxicity.

(b) Cardiovascular—circulatory collapse or bradycardia.

(c) Respiratory complications—distress due to diaphragmatic or vocal cord paralysis.

(3) Other anaesthesia-related complications. These complications were not life threatening. They included:

(a) Blood observed in the epidural catheter during CE anaesthesia.

(b) Blood observed in the stimulating needle during CPB.

(c) Blockade of extraneous nerves (weakness of the upper limbs after CE anaesthesia, or block of cranial nerves associated with CPB).

(4) Other serious systemic complications. The complications in this group were mainly systemic disturbances during surgery or the immediate postoperative period. They included CVA/transient ischaemic attack (TIA), myocardial ischaemia or infarction, haemodynamic instability needing treatment, cardiorespiratory collapse, and death occurring during the hospital stay from any cause.

We also collected data on the need for shunt insertion or conversion to general anaesthesia because of deterioration in neurological status during surgery.

Statistics

The data obtained were analysed using the $\chi^2$ test. For small sample sizes, Fisher’s exact test was employed (Abacus Software, CA, USA). $P<0.05$ was considered significant.

Results

The failure rate of regional anaesthesia was low in both patient groups. The overall failure rate of CPB was 35 of 1166 cases (3%) whereas in the CE anaesthesia sub-group it was 46 of 662 cases (6.9%), $P<0.0001$ (Table 2). The reasons for conversion to general anaesthesia were both anaesthesia- and surgery-related. Patient non-compliance (because of anxiety, pain, or confusion) or inability to adopt the position required to perform the procedure, was noted in five patients in the CPB group (0.4%) and in nine patients in the CE anaesthesia group (1.4%). Technical failure of the regional anaesthesia technique occurred in four cases in the CPB group because of unsuccessful identification of the deep cervical plexus due to anomalous anatomy (0.3%), whereas in the CE anaesthesia group, the frequency of technical failure was nine of 662 patients (1.4%) because of failure to locate the epidural space in five patients and difficulty with catheter insertion in four cases. Insufficient analgesia during the procedure, despite supplementation with sufentanil and/or local anaesthetic by the surgeon, intolerance of position or patient distress were noted in 23 cases in the CPB group (2%) and in 13 in the CE anaesthesia patients (2%). The overall frequency of conversion to general anaesthesia related to the block was significantly higher in the CE anaesthesia group. The frequency of incompliance, technical failure, and insufficient analgesia was similar in both groups.

A significant difference was found in the frequency of life-threatening complications which occurred in three patients in the CPB group (0.3%) and in 15 cases in the CE anaesthesia group (2.3%), $P<0.0001$. We identified 13 cases of local anaesthetic administration into the subarachnoid space in CE anaesthesia patients (2%), leading to high spinal anaesthesia with hypotension and impaired ventilation. All of these patients were given ventilatory support and transferred to the ICU. In the elective patients, the surgery was postponed and performed at a later date under general anaesthesia, whereas in urgent cases the procedure was continued. While inadvertent injection of local anaesthetic mixture into the subarachnoid space was not observed in the group of patients with CPB, we observed two cases of injection into a vertebral artery during deep plexus block (0.2%). Another patient (0.1%) developed neurological symptoms of systemic local anaesthetic toxicity. Further severe complications included unstable haemodynamics with bradycardia and collapse in two patients after block placement in the CE anaesthesia group (0.3%). No signs of acute respiratory insufficiency were noted in our patients.

Table 2 Complications in carotid surgery under regional anaesthesia (CPB, cervical plexus block; CE, cervical epidural anaesthesia). *Fisher’s exact test was employed because of small sample size

<table>
<thead>
<tr>
<th></th>
<th>CPB</th>
<th>CE anaesthesia</th>
<th>$P$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion to general anaesthesia (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical failure of block</td>
<td>32 (2.7)</td>
<td>31 (4.7)</td>
<td></td>
</tr>
<tr>
<td>Life-threatening complications</td>
<td>3 (0.3)</td>
<td>15 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>35 (3)</td>
<td>46 (6.9)</td>
<td>$&lt;0.0001$</td>
</tr>
<tr>
<td>Severe anaesthesia-related complications (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neurological complications</td>
<td>3 (0.3)</td>
<td>13 (2)</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular collapse</td>
<td>0</td>
<td>2 (0.3)</td>
<td></td>
</tr>
<tr>
<td>Respiratory distress</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3 (0.3)</td>
<td>15 (2.3)</td>
<td>$&lt;0.0001$</td>
</tr>
<tr>
<td>Other anaesthesia-related complications (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood in the catheter or needle</td>
<td>7 (0.6)</td>
<td>6 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Blockade of extraneous nerve</td>
<td>49 (4.2)</td>
<td>32 (4.8)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>56 (4.8)</td>
<td>38 (5.7)</td>
<td>0.383</td>
</tr>
<tr>
<td>Other serious complications (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVA/TIA during hospital stay</td>
<td>31 (2.7)</td>
<td>15 (2.3)</td>
<td></td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>2 (0.2)</td>
<td>1 (0.2)</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>9 (0.8)</td>
<td>6 (0.9)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>42 (3.6)</td>
<td>22 (3.3)</td>
<td>0.755</td>
</tr>
</tbody>
</table>
While both conversion to general anaesthesia for block-related reasons and life-threatening complications occurred mainly in the CE anaesthesia group, the frequency of other anaesthesia-related complications was similar in both groups. Blood in the epidural catheter was detected in six patients in the CE anaesthesia group (0.9%) following catheter insertion into the epidural vein. Blood in the stimulating needle during stimulation of the deep cervical plexus was noted in seven cases (0.6%) in the CPB group. Short-term (up to 24 h) hoarseness was observed in 21 patients with CPB (1.8%) and in two patients in the CE anaesthesia group, whereas significant cough occurred only in 15 patients (1.3%) in the CPB group. Twenty-eight patients (2.4%) developed temporary facial or hypoglossal nerve paralysis on the side of the block (all occurring in the CPB group). Temporary weakness of the upper extremities occurred in 30 (4.5%) patients in the CE anaesthesia group (1–3 points as assessed by ESSAM score). The total number of temporary neurological complications was 49 (4.2%) in the CPB group and 32 (4.8%) in the CE anaesthesia group, \( P = 0.528, \) NS (Table 2).

Atropine was administered to 32 (2.7%) patients in the CPB group to treat bradycardia (HR <45 beats min\(^{-1}\)) while ephedrine was administered in 22 patients (1.9%) to counteract bradycardia with hypotension (systolic blood pressure below 100 mm Hg). In the group of CE anaesthesia patients, atropine and ephedrine were used in 96 and 105 cases (14.5 and 15.9%). This was statistically significantly compared with the CPB patients (\( P < 0.0001 \) for atropine, \( P < 0.0001 \) for ephedrine). Pharmacological treatment of hypertension was required in 505 patients in the CPB group (43.3%) and in 31 cases in the CE anaesthesia group (4.7%), \( P < 0.0001 \).

The insertion of a shunt was necessary in 176 CPB patients (15.1%) due to deteriorating consciousness following internal carotid artery clamping and insufficient collateral blood flow. In the CE anaesthesia group of patients, shunt insertion was required in 109 cases (16.5%). If neurological disturbance persisted or if the return of full neurological recovery was too slow (\( >3 \) min) the case was converted to general anaesthesia. This occurred in 38 cases (3.3%) from the CPB group and 23 cases (3.5%) from the CE anaesthesia group. The difference between both methods in the frequency of shunt insertion and switching from regional to general anaesthesia (non-anaesthetic reasons) was not statistically significant. The incidence of CVA/TIA during hospital stay was 31 in the CPB group (2.7%) and 15 in the CE anaesthesia group (2.3%) which was statistically non-significant (\( P = 0.606 \)). There is probably no reason to expect any difference in the influence of various techniques of regional anaesthesia on the frequency of either shunt insertion or CVA/TIA.

In our cohort, 15 (0.8%) patients died during their hospital stay; however, no death was directly related to the anaesthesia technique. The overall combined mortality/serious morbidity risk was 3.5% (3.6% in the CPB group and 3.4% in the CE anaesthesia group—the difference was not statistically significant). Three other patients developed non-fatal circulatory failure, related to serious morbidity (apart from CVA/TIA).

We did not find any significant difference between CPB and CE anaesthesia groups, relating to the frequency of perioperative and postoperative CVA/TIA.

**Discussion**

Regional anaesthesia is frequently selected as the anaesthetic of choice during carotid artery surgery\(^8 11 14\) as it offers the advantage of allowing reliable monitoring of brain perfusion, selective intraluminal shunting, and arguably better perioperative cardiovascular stability.\(^14 – 16\) Our study suggests that, of two methods of regional anaesthesia—CPB and CE anaesthesia—the former is associated with a lower incidence of block failure or block-related complications.

For both blocks, broadly similar failure rates to those we report here have been described in previous studies.\(^5 6 17 18\)

We encountered two cases of inadvertent injection into the vertebral artery with CPB and 13 cases of accidental subarachnoid injection with CE anaesthesia. On the other hand, we did not diagnose any clinically significant respiratory distress as a result of phrenic nerve involvement with the block. Minor neurological complications following CPB usually occur because of non-selective blockade of nerves in the close vicinity of the cervical plexus—hypoglossal, phrenic and laryngeal nerves, and sympathetic structures.\(^19 20\) The reason for adverse neurological outcomes after CE anaesthesia is usually different. Local anaesthesia blocks high thoracic and cervical nerve roots which can affect the sensory and motor functions of the arms. This can confound neurological evaluation in the perioperative period, something that has been previously described in the context of upper thoracic epidural anaesthesia for cardiac surgery.\(^12\)

**Limitations of this study**

This study suffers from the limitations of a retrospective cohort study and should be regarded as offering Level 2b evidence (EBM principles).\(^22\) A large multi-centre prospective randomized study (‘Level 1’) would be necessary to confirm the conclusions of our study. Our data were collected over a 10-yr period; anaesthetic practice has changed considerably during this time and there have been advances in premedication and local anaesthetic drugs. Nonetheless, we have shown that the overall complication rate is very low in a large sample of more than 1800 cases.

At the start of this study, anaesthetists preferred CE anaesthesia because they were experienced with high
thoracic epidural analgesia from their practice in thoracic and cardiac anaesthesia. CPB gradually came into favour over the last 5 yr because of its simplicity, shorter onset, and perceived lower complication risk. We recognize that this could influence both the failure and complication rates. Over the study period, different surgeons performed the procedures. This might have influenced procedure durations and overall outcome.

This study did not examine the cardio-protective effect of CE anaesthesia as described in previous studies.21 We did not collect data on incidence of ST-segment changes on ECG in the perioperative period, or on troponin levels.

Comparison with other studies

In their study of 1000 combined deep and superficial CPBs, Davies and colleagues18 described a 0.2% frequency of inadvertent injection into the vertebral artery and a 0.6% overall frequency of intravascular injection of local anaesthetics. A similar low frequency of life-threatening complications associated with CPB is also described in another large study.23 According to a questionnaire distributed to vascular anaesthetists in the UK, the combined CPB is still the most common technique of regional anaesthesia for carotid surgery.24 However, the complication rate using superficial CPB alone is lower3 4 13 17 25 and it is therefore possible that a comparison of superficial CPB rather than combined CPB with CE anaesthesia may produce even more dramatic differences. Two large series of CE anaesthesia for carotid surgery have been published to date. The reported frequencies of intrathecal local anaesthetic injection were 2.5 and 3.1%, respectively.5 6

Implications for clinical practice

Both methods of regional anaesthesia seem to be acceptable techniques for carotid artery surgery. Since combined CPB has a statistically lower frequency of serious anaesthesia-related complications, we suggest that this technique should be preferred to epidural anaesthesia. CE anaesthesia should not be performed for routine carotid endarterectomy. It may have a place in more extensive procedures26 such as carotid cross-overs and combined carotid-subclavian reconstructions. In such cases, the epidural may be supplemented for longer procedures and also can be extended to provide a more extensive area of block. Where the anatomy is anomalous, for example in the case of a pulsating carotid artery aneurysm or neck tumour, CE anaesthesia may also have a place in the provision of anaesthesia.

Acknowledgements

The authors thank Dr John T. Doherty, Specialist Registrar, Department of Anaesthetics, Antrim Area Hospital, Antrim, UK for his helpful comments and revision of English grammar. The authors also thank Jelena Skibova, consultant statistician, for her contribution.

References

4 Stoneham MD, Doyle AR, Knighton JD et al. Prospective, randomized comparison of deep or superficial cervical plexus block for carotid endarterectomy surgery. Anaesthesia 1998; 89: 907–12
12 Abd Elrazek E, Scott NB, Vohra A. An epidural scoring scale for arm movements (ESSAM) in patients receiving high thoracic epidural analgesia for coronary artery bypass grafting. Anaesthesia 1999; 54: 1104–9
20 Emery G, Handley G, Davies MJ, Mooney PH. Incidence of phrenic nerve block and hypercapnia in patients undergoing...


