Ultrasound-guided carotid sheath block for carotid endarterectomy: a case series of the spread of injectate

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ABSTRACT

Introduction: We aimed to show the spread of local anesthetic following an ultrasound-guided, double-injection technique of a carotid sheath block before carotid endarterectomy.

Methods: The study included 15 patients scheduled for elective carotid endarterectomy. The carotid sheath block was performed after ultrasound-guided localization of the carotid bifurcation (level C4 – C6) at the posterior border of the sternocleidomastoid muscle. A mix of 7.5 mL ropivacaine 0.75%, 7.5 mL prilocaine 1% and 3 mL iopromidum was injected at the base of the carotid bifurcation. An additional 15 mL of the mixture was administered subcutaneously at the surgical incision line. Thirty minutes after the block, a computed tomography scan of the head, neck region and upper thorax was performed to reconstruct a 3-D distribution of the injectate.

Results: All patients achieved C2-C4 dermatomal sensory blockade. None required conversion to general anesthesia. The injectate spread ranged from the vertebral body of C1 to the vertebral body of T3. The mean volume of distribution was 97±13 mL, the craniocaudal spread 138±19 mm, dorsoventral 57±8 mm and coronal 53±8 mm. The mean carotid artery circumference contact was 252°±77, with four patients (27%) presenting with a ring formation (360°) around the carotid artery.

Conclusions: Ultrasound-guided carotid sheath block provided an extensive spread of local anesthetic. A complete ring formation of local anesthetic around the artery does not seem necessary for a successful anesthesia. The resulting nerve blockade thus appears sufficient for surgery, with minor risks compared to blind methods.

Keywords: carotid endarterectomy, cervical plexus block, carotid sheath block, spread of local anesthetic, three-dimensional reconstruction, ultrasonic controlled.

INTRODUCTION

The patient population undergoing carotid endarterectomy (CEA) typically possesses numerous co-morbidities, such as arterial hypertension, diabetes, coronary heart disease, etc. Thus there is a significant risk of myocardial infarction and ipsilateral ischemic stroke during surgery of the internal carotid-artery (1).

During surgery, shunts can be used to protect the brain from stroke during low cerebral blood flow in the carotid cross-clamping phase, but they damage the arterial wall and this can result in cerebral embolism. As such, the surgeon needs to conduct intra-
operative neurological monitoring to assess the cerebral perfusion and make a decision on shunt insertion in cases of clinically relevant cerebral hypoperfusion. The known methods of neurological monitoring during general anesthesia show poor sensitivity and specificity, compared with the awake patient, in terms of the requirement for shunt placement (2, 3). Therefore, regional anesthesia has become the favored technique for CEA, as it allows direct neurological monitoring (4) and provides effective pain relief with a high postoperative patient satisfaction (5).

Carotid surgery requires blockade of the cervical nerves C2-4 and this can be achieved using a cervical plexus block. Due to a lack of muscle response as a result of the use of a neurostimulator, the cervical plexus block is essentially a ‘blind’ injection guided by orientation with anatomical landmarks. There are associated risks as the needle can damage vulnerable structures, e.g. arterial punctures (to the vertebral or carotid artery) resulting in hematoma, or intravascular injection with associated anesthetic toxicity, phrenic-nerve paralysis and subsequent respiratory problems, and intrathecal injection resulting in total spinal anesthesia (4, 6).

Visualization of the carotid artery may reduce the incidence of these accidental punctures, consequently reducing the incidence of complications (7) the total amount of local anesthetic used, and probably leading to a more predictable block (8). The aim of this case series is to show the spread of injected local anesthetic after ultrasound-guided carotid sheath blockade in a three-dimensional computed tomography (CT) scan. We also examined whether the spread of the local anesthetic in vivo totally enclosed the carotid artery and if this ring formation is necessary for a successful anesthesia of the operation area.

**METHODS**

After approval by the institutional ethics committee (Kantonale Ethik-Kommission des Kantons Luzern, protocol number 708) and written informed consent from all patients, 15 American Society of Anesthesiologists class II-III patients undergoing elective CEA were enrolled in the study. Exclusion criteria included: known bleeding disorder, history of allergy to local anesthetics or to iodized X-ray contrast mediums, local sepsis, acute cardiac-decompensation, severe respiratory insufficiency and known diaphragmatic motion abnormalities. After routine monitoring of five-lead electrocardiography, non-invasive blood pressure, pulse oximetry and peripheral insertion of an 18G intravenous cannula, a 20G cannula was placed in the contralateral radial artery for a continuous blood pressure monitoring. Oxygen (2 L/min) was
administered nasally. Regional anesthesia was performed by a senior anesthesiologist, with the patient in the supine position and the head turned slightly away. An ultrasound transducer was wrapped in a sterile cover and placed (after skin disinfection with red-dyed chlorhexidine, 2%) on the level of C4-C6, at the horizontal projection of the cricoid cartilage on the line connecting the angle of mandible and the jugular notch of the manubrium sterni (Figure 1). After finding the base of the carotid artery bifurcation with the ultrasound transducer and skin anesthesia with 1-2 ml lidocaine (1%), an atraumatic needle for peripheral nerve blocks (Stimuplex D 23G x 70 mm, B. Braun, Melsungen, Germany) was inserted using the in-plane technique. We administered a mixture of 7.5 mL ropivacaine (0.75%), 7.5 mL prilocaine (1%), and 3 mL iopromidum (a triiodized, non-ionic, water-soluble X-ray contrast medium with an iodine concentration of 300 mg/mL) on the ventral side of the carotid artery bifurcation. 

**Figure 2**
Spread of the local anesthetic (yellow lines). CA = carotid artery; d = dorsal; l = lateral; m = medial; v = ventral.

**Figure 3**
Axial native CT image of the right-sided contrast media/anesthetic injection at the submandibular level of the neck. No ring-like union of the contrast media around the carotid artery (red arrow) was achieved in this case. The yellow arrow shows to the skin-incisional infiltration. CT = computed tomography.
cation area (Figure 2). After completion of the block, an additional 15 mL of the local anesthetic mixture with 3 mL iopromidum was subcutaneously administered along the line connecting the angle of mandible and the jugular notch of the manubrium sterni. The maximum amount of local anesthetics applied was 3-4 mg/kg for ropivacaine and 7-10 mg/kg for prilocaine. We administered 15 ml ropivacaine 0.75% (112.5 mg) and 15 ml prilocaine 1% (150 mg). With this amount of anesthetic, systemic toxicity is not expected for patients heavier than 15-20 kg for prilocaine and 28-37 kg for ropivacaine. Performance of the carotid sheath block needed about 10 minutes. Twenty till thirty minutes later, a CT scan of the head, neck region and upper thorax was completed to evaluate the distribution of the injectate in a three-dimensional reconstruction (Figures 3 and 4). After return from the CT room, again twenty till thirty minutes later, the operation started. The twenty till thirty minutes delay of surgery through the CT scan has no influence on the quality of the block because ropivacaine has duration of action of about six hours. During the procedure, from the beginning, all patients had a remifentanil drip of 0.02-0.2 µg/kg/min for comfort (mild sedation but easy to awake). Pain during the operation was treated with local anesthetic (lidocaine 1%) administered by the surgeon. Neurological monitoring was provided by spontaneous communication and periodic requests to squeeze a rubber duckling. In scanographic sequential cross section we analyzed the craniocaudal spread of the injectate in relation to the spine, its volume of distribution, its maximal contrast spread (craniocaudal, dorsoventral, and coronal), its distance to the apex of the mastoid and to the end of the medial clavicula, its contact with the circumference of the carotid artery, and its center of contact with the carotid artery.

CEA technique. The carotid bifurcation was identified preoperatively by duplex ultrasound and marked on the skin to keep the oblique incision at the ventral margin of the sternocleidomastoid muscle as short as possible. Subsequently, both vagal and hypoglossus nerve were identified to avoid damage. Dissection of the common, external and internal carotid artery was carried out beyond the diseased segments respectively. The preparation of internal carotid artery was at first performed only in the distal,
non-diseased section to avoid embolization from the plaque. During dissection and before clamping, heparin was given intravenously (50 IU/kg) and systolic blood pressure was raised to 150-160 mmHg and kept at that level until blood flow was restored. After clamping, the neurological status was assessed regarding consciousness and motoric and sensoric function for 2-3 minutes, during which dissection of the stenotic carotid segment was completed. In case of unremarkably neurology, eversion endarterectomy was performed with a standardized technique after oblique transection of the internal carotid artery at the bifurcation. In case of a neurological abnormality, shunting (Argyle Carotid Artery Shunt, Covidien) and conventional endarterectomy with patch plasty (Periguard Bovine Pericardium Patch, Synovis) was chosen. Before suture line closure, flushing and rinsing with heparinized saline was done to prevent any air or thrombus embolisation during declamping. Biplanar completion angiography by retrograde puncture of the common carotid artery was performed routinely to evaluate the technical quality of the arterial reconstruction before wound closure and drainage. Statistical analysis was done using the commercially available software package MS-Excel XP 2003 (Microsoft Corporation, Redmond, WA 98052 USA). Data are depicted as the mean and standard deviation (SD).

RESULTS
From July 2010 to February 2012, we included 15 consecutive patients with a mean age of 76 ± 4 years, and 27 ± 4 kg/m² body mass index. The sex ratio male/female

| Patient/gender | Age (y) | BMI (kg/m²) | Surgical time (min) | Carotid clamping time (min) | Local anesthetic supplemented by the surgeon (mL) |
|----------------|---------|-------------|---------------------|-----------------------------|-----------------------------------------------|
| 1 / m          | 83      | 28.3        | 100                 | 23                          | 7                                             |
| 2 / f          | 81      | 30.1        | 80                  | 30                          | 0                                             |
| 3 / m          | 77      | 27.1        | 80                  | 20                          | 12                                            |
| 4 / m          | 73      | 34.4        | 115                 | 39                          | 4                                             |
| 5 / m          | 69      | 30.1        | 125                 | 45                          | 10                                            |
| 6 / m          | 72      | 27          | 80                  | 30                          | 0                                             |
| 7 / m          | 80      | 23.5        | 155                 | 25                          | 1                                             |
| 8 / m          | 84      | 25.4        | 120                 | 30                          | 3                                             |
| 9 / m          | 78      | 27.3        | 120                 | 40                          | 0                                             |
| 10 / f         | 85      | 20.3        | 90                  | 28                          | 0                                             |
| 11 / f         | 77      | 25.9        | 90                  | 44                          | 2                                             |
| 12 / m         | 81      | 21.2        | 90                  | 30                          | 0                                             |
| 13 / f         | 74      | 28.9        | 75                  | 27                          | 0                                             |
| 14 / m         | 74      | 23.2        | 80                  | 20                          | 10                                            |
| 15 / m         | 67      | 32          | 105                 | 30                          | 11                                            |
| mean (SD)      | 76 (4)  | 27 (4)      | 100 (22)            | 31 (8)                      | 4 (4)                                         |

BMI = body mass index; f = female; m = male; SD = standard deviation.
Spread of ultrasound-guided carotid sheath block

(%) was 73/27. Surgical time and carotid clamping time are listed in table 1. The volume of distribution of the contrast medium was 97 ± 13 mL (mean ± SD), with a maximal craniocaudal spread of 138 ± 19 mm from the upper edge of the vertebral body of C1 to the lower edge of the vertebral body of T3 (Table 2). In the dorsoventral plane there was a mean medium distribution of 57 ± 8 mm, and in the coronal plane, 53 ± 8 mm. The mean distance to the apex of the mastoid was 24 ± 10 mm, and to the medial clavicula, 9 ± 4 mm. The carotid artery circumference contact had a mean of 252° ± 77°. The center of the carotid artery contact of the injectate was placed at

(Table 2 - Spread of radiological contrast agent.)

| Patient | Craniocaudal spread in relation to the spine | Distributing volume (mL) | Maximal contrast spread craniocaudal (mm) | Maximal contrast spread dorsoventral (mm) | Maximal contrast spread coronal (mm) | Circumference of the carotid artery contact (°) |
|---------|-----------------------------------------------|--------------------------|------------------------------------------|-----------------------------------------|----------------------------------------|-----------------------------------------------|
| 1       | lower edge of CVB2 - upper edge of TVB2       | 96                       | 136                                      | 56                                      | 61                                     | 360                                           |
| 2       | upper edge of CVB2 - upper edge of TVB3       | 85                       | 144                                      | 54                                      | 62                                     | 250                                           |
| 3       | lower edge of CVB2 - middle of TVB3           | 85                       | 139                                      | 46                                      | 41                                     | 360                                           |
| 4       | upper edge of CVB1 - lower edge of TVB1       | 121                      | 148                                      | 54                                      | 66                                     | 210                                           |
| 5       | middle of CVB1 - lower edge of TVB1           | 101                      | 145                                      | 55                                      | 69                                     | 270                                           |
| 6       | middle of CVB2 - lower edge of TVB2           | 115                      | 139                                      | 60                                      | 55                                     | 360                                           |
| 7       | middle of CVB2 - lower edge of TVB2           | 88                       | 135                                      | 53                                      | 42                                     | 210                                           |
| 8       | upper edge of CVB2 - upper edge of TVB2       | 92                       | 128                                      | 71                                      | 52                                     | 200                                           |
| 9       | lower edge of CVB1 - middle of TVB1           | 96                       | 116                                      | 55                                      | 53                                     | 270                                           |
| 10      | upper edge of CVB1 - lower edge of TVB3       | 92                       | 169                                      | 73                                      | 51                                     | 80                                            |
| 11      | lower edge of CVB1 - middle of TVB2           | 99                       | 153                                      | 58                                      | 45                                     | 225                                           |
| 12      | upper edge of CVB1 - upper edge of TVB3       | 85                       | 156                                      | 64                                      | 44                                     | 180                                           |
| 13      | middle of CVB2 - middle of TVB2               | 120                      | 123                                      | 63                                      | 54                                     | 270                                           |
| 14      | upper edge of CVB1 - upper edge of TVB2       | 103                      | 158                                      | 45                                      | 52                                     | 360                                           |
| 15      | lower edge of CVB2 - lower edge of CVB7       | 73                       | 88                                       | 51                                      | 49                                     | 175                                           |
| mean (SD) |                                         | **97** (13)              | **138** (19)                             | **57** (8)                              | **53** (8)                             | **252** (77)                                  |

CVB = cervical vertebral body; TVB = thoracic vertebral body; SD = standard deviation.
In four of the 15 patients (27%) there was a ring formation around the carotid artery (360°). The amount of local anesthetic (lidocaine, 1%) supplemented by the surgeon varied between 0 and 12 mL (Table 1), although 10 of the 15 patients (67%) needed only 0-4 mL. The area where the local anesthetic supplementation was necessary included: 1-3 mL for the glomus caroticum, 7-10 mL for the skin incision, and 7-10 mL for the area of the Redon’s suction drainage placement. We observed no clinically relevant side effects of our carotid sheath block technique. No patients required conversion to general anesthesia.

**DISCUSSION**

In the current case series, we demonstrated the spread of injected local anesthetic after standardized ultrasound-guided carotid sheath blockade, using a three-dimensional CT scan reconstruction of the injectate. There was extensive spread of the local anesthetic. A complete ring formation of local anesthetic around the artery does not seem necessary for a successful anesthesia of the operation area.

Blockade of the cervical nerves with conventional techniques as intermediate cervical plexus block [also called superficial cervical plexus block but anatomically correct so called due to the needle-perforation of the investing fascia of the neck (6, 9)] or deep cervical plexus block (so called due to the needle-perforation of the deep cervical fascia) are associated with potentially serious complications, such as injection of the local anesthetic epidurally, subarachnoidally, or into the vertebral artery (6). Ultrasound-guided blocks improve efficacy (with faster onset and longer duration of the block), facilitate performance (less time is required), and reduce the risk of complications (vascular puncture) (7). In addition, the local anesthetic requirements to produce an effective block are reduced with ultrasound-guidance (10). The reduced risk of vascular puncture is very important for carotid surgery, as nearly all patients are under anticoagulation and a hematoma in the operation field can make the surgical procedure more difficult. Ultrasound-guidance remains the only reliable control tool when performing a cervical plexus block, This is because motor responses following nerve stimulation are frequently unreliable due to atrophy in the platysma muscle in this typically older patient population, and because the contact of a stimulation needle with a nerve does not necessarily provoke a motor response (11). Ultrasound-guidance allows a precise injection of the local anesthetic to the carotid artery, the place of the operation. So, we called the block carotid sheath block instead of cervical plexus block because we did not look for the nerve roots of the plexus cervicalis, nor for its nerve fibers, located posteriorly to the sternocleidomastoid muscle. The technique of the ultrasound-guidance block is established but the designation varies between different papers: Rössel et al. named the block “perivascular regional anesthesia of the internal carotid artery” (12) and Martusevicius et al. named the block “locoregional anesthesia” (8).

The administered volume of local anesthetic in our study appears to coincide with the literature where the most common volume reported is between 20 and 40 mL, (4, 8, 12-19) with a range between 10 (20) and 80 mL (21). Patients with a higher dose may benefit in terms of post-operative analgesia (13). We administered 15 mL of local anesthetic to the base of the carotid artery bifurcation. A further 15 mL of local anesthetic was administered subcutaneously along the line of the angle of mandible and the jugular notch of the manubrium sterni, starting at the level C5/C6. This additional local
anesthetic volume should cover the surgical incision line and the area where the surgeons insert the drainage tube from the operation field. Although we administered the local anesthetic under ultrasound-guidance to the carotid artery, we did not move the needle around the artery. We have to anesthetize the area of the sinus caroticus (baroreceptors at the beginning of internal carotid artery) and the glomus caroticum (paraganglioma with chemoreceptors at the carotid artery bifurcation area), as well as the ventral region of the carotid artery, the surgical incision region. Nevertheless we found that in 27% of our patients the local anesthetic had enclosed the full circumference of the carotid artery. Interestingly, we found cases without local anesthetic circumferences of the carotid artery that needed no further local anesthetic supplementation by the surgeons. Of the four patients with total circumference of the carotid artery, one needed no supplementation by the surgeons, two needed only supplementation for the drainage tube insertion and one needed 2 mL of lidocaine 1% to the glomus caroticum area. So, ring formation of the local anesthetic around the carotid artery seems not obligatory. The requirement to locally infiltrate the operation field during arterial adventitia preparation by the surgeons could be necessary due to pain triggered by afferent nerve fibers accompanying the sympathetic innervations of the vessels (14). We noticed that the requirement for local anesthetic supplementation by the surgeon was less obvious when we introduced an ultrasound-guided carotid sheath block as opposed to a cervical plexus block performed without ultrasound. In a former study, we performed a case series with 14 patients for CEA with intermediate cervical plexus block without ultrasound-guidance (22). In that previous series we observed a mean local anesthetic supplementation by the surgeons of 7 ± 3 mL, similar to the case series presented here (5 ± 5 mL). However, in the previous series every patient required supplementary anesthetic, and only two of the 14 (14%) had 0-3 mL supplementary local anesthetic. In comparison, in the current series six patients of 16 (38%) had no supplementary anesthetic and nine of the 16 (56%) patients who had ultrasound-guidance had only 0-3 mL supplementary anesthetic (data not published).

We would like to point out that our case series was designed to show the spread of the local anesthetic by use of a three-dimensional CT-scan reconstruction of the injectate, and not to evaluate the effectiveness of the ultrasound-guided carotid sheath blockade. This has already been done in previous investigations (8, 12). As such, we did not record a visual analog scale (VAS) during surgery as the surgeons wanted to avoid disturbing the patients during the operation. Additionally, a remifentanil drip was being administered to the patient for comfort; nevertheless they were still responsive during the operation. The two CEA-performing surgeons in our institution were satisfied with the ultrasound-guided carotid sheath block, as it minimized their additional local anesthetic application.

It seems possible that with the targeted ultrasound-guided carotid sheath block with administration of the local anesthetic around the carotid artery the local anesthetic volume can be reduced. Further studies are needed to assess whether such a reduction in local anesthetic volume will have the same success as the currently used 20-40 mL, also bearing in mind the post-operative analgesia.

**CONCLUSION**

In conclusion, we have shown the *in vivo* spread of local anesthetic after ultrasound-
guiding carotid sheath blockade using a three-dimensional CT scan reconstruction. A complete ring formation of local anesthetic around the carotid artery does not seem necessary for a successful anesthesia of the operation area.

An ultrasound-guided carotid sheath blockade can be performed rapidly, it is sufficient for surgery and it provides an alternative approach with a lower complication rate compared with current methods of injection that use orientation to anatomical landmarks or with nerve stimulation.

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