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Anaesthesia for carotid endarterectomy. Ultrasound-guided superficial/intermediate cervical plexus block combined with carotid sheath infiltration

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Abstract

Background: Carotid endarterectomy carries a significant risk of intraoperative brain ischaemia. Various methods for intraoperative cerebral function monitoring can be utilized, but the assessment of the patient's consciousness remains the easiest and most available method, requiring that the patient remain awake and under local/regional anaesthesia. The aim of this study was to compare infiltration anaesthesia with an ultrasound-guided superficial/combined cervical plexus block for patient safety and comfort.

Methods: Ninety-eight patients scheduled for carotid endarterectomy were randomly assigned to receive either infiltration anaesthesia performed by the surgeon or an US-guided superficial/combined cervical plexus block. The pain intensity using the numerical rating scale (NRS), the volume of local anaesthetic used and the anaesthesia-related complications were recorded. The data were analysed using selected statistical tools.

Results: In the US-guided group, a significantly lower volume of local anaesthetic was used (25 mL vs. 30 mL), and lower mean (1 vs. 3) and maximal (2 vs. 6) NRS scores were observed. However, hoarseness, cough and difficulty swallowing were significantly more frequent among those patients (90% vs. 27%, 30% vs. 12%, and 36% vs. 6%, respectively).

Conclusions: Compared with infiltration anaesthesia, an US-guided superficial/combined cervical plexus block is an effective method for improving the comfort of the patient and the surgeon. The technique is safe, relatively simple and easy to master and requires little time to perform.

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Key words: carotid endarterectomy, anaesthesia; cervical plexus, block; ultrasound

Carotid endarterectomy (CEA) is performed in cases of the critical obstruction of the carotid artery in patients who are at risk of ischaemic cerebral stroke. The mortality after CEA is approximately 0.3–3%, while stroke risk reduction is estimated to be 5–20% [1, 2].

The surgical technique requires the temporary closure of the carotid artery flow, which poses a considerable risk for ischaemic complications [1–3]. To improve the safety of the procedure, it is essential to monitor the CNS function. Thanks to the early diagnosis of perfusion disorders, interventions that can shorten the time of ischaemia can be performed, and the procedure can be completed quickly or even abandoned. Transcranial Doppler ultrasound that evaluates the flow velocity in the middle cerebral artery, somatosensory evoked potentials and cerebral oximetry enable the assessment of CNS perfusion in patients during general anaesthesia. A significant limitation of the examinations mentioned above is their insufficient accuracy and additional costs. One excellent measure for assessing CNS perfusion is to observe the patient's consciousness and motor activity; therefore, surgeries are often performed in conscious patients while they are under regional anaesthesia [1, 2, 4].

Regional anaesthesia for neck surgical procedures is a serious challenge for anaesthesiologists, especially because of the complex innervation and proximity of many anatomically important and delicate structures [5]. The neck region has predominant sensory inputs from cervical plexus nerves. The main anaesthesia-related problem is the dis-

persed neck structure. The cervical plexus is formed by the rami of C1-C4 abdominal spinal nerves, which give rise to the following four sensory branches: the great auricular, lesser occipital, supraclavicular and transverse cervical nerves. At the level of C4, the nerves run under the sternocleidomastoid muscle in the area limited by the superficial and pre-vertebral fascia. The muscular branches of the cervical plexus are the phrenic nerve (from C3-C5; C4 predominantly innervates the diaphragm and pericardium) and the cervical loop (innervating supra- and sub-hyoid muscles), as well as the branches to the anterior and middle scalene muscles. The tunica adventitia is innervated by the fibres of nerves IX and X and the sympathetic branches from the superior cervical ganglion [5].

To ensure the patient's comfort, local (infiltration) anaesthesia is commonly performed, which proves unsatisfactory in many cases in terms of the quality of analgesia. The additional injections of the operated tissues contribute to swelling, which hinders the preparation, and the total dose of a local anaesthetic can exceed toxic amount [5].

The use of regional anaesthesia for CEA is not a new concept; for years, different variants of a cervical plexus block (predominantly deep) or cervical epidural anaesthesia have been suggested for this purpose [6].

Both deep cervical plexus anaesthesia and cervical epidural anaesthesia require extreme proficiency and carry a high risk of complications the proximity of important anatomical structures, as well as the dangers associated with the perioperative use of anticoagulants. The application of ultrasound for identifying anatomical structures enables the precise deposition of a local anaesthetic, which substantially limits its dose and improves the patient`s safety because toxic doses can be avoided. Moreover, the absence of tissue swelling facilitates the procedure, which shortens its duration.

The aim of this study was to compare the efficacy and incidence of adverse side effects related to infiltration anaesthesia and an US-guided superficial/combined cervical plexus block [7, 8] for carotid endarterectomy.

METHODS

The study design was approved by the Bioethics Committee of the Lower-Silesian Medical Association in Wrocław. The study included 98 patients who underwent endarterectomy of the internal carotid artery and gave their written informed consent for participation.

Patients were randomly assigned to one of the two groups. The L group (local anaesthesia) consisted of 48 patients who underwent infiltration anaesthesia that was performed immediately before the procedure and was supplemented during surgery, if need be. The P group (plexus anaesthesia) included 50 patients who underwent a selective block of the cervical plexus elements on the operated side. The block was US guided (GE LOGIQ-e, GE, USA) using a 13 MHz linear probe. The local anaesthetic was injected using a 22 GA needle, 50 mm, designed for regional blocks (Vygon Echoplex, Ecouen, France). An intermediate cervical plexus block was performed, wherein 15 mL of LA was deposited between the sternocleidomastoid muscle fascia and deep cervical fascia at the C4 level. The appropriate level of insertion was chosen by tracking the brachial plexus course, starting from the supraclavicular region to the area where the brachial plexus elements disappear. The needle was inserted slightly above this place. An additional 5 mL of LA was administered under the vasonervous fascia on the anterior surface of the carotid artery, slightly below its branching into the internal and external carotid artery (Figs 1–3). The block efficacy before the procedure was assessed based on the absence of temperature sensations on the operated side of the neck skin and the occurrence of hoarseness.

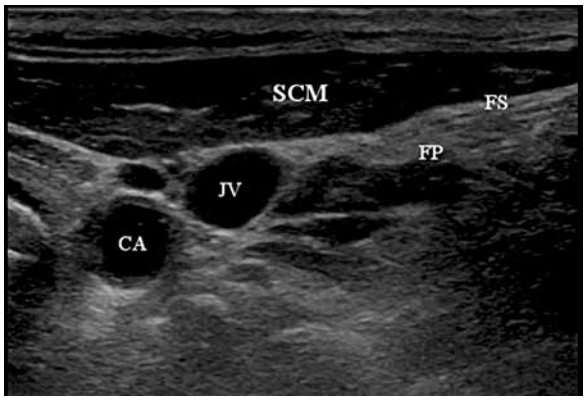

Figure 1. US scan of the transverse section of neck tissues at the level of C4 before LA administration. SCM — sternocleidomastoid muscle; CA — common carotid artery; JV — internal jugular vein; FS — superficial fascia; FP — prevertebral fascia

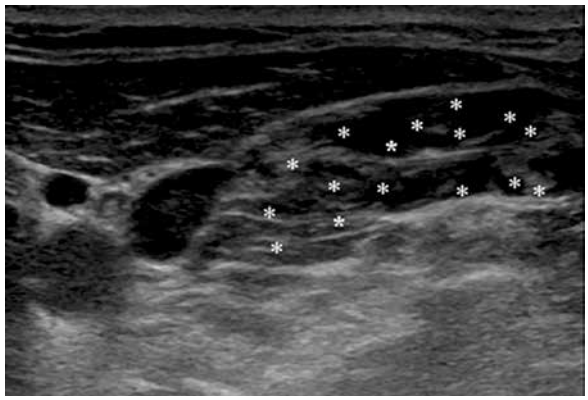

Figure 2. US scan of the transverse section of neck tissues at the level of C4. *LA administered to the area limited by the superficial and prevertebral fascia

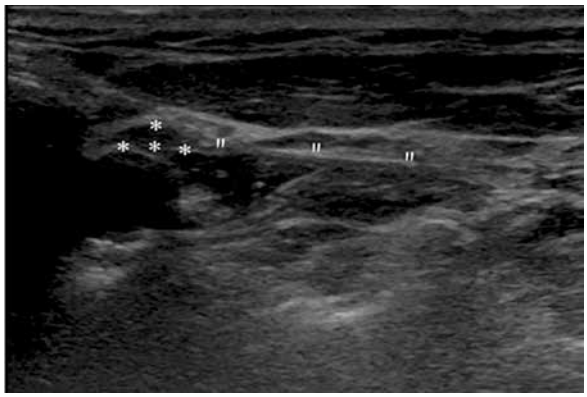

Figure 3. US scan of the transverse section of neck tissues at the level of carotid artery bifurcation. *LA administered to the area under the vasonervous fascia, onto the carotid artery the carotid artery; "the needle used during anaesthesia

Table 1. Characteristics of patients, anaesthesia and side effects. Data are presented as the mean ± SD, median (IQR) or %

	Group L	Group P	*P*-value
Age (years)	67 ± 9	68 ± 7	0.43
Gender male/female	72/28	76/24	0.63
Side operated on			
Left/right	49/51	33/67	0.114
Volume of anaesthetic (mL)	30 (27–39)	25(23–27)	< 0.001
Duration of procedure (min)	58 ± 15	51 ± 12	0.008
Hoarseness	27%	90%	< 0.001
Dyspnoea	6%	8%	0.955
Coughing fit	12%	30%	0.035
Difficulty swallowing	6%	36%	0.0003

Table 2. Intensity of pain according to the NRS. Data are presented as the medians (IQR)

	Group L	Group P	*P*-value
Medium NRS during surgery	3 (2–5)	1 (0–1)	< 0.001
Maximum NRS during surgery	6 (4–8)	2 (0–4)	< 0.001
NRS immediately after surgery	1 (0–2)	0 (0–0)	< 0.001

The local anaesthetic applied in both groups was a 1% solution of lidocaine with additional adrenaline (dilution — 1:200,000).

For organizational reasons, the observer gathering information on the intensity of intra and postoperative pain knew the type of anaesthesia used as, in most cases, the observer was the attending anaesthesiologist.

The type of anaesthesia was one of the elements that differentiated the management of patients in both study groups.

The following parameters were recorded: the duration of surgery (from the moment of skin incision to placing a final stitch), the total volume of LA used throughout surgery, and the level of pain experienced by patients (questions were asked immediately after surgery and were about the medium and maximum pain during the procedure and the level of pain after the completion of surgery). The numerical rating scale (NRS) was applied. Moreover, the patients were observed for possible complications associated with anaesthesia, including hoarseness (defined as a change in the tone and/or strength of the voice), difficulty swallowing (defined as discomfort in the throat) and cough. The observation was performed from the beginning of anaesthesia to transferring the patient to the recovery room.

After surgery, the operators were asked to subjectively assess the operating field conditions using a 4-degree descriptive scale of very good, good, bad and very bad.

STATISTICAL ANALYSIS

The data were statistically analysed using Statistica 10 software (StatSoft, Tulsa, USA). The normality of distribution was assessed with the Shapiro-Wilk W test. Depending on the distribution and number of comparisons, Student's t test, Mann-Whitney U test or Kruskal-Wallis ANOVA was applied. Whenever the results of Kruskal-Wallis ANOVA were significant, the test for multiple comparisons was additionally used. Qualitative variables were compared using the Pearson chi-squared test with Yates correction. $P < 0.05$ was considered significant.

RESULTS

The results are presented in Tables 1 and 2. The differences in the demographic data of the study groups were not statistically significant. The total LA volume was significantly lower in the P group. Likewise, the duration of procedures was significantly shorter in the P group; however, the results might have been affected by factors such as different operating teams and different operating conditions, which could result from the necessity to insert a temporary bypass or patch.

The incidence of side effects — hoarseness and difficulty swallowing — was significantly higher in the P group. Otherwise, the intergroup differences in dyspnoea were not significant. The pain experienced by patients evaluated according to the accepted criteria was substantially less intense in the P group.

A significant correlation was found between the type of anaesthesia and the descriptions of the operating field conditions. In the P group, the percentage of "very good"

answers was 87%, and that of "good" answers was 11%, vs. 29% and 50% in group L ($P < 0.001$).

The efficacy of blocks in the P group (no temperature sensations on the neck skin on the operated side) was confirmed in 40 patients (80%), and hoarseness was present in 45 patients (90%). One of the aforementioned symptoms occurred in each patient.

In the P group, additional local infiltration was required in 14 cases (28%). The volume of additional lidocaine was 8 mL on average, with a range of 3–20 mL.

There were no cases of necessary conversion to general anaesthesia. There was no need for conversion to general anaesthesia in any group.

DISCUSSION

The GALA trial data published in 2008 demonstrated comparable results of regional versus general anaesthesia for CEA; therefore, the choice of anaesthetic management remains relatively subjective [9].

As expected, the method of cervical plexus block presented by our group appeared to be a very interesting alternative to our earlier standard management, i.e., "step-by-step" infiltration anaesthesia (injections of successive layers as the preparation is increasingly deeper) performed by the operator.

Our results clearly demonstrated the better safety and comfort of patients with US-guided cervical plexus blocks. The major advantage is the considerably lower level of pain experienced during the procedure. Unfortunately, the quality of anaesthesia was not good in all patients. The majority of patients experienced slight or no pain; however, in some cases, to achieve satisfactory comfort, local infiltration was additionally required. This limitation of efficacy is likely from the diversity of anatomical structures and the variable innervation of the neck region in individual patients. The cervical transverse nerves may cross the body midline and pass to the opposite side. In such cases, even a fully effective unilateral superficial cervical plexus block is insufficient to promote patient comfort. Another issue is the height of the carotid artery division; this height is usually at the level of C4, but higher divisions are also possible, even at C2. The height of the division decides the course of surgical incision. At a high division, the risk of operating in the region supplied by the trigeminal nerve is higher.

A precise US-guided injection of LA reduces the risk of unintended intravascular administration and markedly limits the drug volume, which decreases the risk of generalized toxic effects. A shorter procedure time translates into a shorter time that the patient spends in an uncomfortable position, which results in better comfort and better cooperation with the surgeon. Because of drug administration to the plexus region instead of directly to the tissues that are operated on, the tissues preserve their anatomy, facilitating the procedure. According to the surgeons participating in the study, a low volume of the drug administered under the vasonervous fascia facilitates vessel preparation, at least in some patients undergoing cervical plexus blocks.

One problem associated with the presented type of cervical plexus anaesthesia is the risk of side effects caused by unilateral palsy of the vagus nerve. In the management described, this palsy is inevitable. The elements of the cervical loop, which are a target of anaesthesia, are situated in the same area under the vasonervous fascia as the vagus nerve. Therefore, at appropriate blocks, we have to consider the high risk of hoarseness, cough, swallowing disorders and temporary dyspnoea [10]. The symptoms experienced are usually not troublesome, especially when the patient is informed in advance of their possible development. Patients with pre-existing unilateral palsy of the vagus or recurrent laryngeal nerve are problematic. If elective surgery was to affect the opposite side, a cervical loop block would cause the bilateral dysfunction of the vocal cords with closure of the true glottis [11]. Therefore, patients with laryngeal nerve paralysis and dysfunction of the vocal cords of any aetiology should not be subjected to cervical loop blocks on the opposite side. In such cases, an intermediate cervical plexus block alone can be considered. None of the patients involved in the study had significant pre-procedure dysfunction of their vocal cords. Notably, similar complications resulting from vagus nerve blocks were observed in the group with infiltration anaesthesia, although their incidence was significantly lower. It seems that the benefit of vagus nerve blocks is the lack of episodes of bradycardia associated with its irritation during tissue preparation. Nevertheless, there are few reports describing differences of intra- and postoperative mean arterial pressure and heart rate [12].

Numerous descriptions are available for using US-guided regional methods for carotid endarterectomy, and comparisons of traditional methods based on anatomical landmarks and those based on US have comparable results. The combination used in our study, i.e., superficial block with perivascular block, has been described in the literature only since a few years [13–15].

Another issue to discuss is the type of local anaesthetic that can be used. In our study, a 1% solution of lidocaine with adrenaline was used, which was dictated by methodological reasons. This solution is a standard used by surgeons. A mixture of lidocaine with bupivacaine or ropivacaine could be interesting option [16], ensuring the expected comfort during the procedure and long after its completion; however, such evaluations were beyond the scope of our study.

It is worth considering whether the mixture of short- and long-acting drugs should be used in cervical loop blocks

where the prolonged time of the block is associated with a longer duration of adverse side effects.

CONCLUSIONS

1. The US-guided superficial cervical plexus and cervical loop elements block is a good alternative to infiltration anaesthesia for carotid endarterectomy, which mainly helps alleviate intraoperative pain.
2. The method significantly reduces the volume of a local anaesthetic, improves patient comfort (lower NRS values) and safety (fewer undesirable movements and smaller volumes of LA administered to the highly innervated region) and improves the operating field conditions, as subjectively assessed by surgeons.
3. The management described is associated with a higher risk of some anaesthesia side effects, such as hoarseness, cough and difficulty swallowing.

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