Case Report

Comparison of the effectiveness of peroperative anesthesia of deep and superficial cervical plexus block with conventional approach or ultrasonography for carotid endarterectomy

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ABSTRACT

Background: To compare the regional anesthesia method (combination of SCPB and DCPB), applied by conventional method or by USG guidance (vertebral loop technique) for CEA in terms of perioperative efficacy, patient-surgeon comfort, and complications. Prospective, randomized, double-blinded study. ASA grades II-III, > 18 years and > 55 kg patients scheduled for elective CEA under the combination of SCPB and DCPB included the study.

Results: There was no statistically significant difference between the groups in terms of demographic data, the number of C3 cervical block and superficial block application attempt, C2 and C4 cervical block procedural time, the time between completion of the block and the start of incision, total surgical time, sensory block formation time, other hemodynamic parameters except basal systolic blood pressure,perioperative additional drug applications, perioperative NADS scores and postoperative surgeon and patient satisfaction scores. There was a statistically significant difference between 2 groups in terms of the number of C2 and C4 cervical block application attempts, C3 cervical block procedure time, superficial cervical block time, total cervical block procedure time and complications.

Conclusion: We thought that combined superficial and deep cervical plexus blocks performed with USG are applicable and much safer anesthesia management compared to the conventional method for carotid endarterectomy.

Key Words: Carotid endarterectomy, conventional approach, deep cervical plexus block, ultrasonography, superficial cervical plexus block.

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INTRODUCTION

Carotid endarterectomy (CEA) and carotid artery stenting are currently used treatment methods in atherosclerotic carotid artery diseases[1]. Carotid endarterectomy was accepted as the best treatment method in patients with a high degree of carotid artery stenosis after 1970[2]. Although it is accepted as the "gold standard treatment method" in cases with a stenosis rate of 70 % or more, its place in asymptomatic cases is still controversial[1, 3, 4, 5, 6].Anesthesia options that can be applied for CEA are general anesthesia, regional anesthesia (interscalen block, cervical plexus block), combination of general and regional anesthesia or combination of regional anesthesia with peripheral nerve block[5, 7]. Although a techniques have their own advantages and disadvantages, there is no definite data on which technique is superior to the other[5 - 10]. The aim of all anesthetic techniques is to prevent pain during the three painful periods: 1. Skin incision, 2. Retromandibular retractor placement and 3. Perivascular preparation[11]. Although regional anesthesia is accepted as the gold standard for CEA with the "Application of the appropriate dose of the appropriate drug to the appropriate place" for all nerve blocks[6, 12]; general anesthesia is still the most preferred anesthetic technique[12, 13]. On the other hand, no monitorization technique is as effective as the assessment of consciousness in an awake patient, for cerebral function evaluation. The cervical plexus block (CPB) is the most widely accepted regional technique for CEA[8]. C2-C3-C4 cervical nerves should be blocked for carotid surgery[1, 14, 15]. Carotid endarterectomy can be performed with applications in the form of superficial, intermediate, deep blocks or combinations of these. Regional anesthesia applications can be performed either by conventional methods as well as with ultrasound (USG) guidance in recent year[12]. The advantages of performing the regional block with ultrasonography guidance compared to the technique are: Ensuring visualization of the nerve and other structures, observing the needle and the distribution of local anesthetic during injection[6, 9, 15, 16], increasing the effectiveness of the block (fast onset and prolongation of the effect), increasing the success of the block, reducing

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the complications associated with a puncture, it is possible to reduce the dose of the administered drug and also thus to decrease tissue swelling[2, 4, 6, 7, 9, 11, 14 - 18].

Superficial Cervical Plexus Block (SCPB), is an easy technique described by Murphy and Scott[6, 18 - 20]. The local anesthetic agent is applied to the posterior border of the sternocleidomastoid muscle, between the skin and the investing fascia[7, 12, 18, 19, 21, 22]. The complication rates are very low[7].

In the Deep Cervical Plexus Block (DCPB), the local anesthetic agent is applied from the cervical transverse fascia under the deep cervical fascia[12, 21] with a single needle or multiple needles (3 separate injections) techniques[7, 8, 19, 21, 22]. It provides excellent analgesia, but it is technically difficult to perform and may cause serious complications (epidural, subarachnoid, subdural or vertebral artery injection, seizure, recurrent laryngeal nerve damage, phrenic nerve palsy, hematoma in the neck region, Horner's syndrome and high rate of need for general anesthesia, etc.)[1, 4, 6, 7, 9, 12, 21, 23]. It can be applied by conventional approach or with USG guidance [][6]. But the introduction of ultrasonography guidance in cervical block applications has made DSPB simpler and more reliable[22]. Four different techniques have been described for DSPB by USG guidance in the literature[23 - 25]. Our aim in this study is to compare the regional anesthesia method (combination of SCPB and DCPB), applied by conventional method or by USG guidance (vertebral loop technique) for CEA in terms of perioperative efficacy, patient-surgeon comfort and complications.

METHODS

After we received approval from the ethical committee and informed consent of patients, 77 patients, ASA grades II-III, > 18 years and > 55 kg scheduled for elective CEA under the combination of SCPB and DCPB were randomized by means of a computer-generated random numbers table to two groups either CPB by conventional approach or ultrasonography guidance. Patients with known bleeding diathesis, a history of allergy to local anesthetics, local sepsis, known diaphragmatic motion abnormalities, uncooperative cases, pregnant women, those with suspected pregnancy, those who did not accept to participate in the study and cases under the age of 18 were not included in the study. Demographic data of the cases (age, gender, weight, height, BMI), ASA risk group, surgical side, comorbidities and smoking were recorded.

After arrival in the operating room, standard monitoring included 3-lead electrocardiography, non-invasive blood pressure and pulse oximetry; a peripheral venous line (18 Gauge) was established. Arterial pressure monitoring was continued via a radial artery catheter (on the contralateral arm of the operation) perioperatively. No premedication was administered. The oxygen was given up to 4 L/min with a mask during the operation. All cervical plexus blocks were performed by the same anaesthesiologist, who was experienced in these techniques. Each patient was placed in a supine position, the head was slightly rotated to the contralateral side of the blockade. A 22 gauge 50 mm needle (Stimuplex® A insulated needle Braun, Melsungen, Germany) was used for blocks. For SCPB 10 mL local anesthetic mixture (5 mL 0.5 % bupivacaine and 5 mL 2 % prilocaine); for DSPB 5 ml local anesthetic mixture from the combination of 10 mL 0.5 % bupivacaine and 10 mL 2 % prilocaine per transverse process was applied. In Group C (Landmark technique): Following skin preparation, first, the DCPB was performed by three needle techniques. After palpation of the mastoid process, we have drawn a line behind the sternocleidomastoid muscle between the mastoid process and the clavicula. The transverse processes of the cervical vertebrae will lie on or near this line. After this line is drawn, we labeled the insertion sites over the C2, C3 and C4, which are respectively located on this line 2 cm, 4 cm and 6 cm, respectively, caudal to the mastoid process. The first palpable transverse process below the mastoid process is C2. The needle was retracted near 1-2 mm to transverse processes of the C2, C3 and C4 vertebras after the needle touched the transverse processes respectively and the local anesthetic mixture was applied after negative aspiration of blood. Then SCPB was applied from the midpoint of the sternocleidomastoid muscle at the C6 level.

In Group U (Ultrasonography guidance): Following skin and linear ultrasound probe (Mindray DC-7 portable ultrasound and 7L4A linear probe) preparation, first the ultrasound probe was moved caudally from the mastoid process under the vertebral artery loop was visible. Then the second, third and fourth cervical transverse processes were identified respectively and the needle was advanced 1 - 2 mm near to transverse processes. Then 5 mL from the local anesthetic mixture was injected into each transverse process of C2, C3 and C4 vertebra after negative aspiration of blood. For SCPB, the needle was inserted underneath the sternocleidomastoid muscle at the level of the sixth cervical transverse process and a 10 mL local anesthetic mixture was injected with visualization under the posterior border of the sternocleidomastoid muscle. The interference times for each block during the applications and the number of attempts for C2, C3, C4 and superficial block interference were noted separately. Systolic and diastolic blood pressure measurements, SpO2, heartbeats and numerical pain assessment scores (NADS) were recorded perioperatively (While the surgical incision, applying the retractors, applying the clamps, removing the clamps, removing the retractors, during skin closure and at the end of the surgery). After the completion of the block application, the time until the skin incision started was recorded. During this period, sensory examinations of the patients were assessed by a pinprick test every three minutes. And the patient's verbal statement of no pain was considered sufficient for the sensory block. All operations were performed by the same surgeon to standardize the surgery. The pain was assessed with the Numerical Pain Rating Scale (NADS) with a 0-10 point scale (0: no pain, 10: very severe pain). Pain control was assessed and recorded 5 minutes after the block, during surgical incision, during insertion of retractors, during carotid artery clamping, removal of carotid artery clamping and skin closure. Infiltration anesthesia with an additional 1 ml of 2 % prilocaine was applied by the surgeon to those with NADS > 3.

Remifentanil infusion was started in cases with NADS > 3, although additional infiltration anesthesia was administered 3 times. After 1 mcg/kg bolus, remifentanil infusion (0.05 - 0.1 mcg/kg/min) was continued until NADS ≤ 3. The amounts of prilocaine and remifentanil added were recorded. General anesthesia was planned in cases with NADS > 3 despite local anesthesia support and sedo-analgesia.

Consciousness examinations of the patients were assessed according to answers of the patients given to the questions during the operation and especially during the carotid clamping phase. The motor functions of the patient were evaluated by the motion of the patient's hands and feet on the opposite side of the operation after the order of the surgeon. Surgeon and patient satisfaction at the end of the operation was evaluated with a Likert satisfaction scale (1: Very satisfied, 2: Satisfied, 3: Moderately satisfied, 4: Dissatisfied, 5: Not at all satisfied.) In addition, hemodynamic parameters during the operation (systolic blood pressure, diastolic blood pressure, pulse, SPO2), additional anesthetic requirements and doses and complications (intravascular puncture, hoarseness, facial paralysis, cough, bradycardia) were noted. Operation time was recorded.

Statistical analysis was performed using SPSS version 21 statistical software (Statistical Package for Social Sciences for Windows version 21). All numerical data were tested for normal distribution by the Kolmogorov-Smirnow test. Differences between mean values were evaluated by Student t-test and Mann Whitney U test for normally and non-normally distributed variables respectively. In the study, quantitative variables were expressed as descriptive statistics as mean ± standard deviation or median (minimum-maximum) values, while qualitative variables were expressed as frequency and related percentage values. Intergroup comparisons of categorical variables were made using chi-square and Fisher's Exact tests. A p value < 0.05 was considered statistically significant.

RESULTS

There was no statistically significant difference between the groups according to demographic data, ASA risk scores, surgical side and smoking (Table1). Also there was no statistically significant difference between the groups in terms of co-morbidities. There was statistically significant difference between the groups according to the number of block application attempts to block C2 and C4 roots (Table 2). Although there was no statistically significant difference in terms of the time spent for C2, C3 and C4 DSCP and SCPB applications one by one; there was a statistically significant difference in terms of total time spent for block applications (Table 3). There was no statistically significant difference between the two groups in terms of the duration of sensory block formation. Furthermore, except for the systolic blood pressure in the baseline measurements, there was no statistically significant difference between the groups in hemodynamic parameters of the patients during skin incision, retractor insertion, clamping, de-clamping, retractor removal, skin closure and at the end of the surgery (Table 4). There was no statistically significant difference between the groups in terms of the adjuvant agents used perioperatively (p > 0.05). However, 50 % of cases in Group U and 26.7 % of cases in Group K required ephedrine administration perioperatively. There was a statistically significant difference between the groups in terms of perioperative complications. When the complications are examined one by one, there was a significant difference between the groups in terms of intravascular puncture (higher in the conventional group). But there were no statistically significant differences between the groups in terms of cough, facial paralysis, hoarseness and bradycardia, which were accepted as complications. There was no statistically significant difference between the groups according to patient and surgeon satisfaction.

Table 1: Demographic data of the patients:

Parameters		Group C	Group U	p
Gender	Male (n)	20 (% 66.7)	20 (% 66.7)	1
	Female (n)	10 (% 33.3)	10 (% 33.3)	
ASA	2 (n)	9 (% 30)	3 (% 10)	0.053
	3 (n)	21(% 70)	27 (% 90)	
Surgery side	Right (n)	17 (% 56.7)	16 (53.3)	0.795
	Left (n)	13 (% 43.3)	14 (46.7)	
Smoking	Yes (n)	18 (60)	19 (% 63.3)	0.798
	No (n)	5 (% 16.7)	6 (% 20)	
	Gave up smoking (n)	7 (% 23.3)	5 (% 16.7)	
Age (Year) (Mean standard ± deviation)		68.7 ± 8.1	70.1 ± 8.1	0.517
Weight (kg) Median (IQR)		79 (16)	74 (9)	0.155
Height (cm) Median (IQR)		169 (14)	169 (12)	0.773
BMI (kg/m²) (Mean ± Standard deviation)		28.2 ± 3.5	26.8 ± 2.6	0.088

n: Number of patients IQR: Interquantil Range BMI: Body Mass Index $p < 0.005$.

Table 2: Number of block application attempts for DSPB and SCPB:

Number of block application attempts	Group C	Group U	*p*
Number of block application attempts for C2	1 (0)	1 (0)	0.011*
Number of block application attempts for C3	1 (0)	1 (0)	0.115
Number of block application attempts for C4	1 (0)	1 (0)	0.005*
Number of block application attempts for SCPB	1 (0)	1 (4)	0.317

$p < 0.005$.

Table 3: Processing time for block applications and time intervals perioperatively:

	Group C	Group U	*p*
Processing time for C2 cervical block (Sec)	16.5 (27)	21 (27)	0.340
Processing time for C3 cervical block (Sec)	17 (15)	27 (24)	0.014
Processing time for C4 cervical block (Sec)	16 (16)	20 (21)	0.059
Processing time for superficial cervical block (Sec)	22 (7)	25.5 (18)	0.020
Total processing time for cervical blocks (Sec)	297.9 ± 116.7	414,4 ± 116.7	$p < 0{,}001$
Time between the end of the cervical blocks and the beginning of the incision (Sec)	558 (219)	634 (382)	0.133
Total surgery time (Min)	68.5 (18)	69 (24)	0.807

Sec: Second Min: Minute $p < 0.005$.

Table 4: Perioperative hemodynamic parameters:

		Group C	Group U	*P*
Systolic blood pressure (mm Hg)	Baseline measurements	172.8 ± 24.5	189.7 ± 32.4	0.026
	Skin incision	176.3 ± 30.4	184.5 ± 35.6	0.340
	Retractor insertion	167.5 (46)	170.0 (43)	0.311
	Clamping	175.6 ± 30.1	164.5 ± 27.6	0.144
	De-clamping	157.3 ± 26.1	166.7 ± 26.9	0.175
	Retractor removal	166.9 ± 19.7	161.6 ± 27.8	0.392
	Skin closure	168.8 ± 20.3	163.3 ± 23.4	0.332
	At the end of the surgery	170.0 ± 21.5	166.0 ± 25.0	0.513
Diastolic blood pressure (mm Hg)	Baseline measurements	84.7 ± 13.5	85.4 ± 18.8	0.863
	Skin incision	83.1 ± 16.0	80.5 ± 17.2	0.541
	Retractor insertion	82.2 ± 14.7	77.4 ± 15.3	0.218
	Clamping	80.1 ± 13.0	75.1 ± 14.9	0.170
	De-clamping	73.6 ± 10.8	75.2 ± 15.2	0.655
	Retractor removal	77.0 (16)	71.0 (17)	0.082
	Skin closure	75.5 (12)	70.5 (19)	0.090
	At the end of the surgery	75.0 (12)	72.0 (15)	0.164
Heart rate (atım/dk)	Baseline measurements	81.4 ± 13.0	85.5 ± 13.9	0.247
	Skin incision	83.6 ± 17.5	85.2 ± 13.6	0.688
	Retractor insertion	80.6 ± 15.0	81.8 ± 14.7	0.742
	Clamping	79 (14)	80 (25)	0.728
	De-clamping	80 (16)	82 (19)	0.496
	Retractor removal	82.1 ± 16.3	84.1 ± 14.3	0.610
	Skin closure	81.9 ± 14.9	82.7 ± 13.2	0.819
	At the end of the surgery	78.5 (20)	81 (17)	0.477
SpO2 (%)	Baseline measurements	99 (3)	99 (2)	0.362
	Skin incision	99 (1)	99 (2)	0.059
	Retractor insertion	98.5 (2)	99 (2)	0.572
	Clamping	98 (2)	98.5 (3)	0.810
	De-clamping	97 (2)	98 (4)	0.603
	Retractor removal	98 (2)	98 (3)	0.201
	Skin closure	98 (2)	98 (2)	0.658
	At the end of the surgery	98 (3)	97.5 (3)	0.833

$p < 0.005$.

DISCUSSION

Although general anesthesia applications still continue to be applied for CEA's; the use of regional anesthesia, especially the combined cervical plexus blocks, is increasing rapidly as an anesthesia method for CEA's. Regional anesthesia provides strict cerebral perfusion monitoring perioperatively and effective protection during carotid cross-clamping. The best regional anesthesia management is achieved by preventing patient discomfort, inadequate block and involuntary vertebral artery puncture with the application of block under USG guidance[9]. So, we preferred the application of combined superficial and deep cervical plexus blocks for CEA under USG guidance to provide more effective anesthesia by avoiding the current limitations of the conventional method.

In our study, the number of interventions for C2 and C4 cervical block was lesser in cases where we applied USG-guided block. We reported that the time spent on C3 cervical block, superficial cervical block and the total block was longer and these were statistically significant. When we evaluated the complications in terms of the number of complications, the number of complications was higher in the conventional block group than in the USG group; and this difference was statistically significant. When the complications were examined within themselves, it was determined that this difference was due to the number of intravascular punctures. NADS scores during skin closure were lower in the group that underwent ultrasound-guided block and were statistically significant. Blocking the cervical nerves with conventional regional anesthetic techniques can cause potentially serious complications.

However, the application of these blocks with USG improves the quality of the block (fast onset and prolonged block time), facilitates the application of the block (requires less time) and reduces complications[21]. In our study,USG-guided application for blocks reduced complications and prolonged the duration of the block, but did not affect the onset of the block and time spend for block application was longer. We did not detect a difference in the onset times of sensory block between the groups. We can explain this difference with our great experience in the conventional method, but the fact that we only meet the definition of "minimum criteria for an experienced anesthesiologist" for USG-guided cervical blocks.

Authors[26] researched the effects of awake carotid endarterectomy under localanesthesia versus carotid endarterectomy under general anesthesia on blood pressure. They stated that there is a significant post-operative reduction in both the systolic and diastolic blood pressure values and the intraoperative fluctuation is minimal when local anesthesia isused. Also, our study results showed that the regional anesthesia method applied for CEA (whether with conventional or USG management) provides stable hemodynamics as the authors stated.

In a study[27] the authors evaluated the feasibility of performing a high interscalene brachial-plexus block for carotid endarterectomy by means of high-resolution ultrasonic imaging; reported that high-resolution ultrasonic imaging allows clear depiction of the target tissues,facilitates accurate needle placement, may minimize the risk of direct puncture related complications, might enhance safety by limiting the injected LA to the actual demand, could potentially avoid central nervous toxicity caused by intravascular injection or

resorption of inadequately high dosages, in particular in nerve blocks of the highly vascularized neck region. In our study, although we used the same local anesthetic doses, we detected a lower NADS score during skin closure in cases where cervical block was applied under USG guidance. We interpreted that as better visibility of target tissues and correct needle position with ultrasound like the authors.

In another study[15] authors compared combined CPB (SCPB and DSCP) or intermediate cervical plexus block (ICPB) by use of ultrasound guidance for carotid endarterectomy. Their result showed that combined CPB compared to ICPB led to less additional analgesic use, lower visual analog scale score and higher patient satisfaction. Although deep cervical block causes more serious complications, it created a more intense mot or block compared to intermediate cervical block. So that we preferred a combined CPB (SCPB and DSCP) in our study. And also to supply better anesthesia management without complications, we compared combined CPB applications conventional versus USG guidance in our study. Patient satisfaction is also an important factor to consider when choosing anesthesia for carotid endarterectomy.

The authors [][28] conducted a questionnaire study on patientswho underwent CEA under local anesthesia. According to their results while a group of patients were very satisfied; another group of patients stated that they would not agree to be operated on with the same anesthesia method. On the other hand, our study results both surgeon and patients were satisfied. In our study, in which we also evaluated the satisfaction of the patients and the surgeon, we detected that both the patients and the surgeon were well satisfied.

Hariharan *et al.*[29] evaluate the perioperative outcome of CEA under regioal anesthesia reported that CEA performed with regional anesthesia reduced morbidity and mortality with their 20-year experience. They stated that regional anesthesia is a safe method for CEA in a limited-resources setting, as it facilitates intraoperative clinical assessment of the effects of ICA clamping. (conventional deep cervical plexus block) in a study retrospectively.

In another study[30] authors declared that cervical plexus block-related complications were significantly less when they compared cervical epidural anesthesia and regional anesthesia (SCPB and CPB with the conventional method) for CEA. Although the last two studies were performed in the years when USG was not yet in use for blocks (2010 and 2007, respectively); reported positive results for the deep cervical block

which has serious complications.

In 2009, Nerurkar *et al.*[31] performed the cervical block application under fluoroscopy to be safer. Nowadays, the fact that these blocks can be performed under USG guidance provides additional advantages to regional anesthesia.

An observational study[18] demonstrated that ultrasound-guided locoregional anesthesia is suitable for eversion carotid endarterectomy and the amount of supplemental anesthetic during the surgery is low.

The limitation of this study was that we were practitioners of defined competence who met the minimum criteria for experienced USG users for cervical blocks. If we had been more experienced in the use of USG in cervical blocks, perhaps statistically different results could have been obtained.

CONCLUSION

We thought that combined superficial and deep cervical plexus blocks performed with USG are applicable and much safer anesthesia management compared to the conventional method for carotid endarterectomy.

ABBREVIATIONS

- **CEA:** Carotid endarterectomy.
- **SCPB:** Superficial cervical plexus block.
- **CPB:** Cervical plexus block.
- **DCPB:** Deep cervical plexus block.
- **USG:** Ultrasound.
- **ASA:** American Society of Anesthesiologist.
- **BMI:** Body mass index.
- **NADS:** Numerical Pain Rating Scale.

CONFLICT OF INTEREST

There are no conflicts of interest.

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