https://doi.org/10.15360/1813-9779-2022-6-4-11

OPEN ACCESS (cc) BY

Regional Anesthesia for Carotid Endarterectomy in Patients with Acute Ischemic Stroke (Pilot Study)

Oleg V. Simonov[1]*, Aleksandr D. Pryamikov[1,2], Ruslan Yu. Loluev[1], Viktor S. Suryakhin[1], Elena V. Perevedentseva[1], Marina A. Safronova[1], Andrey L. Krasnikov[1], Pavel S. Esipov[1], Alexander A. Churkin[1], Aleksey B. Mironkov[1,2], Aleksey I. Khripun[2]

[1] V. M. Buyanov City Clinical Hospital, Moscow Department of Health, 26 Bakinskaya Str., 115516 Moscow, Russia
[2] N. I. Pirogov Russian National Medical Research University, Ministry of Health of Russia, 1 Ostrovityanov Str., 117997 Moscow, Russia

For citation: *Oleg V. Simonov, Aleksandr D. Pryamikov, Ruslan Yu. Loluev, Viktor S. Suryakhin, Elena V. Perevedentseva, Marina A. Safronova, Andrey L. Krasnikov, Pavel S. Esipov, Alexander A. Churkin, Aleksey B. Mironkov, Aleksey I. Khripun.* Regional Anesthesia for Carotid Endarterectomy in Patients with Acute Ischemic Stroke. *Obshchaya Reanimatologiya = General Reanimatology*. 2022; 18 (6): 4–11. https://doi.org/10.15360/1813-9779-2022-6-4-11 [In Russ. and Engl.]

***Corresponding author:** Oleg V. Simonov, dr.sov@mail.ru

Summary

Objective. The aim of this study is to assess the safety of the use of regional anesthesia for performing carotid endarterectomy (CEA) in patients in the acute phase of ischemic stroke.

Material and methods. The study included 66 patients in the acute phase of ischemic stroke (atherothrombotic subtype according to the TOAST classification) who underwent carotid endarterectomy. The inclusion criteria for the study were as follows: acute phase of atherothrombotic ischemic stroke (first 28 days), ipsilateral symptomatic ⩾ 50% stenosis of the internal carotid artery, 1–4 points neurological deficit according to the modified Rankin Scale (mRS), 1–13 points neurological deficit according to the National Institutes of Health Stroke Scale (NIHSS), size of the cerebral ischemic lesion ⩽ 4 cm. This single-center prospective cohort study compared two anesthetic approaches, regional anesthesia (RA, 46 patients) and general anesthesia (GA, 20 patients). The RA techniques included ultrasound-guided superficial and deep cervical plexus blocks on the side of the surgery.

Results. The study found no significant differences in the baseline patient characteristics, surgery techniques and clinical outcomes between the groups. There were no neurological or cardiovascular toxic reactions to the local anesthetics. Conversions from RA to GA were not performed. In the RA group, recurrent ipsilateral ischemic strokes, myocardial infarctions, wound hemorrhagic complications and lethal outcomes did not occur.

Conclusion. This pilot study has demonstrated the safety of RA for performing CEA in patients in the acute phase of ischemic stroke. RA provides adequate neuromonitoring and timely intraoperative recognition of «new» ischemic complications. To compare the efficacy of RA and GA for performing CEA in patients with acute ischemic stroke, large randomized controlled trials are needed.

Keywords: carotid endarterectomy; regional anesthesia; cervical plexus block; ischemic stroke

Conflict of interest. The authors declare no conflict of interest.

Introduction

Currently, the main options of anesthesia for performing carotid endarterectomy (CEA) include regional anesthesia (RA), general anesthesia (GA), and combined anesthesia [1–3]. RA and GA are most often compared to each other as two diametrically opposite anesthetic approaches [4, 5]. Under RA, the patient retains consciousness (from the full wakefulness to superficial sedation) and spontaneous breathing. Under GA, the patient's consciousness and spontaneous breathing are pharmacologically switched off. Various papers indicate both the advantages and disadvantages of each approach.

On the one hand, RA provides a more appropriate neuromonitoring of the operated patient (determination of the level of consciousness, development of movement disorders in the contralateral limbs or their worsening, speech changes), a lesser effect on cerebrovascular autoregulation, hemodynamic stability, better postoperative pain relief, a lower frequency of using a temporary intraluminal shunt and shorter hospital stay [2, 5–7]. On the other hand, such factors as additional psycho-emotional stress, difficulty in the reliable control of external respiration, lack of cerebral protection and muscle relaxation are considered among the disadvantages of RA [8–10].

The National Guidelines for the Management of Patients with Brachiocephalic Arteries Diseases (2013) indicate that GA and RA have the same safety in carotid surgery [4]. The type of anesthesia is determined by a joint decision of the anesthesiologist and surgeon, and is agreed with the patient [4]. These recommendations are largely based on the only large randomized controlled trial, the GALA trial (General Anesthesia versus Local Anesthesia for Carotid Surgery, 2008), comparing RA (n=1773) and GA (n=1753) in 3526 patients who underwent CEA [5, 11]. No benefit was found for either type of anesthesia [5, 11]. The patients in

the acute stage of ischemic stroke were not included in this work, and CEA was performed for both symptomatic and asymptomatic lesions of the internal carotid artery (ICA) [5].

By the acute period of ischemic stroke, we mean the first 28 days after the onset of the disease [12]. In the 2019 American Heart Association (AHA) and American Stroke Association (ASA) Guidelines for the Early Management of Acute Ischemic Stroke, emergency or urgent CEA for acute ischemic stroke is classified as Class IIb recommendation with a B-NR level of evidence [13]. To date, there are no unequivocal recommendations regarding the type of anesthesia for performing CEA in patients in the acute period of ischemic stroke [13].

The aim of this study is to assess the safety of RA for performing CEA in patients in the acute period of ischemic stroke, i. e., in the first 28 days after the onset of the disease.

Material and Methods

This pilot study included 66 patients in the acute stage of ischemic stroke with symptomatic ICA stenosis, who underwent CEA surgery in the Buyanov City Clinical Hospital (Moscow, Russia) in the period from 2015 to 2021.

Study hypothesis: RA is a safe type of anesthesia for performing CEA in patients in the acute period of ischemic stroke.

Study design: a single-center prospective cohort clinical study.

The present study was approved by the local ethics committee of the Pirogov Medical University (protocol 2, dated January 27, 2016). All patients signed an informed consent before the operation.

The inclusion criteria for the study were as follows:

— acute period of atherothrombotic ischemic stroke (first 28 days),

— ipsilateral «symptomatic» stenosis of the internal carotid artery of 50% or more,

— neurological deficit according to the modified Rankin Scale (mRS) 1–4 points,

— neurological deficit according to the National Institutes of Health Stroke Scale (NIHSS) 1–13 points, corresponding to minor to moderate stroke severity,

— size of the cerebral ischemic lesion $\leqslant$4 cm.

The exclusion criteria for the study:

— concomitant cardiac arrhythmia (atrial fibrillation),

— ipsilateral stenosis of the ICA$<$50%,

— neurological deficit $\geqslant$5 points according to the mRS,

— neurological deficit $\geqslant$14 points according to the NIHSS,

— size of the cerebral ischemic lesion $>$4 cm,

— endovascular procedures on carotid and cerebral arteries.

Patients with concomitant cardiac arrhythmias, mainly with atrial fibrillation, were not included in this study. Thus, with a certain degree of confidence, it can be argued that all of the selected patients had ischemic stroke of the atherothrombotic subtype according to the TOAST classification (Trial of Org 10172 in Acute Stroke Treatment), i. e., the main cause of the disease was atherosclerosis of large arteries [14].

The primary endpoint was ipsilateral ischemic stroke in the postoperative period. The secondary endpoints were any stroke, myocardial infarction, wound hemorrhagic complications, temporary intraluminal shunt use, duration of the postoperative period, and death.

RA was used in 46 patients (69.7%), GA was chosen in 20 patients (30.3%). Both groups were comparable in baseline patient characteristics (Table 1).

RA was performed under ultrasound guidance, using an ultrasound machine «LOGIQ e» (GE Healthcare, USA). Using the aseptic technique, we performed a combined superficial and deep cervical plexus block on the side of the operation with 0.5–0.75% ropivacaine or 0.5% levobupivacaine solution in a total dose of 150–300 mg. The effectiveness of the block was assessed by determining pain and tactile sensitivity on the corresponding anterolateral surface of the neck from the edge of the mandible to the clavicle. The average time from the block to the start of the operation was 29.9±5.7 minutes. Intraoperatively, if necessary (persistent pain sensitivity), the surgeon additionally irrigated the surgical wound with 2% lidocaine solution. After opening the carotid fascial sheath, almost all patients additionally required irrigation of the carotid arteries with a local anesthetic (5 ml of 2% lidocaine solution) due to the development of pain syndrome during their mobilization. In addition, irrigation of carotid glomus with local anesthetic (5 ml of 2% lidocaine solution) was routinely performed in all patients. In all cases, RA was supplemented with intravenous bolus injections of fentanyl in a total dose of 200–300 μg for optimal analgesia and superficial sedation. To prevent involuntary arm movements and to prevent the patient falling off the operating table during surgery, we used wrist restraints and a thigh belt. We placed a squeaky toy in the contralateral hand for non-verbal communication with the patient.

In the GA group, we used balanced endotracheal anesthesia with tracheal intubation. Induction of GA was carried out with fentanyl, propofol and an intermediate-acting neuromuscular blocking agent (atracurium, cisatracurium, or rocuronium); the maintenance of anesthesia — with fentanyl, sevoflurane and a neuromuscular blocking agent. Tracheal extubation was performed on the operating table 10–15 minutes after the end of the operation

Table 1. Comparative baseline characteristics of patients in the RA and GA groups.

Parameters	Parameters values in groups		*P*-value
	Regional anesthesia (*n*=46)	General anesthesia (*n*=20)	
Age (years)	64.9±7.0	63.6±10.6	0.65
Men (*n*, %)	34 (73.9)	13 (65)	0.46
Comorbidities (*n*, %)			
Arterial hypertension	45 (97.8)	19 (95)	0.54
Coronary artery disease	18 (39.1)	9 (45)	0.66
Previous myocardial infarction	7 (15.2)	5 (25)	0.34
Previous stroke	10 (21.7)	6 (30)	0.47
Diabetes	15 (32.6)	5 (25)	0.54
Smoking	21 (45.7)	7 (35)	0.42
Baseline neurological deficit			
mRS (scores)	3.4±0.7	3.3±0.8	0.8
NIHSS (scores)	5.8±2.8	5.6±2.8	0.95
Number and size of cerebral ischemic lesions			
Single lesion (*n*, %)	23 (50)	8 (40)	0.45*
Several lesions (*n*, %)	23 (50)	12 (60)	
Lesion dimensions (mm)	15.9±10.4	17.6±13.7	0.81
Thrombolysis			
Systemic thrombolytic therapy (*n*, %)	3 (6.5)	2 (10)	0.62

Note. * — Chi-Square test was used for multi-field tables.

to conduct an early assessment of the patient's neurological status.

Oxygenation was monitored using pulse oximetry with target values of 99–100%. Invasive blood pressure monitoring was performed through a 20G catheter placed in the radial artery. It began before the induction of anesthesia and lasted for 24 hours. In addition, ECG monitoring with ST-segment analysis, non-invasive measurement of blood pressure, and urine output assessment were carried out. During GA, bispectral index/cerebral oximetry, respiratory mechanics indicators, analysis of gas mixture in the respiratory circuit, and body temperature monitoring were performed as well.

Intraoperatively, the cerebral tolerance to ischemia was assessed objectively and subjectively. As an objective criterion, stump pressure was measured in all patients (groups RA and GA) during clamping of the common and external carotid arteries. In cases of mean stump pressure below 30 mm Hg and the absence of a characteristic stump pressure waveform, the indications for the insertion of a temporary intraluminal shunt were presented. In the RA group, subjective criteria for assessing the cerebral tolerance to the cross-clamping were additionally used (dynamic neuromonitoring including assessment of the patient's level of consciousness, cognitive status, motor function of the contralateral upper limb by squeezing and releasing a squeaky rubber toy in the hand, and speech). Subjective indications for the insertion of a temporary intraluminal shunt were the development of depression of consciousness or confusion, the appearance or deterioration of paresis in the contralateral hand, the appearance or deterioration of aphasia. Dynamic neuromonitoring continued throughout the entire period of cross-clamping and made it possible to track the slightest changes in the patient's neurological status. In addition, since 2020, we have begun to routinely perform cerebral oximetry of both cerebral hemispheres using INVOS technology for all patients in our study. Thus, we got a second objective criterion for assessing the cerebral tolerance to the clamping — the absolute values of ipsilateral rSO_2 below 40–50%.

Statistical analysis of clinical data was performed using Statistica 12 software for Windows (StatSoft Inc., USA). The sample size was not predefined. Normality of data distribution was assessed using the Kolmogorov–Smirnov test and Shapiro–Wilk's test. To compare continuous variables with a normal distribution, Student's *t*-test was used for independent samples; to compare variables that do not have a normal distribution, the Mann–Whitney *U*-test was used. Nominal data were compared using Pearson's Chi-Square test. The differences between the groups were considered significant at $P<0.05$. The data obtained during the study were analyzed according to the basic principles of evidence-based medicine.

Results

Significant differences in surgery types and clinical outcomes between both groups were not found (Table 2). There were no neurological or cardiovascular toxic reactions to the local anesthetics. No conversion from RA to GA was performed. The frequency of using a temporary intraluminal shunt was lower in the RA group (23.9% vs 35%), but no significant differences were found due to the small size of the groups (P=0.35). At the hospital stage in the RA group, recurrent ipsilateral ischemic stroke, myocardial infarction, wound hemorrhagic complications, as well as deaths did not occur. However,

Table 2. Comparative results of the use of RA and GA for CEA in the acute period of ischemic stroke.

Parameters	Parameters values in groups		*P*-value
	Regional anesthesia (*n*=46)	General anesthesia (*n*=20)	
Time from stroke to surgery (days)	8.8±5.3	7.0±4.3	0.26
Operation in the first 72 hours after the onset of the stroke (*n*, %)	5 (10.9)	3 (15)	0.64
Duration of surgery (minutes)	97.2±26.0	91.8±18.8	0.56
Duration of cross-clamping (minutes)	26.8±11.0	26.6±15.4	0.78
Temporary intraluminal shunt (*n*, %)	11 (23.9)	7 (35)	0.35
Duration of the postoperative period (days)	5.2±1.8	5.6±2.0	0.46
Length of hospital stay (days)	11.6±5.3	11.2±4.2	1.0
Death (*n*, %)	0 (0)	0 (0)	1.0
Postoperative complications (*n*, %)			
Ipsilateral ischemic stroke	0 (0)	0 (0)	1.0
Any stroke	2 (4.4)	0 (0)	0.34
Myocardial infarction	0 (0)	0 (0)	1.0
Wound hemorrhagic complications	0 (0)	1 (5)	0.13
Neurological status at discharge			
mRS (scores)	1.1±1.1	1.0±1.1	0.5
NIHSS (scores)	1.9±2.1	2.0±1.7	0.67

two strokes (4.4%) happened in the RA group: an intracerebral hematoma in the area of previously described gliosis lesions on the side of the operation (1 patient) and an ischemic stroke on the contralateral side (1 patient). Both patients were discharged from the hospital with moderate neurological deficit. A postoperative wound hematoma developed in the early postoperative period in one patient from the GA group (5%), which required its revision and hemostasis.

Discussion

Currently, RA is becoming a more and more popular method of anesthesia in carotid surgery, although the use of a specific type of anesthesia is largely determined by the preferences of the vascular surgeon, anesthesiologist and the individual patient [2, 5, 6]. The wide use of RA was facilitated by the universal implementation of ultrasound guidance and neurostimulation, as well as the emergence of more effective and safer local anesthetics and sedatives [7, 15, 16]. In addition, the popularity of RA in carotid surgery is explained by the imperfection of surrogate methods of neuromonitoring (cerebral oximetry, transcranial Doppler, bispectral index, electroencephalography, somatosensory evoked potentials), which are commonly used during GA and do not always accurately reflect the state of the brain during cross-clamping [6, 17, 18]. It should be noted that patient cooperation is a crucial factor during operations under RA. Therefore, psychiatric disorders, irregular or unpredictable behavior, claustrophobia are contraindications to RA.

Surgical stress, cited as one of the main drawbacks of RA, is currently successfully suppressed using sedation [10]. A number of works indicate the need for additional use of opioids (fentanyl, remifentanil) and sedatives (dexmedetomidine, clonidine, benzodiazepines, propofol, etc.) when performing CEA under RA, which reduces the level of perioperative stress, provides the necessary psychological comfort to the patient, especially in the case of incomplete pain relief [10, 19]. Based on the measurement of plasma cortisol levels, Szabo P. M. et al. (2020) demonstrated that additional target controlled propofol infusion during RA has a significant positive effect on perioperative stress [10]. In our study, fentanyl was administered for complete analgesia but sedation was not routinely used. However, if it was necessary to use a temporary intraluminal shunt, the propofol infusion was adjusted to ensure neuroprotection and prevention of psychomotor agitation during cross-clamping. In patients being operated on in the acute period of stroke, delayed placement of intraluminal shunt or arteriorrhaphy may create a risk of new ischemic cerebral complications. Therefore, before the carotid artery clamping, arteriotomy and shunt placement, we made an intravenous bolus of propofol at a dose of 50–100 mg and started an intravenous infusion of propofol at a rate of 300–400 mg/hour. After reaching the required level of sedation (the Richmond Agitation Sedation Scale of –3 or –4 points, the Ramsay Sedation Scale of 5 points), the arteries were clamped and a temporary shunt was inserted. Similar steps were taken before extraction of the shunt and arteriorrhaphy. Propofol infusion was continued during the cross-clamping periods. During intravenous sedation, the patient was observed to maintain adequate spontaneous breathing. After recovery of clear consciousness, the strength of the contralateral hand and speech were assessed.

Temporary intraluminal shunt. Opinions about the use of a temporary intraluminal shunt for CEA are controversial, and the rate of its use in patients operated on under RA, according to the literature, ranges from 8.9% to 31.6% [20–22]. In our study, a temporary shunt was used in 23.9% of cases in the

RA group and in 35% of cases in the GA group (not significant difference). Reducing the frequency of temporary shunting is really important, since the intraoperative shunt use itself may be an additional risk factor for cerebral ischemic complications [18]. Rocha-Neves J. M. et al. (2020) showed that the use of the temporary shunt has not demonstrated an advantage in the incidence of perioperative complications of CEA (stroke, hyperperfusion syndrome, myocardial infarction, surgical hematoma) among patients operated on under RA, who developed neurological deficit during carotid cross-clamping [21]. Zakirzhanov N. R. et al. (2021) succeeded in avoiding the use of temporary shunt in patients in hyperacute and acute stages of ischemic stroke [23]. The authors used RA, which, in combination with intraoperative transcranial Doppler and dynamic neuromonitoring in real time, provided an accurate and qualitative assessment of the cerebral tolerance to ischemia during carotid cross-clamping [23].

Neurological complications. In the largest randomized clinical study, the GALA trial, the incidence of stroke in the RA group was 3.7% (7 of 66 strokes were contralateral to the side of the operation), and in the GA group it was 4% (15 of 70 strokes were contralateral); the difference between the groups was insignificant [5]. Orlický M. et al. (2019) compared the incidence of asymptomatic strokes (according to diffusion-weighted magnetic resonance imaging of the brain) in patients undergoing CEA under RA (n=105) and under GA (n=105). MRI was performed before surgery and 24 hours after it. The frequency of newly identified asymptomatic ischemic lesions was significantly lower in the RA group: 6.7% versus 17.1% (P=0.031). Most lesions after RA (71.4%) were associated with embolization, and more than half of the new ischemic injuries after GA (55.5%) were due to cerebral hypoperfusion [24]. The authors believe that such asymptomatic ischemic damages may further impair cognitive function [24]. There was no significant difference in the incidence of strokes, transient ischemic attacks and other perioperative complications [24]. The literature describes various reactions to cerebral hypoperfusion during carotid cross-clamping under RA including depression of consciousness or confusion, psychomotor agitation, aphasia, paresis of the contralateral limbs or seizures [7, 18].

According to the literature, the frequency of conversion from RA to GA in CEA patients ranges from 0.3% to 14.3% [5, 19, 25]. The main reasons for conversion are insufficient anesthesia, psychomotor agitation of the patient, claustrophobia, intravascular injection of local anesthetic, manifestations of severe respiratory failure, prolongation of surgery due to various reasons [5, 19, 20, 25]. In our study, conversions from RA to GA were not performed, and the appearance of pain due to the expansion of the surgical field or due to the opening of the carotid fascial sheath was stopped by irrigating the surgical field with 2% lidocaine solution and additional IV administration of opioids. The development of pain syndrome during mobilization of the carotid arteries is due to the fact that the carotid sheath is abundantly innervated by the glossopharyngeal and vagus nerves and cannot be anesthetized with cervical plexus blocks [15]. Irrigation of carotid glomus with a local anesthetic (5 ml of 2% lidocaine solution) was carried out to suppress unwanted hemodynamic reactions (bradycardia, excessive arterial hypertension, blood pressure fluctuations). We emphasize that we use the irrigation technique instead of the injection technique in order to exclude the possibility of inadvertent intravascular injection.

According to Grieff A.N. et al. (2021), RA was accompanied by a significantly lower incidence of cranial nerve injury compared to GA: 1.7% versus 2.9%, respectively (P<0.002) [26]. Analysis of the literature has shown that the most commonly injured during CEA are hypoglossal nerve and the marginal mandibular branch of the facial nerve followed by glossopharyngeal, vagus and spinal accessory nerves [7, 26]. Damage to the hypoglossal nerve is manifested by deviation of the tongue towards the injury. Damage to the marginal mandibular branch of the facial nerve usually causes permanent paralysis of the muscle of the corresponding half of the lower lip and is manifested by a drooping mouth corner and an asymmetric smile [27]. Manipulations with the vagus nerve cause hemodynamic reactions (bradycardia, hypotension), nausea and vomiting. Damage to the vagus nerve (for example, after compression with a Farabeuf retractor) is manifested by persistent sinus tachycardia after surgery. Most cranial nerve palsies spontaneously resolve within 1 year, with the exception of the spinal accessory nerve palsy, which may be irreversible [26].

Myocardial ischemia and myocardial infarction. In the largest randomized GALA trial, the incidence of myocardial infarction in the RA group was 0.5% versus 0.2% in the GA group (not significant difference) [5]. Grobben R.B. et al. (2016) found that troponin I elevation in the first 3 days after surgery was detected in 15.1% of patients who underwent CEA under GA, but myocardial infarction developed in 3.6% in the first 30 days [28]. Thus, clinically confirmed myocardial infarction was observed in only 23.5% of patients with elevated troponin I levels after surgery under GA [28]. Pereira Macedo J. et al. (2019) found that troponin I elevation in the first 2 days after surgery was detected in 15.3% of patients who underwent CEA under RA [29]. In the long-term follow-up period, patients with diagnosed myocardial injury after CEA under RA remained at a high risk of developing myocardial

infarction and other major adverse cardiovascular events [29]. In an earlier trial, Sbarigia E. et al. (1999) performed intraoperative 12-lead ECG monitoring with ST segment analysis [22]. In the general sample, the signs of myocardial ischemia were found in 18% of patients operated on under RA, and in 23% of patients operated on under GA (the difference was not significant) [22]. When selecting subgroups depending on the presence / absence of coronary artery disease (CAD) and the type of anesthesia (RA or GA), the most frequent episodes of myocardial ischemia occurred in the CAD-GA subgroup (83%). The data may indicate a preference for the use of RA for CEA in patients with high cardiac risk [22].

Complications of RA. Complications of RA develop in 0–4.4% of patients [5, 7, 15]. The most dangerous complications associated with inadvertent intravascular injection of local anesthetic, causing systemic toxic reactions (up to generalized seizures, coma, refractory asystole). Respiratory distress can develop as a result of an unintentional blocking of the phrenic or recurrent laryngeal nerves. A unilateral phrenic nerve block is a common complication of deep cervical plexus anesthesia (55–80%), but is usually asymptomatic [15]. Clinically significant respiratory disorders (complete paralysis of the diaphragm, asphyxia) can occur in the presence of a previous paresis of the contralateral phrenic or recurrent laryngeal nerves [7]. Among the cardiovascular complications of RA, hypertensive emergency, angina episode, tachy- and bradyarrhythmias are possible [5]. The development of RA complications leaves the multidisciplinary team with a difficult choice whether to convert to GA and perform the scheduled surgery or postpone surgical intervention. The decision is made individually in each case, but always by a team.

In a recent systematic review with meta-analysis, Harky A. et al. (2020) compared two large samples of patients operated on under RA (n=26094) and GA (n=126282), which included both cohort studies (prospective and retrospective) and randomized controlled trials [30]. The comparative analysis demonstrated the significant advantages of RA in almost all criteria: neurological and cardiovascular complications, length of intensive care unit stay, length of hospital stay, and most importantly, mortality. However, when separately comparing RA (n=1987) and GA (n=1969) in patients included only in randomized controlled trials, no significant difference was identified for any item [30].

In the international literature, we found no large randomized controlled trials comparing different types of anesthesia for performing CEA in patients in the acute period of ischemic stroke.

Our preference for RA when performing CEA in patients in hyperacute (up to 72 hours) and acute (up to 28 days) periods of ischemic stroke is due to the following considerations. The main advantage of RA in this cohort of patients is the ability to perform dynamic neuromonitoring during the entire operation. In case of a worsening of the initial neurological deficit or the development of a new one, this complication is diagnosed immediately and the necessary measures are taken in a timely manner to adjust the treatment strategy. According to Stoneham M.D. et al. (2015), observing an awake patient during cross-clamping is the most reliable method for assessing his neurological status [7]. In the case of GA, an intraoperative recurrent stroke can be diagnosed only after recovery of consciousness and tracheal extubation, with the loss of a very important time. The second advantage of RA is the reducing the frequency of temporary shunting. The third advantage of RA, in our opinion, is the possibility of performing an emergency revision of the surgical site in the first 6-8 hours after CEA without using additional anesthesia, which is extremely important in the case of local postoperative complications (neck hematoma, bleeding, arterial thrombosis).

Limitations. The present study has several limitations:

1. Our study did not use randomization to evenly and randomly allocate patients between the RA and GA groups. The type of anesthesia was determined in each case individually, taking into account the wishes of the vascular surgeon, anesthesiologist and the patient.

2. For objective reasons, the study could not be carried out in a blind manner: the entire multidisciplinary medical team and the patients themselves knew exactly about the type of anesthesia.

3. Based on many years of experience in carotid surgery, researchers have developed a clear preference for RA.

Conclusion

This pilot study has demonstrated the safety of RA for performing CEA in patients in the acute period of ischemic stroke. RA allows the most complete control and assessment of the impaired neurological status of the patient during the operation. To compare the efficacy of RA and GA for performing CEA in patients with acute ischemic stroke, large randomized controlled trials are needed.

References

1. *Mracek J., Kletecka J., Mork J., Stepanek D., Dostal J., Mrackova J., Priban V.* Indications for general versus local anesthesia during carotid endarterectomy. *Neurol Surg A Cent Eur Neurosurg*. 2019; 80 (4): 250–254. DOI: 10.1055/s-0039-1678601. PMID: 30887487.
2. *Симонов О.В., Тюрин И.Н., Прямиков А.Д., Миронков А.Б.* Выбор метода анестезии при каротидной эндартерэктомии (обзор). *Общая реаниматология*. 2018; 14 (6): 95–113. DOI: 10.15360/1813-9779-2018-6-95-113. [*Simonov O.V., Tyurin I.N., Pryamikov A.D., Mironov A.B.* The choice of the type of anesthesia for carotid endarterectomy (review). *General reanimatology/Obshchaya reanimatologya*. 2018; 14 (6): 95–113. (in Russ.). DOI: 10.15360/1813-9779-2018-6-95-113].
3. *Осипенко Д.В., Марочков А.В.* Общая комбинированная анестезия в сочетании с блокадой поверхностного шейного сплетения при операциях на сонных артериях. *Общая реаниматология*. 2012; 8 (2): 47–52. DOI: 10.15360/1813-9779-2012-2-47. [*Osipenko D.V., Marochkov A.V.* General combined anesthesia in combination with superficial cervical plexus block during carotid artery surgery. *General reanimatology/Obshchaya reanimatologya*. 2012; 8 (2): 47–52. (in Russ.). DOI: 10.15360/1813-9779-2012-2-47].
4. Национальные рекомендации по ведению пациентов с заболеваниями брахиоцефальных артерий. Российская Федерация; 2013: 1–70. URL: http: //www.angiolsurgery.org/recommendations/2013/recommendations_brachiocephalic.pdf. [National guidelines for management of patients with diseases of brachiocephalic arteries. Russian Federation; 2013: 1–70. (in Russ.). URL: http: //www.angiolsurgery.org/ recommendations/2013/recommendations_brachiocephalic.pdf].
5. *GALA Trial Collaborative Group. Lewis S.C., Warlow C.P, Bodenham A.R., Colam B., Rothwell P.M., Torgerson D., Dellagrammaticas D., Horrocks M., Liapis C., Banning A.P., Gough M., Gough M.J.* General Anaesthesia versus Local Anaesthesia for carotid surgery (GALA): a multicentre, randomised controlled trial. *Lancet*. 2008; 372 (9656): 2132–2142. DOI: 10.1016/S0140-6736 (08)61699-2. PMID: 19041130.
6. *Macfarlane A.J.R., Vlassakov K., Elkassabany N.* Regional anesthesia for vascular surgery: does the anesthetic choice influence outcome? *Curr Opin Anaesthesiol*. 2019; 32 (5): 690–696. DOI: 10.1097/ACO. 0000000000000781. PMID: 31415047.
7. *Stoneham M.D., Stamou D., Mason J.* Regional anaesthesia for carotid endarterectomy. *Br J Anaesth*. 2015; 114 (3): 372–383. DOI: 10.1093/bja/aeu304. PMID: 25173766.
8. *Ericsson A., Hult C., Kumlien C.* Patients' experiences during carotid endarterectomy performed under local anesthesia. *J Perianesth Nurs*. 2018; 33 (6): 946–955. DOI: 10.1016/j.jopan.2017.09.011. PMID: 30449443.
9. *Licker M. Eur J Anaesthesiol*. 2016; 33 (4): 241–243. DOI: 10.1097/EJA. 0000000000000376. PMID: 26928169.
10. *Szabó P., Mayer M., Horváth-Szalai Z., Tóth K., Márton S., Menyhei G., Sínay L., Molnár T.* Awake sedation with propofol attenuates intraoperative stress of carotid endarterectomy in regional anesthesia. *Ann Vasc Surg*. 2020; 63: 311–318. DOI: 10.1016/j.avsg.2019.06.047. PMID: 31563659.
11. *Gough M.J.* The GALA Trial — a summary of the findings. *Eur J Vasc Endovasc Surg*. 2008; 36 (5): 505–506. DOI: 10.1016/j.ejvs.2008.09.001. PMID: 18815058.
12. *Гусев Е. И., Коновалов А. Н., Гехт А. Б.* Неврология. Национальное руководство. Краткое издание. М.: ГЭОТАР-Медиа; 2018: 688. ISBN 978-5-9704-4405-4. [*Gusev E.I., Konovalov A.N., Geht A.B.* Neurology. National manual. Compendium. M.: GEOTAR-Media; 2018: 688. ISBN 978-5-9704-4405-4].
13. *Powers W.J., Rabinstein A.A., Ackerson T., Adeoye O.M., Bambakidis N.C., Becker K., Biller J., Brown M., Demaerschalk B.M., Hoh B., Jauch E.C., Kidwell C.S., Leslie-Mazwi T.M., Ovbiagele B., Scott P.A., Sheth K.N., Southerland A.M., Summers D.V., Tirschwell D.L.* Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2019; 50 (12): e344–e418. DOI: 10.1161/STR.0000000000000211. PMID: 31662037.
14. *Adams Jr. H.P., Bendixen B.H., Kappelle L. J., Biller J., Love B.B., Gordon D.L., Marsh E.E. 3rd.* Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in acute stroke treatment *Stroke*. 1993: 24 (1); 35–41. DOI: 10.1161/01.str.24.1.35. PMID: 7678184.
15. *Rössel T., Uhlig C., Pietsch J., Ludwig S., Koch T., Richter T., Spieth P.M., Kersting S.* Effects of regional anesthesia techniques on local anesthetic plasma levels and complications in carotid surgery: a randomized controlled pilot trial. *BMC Anesthesiol*. 2019; 19 (1): 218. DOI: 10.1186/s12871-019-0890-8. PMID: 31771512.
16. *Zeidan A., Hayek F.* Nerve stimulator-guided cervical plexus block for carotid endarterectomy. *Anaesthesia*. 2007; 62 (3): 299–300. DOI: 10.1111/j.1365-2044.2007.05017.x. PMID: 17300326.

17. *Chongruksut W., Vaniyapong T., Rerkasem K.* Routine or selective carotid artery shunting for carotid endarterectomy (and different methods of monitoring in selective shunting). *Cochrane Database Syst Rev.* 2014; 6: CD000190. DOI: 10.1002/14651858. CD000190.pub3. PMID: 24956204.
18. *Guay J.* Regional anesthesia for carotid surgery. *Curr Opin Anaesthesiol.* 2008; 21 (5): 638–644. DOI: 10.1097/ACO.0b013e328308bb70. PMID: 18784492.
19. *Pasin L., Nardelli P., Landoni G., Cornero G., Magrin S., Tshomba Y., Chiesa R., Zangrillo A.* Examination of regional anesthesia for carotid endarterectomy. *J Vasc Surg.* 2015; 62 (3): 631–634.e1. DOI: 10.1016/j.jvs.2015.03.074. PMID: 26141693.
20. *Forssell C., Takolander R., Bergqvist D., Johansson A., Persson N.H.* Local versus general anaesthesia in carotid surgery. A prospective, randomised study. *Eur J Vasc Surg.* 1989; 3 (6): 503–509. DOI: 10.1016/s0950-821x (89)80124-0. PMID: 2696648.
21. *Rocha-Neves J.M., Pereira-Macedo J., Dias-Neto M.F., Andrade J.P., Mansilha A.A.* Benefit of selective shunt use during carotid endarterectomy under regional anesthesia. *Vascular.* 2020; 28 (5): 505–512. DOI: 10.1177/1708538120922098. PMID: 32356684.
22. *Sbarigia E., DarioVizza C., Antonini M., Speziale F., Maritti M., Fiorani B., Fedele F., Fiorani P.* Locoregional versus general anesthesia in carotid surgery: is there an impact on perioperative myocardial ischemia? Results of a prospective monocentric randomized trial. *J Vasc Surg.* 1999; 30 (1): 131–138. DOI: 10.1016/s0741-5214 (99)70185-0. PMID: 10394163.
23. *Закиржанов Н.Р., Комаров Р.Н., Халилов И.Г., Баязова Н.И., Евсеева В.В.* Сравнительный анализ безопасности выполнения каротидной эндартерэктомии в острейший и острый периоды ишемического инсульта. *Ангиология и сосудистая хирургия.* 2021; 27 (1): 97–106. DOI: 10.33529/ANGIO2021103. [*Zakirzhanov N.R., Komarov R.N., Khalilov I.G., Baiazova N.I., Evseeva V.V.* Comparative analysis of safety of carotid endarterectomy performed in the acutest and acute periods of ischemic stroke. *Angiology and vascular surgery/ Angiol Sosud Khir.* 2021; 27 (1): 97–106. (in Russ.). DOI: 10.33529/ANGIO2021103. PMID: 33825735].
24. *Orlický M., Hrbáč T., Sameš M., Vachata P., Hejčl A., Otáhal D., Havelka J., Netuka D., Herzig R., Langová K., Školoudík D.* Anesthesia type determines risk of cerebral infarction after carotid endarterectomy. *J Vasc Surg.* 2019; 70 (1): 138–147. DOI: 10.1016/j.jvs.2018.10.066. PMID: 30792052.
25. *Davies M.J., Silbert B.S., Scott D.A., Cook R.J., Mooney P.H., Blyth C.* Superficial and deep cervical plexus block for carotid artery surgery: a prospective study of 1000 blocks. *Reg Anesth.* 1997; 22 (5): 442–446. DOI: 10.1016/s1098-7339(97)80031-4. PMID: 9338906.
26. *Grieff A.N., Dombrovskiy V., Beckerman W., Ventarola D., Truong H., Huntress L., Rahimi S.* Anesthesia type is associated with decreased cranial nerve injury in carotid endarterectomy. *Ann Vasc Surg.* 2021; 70: 318–325. DOI: 10.1016/j.avsg.2019.12.033. PMID: 31917229.
27. *Batra A.P.S., Mahajan A., Gupta K.* Marginal mandibular branch of the facial nerve: an anatomical study. *Indian J Plast Surg.* 2010; 43 (1): 60-64. DOI: 10.4103/0970-0358.63968. PMID: 20924452.
28. *Grobben R.B., Vrijenhoek J.E.P., Nathoe H.M., Den Ruijter H.M., van Waes J.A.R., Peelen L.M., van Klei W.A., de Borst G.J.* Clinical relevance of cardiac troponin assessment in patients undergoing carotid endarterectomy. *Eur J Vasc Endovasc Surg.* 2016; 51 (4): 473–480. DOI: 10.1016/j.ejvs.2015.09.023. PMID: 26553374.
29. *Pereira-Macedo J., Rocha-Neves J.P., Dias-Neto M.F., Andrade J.P.V.* Prognostic effect of troponin elevation in patients undergoing carotid endarterectomy with regional anesthesia — a prospective study. *Int J Surg.* 2019; 71: 66–71. DOI: 10.1016/j.ijsu.2019.09.015. PMID: 31542388.
30. *Harky A., Chan J.S.K., Kot T.K.M., Sanli D., Rahimli R., Belamaric Z., Ng M., Kwan I.Y.Y., Bithas C., Makar R., Chandrasekar R., Dimitri S.* General anesthesia versus local anesthesia in carotid endarterectomy: a systematic review and meta-analysis. *J Cardiothorac Vasc Anesth.* 2020; 34 (1): 219–234. DOI: 10.1053/j.jvca. 2019.03.029. PMID: 31072705.

Received 06.06.2022
Online First 18.11.2022