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Original Article

The effect of anesthesia technique in carotid endarterectomy: Regional versus general anesthesia

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ABSTRACT

Objectives: The aim of this study was to evaluate the impact of anesthesia techniques on perioperative outcomes in patients undergoing carotid endarterectomy.

Patients and methods: This retrospective study included a total of 264 patients (164 males, 100 females; mean age 67.2 years; range, 58 to 84 years) who underwent carotid endarterectomy in our clinic between April 2016 and October 2019. The patients were divided into two groups according to the type of anesthesia as those undergoing regional anesthesia (RA group, n=128) and those undergoing general anesthesia (GA group, n=136). Pre-, intra-, and postoperative data of the patients were evaluated.

Results: The incidence of myocardial infarction and cerebral complications was similar between the groups (1.6% in RA group vs. 1.5% in GA group, p=1.00; 2.3% in RA group vs. 2.2% in GA group, p=1.00, respectively). The mean total operating time was significantly shorter in the RA group (92.5±7.7 min vs. 97.1±7.2 min, respectively; p<0.0001). The mean time to first postoperative analgesia requirement was significantly shorter in the GA group (193.9±20.8 min vs. 114.5±17.1 min, respectively; p<0.0001). The intraoperative hypotension rates were higher in the GA group (13.3% vs. 31.6%, respectively; p=0.0004), while the intraoperative hypertension rates were higher in the RA group (41.4% vs. 26.5%, p=0.0132). Postoperative hypotension (1.6% vs. 8.1%, respectively; p=0.0201), hypertension (26.6% vs. 69.1%, respectively; p<0.0001), and coexistence of hypotension and hypertension rates (2.3% vs. 9.6%, respectively; p=0.0185) were higher in the GA group compared to the RA group.

Conclusion: Our study results demonstrate that anesthesia techniques do not substantially affect cerebral complications, postoperative myocardial infarction, and mortality in carotid surgery. Furthermore, RA provides better hemodynamic stability, less pulmonary complications, less analgesic use, and shorter length of hospital stay.

Keywords: Carotid endarterectomy, general anesthesia, regional anesthesia.

Carotid endarterectomy (CEA) has been the most common surgical procedure for many years.[1] Several prospective, randomized clinical trials have demonstrated the safety and efficacy of this procedure in the prevention of ischemic stroke in symptomatic and carefully selected asymptomatic patients with severe carotid stenosis.[1,2] However, the ideal anesthetic technique for CEA is still controversial. Carotid endarterectomy can be performed under general anesthesia (GA) or regional anesthesia (RA) with deep or superficial cervical block.[1] A meta-analysis of 41 non-randomized studies (25,000 CEAs) reported that CEA under RA was associated with a 40% relative risk reduction in 30-day death/stroke, compared to CEA under GA, as well as a significant reduction in myocardial infarction (MI) and respiratory complication rates.[2] The General Anaesthesia versus Local Anaesthesia for Carotid Surgery (GALA) trial

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(n=3,526) is the largest randomized-controlled trial (RCT) to date and found no significant difference in the perioperative death, stroke, or MI between the GA (4.8%) and RA (4.5%).[3] Similarly, a previous analysis of pooled data from randomized-controlled trials (RCTs) showed no significant difference in the perioperative outcomes between the local anesthesia and GA during CEA.[3,4] However, the majority of the data were from one large RCT in which the perioperative adverse event rate was very low in both groups.[4] Although RCTs are the gold-standard study designs for comparative studies, most patients undergoing carotid artery interventions are not randomly allocated across the trials.[4]

In the present study, we aimed to analyze the impact of anesthesia techniques on perioperative outcomes in patients undergoing CEA.

PATIENTS AND METHODS

This single-center, retrospective study included a total of 264 patients (164 males, 100 females; mean age 67.2 years; range, 58 to 84 years) who underwent CEA at the Department of Cardiovascular Surgery of Ankara University School of Medicine between April 2016 and October 2019. The patients were divided into two groups according to the type of anesthesia as those undergoing RA (RA group, n=128) and those undergoing GA (GA group, n=136). Pre-, intra-, and postoperative data of the patients including total operation and total clamping time, perioperative hemodynamic parameters, intraoperative near-infrared spectroscopy (NIRS) value, postoperative complications (i.e., cerebral complications, MI, pulmonary complications), postoperative analgesic requirement, intensive care unit (ICU) requirement, length of hospital stay and mortality were recorded. The choice of anesthesia was dictated by the preference of the attending anesthesiologist and surgery team. The indication for surgery was ipsilateral severe (70 to 99%) or moderate (50 to 69%) carotid stenosis in symptomatic patients (history of transient ischemic attack and/or syncope within the last six months) or high risk for future stroke (unstable carotid plaque or progression in the severity of asymptomatic carotid stenosis) in asymptomatic patients.[5] Patients undergoing combined CEA and coronary artery bypass grafting and those undergoing carotid percutaneous transluminal angioplasty were excluded. A written informed consent was obtained from each patient. The study protocol was approved by the institutional Ethics Committee of Ankara University, Faculty of Medicine (İ5-283-20). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Anesthetic regimens

For all patients, the peripheral vascular access was placed upon the arrival of the patient to the operating theater. The NIRS probe was placed for all patients before anesthesia. After the standard monitoring (non-invasive blood pressure, electrocardiograph, and pulse oximetry), all patients were premedicated with intravenous (IV) bolus of midazolam at a dose of 0.015 mg/kg. Oxygen therapy was administered with a nasal cannula during all procedures. Induction in GA was performed with propofol, fentanyl and rocuronium, and maintenance of anesthesia was conducted with isoflurane, fentanyl and rocuronium. All cervical plexus blocks were performed by a single anesthesiologist experienced in these techniques using a blunt-end, 22-gauge, 50-mm needle (Echoplex®; VYGON, Paris, France). Bupivacaine 0.5% was used at a maximal dose of 2 mg/kg.

Following the supine positioning, the head was rotated to the contralateral side of the blockade. The skin was cleared with 2 chlorhexidine % for the deep part of the combined block. For the superficial part of the combined block, the needle was inserted underneath the muscle at the level of the fourth cervical transverse process, and 10 mL of bupivacaine 0.5% was injected with clear visualization under the posterior border of the sternocleidomastoid muscle (SCM). Then, a 12-MHz linear transducer (Logiq E ultrasound machine; GE Healthcare, WI, USA) with a sterile cover was placed along a line joining the mastoid process and transverse process of C6 level. The second cervical transverse process was identified at the transverse plane. The needle was advanced near 1 to 2 mm to the transverse process and 5 mL of 0.5% bupivacaine was injected after negative aspiration for blood. Afterwards, the probe was continued to move caudally, the third and fourth cervical transverse processes were viewed, respectively, and 5 mL of 0.5% bupivacaine was injected into the transverse processes of the third and fourth cervical vertebrae.

Surgical and medical management

A surgical incision was made from the anterior border line of the SCM. Intravenous heparin (100 IU/kg) was administrated prior to carotid cross-clamping. During the clamping, mental status of the patients was evaluated with questions and answers, and the NIRS values were assessed. Shunt was placed, when the NIRS value reduced by more than 15%.[6]

Table 1. Demographic characteristics and preoperative comorbidities of patients

	RA group (n=128)			GA group (n=136)			95% CI	
	n	%	Mean±SD	n	%	Mean±SD	Median	*p*
Age (year)			67.0±5.1			67.4±5.1	0.969-1.022	0.604
Sex								
Male	80	62.5		84	61.8			1.00
Female	48	37.5		52	38.2			1.00
Symptomatic carotid lesion	82	64		90	66.2			0.796
CAD	51	39.8		56	41.2			0.900
Hypertension	112	87.5		122	89.7			0.698
Diabetes mellitus	43	33.6		50	36.8			0.608
COPD	15	11.7		16	11.8			1.00
Chronic renal failure	2	1.6		2	1.5			1.00

RA: Regional anesthesia; GA: General anesthesia; CI: Confidence interval; SD: Standard deviation; CAD: Coronary artery disease; COPD: Chronic obstructive pulmonary disease.

After endarterectomy, carotid artery was closed with patching routinely. The patients were monitored in the observation room after surgery.

The primary outcome measures were cardiac and neurological complications, intra- and postoperative blood pressures, NIRS values, and postoperative analgesic requirement.

Statistical analysis

Statistical analysis was performed using the SPSS for Windows version 11.5 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency. The Mann-Whitney U test was used to analyze differences between two independent groups in terms of non-normally distributed variables, whereas the chi-square test was used to examine differences between the categorical variables. A *p* value of <0.05 was considered statistically significant with 95% confidence interval (CI).

RESULTS

Baseline demographic characteristics and preoperative comorbidities of the patients are presented in Table 1. There was no significant difference in the age and sex between the RA and GA groups p=0.604 and p=1.00, respectively). Also, we found no significant differences in the number of patients with coronary artery disease (p=0.900), hypertension (p=0.698), diabetes mellitus (p=0.608), chronic obstructive pulmonary disease (p=1.00), and chronic renal failure (p=1.00).

Table 2. Operative and postoperative data of patients

	RA group (n=128)			GA group (n=136)			95% CI	
	n	%	Mean±SD	n	%	Mean±SD	Median	*p*
Total operating time (min)			92.5±7.7			97.1±7.2	0.93-0.98	<0.0001
Total clamping time (min)			21.6±3.25			21.9±3.31	0.921-1.027	0.458
Shunt use	18	14		18	13.2			0.859
Cerebral complication (Transient ischemic attack)	3	2.3		3	2.2			1.00
Postoperative MI	2	1.6		2	1.5			1.00
Pneumonia	0	0		3	2.2			0.247
Death	2	1.6		3	2.2			1.00
Intensive care unit requirement	10	7.8		23	16.9			0.0263
Length of hospital stay (days)			3.2±0.9			4.2±1.1	0.810-0.933	<0.0001
Reintervention	1	0.8		1	0.7			1.00
Time to first postoperative analgesic (min)			193.9±20.8				1.618-1.773	<0.0001

RA: Regional anesthesia; GA: General anesthesia; CI: Confidence interval; SD: Standard deviation; MI: Myocardial infarction.

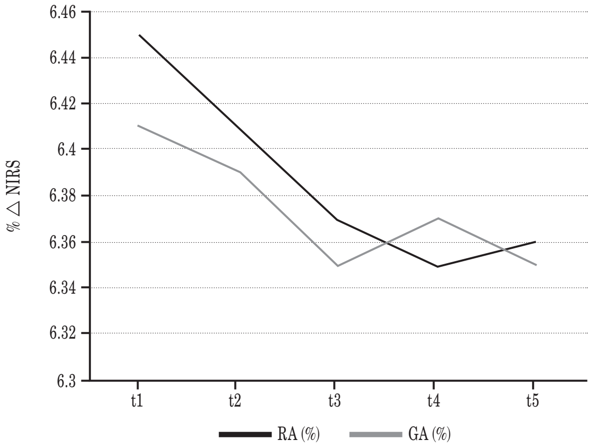

Figure 1. Intraoperative changing of NIRS values during clamping.
NIRS: Near-infrared spectroscopy; RA: Regional anesthesia; GA: General anesthesia.

Table 3. Intraoperative NIRS values at different time points

	RA group (n=128)	GA group (n=136)	95% CI	
	Mean±SD	Mean±SD	Median	*p*
T0	58.1±6.01	58.8±6.06	0.952-1.025	0.347
	RA group (n=110)	GA group (n=118)	95% CI	
	Mean±SD	Mean±SD	Median	*p*
T1	6.45±1.48	6.41±1.44	0.921-1.098	0.836
T2	6.41±1.42	6.39±1.34	0.922-1.090	0.913
T3	6.37±1.34	6.35±1.22	0.927-1.084	0.906
T4	6.35±1.37	6.37±1.38	0.917-1.083	0.912
T5	6.37±1.34	6.35±1.31	0.925-1.087	0.909
	RA group (n=128)	GA group (n=136)	95% CI	
	Mean±SD	Mean±SD	Median	*p*
T6	61.82±4.99	61.86±5.34	0.970-1.030	0.950

NIRS: Near-infrared spectroscopy; RA: Regional anesthesia; GA: General anesthesia; CI: Confidence interval; SD: Standard deviation; T0: Time when preclamping of carotid artery after anesthesia procedures which was recorded as baseline reference; T1: At clamping time decrease of ipsilateral NIRS value (%) (The patients whose NIRS value decreased by more than 15% and in whom shunt was placed were excluded); T2: At 5 min, decrease of ipsilateral NIRS value (%); T3: At 10 min, decrease of ipsilateral NIRS value (%); T4: At 15 min, decrease of ipsilateral NIRS value (%); T5: At 20 min, decrease of ipsilateral NIRS value (%); T6: NIRS value after declamping of carotid artery and stabilization of cerebral perfusion.

Operative data of both RA and GA groups are shown in Table 2. The mean total operating time of the RA group was significantly shorter, compared to GA group (92.5±7.7 min vs. 97.1±7.2 min, respectively; p<0.0001). However, we found no significant differences in the shunt use (p=0.859), cerebral complication as a transient ischemic attack (p=1.00), and postoperative MI (p=1.00) between the groups. Postoperative pneumonia was higher in the GA group (0% vs. 2.2%, respectively; p=0.247). There was no significant difference in mortality (p=1.00) and reintervention rates (p=1.00) between the groups. However, we found a significant difference in the ICU requirement (p=0.0263) and length of hospital stay (p<0.0001) in favor of the RA group. The patients in the RA group needed their first analgesic medication later than the patients in GA group (193.9±20.8 min vs. 114.5±17.1 min, respectively; p<0.0001).

Intraoperative NIRS values are shown in Table 3. Before clamping, the NIRS values were similar between the two groups. After clamping, in 18 (14%) patients in the RA group and in 18 (13.2%) patients in the GA group, shunt was placed due to decreased NIRS values by more than 15%. During clamping, the NIRS values were recorded at baseline and 5, 10, 15, and 20 min for both groups and there was no significant difference (Figure 1). After declamping, the increase of NIRS values were similar for both groups.

In terms of hemodynamic parameters, we found a significant difference between the two group. The intraoperative hypotension rates were higher in the GA group (13.3% vs. 31.6%, respectively; p=0.0004), while the intraoperative hypertension rates were higher in the RA group (41.4% vs. 26.5%, respectively; p=0.0132). Postoperative hypotension (1.6% vs. 8.1%, respectively; p=0.0201), hypertension (26.6% vs.

Table 4. Intraoperative and postoperative blood pressure changes

	RA group (n=128)		GA group (n=136)		
Variables	n	%	n	%	*p*
Intraoperative blood pressure changes					
Hypotension	17	13.3	43	31.6	0.0004
Hypertension	53	41.4	36	26.5	0.0132
Hypotension and hypertension	31	24.2	30	22	0.770
Postoperative blood pressure changes					
Hypotension	2	1.6	11	8.1	0.0201
Hypertension	34	26.6	94	69.1	<0.0001
Hypotension and hypertension	3	2.3	13	9.6	0.0185

RA: Regional anesthesia; GA: General anesthesia.

69.1%, respectively; $p<0.0001$), and coexistence of hypotension and hypertension rates (2.3% vs. 9.6%, respectively; $p=0.0185$) were higher in the GA group compared to the RA group (Table 4).

DISCUSSION

Carotid stenosis is responsible for approximately 7% of all cases of ischemic strokes. Although CEA is the most popular intervention, neurological and cardiac complications are still the most feared complications after this surgery.[7-11] Such complications include the ones that are due to the nature of the intervention (i.e., bleeding, local infections and sepsis; tracheal, vascular and nerve compression due to expanding hematomas, iatrogenic damage to hypoglossal nerve, and hyperperfusion syndrome) and comorbidities due to the patient profile requiring endarterectomic interventions (i.e., postoperative MI, stroke and pulmonary complications).[12,13]

Based on these facts, it becomes increasingly important to avoid further complications caused by anesthetic procedures. During the past decade, several studies have been performed to establish what the most ideal anesthesia regimen would be in the surgical treatment of carotid disease: GA or RA. In many of this studies, the rate of cerebral complications, MI, and death were assessed for both techniques.[13,14] However, many researchers examined different parameters such as perioperative complication rates, operation time, clamping time, hospitalization duration, and time before the first analgesic dose and compared GA with RA.[3,12]

Better perioperative hemodynamic stability, intraoperative awake neurological monitoring and better cerebrovascular autoregulation are the main advantages of CEA under RA, compared to GA.[12] However, hemodynamic instability is one of the significant problems for this population, as patients with carotid artery disease often have ischemic heart disease, as well.[15] The increased rate of postoperative MI observed in CEA under GA in our study can be explained by the higher incidence of hypotension and hemodynamic instability in this population. Hypotension in CEA under GA is multi-factorial and includes direct cardiac effects, such as decreased cardiac preload or suppression of the sympathetic nervous system.[17] In addition to hypotension, GA agents may induce a thrombophilic state which may further contribute to the development of MI.[16,17] Kfoury et al.[15] reported significant differences between the two groups. In the aforementioned study, CEA under RA or LA had significantly lower 30-day postoperative MI rates, compared to CEA under GA. However, there were no significant differences in the postoperative stroke and mortality rates between RA and GA respectively. Similarly, in our study, there were no significant differences in the cerebral complication, postoperative MI, and mortality rates between the groups.

It has been well established that major complications of CEA may result from hemodynamic factors. Cardiovascular lability in carotid patients undergoing anesthesia and surgery is a well-documented problem. In a study by Markovic et al.,[12] hemodynamic stability was better in favor of the RA. Consistent with these findings, our results also showed that patients who underwent CEA under RA had better hemodynamic parameters.

Many recent reports have described NIRS as a tool for preventing cerebral ischemia during clamping.[6] A number of different regional oxygen saturation (rSO_2) cut-off values have been proposed.[6] Pennekamp et al.[18] applied a decrease of 16% from baseline as the cut-off value after clamping and reported a positive predictive value of 76% and negative predictive value of 99% Pedrini et al.[19] also reported that the most reliable cut-off value was 25% reduction from baseline. We performed 15% ipsilateral NIRS value reduction as a cut-off value for internal carotid artery shunting, consistent with the published reports.[7,20] In the literature, there was a very limited number of studies regarding the effects of anesthesia regimen on the NIRS values. Our study showed that the anesthesia techniques had no effect on the NIRS values.

The blockage of afferent impulses from the surgical site to the central nervous system with the use of regional anesthesia such as carotid plexus block and the stress response to surgical trauma is believed to be lessened, thereby, reducing the level of circulating stress hormones.[21] It also avoids the occurrence of hypercoagulability state, improves the graft flow, reduces graft thrombosis, and avoids mechanical ventilation, intubation and extubation, and all potential complications related to mechanical ventilation such as pneumonia.[12,21] In our study, there were no significant differences in the number of reinterventions due to thrombosis or hematoma between the groups. As expected, however, the patients in the RA group had a lower risk of pneumonia due to the lack of mechanical ventilation and other complications related to mechanical ventilation.[12] In our study, postoperative pneumonia was higher in the GA group.

In a study by Weber et al.,[22] RA was superior in terms of less postoperative pain compared to GA. According to this study, in the GA group, the postoperative analgesic requirement time was significantly shorter. In our study, similarly, the patients in the RA group needed their first analgesic medication later than the patients in the GA group.

The CEA under RA may be a more cost-effective option compared to GA.[23] In addition, CEA under RA is associated with a lower ICU requirement, shorter total operation time, shorter length of hospital stay and, consequently, decreased costs compared to CEA under GA.[24,25] Likewise, in our study, we found a significant difference in the length of hospital stay in favor of the RA group.

The main limitations of the present study include its single-center and retrospective design and the lack of a randomization. Therefore, further large-scale, prospective, randomized studies including consecutive patients are needed to confirm our findings.

In conclusion, carotid artery surgery can be performed safely under RA. In this study, we demonstrate that anesthesia technique does not substantially affect cerebral complications, postoperative MI, and mortality in carotid surgery. Furthermore, RA provides better hemodynamic stability, less pulmonary complications, less analgesic use, and shorter length of hospital stay compared to GA. Nonetheless, further studies are warranted to draw a definitive conclusion.

Declaration of conflicting interests

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