TJVS Turkish Journal of Vascular Surgery

Turk J Vasc Surg 2024;33(2):71-7
DOI: 10.9739/tjvs.2024.04.017

Available online at www.turkishjournalofvascularsurgery.org

Original Article

Carotid endarterectomy outcomes according to anesthesia method: General anesthesia or regional anesthesia?

Fehim Can Sevil, Serkan Gume, Mehmet Tort, Necip Becit

Afyonkarahisar Health Sciences University, Health, Research and Practice Center, Department of Cardiovascular Surgery, Afyonkarahisar, Türkiye

Received: April 16, 2024 Accepted: July 01, 2024 Published online: July 08, 2024

Abstract

Aim: Surgical strategies in carotid endarterectomy (CEA) vary according to the method of anesthesia, neurological monitoring, shunt use, and closure methods, and the gold standard method has not yet been determined. In this study, we aimed to analyze the superiority and feasibility of CEA under general anesthesia and regional anesthesia.

Material and Methods: Demographic characteristics, operative information and follow-up results of 237 patients who underwent CEA between January 2015 and June 2020, 165 patients under regional anesthesia (RA: Group 1) and 72 under general anesthesia (GA: Group 2), were retrospectively analyzed. In Group 1, carotid shunt was placed in patients with a negative awake test (n: 21, 12.7%) and in Group 2 carotid shunt was placed in all cases.

Results: There was no statistically significant difference in postoperative stroke, transient ischemic attack (TIA) and cardiovascular mortality (p: 0.48; p: 0.30; p: 0.63, respectively). Although the operation and clamp time were shorter in Group 1, no significant difference was observed (97.93±11.02 min, 101.46±9.49 min p: 0.23; 19.60±5.62 min, 25.62±7.47 min p: 0.24, respectively). The duration of intensive care unit (ICU) stay was shorter and statistically significant in Group 1. (p: 0.003). There was no significant difference for restenosis rates (p: 0.34).

Conclusion: There was no significant increase in postoperative complications in the RA group compared to the GA group despite shunting according to the awake test. Also, patients who underwent RA stayed in ICU for a shorter period of time. CEA can be performed under both GA and RA with similar complication rates.

Keywords: Carotid arteries, endarterectomy, regional anesthesia

INTRODUCTION

Carotid endarterectomy (CEA) is the standard procedure for stroke prevention in patients with atherosclerotic carotid stenosis [1]. The goals of CEA are to prevent cerebral infarction due to carotid artery stenosis and to alleviate neurologic symptoms, thereby improving patients' quality of life. In the prevention of major strokes, CEA has been shown to be superior to other medical therapies in cases with asymptomatic carotid stenosis over 70% and ipsilateral symptomatic carotid stenosis over 50% [2]. However, CEA itself carries a risk of stroke and death [3]. Various studies have shown that there is no definitively proven superiority in terms of anesthesia method and shunt use [4-6]. In this study, we aimed to compare the perioperative and postoperative outcomes of CEA cases performed under general anesthesia (GA) and regional anesthesia (RA) in our center.

MATERIAL AND METHODS

The study is based on the guidelines stipulated in the Declaration of Helsinki. Since the Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (2021/10- 2011-KAEK-2) approved this study as an electronic medical record-based

CITATION
Sevil FC, Gume S, Tort M, Becit N. Carotid endarterectomy outcomes according to anesthesia method: General anesthesia or regional anesthesia?. Turk J Vasc Surg. 2024;33(2):71-7.

Corresponding Author: Serkan Gume, Afyonkarahisar Health Sciences University, Health, Research and Practice Center, Department of Cardiovascular Surgery, Afyonkarahisar, Türkiye
Email: s.gume@hotmail.com

retrospective study, it was not necessary to obtain informed consent from the patients before participation in the study.

Patient Characteristics

Clinical data of 237 patients who underwent CEA between January 2015 and June 2020 at Afyonkarahisar Health Sciences University Hospital were obtained from the files and analyzed retrospectively. Patients were divided into two groups: under regional anesthesia (RA group, Group 1, n=165) and under general anesthesia (GA group, Group 2, n=72). The method of anesthesia was determined according to the patient's comorbidities, the surgeon's preference and the patient's choice.

All patients were evaluated preoperatively with carotid CT angiography in addition to carotid doppler ultrasonography. Patients with transient ischemic attack (TIA) or stroke in the preoperative 3-month period were defined as symptomatic patients. The degree of stenosis was determined according to the algorithm used in the North American Symptomatic Carotid Endarterectomy trial [1]. According to the degree of stenosis, surgery was performed in symptomatic patients with lesions over 50% and in patients with lesions over 70% regardless of symptoms. Emergency CEA or bilateral CEA was not administered to any patient. Sample size was calculated with g power.

All patients were preoperatively examined in detail. GA was administered in patients who could not undergo awake test, who had a relatively high carotid bifurcation, impaired bleeding function tests, skin infection or impaired tissue integrity at the site of RA and who asked for GA. On the other hand, RA was applied in elderly patients in whom GA was deemed high risk, in patients with severe cardiac and pulmonary insufficiency, those in whom endotracheal intubation was thought to be difficult, and who requested RA.

Anesthesia

Regional anesthesia

Cervical plexus block (CPB) is the most commonly used technique in CEA operations. Although the landmark method can also be used, we used the ultrasound-guided approach which is safer and more effective. Arterial blood pressure, 5 lead ECG, pulmonary oxygen saturation and near infrared spectroscopy (NIRS) were monitored. To achieve total cervical plexus blockage, 1.4 mg/kg bupivacaine (i.e. approximately 25 ml of 0.375% bupivacaine) was used [7].

Since the awake test is the most reliable method to detect hypoperfusion [8], an awake test including commands such as talking, toe flexion-extension, and grasping a plastic ball was performed 5 minutes before clamping the carotid artery. After clamping, the awake test was repeated immediately and every 5 minutes afterward. A carotid shunt was used for patients who had problems in the awake test.

General anesthesia

Arterial blood pressure, 5 lead ECG, pulmonary oxygen saturation and NIRS were monitorized. After induction of anesthesia with propofol (2 m/kg) and rocuronium (0.6 mg/kg) injections, the patients were intubated. Surgery was performed under remifentanil (0.05-2.00 µg/kg/min) and 2% sevoflurane [9]. A carotid shunt was used in all patients.

Surgical Technique

A skin incision was made along the anterior border of the sternocleidomastoid muscle extending to the jugular process. The common carotid, internal carotid, external carotid and superior thyroid arteries were dissected and rotated with tapes. After administration of 100 IU/kg unfractionated heparin, vascular clamps were placed on each vessel. Arteriotomy was applied to the region of plaque. With the help of an elevator, the plaque was separated from the endothelium. After that, the vessel lumen was flushed with heparinized solution to protect against thromboembolism. Arteriotomy was closed with a biological pericardial patch (Xenosure biologic patch, Lemaitre, USA) in all patients. Firstly, pericardial patch was removed from the container, it was submerged in the sterile saline. Using the same forceps, we gently agitated the patch in the basin. It remained in the rinse container until requested by the surgeon. We preferred biological pericardial patches to carotid fabric patches because they are more biological and adjustable in width and length.

Postoperative Care

All patients who underwent CEA were intubated and admitted to the Intensive Care Unit (ICU) in the postoperative period. Patients taken under GA were extubated after full consciousness and muscle recovery was maintained. Detailed neurological examination of each patient was carried out. Patients with no complications and stable vital signs were transferred to the inpatient ward. They were closely observed for signs of potential wound hematomas, infections and neurological complications. After discharge, patients were followed up at 3-month intervals: Neurological examinations were done, the wound sites were checked and carotid doppler ultrasonography was performed to detect possible restenosis.

Statistical Analysis

Normally distributed variables were expressed as mean and standard deviation, non-normally distributed variables were expressed as median and IQR, and categorical variables were expressed as percentage. To compare pre- and post-treatment values, chi-square was used for categorical variables, paired T test was used for normally distributed ones, and Wilcoxon test was used for non-normally distributed ones. Kolmogorov Smirnov test was used to test normality. All statistical analyses were performed using R Statistical software version 3.2.2 (R Foundation for Statistical Computing, Vienna, Austria). A p-value less than 0.05 was considered statistically significant.

 DOI: 10.9739/tjvs.2024.04.017

RESULTS

Of the 237 patients who underwent CEA, 195 (82.3%) were male and the mean age was 70.08±8.65 years. There was no statistical difference in terms of age, gender and comorbid diseases (Table 1). Demographic characteristics and comorbid diseases of the patients are shown in Table 1.

Carotid artery stenosis was detected incidentally in 39 (16.5%) patients without symptoms. Symptomatic patients most commonly presented with hemispheric infarction (n=132, 55.7%) (Table 1). The information about carotid artery imaging methods is detailed in Table 2.

Surgical time and cross-clamp time were shorter in Group 1, but no statistical difference was identified (97.93±11.02 min; 101.46±9.49 min; p 0.23; 19.60±5.62 min; 25.62±7.47 min; p=0.24, respectively). In Group 1, 21 (12.7%) patients with the negative awake test were shunted (Table 3).

Although respiratory problems were most prevalent in the postoperative period, no significant difference was seen (p=0.06). There was no statistical difference in terms of nerve damage (p=0.21), wound hematoma (p=0.66), wound infection (p=0.48) and in-hospital mortality (p=0.09). The patients with hematoma and infection at the wound site were followed up and infection recovered without any surgical intervention. Among those with nerve injury, 3 patients suffered from recurrent laryngeal and 6 developed hypoglossal nerve damage, and no permanent results showed up in the 6-month follow-up. Of the 15 (6.3%) cases who needed blood transfusion, 12 were from the GA group and this difference was statistically significant (p=0.02). The mean number of days the patients stayed in the ICU was 1.51±3.26 and GA patients remained longer (p=0.003). Operative and postoperative data are provided in Table 3.

Patients were followed up for a mean of 27.23±20.3 months in the postoperative period. Eight participants (3.3%) experienced carotid artery restenosis, which is defined as more than 70% stenosis of the carotid artery, and there was no significant difference (p=0.34). Although stroke occurred in 4 (1.6%) of the participants, the cause was the contralateral carotid artery in 3. There was no significant difference in the development of stroke (p=0.48). During this period, mortality occurred in 12 (5.1%) patients and the cause was aspiration pneumonia in 3 and coronary artery disease for the others. No significant difference was seen in terms of mortality rates (Group 1; n=9, 5.6%; Group 2; n=3, 4.2%; p=0.63). The information during the follow-up period can be seen in Table 4.

Table 1. Characteristic of patients

Characteristic	Total (n=237)	Regional anesthesia (n=165)	General anesthesia (n=72)	p
Age (yr)	70.08±8.65	69.25±9.5	71.96±6.03	0.423
Male	195 (82.3)	135 (21.8)	60 (83.3)	0.573
Comorbidity				
Hypertension	177 (74.7)	120 (72.7)	57 (79.2)	0.545
Coronary artery disease	150 (63.3)	108 (65.5)	42 (58.3)	0.546
Diabetes mellitus	111 (46.8)	81 (49.1)	30 (41.7)	0.543
Angina	93 (39.2)	72 (43.6)	21 (29.7)	0.226
Hyperlipidemia	84 (35.4)	54 (32.7)	30 (41.7)	0.445
Chronic obstructive pulmonary disease	54 (22.8)	42 (25.5)	12 (16.7)	0.392
Myocardial infarction	33 (13.9)	279 (16.4)	6 (8.3)	0.489
Peripheral arterial disease	33 (13.9)	21 (12.7)	12 (16.7)	0.727
Chronic kidney disease	21 (8.9)	12 (7.3)	9 (12.5)	0.429
Current or ex-smoker	72 (30.4)	45 (27.3)	27 (37.5)	0.363
Neurological symptoms				
Asymptomatic	39 (16.5)	30 (18.2)	9 (12.5)	0.744
Symptomatic				
Hemispheric infarct	132 (55.7)	99 (60)	33 (45.8)	0.244
Hemispheric TIA	48 (20.3)	21 (12.7)	27 (37.5)	**0.017**
Retinal infarct	9 (3.8)	9 (5.5)	0 (0)	0.549
Retinal TIA	9 (3.8)	6 (3.6)	3 (4.2)	0.668

Values are presented as mean±standard deviation or number (%); TIA: transcient ischemic attack; P values calculated by Pearson Chi-Square, paired T Test and Wilcoxon test

 DOI: 10.9739/tjvs.2024.04.017

Table 2. Characteristics of carotid arteries

Characteristic	Total (n=237)	Regional anesthesia (n=165)	General anesthesia (n=72)	p
Peak systolic velocity of CCA on doppler ultrasound	52.51±14.97	53.77±14.33	49.71±16.25	0.140
Peak systolic velocity of ICA on doppler ultrasound	138.37±38.76	133.22±28.52	150.17±54.56	0.368
Carotid artery stenosis on doppler ultrasound				
50-69%	24 (10.1)	21 (12.7)	3 (4.2)	0.363
>70%	213 (89.9)	144 (87.3)	69 (95.8)	0.423
Carotid artery stenosis on computed tomography				
50-69%	9 (3.8)	9 (5.5)	0	0.392
>70%	228 (96.2)	156 (94.5)	72 (100)	0.549
Contralateral carotid stenosis on computed tomograpy				
<50%	81 (34.2)	57 (34.5)	24 (33.3)	0.543
≥50	156 (65.8)	108 (65.5)	48 (66.7)	0.917

Values are presented as mean±standard deviation or number (%); CCA: common carotid artery, ICA: internal carotid artery; P values calculated by Pearson Chi-Square, paired T Test and Wilcoxon test

Table 3. Operative details and outcomes of carotid endarterectomy

Variable	Total (n=237)	Regional anesthesia (n=165)	General anesthesia (n=72)	p
Carotid endarterectomy side				
Right-sided CEA	117 (49.4)	72 (43.6)	45 (62.5)	0.147
Left-sided CEA	120 (50.6)	93 (56.4)	27 (37.5)	0.123
Operative time (min)	108.11±18.75	97.93±11.02	101.46±9.49	0.231
Clamp time (min)	24.77±10.02	19.60±5.62	25.62±7.47	0.243
Usage of shunt	93 (39.2)	21 (12.7)	72 (100)	**<0.001**
Complications				
Respiratory	18 (7.6)	6 (3.6)	12 (16.7)	0.066
Nerve injury	9 (3.8)	3 (1.8)	6 (8.3)	0.218
Hematoma	5 (2.1)	3 (1.8)	2 (2.7)	0.668
Wound infection	3 (1.2)	3 (1.8)	0	0.482
In-hospital mortality	6 (2.5)	0	6 (8.3)	0.090
Use of intravenous painkiller	27 (11.4)	21 (12.7)	6 (8.3)	0.445
Use of intravenous blood pressure control drug	27 (11.5)	24 (14.5)	3 (4.2)	0.173
Blood transfusion	15 (6.3)	3 (1.8)	12 (16.7)	**0.028**
Intensive care unit stay (day)	1.51±3.26	1.07±0.26	2.5±5.87	**0.003**
Hospital stay (day)	3.48±3.05	3.05±1.07	4.46±5.23	0.394

Values are presented as mean±standard deviation or number (%); CEA: carotid endarterectomy; P values calculated by Pearson Chi-Square, paired T Test and Wilcoxon test

Table 4. Outcomes of postoperative follow up

Variable	Total (n=237)	Regional anesthesia (n=165)	General anesthesia (n=72)	p
Carotid artery restenosis				
≥70%	8 (3.3)	6 (3.6)	2 (2.7)	0.341
Stroke	4 (1.6)	4 (2.4)	0	0.482
TIA	3 (1.3)	0	3 (4.2)	0.304
Mortality	12 (5.1)	9 (5.6)	3 (4.2)	0.639

Values are presented as mean±standard deviation or number (%); P values calculated by Pearson Chi-Square, paired T Test and Wilcoxon test

DISCUSSION

Based on the findings of this study, surgery and cross-clamping times were found to be longer for Group 2. The utmost advantage of RA is eluding nonessential intraluminal shunt. Diminishing the usage of shunts in patients with RA was effective in shortening the operation time. The shunt itself can carry forward the atheroma plaque through the distal bed, cause intimal damage, and create a potential new source of intraoperative or early postoperative thrombosis. This may also lead to postoperative restenosis [10]. Despite the shunt being used in all patients in the GA group, no significant difference was noted in terms of postoperative complications. In addition, patients taken under GA required more blood transfusions. We assume that this disparity is due to the administration of GA in patients with abnormal bleeding function tests in the preoperative evaluation. As blood transfusion is, in a sense, tissue transplantation, it constitutes a big problem with regard to possible complications. Moreover, the postoperative ICU stay of patients taken under GA was detected to be longer (P=0.003). Prolonging this period leads to psychological disorders and increased health expenses.

Carotid artery stenosis is more commonly seen in the geriatric population. The age distribution of patients in the research was comparable (p=0.42) with 82.3% of the patients being male. No significant difference was detected between the two groups in terms of gender (p=0.57) and gender distribution was found to be coherent with the literature [11]. No significant difference was noted between both groups with regard to comorbid diseases. A comprehensive analysis involving 22.845 patients found no discernible disparity in death rates between GA and RA, and furthermore the study's conclusions closely aligned with our own findings [12]. In another study, the GALA study (Lancet, 2008) carried out on 3.526 patients from 95 centers in 24 countries, no difference was detected between GA and RA with regard to perioperative mortality and morbidity; no difference in quality of life was noted in the short term, nor was there a difference in the 1-year period without stroke or myocardial infarction (MI) [13]. In the National Surgical Quality İmprovement Program (NSQIP) study, the risk of postoperative MI was found to be higher in CEA performed under GA; therefore, it was pointed out that CEA under RA might be preferred for patients at postoperative MI risk [14]. In another research by Markovic et al., it was stated that the type of anesthesia did not affect the surgical outcomes of CEA, and they showed that local techniques were associated with fewer respiratory complications, a later first postoperative analgesic requirement, and a more waking patient after surgery as well [15]. In our opinion, the anesthesia method to be implemented should be preferred regardless of comorbid diseases. Regional anesthesia in CEA has been shown to be safe and efficient in patients with serious comorbid diseases as well [16].

Operation time and carotid artery clamp time were detected to be longer in Group 2 (p<0.001). We assume that the reason is that, a shunt was utilized in all patients and the shunt could obstruct vision and make the surgery challenging, and in Group 1, unnecessary shunt use was reduced and the surgeon was more comfortable. Operation and clamp time are directly associated with postoperative complications, and the length of the surgery plays a role in the development of hemodynamic instability. Furthermore, microplaques in the carotid artery subsequent to clamping are likely to cause cerebrovascular events. The susceptibility to cerebrovascular events increases as the clamp duration prolongs [17]. In our study, even though the operation and clamp time were longer in Group 2, no significant difference was noted in terms of postoperative complications.

There is no consensus yet regarding the utilization of shunts [6]. Shunts were not routinely applied to patients since they may cause various complications such as plaque embolization from the carotid artery, air embolism, dissection, shunt occlusion, prolonged surgery time, and, indeed, blood flow disorder in the unilateral arm [18]. Besides, the awake patient is the gold standard for imaging cerebral function [19-22]. With this design, shunts were used in patients with problems in the awake test in RA Group.

The most frequent complication in patients throughout postoperative follow-up was respiratory failure. The majority of these patients were in Group 2, while no statistically significant difference was noted, and we believe that is associated with intubation. Another study revealed local methods were related to fewer respiratory complications, and it was found to be compatible with our study [23]. While nerve damage was observed in a total of 9 patients, no permanent damage occurred. We assume that temporary nerve damage is due to exclusion and edema in the nerve. There was no significant difference between the two groups with regard to hematoma and wound infection. The requirement for blood transfusion was found to be higher in Group 2 (p=0.02). We think that the reason why hematomas were encountered in more patients in Group 1 and more transfusion was required in Group 2 is due to the disorder in the bleeding functions and general condition of the patients in Group 2.

The period of stay in the hospital and ICU for patients was shorter in Group 1. Antibiotic treatment was administered intravenously in hospitalized patients, and oral antibiotic therapy was sustained after discharge as well. We think that the reason for the higher rate of wound infections in this group of patients is associated with the shorter duration of hospital stay and the more frequent occurrence of hematomas. Besides, it should be remembered that as the period of stay in ICU prolongs, costs increase, and patients are negatively affected [5]. We believe that performing CEA under RA reduces costs and promotes patient comfort.

Mortality was observed in 6 patients (2.5%), and while all of these patients were in Group 2, no statistical difference was detected between both groups. The mortality rate is reported below 3% in the literature and is consistent with our study [24]. Although there was no significant difference in terms of CEA-associated complications, we assume that RA is safer and more efficient in patients with serious comorbidities, in line with the literature [25]. The need for postoperative blood transfusion was determined more in the GA group, compatible with the literature (p=0.02) [25]. We believe that RA may be more practical in CEA to avoid the undesirable side effects of blood transfusion.

Throughout the mean follow-up period of 27.23±20.3 months, carotid artery restenosis occurred in a total of 8 (3.3%) patients, and no significant difference was identified (p=0.34). In another study, carotid artery restenosis was noted to be 14.7% in a 1-year period [26], and we speculate that it was higher in that study since the degree of restenosis was based on a stenosis of 50% and above. Stroke developed in 4 (1.6%) patients during follow-ups. All these patients were in the RA group, and although no significant difference was observed, it was determined to be 1.4% in another study and is consistent with the literature [26]. During long-term follow-up, mortality was seen in 12 patients (5.1%) and no significant difference was found. Meanwhile, this rate was determined to be compatible with the literature [24]. The long term follow-up did not reveal any statistically important distinction between the two groups, leading us to conclude that RA is equally effective in GA.

CONCLUSION

General anesthesia is still the most preferred anesthesia method in CEA [19,27]. Moreover, there is no consensus on the anesthesia method for CEA yet, and both local anesthesia and general anesthesia are still debated issues. In our study, no difference was detected with regard to complications between the two groups in the postoperative period. Despite all, we believe that the anesthesia method should be decided by taking into account the personal preferences of the anesthesiologist and the surgeon, the patient's comorbidities, patient satisfaction, and the conditions of the present hospital; thus, lower morbidity and mortality rates may be achieved.

Ethics Committee Approval: The Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (2021/10- 2011-KAEK-2) approved this study on 03.09.2021.

Patient Consent for Publication: This study as an electronic medical record-based retrospective study, it was not necessary to obtain informed consent from the patients before participation in the study.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: All authors contributed equally to the article.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Barnett HJM, Taylor DW, Haynes RB, Sackett DL, Peerless SJ, Ferguson GG, et al.; North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. N Engl J Med. 1991;325:445-53.
2. North American Symptomatic Carotid Endarterectomy Trial (NASCET) investigators. Clinical alert: benefit of carotid endarterectomy for patients with high-grade stenosis of the internal carotid artery. National Institute of Neurological Disorders and Stroke Stroke and Trauma Division. Stroke. 1991;22:816-7.
3. Bond R, Rerkasem K, Rothwell PM. Routine or selective carotid artery shunting for carotid endarterectomy (and different methods of monitoring in selective shunting). Stroke. 2003;34:824-5.
4. Rerkasem K, Rothwell PM. Local versus general anaesthesia for carotid endarterectomy. Cochrane Database Syst Rev. 2008;CD000126. doi: 10.1002/14651858.CD000126.pub3. Update in: Cochrane Database Syst Rev. 2013;CD000126. doi: 10.1002/14651858.CD000126.pub4
5. Schechter MA, Shortell CK, Scarborough JE. Regional versus general anesthesia for carotid endarterectomy: the American College of Surgeons National Surgical Quality Improvement Program perspective. Surgery. 2012;152:309-14.
6. Aburahma AF, Mousa AY, Stone PA. Shunting during carotid endarterectomy. J Vasc Surg. 2011;54:1502-10.
7. Kavrut Ozturk N, Kavakli AS, Sagdic K, Inanoglu K, Umot Ayoglu R. A randomized controlled trial examining the effect of the addition of the mandibular block to cervical plexus block for carotid endarterectomy. J Cardiothorac Vasc Anesth. 2018;32:877-82.
8. Lee J, Huh U, Song S, Chung SW, Sung SM, Cho HJ. Regional anesthesia with dexmedetomidine infusion: a feasible method for the awake test during carotid endarterectomy. Ann Vasc Dis. 2016;9:295-9.
9. Kuzkov VV, Obraztsov MY, Ivashchenko OY, Ivashchenko NY, Gorenkov VM, Kirov MY. Total intravenous versus volatile induction and maintenance of anesthesia in elective carotid endarterectomy: effects on cerebral oxygenation and cognitive functions. J Cardiothorac Vasc Anesth. 2018;32:1701-8.
10. Saraç A, Jahollari A. Carotid endarterectomy under local anesthesia: An institutional report of experience. Turk J Vasc Surg. 2020;29:101-6.
11. Vang S, Hans SS. Carotid endarterectomy in patients with high plaque. Surgery. 2019;166:601-6.
12. Malik OS, Brovman EY, Urman RD. The use of regional or local anesthesia for carotid endarterectomies may reduce blood loss and pulmonary complications. J Cardiothorac Vasc Anesth. 2019;33:935-42.
13. Lewis SC, Warlow CP, Bodenham AR, Colam B, Rothwell PM,

Torgerson D, et al.; GALA Trial Collaborative Group. General anaesthesia versus local anaesthesia for carotid surgery (GALA): a multicentre, randomised controlled trial. Lancet. 2008;372:2132-42.

14. Kfoury E, Dort J, Trickey A, Crosby M, Donovan J, Hashemi H, Mukherjee D. Carotid endarterectomy under local and/or regional anesthesia has less risk of myocardial infarction compared to general anesthesia: an analysis of national surgical quality improvement program database. Vascular. 2015;23:113-9.
15. Markovic D, Vlajkovic G, Sindjelic R, Markovic D, Ladjevic N, Kalezic N. Cervical plexus block versus general anesthesia in carotid surgery: single center experience. Arch Med Sci. 2012;8:1035-40.
16. Shin HJ, Yu HN, Yoon SZ. Ultrasound-guided subcutaneous cervical plexus block for carotid endarterectomy in a patient with chronic obstructive pulmonary disease. J Anesth. 2014;28:304-5.
17. de Borst GJ, Moll FL, van de Pavoordt HD, Mauser HW, Kelder JC, Ackerstaf RG. Stroke from carotid endarterectomy: when and how to reduce perioperative stroke rate?. Eur J Vasc Endovasc Surg. 2001;21:484-9.
18. Waring PH, Kraftsow DA. Another complication of carotid artery shunting during carotid endarterectomy. Anesthesiology. 1990;72:1099.
19. Patelis N, Diakomi M, Maskanakis A, Maltezos K, Schizas D, Papaioannou M. General versus local anesthesia for carotid endarterectomy: special considerations. Saudi J Anaesth. 2018;12:612-7.
20. Zdrehuş C. Anaesthesia for carotid endarterectomy - general or loco-regional?. Rom J Anaesth Intensive Care. 2015;22:17-24.
21. Ciccozzi A, Angeletti C, Guetti C, Pergolizzi J, Angeletti PM, Mariani R, Marinangeli F. Regional anaesthesia techniques for carotid surgery: the state of art. J Ultrasound. 2014;17:175-83.
22. Casutt M, Breitenmoser I, Werner L, Seelos R, Konrad C. Ultrasound-guided carotid sheath block for carotid endarterectomy: a case series of the spread of injectate. Heart Lung and Vessel. 2015;7:168-76.
23. Yılmaz Barut F. Anesthesia management for carotid endarterectomy: review article. E J Cardiovasc Med. 2019;7:50-9.
24. Babu MA, Meissner I, Meyer FB. The durability of carotid endarterectomy: Long-term results for restenosis and stroke. Neurosurgery. 2013;72:835-8.
25. Malik OS, Brovman EY, Urman RD. The use of regional or local anesthesia for carotid endarterectomies may reduce blood loss and pulmonary complications. J Cardiothorac Vasc Anesth. 2019;33:935-42.
26. Robert D, Abdullah A, Steinmetz-Wood S, Mekhaiel S, Steinmetz OK, Obrand D, et al. Carotid endarterectomy outcomes in the elderly: a Canadian institutional experience. Journal of Vascular Surgery. 2019;59:16-20.
27. Lomivorotov VV, Shmyrev VA, Moroz GB. Volatile anesthesia for carotid endarterectomy: friend or foe for the brain?. J Cardiothorac Vasc Anesth. 2018;32:1709-10.