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Comparison of eversion carotid endarterectomy under local anesthesia and eversion/conventional carotid endarterectomy under general anesthesia

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Abstract

Introduction: Studies searching outcomes of eversion carotid endarterectomy (E-CEA) under local anesthesia are lacking.
Aim: To evaluate the postoperative outcomes of E-CEA under local anesthesia and compare it with E-CEA/Conventional CEA under general anesthesia in symptomatic or asymptomatic patients.
Material and methods: From February 2010 to November 2018 a total of 182 patients (143 males, 39 females; mean age: 69.69 ±9.88 years; range: 47 to 92 years) who underwent eversion CEA or conventional CEA with patchplasty under general or local anesthesia in two tertiary centers were included in this study.
Results: Overall in-hospital stay ($p = 0.01$), postoperative in-hospital stay (p = 0.022) took significantly less time in favor of E-CEA under local anesthesia. Overall, 6 patients developed major stroke (3.2%), among them 4 (2.1%) patients passed away, 7 (3.8%) patients developed cranial nerve injury (the marginal mandibular branch of the facial nerve and hypoglossal nerve), 10 (5.4%) patients developed a hematoma in the postoperative period. No difference was found in terms of postoperative stroke ($p = 0.470$), postoperative death ($p = 0.703$), postoperative bleeding rate ($p = 0.521$) or postoperative cranial nerve injury ($p = 0.481$) between the groups.
Conclusions: The mean operation time, postoperative in-hospital stay, overall in-hospital stay, and need for shunting were lower in patients who underwent E-CEA under local anesthesia. E-CEA under local anesthesia seemed to do better in stroke, death, and bleeding rate, however, this difference was not significant.

Key words: carotid artery endarterectomy, eversion technique, conventional technique, stroke, hypertension.

Introduction

Carotid endarterectomy (CEA) has been performed for more than 50 years to reduce the stroke risk, as a safe and effective surgical technique. Stroke, myocardial infarction, death, cranial nerve injury, blood pressure variance, and bleeding are the main complications [1]. The type of anesthesia, type of surgical technique and shunt usage influence the outcomes of CEA. CEA can be performed under general anesthesia, regional anesthesia, and local anesthesia. Superficial (subcutaneous injection to the posterior of sternocleidomastoid muscle), intermediate (local anesthetic injection between the superficial and deep cervical fascia through the posterior border of the SCM) and deep (paravertebral block of the C2, C3, and C4 spinal nerves) cervical plexus blockade can be applied during carotid endarterectomy under regional anesthesia [2]. Eversion CEA technique is thought to reduce the total operative and cross-clamping time; furthermore the local anesthetic technique is thought to contribute to this drop [3]. Carotid endarterectomy affects cognitive function, which has not yet been fully clarified.

Aim

The aim of our study was to evaluate the postoperative outcomes of eversion carotid endarterectomy (E-CEA) under local anesthesia and E-CEA/C-CEA under general anesthesia in symptomatic or asymptomatic patients.

Material and methods

Study population

From February 2010 to November 2018 consecutive patients who were admitted with symptomatic or asymptomatic severe internal carotid artery (ICA) stenosis were

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included in this multicenter (two tertiary) retrospective study. Preoperative symptoms were considered as major stroke, transient ischemic attack, and amaurosis fugax and speech disorder. Physical examination and laboratory results, medical history (e.g. coronary artery disease and peripheral artery disease), comorbidities (e.g. diabetes mellitus, hypertension, hyperlipidemia, chronic renal failure) and postoperative outcomes (e.g. stroke, death, hyperperfusion syndrome, cranial nerve injury, bleeding, myocardial infarction) were analyzed. Treatment indications were considered as more than 50% stenosis of the ICA in symptomatic patients and more than 70% stenosis of the ICA in asymptomatic patients according to the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria (1991), and the European Society for Vascular Surgery (ESVS) guidelines for the Management of Atherosclerotic Carotid and Vertebral Artery Disease (2017) [4, 5]. The severity of carotid artery stenosis was routinely examined by carotid color Doppler ultrasonography and then confirmed by computed tomography angiography (Aquilion 16 system, Toshiba Medical Systems Corporation, Japan). All patients were divided into three groups with respect to the type of CEA surgery and type of anesthesia: group 1 (E-CEA under local anesthesia), group 2 (E-CEA under general anesthesia) and group 3 (C-CEA under general anesthesia). Table I summarizes the baseline characteristics. The preferred surgical and anesthetic techniques were based on the attending surgeon and preoperative angiographic examination of the patient. Routine transthoracic echocardiographic imaging was performed in all patients and selective preoperative coronary angiography was performed according to the ejection fraction and motion disorder of the left ventricle wall.

Surgical and anesthesia technique

Continuous bilateral regional cerebrovascular oxygen saturation was continuously monitored using near-infrared spectroscopy (INVOS® 5100C Cerebral/Somatic Oximeter, Somanetics Corporation, Troy, MI, USA). Stump pressure measurement, invasive blood pressure, electrocardiography, and pulse oximetry were monitored during the procedure either under local anesthesia or general anesthesia during cross-clamping. Javid shunt (Bard® Javid™ Carotid Shunts, Bard Ltd., Forest House, Brighton Rd., Crawley, West Sussex, UK) or Pruitt-Inahara shunt (Horizon Medical, Santa Ana, CA, USA) were used when necessary. 100 IU/kg heparin was administered intravenously before cross-clamping. Single antiplatelet treatment (acetic salicylic acid 100 mg/day or clopidogrel 75 mg/day) was administered preoperatively and continued with dual antiplatelet treatment throughout the life. In addition, low molecular weight heparin was administered 3 days after the surgery. 0.2% 20 mg/ml prilocaine (maximum dosage 400 mg) was administered locally through the anterior border of the SCM with a 24-gauge needle for local anesthesia. The neurocognitive function of the patient was controlled with a contralateral squeezing a duck making a sound during surgery under local anesthesia for speaking impairments, contralateral motor impairments, any onset of states of confusion and altered consciousness. All surgeons preferred the anterior approach for exposure of the carotid artery. A traditional/modified eversion endarterectomy and conventional longitudinal endarterectomy with PTFE, Dacron or saphenous patch closure of the arteriotomy were performed during CEA. After the complete oblique transaction of the ICA at the bifurcation, eversion endarterectomy was performed

Table I. Baseline data of patients who underwent eversion carotid endarterectomy and conventional carotid endarterectomy

Variable	Group 1 C-CEA under general anesthesia *n* = 112 patients			Group 2 E-CEA under general anesthesia *n* = 44 patients			Group 3 E-CEA under local anesthesia *n* = 26 patients			Total		*P*-value
	n	%	Mean ± SD	*n*	%	Mean ± SD	*n*	%	Mean ± SD	*n*	%	
Age			70.13 ±9.66			68.93 ±11.18			69.08 ±8.68			0.752
Gender:												
Male	89	79.4		38	86.3		16	61.5				0.047
Surgical side:												
Right	47	41.9		18	40.9		13	50				0.723
Symptomatic	50	44.6		44	100		14	53.8				0.067
Asymptomatic	62	55.3		–	–		12	46.1				0.056
Current smoking	37	33		16	36.3		7	26.9				0.719
Hypertension	51	45.5		23	52.2		14	53.8				0.624
DM	70	62.5		25	56.8		16	61.5				0.805
Peripheral artery disease	21	18.7		10	22.7		4	15.3				0.046
Coronary artery disease	24	21.4		9	20.4		5	19.2				0.966
ICA stenosis			83.67 ±11.19			82.59 ±11.9			81.65 ±12.69			0.684
Contralateral ICA stenosis	28	25		6	13.6		5	19.2		39	21.4	0.285

ICA – internal carotid artery, DM – diabetes mellitus.

Table II. Preoperative, postoperative comparison of patients

Variable	Group 1 C-CEA under general anesthesia *n* = 112 patients			Group 2 E-CEA under general anesthesia *n* = 44 patients			Group 3 E-CEA under local anesthesia *n* = 26 patients			Total		*P*-value
	n	%	Mean ± SD	*n*	%	Mean ± SD	*n*	%	Mean ± SD	*n*	%	
Hb [g/dl]			12.42 ±1.57			13.2 ±2.2			11.96 ±1.69			0.006
Htc (%)			37.2 ±4.49			40.3 ±5.91			35.95 ±4.59			0.001
Plt [1000/µl]			261.82 ±103.6			244.5 ±68			285.26 ±145.4			0.292
Lymphocyte [1000/µl]			1.92 ±0.94			1.82 ±0.96			1.80 ±0.99			0.775
Creatinine [mg/dl]			2.82 ±17.44			1.19 ±1.26			0.91 ±0.37			0.716
Total cholesterol [mg/dl]			170.94 ±40			179.2 ±55.7			171.5 ±45			0.595
Triglycerides [mg/dl]			164.2 ±96.1			153.14 ±65.13			169.2 ±104.2			0.737
HDL-C [mg/dl]			39.6 ±16.3			45.4 ±19.4			40.6 ±10			0.159
LDL-C [mg/dl]			102.6 ±35.7			103.21 ±45.5			102.27 ±40.3			0.995
Shunting	19	16.9		–	–		–	–		19	10.4	0.0005
Post op. stroke	5	4.4		1	2.2		–	–		6	3.2	0.470
Post op. death	3	2.6		1	2.2		–	–		4	2.1	0.703
Post op. cranial nerve injury	3	2.6		3	6.8		1	3.8		10	5.4	0.481
Post op. bleeding	6	5.3		3	6.8		–	–		10	5.4	0.521

Hb – hemoglobin, Htc – hematocrit, HDL-C – high density lipoprotein, LDL-C – low density lipoprotein.

using the Raithel, Berguer, and Vanmaele's technique [5–7]. The patients were examined by Doppler ultrasonography for residual stenosis, restenosis, occlusion, and pseudoaneurysm in the 6th and 12th months. Outcomes of three operation types were compared simultaneously. Table II summarizes the postoperative outcomes.

The study protocol was approved by the local ethics committee (OMU KAEK 2018/496). The study was carried out in accordance with the Helsinki Declaration principles.

Statistical analysis

The Statistical Package for the Social Sciences, Windows Version 21 (SPSS Inc, Chicago, IL, USA) was used to compare the data. The Kolmogorov-Smirnov test was used to analyze normally distributed continuous variables. Categorical variables were presented in percentages and frequencies. The categorical data were tested with the χ^2 test or Fisher's exact test. Continuous variables were presented in mean ± standard deviation (SD). The continuous variables were compared using the *T*-test and the Mann-Whitney *U* test. One-way analysis of variance (ANOVA) and post hoc multiple comparison tests (Bonferroni) were used to compare groups. A *p*-value of < 0.05 was considered statistically significant.

Results

Sample size and demographic features

A total of 182 patients (143 males, 39 females; mean age: 69.69 ±9.88 years; range: 47 to 92 years) who underwent eversion CEA or conventional CEA with patchplasty under general or local anesthesia were included in this study. Eighty-four (46.2%) patients had stenosis in the right carotid artery, 88 (48.4%) patients had stenosis in the left carotid artery and 10 (5.4%) patients had bilateral carotid artery stenosis. A hundred and eight (59.3%) patients were symptomatic, and 74 (40.7%) patients were asymptomatic. The mean ICA stenosis ipsilateral to the surgical side was 83.12 ±12.58 (range: 50–99%). The median time between the last neurologic symptoms and subsequent CEA was 12.4 ±21.92 days (range: 4–35 days). No significant difference was found with respect to age ($p = 0.752$), surgical side ($p = 0.723$), platelets (PLT) ($p = 0.292$), lymphocyte ($p = 0.775$), creatinine ($p = 0.716$), total cholesterol ($p = 0.595$), triglycerides ($p = 0.737$), high-density lipoprotein (HDL) ($p = 0.159$), LDL ($p = 0.995$), post-operative stroke ($p = 0.47$), post-operative death ($p = 0.703$), post-operative bleeding ($p = 0.865$) and post-operative cranial nerve injury ($p = 0.481$) between the groups. Female sex was more common in the C-CEA under general anesthesia group ($p = 0.047$). The groups were homogenous in terms of demographic characteristics. The clinical, demographic and laboratory features are shown in Table I.

Surgical outcomes

Neither systemic toxicity nor conversion to general anesthesia was encountered during surgery under local anesthesia. The mean operation time was 90.61 ±24.96 minutes (range: 55–140 minutes). No difference was detected in terms of the mean operative time in patients with contralateral severe ICA stenosis and patients without contralateral severe ICA stenosis (102.38 ±26.6 minutes vs. 105.05 ±27.7 minutes, $p = 0.523$). Intraluminal shunt was used in 19 patients who all underwent C-CEA under general anesthesia, however, no shunt was required for the E-CEA group

(p = 0.0005). Of those, 5 patients with contralateral severe ICA stenosis, 14 patients without, 11.5% vs. 9.5%, p = 0.56. Nineteen (16.9%) patients who needed shunting were older (73.47 ±6.27, 69.25 ±10.14, respectively, p = 0.005). E-CEA under local anesthesia (83.08 ±15.1 minutes), E-CEA under general anesthesia (103.46 ±23.44 minutes), C-CEA under general anesthesia (113.41 ±33.5 minutes). When we compare the groups in terms of mean operation time, we found a significant difference in favor of E-CEA under local anesthesia (p = 0.001) while no difference was noted between E-CEA under general anesthesia and C-CEA under general anesthesia (p = 0.87). Additionally, overall E-CEA took significantly less time than C-CEA.

Overall, 6 (3.2%) patients developed major stroke (p = 0.470), among them 4 (2.1%) patients passed away (p = 0.703), 7 (3.8%) patients developed cranial nerve injury (the marginal mandibular branch of the facial nerve and hypoglossal nerve) (p = 0.481), 10 (5.4%) patients developed bleeding in the postoperative period (p = 0.521). Of the 6 patients who developed major stroke, 5 were asymptomatic. Of the 4 patients who died, 3 patients were asymptomatic. The most common reason for the perioperative stroke was comprising thromboembolic event in 2 (1%) patients, hyperperfusion in 2 (1%) patients, and ipsilateral internal carotid artery occlusion in 2 (1%) patients. Permanent neurological sequelae were reported in 1 (0.5%) patient. Of the 6 patients with major stroke, 5 patients underwent C-CEA under general anesthesia and, 1 patient underwent E-CEA under general anesthesia while none of the patients underwent E-CEA under local anesthesia, however, no statistically significant difference was detected (p = 0.470). Of those 6 patients, permanent neurological sequelae were developed in 1 (0.5%) patient while the other patient fully recovered in 6 months. All 7 patients with cranial nerve injury completely recovered at the end of 6 months. Only 1 (0.5%) patient had a myocardial infarction in C-CEA under general anesthesia while no heart failure was seen perioperatively. 30-day stroke or death rate was 3.2% and 2.1%, respectively.

Follow-up

The mean follow-up period was 617.45 ±265.1 days (range: 142–1551 days). When we compare the groups with regard to postoperative in-hospital stay (2.58 ±2.35 days for E-CEA under local anesthesia, 7.34 ±6.43 days for E-CEA under general anesthesia, 6.96 ±8.73 days for C-CEA under general anesthesia), we found a significant difference between groups (p = 0.022), between E-CEA under local anesthesia and E-CEA under general anesthesia (p = 0.037), between E-CEA under local anesthesia and C-CEA under general anesthesia (p = 0.027) while no difference was noted between E-CEA under general anesthesia and C-CEA under general anesthesia (p = 1). The mean length of overall in-hospital stay in patients who underwent E-CEA under local anesthesia was 4.04 ±2.5 days, in patients who underwent E-CEA under general anesthesia was 8.02 ±5.53 days, in patients who underwent C-CEA under general anesthesia was 8.38 ±7.51 days (p = 0.01). We found a significant difference between E-CEA under local anesthesia and E-CEA under general anesthesia (p = 0.046), between E-CEA under local anesthesia and C-CEA under general anesthesia (p = 0.008) in terms of in-hospital stay while no difference was noted between E-CEA under general anesthesia and C-CEA under general anesthesia (p = 1) in terms of overall in-hospital stay. Surgery under local anesthesia took significantly less time (p = 0.048).

Discussion

There are numerous articles in the literature comparing the outcomes of general anesthesia and local anesthesia for all techniques of CEA surgery, however, studies which investigate the effects of local anesthesia especially E-CEA are lacking. In this study, we focused on the potential advantages of the local anesthesia technique on E-CEA rather than general anesthesia. Despite that no statistically significant difference was detected, postoperative stroke, death and bleeding rates were lower in patients who underwent E-CEA under local anesthesia. In addition, the mean operation time, postoperative in-hospital stay, overall in-hospital stay and need of shunting were lower in patients who underwent E-CEA under local anesthesia.

Neurological outcomes of CEA under local anesthesia regardless of the surgical technique has also been widely examined in several studies [8–16] and reported to have positive impacts on outcomes including reduced postoperative and overall in-hospital stay, rate of shunt usage, surgery time, cross-clamping time and provides assessment of the neurological dysfunction during CEA [11]. In addition, cognitive functions were found to be improved in patients who were younger than 75 years old after E-CEA under local anesthesia [10]. However, the GALA study revealed that no superiority was found in favor of local anesthesia (93% cervical plexus block, 7% local anesthesia) over general anesthesia regardless of the surgical technique, in terms of neurological outcomes (4.5% local vs. 4.8% general anesthesia) [17]. Interestingly, E-CEA was applied in 20.5% of patients who underwent surgery under local anesthesia in the GALA study, however, no comments have been made on this subject. Our results were similar with the previous study [9] confirming that E-CEA under local anesthesia reduced surgery time, in-hospital stay and shunt usage. Bajwa *et al.* [11] reported that carotid endarterectomy can be performed under regional anesthesia with 89% patient satisfaction. Assadian *et al.* [9] reported that E-CEA under regional anesthesia reduces homocysteine levels which is an independent risk factor for coronary, cerebral, postprocedural intimal hyperplasia and arterial thrombosis and peripheral arterial occlusive disease and, lowers cardiac and cerebral morbidity. Kalko *et al.* [14] reported a 300-patient study that the rate of shunt usage was 5.3%, postoperative stroke rate was 3%, the postoperative death rate was 0.33% during conventional CEA under local anesthesia. In contrast, no postoperative stroke and death were encountered in the E-CEA under local anesthesia group in our study.

Lutz *et al.* [15] reported a 1341-patient study which compared 876 patients who underwent C-CEA with patch closure under general anesthesia and 465 patients who underwent C-CEA under local anesthesia and reported that no statistically significant difference was observed in terms of postoperative death. On the contrary, Watts *et al.* [18] reported a 548-patient study that CEA was performed as either E-CEA or conventional CEA with patch closure which compared the outcomes of local anesthesia and general anesthesia. No difference was detected in terms of in-hospital stay, postoperative stroke, death rate, and surgical complications. Interestingly, the proportion of patients who underwent E-CEA under local anesthesia was not specified and commented. In addition, regression analysis revealed that preoperative symptoms, overall surgery time and anesthesia type were associated with postoperative stroke [15]. Interestingly, Lutz *et al.* [15] found that patients who underwent surgery under local anesthesia with better postoperative neurological outcomes were older.

There is no consensus on local anesthesia, regional anesthesia, or both at the same time for the application of locoregional anesthesia and drug dose. There are several protocols for the use of local anesthetic drugs such as ropivacaine, xylocaine, bupivacaine, prilocaine, lidocaine [13–19]. Lutz *et al.* [15] reported that 15–18 ml 0.75% ropivacaine and 1–5 ml additional xylocaine were administered when needed as local anesthesia and sedatives. Kalko *et al.* [14] proposed a mixture of local anesthesia consisting of 0.5% bupivacaine (10 ml) and prilocaine (10 mg/ml, 10 ml). Cinar *et al.* [20] have recommended 0.25% bupivacaine as local anesthesia. Beside that McCarthy [16] reported a mixture of 0.5% bupivacaine and 1% xylocaine containing 1 : 200000 adrenaline as local anesthesia. Watts *et al.* [18] administered 10 ml of 1% lidocaine without any sedative or anxiolytic agent during CEA under local anesthesia. Intraoperative sedation was applied in 48% of patients under local anesthesia in the GALA study [17] however we did not apply intravenous sedation to patients. Migliara *et al.* [10] noted that neither systemic toxicity nor hoarseness was encountered during surgery under local anesthesia. Our result was similar to the previous study [9]. Martusevicius *et al.* [2] reported that intravenous remifentanil (0.05 mg kg/min) was administered for sedation during surgery, however, we did not apply any sedative drug for the proper examination of neurocognitive functions during surgery. Martusevicius *et al.* [2] applied ropivacaine (7.5 mg/ml) beneath the sternocleidomastoid muscle and surgical region for locoregional anesthesia. Local anesthesia was considered faster and more comfortable rather than regional anesthesia [13]. The incidence of accidental intravascular injection of local anesthetic was the most important complication with a 0.25% rate, which increases postoperative morbidity and mortality [19].

Anesthetics agents affect C2-C4 spinal nerve roots into the deep cervical space during regional anesthesia. Recurrent laryngeal nerve and cervical sympathetic branches were influenced by locoregional anesthesia, which is the most common complication and low-dose anesthetics decrease the incidence of adverse effects. The incidence of hoarseness was 72% during the blocking technique [20]. An additional local anesthetic during cervical plexus blockade was administered in 32–100% of CEA surgeries (2 to 10 ml) [16, 19, 21]. Martusevicius *et al.* [2] reported that locoregional anesthesia which is administered close to the carotid sheath enhances the effect.

In our study, despite that neither postoperative death nor stroke was encountered, no statistical difference was found in favor of E-CEA under local anesthesia. We thought that this result was due to the low number of patients who underwent E-CEA under local anesthesia.

The shunt was found to be an independent predictor for postoperative stroke and death which was less used during local anesthesia [22]. In addition, the rate of unnecessary shunting during CEA under local anesthesia was 85–90% [23–26]. The rate of shunt usage under regional anesthesia ranges from 5% to 20% [2, 6, 8, 13, 24–27]. Shunting may prolong cross-clamping and surgery time. Bourke *et al.* [23] reported that perioperative subclinical cerebral lesions were higher during awake surgery which needed shunt via DWI. Despite shunting (27.9%), subclinical cerebral lesions were more common under general anesthesia (43% vs. 14%) in the GALA study [17], Migliara *et al.* [10] reported that no shunt was used during surgery during E-CEA under local anesthesia. Our findings were similar to Migliara *et al.* that we did not use shunt during E-CEA under local anesthesia [10]. In addition, the rate of conversion to general anesthesia was found to be 1.4% [17] however we did not encounter any conversion.

This study has a number of limitations worth noting. First, we conducted a retrospective study. Second, a relatively high number of patients underwent C-CEA under general anesthesia. Third, the number of patients included in our study may seem relatively small compared to other studies. Fourth, we did not perform any patient under regional anesthesia. Confirmation of our findings will require randomized controlled prospective studies.

Conclusion

In this study, E-CEA under local anesthesia was associated with a significant reduction in operative time, overall in-hospital stay, postoperative in-hospital stay and shunt usage. Despite that postoperative stroke, death and bleeding rates were found to be lower in E-CEA under local anesthesia, no statistically significant difference was observed between local and general anesthesia. Local anesthesia could be better to prevent acute myocardial infarction. To sum up, the current study demonstrates that, as compared to the E-CEA and C-CEA techniques under general anesthesia, E-CEA under local anesthesia seemed to do better in stroke, death and bleeding rate, however this difference was not significant.

Disclosure

The authors report no conflict of interest.

References

1. Pandit JJ, Bree S, Dillon P, Elcock D, McLaren ID, Crider B. A comparison of superficial versus combined (superficial and deep) cervical plexus block for carotid endarterectomy: a prospective, randomized study. Anesth Analg 2000; 91: 781-786.
2. Martusevicius R, Swiatek F, Joergensen LG, Nielsen HB. Ultrasound-guided locoregional anaesthesia for carotid endarterectomy: a prospective observational study. European J Vasc Endovasc Surg 2012; 44: 27-30.
3. Cao P, De Rango P, Cieri E, Giordano G. Eversion versus conventional endarterectomy. Semin Vasc Surg 2004; 17: 236-242.
4. Barnett HJM, Taylor DW, Haynes RB, Sackett DL, Peerless SJ, Ferguson GG, Fox AJ, Rankin RN, Hachinski VC, Wiebers DO, Eliasziw M. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. North American Symptomatic Carotid Endarterectomy Trial Collaborators. N Engl J Med 1991; 325: 445-453.
5. Naylor AR, Ricco JB, de Borst GJ, Debus S, de Haro J, Halliday A, Hamilton G, Kakisis J, Kakkos S, Lepidi S, Markus HS, McCabe DJ, Roy J, Sillesen H, van den Berg JC, Vermassen F, Esvs Guidelines Committee, Kolh P, Chakfe N, Hinchliffe RJ, Koncar I, Lindholt JS, Vega de Ceniga M, Verzini F, Esvs Guideline Reviewers, Archie J, Bellmunt S, Chaudhuri A, Koelemay M, Lindahl AK, Padberg F, Venermo M. Editor's Choice e Management of Atherosclerotic Carotid and Vertebral Artery Disease: 2017 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg 2018; 55: 3-81.
6. Raithel D, Kasprzak P. The eversion endarterectomy – a new technique. In: Surgery for Stroke. Greenhalgh RM, Hollier LH (eds.). WB Saunders Company Ltd., London 1993; 183-191.
7. Berguer R. Eversion endarterectomy of the carotid bifurcation. In: Current Critical Problems in Vascular Surgery. Veith FJ (ed.). Quality Medical Publishing Inc., St. Louis, Missouri 1993; 441-447.
8. Vanmaele RG, Van Schil PE, DE Maeseneer MG, Lehert P, Van Look RF. Endarterectomy and reimplantation for carotid stenosis. In: Modern Vascular Surgery. Chang JB (ed.). Springer-Verlag Inc., New York 1994; 85-95.
9. Assadian A, Eidher U, Senekowitsch C, Assadian O, Rotter R, Hagmuller GW, Hubl W. Carotid endarterectomy under local anaesthesia does not increase plasma homocysteine concentration. Eur J Vasc Endovasc Surg 2005; 30: 617-620.
10. Migliara B, Trentin M, Idone D, Mirandola M, Griso A, Lino M, del Garda P. Neurocognitive changes after eversion carotid endarterectomy under local anesthesia. Ann Vasc Surg 2013; 27: 727-735.
11. Bajwa SP, Ul Haq I, Masood N, Jameel M. Advantages of carotid endarterectomy under local anaesthesia with minimal cerebral moniioring: an experience of 45 cases. Pak Armed Forces Med J 2014; 64: 90-95.
12. Karasu A, Kuscu DY, Bakac G et al. Carotid endarterectomy with regional anesthesia: an audit of 71 cases. Turk Neurosurg 2009; 19: 21-28.
13. Gabelman C, Gann D, Ashworth C, Carney Jr W: One hundred consecutive carotid reconstructions: local versus general anaesthesia. Am J Surg 1983; 145: 477-482.
14. Kalko Y, Aydın U, Bayrak Y, Kafa U, Kosker T, Başaran M, Yangın Z, Yaşar T. Carotid endarterectomy under local anaesthesia: single institutional experience. Interact Cardiovasc Thorac Surg 2006; 5: 570-573.
15. Lutz HJ, Michael R, Gahl B, Savolainen H. Local versus general anaesthesia for carotid endarterectomy e improving the gold standard? Eur J Vasc Endovasc Surg 2008; 36: 145-149.
16. McCarthy RJ, Walker R, McAteer P, Budd JS, Horrocks M. Patient and hospital benefits of local anaesthesia for carotid endarterectomy. Eur J Vasc Endovasc Surg 2001; 22: 13-18.
17. GALA Trial Collaborative Group, Lewis SC, Warlow CP, Bodenham AR, Colam B, Rothwell PM, Torgerson D, Dellagrammaticas D, Horrocks M, Liapis C, Banning AP, Gough M, Gough MJ. General anaesthesia versus local anaesthesia for carotid surgery (GALA): a multicentre, randomised controlled trial. Lancet 2008; 372: 2132-2142.
18. Watts K, Lin PH, Bush RL, Awad S, McCoy SA, Felkai D, Zhou W, Nguyen L, Guerrero MA, Shenaq SA, Lumsden AB. The impact of anesthetic modality on the outcome of carotid endarterectomy. Am J Surg 2004; 188: 741-747.
19. Pandit JJ, Satya-Krishna R, Gration P. Superficial or deep cervical plexus block for carotid endarterectomy: a systematic review of complications. Br J Anaesth 2007; 99: 159-169.
20. Cinar B, Goksel O, Aydogan H, Filizcan U, Cetemen S, Eren E. Early and midterm results of carotid endarterectomy with anterior transverse arteriotomy. Türk Gögüs Kalp Damar Cer Derg 2005; 13: 255-259.
21. Ramachandran SK, Picton P, Shanks A, Dorje P, Pandit JJ. Comparison of intermediate vs subcutaneous cervical plexus block for carotid endarterectomy. Br J Anaesth 2011; 107: 157-163.
22. Allen BT, Anderson CB, Rubin BG, Et al. The influence of anesthetic technique on perioperative complications after carotid endarterectomy. J Vasc Surg 1994; 19: 834-842.
23. Bourke VC, Bourke BM, Beiles CB. Operative factors associated with the development of new brain lesions during awake carotid endarterectomy. Eur J Vasc Endovasc Surg 2016; 51: 167-173.
24. Schnaudigel S, Groschel K, Pilgram SM, Kastrup A. New brain lesions after carotid stenting versus carotid endarterectomy: a systematic review of the literature. Stroke 2008; 39: 1911-1919.
25. Schneider JR, Helenowski IB, Jackson CR, Verta MJ, Zamor KC. Comparison of results with eversion versus conventional carotid endarterectomy from the Vascular Quality Initiative and the Mid-America Vascular Study Group. J Vasc Surg 2015; 61: 1216-1222.
26. Harbaugh RE. Carotid endarterectomy using regional anaesthesia. Neurosurg Clin N Am 2000; 11: 299-307.
27. Mayer RC, Bingley J, Westcott MJ, Deshpande A, Davies MJ, Lovelock ME, Vidovich J, Doyle J, Denton MJ, Gurry JF. Intraoperative neurological changes in 1665 regional anaesthetic carotid endarterectomies predicts postoperative stroke. ANZ J Surg 2007; 77: 49-53.