Scientific Foundation SPIROSKI, Skopje, Republic of Macedonia
Open Access Macedonian Journal of Medical Sciences. 2022 Jul 08; 10(B):1642-1647.
https://doi.org/10.3889/oamjms.2022.9475
eISSN: 1857-9655
Category: *B - Clinical Sciences*
Section: *Surgery*

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The Effect of Severe Contralateral Carotid Stenosis or Occlusion on Early Outcomes after Carotid Endarterectomy

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Edited by: Ksenija Bogoeva-Kostovska
Citation: Djedovic M, Hadzimehmedagic A, Granov N, Haxhibeqiri-Karabdic I, Štraus S, Banjanovic B, Kabil E, Selimovic T. The Effect of Severe Contralateral Carotid Stenosis or Occlusion on Early Outcomes after Carotid Endarterectomy. Open-Access Maced J Med Sci. 2022 Jul 08; 10(B):1642-1647. https://doi.org/10.3889/oamjms.2022.9475
Keywords: CEA; Stenosis; Stroke; Mortality
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Received: 21-Mar-2022
Revised: 04-Apr-2022
Accepted: 27-Jun-2022

Funding: This research did not receive any financial support
Competing Interest: The authors have declared that no competing interest exists

Abstract:

BACKGROUND: Stenosis of the carotid arteries, as a consequence of atherosclerosis, is the most common cause of cerebrovascular insult (CVI). Severe (>70%) contralateral stenosis or occlusion (SCSO) of the carotid artery may represent an additional pre-operative risk factor for neurologic incidents.

AIM: The aim of this study was to confirm and compare early perioperative results (0–30 days) of carotid endarterectomy (CEA) in patients with and without SCSO.

PATIENT AND METHODS: In our retrospective-prospective study, we analyzed the results of 273 CEA, divided into two groups based on the presence of significant contralateral stenosis or occlusion (non-SCSO and SCSO groups)

RESULTS: A total of 273 CEAs were performed, divided into two groups: SCSO groups 40 (14.7%) and non-SCSO group 233 (85.3%). Between the two groups, a statistically significant difference between patients was found (54.1% compared to 87.5%; $p < 0.0005$), CEA with patch angioplasty (25.3% compared to 52.5%; $p = 0.001$), and CEA with the use of a shunt (3.9% compared to 35%; $p < 0.0005$) in favor of the SCSO group. There was no statistically significant difference (SCSO was not identified as a risk factor) for any type of stroke or mortality. Logistically regression confirmed SCSO to be an independent predictor of 30-day mortality (OR: 21.58; 95% CI: 1.27–36.3; $p = 0.033$) and any type of stroke or mortality (OR: 9.27; 95% CI: 1.61–53.22; $p = 0.012$). SCSO was not a predictor of any type of stroke within 30 days. Predictors of any type of stroke were dyslipidemia (OR: 0.12, 95% CI: 0.02–0.76; $p = 0.024$).

CONCLUSIONS: There was no statistically significant difference in the incidence of early (30 day) perioperative complications between the analyzed groups. The percentage of perioperative complications remains within the accepted parameters, and thus, SCSO should not be qualified as a significant risk factor for CEA. We are of the opinion that CEA remains a safe and acceptable option for patients with SCSO, and SCSO should not be a reason for preferential use of carotid stenting.

Introduction

Cerebrovascular insult (CVI) as a consequence of atherosclerotic disease of the carotid arteries (stenosis and occlusion) is the third most common cause of death in developed countries. It is the most common neurologic diagnosis requiring hospitalization [1] and the leading cause of long-term disability [2].

Carotid endarterectomy (CEA), according to the most recent guidelines, remains the recommended "gold standard" in treating symptomatic stenosis of the carotid arteries (50–99%) and prevention of cerebrovascular events [3], [4], [5], [6]. Reported outcomes of severe (>70%) contralateral carotid stenosis or occlusion (SCSO) on perioperative and long-term results of CEA differ in the previous studies. The North American Symptomatic Carotid Endarterectomy Trial (NASCET) reported on the increased risk of perioperative stroke after CEA, in patients with contralateral occlusion of carotid arteries [7], [8]. Surgical intervention, in the aforementioned study, had increased benefits compared to conservative (pharmacologic) treatment, despite the increased perioperative risks. Further analysis of studies regarding asymptomatic carotid atherosclerosis (ACAS) showed that CEA in an asymptomatic patient with contralateral carotid occlusion does not provided long-term benefits in prevention of stroke and death (medical vs. surgical treatment group, 3.5% vs. 5.5%; $p = 0.58$) [9].

Several multicenter studies indicated that SCSO is a risk factor for poor outcome after CEA [10], [11], [12], [13]. Other studies reported an insignificant larger risk of stroke in patients with contralateral carotid disease [14], [15] while many single-center studies reported about the comparable perioperative results for both groups [16], [17], [18], [19], [20].

The goal of this study was to confirm and compare early perioperative results (0–30 days) CEA in patients with and without SCSO.

Patients and Methods

In this retrospective study, 249 patients were included, which underwent CEA due to stenosis of the carotid arteries, in the period from May 1, 2017, to January 31, 2022, in the Clinic for Cardiovascular surgery at the University Clinical Centre of Sarajevo. Patients were dived into two groups: A non-SCSO group (n = 233) in which patients without stenosis of the contralateral internal carotid artery, as well as those with mild (<50%) or moderate (50%–70%), disease of the contralateral carotid arteries. The SCSO group (n = 40) included those patients with severe stenosis (70%-89%), very severe stenosis (90%–99%), or occlusion of the contralateral internal carotid artery.

Our study was conducted in accordance with the Helsinki Declaration of 1975; informed consent was attained from all our patients.

Patients were considered symptomatic if they had transient ischemic attacks, amaurosis fugax, or non-disabling stroke which is ipsilateral compared to the site of significant carotid stenosis of the past 6 months.

In patients with bilateral carotid stenosis, the choice of carotid artery, which was first surgically treated, was conducted according to the following criteria, presence of neurologic symptoms, degree of carotid stenosis, and presence of asymptomatic cerebral infarction.

We gather the following variables for each patient: Age, gender, history of hypertension (HTN), hyperlipidemia (HLP), diabetes mellitus (DM), smoking status, and presence of coronary artery disease (CAD) which was not surgically treated, presence of peripheral arterial disease (PAD), status of symptoms, and details regarding the CEA technique (eversion or classic), type of anesthesia (local or general), and the use of a shunt. Of the post-operative complications, we analyzed the total number of CVI, mortality, and CVI/mortality.

Patients were surgically treated in regional anesthesia, or alternatively, in general anesthesia whenever local anesthesia was not suitable. CEA was conducted with the eversion and classically technique with patch plasty (Dacron patch), along with selective use of shunts.

In patients operated under regional anesthesia, shunts were used according to the level of consciousness and motor function after brief clamping of the carotid artery. Tests for evaluating the degree of consciousness including having the patient count numbers, and motor function was examined by having the patient squeeze rubber toys with the contralateral hand. Following this evaluation, carotid shunts were immediately placed following auditory or motor dysfunction. In the event that pressure in the ICA was lower than 40 mmHg following clamping, shunts were used in patients operated on under general anesthesia [21].

Degree of stenosis was determined by Doppler ultrasound and CT angiography or MR angiography. The source of data was the computerized database and charts of disease history of hospitalized patient records.

Technique eversion CEA entailed transection at the level of the carotid bifurcation with the removal of atherosclerotic plaque distal displacement artery, followed by removal of plaque from the ACC and ACE anatomical reimplantation of ACI.

Clasiccal CEA technique performed with longitudinal arteriotomy of the ACI and ACC and removal of atherosclerotic plaque. Arteriotomy was closed using prosthetic patch. For this study, patients were followed 30 days after the operation.

The inclusion criteria for the study were as follows: Patients with restenosis of the carotid artery, stenosis of the carotid artery with accompanying stenosis of the aortic branches, dissection of the carotid arteries, aneurysm of the carotid arteries, simultaneous CEA operation, and aortic-coronary bypass or peripheral revascularization.

Thirty-day complications were followed in all patients, including all types of stroke, death, and stroke/mortality. Postoperatively, neuroimaging was conducted in only those patients who had neurologic deficits.

Statistical analysis

Basic characteristics of our study were attained and displayed as the number of cases and percentage of prevalence. Categorical values were analyzed using the χ^2 test and Fisher's test. The Student's t-test and Mann–Whitney U-test were used in analyzing quantitative values. Conducted was a univariational logistic regression analyses for the identify the association between clinical variables and perioperative outcomes (within 30 days after CEA). Statistically hypothesis was tested on a level of $\alpha = 0.05$, that is, the difference between samples was considered significant if $p < 0.05$. Statistical analysis was conducted with the help of IBM SPSS Statistics ver. 21.0.

Results

In our retrospective comparative study, a total of 273 CEA were performed, (171 (62.6%) males and 102 (37.4%) females underwent CEA). In the SCSO group were 40 CEA (14.7%) and in the non-SCSO group were 233 (85.3%). During the study, the staging procedure of bilateral CEA was performed on 24 patients: Nine CEA in the group which was non-SCSO and 15 CEA in the SCSO group. Of the patients in the SCSO group who underwent the staging procedure of bilateral CEA, the first CEA which was done on the primary (ipsilateral) lesion was included in the SCSO group, and the second CEA (contralateral lesion) after the first CEA was included in the non-SCSO group.

The average age of patients in the study was 66.17 years (standard deviation ± 8.1, in the range of 46–86 years), the average age of patients in the non-SCSO group was 66.06 years (standard deviation, ± 8.2) (p = 0.596), while the average age of patients in the SCSO group was 66.08 years (standard deviation, ±7.1) (p = 0.689), the presence of males is larger in both groups (62.2% compared 65%) without statistical significance, p = 0.875. The presence of pre-operative risk factors and comorbidities, in the studied groups, was without statistical significance smoking 106 (45.5%) compared to 14 (35 %), p = 0.288; HTN 202 (86.7%) compared to 35 (87.5%), p = 0.998; HLP 195 (83.7%) compared to 33 (82.5%), p = 0.964; DM 73 (31.3%) compared 19 (47.5%), p = 0.069; CAD 51 (21.9%) compared 12 (30%); p = 0.357; and PAD 53 (22.7%) compared 7 (17.5%), p = 0.594 (Table 1). Analyzing the statistics regarding the CEA procedure, no statistically significant differences between the examined groups in anesthesia technique which was used during the procedure (local anesthesia 74.2% compared. 72.5%, general anesthesia 25.8% compared 27.5%); p = 0.970. The SCSO group had a larger, more statistically significant number: Symptomatic patients (54.1% compared to 87.5%; p < 0.0005), CEA with patch angioplasty (25.3% compared to 52.5%; p = 0.001), and CEA with the use of a shunt (3.9% compared to 35%; p < 0.0005) (Table 1).

Perioperative outcomes are displayed in Table 2. For all patients, the rate of stroke of any cause within 30 days was 1.8%, ipsilateral 1.1%, while the rate of contralateral measured 0.7%. The rate of mortality within 30 days for all patients was 0.7%, and the combined rate of stroke/mortality was 2.5%. There was no statistically significant difference between the compared groups regarding any type of stroke (1.8% vs. 2.5%; p = 0.55), ipsilateral (0.9% vs. 2.5%; p = 0.379), mortality (0.4% vs. 2.5%; p = 0.272), and combined rate of mortality/stroke (2.2% vs. 5%; p = 0.273).

Logistically regression showed that SCSO is an independent predictor of 30-day mortality (OR 21.58; 95% CI 1.27–36.3; p = 0.033) and any type of stroke/mortality (OR 9.27; 95% CI 1.61–53.22; p = 0.012). SCSO was not a predictor of stroke of any type within 30 days. Predictors of stroke of any type were dyslipidemia (OR 0.12, 95% CI 0.02–0.76; p = 0.024) (Table 3).

Discussion

Following the first CEA done by DeBakey [22], the procedure has been established as a safe and effective method in lowering the risk of CVI in patients with significant carotid stenosis. Today, CEA is a method with low mortality and perioperative complications, in symptomatic [23] and in unsymptomatic stenosis of the carotid arteries [24].

The results of our study indicate that SCSO is a predictor of 30-day mortality in combined stroke of any cause/death. These conclusions are in line with the findings of Kanga *et al*. [25]. The research by Goodney *et al.* showed that contralateral carotid occlusion was an independent predictor of any type of perioperative stroke/death (OR: 2.8; 95% CI: 1.3–6.2; p = 0.009) [26]. Similar results were published in other studies as well [27].

In contrast to the results of our study, certain research did not show a statistically significant difference in perioperative results following CEA in patients with contralateral carotid disease [18], [20]. SCSO was a predictor of stroke of any cause/death within 30 days, but it was not an independent predictor of ipsilateral or contralateral stroke. In terms of percentages, perioperative stroke in our study was found in a higher number on the contralateral side.

Table 1: Clinical characteristics of the study's patients

Variable	Total (n = 273), n (%)	Non-SCOS (n = 233), n (%)	SCSO (n = 40), n (%)	p
Age (years) ± SD	66.17 ± 8.1	66.06 ± 8.2	66.08 ± 7.1	0.689
Gender				
Male	171 (62.6)	145 (62.2)	26 (65)	0.875
Female	102 (37.4)	88 (37.8)	14 (35)	
Comorbidities				
CAD	63 (23.1)	51 (21.9)	12 (30)	0.357
PAOD	60 (22)	53 (22.7)	7 (17.5)	0.594
Carotid stenosis				
SCSO	40 (14.7)	NA	40 (100)	NA
Several stenosis	27 (9.9)	NA	27 (67.5)	NA
Total occlusion	13 (4.8)	NA	13 (32.5)	NA
Symptomatic status, CEA	161 (59)	126 (54.1)	35 (87.5)	<0.0005*
General anesthesia	71 (26)	60 (25.8)	11 (27.5)	0.970
Local anesthesia	202 (74)	173 (74.2)	29 (72.5)	
Use of shunt	23 (8.4)	9 (3.9)	14 (35)	<0.0005*
Reconstruction technique				
Patch angioplasty	80 (29.3)	59 (25.3)	21 (52.5)	0.001*
Eversion	193 (70.7)	174 (74.7)	19 (47.0)	
Risk factor				
Hypertension	237 (86.4)	202 (86.7)	35 (87.5)	0.998
Dyslipidemia	228 (83.5)	195 (83.7)	33 (82.5)	0.964
Diabetes mellitus	92 (33.7)	73 (31.3)	19 (47.5)	0.069
Smoking	120 (44)	106 (45.5)	14 (35)	0.286

Values are presented as mean ± SD or n (%). SD: Standard deviation, CAD: Coronary artery disease, CEA: Carotid endarterectomy, NA: Not applicable; PAOD: Peripheral arterial occlusive disease, SCSO: Severe contralateral carotid stenosis or occlusion.

Similar findings to those in our study were found in other studies [28]. The reason for such results in our research may be found in the fact that post-occlusive pressure following clamping of the carotid arteries in the SCSO group was significantly lower compared to the non-SCSO patient group, and in those cases, to protect the cerebral circulation, intraoperative use of a temporary shunt (3.9% vs. 35%; p < 0.0005), which resulted in a statistically larger number of CEA PA patch plasty (25.3% vs. 52.5% p < 0.001). Similar to our findings, in other studies, we may also identify a larger rate of the usage of intraoperative shunts in patients with contralateral carotid disease [18], [29], [30].

Table 2: Perioperative outcomes of all patients undergoing carotid endarterectomy comparing those with versus those without severe contralateral carotid stenosis or occlusion

Variable	Within 30-day outcomes after CEA			p
	Total (273), n (%)	Non-SCOS (n = 233), n (%)	SCSO (n = 40), n (%)	
Any stroke	5 (1.8)	4 (1.8)	1 (2.5)	0.550
Ipsilateral	2 (0.7)	2 (0.9)	0	0.984
Contralateral	3 (1.1)	2 (0.9)	1 (2.5)	0.379
Death	2 (0.7)	1 (0.4)	1 (2.5)	0.272
Any stoke/death	7 (2.5)	5 (2.2)	2 (5)	0.273

CEA: Carotid endarterectomy, SCSO: Severe contralateral carotid stenosis or occlusion .

In their research, Hans *et al.* reported the lower rate of shunt usage in patients in whom there is continued monitoring of neurologic status, meaning in patients in whom CEA was conducted under regional anesthesia [31]. This study shows that SCSO is a risk factor for early perioperative (0–30 day) death and stroke of any cause/death following CEA. Despite this, SCSO must not be a reason why CAS should be favored over CEA [32]. Other studies also dispute the plausibility that contralateral occlusion is used as an indication to favor CAS over CEA [33]. Regarding the larger number of post-operative neurologic complications following CAS compared to CEA in patients with contralateral carotid occlusion and occlusion of the vertebral arteries, Yang *et al*. [34] reported similar findings to the specific study, and other studies point out that contralateral occlusion may not be an indication to favor CAS over CEA [35].

The study by Demirel *et al*. illuminates the advantage belonging to C-CEA, by reporting the larger 30-day risk of CVI and death in patients treated with the E-CEA technique (9% compared to 3%, p = 0.005) [36], differing from other studies, which do not have similar findings to our study, and which show the significantly lower mortality and morbidity (1,35% compared to 4%, p < 0.005) [37] as well as the smaller number of CVI (0,9% compared to 2.9%, p < 0.01) and the rate of death 1.8%, compared to 0,54%, p < 0.05 [38], in patients operated on with the E-CEA technique.

Table 3: Independent predictors of 30-day outcomes after carotid endarterectomy

Variable	OR (95% CI)	p
Any stroke		
Dyslipidemia	0.12 (0.02–0.76)	0.024
Death		
SCSO	21.58 (1.27–36.3)	0.033
Any stoke/death		
CEA	6.36 (1.2–33.53)	0.029
SCSO	9.27 (1.61–53.22)	0.012

CEA: Carotid endarterectomy, SCSO: Severe contralateral carotid stenosis or occlusion, OR: Odds ratio, CI: Confidence interval.

Conclusions

Our results contribute to the ongoing debate about the effects of SCSO on early 30-day outcomes following CEA. We identified SCSO as a risk factor for mortality and stroke of any cause/mortality. The results of our research lower cerebral perfusion pressures exist in patients with SCSO which results in more significant preoperative symptoms and exemplifies the need for the usage of an intraoperative intraluminal shunt. SCSO is a predictor of early death following CEA. These patients have a significant burden of cardiovascular risk factors, and thus, aggressive control of these risk factors should be undertaken. Patients with SCSO in whom CEA is planned may benefit from attentive perioperative hemodynamic monitoring and as previously mentioned, usage of a selective intraoperative shunt.

References

1. Wolf PA, Clagett GP, Easton JD, Goldstein LB, Gorelick PB, Kelly-Hayes M, *et al*. Preventing ischemic stroke in patients with prior stroke and transient ischemic attack: A statement for healthcare professionals from the stroke council of the American heart association. Stroke. 1999;30(9):1991-4. https://doi.org/10.1161/01.STR.30.9.1991

   PMid:10471455
2. Centers for Disease Control and Prevention. Prevalence of disabilities and associated health conditions among adults-United States 1999. MMWR Morb Mortal Wkly Rep. 2001;50(7):120-5.

   PMid:11393491
3. Eckstein HH, Kühnl A, Dorfler A, Kopp IB, Lawall H, Ringleb PA. The diagnosis, treatment and follow-up of extracranial carotid stenosis. Multidisciplinary German-Austrian guideline based on evidence and consensus. Dtsch Arztebl Int. 2013;110:468-76. https://doi.org/10.3238/arztebl.2013.0468

   PMid:23964303
4. Brott TG, Halperin JL, Abbara S, Bacharach JM, Barr JD, Bush RL, *et al*. 2011 ASA/ACCF/AHA/AANN/AANS/ACR/ASNR/CNS/SAIP/SCAI/SIR/SNIS/SVM/SVS guideline on the management of patients with extracranial carotid and vertebral artery disease. Stroke. 2011;42(8):e464-540. https://doi.org/10.1161/STR.0b013e3182112cc2

   PMid:21282505
5. Tendera M, Aboyans V, Bartelink ML, Baumgartner I, Clement D, Collet JP, *et al.* ESC guidelines on the diagnosis and treatment of peripheral artery diseases: Document covering atherosclerotic disease of extracranial carotid and vertebral, mesenteric, renal, upper and lower extremity arteries: The task force on the diagnosis and treatment of peripheral artery diseases of the European society of cardiology (ESC). Eur Heart

J. 2011;32(22):2851-906. https://doi.org/10.1093/eurheartj/ehr211

PMid:21282505

6. Naylor AR, Ricco JB, De Borst GJ, Debus S, De Haro J, Halliday A, *et al*. 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. 2017;55(1):3-81. https://doi.org/10.1016/j.ejvs.2017.06.021

PMid:28851594

7. Gasecki AP, Eliasziw M, Ferguson GG, Hachinski V, Barnett HJ. Long-term prognosis and effect of endarterectomy in patients with symptomatic severe carotid stenosis and contralateral carotid stenosis or occlusion: Results from NASCET. North American symptomatic carotid endarterectomy trial (NASCET) group. J Neurosurg. 1995;83(5):778-82. https://doi.org/10.3171/jns.1995.83.5.0778

PMid:7472542

8. Ferguson GG, Eliasziw M, Barr HW, Clagett GP, Barnes RW, Wallace CM, *et al*. The North American symptomatic carotid endarterectomy trial: Surgical results in 1415 patients. Stroke. 1999;30(9):1751-8. https://doi.org/10.1161/01.STR.30.9.1751

PMid:10471419

9. Baker WH, Howard VJ, Howard G, Toole JF. Effect of contralateral occlusion on long-term efficacy of endarterectomy in the asymptomatic carotid atherosclerosis study (ACAS). ACAS investigators. Stroke. 2000;31(10):2330-4. https://doi.org/10.1161/01.STR.31.10.2330

PMid:11022059

10. Menyhei G, Björck M, Beiles B, Halbakken E, Jensen LP, Lees T, *et al*. Outcome following carotid endarterectomy: Lessons learned from a large international vascular registry. Eur J Vasc Endovasc Surg. 2011;41(6):735-40. https://doi.org/10.1016/j.ejvs.2011.02.028

PMid:21450496

11. Ricotta JJ 2nd, Upchurch GR, Landis GS, Kenwood CT, Siami FS, Tsilimparis N, *et al*. The influence of contralateral occlusion on results of carotid interventions from the society for vascular surgery vascular registry. J Vasc Surg. 2014;60(4):958-65. https://doi.org/10.1016/j.jvs.2014.04.036

PMid:25260471

12. Maatz W, Köhler J, Botsios S, John V, Walterbusch G. Risk of stroke for carotid endarterectomy patients with contralateral carotid occlusion. Ann Vasc Surg. 2008;22(1):45-51. https://doi.org/10.1016/j.avsg.2007.07.034

PMid:18083336

13. Antoniou GA, Kuhan G, Sfyroeras GS, Georgiadis GS, Antonious SA, Murray D, *et al.* Contralateral occlusion of the internal carotid artery increases the risk of patients undergoing carotid endarterectomy. J Vasc Surg. 2013;57(4):1134-45. https://doi.org/10.1016/j.jvs.2012.12.028

PMid:23462196

14. Mozes G, Sullivan TM, Torres-Russotto DR, Bower TC, Hoskin TL, Sampaio SM, *et al*. Carotid endarterectomy in SAPPHIRE-eligible high-risk patients: Implications for selecting patients for carotid angioplasty and stenting. J Vasc Surg. 2004;39(5):958-66. https://doi.org/10.1016/j.jvs.2003.12.037

PMid:15111844

15. Ballotta E, Da Giau G, Guerra M. Carotid endarterectomy and contralateral internal carotid artery occlusion: Perioperative risks and long-term stroke and survival rates. Surgery. 1998;123(2):234-40. https://doi.org/10.1016/S0039-6060(98)70263-6

PMid:9481411

16. Rockman CB, Su W, Lamparello PJ, Adelman MA, Jacobowitz GR, Gagne PJ, *et al*. A reassessment of carotid endarterectomy in the face of contralateral carotid occlusion: Surgical results in symptomatic and asymptomatic patients. J Vasc Surg. 2002;36(4):668-73.

PMid:12368723

17. Grego F, Antonello M, Lepidi S, Zaramella M, Galzignan E, Menegolo M, *et al*. Is contralateral carotid artery occlusion a risk factor for carotid endarterectomy? Ann Vasc Surg. 2005;19(6):882-9. https://doi.org/10.1007/s10016-005-7719-2

PMid:16200472

18. Kretz B, Abello N, Astruc K, Terriat B, Favier C, Bouchot O, *et al*. Influence of the contralateral carotid artery on carotid surgery outcome. Ann Vasc Surg. 2012;26(6):766-74. https://doi.org/10.1016/j.avsg.2011.12.009

PMid:22717355

19. Pulli R, Dorigo W, Barbanti E, Azas L, Russo D, Matticari S, *et al*. Carotid endarterectomy with contralateral carotid artery occlusion: Is this a higher risk subgroup? Eur J Vasc Endovasc Surg. 2002;24(1):63-8. https://doi.org/10.1053/ejvs.2002.1612

PMid:12127850

20. Dalainas I, Nano G, Bianchi P, Casana R, Malacrida G, Tealdi DG. Carotid endarterectomy in patients with contralateral carotid artery occlusion. Ann Vasc Surg. 2007;21(1):16-22. https://doi.org/10.1016/j.avsg.2006.06.003

PMid:17349330

21. Calligaro KD, Dougherty MJ. Correlation of carotid artery stump pressure and neurologic changes during 474 carotid endarterectomies performed in awake patients. J Vasc Surg. 2005;42(4):684-9. https://doi.org/10.1016/j.jvs.2005.06.003

PMid:16242555

22. De Bakey ME, Crawford ES, Cooley DA, Moriss GC Jr. Surgical considerations of occlusive disease of innominate, carotid, subclavina and vertebral arteries. Ann Surg. I959;149(5):690-710. https://doi.org/10.1097/00000658-195905000-00010

PMid:13637687

23. Barnett HJ, Taylor DW, Eliasziw M, Fox A, Gary F, Brian H, *et al*. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. North American symptomatic carotid endarterectomy trial collaborators. N Engl J Med. 1998;339(20):1415-25. https://doi.org/10.1056/NEJM199811123392002

PMid:9811916

24. Halliday A, Mansfield A, Marro J, Peto C, Peto R, Potter J, *et al*. Prevention of disabling and fatal strokes by successful carotid endarterectomy in patients without recent neurological symptoms; Randomized controlled trial. Lancet. 2004;363(9420):1491-502. https://doi.org/10.1016/S0140-6736(04)16146-1

PMid:15135594

25. Kang J, Conrad MF, Patel VI, Mukhopandhyay S, Garg A, Cambria MR, *et al*. Clinical and anatomic outcomes after carotid endarterectomy. J Vasc Surg. 2014;59(4):944-9. https://doi.org/10.1016/j.jvs.2013.10.059

PMid:24661892

26. Goodney PP, Likosky DS, Cronenwett JL. Factors associated with stroke or death after carotid endarterectomy in Northern New England. J Vasc Surg. 2008;48(5):1139-45. https://doi.org/10.1016/j.jvs.2008.05.013

PMid:18586446

27. Tu JV, Wang H, Bowyer B, Green L, Fang J, Kucey D. Risk factors for death or stroke after carotid endarterectomy: Observations from the ontario carotid endarterectomy registry. Stroke. 2003;34(11):2568-73. https://doi.org/10.1161/01.STR.0000092491.45227.0F

PMid:14526040

28. AbuRahma AF, Stone PA, Abu-Halimah S, Welch CA. Natural

history of carotid artery occlusion contralateral to carotid endarterectomy. J Vasc Surg. 2006;44(1):62-6. https://doi.org/10.1016/j.jvs.2006.03.010

PMid:16828427

29. Chiriano J, Abou-Zamzam AM, Nguyen K, Molkara AM, Zhang WW, Bianchi C, *et al*. Preoperative carotid duplex findings predict carotid stump pressures during endarterectomy in symptomatic but not asymptomatic patients. Ann Vasc Surg. 2010;24(8):1038-44. https://doi.org/10.1016/j.avsg.2010.05.014

PMid:21035695

30. AbuRahma AF, Mousa AY, Stone PA, Hass SM, Dean LS, Keiffer T. Correlation of intraoperative collateral perfusion pressure during carotid endarterectomy and status of the contralateral carotid artery and collateral cerebral blood flow. Ann Vasc Surg. 2011;25(6):830-6. https://doi.org/10.1016/j.avsg.2011.04.002

PMid:21680143

31. Hans SS, Jareunpoon O. Prospective evaluation of electroencephalography, carotid artery stump pressure, and neurologic changes during 314 consecutive carotid endarterectomies performed in awake patients. J Vasc Surg. 2007;45(3):511-5. https://doi.org/10.1016/j.jvs.2006.11.035

PMid:17275248

32. Brewster LP, Beaulieu R, Kasirajan K, Corriere MA, Ricotta JJ 2nd, Patel S, *et al*. Contralateral occlusion is not a clinically important reason for choosing carotid artery stenting for patients with significant carotid artery stenosis. J Vasc Surg. 2012;56(5):1291-5. https://doi.org/10.1016/j.jvs.2012.04.033

PMid:22840742

33. Paraskevas KI, Veith FJ. The indications of carotid artery stenting in symptomatic patients may need to be reconsidered. Ann Vasc Surg. 2015;29(1):154-9. https://doi.org/10.1016/j.avsg.2014.08.010

PMid:25305422

34. Yang SS, Kim YW, Kim DI, Kim KH, Jeon P, Kim GM, *et al*. Impact of contralateral carotid or vertebral artery occlusion in patients undergoing carotid endarterectomy or carotid artery stenting. J Vasc Surg. 2014;59(3):749-55. https://doi.org/10.1016/j.jvs.2013.10.055

PMid:24360588

35. Samson RH, Cline JL, Showalter DP, Lepore MR. Contralateral carotid artery occlusion is not a contraindication to carotid endarterectomy even if shunts are not routinely used. J Vasc Surg. 2013;58(4):935-40. https://doi.org/10.1016/j.jvs.2013.04.011

PMid:24075103

36. Demirel S, Attigah N, Bruijnen H, Ringleb P, Eckstein HH, Fraedrich G, *et al*. Multicenter experience on eversion versus conventional carotid endarterectomy in symptomatic carotid artery stenosis: Observations from the stent-protected angioplasty versus carotid endarterectomy (SPACE-1) trial. Stroke. 2012;43(7):1865-71. https://doi.org/10.1161/STROKEAHA.111.640102

PMid:22496334

37. Entz L, Jaranyi ZS, Nemes A. Comparison of perioperative results obtained with eversion endarterectomy and with conventional patch plasty. Cardiovasc Surg. 1997;5(1):16-20. https://doi.org/10.1016/S0967-2109(96)00078-6

PMid:9158117

38. Green RM, Greenberg R, Illig K, Shortell C, Ouriel K. Eversion endarterectomy ofthe carotid artery: Technical considerations and recurrent stenosis. J Vasc Surg. 2000;32(6):1052-61. https://doi.org/10.1067/mva.2000.111283

PMid:11107076