



Association between index symptom and timing on perioperative stroke rate in patients undergoing carotid endarterectomy

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ARTICLE INFO

Keywords:

Carotid endarterectomy
Timing of intervention
Index symptoms
Post-operative stroke

ABSTRACT

Background and Purpose: Carotid endarterectomy (CEA) in symptomatic carotid stenosis (SCS) may have a higher risk of perioperative stroke due to disease severity or hemorrhagic conversion. This study aimed to evaluate CEA outcomes for SCS and examine causes of post-operative stroke based on intervention timing and preoperative symptoms.

Methods: All CEAs performed for SCS from 2012 to 2023 across two metropolitan hospitals were analyzed. CEAs were performed with general anesthesia, patching, and shunting. Post-operative (30-day) strokes were classified as technical, hemorrhagic, or embolic and were evaluated by timing (<48 h, 48h–2 weeks, >2 weeks) and preoperative symptoms (TIA/amaurosis fugax, minor stroke, moderate-severe stroke, crescendo TIAs/stroke in evolution). Stroke severity was assessed using the modified Rankin Scale (mRS).

Results: Among 664 CEAs, post-operative stroke occurred in 3.0 % of cases. Timing significantly influenced stroke rates: 5.7 % <48 h, 4.0 % between 48h–2 weeks, and 1.4 % >2 weeks ($P = .04$). Preoperative symptoms also affected stroke rates, with highest rates following crescendo TIAs/stroke in evolution (7.5 %, $P = .02$). Early CEA (<48 h) independently increased stroke risk (odds ratio 5.6, $P = .04$), and hemorrhagic strokes were associated with <48 h interventions ($P = .005$). Major strokes occurred in 1.1 % of cases, linked to preoperative symptoms ($P = .05$), but not intervention timing.

Conclusions: CEA for SCS carries an acceptable stroke risk overall, though early intervention (<48 h) increases hemorrhagic stroke risk. Major strokes are more frequent following crescendo TIA/stroke in evolution, with no association to timing.

Introduction

Carotid endarterectomy (CEA) has been proven to be effective for stroke prevention in patients with symptomatic carotid stenosis (SCS). However, the long-term benefit of CEA in stroke prevention is still hampered by strokes that occur within the perioperative phase. Recent recommendations suggest to perform CEA within 14 days from the index symptoms to reduce the risk of recurrent ischemic events. However, the recommendations regarding a very early CEA (i.e. within 48 hours) differ among the major society guidelines^{2,3} (EJVES - European Society for Vascular and Endovascular Surgery and SVS - Society for Vascular Surgery) as a consequence of a diverse analysis of the literature. The Swedish experience,⁴ compared with the UK⁵ and the German⁶ data,

reports a significantly higher rate of post-operative stroke in CEA performed within 48 hours from symptoms. Considering these results and those of the Vascular Quality Initiative,⁷ the SVS guidelines³ recommend to perform CEA within 2 weeks from symptoms onset yet after 48 h. Differently The ESVS guidelines² recommend CEA within 2 weeks from symptoms with no mention about a possible treatment within 48 h from symptoms.

Another element possibly affecting the CEA outcome is the type of the index symptom. Patients suffering from stroke seem to have a higher risk of post-operative events compared to patients with TIA, and the risk is further increased in case of moderate/severe stroke or crescendo TIA/stroke in evolution.¹ However, the data on the outcome of SCS according to the type of index symptom are contradictory.⁸⁻¹⁰ A recent experience⁸

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<https://doi.org/10.1016/j.jstrokecerebrovasdis.2025.108441>

Received 4 December 2024; Received in revised form 5 August 2025; Accepted 25 August 2025

Available online 26 August 2025

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reports a similar rate of postoperative stroke independently of the type of index symptom: 2 % in patients with mRS <3 and 5 % in patients with moderate/severe stroke (mRS 3-5). However, the low number of patients included in the study may affect these results. A recent systematic review confirmed a worse outcome of CEA after stroke compared with transient symptoms of TIA and AF1.

Overall, the interaction between the timing of CEA after the index event and the type of index symptom has been scarcely investigated in the literature but is extremely important in practical clinical activities. In our previous experiences we investigated selectively patients with moderate stroke and large volume cerebral ischemic lesions submitted to CEA,^{9,11} and we identified a significant higher post-operative complications rate in those surgically treated in the first month from symptoms.

Moreover, different aetiologies can lead to a post-operative stroke: haemorrhagic conversions of the ischemic lesions, technical flaws, or plaque embolization during the carotid dissection, which can be a confounding factor in the analysis of SCS revascularization outcomes. The present study aimed to evaluate the outcome of CEA for SCS and to investigate the severity and possible causes of post-operative strokes according to the timing of intervention and index symptom.

Methods

Patients

All CEAs performed from 2012 to 2023 in two large community hospitals, hubs for 6 peripheral hospitals for patients who suffered of stroke. Patients were prospectively entered into a dedicated database, reporting the clinical characteristics, cardiovascular risk factors and technical surgical aspects, as previously reported.¹¹ The patients included in the study had a SCS >50 %, in accordance with the current guidelines for CEA.²

The study was performed following the rules of our institutional Ethical Review Board (CE-AVEC – n. 3686) and all patients gave their informed consent. The database was de-identified according to the European General Data Protection Regulation (EU 2016/679).

Neurological symptoms definitions and timing of CEA after index event

All patients were preoperatively evaluated by an in-hospital neurologist and preoperative neurological symptoms were categorized according to the current guidelines and modified Rankin scale (mRS)¹² in: transient ischemic attack (TIA)/Amaurosis fugax (AF), minor stroke (mRS: 0-2), Moderate severe stroke (mRS: 3-4), crescendo TIA (cTIA) / stroke in evolution (Se). mRS grades stroke-related disability as 0 (none), 1 (not significant), 2 to 3 (moderate), 4 to 5 (severe), and 6 (dead). The timing of CEA was defined with the neurologist according to the ABCD2 score,¹³ the clinical condition and logistic issues. The main timing target was to operate the patients within 2 weeks from the index event, except for moderate /severe stroke that are procrastinated up to neurological symptoms stabilization. For patients referring from other hospitals or with neurological symptoms with an uncertain timing onset, CEA was performed in the earliest possible time.

Definition of procedural stroke

Both ipsilateral and contralateral post-operative (30 days) strokes were considered. Procedural and post-operative stroke was defined major with mRS¹² values ≥ 3 ; mRS ≤ 2 strokes were classified as minor.

Stroke etiology was classified according to the following definition:

Technical. The stroke was likely caused by a technical defect of the endarterectomy or other intraoperative complications. Specifically: i) *Acute thrombosis*; stroke was associated with a sudden complete thrombosis localized at the endarterectomy site. ii) *Residual flap*; a residual flap was identified at the site of endarterectomy by radiological assessment

after the stroke onset or during a surgical revision. iii) *Intraoperative complications*; other possible causes of stroke associated with the intervention, such as an iatrogenic dissection or other injury of the internal carotid artery.

Embolic. No defects were identified at the site of endarterectomy by radiological imaging or during the surgical revision, and were further divided into i) *immediate embolic stroke*; possible embolization during the dissection and *late embolic stroke*; embolization from other possible sources occurring after the index procedure.

Hemorrhagic. Hemorrhagic stroke

Contralateral. Any stroke - ischemic or hemorrhagic - in the contralateral hemisphere of CEA. This particular etiology of stroke was considered in the analysis of the different causes of stroke and their intensity.

In case of stroke identified immediately after CEA, the patient was re-anesthetized and the carotid bifurcation re-explored. A direct carotid digital subtraction angiography was performed to identify possible causes of stroke and a surgical revision of the endarterectomy was performed if necessary. In case of stroke occurring outside the operating room, a cerebral computed tomography angiography of the supra-aortic and intracerebral vessels was performed in order to establish the necessity of a surgical revision.

Surgical technique

CEA was routinely performed under general anesthesia, with longitudinal arteriotomy, routine shunting and patching (Dacron) and cerebral near infrared spectroscopy monitoring (NIRS). Eversion endarterectomy was alternatively performed when anatomically indicated. Shunting (Bard, 8195 Industrial Blvd. Covington, GA 30014 USA) was used routinely after plaque removal. NIRS monitoring was employed in all cases despite routine shunting, in order to ascertain efficacy of brain perfusion. Intraoperative duplex ultrasonography was performed for quality control.

Statistical analysis

Continuous variables were described with mean and standard deviation (SD) for normal distribution and were compared by unpaired Student' t-test. The differences between percentages were assessed using Fisher's test or Chi-square test, when appropriate. Multivariate analysis was performed to investigate the influence of different risk factors on post CEA stroke by binary logistic regression including in the model timing of surgery and type of symptoms, as the categories of reference were considered the factors with lower risk at the univariable analysis. Risk factors were reported as odds ratio (OR) and 95 % of confidence interval (CI). A value of $p \leq .05$ (two-tailed) was considered to be significant. The statistical tests were performed using SPSS® 21.0 for Windows® (SPSS, Chicago, IL, USA).

Results

Post-operative stroke according to the timing and type of index symptoms

Over a total of 664 CEAs for SCS, (general clinical characteristics are reported in the supplementary appendix) 262 (40 %) were performed for stroke, 322 (48 %) for TIA/FA, and 80 (12 %) for cTIA/Se. [Table 1](#) summarizes the clinical characteristics and the index events.

The mean time elapsed from the index event to CEA was 21 ± 7 days. Ten % (70) of patients were treated within 48 h, 46 % (303) in the period between 2 and 14 days and 44 % (291) after 2 weeks, as reported in [Table 1](#).

Twenty (3.0 %) post-operative strokes occurred, as reported in detail in [Table 2](#). Three post-operative strokes were contralateral. One stroke was haemorrhagic and occurred in the first 24 h after CEA; the other two cases were cardio-embolic and occurred in the post-operative day 2.

Table 1
clinical and operative characteristics of the population examined.

Preoperative symptoms	N (%)
Transient ischemic attack or amaurosis fugax	322 (48)
Minor stroke (mRS <2)	130 (20)
Moderate Severe stroke (mRS 3-4)	132 (20)
Crescendo TIA/stroke in evolution	80 (12)
Timing of CEA	
<48h	70 (10)
3-14 days	303 (46)
>14 days	291 (44)

mRS: modified Rankin scale; CEA: carotid endarterectomy.

Table 2
30-day post operative event.

Events	n	%
Stroke	20	3.0
Ipsilateral stroke	17	2.5
Stroke >2 mRS	7	1.1
Etiology		
Ipsilateral Hemorrhagic stroke	3	0.5
Ipsilateral Technical stroke	7	1.1
Ipsilateral Micro-embolic	7	1.1
Contralateral (1 hemorrhagic, 2 micro-embolic)	3	0.5

Excluding the contralateral strokes the 30-day stroke rate was 2.5 % (n:17).

Two deaths occurred at 30-day for a stroke/death rate of 3.1 %.

The majority, 16/20 (80 %) of post-operative strokes occurred in the first 24 h after CEA.

The timing from index event to CEA had a significant association with the post-operative stroke rate: 5.7 % within 48 h, 4.0 % between 48h-2 weeks, and 1.4 % after 2 weeks, $P = .04$. Similarly, the type of preoperative symptom affected the post-operative stroke rate: 3 % after stroke, 1.8 % after TIA/AF, and 8.7 % after cTIA/Se, $P = .02$. Table 3 reports the stratification of post-operative stroke according with the type of index event and the timing of CEA.

On binary logistic regression analysis of post-operative stroke according with timing of surgery and type of index event identified that patients with treated in <48 h had higher rate of post-operative stroke, OR 5.6 (95 % CI: 1.4-23), $P = .02$, Table 4.

Type and severity of post-operative stroke

Twenty (3.0 %) post-operative strokes occurred, 3 (15 %) haemorrhagic, 6 (30 %) technical, and 11 (55 %) embolic. Only the timing of CEA was associated with the type of post-operative stroke. In particular, CEA performed <48 h was associated with haemorrhagic strokes (all 4 haemorrhagic strokes occurred in CEA <48 h, $P = .01$), Table 5.

Table 3
30-day stroke rate after carotid endarterectomy for symptomatic carotid artery stenosis according with the type of preoperative symptoms and the timing of surgery from symptoms onset.

Preoperative symptoms	Total	<48h	3-14 days	>14 days	P
TIA/AF	322	5.6 % (2/36)	2.9 % (4/136)	0 % (0/150)	.02
Minor stroke	130	7.1 % (1/14)	0 % (0/50)	1.5 % (1/66)	.12
Moderate severe stroke	132	12.5 % (1/8)	3.1 % (2/65)	5.1 % (3/59)	.46
Crescendo TIA / Stroke in evolution	80	0 % (0/12)	11.5 % (6/52)	0 % (0/16)	.17
P		.69	.02	.04	
Total	664	70	303	291	

TIA: transient ischemic attack, AF: amaurosis fugax.

Table 4
Binary logistic regression analysis for risk factors for post-operative stroke.

Factor	OR (95 %CI)	P
Timing: 24-48h	5.6 (1.4-23)	.02
Timing: 3-14 days	1.5 (0.4-5.6)	.50
Timing: >14 days	ref	-
Symptom: TIA/AF	ref	-
Symptom: minor stroke	0.83 (0.84-0.16)	.83
Symptom: moderate/severe stroke	2.8 (0.8-9.2)	.08

TIA: transient ischemic attack, AF: amaurosis fugax; OR: odd ratio; CI: confidence interval.

Crescendo TIA/ stroke in evolution was not included in the model 'a priori'.

Table 5
type of perioperative stroke and timing of carotid endarterectomy.

Type of post-op stroke	<48h	3-14 days	>14 days	P
Hemorrhagic	4.3 %	0 %	0 %	.005
Technical	2.9 %	0.7 %	1.0 %	.26
Embolic	1.4 %	2.0 %	0 %	.06

Major post-operative strokes occurred in 7/664 (1.1 %) cases and were significantly associated with the index event with a higher rate in patients with cTIA/Se. The timing of intervention was not associated with the severity of postoperative stroke, Table 6.

Discussion

This study investigates the outcomes of a prospective maintained registry of 664 patients who underwent CEA for SCS. This real-world registry reflects the typical population of SCS patients undergoing CEA, with about half presenting with transient symptoms (TIA/AF), 40 % with stroke, and 12 % with cTIA/Se. The timing of CEA after index event is reasonably acceptable; 56 % of patients were treated within two weeks of symptom onset, considering also patients with moderate to severe stroke (20 %), who usually experience longer waiting times before surgery.

The overall post-operative stroke rate of 3 % aligns with the existing literature,⁴⁻⁷ with specific rates of 1.9 % and 1.4 % for patients with perioperative TIA/AF or minor stroke, respectively. The study confirms a higher rate of post-operative stroke in patients with preoperative moderate to severe stroke or crescendo symptoms.^{14,15} This finding is consistent with the literature, which often reports a higher rate of post-operative events in patients with crescendo symptoms, distinguishing them from the typical symptomatic carotid stenosis patients, who are generally treated after single episodes. However, this study found a higher post-operative stroke rate in patients with moderate to severe stroke, differently from other studies, where patients with minor and more severe strokes have similar outcomes.⁸

Stratification of index event and surgery timing revealed that undergoing surgery within 48 hours is an independent risk factor for post-

Table 6
severe stroke (mRS>2) after CEA according with preoperative symptoms and timing of surgery.

Preoperative symptoms	%	P
Transient ischemic attack or amaurosis fugax	0 %	
Minor stroke (mRS <2)	1.5 %	
Moderate Severe stroke (mRS 3-4)	1.5 %	.05
Crescendo TIA/stroke in evolution	3.8 %	
Timing of CEA		
<48h	1.4 %	
3-14 days	1.3 %	.16
>14 days	0.7 %	

CEA: carotid endarterectomy; mRS: modified Rankin scale; TIA: transient ischemic attack.

operative stroke. Moderate to severe stroke showed a trend towards significance. These results corroborate findings from other registries, confirming the increased risk associated with urgent CEA (<48 h), regardless of preoperative symptoms. Similar data from the Swedish registry⁴ and VQI⁷ analysis support this finding. The UK registry⁵ similarly reported a higher rate of 30-day stroke/death in patients treated within 48 h but with an acceptable event rate of 3.7%. Conversely, the German registry⁶ reports a similar in-hospital stroke/death rate in the different timing of surgery; however, the in-hospital analysis reduces the time of evaluation of post-operative (30-day) events.

These discrepancies suggest that detailed patient data, including preoperative symptoms, should be considered when assessing post-operative stroke rate, causes and severity.

Evaluating the causes of the post-operative stroke, haemorrhagic strokes were predominantly associated with CEA performed within 48 hours of symptom onset, with all haemorrhagic events occurring in patients operated urgently. This observation can reduce potential confounding factors in the analysis of post-operative stroke concerning surgery timing, highlighting a non-technical bias towards worse outcomes in urgent settings.¹⁶⁻¹⁹

The analysis of the causes of post-operative stroke after CEA is surprising low evaluated in literature; there are some evaluations for asymptomatic patients but few studies on symptomatic patients,^{20,21} probably for the difficulty to establish the causes of post-operative stroke considering that in some experience about 7% are contralateral and 18% are haemorrhagic.

Severe post-operative stroke, leading to significant disability, is relatively rare, with a 1.1% event rate. This severe complication is associated with preoperative cTIA/Se, suggesting increased cerebral tissue sensitivity to ischemia in these patients. However, surgery timing did not correlate with post-operative stroke severity.

The present data raise some concerns regarding the treatment with CEA within 48 hours, especially considering the potential reduction in the risk of recurrent stroke after symptoms with modern medical therapies such as dual antiplatelet therapy, high-dose antihypertensive medication, and statins. Some studies²²⁻²⁴ have reported that symptom recurrence in the first 48 hours can be significantly reduced to <1% compared to the NASCET²⁵ or ECST²⁶ trials with an aggressive medical approach; nevertheless, half of the strokes recurred in the first 48 h from index event. The previous data in literature are still contradictory: some experiences indicate that the 48-hour recurrence ischemic neurological events rate is as low as 5%,^{27,28} up to 9% of Mono et al.²⁹ and as high as 21% in the experience of Ois et al.,³⁰ but in these studies no aggressive medical therapy was applied.

By the way, the risk of stroke at 48 h after neurological symptoms need an accurate analysis also according to the type of index event: in NASCET trial the 48 h risk of stroke after TIA was 5.5% and after stroke was 0%, therefore according to the present data the benefit from a 48 h CEA after stroke is dubitable.³¹

The present study suffers from some limits. The observational nature of the study affects the patients selection for CEA and also the timing as well the logistic issues from the peripheral hospitals can delay same urgent treatment and the absence of a control group with modern and aggressive medical therapies after symptoms onset did not allow a complete view on this topic.

Additionally, given that the majority of post-operative strokes occurred within 24 hours of surgery, it is difficult to completely rule out the possibility that some of these events represented ongoing or recurrent ischemic events that began immediately prior to or during the procedure.

The findings of the present study suggest that an adequate patient selection for urgent CEA should involve evaluating the risk of stroke recurrence, potentially using the ABCD² score, and employing more sensitive imaging modalities than computed tomography, such as magnetic resonance imaging, to identify cerebral conditions that may pose risks for surgery. This approach could help mitigate the heightened

risk associated with performing CEA within 48 hours of symptom onset, which should be considered with an adequate patient selection.

In conclusion, the data of the present work suggest a higher risk for post-operative stroke after CEA within the first 48 hours from symptom onset, independently of the type of preoperative symptoms, with a significantly higher risk of haemorrhagic strokes. Severe post-operative stroke is infrequent (1.1%) and it is not associated with the timing of CEA.

CRedit authorship contribution statement

Rodolfo Pini: Writing – review & editing, Writing – original draft, Formal analysis, Data curation, Conceptualization. **Gianluca Faggioli:** Writing – review & editing, Visualization, Supervision. **Gert J de Borst:** Writing – review & editing, Supervision. **Marcello Lodato:** Writing – original draft, Data curation, Conceptualization. **Andrea Vacirca:** Validation. **Gemmi Sufali:** Data curation. **Enrico Gallitto:** Validation, Supervision. **Cristina Rocchi:** Data curation. **Mauro Gargiulo:** Validation, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jstrokecerebrovasdis.2025.108441](https://doi.org/10.1016/j.jstrokecerebrovasdis.2025.108441).

References

- Ball S, Ball A, Antoniou GA. Editor's Choice - prognostic role of pre-operative symptom status in carotid endarterectomy: a systematic review and meta-analysis. *Eur J Vasc Endovasc Surg.* 2020;59(4):516–524.
- Naylor R, Rantner B, Ancetti S, de Borst GJ, De Carlo M, Halliday A, et al. Editor's Choice - European Society for Vascular Surgery (ESVS) 2023 Clinical practice Guidelines on the management of atherosclerotic carotid and vertebral artery disease. *Eur J Vasc Endovasc Surg.* 2023;65(1):7–111.
- AbuRahma AF, Avgerinos ED, Chang RW, Darling 3rd RC, Duncan AA, Forbes TL, et al. Society for Vascular Surgery clinical practice guidelines for management of extracranial cerebrovascular disease. *J Vasc Surg.* 2022;75(1S):4S–22S.
- Strömberg S, Gelin J, Osterberg T, Bergström GM, Karlström L, Osterberg K. Swedish Vascular Registry (Swedvasc) Steering Committee. Very urgent carotid endarterectomy confers increased procedural risk. *Stroke.* 2012;43(5):1331–1335.
- Lofthus IM, Paraskevas K, Johal A, Waton S, Heikkilä K, Naylor AR, et al. Delays to surgery and procedural risks following carotid endarterectomy in the UK National Vascular registry. *Eur J Vasc Endovasc Surg.* 2016;52:438e43.
- Tsantilas P, Kuehl A, König T, Breikreuz T, Kallmayer M, Knappich C, et al. Short time interval between neurologic event and carotid surgery is not associated with an increased procedural risk. *Stroke.* 2016;47(11):2783–2790. Erratum in: *Stroke.* 2016;47(12):e279.
- Tanious A, Pothof AB, Boitano LT, Pendleton AA, Wang LJ, de Borst GJ, et al. Timing of carotid endarterectomy after stroke: retrospective review of prospectively collected national database. *Ann Surg.* 2018;268(3):449–456.
- Cruddas L, Baker DM. Does modified rankin score (mRS) matter? The impact of stroke severity on carotid artery endarterectomy (CEA) outcomes. *Ann Vasc Surg.* 2023;93:351–354.
- Pini R, Faggioli G, Vacirca A, Dieng M, Goretti M, Gallitto E, et al. The benefit of deferred carotid revascularization in patients with moderate-severe disabling cerebral ischemic stroke. *J Vasc Surg.* 2021;73(1):117–124.
- Faggioli G, Pini R, Mauro R, Gargiulo M, Freyrie A, Stella A. Perioperative outcome of carotid endarterectomy according to type and timing of neurologic symptoms and computed tomography findings. *Ann Vasc Surg.* 2013;27(7):874–882.
- Pini R, Faggioli G, Longhi M, Ferrante L, Vacirca A, Gallitto E, et al. Impact of acute cerebral ischemic lesions and their volume on the revascularization outcome of symptomatic carotid stenosis. *J Vasc Surg.* 2017;65(2):390–397.
- Kasner SE. Clinical interpretation and use of stroke scales. *Lancet Neurol.* 2006;5(7):603–612.
- Fonseca AC, Merwick Á, Dennis M, Ferrari J, Ferro JM, Kelly P, et al. European Stroke Organisation (ESO) guidelines on management of transient ischaemic attack. *Eur Stroke J.* 2021;6(2):V.
- Golledge J, Cumming R, Beattie DK, Davies AH, Greenhalgh RM. Influence of patient-related variables on the outcome of carotid endarterectomy. *J Vasc Surg.* 1996;24(1):120–126.

15. De Blasis S, Pulli R, Di Domenico R, Nesi M, Nencini P, Fargion AT, et al. Elective or urgent carotid endarterectomy in symptomatic patients: analysis based on the type and timing of neurological symptoms. *Ann Vasc Surg.* 2023;90:7–16.
16. Huibers A, de Borst GJ, Thomas DJ, Moll FL, Bulbulia R, Halliday A. ACST-1 Collaborative Group. The mechanism of procedural stroke following carotid endarterectomy within the asymptomatic carotid surgery trial 1. *Cerebrovasc Dis.* 2016;42(3–4):178–185.
17. Poorthuis MHF, Bulbulia R, Morris DR, Pan H, Rothwell PM, Algra A, et al. Carotid stenosis trialists' Collaboration. Timing of procedural stroke and death in asymptomatic patients undergoing carotid endarterectomy: individual patient analysis from four RCTs. *Br J Surg.* 2020;107(6):662–668.
18. Coelho A, Peixoto J, Canedo A, Kappelle LJ, Mansilha A, de Borst GJ. Critical analysis of the literature and standards of reporting on stroke after carotid revascularization. *J Vasc Surg.* 2022;75(1), 363-371.e2.
19. 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(6):484–489.
20. Huibers A, Calvet D, Kennedy F, Czoriga-Kovács KR, Featherstone RL, Moll FL, et al. Mechanism of procedural stroke following carotid endarterectomy or carotid artery stenting within the international carotid stenting study (ICSS) randomised trial. *Eur J Vasc Endovasc Surg.* 2015;50(3):281–288.
21. Meershoek AJA, de Waard DD, Trappenburg J, Zeebregts CJ, Bulbulia R, Kappelle JLJ, et al. Delphi consensus experts panel. Clinical response to procedural stroke following carotid endarterectomy: a Delphi consensus study. *Eur J Vasc Endovasc Surg.* 2021;62(3):350–357.
22. Shahidi S, Owen-Falkenberg A, Hjerpsted U, Rai A, Ellemann K. Urgent best medical therapy may obviate the need for urgent surgery in patients with symptomatic carotid stenosis. *Stroke.* 2013;44(8):2220–2225.
23. Eriksson H, Koskinen S, Nuotio K, Heikkilä HM, Vikatmaa P, Silvennoinen H, et al. Predictive factors for pre-operative recurrence of cerebrovascular symptoms in symptomatic carotid stenosis. *Eur J Vasc Endovasc Surg.* 2020;60(6):809–815.
24. Lawaetz M, Sandholt B, Eilersen EN, Petersen C, Tørslev K, Shilenok D, et al. Low risk of neurological recurrence while awaiting carotid endarterectomy: results from a Danish multicentre study. *Eur J Vasc Endovasc Surg.* 2021;62(2):160–166.
25. North American Symptomatic Carotid Endarterectomy Trial Collaborators, HJM Barnett, Taylor DW, Haynes RB, Sackett DL, Peerless SJ, Ferguson GG, Fox AJ, et al. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med.* 1991;325(7):445–453.
26. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST). *Lancet.* 1998 May 9;351(9113):1379–1387.
27. Marnane M, Ni Chroinin D, Callaly E, Sheehan OC, Merwick A, Hannon N, et al. Stroke recurrence within the time window recommended for carotid endarterectomy. *Neurology.* 2011;77(8):738–743.
28. Johansson EP, Arnerlöf C, Wester P. Risk of recurrent stroke before carotid endarterectomy: the ANSYSCAP study. *Int J Stroke.* 2013;8(4):220–227.
29. Mono ML, Steiger I, Findling O, Jung S, Reinert M, Galimanis A, et al. Risk of very early recurrent cerebrovascular events in symptomatic carotid artery stenosis. *J Neurosurg.* 2013;119(6):1620–1626.
30. Ois A, Cuadrado-Godia E, Rodríguez-Campello A, Jimenez-Conde J, Roquer J. High risk of early neurological recurrence in symptomatic carotid stenosis. *Stroke.* 2009; 40(8):2727–2731.
31. Eliasziw M, Kennedy J, Hill MD, Buchan AM, Barnett HJ. Early risk of stroke after a transient ischemic attack in patients with internal carotid artery disease. *CMAJ.* 2004;170(7):1105–1109.