Editorial

Is it time to update the treatment result of extracranial internal carotid artery stenosis?

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Extracranial internal carotid artery stenosis is one of the major causes of ischemic strokes accounting for 8–20% (1,2). Its management includes the best medical treatment (BMT), carotid artery stenting (CAS), and carotid endarterectomy (CEA). The comparisons between these three methods have been studied extensively. To decide the treatment, we need to consider whether it is symptomatic. Symptomatic disease is characterized by one or more transient ischemic attacks of neurologic dysfunction, amaurosis fugax, or one or more ischemic strokes within the previous six months (3,4). If symptomatic with 50–99% stenosis of the internal carotid artery, CAS and CEA can be considered (5-8). On the other hand, if asymptomatic, CAS and CEA can be considered for 60–99% stenosis (6,8-10). We need to factor in patients' specific factors including age, sex, comorbidities, and anatomical factors among others, to decide CAS or CEA. Patients 75 years old or younger had a better outcome after CAS compared to older patients (11,12). However, even for elderly patients, if there is no vascular tortuosity, calcification, or decreased cerebral reserve, CAS was shown to be safely performed (13).

Non-exhaustive past studies on the outcomes of CAS and CEA were summarized in *Table 1* (5-10,14-19). In earlier studies, periprocedural strokes were more common in patients treated with CAS (5-7). However, in the later studies including the one performed by Cho *et al.*, periprocedural strokes after CAS and CEA were comparable (8-10,16). One study even showed periprocedural stroke rate was higher in patients treated with CEA (18). In the study performed by Cho *et al.* (16), they performed a single-center retrospective study on the patients treated with CEA (107 patients) and CAS (128 patients) between 2012 and 2020. No statistically significant differences were observed in myocardial infarction (CAS group, 0.8%; CEA group, 0.9%), cerebral infarction (CAS group, 3.1%; CEA group 0.9%), or death (CAS group, 0.8%; CEA group 0%), within 30 days after surgery. In their study, they found no difference in outcome between CEA and CAS. This may reflect the advancement of the endovascular device including stroke protection filter and flow-reversal technique (20,21). We need to keep in mind that compared to the past now that various endovascular devices are developed, we need to update the result from past studies (22). The way of embolic protection during CAS is not necessarily the same as in past studies, which showed higher periprocedural stroke rates in patients treated with CAS (5-7). A nationwide study on patients treated either with CEA or CAS during 2010–2015 showed CEA patients had a higher periprocedural stroke rate than CAS patients after matching for characteristics and morbidity (18).

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Table 1 Summary of studies on carotid endarterectomy and carotid artery stenting

Author, year	Study design[†]	Study period	Results 1	Results 2
Yadav *et al.*, 2004 (SAPPHIRE)	RCT; symptomatic with 50–99%; asymptomatic with 80–99%; high risk patients	2000–2002	CAS with an embolic-protection device is not inferior to CEA	The 1-year incidence of major cardiovascular event: CEA group, 20%; CAS group 12%
Mas *et al.*, 2006 (EVA-3S)	RCT; symptomatic with 60–99%	2000–2005	The rate of stroke or death at 1 and 6 months more common in CAS	30-day incidence of any stroke or death: CEA group, 3.9%; CAS group, 9.6%
Brott *et al.*, 2010 (CREST)	RCT; symptomatic with 50–99% stenosis; asymptomatic with 60–99% stenosis	2000–2008	No difference in 4-year rates of the primary endpoint. The 4-year rate of stroke or death more common in CAS. Periprocedural stroke more common in CAS. Periprocedure MI more common in CEA	Periprocedural[‡] incidence: death (CEA group, 0.3%; CAS group, 0.7%), stroke (CEA, 2.3%; CAS, 4.1%), MI (CEA, 2.3%; CAS, 1.1%)
Bonati *et al.*, 2015 (ICSS)	RCT; symptomatic with 50–99% stenosis	2001–2008	Median follow-up of 4.2 (IQR, 3.0–5.2) years. Strokes more common in CAS. No difference in the number of fatal or disabling strokes	–
Howard *et al.*, 2016	Meta-analysis; symptomatic	–	Periprocedural stroke and death more common in CAS for patients aged 70–74 years old	–
Rosenfield *et al.*, 2016 (ACT-1)	RCT; asymptomatic with 70–99% stenosis	2005–2013	CAS non-inferior to CEA with regard to the primary composite endpoint. No difference in stroke or death rates up to 5 years of follow-up	–
Cole *et al.*, 2020	Data base analysis with matching; symptomatic and asymptomatic	2010–2015	Periprocedural stroke more common in CEA for symptomatic patients. Inpatient mortality higher in CAS	–
Halliday *et al.*, 2021 (ACST-2)	RCT; asymptomatic with 60–99% stenosis	2008–2020	No difference in stroke rate between CEA and CAS during a mean 5 years of follow-up	30-day incidence: any stroke (CEA, 2.4%; CAS, 3.6%), any MI (CEA, 0.7%; CAS, 0.3%)
Pasqui *et al.*, 2021	Retrospective study; women; symptomatic with 50–99% stenosis; asymptomatic with 80–99% stenosis	2013–2019	No difference in periprocedural ischemic stroke. No difference in 6-year ipsilateral stroke/TIA/ mortality. Restenosis rate during 6 years more common in CEA	30-day incidence: death (CEA, 0%; CAS, 0.8%), stroke 0%, MI 0%
Hasan *et al.*, 2022	Systematic review	–	Symptomatic low-risk surgical patients: 120-day stroke and mortality favored CEA	–

Table 1 (*continued*)

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Author, year	Study design[†]	Study period	Results 1	Results 2
Cho *et al.*, 2022	Retrospective study; CEA [107], CAS [128]; symptomatic with 50–99% stenosis [164]; asymptomatic with 70–99% stenosis [71]; CAS for certain conditions[§]	2012–2020	No difference in 30-day MI and mortality. No difference in stroke during the follow-up of 34±29 months	30-day incidence: death (CEA, 0%; CAS, 0.8%), cerebral infarct (CEA, 0.9%; CAS, 3.1%), MI (CEA, 0.9%; CAS, 0.8%)
CREST-2	RCT; asymptomatic with 70–99% stenosis	2014–2026	Estimated completion in 2026	–

[†], stenosis by NASCET criteria; [‡], when the procedure was performed within 30 days after randomization, the periprocedural period was defined as the period from randomization through 30 days after the procedure. When the procedure was not performed within 30 days after randomization, the periprocedural period was defined as the period from randomization through 36 days after randomization; [§], Class III/IV congestive heart failure or angina, coronary artery occlusive disease involving more than two vessels or left main coronary artery, ejection fraction ≤30%, recent MI, and severe lung or renal disease. Prior neck surgery or radiation. Prior CEA. Lesion above the C2 vertebra. SAPPHIRE, stenting and angioplasty with protection in patients at high risk of endarterectomy; RCT, randomized controlled trial; CAS, carotid artery stenting; CEA, carotid endarterectomy; EVA-3S, endarterectomy versus angioplasty in patients with symptomatic severe carotid stenosis; CREST, carotid revascularization endarterectomy versus stenting trial; MI, myocardial infarction; ICSS, international carotid stenting study; IQR, interquartile range; ACT, asymptomatic carotid trial; ACST, asymptomatic carotid surgery trial; TIA, transient ischemic attack; NASCET, north American symptomatic carotid endarterectomy trial.

This result is contradictory to that of the CREST study which studied patients treated during 2000–2008 (6). Since drugs, surgical armamentariums, and devices are constantly improving, we may need to update the outcomes of the three approaches. As for BMT, we need to keep in mind that it is one thing to recommend the BMT and it is another that the patients are complying with the BMT. It is sometimes hard to abide by diet restrictions and smoking cessation (23-25). We need to consider the medical cost as well. The mean hospital costs were lower for CEA compared with CAS (18).

Since no distinctly superior method has been identified in the many high-quality studies, both CAS and CEA may be acceptable in the hands of well-trained surgeons if patients are appropriately selected. We need to consider the advancement of endovascular devices among advancements in other fields and update the treatment result periodically.

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