Commentary on:
Use of Intraoperative Duplex Ultrasonography for Identification and Patch Repair of Kinking Stenosis After Carotid Endarterectomy: A Single-Surgeon Retrospective Experience
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Cervical Carotid Disease: Carotid Endarterectomy and Stenting

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Carotid endarterectomy (CEA) for symptomatic extracranial carotid stenosis more than 60% is now a well-established procedure, provided that the treating surgeon can perform it with a combined morbidity (usually stroke) and mortality (usually myocardial infarction) rate of less than 6%. The results of the NASCET trial (29) showed that CEA is highly beneficial to patients with recent hemispheric and retinal transient ischemic attacks and ipsilateral high-grade stenosis of 70% to 99%. The European study on carotid endarterectomy (ECST) (10) showed benefit of CEA on recent nondisabling carotid territory ischemic event when the symptomatic stenosis was more than 80%. The Veterans Affairs Cooperative Studies Program 309 Trialist Group (VASCP) (23) (carotid endarterectomy and prevention of cerebral ischemia in symptomatic carotid stenosis) study showed that in a selected cohort of men with symptoms of cerebral or retinal ischemia in the distribution of a high-grade internal carotid artery (ICA) stenosis, CEA can effectively reduce the risk of subsequent ipsilateral cerebral ischemia. Cina et al. (6) reviewed NASCET, ECST, and VASCP trials and concluded that CEA reduced the risk of disabling stroke or death for patients with stenosis exceeding 70%, measured by ECST, or 50% as measured by NASCET, compared to medical therapy. But they also concluded that the results are generalizable only to surgically fit patients operated on by surgeons with low complication rates (<6%).

For asymptomatic carotid stenosis more than 60%, the role of CEA is less well established. Various studies compared the effect of CEA versus medical therapy in asymptomatic patients. The Veterans Affairs Cooperative Study Group (23) showed that CAE reduced the overall incidence of ipsilateral neurological events in a selected group of male patients with asymptomatic carotid stenosis. However, there was no significant influence of CEA on the combined incidence of stroke and death. The results of the Asymptomatic Carotid Atherosclerosis Study trial (11) showed that in asymptomatic cases with carotid artery stenosis of 60% or more, and with complication rates of less than 3%, there was a benefit from CEA over medical treatment. In addition, recent data by magnetic resonance imaging shows that patients presumed to have asymptomatic carotid stenosis may not in fact be truly asymptomatic as evidenced by silent cerebral infarctions in the distribution of the carotid lesion (2, 13, 35, 36).

In recent years, it appeared that the procedure of surgical CEA may disappear, due to the increasing popularity of endovascular carotid stenting (CAS) (5, 7, 9, 24, 30, 34). However, randomized studies that have compared carotid stenting with CEA have yielded conflicting results. The Carotid and Vertebral Artery Transluminal Angioplasty Study (CAVATAS) (8) in 2001 showed that there was no difference in rate of 30-day disabling stroke or death in CAS and CEA. At 1 year after treatment, severe (70%–99%) ipsilateral carotid stenosis was more usual after endovascular treatment. However, no substantial difference in the rate of ipsilateral stroke was noted with survival analysis up to 3 years after randomization. The Stent-Protected Angioplasty versus Carotid Endarterectomy study trial (37) showed that in lower surgical risk patients, 30-day stroke death rates were similar in both groups, but failed to prove non-inferiority of CAS, and the trial was halted early for lack of funding. In another trial Endarterectomy Versus Angioplasty in Patients with Symptomatic Severe Carotid Stenosis (EVA-3S) (25), the early results showed a rate of stroke and death that was higher in the stenting group,

Key words
- Carotid endarterectomy
- Intraoperative duplex ultrasonography
- Kinking
- Restenosis

Abbreviations and Acronyms
CAS: Endovascular carotid stenting
CEA: Carotid endarterectomy
ICA: Internal carotid artery

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whereas long-term follow-up showed no difference in the efficacy of both procedures in preventing strokes. In the International Carotid Stenting Study (ICSS) (17) 30-day risk of stroke (65 vs. 35 events) and all-cause death events (19 vs. 7 events) were higher in the stenting group than in the endarterectomy group. The results of the Carotid Revascularization Endarterectomy versus Stenting Trial (CREST) (26) showed that among patients with symptomatic or asymptomatic carotid stenosis, the risk of the composite primary outcome of stroke, myocardial infarction, or death did not differ significantly in the group undergoing carotid artery stenting and the group undergoing CEA. However, during the periprocedural period, there was a higher risk of stroke with stenting and a higher risk of myocardial infarction with endarterectomy. In addition, patients younger than 70 years had improved outcomes with CAS, and patients older than 70 years had improved outcomes with CEA.

Recently, a meta-analysis of randomized clinical trials comparing carotid artery stenting and CEA in the treatment of carotid stenosis was carried out by Liu et al. (22) The analysis included Leicester (1), Lexington 1 (23), CAVATAS (8), Lexington 2 (19), Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy (SAPPHIRE) (40), EVA-3S (25), Stent-Protected Angioplasty versus Carotid Endarterectomy (SPACE) (37), endarterectomy versus stenting for the treatment of carotid atherosclerotic stenosis in China (TESCAS-C) (21), Regensburg (38), carotid artery stenting versus carotid endarterectomy: a prospective, randomized controlled single-centre trial with long term follow-up (BACASS) (14), ICSS (17), and CREST (26) studies. The results concluded that CEA was associated with a lower risk of the primary end point of death or stroke, and this difference was mainly driven by the lower incidence of periprocedural nondisabling or minor strokes. Significantly fewer myocardial infarctions occurred with CAS. CEA should be the first choice for symptomatic patients requiring carotid revascularization, whereas CAS could be reserved for patients with high surgical risks. Thus, CEA and CAS may be considered complementary rather than competing modes of therapy, each of which can be optimized with careful patient selection.

The inconclusive benefits of CAS over CEA have led a rebirth of the surgical procedure, with carotid stenting still being performed for patients who have a high medical risk, or patients with very complex anatomy (high carotid stenosis, above the C2 level), and recurrent carotid stenosis (postendarterectomy), or carotid stenosis in a patient with tracheotomy.

More recently, the Carotid Occlusion Surgery Study (COSS) trial (32) was concluded and showed that the technique of cerebral revascularization by superficial temporal artery to middle cerebral artery anastomosis was no better than an intensive medical therapy for patients with symptomatic ICA occlusion, who also have an increased oxygen extraction fraction by positron emission tomography scanning. When these results were analyzed, it was discovered that the medically treated patients in the study did much better than the medically treated cohorts in CEA trials, which may be due to the liberal use of statins in these patients. This may lead to new randomized trials comparing the value of CEA, carotid stenting, and intensive medical therapy in the near future.

There are many variations in the techniques of CEA, none of which have been studied by randomized trials. There are surgeons (like L.N.S.) who perform the procedure under general anesthesia, with neurophysiologic monitoring of the spectral electroencephalogram, somatosensory-evoked potentials, and motor-evoked potentials. In such patients, at the time of carotid clamping, the patient's blood pressure is often increased by 20%, and the patient is placed in burst suppression with intravenous propofol or etomidate to reduce the brain metabolism. When changes are detected in the somatosensory-evoked potentials or motor-evoked potentials, then an intraluminal shunt is inserted to maintain the flow, which makes the procedure technically slightly more difficult. There is another set of surgeons (like D.M.) who perform the procedure under local anesthesia, monitoring the patient neurologically during the procedure, and shunting if the patient develops neurological deficits. Dipankar Mukherjee and his co-authors have recently reported that CEA under local anesthesia has a low perioperative myocardial infarction rate similar to CAS, and lower than CEA under general anesthesia (28). There is a third set of surgeons who shunt every patient with the CEA, although this makes every operation technically more difficult.

The CEA operation is often done with loupe magnification. However, many neurosurgeons (including L.N.S.) perform the procedure using the surgical microscope, due to the improved lighting, magnification, comfort to the assistant, and the ability for the rest of the operative team to see the procedure. When the procedure is performed under general anesthesia, due to the developments in the field of skull base surgery, a high carotid exposure is not a problem (the digastric muscle can be divided to enhance the exposure). The cranial nerves can be visualized, avoiding injury to them.

Patching after CEA is also surgeon dependent. The use of vein patching has generally been abandoned due to the formation of a pseudoaneurysm in some patients in a delayed fashion (1, 3, 4, 12, 15, 16, 20, 27, 31, 39). Many surgeons use a synthetic patch to reduce the incidence of postendarterectomy narrowing and delayed stenosis at the endarterectomy site. L.N.S. uses a Hemashield patch (MAQUET Medical Systems USA, Wayne, New Jersey, USA) and D.M. uses a bovine pericardial patch (Le Maitre Vascular Inc., Burlington, Massachusetts, USA). There are other surgeons who use patching selectively if they observe a narrowing of the ICA after the endarterectomy, which is more likely when the patient already has a narrow ICA distal to the endarterectomy site.

We have used patch repair secondarily after the CEA was performed, and the vessel was repaired, based on the findings of intraoperative duplex scanning, to alleviate kinks that were observed. This is a reasonable approach, although it means that the repair site will have to be reopened, and the ICA will have to be temporarily occluded again.

Duplex imaging and elevation in peak systolic velocities may indicate stenosis at the distal end of the primary closure of the vessel rather than as a result of kinking, although this can occur (33). The velocity criteria used here were too low to signify a hemodynamically significant stenosis (i.e., >50%). Imaging after endarterectomy is important, not only to detect kinking, but also to detect instances of stenosis, or luminal flaps. Duplex ultrasound provides a rapid technology for this assessment.