# Impact of postoperative transient ischemic attack on survival after carotid revascularization

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***Objective:*** **Major postoperative complications such as stroke and myocardial infarction are usually carefully evaluated in the analysis of carotid revascularization performance. Although transient ischemic attacks (TIAs) are often left unreported, they also may influence long-term outcome. The aim of our study was to evaluate the influence of postoperative TIA in the long-term survival of patients submitted to carotid revascularization.**

***Methods:*** **All consecutive patients submitted to either carotid artery stenting or carotid endarterectomy for symptomatic or asymptomatic carotid stenosis from 2005 to 2012 were retrospectively analyzed. Patients were stratified according to their postoperative (30-day) neurologic course (no symptoms, TIA, or stroke). Kaplan-Maier with log-rank analysis was performed to compare the 5-year survival of patients with postoperative TIA, stroke, or neither; factors affecting the 5-year mortality were evaluated by multivariable Cox proportional hazards models.**

***Results:*** **Over a total of 1390 carotid revascularizations (carotid endarterectomy, n = 868 [62.4%]; carotid artery stenting, n = 522 [37.6%]), neurological perioperative complications occurred in 67 (4.7%) cases (38, 2.7% TIA; 29, 2.0% stroke). At 5-year follow-up, overall survival was significantly lower in patients with postoperative TIA (78.4 ± 8.0% vs 97.4 ± 0.6%; $P < .001$) and postoperative stroke (68.2 ± 14.4% vs 97.4 ± 0.6%; $P = .03$) compared with patients without neurological complications. By means of multivariate Cox analysis, postoperative TIA and stroke were independent predictors of decreased survival (hazard ratio [HR], 3.10; 95% confidence interval [CI], 1.01-9.72; $P = .04$, and HR, 3.87; 95% CI, 1.13-13.19; $P = .03$, respectively), other than age >80 years, postoperative myocardial infarction, and chronic renal failure (HR, 2.07; 95% CI, 1.41-4.90; $P = .01$; HR, 4.33; 95% CI, 2.74-23.79; $P = .04$; HR, 2.54; 95% CI, 1.04-6.19; $P = .04$, respectively).**

***Conclusions:*** **TIAs are significant events, possibly determined by a wider extent of atherosclerotic disease, with important effects on long-term mortality similar to that in strokes. Different from most trials evaluating the outcomes of revascularization techniques, the incidence of perioperative TIA should be accurately considered in the analysis. (J Vasc Surg 2014;59:1570-6.)**

The outcomes of patients undergoing carotid artery revascularization have been extensively evaluated for both carotid endarterectomy (CEA) and carotid artery stenting (CAS) in a variety of clinical studies[1,2] and randomized controlled trials (RCTs)[3-6] to evaluate the performance of the two techniques. Whereas stroke and death are usually considered as primary end points in most studies, transient ischemic attacks (TIAs) have been left underreported in almost all the RCTs.[3-6] TIA is defined as a transient ischemic cerebral event with a complete resolution of the clinical symptoms within 24 hours, without a permanent organic impairment.[7] Its benign short-term evolution therefore could be a conceivable reason for considering TIA as an irrelevant postoperative event in the analysis of long-term survival. In a different way, other types of apparently minor complications—such as silent myocardial infarction detected only by serological modifications—have been considered in the aggregate primary end point of many RCTs[5,6] because of their effects on long-term survival.[8] As a matter of fact, patients with silent myocardial infarction have higher mortality rates (25%) compared with patients with no postoperative cardiac events (7%) at late follow-up (>1 year).[8]

TIAs have been shown to be independent predictors of long-term mortality in the general population[9]; nevertheless, their effect on long-term survival in patients submitted to carotid revascularization has never been specifically investigated. Similarly, only few studies evaluated the impact of postoperative stroke on late survival after carotid revascularization,[10] and data on long-term survival and disability are available mostly in the general population.[11]

Thus, we conducted the following study to evaluate if postoperative TIAs and stroke can affect the long-term survival of carotid revascularization procedures.

## METHODS

**Study design and setting.** Consecutive patients submitted to carotid revascularization either through CEA or CAS from January 2005 to December 2012 in a single academic center were prospectively entered into a dedicated database and were retrospectively reviewed. All patients gave their informed consent for the procedure. The study was performed according to the rules of the ethics review board of our institution.

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The primary end point was to evaluate and compare the long-term survival of patients who had postoperative TIA, stroke, or had no cerebral event and to evaluate other factors affecting the long-term survival in patients submitted to carotid revascularization. The secondary end point was to compare the long-term survival of patients with TIA, stroke, or no cerebral events according to preoperative neurological symptoms (symptomatic vs asymptomatic).

**Patients.** Carotid revascularization was performed for symptomatic carotid artery bifurcation stenosis >50% (according to the North American Symptomatic Carotid Endarterectomy Trial criteria[12]) and asymptomatic carotid artery stenosis >60% (according to the North American Symptomatic Carotid Endarterectomy Trial criteria[12]).

Clinical characteristics, technical aspects, preoperative neurologic symptoms, and perioperative (30-day) outcome were entered into a dedicated database. The clinical characteristics included the following: age; sex; hypertension (presence of systolic blood pressure >140 or/and diastolic >90 mm Hg, or specific therapy); dyslipidemia (total cholesterol >200 mg/dL or low-density lipoprotein >120 mg/dL or specific therapy); diabetes mellitus (prediagnosed in therapy with oral hypoglycemic drugs or with insulin); current smoking; coronary artery disease (defined as a history of angina pectoris, myocardial infarction, or coronary revascularization); chronic obstructive pulmonary disease (defined as chronic bronchitis or emphysema); and chronic renal failure (glomerular filtration rate <60 mL/min). The preoperative neurological symptoms were evaluated by independent in-hospital neurologists and were defined as TIAs or strokes, occurring in the past 24 weeks in the hemisphere ipsilateral to the target carotid stenosis. All patients, both symptomatic and asymptomatic, had a preoperative cerebral computed tomography (CT) scan evaluation as a standard procedure before carotid revascularization, which was performed according to the Society for Vascular Surgery guidelines[13] and surgeon preference. Specifically, patients at high cardiologic or respiratory risk or with hostile neck were preferentially submitted to CAS if the preoperative CT angiography showed a normal arch anatomy.

All CEA procedures were performed by trained vascular surgeons, under general anesthesia with routine shunting and patching. Postoperative antiplatelet therapy was delivered routinely. In patients with appropriate clinical and anatomical characteristics, CAS was performed by a single vascular surgeon (G.F.) with an experience of more than 500 procedures as previously described.[14] Briefly, the patients were taken to the angiographic suite after providing appropriate informed consent. The patients were medicated with 100 mg aspirin and 75 mg clopidogrel for 3 days before the procedure. All procedures were performed under local anesthesia and systemic heparinization and with an 8F groin introducer. Common carotid cannulation was achieved by use of 40° (Boston Scientific, Natick, Mass) or HS I and II catheters (Medtronic Cardiovascular, Santa Rosa, Calif) over a Terumo stiff guide wire (Terumo, Tokyo, Japan). When cannulation could not be achieved by these means, several different alternative techniques were used (ie, buddy wire or coaxial). Brachial or carotid access was not attempted in any case. Routine cerebral protection was accomplished with the use of FilterWire EZ (Boston Scientific), and closed-cell stenting (Wallstent; Boston Scientific) was used.

**Table I.** General characteristics of the population examined

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|---|---|
| Clinical characteristics | |
| Mean age ± SD, years | 72.4 ± 8.3 |
| Male sex | 898 (64.8) |
| Preoperative neurological symptoms | 372 (27.3) |
| Hypertension | 1235 (89.2) |
| Dyslipidemia | 736 (53.2) |
| Diabetes | 386 (27.9) |
| Smoking | 216 (15.6) |
| Coronary artery disease | 421 (30.4) |
| Chronic obstructive pulmonary disease | 227 (16.4) |
| Chronic renal failure | 189 (13.7) |
| Carotid revascularization techniques | |
| CEA | 868 (62.4) |
| CAS | 522 (37.6) |
| Postoperative (30-day) events | |
| TIA | 38 (2.7) |
| CEA | 10 (1.2)[a] |
| CAS | 28 (5.3) |
| Stroke | 29 (2.0) |
| CEA | 14 (1.6)[b] |
| CAS | 15 (2.8) |
| Myocardial infarction | 9 (0.6) |
| CEA | 8 (0.9)[a] |
| CAS | 1 (0.1) |
| Death | 7 (0.5) |
| CEA | 6 (0.6)[a] |
| CAS | 1 (0.1) |

*CAS,* Carotid artery stenting; *CEA,* carotid endarterectomy; *SD,* standard deviation; *TIA,* transient ischemic attack.
Data are presented as number (%) unless otherwise indicated.
[a]$P < .05$.
[b]$P =$ NS.

Postoperative (30-day) outcome was analyzed in terms of:

- Stroke, clinically evaluated by the neurologist (according to the National Institutes of Health Stroke Scale[15]) and with a new acute ischemic or hemorrhagic lesion identified by a cerebral CT scan with >24-hour disability;
- TIA, also evaluated clinically by an independent in-hospital neurologist as transient focal neurologic deficit with complete resolution within 24 hours, without new ischemic lesion on the cerebral CT scan, performed both immediately after the event and 24 hours later.[7] All patients with suspected postoperative TIA or stroke were evaluated by duplex ultrasound to disclose possible technical problems; in such a case, or in the case of doubtful interpretation, contrast-enhanced CT scan or surgical exploration was performed immediately;