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Clinical Research

Long-Term Clinical Outcomes and Cardiovascular Events after Carotid Endarterectomy

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Background: Long-term atherosclerotic adverse events are anticipated in patients undergoing carotid endarterectomy (CEA); however, their incidence and risk predictors remain unknown.
Methods: A consecutive cohort of CEAs between 1/1/2000−12/31/2007 was analyzed. End points were any stroke, coronary event (myocardial infarction, coronary bypass, or stenting), vascular interventions for critical limb ischemia, aortic aneurysm or carotid disease, and death. Survival analysis and Cox regression models were used to identify clinical predictors.
Results: A total of 1,136 CEAs (bilateral, 89; mean age, 71.2 ± 9.2 years; 56.5% male; 36.3% symptomatic, and 3.9% combined with coronary bypass) were performed during the study period with a mean clinical follow-up of 60 months (0−155 months). The postoperative combined stroke and/or death rate was 2.7% and 1.9% for asymptomatic and 4.1% for symptomatic patients. Five and 10-year risks of the end points were 7.2% and 16.1% for stroke, 18.4% and 31.5% for coronary interventions, 20.6% and 28.5% for major vascular interventions, and 25.8% and 50.1% for death. Statins conferred a significant protective effect for stroke (hazard ratio [HR], 0.53; $P = 0.016$) and death (HR, 0.66; $P < 0.0001$). Baseline vascular disease predicted future vascular interventions: aortic aneurysm (HR, 1.90; $P = 0.003$), peripheral arterial disease (HR, 2.03; $P < 0.0001$), and contralateral internal carotid artery (ICA) stenosis ≥50% (HR, 4.61; $P < 0.0001$). Renal insufficiency predicted worse outcomes for all other end points (HR, 2.21; $P = 0.023$ for stroke; HR, 1.62; $P = 0.008$ for coronary events; HR, 2.38; $P < 0.0001$ for death).
Conclusions: Patients undergoing CEA continue to derive long-term low stroke rate benefit but still sustain major coronary events and require vascular interventions, indicating a need for more intensive medical treatment and rigorous follow-up.

INTRODUCTION

Carotid artery occlusive disease typically reflects a systemic atherosclerotic burden, manifested by coexisting coronary artery disease, peripheral arterial disease, or aortic aneurysmal disease.[1−4] Carotid endarterectomy (CEA) is currently the established gold standard for management of symptomatic and selected asymptomatic patients and is still among the most common procedures performed by vascular surgeons in the nation.[1,2,5] Although it does prevent future strokes, patients treated with CEA remain susceptible to major cardiovascular events and interventions involving all arterial beds; although these adverse events are anticipated during long-term follow-up, their incidence and risk predictors remain underinvestigated. This particular information is paramount in a contemporary practice that encompasses best medical treatment for global vascular care.[6−8] The most recent report indicated a 6−35% risk of myocardial infarction (MI), stroke, or cardiovascular death at 3 years,

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depending on the baseline risk profile of the patients.[1]

The present study was undertaken to determine the incidence of long-term cardiovascular events, interventions, and mortality rates of patients undergoing CEA in contemporary practice, to identify risk predictors and guide secondary prevention strategies.

METHODS

This study was approved by the Institutional Review Board at the University of Pittsburgh.

Study Design

Consecutive individuals who underwent CEA at the Division of Vascular Surgery of the University of Pittsburgh between 1/1/2000 and 12/31/2007 were identified by the Current Procedural Terminology (CPT) code 35301. The records were reviewed for demographics, baseline risk factors, carotid duplex studies, operative indications, intraprocedural data, periprocedural complications, and long-term outcomes. The social security death index was used to record death dates. Patients who underwent other concomitant cervical vascular procedures (e.g., carotid-to-carotid bypass and carotid thrombectomy) were excluded from the study.

End Points

The end points were major coronary events, major cerebrovascular events, noncardiac major vascular interventions, and mortality. Subgroup analysis according to preoperative indication (symptomatic or asymptomatic) was performed.

Definitions

All baseline risk factors were recorded based on established diagnoses identified in the medical records (CPT codes). Preoperative parameters of interest included age, gender, ethnicity, and a history of any of the following: hypertension, diabetes mellitus, chronic renal insufficiency (CRI), hyperlipidemia (HLD), smoking, coronary artery disease (CAD), chronic obstructive pulmonary disease (COPD), aortic aneurysm (active disease or previous repair; AA), and peripheral arterial disease (PAD). Renal insufficiency was defined as serum creatinine consistently greater than 1.5 mg/dL. Preoperative and discharge medications were also documented. Symptomatic carotid stenosis was defined as a preprocedural ipsilateral ischemic stroke or transient ischemic attack over the past 6-month time.

Major coronary events included MI, coronary artery bypass grafting (CABG), or percutaneous coronary angioplasty (PTCA) with or without stent placement. Major cerebrovascular events included any stroke (ischemic or hemorrhagic) ipsilateral or contralateral. Both MIs and cerebrovascular events were recorded based on chart diagnoses. Noncardiac major vascular interventions included aortic procedures for aneurysm repair, carotid procedures for carotid artery disease, and peripheral arterial procedures for critical limb ischemia (rest pain or foot ulcer).

Statistical Analysis

Descriptive characteristics are reported as means ± standard deviations or as number of cases and percentages. Survival functions were estimated by the Kaplan–Meier method and evaluated using a log-rank test. Cox regression models were used to assess the effect of baseline predictors. The time component started on the date of the initial procedure. For survival analyses, cases were censored on the date of the last recorded clinical follow-up that allowed accurate information collection, unless the studied event occurred at an earlier time point. For the mortality end point, cases were censored on the date of search of the social security death. Results were considered statistically significant when P value was less than 0.05. Data analysis was performed using Statistical Package for the Social Sciences, version 17 (SPSS Inc., Chicago, IL).

RESULTS

Over the 8-year study period, 1,048 patients underwent 1,136 carotid endarterectomies (50% patch closure, 28% primary closure, 22% eversion, and 3.9% combined with CABG). In brief, 36.3% were symptomatic within 6 months before CEA, 56.5% were men, and the mean age of the cohort was 71.2 ± 9.2 years. All baseline characteristics are summarized in Table I. Sixty-five percent of patients were discharged on a statin regimen over the 8-year period with a significant change over time (51% in 2000 and 72% in 2007, $P < 0.001$). Fifty-three percent of patients were discharged on an angiotensin converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) over the 8-year period with a significant change over time (41% in 2000 and 58% in 2007, $P < 0.007$).

Perioperative Outcomes

The perioperative stroke, MI, and death rates were 2.0% (1.8% ipsilateral and 1.5% for asymptomatic