Predictors and consequences of unplanned hospital readmission within 30 days of carotid endarterectomy

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Objective: **In the United States, vascular surgeons frequently perform carotid endarterectomy (CEA). Given the resource burden of unplanned readmission (URA), we sought to identify the predictors and consequences of URA after this common vascular surgery procedure to identify potential points of intervention.**

Methods: **Using a prospective single-institution database, we retrospectively identified consecutive patients undergoing CEA (2001-2011). Demographic and perioperative factors were prospectively collected. The primary end point was 30-day postdischarge URA after CEA. The secondary end point was 1-year survival. We performed a univariable analysis for URA followed by a multivariable Cox model. A Kaplan-Meier analysis was performed for 1-year survival.**

Results: **During the study period, 840 patients underwent 897 CEAs. The 30-day postdischarge overall readmission rate and URA rate were 8.6% and 6.5%, respectively. Most URA patients (n = 42; 73.4%) were readmitted for a CEA-related reason (headache, cardiac, hypertension, surgical site infection, bleeding/hematoma, stroke/transient ischemic attack, dysphagia, or hyperperfusion syndrome). Seventeen patients (29.3%) had more than one reason for URA. Median time to URA was 4 days (interquartile range, 1-9 days). Postoperative length of stay, indication for CEA, and discharge destination were not associated with URA. In multivariable analysis, in-hospital occurrence of congestive heart failure (hazard ratio [HR], 15.1; 95% confidence interval [CI], 4.7-48.8; $P < .001$), stroke (HR, 5.0; 95% CI, 1.8-14.0; $P < .001$), bleeding/hematoma (HR, 3.1; 95% CI, 1.4-6.9; $P = .003$), and prior coronary artery bypass grafting (HR, 2.0; 95% CI, 1.2-3.5; $P = .01$) were significantly associated with URA. Patients in the URA group also had decreased survival during 1 year (91% vs 96%; $P = .01$, log-rank).**

Conclusions: **The 30-day URA rate after CEA is low (6.5%). Prior coronary artery bypass grafting and in-hospital postoperative occurrence of stroke, bleeding/hematoma, and congestive heart failure identify those at increased risk of URA, and URA signals increased long-term risk of postoperative mortality. (J Vasc Surg 2014;60:77-84.)**

Outcomes evaluation is integral to defining the cost-effectiveness of surgical procedures. One outcome that has gained traction as a measure of quality of care and health care resource utilization is hospital readmission within 30 days. Our objective was to precisely estimate the 30-day readmission rate after carotid endarterectomy (CEA), one of the procedures most frequently performed by vascular surgeons in the United States,[1] to understand the factors that contribute to early unplanned readmission (URA) and to identify targets for improvement.

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METHODS

Data source. This is an Institutional Review Board–approved, single-center cohort study of patients undergoing CEA between November 29, 2001, and June 29, 2011. Demographics, comorbidity, intraoperative, and outcome data were captured prospectively in an institutional registry. All combined procedures, including combined coronary artery bypass grafting (CABG)-CEA procedures, were excluded.

Perioperative details. All CEAs were performed by attending vascular surgeons under general anesthesia with routine electroencephalographic (EEG) monitoring. Patients were given acetylsalicylic acid (81 mg or 325 mg) by mouth up to and including the morning of surgery. Endarterectomies were performed in a standard fashion with patch angioplasty closure. Shunting was performed selectively. Protamine was given at the end of the case at the discretion of the surgeon.

Variables and end points. The primary end point was URA, defined as any unanticipated, nonelective hospital readmission within 30 days of date of discharge after CEA. The secondary end point was 1-year survival. A CEA-related reason for readmission was defined as any medical or surgical complication that occurred as a sequela of surgery[2]; perforated colon cancer is an example of an

unplanned and unrelated readmission. Surgical complications were defined as hematoma, surgical site infection, wound dehiscence, or neurologic event (intracerebral hemorrhage, seizure, transient ischemic attack [TIA], or stroke). A medical complication was defined as any medical condition that occurred as a sequela of CEA. These conditions were broadly grouped into cardiac (eg, congestive heart failure [CHF], myocardial infarction [MI], arrhythmia, or angina pectoris), headache, hypertension (systolic blood pressure >140 mm Hg), and "other medical problems," including respiratory or pulmonary issues, renal insufficiency, and gastrointestinal problems.

Statistical analysis. We performed a univariate analysis for URA with two-tailed Student *t*-tests for continuous variables (Mann-Whitney *U* tests for nonparametric continuous variables) and χ^2 tests for categorical variables (Fisher exact tests for nonparametric categorical variables), followed by a multivariable Cox model with variables that were statistically significant at the $P < .05$ level on univariable analysis. The Cochran-Armitage trend test was used to assess for a trend in the annual rate of URA. The Kaplan-Meier method was used to estimate 1-year survival data.

RESULTS

During the study period, 840 patients underwent 897 CEA procedures by 10 vascular surgery attending surgeons. Baseline characteristics are reported in Table I. Median age was 70.1 years (interquartile range [IQR], 64-77 years); 142 patients (15.8%) were octogenarians and eight (0.9%) were nonagenarians. In 102 cases (11.4%), patients were admitted before the day of CEA ("preadmitted"), whereas the rest were admitted on the day of surgery. Median follow-up was 3.4 years (IQR, 1.2-5.2 years).

Most cases were performed under general anesthesia (99.1%) with EEG monitoring (94.3%). One hundred four patients (12.2%) had EEG changes. One hundred sixty-three patients (18.2%) had intraoperative shunts. Drains were placed in 236 (26.4%) cases. Median operating room time was 2.8 hours (IQR, 2.3-3.3 hours).

One hundred twenty-four patients (13.9%) required transfer to the intensive care unit postoperatively, usually in the setting of hypotension (n = 69; 55.6%) or hypertension (n = 38; 30.6%). Median and mean postoperative length of stay (LOS) were 1 day (IQR, 1-2 days) and 2.4 ± 4.4 days, respectively. The range was 1 to 66 days. Most patients (n = 837; 93.7%) were discharged to home; of these, 312 (34.9%) were discharged with visiting nurse services. Fifty-eight (6.5%) had a 30-day postdischarge URA. There was no association between LOS and URA (6.0% vs 7.0%; $P = .59$).

As shown in Table II, 9.9% of patients (n = 89) suffered at least one in-hospital complication and 2.8% (n = 25) suffered two or more in-hospital complications. Among patients who had a complication, mean and median number of complications was 1.3 ± 0.7 and 1 (IQR, 1-2), respectively. The most frequent complication was bleeding or hematoma, which occurred in 4.1% (n = 37) of cases. Three percent (n = 27) of patients required reoperation, usually for a bleeding complication (n = 24; 88.9%). There were 15 postoperative strokes (1.7%), six of which occurred after initial discharge, two of which were disabling, and none of which was fatal. Cause of death was known in three of the five patients who died within 30 days of CEA (ruptured thoracoabdominal aortic aneurysm, *Clostridium*

Table I. Baseline characteristics

Baseline characteristic	*No. (%)*
Median age, years (IQR)	70.1 (64-77)
Female gender	349 (39.0)
White	850 (95.0)
Past medical history	
Diabetes	271 (30.3)
Smoking	246 (27.5)
HTN	736 (82.2)
CAD	390 (43.6)
CHF	58 (6.5)
Prior CABG	179 (20.1)
COPD	89 (9.9)
CKD (serum Cr > 2.0 mg/dL)	37 (4.1)
ESRD	3 (0.3)
Indication	
Asymptomatic	586 (65.4)
TIA	122 (13.6)
Recent stroke	95 (10.6)
Amaurosis fugax	92 (10.3)
Contralateral occlusion	58 (6.5)
Reoperative CEA	22 (2.5)
Preadmit	102 (11.4)

CABG, Coronary artery bypass graft; *CAD,* coronary artery disease; *CEA,* carotid endarterectomy; *CHF,* congestive heart failure; *CKD,* chronic kidney disease; *COPD,* chronic obstructive pulmonary disease; *Cr,* creatinine; *ESRD,* end-stage renal disease; *HTN,* hypertension; *IQR,* interquartile range; *TIA,* transient ischemic attack.

Table II. Frequency of in-hospital morbidity after CEA

In-hospital morbidity	*No. (%)*
At least 1 in-hospital complication	89 (9.9)
2 or more in-hospital complications	25 (2.8)
In-hospital complications	
TIA	6 (0.7)
Stroke	9 (1.0)
Bleeding/hematoma	37 (4.1)
Arrhythmia	19 (2.1)
Seizure	2 (0.2)
MI	11 (1.2)
PNA	9 (1.0)
Respiratory failure	7 (0.8)
Renal failure	7 (0.8)
CHF	4 (0.5)
Wound infection	9 (1.0)
Pulmonary embolism	1 (0.1)
Carotid thrombosis	2 (0.2)
Dysphagia	15 (1.7)
Reoperation	27 (3.0)

CEA, Carotid endarterectomy; *CHF,* congestive heart failure; *MI,* myocardial infarction; *PNA,* pneumonia; *TIA,* transient ischemic attack.