Factors that determine the length of stay after carotid endarterectomy represent opportunities to avoid financial losses

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Background: **A postoperative length of stay (LOS) >1 day after elective surgery incurs financial losses for hospitals, given fixed diagnosis-related group-based reimbursement. We sought to identify factors leading to a prolonged LOS (>1 postoperative day) after carotid endarterectomy (CEA).**
Methods: **Patients undergoing CEA in 23 centers of the Vascular Study Group of New England between 2003 and 2011 (n = 8860) were analyzed. Only elective, primary CEAs were analyzed, leaving a study cohort of 7108 procedures. Hierarchical multivariable logistic regression analysis was performed to identify predictors of a postoperative LOS >1 day. A Knaus-Wagner chi-pie analysis was performed to determine the relative contributions of each significant covariate to a postoperative LOS >1 day.**
Results: **A postoperative LOS >1 day occurred in 17.5% of the sample (n = 1244). The average LOS was 1.4 days (range, 1-91 days; median, 1). There was significant variation in rates of postoperative LOS >1 day across centers (range, 5%-100%; $P < .001$). Factors independently associated with a postoperative LOS >1 day and their percentage contribution to the prediction model included the need for postoperative intravenous medications for hypertension or hypotension (26%), any major adverse event (MAE) postoperatively (21%), low-volume (<15 CEAs per year) surgeons (28%), increasing age (7%), female gender (4%), positive result on a preoperative stress test (3%), preoperative major stroke ≤30 days (2%), medication-dependent diabetes (1%), severe chronic obstructive pulmonary disease (1%), history of congestive heart failure (1%), and CEA performed on Friday (2%).**
Conclusions: **Certain patient characteristics predispose to a postoperative LOS >1 day after elective CEA. However, patient characteristics play only a modest (17%) role in determining LOS. The need for postoperative blood pressure control and MAEs are the biggest drivers of postoperative LOS >1 day, but system factors, such as low operative volume, contribute substantially to postoperative LOS >1 day, independent of MAEs. These findings can be used to guide quality improvement efforts designed to reduce LOS after elective CEA. (J Vasc Surg 2014;60:966-72.)**

As health care reform comes under increasing focus, metrics of cost-effectiveness and efficiency are likely to become important markers, and areas of excess cost may receive more scrutiny. A prolonged length of stay (LOS) results in increased costs in knee and hip replacement,[1] endocrine surgeries,[2] coronary artery bypass grafting (CABG),[3] and trauma.[4] Clinical pathways that decrease LOS have produced a decrease in cost per case of up to $2240 in colon resection,[5] $3490 in total hip or knee arthroplasty,[1] and $4628 in endocrine surgery.[2] Each additional day in the hospital is estimated to increase by 8% the overall cost of the stay.[6] Eliminating excessive or unnecessary LOS would therefore reduce costs and improve the bottom line.

Carotid endarterectomy (CEA) is a common and uniform operation, with >300,000 procedures performed in Medicare beneficiaries alone between 2003 and 2006,[7] Perioperative care for CEA has become pathway-driven and highly standardized. Most would argue that discharge 1 day after CEA is a safe, if not standard of care, practice.[8] In addition, discharge on postoperative day 1 is not associated with an increased rate of readmission compared with a longer postoperative stay.[9] Diagnosis-related group (DRG) reimbursement is based on an average LOS of 1.4 days for an uncomplicated CEA.[10] An analysis of billing data from Dartmouth Hitchcock Medical Center revealed that the Medicare payment for CEA in patients without major complications or comorbidities (DRG 039) exceeds expenses only if the patient is discharged before postoperative day 2. The hospital incurs a financial loss for patients who stay >1 postoperative day, with a longer stay corresponding to a greater loss (Fig 1).

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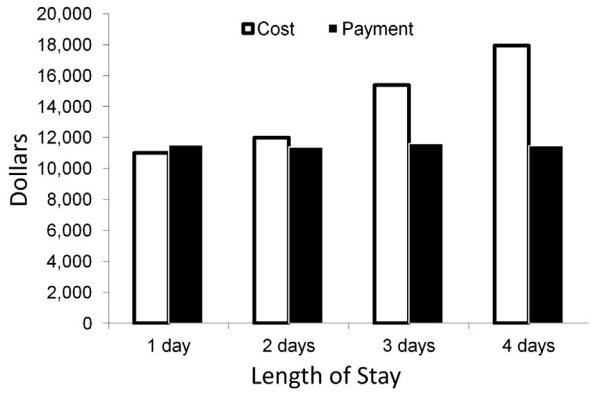

Fig 1. Costs and payment received by Dartmouth Hitchcock Medical Center for carotid endarterectomy (CEA). Cost exceeds payment for length of stay (LOS) >1 day.

LOS after CEA is influenced by many factors, including practice patterns, and therefore, may vary significantly between hospitals. Reducing hospital losses associated with unnecessary postoperative LOS requires identifying the sources of variation and its extent. The purpose of this study was therefore to define the regional variation in LOS and determine the factors associated with increased LOS within the region.

METHODS

Database. The Vascular Study Group of New England (VSGNE) database was used. This database and this study have been approved by the Institutional Review Board at each of the participating institutions. This regional quality improvement database included 23 centers in the six New England states during the time interval of this study. Data are entered prospectively by trained nurses, clinical data abstractors, or physicians. Further details about this database have been published previously.[11]

Patients. The patient population consisted of those undergoing elective, primary CEAs between 2003 and 2011 (n = 8860) in selected New England hospitals that were participating in the VSGNE. Patients were excluded if their procedure took place on a Saturday or Sunday (n = 152), if they were transferred from another institution (n = 442), if the surgery was an emergency or urgent (n = 1025), or if they had a planned concomitant CABG (n = 205) or any history of an ipsilateral CEA (n = 196). Some patients met multiple exclusion criteria. A postoperative LOS >1 day was considered prolonged after an initial analysis indicated that >80% of patients were discharged on postoperative day 1.

Data captured in VSGNE include the symptomatic or asymptomatic status of each patient. Comorbid factors, including history of smoking, hypertension, diabetes mellitus, coronary artery disease (CAD) and associated symptoms, chronic obstructive pulmonary disease (COPD), and American Society of Anesthesiologists Physical Status Classification, are recorded in the database and stratified, as previously reported.[11] Medical history, including prior CABG, percutaneous coronary intervention, prior neurologic events, and recent abnormal results on stress tests are also tabulated.

Health care system characteristics. Annualized surgeon and center volumes were calculated and analyzed in quartiles. The type of anesthesia and day of the week of surgery are also recorded within the VSGNE registry and were used in our analysis. Surgeon specialty and service caring for the patient were not available in the database and were not considered in the analysis.

Outcomes and complications. In-hospital complications, including cranial nerve injury, myocardial infarction (MI), congestive heart failure (CHF), postoperative ipsilateral or contralateral neurologic symptoms, reperfusion syndrome, dysrhythmia, or return to the operating room were recorded and combined to form a composite end point of any major adverse event (MAE). MI, as included in this database, includes an elevated troponin and an MI diagnosed clinically or by electrocardiogram. The use of intravenous (IV) drugs to treat hypertension or hypotension postoperatively was recorded separately from the composite MAE end point. The timing of complications is not recorded in the VSGNE; all complications were assumed to occur on postoperative day 0 or 1.

Statistical analysis. Univariate analysis was conducted to determine factors that were associated with a postoperative LOS >1 day. Factors significant in multivariate analysis, hierarchical, also known as mixed-effects, were used to perform multivariable logistic regression analysis to determine factors that were independently predictive of a postoperative LOS >1 day while controlling for center-level variation. Predictors in three categories were evaluated:

- Patient characteristics of age, gender, and comorbidities;
- Complications and the need for IV medications for hypertension or hypotension; and
- System characteristics of operative day of the week and annualized center and surgeon volumes.

On the basis of patient and system characteristics that were predictive, the proportion of patients expected to have a LOS >1 day was calculated and compared with the actual observed proportion for each center in the VSGNE.

The relative contributions of complications and patient and system characteristics were evaluated in a multivariable model using the Knaus-Wagner chi-pie method[12] In this method, variables are sequentially removed, and tmultivariable model is recalculated, and the percentage of the χ^2 value associated with each variable is then determined. The relative contribution of each predictive factor to the overall model can then be inferred. Statistical analyses were performed using STATA 12 software (StataCorp LP, College Station, Tex).

RESULTS

Patients. The study cohort consisted of 7108 patients (Fig 2). The average LOS was 1.4 days (range, 1-91 days; median, 1 day; interquartile range, 1-1 day). Of the study cohort, 1244 (17.5%) stayed >1 day postoperatively (Fig 3).

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