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Clinical Research

Relationships between 2-Year Survival, Costs, and Outcomes following Carotid Endarterectomy in Asymptomatic Patients in the Vascular Quality Initiative

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Background: Carotid endarterectomy (CEA) for asymptomatic patients with limited life expectancy may not be beneficial or cost-effective. The purpose of this study was to examine relationships among survival, outcomes, and costs within 2 years following CEA among asymptomatic patients.
Methods: Prospectively collected data from 3097 patients undergoing CEA for asymptomatic disease from Vascular Quality Initiative VQI registry were linked to Medicare. Models were used to identify predictors of 2-year mortality following CEA. Patients were classified as low, medium, or high risk of death based on this model. Next, we examined costs related to cerebrovascular care, occurrence of stroke, rehospitalization, and reintervention within 2 years following CEA across risk strata.
Results: Overall, 2-year mortality was 6.7%. Age, diabetes, smoking, congestive heart failure (CHF), chronic obstructive pulmonary disease, renal insufficiency, absence of statin use, and contralateral internal carotid artery (ICA) stenosis were independently associated with a higher risk of death following CEA. In-hospital costs averaged $7500 among patients defined as low risk for death, and exceeded $10,800 among high risk patients. Although long-term costs related to cerebrovascular disease were 2 times higher in patients deemed high risk for death compared with low risk patents ($17,800 vs. $8800, $P = 0.001$), high risk of death was not independently associated with a high probability of high cost. Predictors of high cost at 2 years were severe contralateral ICA stenosis, dialysis dependence, and American Society for Anesthesia Class 4. Both statin use and CHF were protective of high cost.
Conclusions: Greater than 90% of patients undergoing CEA live long enough to realize the benefits of their procedure. Moreover, the long-term costs are supported by the effectiveness of this procedure at all levels of patient risk.

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INTRODUCTION

Controversy exists regarding the need for carotid revascularization in patients with asymptomatic carotid stenosis.[1–8] Asymptomatic patients have a much lower annual risk of stroke than those who have experienced neurologic sequelae related to their carotid stenosis—approximately 3% per year in each year of the patient's remaining life. This makes the absolute benefit of revascularization uncertain for many patients, especially those who may not live long enough to reap the prophylactic benefits of revascularization.[6] Decision making surrounding carotid revascularization must include consideration of the up-front risks of a procedure, the long-term risk of stroke, and the patient's life expectancy.[9–11] Furthermore, patients, payers, and policymakers alike are anxious to avoid ''unnecessary'' procedures, as well as procedures where complications and their associated expense are likely to occur without the potential to achieve a clinical benefit.

However, while avoiding unnecessary carotid revascularization seems simple and plausible, 2 gaps in knowledge exist. First, despite several studies that describe factors associated with short-term risks of stroke or death, it is difficult for physicians to recognize when patients are likely to have poor long-term survival following carotid endarterectomy (CEA). Second, while many have studied factors associated with adverse clinical outcomes following CEA, little is known about the patient and procedural factors associated with higher long-term costs after CEA for asymptomatic carotid stenosis.

Therefore, we use data from the Vascular Quality Initiative (VQI), linked to Medicare claims, to examine relationships among survival, outcomes, and costs related to cerebrovascular care within the first 2 years following CEA among asymptomatic patients. Our primary aim was to identify spending related to unnecessary carotid revascularization. We sought to define a cohort of high risk patients who were unlikely to survive 2 years following CEA and to examine spending among this cohort of patients. We hypothesized that the majority of excess spending in carotid revascularization was attributable to care provided to these high risk patients.

METHODS

Datasets and Cohort Construction

We identified all asymptomatic patients (those without prior stroke or transient ischemic attack) who underwent CEA between January 1, 2003 and December 31, 2011 in each of the VQI for the Society of Vascular Surgery Registry and in Medicare claims datasets. Then, using date of surgery, location of surgery (zip code), and gender, the datasets were matched to one another on a patient level using a probabilistic matching algorithm. This matching process was successful in matching 70% of patients. Addition of the matched Medicare dataset allows long-term follow-up, as well as examination of late outcomes that can be identified in Medicare claims. Further details regarding the matched clinical claims dataset can be found at vascularqualityinitiative.org.

Identifying Factors Associated with 2-Year Survival

First, we sought to define patient characteristics associated with reduced 2-year survival. To do this, we identified patients who died from any cause within 2 years following CEA. Next, Kaplan–Meier survival analyses with log-rank test (for categorical variables) and Cox proportional hazard regression (for continuous variables) were used to examine univariate associations between 2-year mortality and a variety of patient-related characteristics. All variables that were associated with mortality with $P < 0.2$ were entered into a multivariate model and backwards stepwise Cox proportional hazard regression with nested likelihood ratios was performed to generate a final model for predicting mortality at 2 years. Following this, we created 3 risk strata for mortality—low, medium, and high. To do this, scores to predict risk-of-death within 2 years were assigned to each patient in our cohort. These scores were calculated by summing the beta coefficients for each covariate in our Cox model for each individual. Cut points for defining patients as low, medium, or high risk were selected based on the distribution of risk scores. CEA in high risk patients was deemed potentially unnecessary, as these patients are most likely to die before experiencing the potential benefit of CEA. The 2-year timeframe was chosen based on recent national guidelines and multispecialty society expert recommendations.[10,12–14]

Identifying Factors Associated with High Cost (Highest 10th Percentile of Costs >$18,000)

To examine in-hospital and 2-year costs for patients undergoing CEA, we used price-adjusted Medicare spending beginning on the date of CEA. Price-adjusted Medicare spending is a regional and inflation-adjusted measure of actual Medicare