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Carotid Endarterectomy in the Southern California Vascular Outcomes Improvement Collaborative

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Abstract

Background—The objective of this study was to examine the variation in practice patterns and associated outcomes for carotid endarterectomy (CEA) within the Southern California Vascular Outcomes Improvement Collaborative (So Cal VOICe), a regional quality group of the Vascular Quality Initiative.

Methods—All cases entered in the CEA registry by the So Cal VOICe were included in the study.

Results—From September 2010 through September 2015, 1,110 CEA cases were entered by 9 centers in the So Cal VOICe. Six hundred seventy-seven patients (61%) were male with mean age of 73 years. Nine hundred eighty-eight (89%) were hypertensive, 655 (59%) were prior or current smokers, 389 (35%) were diabetics, and 233 (21%) had coronary artery disease. Eight hundred twenty-one (74%) patients were asymptomatic (no history of ipsilateral neurologic event). The percentage of asymptomatic patients varied across the 9 centers from 57% to 91%. Preoperatively, 344 (31%) underwent cardiac stress test, center variation 13–75%, 500 (45%) underwent only duplex, center variation 11–72%. Intraoperatively, 600 (54%) underwent routine shunting, whereas 67 (6%) were shunted for an indication, and 444 (40%) were not shunted. Wound drainage was used in 422 (38%) cases, center variation 2–98%. Completion imaging by duplex and/or angiogram was performed in 766 (69%) cases, center variation 0–100%. Postoperatively, 11 (1%) patients had a new ipsilateral postoperative neurologic event, center variation 0–1.3%, 6 (0.5%) had a postoperative myocardial infarction, center variation 0–1.3%, and 8 (0.7%) required return to operating room for bleeding, center variation 0–1.3%.

Conclusions—Despite wide variation in practice patterns surrounding CEA in the So Cal VOICe, postoperative complications were uniformly low. Further work will focus on identifying practices that can be modified to improve cost-effectiveness while maintaining excellent outcomes.

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INTRODUCTION

Carotid endarterectomy (CEA) is one of the most common peripheral vascular procedures performed in the United States, with approximately 93,000 CEA procedures performed in the United States in 2009.¹ CEA is also one of the most extensively studied procedures in vascular surgery with numerous randomized and multiinstitutional trials.^{2–5} Nevertheless, many aspects of CEA remain controversial in the vascular surgery community including endarterectomy technique, shunt use, protamine use, and completing imaging with variations in practice preferences.^{6–11}

It has been demonstrated in numerous areas of medicine in the United States that variability in the delivery of care results in higher costs with no measurable differences in outcomes.^{12–15} In the area of peripheral arterial disease, revascularization has been shown to be associated with higher spending, but higher spending is not associated with lower amputation rates.¹⁶ Significant variation at the national level has been demonstrated in the imaging criteria used to select patients for CEA for asymptomatic carotid stenosis.¹⁷ The objective of this study was to examine variation on a regional level in practice patterns and outcomes of CEA in the Southern California Vascular Outcomes Improvement Collaborative (So Cal VOICe).

METHODS

A retrospective review was conducted of the So Cal VOICe CEA registry for all procedures performed from September 2010 through September 2015. The So Cal VOICe is 1 of 17 regional quality groups of the Vascular Quality Initiative® (VQI). All practice patterns and outcomes were assessed by the center. Practice patterns studied were rate of asymptomatic CEA, preoperative cardiac stress test, type of preoperative carotid imaging, shunting, protamine use, drain use, and completion imaging in the operating room. Outcomes were those recorded before discharge. Outcomes studied were return to the operating room for any reason, cranial nerve injury, new myocardial infarction, new ipsilateral neurologic event, and in-hospital stroke and death.

Asymptomatic CEA was defined as patients who never had a previous ipsilateral ocular or cortical neurologic event. Preoperative cardiac stress test includes stress electrocardiogram (EKG), stress echocardiogram, and nuclear stress scan. Myocardial infarction includes elevated blood troponin level and/or EKG positive for infarction or clinical symptoms consistent with myocardial infarction. New ipsilateral neurological event is defined as new cortical or ocular transient ischemic attack or stroke.

For each practice pattern, the highest and lowest prevalence by center was compared using the chi-squared test. Due to the low rate of complications overall, no statistical comparison was made by center of outcomes. Categorical variables are presented as percentages, and continuous variables are presented as means.

RESULTS

During the 5-year study period, 1,110 CEA were performed in 9 centers by 46 surgeons in the So Cal VOICE. The mean age was 72.9 years (range: 33–89), with 61% male and 86% white. Comorbidities were typical for peripheral vascular disease patients with the great majority being hypertensive and the majority being prior or current smokers (Table I). About 91% of the patients were independently ambulatory, and 8.5% were ambulatory with assistance. Ninety-eight percent lived at home. There were 2.7% who had a previous ipsilateral CEA, 0.3% had a previous ipsilateral carotid artery stent, 1.7% had previous neck radiation, and 1.5% had previous neck surgery.

Overall, 74% of patients had no history of ever having an ipsilateral ocular or cortical neurologic event. The distribution of asymptomatic patients by center ranged from a low of 57% to a high of 91% (Fig. 1A). The difference between the center with the highest and lowest percentage was significant at $P < 0.001$. Seven hundred thirty-eight of the CEA were elective and performed in patients who had no history or symptoms of coronary artery disease. Of those 738 patients, 31% underwent preoperative cardiac stress test. The distribution of stress test by center ranged from 10% to 77% ($P < 0.001$; Fig. 1B). About 45% of patients underwent preoperative carotid imaging by duplex alone, with 37% undergoing either computed tomography or conventional angiogram in addition to duplex. By center, imaging by duplex alone ranged from 11% to 72% ($P < 0.001$; Fig. 1C).

About 85% of cases were done electively with 98% under general anesthesia. A conventional endarterectomy was performed in 77% of cases, and a prosthetic patch was used in 96% of the conventional endarterectomies. A shunt was used in 60% of cases with 54% of those done as routine and the remainder done for an indication. The distribution of shunt use by center ranged from 0% to 100% ($P < 0.001$; Fig. 2A). Protamine was given in 85% of cases, and the variation of protamine use by center ranged from 0% to 100% ($P < 0.001$; Fig. 2B). Overall, a drain was used in 38% of cases, ranging from 6% to 98% by center ($P < 0.001$; Fig. 2C).

Overall, completion imaging, in the form of intraoperative duplex and/or angiogram, was performed in 19% of cases, ranging from 0% to 100% by center (Fig. 2D). The mean procedure time from incision to close overall was 99 min (range: 67–150).

The return to operating room rate overall was 1.3%, ranging from 0% to 4% by center. Cranial nerve injury was 1.8% and ranged from 0% to 6%. The new myocardial infarction rate was 0.5% and ranged from 0% to 3% by center. Of the six patients who had a new myocardial infarction, 4 did not have a preoperative cardiac stress test. One had a stress test that was normal, and one had a stress test that was abnormal. New ipsilateral neurologic event rate was 1% and ranged from 0 to 1.8% by center. In-hospital stroke and death was 1.38% overall and ranged from 0% to 2.5% by center. (Due to the low rates of complications, statistical analysis was not performed on the variation in complication rates by center.)

DISCUSSION

Standardization of care has been demonstrated in numerous areas to reduce cost without compromising outcomes. In one simple example, the implementation of a uniform doctor's preference card for pediatric laparoscopic appendectomy resulted in a decrease in the device cost for the procedure from \$844 to \$305 without any change in the procedure time or the outcomes.¹⁸ A more complex example is the implementation of Standardized Clinical Assessment and Management Plans. These are standardized care pathways that use decision trees to allow for the care of individualized patients and take into account physician expertise and preference.¹⁹ Implementation of an SCAMP for the evaluation of pediatric chest pain in one institution significantly decreased the practice variation and decreased utilization of resources; there was a 26% decrease in the number of exercise stress tests obtained, a 66% decrease in Holter monitors, and a 75% decrease in long-term event monitors.²⁰

The primary goal of the VQI was to improve the quality, safety, effectiveness, and cost of vascular health care. One example of a regional quality group achieving this goal is from the Vascular Study Group of New England (VSGNE), which demonstrated that a focus on protamine use during CEA in their region resulted in an increase in protamine use from 46% before 2009 to 61% after 2009.²¹ Corresponding to the increase in protamine use, there was a decrease in the incidence of reoperation for bleeding from 1.2% to 0.6%, with no change in the incidence of postoperative neurologic events.

The present study demonstrates wide variations in the practice patterns surrounding CEA in the So Cal VOICE. Although the classically measured outcomes for CEA were uniformly low throughout the region, these variations represent potential areas to focus quality improvement projects. Further investigation and collaboration through the regional group could lead to decreased resource utilization with potential for further improvement in outcomes.

One area in particular to focus on is in the use of preoperative cardiac stress testing for patients undergoing elective CEA who do not have history or symptoms of coronary artery disease. This topic has long been a controversial issue and demonstrated an extremely wide variation in the So Cal VOICE. The indication for stress testing, according to the American College of Cardiology and American Heart Association guidelines, is a patient with poor or unknown functional capacity where the results of testing will change the clinical management.²² The indications for cardiac stress testing are not recorded in the VQI database. However, it is unlikely that 31% of the patients who underwent elective CEA in the So Cal VOICE met this criterion, and it is further unlikely that the variation in patients who met the criterion varied to such a great degree across institutions in a relatively small geographic area.

The issue of whether CEA is more effective than medical management for asymptomatic carotid stenosis is being addressed by the currently enrolling Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Study (CREST-2), a randomized controlled multiinstitutional study sponsored by the National Institutes of Health.²³ The

wide variation in the proportion of CEA performed for asymptomatic carotid stenosis among the centers in the So Cal VOICE is more likely to be related to variations in management practices rather than variation in the proportion of patients who present with symptomatic carotid stenosis. This underscores the need for further evidence regarding the treatment of asymptomatic carotid stenosis.

Another controversial topic in CEA is the use of completion imaging which varied widely across the So Cal VOICE. The VSGNE demonstrated similar variation in their region with little evidence that completion imaging is associated with lower perioperative rates of stroke and/or death.¹⁰ In light of the increased time and cost associated with performing intraoperative completion imaging, further study on the influence of completion imaging on outcomes is warranted. Standardization of completion imaging practices could result in significant cost-savings given the variation observed in both the VSGNE and the So Cal VOICE. Although outside the scope of this study, an important area of future study would be the influence of completion imaging on the incidence of early recurrent stenosis.

CONCLUSION

There are wide variations in the practice patterns surrounding CEA in the So Cal VOICE. Despite these variations, there are uniformly good outcomes after CEA, with complication rates at all centers well within accepted ranges. Each of these variations in practice patterns serves as a fertile area for potential quality improvement. Future directions for the So Cal VOICE will focus on drivers for these variations and examining ways to standardize practice with the goal of reducing cost while maintaining excellent outcomes.

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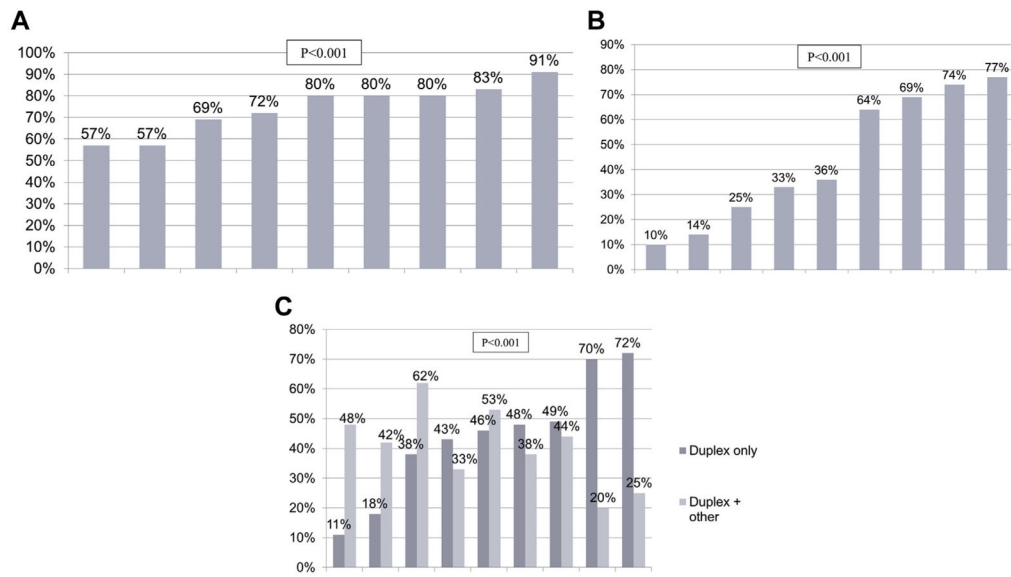


Fig. 1. (A) Distribution of asymptomatic carotid endarterectomy by center. (B) Distribution of preoperative cardiac stress test by center. Performed in patients undergoing elective carotid endarterectomy with no history or symptoms of coronary artery disease. (C) Preoperative carotid imaging by center.

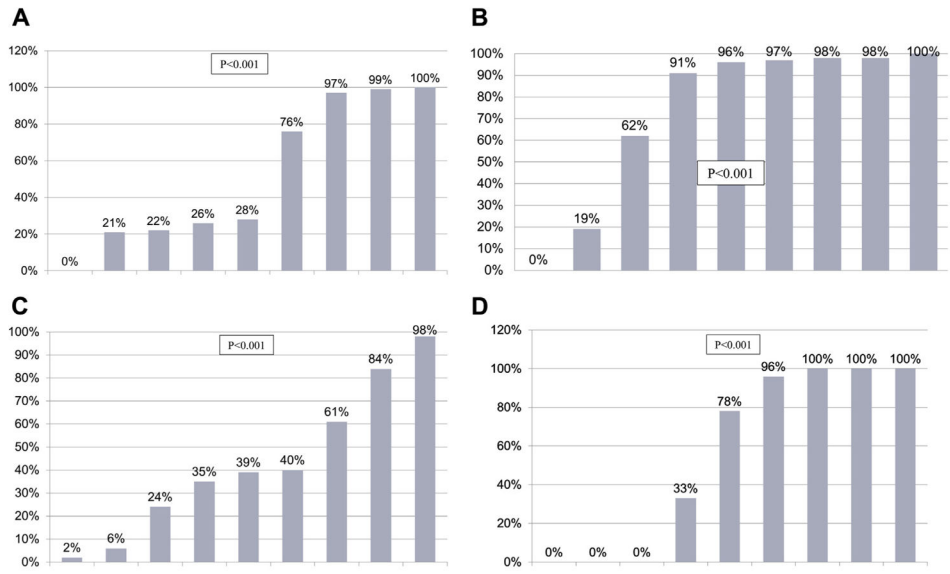


Fig. 2. (A) Shunt use; (B) protamine use; (C) drain use; (D) completion imaging (duplex and/or angiogram).

Table I

Demographics and comorbidities

Demographic/comorbidity	<i>n</i> (%)
Male	672 (60.5)
Hypertension	988 (89)
Smoking (prior or current)	655 (59)
Diabetes	389 (35)
Coronary artery disease	231 (20.8)
Chronic obstructive pulmonary disease	155 (14)
Congestive heart failure	100 (9)
Renal failure requiring dialysis	22 (2)

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