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Early Outcomes after Carotid Endarterectomy and Carotid Artery Stenting for Carotid Stenosis in the ACS-NSQIP Database

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Abstract

Background—Carotid endarterectomy (CEA) and carotid artery stenting (CAS) are both viable treatment options for carotid artery stenosis. We sought to compare perioperative outcomes after CEA and CAS for the management of carotid stenosis using a “real-world” sample.

Methods—We conducted a retrospective observational study using the National Surgical Quality Improvement Program database to compare 30-day (periprocedural) outcomes in patients with carotid stenosis undergoing CEA versus CAS from 2005 to 2012. Baseline characteristics and periprocedural outcomes including stroke, myocardial infarction, mortality and combined outcome (composite of any stroke, myocardial infarction, or death) were compared.

Results—A total of 54,640 patients were identified who underwent CEA and 488 who underwent CAS. Patients undergoing CEA were more likely to be older and have symptomatic stenosis, and less likely to be white, have congestive heart failure, and have chronic obstructive pulmonary disease. There were no significant differences between CEA and CAS in periprocedural mortality (0.9% vs. 1.2%, $p = 0.33$), stroke (1.6% vs. 1.6 $p = 0.93$), myocardial infarction (0.9% vs. 1.6%, $p = 0.08$), or combined outcome (3.0% vs. 4.9%, $p = 0.09$). The interaction between symptomatic status and procedure type was not significant, indicating the association of symptomatic status with 30-day mortality ($p = 0.29$) or the combined periprocedural outcome ($p = 0.57$) were similar in cases receiving CEA and CAS.

Conclusion—Early outcomes after CEA and CAS for carotid artery stenosis appear to be similar in a “real-world” sample and comparable to clinical trials. Patients undergoing CAS were more likely to be younger and surgically have higher risk based on baseline characteristics likely reflecting clinical practice case selection.

Introduction

Carotid artery stenosis accounts for 10%–20% of all ischemic strokes [1]. Atherosclerosis typically occurs at the proximal internal carotid artery at the carotid bifurcation and is the major reason for carotid stenosis [1]. Evidence supporting carotid endarterectomy (CEA) for symptomatic carotid stenosis in secondary stroke prevention dates back to the 1990’s with the landmark North American Symptomatic Carotid Endarterectomy Trial and the European Carotid Surgery Trial [2–4]. More recent evidence such as the Carotid Revascularization Endarterectomy versus Stenting Trial (CREST), suggests carotid artery stenting (CAS) may be a viable, less invasive alternative for the management of carotid stenosis [5,6]. Nevertheless, significant controversy and uncertainty remains regarding the best modality depending on a number of factors including patient demographics, symptomatic status, degree of stenosis, and plaque location and morphology. In this study, we utilized the data from the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) database to compare contemporary, real-world, perioperative outcomes between CAS and CEA.

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Table 1. Patient characteristics

Variable	CEA (*n*= 54,640)	CAS (*n*-488)	*p*-value
Mean age ± SD	71.1 ± 9.6	69.4 ± 9.6	<0.0001
Women, *n* (%)	22,112 (40.5)	203 (41.6)	0.63
Mean body mass index, kg/m^2 ± SD	28.4 ± 5.9	28.7 ± 6.3	0.22
Race, *n* (%)	1850 (3.4%)	23 (4.7%)	<0.0001
Black	37,479 (68.6%)	392 (80.3%)	
White	15,311 (28.0%)	73 (15.0%)	
Other/unknown			
Smoker, *n* (%)	15,285 (28.0%)	137 (28.1%)	0.96
Diabetes, *n* (%)	15,638 (28.6%)	150 (30.7%)	0.30
Hypertension, *n* (%)	46,705 (85.5%)	422 (86.5%)	0.53
Congestive heart failure, *n* (%)	619 (1.1%)	12 (2.5%)	0.006
Recent myocardial infarction, *n* (%)	642 (1.5%)	3 (1.7%)	0.75
Chronic obstructive pulmonary disease, *n* (%)	5937 (10.9%)	83 (17.0%)	<0.0001
Symptomatic carotid stenosis, *n* (%)	19,913 (36.4%)	95 (19.5%)	<0.0001

CEA, carotid endarterectomy; CAS, carotid artery stenting.

Methods

We conducted a retrospective observational study using the ACS-NSQIP database. The ACS-NSQIP is a multicenter national database, that contains prospectively collected data of >150 variables from both academic and private US hospitals, including preoperative risk factors, intraoperative variables, and 30-day postoperative (periprocedural) outcomes of patients undergoing surgical procedures (URL: https://www.facs.org/quality-programs/acs-nsqip). In 2005, there were 121 participating hospitals/centers in NSQIP which increased to 375 by 2012. The data are collected via chart review/abstraction by trained data abstractors. The study was approved by the local institutional review board.

Current Procedural Terminology codes were used to search the database and identify patients who underwent CEA (35301) and CAS (37215 and 37216). Patients who underwent both a CEA and CAS were excluded. Symptomatic status was defined as a history of preoperative stroke (with or without neurological deficit) or a history of a transient ischemic attack (TIA). Baseline characteristics including age, sex, race, body mass index (BMI), chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), hypertension, and diabetes were identified. Periprocedural outcomes including mortality, stroke, and myocardial infarction were compared between patients undergoing CEA versus CAS.

Cases were defined as symptomatic if they had a preoperative diagnosis of stroke or TIA [variables CVA (history of ischemic or hemorrhagic stroke with residual neurologic deficit), CVANO (history of ischemic or hemorrhagic stroke with no neurologic deficit), or HXTIA (history of TIA) in the NSQIP database] or if they had an International Classification of Diseases-Ninth Edition (ICD-9) code 362.34, 435.0, 781.4, 342.xx or 438.xx.

Statistical Analysis

Categorical variables were compared using chi-square analysis and continuous variables were compared using *t*-test or Kruskal–Wallis test. We tested the independent association of procedure with binary outcomes using logistic regression, adjusting for any presurgery variable that was associated with procedure with $p < 0.10$. A model that included the symptomatic status × procedure interaction was tested, to determine whether the association of symptomatic status with outcomes differed in CEA versus CAS cases. SAS version 9.3 (Cary, NC, USA) was used for data analysis with $p < 0.05$ considered significant.

Results

A total of 54,640 patients undergoing CEA and 488 undergoing CAS between 2005 to 2012 were identified. Patients who underwent CEA were more likely to be older (71.1 ± 9.6 vs. 69.4 ± 9.6, $p < 0.0001$) and have symptomatic stenosis (36.4% vs. 15.5%, $p < 0.0001$) and less likely to be white (68.6% vs. 80.3%, $p < 0.0001$), have CHF (1.1% vs. 2.5%, $p = 0.006$), and have COPD (10.9% vs. 17.0%, <0.0001) (Table 1).

There was no significant difference between CEA and CAS in periprocedural mortality (0.9% vs. 1.2%, $p = 0.33$), stroke (1.6% vs. 1.6%, $p = 0.93$), myocardial infarction (0.9% vs. 1.6%, $p = 0.08$), or combined outcome (3.0% vs. 4.9%, $p = 0.09$) (Figure 1).

In multivariate analysis, predicting periprocedural mortality using symptomatic status, procedure, race, COPD, CHF, age, and BMI, significant predictors included symptomatic status (OR, 1.86; 95% CI, 1.55–2.24), age (OR, 1.05; 95% CI 1.03–1.06), COPD (OR, 2.68; 95% CI, 2.17–3.31), and CHF (OR, 6.14; 95% CI, 4.32–8.72) (Table 2). The symptomatic x procedure interaction was not significant ($p = 0.29$), indicating that the association

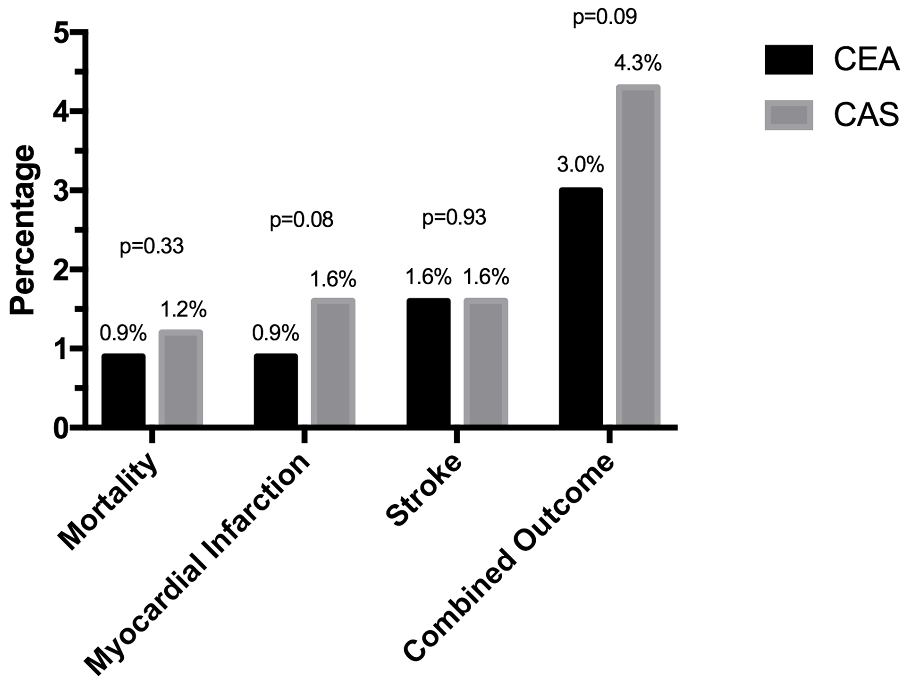

Figure 1. Perioperative (30 day) complications after CEA and CAS in the NSQIP database from 2005 to 2012.

Table 2. Multivariate model predicting outcome with interaction of symptomatic × procedure

Outcome	Predictor	OR (95% CI)	*p*	Symptomatic × procedure *p*
Periprocedural mortality	Symptomatic	1.86 (1.55–2.24)	<0.0001	0.29
	Procedure: CAS versus CEA	1.52 (0.67–3.45)	0.32	
	Age	1.05 (1.03–1.06)	<0.0001	
	BMI	0.99 (0.98–1.01)	0.37	
	Race	n/a	n/a	
	White (reference)	1.48 (0.94–2.34)	0.09	
	Black	1.13 (0.92–2.34)	0.24	
	Other			
	COPD	2.68 (2.17–3.31)	<0.0001	
	CHF	6.14 (4.32–8.72)	<0.0001	
Periprocedural combined outcome (mortality, stroke or myocardial infarction)	Symptomatic	1.72 (1.56–1.90)	<0.0001	0.57
	Procedure: CAS versus CEA	1.56 (1.00–2.42)	0.051	
	Age	1.02 (1.01–1.02)	<0.0001	
	BMI	1.00 (0.99–1.01)	0.76	
	Race	n/a	n/a	
	White (reference)	1.29 (1.01–1.65)	0.045	
	Black	0.88 (0.78–0.98)	0.022	
	Other			
	COPD	1.55 (1.35–1.77)	<0.0001	
	CHF	3.08 (2.34–4.06)	<0.0001	

CEA, carotid endarterectomy; CAS, carotid artery stenting; BMI, body mass index.

of symptomatic status with periprocedural mortality was similar in cases receiving CEA and stent. In the model predicting the combined periprocedural outcome, symptomatic status (OR, 1.72; 95% CI, 1.56–1.90), age (OR, 1.02; 95% CI, 1.01–1.02), COPD (OR, 1.55; 95% CI 1.35–1.77), and CHF (OR 3.08, 95% CI, 2.34–4.06) were once again significant, along with race (black-OR, 1.29; 95% CI 1.01–1.65, and other-OR 0.88; 95% CI 0.78–0.98) (Table 2). However, once again, the symptomatic x procedure interaction was not significant (p = 0.57).

Discussion

Using a contemporary dataset, we observed similar periprocedural outcomes after CAS and CEA for the management of carotid stenosis. Additionally, the incidence of periprocedural stroke, myocardial infarction, and death were relatively low.

In the CREST study, comparing CEA to CAS, there was a lower incidence of periprocedural stroke (2.3% vs. 4.1%) and a higher incidence of periprocedural myocardial infarction (2.3% vs. 1.1%) in patients undergoing CEA compared to CAS [5]. In our cohort, however, we observed a similar incidence of periprocedural stroke (1.6% vs. 1.6%) and myocardial infarction (0.9% vs. 1.6%) after CEA and CAS. We postulate the divergence in our findings with the CREST study regarding periprocedural myocardial infarction likely reflects appropriate case selection in real world practice. Indeed, patients undergoing CEA in our study were less likely to have cardiopulmonary comorbidities including CHF and COPD compared to patients undergoing CAS. Also, the definition of periprocedural myocardial infarction in CREST and our study are different and may also account to our study's lower incidence of periprocedural myocardial infarction. In CREST, myocardial infarction was defined as a creatine kinase MB or troponin level greater than twice the upper limit of the reference, in addition to either chest pain or symptoms consistent with ischemia or ECG evidence of ischemia. In our study, the definition of myocardial infarction was more stringent consisting of new elevation in troponin greater than three times the upper level and ECG changes indicative of acute myocardial infarction including ST elevation > 1 mm in two or more contiguous leads, new left bundle branch, new *q*-wave in two of more contiguous leads.

Furthermore, as previously observed in the CREST along with the stent-protected angioplasty versus carotid endarterectomy in symptomatic patients trial and the international carotid stenting study, there was an association between age and periprocedural outcomes with younger patients having a slightly better outcome with CAS and older patients having a better outcome with CEA [7]. Congruent with these observations, in our population, patients undergoing CEA were in fact older compared to the patients undergoing CAS. Interestingly, the majority of our study population in the NSQIP database were prior to the publication of CREST in 2010 suggesting surgeons and interventionalists may have instinctively realized inherent risks associated with age and comorbidities in deciding between CEA and CAS.

Another important observation from our study is the relatively low incidence of perioperative complications for both CEA and CAS. With univariate analysis, we observed no significant difference in 30-day mortality, periprocedural stroke, myocardial infarction, or combined outcome. It should be noted, however, that there was a trend toward worse combined outcome in patients who underwent CAS with univariate analysis (4.3% vs. 3.0%, p 0.09) and with multivariate analysis [OR 1.56 (1.00–2.42), p = 0.051] adjusting for symptomatic status, race, age, BMI, and comorbidities. The combined perioperative outcome was similar, if not slightly lower for CEA, in our study compared to CREST. In addition, a higher percentage of the cases in our study were defined as asymptomatic (63.6% of CEA cases and 80.5% of CAS) compared to the CREST population (47.3% of CEA cases and 47.1% of CAS cases), and may account for the slightly lower incidence of perioperative complications after CEA in our study. Additionally, the relatively low incidence of perioperative complications in our study may be in part attributable to the inherent self-selection of hospitals interested in quality improvement in the NSQIP database. It should also be noted, a disproportionate number of tertiary care, high volume, academic centers are represented in the NSQIP population. Nevertheless, recent observational studies found no difference between NSQIP participating centers and non-participating centers in improvement of perioperative complications and mortality over time [9,10]. These findings perhaps suggest the NSQIP population may be more generalizable compared to enrollment centers in previous randomized control trials. Overall, our findings provide reassurance that contemporary practices in United States in the management of carotid artery stenosis are overall appropriate and safe. There are limitations to our study. First, the definition of symptomatic status in our study is based on having a prior diagnosis of stroke or TIA in the medical record and due to the nature of the study, it is impossible to affirm if the stroke or TIA was related or attributable to the carotid artery undergoing intervention. Additionally, timing of the stroke or TIA in relation to the index procedure cannot be determined from the database. Second, the database does not include information regarding severity of stenosis, which is a major predictor of recurrent stroke. Also, factors that may influence procedure selection and outcome such as plaque morphology and location, patient preference, and hospital resources/availability of procedures are not available in the database. Third, long-term data reflecting the durability of the procedure is not available in the NSQIP database. Lastly, there was a disproportionately lower number of CAS compare to CEA cases in the database.

In summary, our findings provide reassurance that early outcomes after CEA and CAS for carotid artery stenosis in the 'real-world' appear to be similar to randomized control trials. Appropriate case selection likely drives low perioperative complications after CEA and CAS for the management of carotid artery stenosis.

References

1. Grotta JC. Carotid stenosis. *N Engl J Med* 2013;369(24):2360–2361.
2. North American Symptomatic Carotid Endarterectomy Trial Collaborators. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade carotid stenosis. *N Engl J Med* 1991;325(7):445–453.
3. Barnett HJ, et al. Benefit of carotid endarterectomy in patients with symptomatic moderate or severe stenosis. North American Symptomatic Carotid Endarterectomy Trial Collaborators. *N Engl J Med* 1998;339(20):1415–1425.
4. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST). *Lancet* 1998;351(9113):1379–1387.
5. Brott TG, et al. Stenting versus endarterectomy for treatment of carotid-artery stenosis. *N Engl J Med* 2010;363(1):11–23.
6. Brott TG, et al. Long-term results of stenting versus endarterectomy for carotid-artery stenosis. *N Engl J Med* 2016;374(11):1021–1031.
7. Voeks JH, et al. Age and outcomes after carotid stenting and endarterectomy: the Carotid Revascularization Endarterectomy versus Stenting Trial. *Stroke* 2011;42(12):3484–3490.
8. Yadav JS, et al. Protected carotid-artery stenting versus endarterectomy in high-risk patients. *N Engl J Med* 2004;351(15):1493–1501.
9. Osborne NH, et al. Association of hospital participation in a quality reporting program with surgical outcomes and expenditures for Medicare beneficiaries. *JAMA* 2015;313(5):496–504.
10. Etzioni DA, et al. Association of hospital participation in a surgical outcomes monitoring program with inpatient complications and mortality. *JAMA* 2015;313(5):505–511.