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Carotid Revascularization Immediately Before Urgent Cardiac Surgery

Practice Patterns Associated With the Choice of Carotid Artery Stenting or Endarterectomy: A Report From the CARE (Carotid Artery Revascularization and Endarterectomy) Registry

Creighton W. Don, MD, PHD,* John House, MS,† Christopher White, MD,‡ Thomas Kiernan, MD,‖ Mary Weideman, MS,§ Nicholas Ruggiero, MD,¶ Andrew McCann, MD,# Kenneth Rosenfield, MD**

Seattle, Washington; Kansas City, Missouri; New Orleans, Louisiana; Washington, DC; Cork, Ireland; Philadelphia, Pennsylvania; Brisbane, Australia; and Boston, Massachusetts

Objectives We describe characteristics associated with use of endarterectomy (CEA) versus stenting (CAS) in patients before urgent cardiac surgery.

Background The optimal modality of carotid revascularization preceding cardiac surgery is unknown.

Methods Retrospective evaluation of the CARE (Carotid Artery Revascularization and Endarterectomy) registry from January 2005 to April 2010 was performed on patients undergoing CEA or CAS preceding urgent cardiac surgery within 30 days. Baseline characteristics were compared, and multivariate adjustment was performed.

Results Of 451 patients who met study criteria, 255 underwent CAS and 196 underwent CEA. Both procedures increased over time to a similar degree ($p = 0.18$). Patients undergoing CAS had more frequent history of peripheral artery disease (38.2% vs. 26.5%, $p < 0.01$), neck surgery (5.5% vs. 1.0%, $p = 0.01$), neck radiation (4.3% vs. 1.0%, $p = 0.04$), left-main coronary disease (34.8% vs. 23.5%, $p < 0.01$), neurological events (45.8% vs. 31.3%, $p < 0.01$), carotid intervention (20.8% vs. 7.6%, $p < 0.01$), and higher baseline creatinine (1.3 vs. 1.1 mg/dl, $p = 0.02$). The target carotid arteries of CAS patients were more likely to be symptomatic in the 6 months before revascularization and have restenosis from prior CEA. Patients undergoing CAS had a lower American Society of Anesthesiology grade. Midwest hospitals were less likely to perform CAS than CEA, whereas in the other regions CAS was more common ($p < 0.01$). Non-Caucasian race, a history of heart failure, previous carotid procedures, prior stroke, left main coronary artery stenosis, lower American Society of Anesthesiology grade, and teaching hospital were independent predictors of patients who would receive CAS.

Conclusions Carotid artery stenting and CEA have increased among patients undergoing urgent cardiac surgery. Patients who underwent CAS had more vascular disease but lower acute pre-surgical risk. Significant regional variation in procedure selection exists. (J Am Coll Cardiol Intv 2011;4: 1200–8) © 2011 by the American College of Cardiology Foundation

From the *Division of Cardiology, University of Washington Medical Center, Seattle, Washington; †Saint Luke's Mid America Heart and Vascular Institute, Kansas City, Missouri; ‡Ochsner Heart and Vascular Clinic, New Orleans, Louisiana; §American College of Cardiology, Washington, DC; ‖University College Cork School of Medicine, Cork University Hospital, Cork, Ireland; ¶Thomas Jefferson University Hospital, Philadelphia, Pennsylvania; #Princess Alexandra Hospital, Brisbane, Australia; and the **Cardiac and Vascular Invasive Service, Massachusetts General Hospital, Boston, Massachusetts. This study was funded under NCRR Grant 5 KL2 RR025015. Dr. Rosenfield is a consultant for Abbott Vascular; has received royalty for Angioguard from Cordis; and has received research support from Abbott Vascular, Lutonix, Atrium, and IDEV. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose. George W. Vetrovec, MD, has served as Guest Editor for this paper.

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Patients with symptomatic carotid disease or asymptomatic significant carotid artery stenoses (>80%) are at higher risk for neurological complications when undergoing cardiac surgery (1) and potentially benefit from carotid endarterectomy (CEA) before or concomitant with surgery (2,3). Carotid revascularization with CEA before cardiac surgery is given a class IIA recommendation under current guidelines (3). Clinical trials of carotid artery stenting (CAS) and surgical CEA have shown that both techniques are comparably safe in stable patients but have excluded those with recent myocardial infarction (MI) or requiring urgent cardiac surgery within 30 days (4–6).

Although no randomized trials have compared preoperative CAS with CEA in patients undergoing urgent cardiovascular surgery, an expert consensus panel has recommended its use in high-risk patients (7), and CAS has been increasingly used in this population (1,8–12). Because the optimal modality for carotid revascularization before cardiac surgery is not known, and there is no consensus regarding the type of patient best-suited for each procedure, it is expected that practice patterns vary widely.

In patients undergoing carotid revascularization in preparation for urgent cardiac surgery within 30 days, we describe the current clinical, demographic, and hospital characteristics associated with the choice to use CEA versus CAS among practitioners in the United States.

Methods

This is a retrospective evaluation of patient data in the CARE (Carotid Artery Revascularization and Endarterectomy) registry, a voluntary registry that receives data from 91 participating hospitals across the United States. There is a standard dataset with written definitions, uniform data entry and transmission requirements, and data quality checks. Details on the data collection process have previously been published (13). For this study, we examined registry patients undergoing carotid revascularization procedures from January 2005 to April 2010. Patients whose indication for CEA or CAS was the need for urgent cardiac surgery within 30 days were included. Cardiac surgery was defined as bypass, valve, implantable cardiac defibrillator patch implantation, and transplant surgery. All other patients were excluded.

Patient demographic data, clinical characteristics, carotid anatomy and procedural data, and hospital characteristics were evaluated. The definitions for the data elements are publicly available from the National Cardiovascular Database registry website (14). Death, cause of death, MI, and stroke were reported for all patients at hospital discharge. Death at 30 days after hospital discharge was collected for all patients.

Baseline characteristics were compared between those undergoing CEA and CAS. Multivariate adjustment was used to determine clinical factors independently associated with procedure type. The relative frequency of CEA and CAS procedures were evaluated in terms of hospital type and region. The proportion of each procedure type was evaluated over time.

Statistical analysis. Demographic data were described between the 2 treatment groups CEA and CAS as mean ± SD for continuous variables and number (%) for categorical variables. A logistic regression model was developed to determine predictors of the type of procedure performed in the urgent cardiac surgery population. A stepwise selection process with a 0.05 criteria to enter was developed with the following available elements: age, sex, Caucasian, current dialysis, history of smoking, hypertension, dyslipidemia, peripheral arterial disease, diabetes, chronic obstructive pulmonary disease, major surgery, ischemic heart disease, MI within 6 weeks, Canadian Cardiology Society angina class III or IV within 6 weeks, history heart failure, New York Heart Association functional class III or IV within 6 weeks, history of atrial fibrillation, pacemaker, dementia, history seizure, previous carotid intervention, acute evolving stroke, carotid duplex ultrasound performed, magnetic resonance angiogram performed, computed tomographic angiography performed, 2 or more major coronary arteries >70% stenosis, left main stenosis >50%, moderate-to-severe aortic stenosis, previous neurological event, pre-procedure creatinine, previous neck radiation, contralateral carotid artery occlusion, American Society of Anesthesiology (ASA) grade, and hospital teaching status. All elements significant at the 0.05 level were displayed in a forest plot with corresponding odds ratios (c-statistic = 0.82). Statistical significance was defined as $p < 0.05$. All statistical analyses were performed by the Saint Luke's Mid America Heart and Vascular Institute Department of Biostatistics with SAS (version 9.2, SAS Institute, Cary, North Carolina).

Abbreviations and Acronyms

ASA = American Society of Anesthesiology
CAS = carotid artery stenting
CEA = carotid endarterectomy
MI = myocardial infarction

Results

Between January 2005 and April 2010, 14,874 patients in the CARE registry underwent a carotid revascularization procedure; of these, 451 patients (3.3%) were revascularized in preparation for urgent cardiovascular surgery to be performed within 30 days. The proportion of patients being revascularized for this indication remained stable at 3.1% to 4.1% from year to year ($p = 0.74$). Of these, 255 underwent CAS (56.6%) and 196 underwent CEA (43.4%). The year-to-year variation over the 5-year period in the relative proportion of patients undergoing CAS versus CEA was not significant (Fig. 1) ($p = 0.16$).

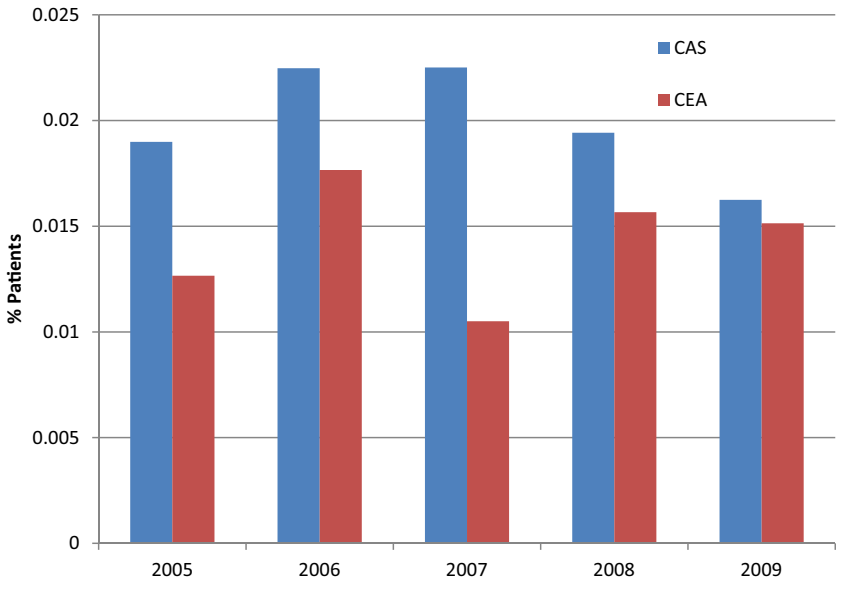

Figure 1. Relative Percentage of Patients Undergoing CAS or CEA

Relative percentage of patients undergoing carotid artery stenting (CAS) or carotid endarterectomy (CEA) before urgent cardiac surgery by year. Test of trend, p = 0.161.

Comparison of baseline differences between the 2 groups is shown in Table 1. Patients undergoing CAS had significantly more peripheral artery disease, left-main coronary disease, prior neurological events, prior carotid artery intervention, and higher baseline creatinine. Patients with prior neck surgery were 5 times as likely to undergo CAS as CEA (p = 0.01) and 4 times as likely if they had prior neck radiation (p = 0.04). The 2 groups were otherwise similar in terms of demographic data, medical history, and major cardiovascular risk factors.

There was some variation in the degree of stenoses of the common carotid arteries, but the internal carotid arteries and the target vessels had a similar degree of disease measured by ultrasound, magnetic resonance angiographic imaging, and computed tomography (Table 2). There was a much greater likelihood, however, that patients undergoing CAS had a history of carotid intervention (20.8% vs. 7.6%, p < 0.01) and had an occluded contralateral carotid artery (p = 0.02). The target artery in patients undergoing CAS, compared with those undergoing CEA, was much more likely to be symptomatic within the prior 6 months (p < 0.01) and to have been restenotic after prior CEA (8.2% vs. 2.0%, p < 0.01). The frequency of other high-risk features, such as fibromuscular dysplasia and carotid artery dissection, was similar (Table 2).

Despite the greater burden of coronary, peripheral, and carotid vascular disease at baseline, patients undergoing CAS had a lower pre-procedural risk on the basis of ASA grade of physical status (2.7 vs. 3.4, p < 0.01). Among patients undergoing CAS, the majority had an ASA grade of 3, whereas most of the patients undergoing CEA had an ASA grade of 4 (Fig. 2). Fifteen patients (6.1%) undergoing CAS had an ASA grade of 1, whereas none of the CEA patients were classified as such. Likewise, none of the CAS patients were ASA grade 5, whereas 1 CEA patient was in this very-high-risk category.

Nearly one-half of patients receiving CAS received their stent through enrollment in clinical trials, which were primarily post-market surveillance studies. In contrast, only 6.1% of patients undergoing CEA had their procedure performed as part of a clinical trial (Table 2).

University and teaching hospitals were more likely to perform CAS than private community hospitals or government-run facilities (Table 3). Hospitals in the Midwest were significantly less likely to perform CAS (35.3%) than CEA (64.7%), whereas in other regions two-thirds of cases were CAS and one-third were CEA (Fig. 3). The distribution of teaching hospitals did not explain this variation, because teaching hospitals constituted 47.7% of sites in the Midwest, 65.2% in the Northeast, 29.6% in the West, and 30.1% in the South. The difference in the Midwest was still significant, even after stratification by whether a site was a teaching hospital (p < 0.01). Medicaid patients were more than twice as likely to receive CAS as CEA (p = 0.01), but there were no other significant differences in insurance between patients receiving these procedures (Table 3). Insurance type did not vary significantly by region, so payer type would not explain the regional variation either (data not shown). In

Table 1. Baseline Characteristics of Patients Who Underwent CAS Compared With CEA

	Total (N = 451)	Procedure Type		p Values
		CAS (n = 255)	CEA (n = 196)	
Demographic data				
Age (yrs)	69.8 ± 8.89	69.68 ± 8.95	70.00 ± 8.92	0.707
Age ≥80 yrs	62 (13.75%)	28 (10.98%)	34 (17.35%)	0.052
Male	297 (65.85%)	167 (65.49%)	130 (66.33%)	0.853
Race				
White	405 (89.80%)	222 (87.06%)	183 (93.37%)	0.095
Black/African American	25 (5.54%)	17 (6.67%)	8 (4.08%)	
Asian	8 (1.77%)	7 (2.75%)	1 (0.51%)	
American Indian/Alaskan native	1 (0.22%)	0 (0.00%)	1 (0.51%)	
Other	12 (2.66%)	9 (3.53%)	3 (1.53%)	
Medical history				0.135
Hypertension	418 (92.68%)	240 (94.12%)	178 (90.82%)	0.182
Dyslipidemia	368 (81.60%)	208 (81.57%)	160 (81.63%)	0.986
Peripheral arterial disease	149 (33.11%)	97 (38.19%)	52 (26.53%)	0.009
Diabetes mellitus	193 (42.79%)	101 (39.61%)	92 (46.94%)	0.119
Chronic lung disease	122 (27.05%)	74 (29.02%)	48 (24.49%)	0.283
Tobacco history				
Current	141 (31.40%)	80 (31.37%)	61 (31.44%)	0.584
Former	202 (44.99%)	112 (43.92%)	90 (46.39%)	0.798
Creatinine	1.24 ± 0.91	1.28 ± 1.00	1.18 ± 0.77	0.021
Currently on dialysis	16 (3.56%)	8 (3.14%)	8 (4.10%)	0.156
Prior neck complications				
Previous neck radiation	13 (2.88%)	11 (4.31%)	2 (1.02%)	0.038
Previous neck surgery	16 (3.55%)	14 (5.49%)	2 (1.02%)	0.011
Tracheostomy present	5 (1.11%)	4 (1.57%)	1 (0.51%)	0.287
Previous laryngeal nerve palsy	1 (0.22%)	1 (0.39%)	0 (0.00%)	0.380
Cardiac history				
Prior ischemic heart disease	364 (80.71%)	209 (81.96%)	155 (79.08%)	0.442
≥2 major coronary arteries (stenosis ≥70%)	319 (70.89%)	177 (69.69%)	142 (72.45%)	0.522
MI within 6 weeks	77 (17.07%)	41 (16.08%)	36 (18.37%)	0.522
Angina CCS class III or IV within 6 weeks	148 (32.89%)	85 (33.46%)	63 (32.14%)	0.767
History of heart failure	91 (20.18%)	58 (22.75%)	33 (16.84%)	0.121
NYHA III or IV within 6 weeks	107 (23.73%)	60 (23.53%)	47 (23.98%)	0.911
Left ventricular ejection fraction, %	52.21 ± 14.57	51.46 ± 15.28	53.13 ± 13.61	0.339
Atrial fibrillation or flutter	55 (12.22%)	33 (12.99%)	22 (11.22%)	0.570
Left main coronary artery stenosis ≥50%	134 (29.84%)	88 (34.78%)	46 (23.47%)	0.009
Moderate to severe aortic stenosis	68 (15.11%)	35 (13.78%)	33 (16.84%)	0.369
Neurological history				
Dementia or Alzheimer's disease	9 (2.00%)	6 (2.35%)	3 (1.53%)	0.536
History of seizure or known seizure disorder	7 (1.55%)	4 (1.57%)	3 (1.53%)	0.974
Previous carotid intervention	68 (15.08%)	53 (20.78%)	15 (7.65%)	<0.001
Neurological event(s) before procedure	178 (39.56%)	117 (45.88%)	61 (31.28%)	0.002
NIH stroke scale score	0.50 ± 1.28	0.50 ± 1.30	0.33 ± 0.52	0.074

Values are mean ± SD or n (%). Baseline characteristics of patients with symptomatic or asymptomatic ≥80% carotid artery stenosis who underwent carotid artery stenting (CAS) compared with those who underwent carotid endarterectomy (CEA) in preparation for urgent cardiac surgery within 30 days.

CCS = Canadian Cardiovascular Society; MI = myocardial infarction; NIH = National Institutes of Health; NYHA = New York Heart Association functional class.

an unadjusted comparison of major in-hospital and 30-day outcomes (Table 4) there were no statistically significant differences between the 2 groups.

In the multivariate analysis, non-Caucasian race, a history of heart failure, previous carotid procedures, prior stroke, left main coronary artery stenosis, lower ASA grade, and

JACC: CARDIOVASCULAR INTERVENTIONS, VOL. 4, NO. 11, 2011
NOVEMBER 2011:1200–8

Table 2. Anatomic and Procedural Characteristics of Patients Who Underwent CAS Compared With CEA

	Total (N = 451)	Procedure Type		p Value
		CAS (n = 255)	CEA (n = 196)	
Pre-procedure noninvasive studies				
Carotid duplex ultrasound	323 (71.78%)	174 (68.24%)	149 (76.41%)	0.056
Peak systolic velocity—right	271.85 ± 182.32	270.15 ± 185.43	273.87 ± 179.22	0.860
Peak systolic velocity—left	264.55 ± 176.33	255.49 ± 173.73	275.32 ± 179.42	0.331
MRA angiography performed	66 (14.80%)	34 (13.49%)	32 (16.49%)	0.376
CCA highest % stenosis—right	15.23 ± 28.01	18.86 ± 32.58	11.43 ± 22.42	0.391
CCA highest % stenosis—left	6.41 ± 20.45	7.89 ± 21.23	5.00 ± 20.13	0.665
ICA highest % stenosis—right	59.58 ± 33.83	58.35 ± 33.41	60.56 ± 34.81	0.712
ICA highest % stenosis—left	52.65 ± 38.52	57.50 ± 35.55	48.43 ± 41.24	0.959
CT angiography performed	113 (25.34%)	52 (20.72%)	61 (31.28%)	0.011
CCA high % stenosis—right	12.43 ± 26.48	20.89 ± 32.40	6.00 ± 18.84	0.008
CCA high % stenosis—left	11.67 ± 25.31	21.57 ± 33.13	4.75 ± 14.77	0.002
ICA high % stenosis—right	71.60 ± 31.50	71.24 ± 32.62	71.86 ± 30.99	0.928
ICA high % stenosis—left	60.47 ± 34.5	61.03 ± 35.91	59.98 ± 33.63	0.892
Pre-procedure lesion characteristics				
Target lesion symptomatic in prior 6months	127 (28.16%)	87 (34.12%)	40 (20.41%)	0.001
Restenosis of target vessel after prior CAS	7 (1.55%)	6 (2.35%)	1 (0.51%)	0.117
Restenosis of target vessel after prior CEA	25 (5.54%)	21 (8.24%)	4 (2.04%)	0.004
Contralateral carotid artery occlusion	45 (9.98%)	33 (12.94%)	12 (6.12%)	0.017
Fibromuscular dysplasia	5 (1.11%)	4 (1.57%)	1 (0.51%)	0.287
Spontaneous carotid artery dissection	6 (1.33%)	4 (1.57%)	2 (1.02%)	0.614
Procedure information				
Bilateral carotid intervention	29 (6.43%)	13 (5.10%)	16 (8.16%)	0.215
Target carotid vessel				0.804
Right	217 (48.12%)	124 (48.63%)	93 (47.45%)	
Left	234 (51.88%)	131 (51.37%)	103 (52.55%)	
Procedure part of clinical trial	138 (30.67%)	126 (49.41%)	12 (6.15%)	<0.001
Post-market surveillance	123 (90.44%)	113 (89.68%)	10 (83.33%)	0.500
Anesthesia type				<0.001
General	182 (40.35%)	8 (3.14%)	174 (88.78%)	
Local	269 (59.65%)	247 (96.86%)	22 (11.22%)	
ASA grade	3.0 ± 0.3	2.7 ± 0.3	3.4 ± 0.4	<0.001

Values are n (%) or mean ± SD. Anatomic and procedural characteristics of patients with symptomatic or asymptomatic ≥80% carotid artery stenosis who underwent CAS compared with those who underwent CEA in preparation for urgent cardiac surgery within 30 days.

CT = computed tomography; CCA = common carotid artery; ICA = internal carotid artery; MRA = magnetic resonance angiography; other abbreviations as in Table 1.

teaching hospital were independent predictors of patients who would receive CAS (Fig. 4). Patients undergoing CAS were less likely to have carotid ultrasound as the primary imaging modality.

Discussion

Among patients included in the CARE registry between 2005 and 2010, roughly 3% to 4% underwent pre-operative carotid revascularization before urgent cardiac surgery. Patients selected for CAS had higher risk features, such as left main coronary artery stenosis, prior cerebral vascular accidents, recent symptoms attributable to the target vessel, and an occluded contralateral carotid artery. Nevertheless, patients who underwent CEA had a significantly higher ASA grade, many had Grade 4 and higher, suggesting that these patients might have presented more acutely decompensated, despite having fewer chronic risk factors.

Current American College of Cardiology/American Heart Association guidelines recognize the possible benefit of pre-operative carotid revascularization before cardiac surgery, while acknowledging that the level of data to support this practice only allows a class IIA recommendation (3,7). Although it is accepted that patients with severe carotid artery disease undergoing cardiac surgery are at higher risk for complications (2), retrospective studies suggest that perioperative risk from cardiac surgery might be

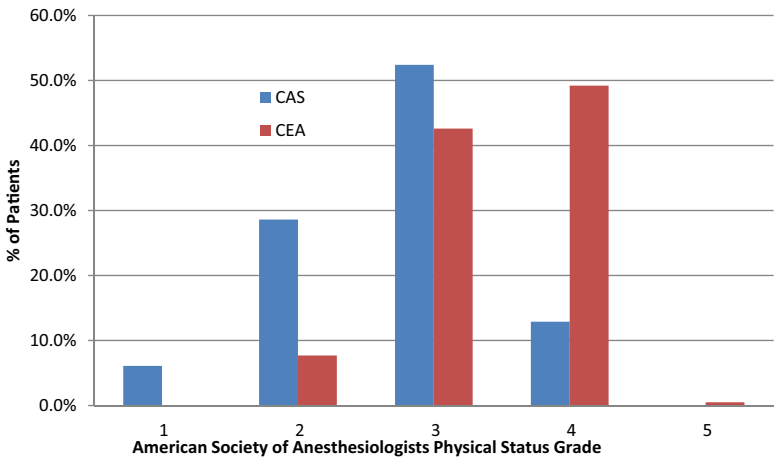

Figure 2. Comparison of Pre-Operative Physical Status of Patients Undergoing CAS or CEA

Comparison of pre-operative physical status of patients undergoing CAS or CEA before urgent cardiac surgery. Comparison of overall American Society of Anesthesiology (ASA) grades between CAS and CEA, test of homogeneity, $p < 0.001$. Abbreviations as in Figure 1.

Table 3. Comparison of Patients Undergoing CAS Versus CEA by Hospital Characteristics and Insurance Carriers

		Procedure Type		
	Total (N = 451)	CAS (n = 255)	CEA (n = 196)	p Value
Hospital characteristics				
Hospital type				<0.001
Government	16 (3.55%)	2 (0.78%)	14 (7.14%)	
Private/community	399 (88.47%)	218 (85.49%)	181 (92.35%)	
University	36 (7.98%)	35 (13.73%)	1 (0.51%)	
Hospital setting				0.054
Rural	24 (5.32%)	15 (5.88%)	9 (4.59%)	
Suburban	141 (31.26%)	68 (26.67%)	73 (37.24%)	
Urban	286 (63.41%)	172 (67.45%)	114 (58.16%)	
Number of beds	508.32 ± 184.86	494.02 ± 205.43	526.93 ± 152.56	0.061
Teaching hospital	211 (46.78%)	131 (51.37%)	80 (40.82%)	0.026
Hospital region				<0.001
West	66 (14.63%)	47 (18.43%)	19 (9.69%)	
Northeast	59 (13.08%)	36 (14.12%)	23 (11.73%)	
Midwest	116 (25.72%)	41 (16.08%)	75 (38.27%)	
South	210 (46.56%)	131 (51.37%)	79 (40.31%)	
Patient insurance				
Medicare	309 (68.51%)	182 (71.37%)	127 (64.80%)	0.136
Medicaid	41 (9.09%)	31 (12.16%)	10 (5.10%)	0.010
Health maintenance organization	253 (56.10%)	136 (53.33%)	117 (59.69%)	0.177
Military/veterans administration	6 (1.33%)	5 (1.96%)	1 (0.51%)	0.183
Non-U.S. insurance	3 (0.67%)	2 (0.78%)	1 (0.51%)	0.723
Self-pay	27 (5.99%)	19 (7.45%)	8 (4.08%)	0.135

Values are n (%) or mean ± SD. Comparison of patients undergoing CAS versus CEA in preparation for urgent cardiac surgery within 30 days by hospital characteristics and insurance carriers.

Abbreviations as in Table 1.

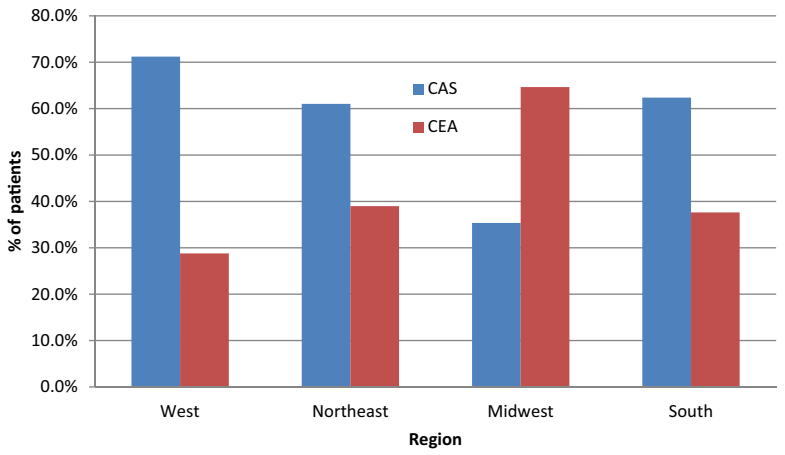

Figure 3. Regional Differences in the Proportion of Patients Undergoing CAS or CEA

Regional differences in the proportion of patients undergoing CAS or CEA before urgent cardiac surgery. Comparison of regional differences between CAS and CEA, test of homogeneity, $p < 0.001$. Abbreviations as in Figure 1.

reduced by prophylactically performing carotid revascularization (15,16). Yet other studies have shown less favorable results (17,18). No randomized clinical trials have been performed to validate this practice, compared with optimal medical management at time of surgery.

Although clinical trials comparing CAS with CEA have typically excluded patients undergoing urgent cardiac surgery, there have been several reports describing and advocating the use of percutaneous stenting in patients undergoing urgent cardiac surgery (1,8,12,16,19). The use trends for both procedures are very similar, although one should caution against conclusions about general practice patterns in the United States, because the CARE registry has been historically directed toward sites that perform both CAS and CEA; therefore, this sample would under-represent sites that perform CEA primarily. Nevertheless, the increased use of CAS is consistent with the trends reported in other large registries (20).

Table 4. Unadjusted Patient Outcomes of Patients Who Underwent CAS Compared With CEA

		Procedure Type		
	Total (N = 451)	CAS (n = 255)	CEA (n = 196)	p Value
In-hospital outcomes				
New stroke or TIA	25 (5.54%)	16 (6.27%)	9 (4.59%)	0.439
MI	41 (9.09%)	21 (8.24%)	20 (10.20%)	0.471
Death	12 (2.66%)	6 (2.35%)	6 (3.06%)	0.643
Death, stroke, or MI	37 (8.20%)	22 (8.63%)	15 (7.65%)	0.709
30-day outcome				
Death	14 (5.28%)	7 (4.27%)	7 (6.93%)	0.347
Death, stroke, or MI	48 (17.78%)	25 (14.97%)	23 (22.33%)	0.124

Values are n (%). Unadjusted patient outcomes of patients with symptomatic or asymptomatic ≥80% carotid artery stenosis who underwent CAS compared with those who underwent CEA in preparation for urgent cardiac surgery within 30 days.

TIA = transient ischemic attack; other abbreviations as in Table 1.

Our study demonstrates that physicians are more likely to perform CAS on patients with high-risk comorbidities, such as left main coronary artery disease, significant contralateral carotid disease, and recent neurological events. By contrast, CEA is more frequently performed on acutely decompensated patients. This practice pattern is consistent with previous reports showing a greater use of elective CAS in older, higher-risk patients (21) as well as the design of initial trials comparing the 2 modalities among patients with high-risk surgical features (4). The lower ASA grades among CAS patients might be because many of these patients received stents through a clinical trial; so either by study design or physician bias, more stable patients were selectively chosen to receive this therapy. Furthermore, the ASA grade given by anesthesiologists at time of surgery might vary in consistent ways from the grades given by interventional cardiologists, especially because this is a scale developed by anesthesiologists for surgical risk assessment. Nevertheless, our findings underscore the increasing willingness of practitioners to stent high-risk patients and for surgeons to perform cardiac surgery soon after a patient has received a carotid stent, for which they might be required to take concurrent antiplatelet agents.

The increased proportion of CAS in teaching and university-based hospitals is most likely a reflection of the initial penetration of this relatively newer procedure, because access to CAS technology and expertise is still emerging. Additionally, many carotid stents are placed within the framework of clinical trials and post-market surveillance registries, which are more likely to be coordi-

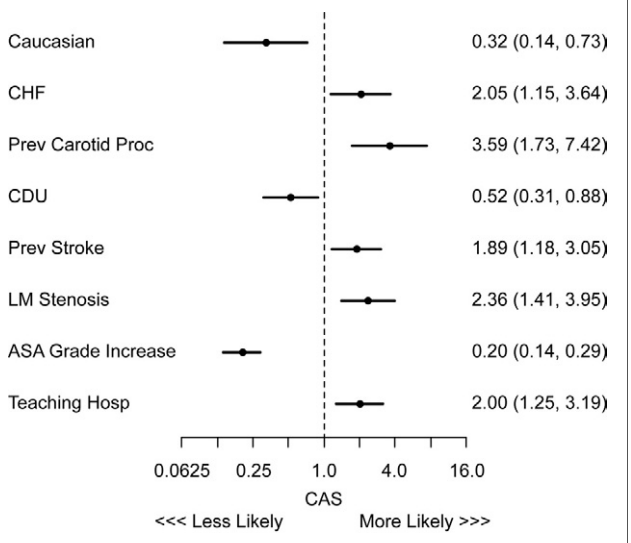

Figure 4. Adjusted Analysis of Clinical and Hospital Features Associated With CAS Before Urgent Cardiac Surgery

The use of CAS was adjusted for the listed variables in addition to age, sex, current dialysis, prior smoking, hypertension, dyslipidemia, peripheral arterial disease, diabetes, chronic obstructive lung disease, coronary artery disease, myocardial infarction within 6 weeks, angina class III or IV within 6 weeks, New York Heart Association functional class III or IV within 6 weeks, atrial fibrillation, pacemaker, dementia, seizure history, acute evolving stroke, magnetic resonance angiogram performed, computed tomography angiography performed, 2 or more major coronary arteries with >70% stenosis, moderate to severe aortic stenosis, previous neurological event, preprocedure creatinine, neck radiation, and contralateral carotid artery occlusion. Values given as odds ratio (95% confidence interval). CDU = carotid duplex ultrasound; CHF = congestive heart failure; Hosp = hospital; LM = left main; other abbreviations as in Figure 1.

nated by teaching institutions. It is notable, however, that CARE registry participating facilities in the Midwest have a very different use of these 2 procedures, heavily favoring CEA. This heterogeneity was not explained by the proportion of university/teaching hospitals or insurance type. It might be the case that fewer of these Midwest hospitals are involved in clinical trials and post-marketing CAS studies, have a larger number of vascular surgeons submitting data, or have local insurance issues that prevent CAS from being performed outside of currently active studies, but the CARE registry does not have the granularity of data to evaluate this.

Study limitations. This is an observational study of facilities voluntarily participating in the CARE registry. Participating centers might vary in terms of the types and number of procedures they provide, compared with nonparticipating centers; therefore, these results might not necessarily represent more generalized practice patterns. The clinical variables that can be included in the adjusted analysis are limited to the types of data the registry collects, such that unmeasured patient and hospital variables that might impact practice patterns cannot be accounted for by this analysis. Whether CEA was performed concomitantly with surgery was not recorded. Also, these data are collected during hospital stays and thus might overlook patients who are scheduled for outpatient procedures. Finally, although death, MI, and stroke were reported at hospital discharge, with regard to the 30-day endpoint, we could ascertain deaths through the Social Security Death Index, but there were several missing 30-day evaluations of MI and stroke.

Conclusions

In summary, carotid artery stenting is being used increasingly in patients who are undergoing urgent cardiovascular surgery within 30 days. Although practitioners are performing CAS in patients with high-risk comorbid conditions, unstable patients seem more likely to receive CEA. There is significant heterogeneity of practice patterns across hospitals and regions that potentially represents differences in access to technology as well as differences in physician preferences.

Reprint requests and correspondence: Dr. Creighton W. Don, University of Washington Medical Center, Medicine–Division of Cardiology, 1959 Northeast Pacific Street, Seattle, Washington 98195. E-mail: cwdon@u.washington.edu.

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Key Words: carotid artery stenting ■ carotid endarterectomy ■ carotid revascularization.