Comparison of outcomes in women and men following carotid interventions in the Washington state's Vascular Interventional Surgical Care and Outcomes Assessment Program

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ABSTRACT

Background: The benefit for carotid endarterectomy (CEA) to prevent a potential stroke has been shown to be less beneficial for women compared with men and the risk of carotid stenting (CAS) is higher in women than men. We hypothesized that a community-based Washington state registry data would also reveal increased morbidity and mortality for women undergoing carotid interventions.

Methods: Deidentified data for CEA and CAS between 2010 and 2015 were obtained from 19 hospitals participating in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program. Data analysis compared in-hospital composite outcome of stroke and mortality from CEA and CAS between women and men.

Results: Over the study period, 3704 individuals underwent CEA (n = 2759; 49.5% symptomatic) and CAS (n = 945; 60.9% symptomatic). Women accounted for 39.5% of the cohort. Women were slightly younger than men (70.0 ± 10.2 vs 71.0 ± 9.6 years respectively; $P < .01$), less likely to be smokers (70.1% vs 75.6%; $P < .01$), and less likely to have a diagnosis of coronary artery disease (32.9% vs 46.5%; $P < .01$). Fewer women underwent CEA for symptomatic carotid disease (46.1% vs 51.8%; $P < .01$). There were no statistically significant differences in the postoperative in-hospital stroke and mortality among women and men undergoing CEA (asymptomatic, 0.8% vs 1.4% [$P = .36$]; symptomatic, 1.8% vs 2.2% [$P = .58$]) and CAS (asymptomatic, 1.4% vs 2.2% [$P = .56$]; symptomatic, 4.6% vs 2.5% [$P = .18$]). Hospital duration of stay and discharge disposition were similar for women and men. A subanalysis of the octogenarian cohort undergoing CAS demonstrated a substantial increase in-hospital stroke and mortality among women and men (11.6% [CAS] vs 2.2% [CEA]; $P = .024$).

Conclusions: In the Washington state Vascular-Interventional Surgical Care and Outcomes Assessment Program registry, hospital composite outcome of stroke and mortality following carotid interventions from 2010 to 2015 were noted to be similar for women and men. The notable exception to this finding was observed in subcohort of women undergoing CAS for symptomatic carotid disease at age 80 years or older. These findings should be taken into account when risk stratifying patients for carotid interventions. (J Vasc Surg 2019;69:1121-8.)

Keywords: Carotid endarterectomy; Carotid artery stenting; Sex differences; Gender differences

There is an extensive body of literature comparing the outcomes post carotid interventions between women and men.[1] This literature includes randomized controlled trials, retrospective institutional experience, and large regional and national administrative datasets analyses of carotid endarterectomy (CEA) and carotid stenting (CAS) outcomes.[2-14] Based on a subanalysis of the North American Symptomatic Carotid Endarterectomy trial, women undergoing CEA for symptomatic carotid disease have a higher 30-day risk of stroke and mortality compared with men.[2] A recent meta-analysis of case series and databases focusing on post-CEA outcomes also demonstrated a worse outcome for women with an increased risk of 30-day stroke and mortality compared with men.[15] Women also have an increased perioperative morbidity and mortality related to CAS when compared with CEA and when compared with men.[3,4,8,9,14] As such, women in general are counselled

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that the risk reduction benefit of carotid interventions is lower than that for men. This finding is based on a slightly greater perioperative risk for women, who are generally older than men at the time of presentation and have a lower natural history risk of stroke.[5-7] In contrast with these reports, an analysis of large, single-center datasets and administrative databases have demonstrated similar outcomes among women and men undergoing CEA and CAS.[8-12,16]

We sought to review the practice and outcomes differences between women and men undergoing carotid interventions for symptomatic and asymptomatic carotid disease in Washington State using the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry. We hypothesized that, similar to national trends, women experience an increased perioperative morbidity and mortality with carotid intervention compared with men.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected data from the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program
- **Key Findings:** In 3704 patients with carotid stenosis, women and men had similar in-hospital stroke and death rates after either carotid endarterectomy (CEA) or carotid stenting (CAS). Both CAS and CEA had significant increase in stroke and mortality (11.6% and 2.2%) in octogenarians, and CEA and CAS in octogenarians was associated with high stroke rate.
- **Take Home Message:** The authors suggest that younger women with carotid stenosis be managed in a similar fashion to men, but octogenarians should be managed selectively since they are at much higher risk for stroke when carotid stenting is used.

METHODS

The registry. The Washington State VI-SCOAP is a Washington State surgical quality outcomes improvement registry with different participation modules to evaluate care offered at participating academic and community hospitals in the State. VI-SCOAP is a program of the Foundation for Health Care Quality. The data are linked to hospital admission/discharge and vital status records for patients undergoing select surgical procedures identified by Current Procedural Terminology and *The International Classification of Diseases*, Ninth Revision, codes. Data abstraction was performed locally at each participating hospital. Data are audited for quality control among participating sites.[17]

The cohort. Deidentified data from the 19 participating hospitals (also deidentified) for consecutive carotid interventions (CEA and CAS) performed at participating hospitals between 2010 and 2015 were obtained for analysis. This study did not meet criteria for human subjects review in line with University of Washington policies.[18] Data included demographics, comorbid conditions, indication for the carotid interventions (symptomatic vs asymptomatic), operative details, postoperative complications, and discharge status. A patient with symptomatic carotid disease was defined as a patient admitted with neurologic symptoms suggestive of stroke, transient ischemic attack (TIA), or amaurosis fugax as noted in the hospital admission, preoperative, and operative notes. It is worth noting that the time frame for stroke, TIA, or amaurosis fugax was not specifically abstracted. TIA was defined as a reversible neurologic deficit in the carotid distribution that resolved within 24 hours. Symptoms of stroke or TIA included contralateral numbness or weakness, confusion or trouble speaking or understanding speech, difficulty seeing in one or both eyes, or loss of balance or coordination secondary to contralateral lower extremity motor weakness. A patient with asymptomatic carotid disease was defined as a patient without neurologic symptoms suggestive of stroke, TIA, or amaurosis fugax. Patient with dizziness were not considered symptomatic. The degree of carotid stenosis was not abstracted as part of the registry. Cerebral monitoring included stump pressure measurement, electroencephalograph, transcranial Doppler, cerebral oximetry, or if the patient was awake during the monitoring.

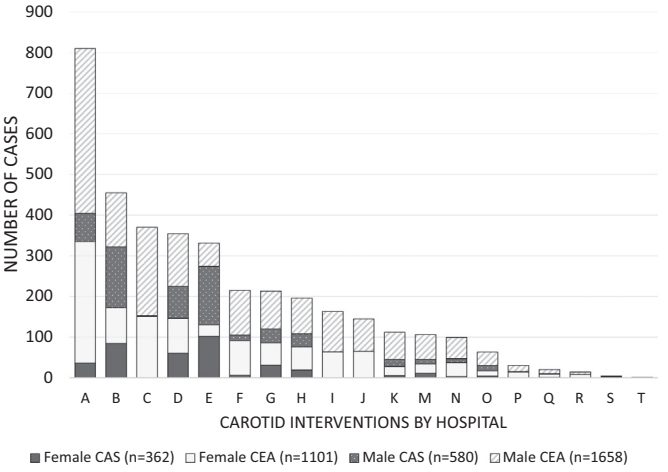

Fig 1. Distribution of carotid interventions by participating hospital in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry between 2010 and 2015. *CAS*, Coronary stenting; *CEA*, coronary endarterectomy.

Comorbid conditions in the registry were defined as follows.

- *Hypertension*: Any mention of hypertension in the medical record on admit but not including

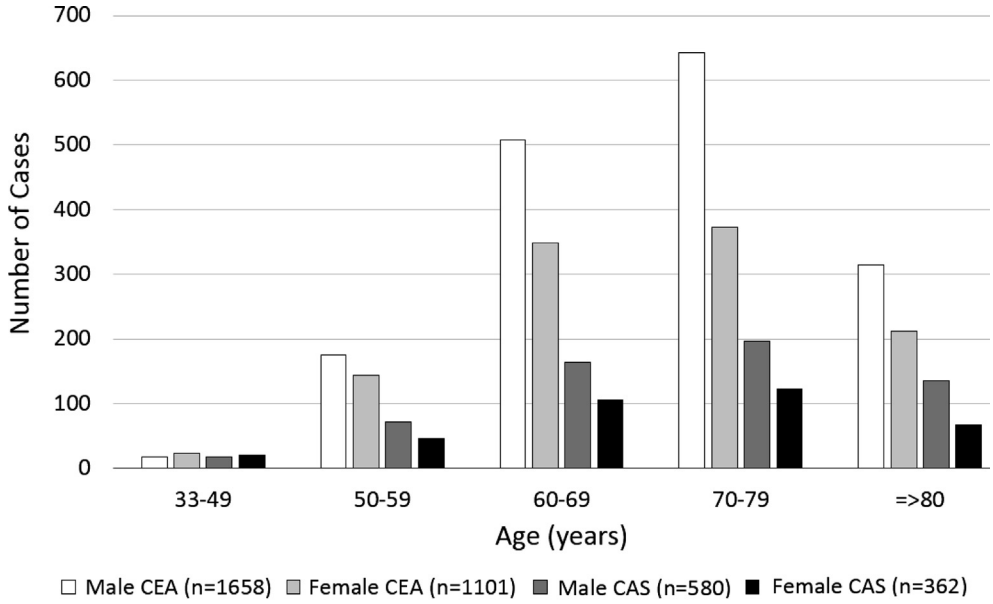

Fig 2. Age distribution of patients undergoing carotid interventions in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry between 2010 and 2015. *CAS,* Coronary stenting; *CEA,* coronary endarterectomy.

hypertension diagnosed during the current hospital stay. "White coat hypertension" was not counted as a diagnosis of hypertension.

- *Coronary artery disease (CAD)*: Any diagnosis of CAD or angina.
- *Diabetes mellitus*: Any diagnosis of diabetes mellitus in the medical record on admit or during the hospitalization, including diagnosis of borderline diabetic.
- *Severe chronic obstructive pulmonary disease (COPD)*: Any documentation of COPD, emphysema, and/or chronic bronchitis resulting in any one or more of the following: functional disability from COPD, past hospitalization for treatment of COPD, the patient requires chronic bronchodilator therapy with oral or inhaled agents, or the patient has an FEV_1 of less than 75% of predicted on pulmonary function testing. This parameter did not include the diagnosis of asthma, diffuse interstitial fibrosis, or sarcoidosis.
- *Smoker (current or past)*: If the patient is a current smoker or has any documented history of smoking cigarettes. There was a high degree of missing data for the status of current smoking (66.8%) and as such the variable of current smoking was not used.

Postoperative complications were defined as follows.

- *Myocardial infarction (MI)*: An MI was noted if one of the following occurred: (1) documentation of electrocardiographic changes indicative of an acute MI (ST elevation >1 mm in ≥2 contiguous leads, new left bundle branch block, new Q-wave in ≥2 contiguous leads), or (2) new elevation in troponin of more than 3 times the upper level of the reference range in the setting of suspected MI, and/or (3) a physician diagnosis of MI or cardiac arrest after CEA or CAS was noted.
- *Stroke*: Stroke was noted if the patient developed an embolic, thrombotic, or hemorrhagic stroke with motor, sensory, or cognitive dysfunction that persists for 24 or more hours.
- *Postoperative cranial nerve injury*: Postoperative cranial nerve injury included those to the hypoglossal, recurrent laryngeal, and glossopharyngeal nerves.

Statistical analysis. The primary outcome was a composite outcome of in-hospital stroke and mortality. Data were analyzed using Microsoft Excel 2010 software (Microsoft, Redmond, Wash). Statistical analysis was performed using SPSS 19.0 for Windows (SPSS, Inc., Chicago, Ill). Continuous data are presented as means and standard error of the mean and compared using the Student *t*-test. Categorical data were compared using the Fisher exact test or Pearson χ^2 test analysis, where appropriate. Differences were considered statistically significant at a *P* values of greater than .05. To evaluate the difference in the rates of the composite outcome between women and men after CEA and CAS, two multivariate logistic regressions were performed controlling for preoperative characteristics that were significantly different between women and men. For the CEA model, the factors that were considered significantly different included age at the time of the CEA, smoking history, private insurance status, CAD, statin, antiplatelet therapy (aspirin and/or clopidogrel [Plavix]), angiotensin-converting enzyme inhibitor, and symptomatic carotid disease. For the CAS model, factors that were considered significantly different included age, CAD, beta-blocker, and private insurance. Given the low rates of composite events, we also performed a sensitivity analysis to avoid

Table I. Demographic characteristics of patients undergoing carotid interventions in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry (2010-2015)

	CEA (n = 2756)			CAS (n = 941)		
	Women (n = 1101)	Men (n = 1658)	*P* value	Women (n = 362)	Men (n = 583)	*P* value
Mean age at procedure	69.4 ± 10.8	70.7 ± 10.7	.02	70.1 ± 10	71.1 ± 9.2	.06
Indication						
Symptomatic carotid disease	507 (46.1)	858 (51.8)	<.01	217 (60.1)	356 (61.4)	.70
Amaurosis fugax[a]	82 (16.2)	142 (16.6)	.85	19 (8.8)	41 (11.5)	.30
TIA[a]	193 (38.1)	318 (37.1)	.72	74 (34.3)	129 (36.2)	.63
Stroke[a]	221 (43.6)	359 (41.9)	.54	105 (48.4)	180 (50.7)	.59
Race						
Caucasian	998 (90.1)	1509 (91)	.11	314 (86.4)	517 (88.7)	.19
African American	18 (1.6)	14 (0.8)	.36	12 (3.3)	13 (2.2)	.77
Asian	23 (2.1)	34 (2.1)	.94	6 (1.7)	9 (1.5)	.93
American Indian/Alaskan Native	16 (1.5)	17 (1.0)	.38	5 (1.4)	1 (0.2)	.03
Native Hawaiian/Pacific Islander	8 (0.7)	4 (0.2)	.07	4 (1.1)	0	.01
Other	0	4 (0.2)	.10	3 (1.0)	6 (1.0)	.72
Unknown	38 (3.5)	76 (4.6)		18 (5)	37 (6.5)	—
Comorbid conditions						
Hypertension	926 (84.1)	1420 (85.6)	.28	298 (82.3)	459 (78.8)	.18
CAD	356 (32.3)	773 (46.7)	<.01	126 (34.8)	269 (46.2)	<.01
Diabetes	372 (33.8)	546 (32.9)	.64	118 (32.6)	189 (32.4)	.96
Severe COPD	154 (14.0)	226 (13.6)	.79	50 (13.8)	64 (11.0)	.19
Smoker (past or current)	773 (70.2)	1257 (76.0)	<.01	252 (69.6)	433 (74.5)	.20
Body mass index	28.7 ± 6.7	28.4 ± 4.9	.34	30.7 ± 27.6	28.4 ± 5.4	.05
Preoperative medications						
Antiplatelet therapy[b]	935 (84.9)	1428 (86.2)	.34	308 (85.1)	486 (83.5)	.52
Therapeutic anticoagulation within 1 week of intervention	212 (19.5)	307 (18.7)	.58	53 (15.2)	82 (14.6)	.81
Beta-blocker	530 (48.1)	811 (51.0)	.67	166 (45.9)	305 (52.3)	.05
ACE inhibitor/angiotensin receptor blocker	563 (51.1)	931 (56.2)	.01	194 (53.6)	311 (53.3)	.94
Statin	796 (72.3)	1274 (76.8)	.01	258 (71.3)	434 (74.4)	.28
Preoperative functional status			.45			.15
Totally independent	962 (87.3)	1460 (88.1)	—	304 (84)	494 (84.7)	—
Partially independent	90 (8.2)	125 (7.5)	—	40 (11.4)	51 (8.7)	—
Totally dependent	10 (0.9)	5 (0.3)	—	4 (1.1)	12 (2.1)	—
Not recorded	39 (3.5)	68 (4.1)	—	14 (3.8)	26 (4.5)	—

ACE, Angiotensin-converting enzyme; *CAD*, coronary artery disease; *CAS*, carotid stenting; *CEA*, carotid endarterectomy; *COPD*, chronic obstructive pulmonary disease; *TIA*, transient ischemic attack.
Values are presented as number (%) or mean ± standard deviation.
[a]Not mutually exclusive.
[b]Aspirin, clopidogrel, and/or aspirin with dipyridamole (Aggrenox).

overfitting using backward stepwise logistic regressions to select the most significant parameters ($P < .2$) for the models.

RESULTS

Cohort. During the study period, 3704 individuals underwent carotid interventions (74.5% CEA, 25.5% CAS) at 19 participating hospitals in Washington State. Fig 1 details the distribution of cases by participating hospitals and by case numbers. Women accounted for 39.5% of the cohort. Women were slightly younger than men at the time of intervention with a mean age of 70.0 ± 10.2 vs 71.0 ± 9.6 years, respectively ($P < .01$) and had similar preoperative functional status. Fig 2 details the number of cases by age groups among women and men. Women were less likely to have a previous

Table II. Technical procedure details for 2759 patients undergoing carotid endarterectomy (*CEA*) in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry (2010 and 2015)

	Women (n = 1101)	Men (n = 1658)	*P* value
Technique			
Eversion endarterectomy	147 (13.4)	209 (12.6)	.57
Patch angioplasty	889 (80.9)	1355 (81.7)	.58
Patch type (% patch angioplasty)			.08
Bovine pericardium	601 (67.7)	924 (68.2)	—
Dacron	147 (16.6)	263 (19.4)	—
GORE-TEX or PTFE	50 (5.6)	51 (3.8)	—
Vein	13 (1.4)	14 (1.0)	—
Other	78 (8.7)	103 (7.6)	—
Shunt	716 (65.3)	1009 (60.9)	.02
Neuromonitoring[a]			
No.	361	523	—
Awake	55 (15.2)	72 (13.8)	.541
Cerebral oximetry	19 (5.3)	26 (5)	.85
Electroencephalograph	127 (7.5)	34 (6.5)	.57
Transcranial Doppler	107 (29.6)	201 (38.4)	<.01
Stump pressure measurement	173 (47.9)	227 (43.5)	.19

CEA, Carotid endarterectomy.
Values are presented as number (%).
[a]Categories are not mutually exclusive.

diagnosis of CAD (32.9% vs 46.5%; $P < .001$) and were less likely to have a smoking history at the time of the intervention (70.1% vs 75.6%; $P < .001$). There was a near equal distribution of CEA and CAS among women and men. Symptomatic carotid disease was the indication for carotid interventions in 53.2% of the cases. The mean interval from admission to CEA or CAS was shorter for asymptomatic vs symptomatic carotid disease (0.29 days vs 1.14 days; $P < .01$). The cohort's demographics and characteristics are detailed in Table I.

CEA. A total of 2756 individuals underwent CEAs. Among those, 39.9% (n = 1100) were women. Vascular surgeons performed the majority of CEAs (86.9%). A lower percentage of women in the CEA group were on statins preoperatively compared with men (72.3% vs 76.8%; $P = .01$). The interval from admission to CEA was similar among women and men (0.6 ± 2.1 days vs 0.7 ± 2.3 days, respectively; $P = .05$). Overall, a lower percentage of women (46.1%) underwent CEA for symptomatic carotid disease compared with men (46.1% vs 51.8%; $P = .003$). Patch angioplasty of the carotid artery was the most common operative technique and bovine pericardium was the most commonly used patch (Table II). Details regarding cerebral monitoring were available in 360 women and 523 men and demonstrated lower use of transcranial Doppler in women compared with men (29.7% vs 38.5%; $P < .01$). Women had a shunt used more frequently than men (65.3% vs 60.9%; $P = .02$).

Women had a lower in hospital mortality after CEA compared with men (0.1% vs 0.8%; $P = .012$). However, there were no differences in the composite outcome of postoperative stroke and mortality among women compared with men undergoing CEA for asymptomatic (0.8% vs 1.4%; $P = .36$) and symptomatic (1.8% vs 2.2%; $P = .58$) carotid stenosis (Table III). This finding was also demonstrated in a multivariate analysis with no statistical difference seen in the odds of the composite outcome (odds ratio [OR], 1.47; 95% confidence interval [CI], 0.77-2.81). Sensitivity analysis demonstrated the same results (OR, 1.50; 95% CI, 0.79-2.86). Of note, given the small number of combined events (1.3% vs 1.8%), the sample size needed to detect a statistically significant differences would be 17,056 CEAs. In a subanalysis of symptomatic individuals, there were again no significant differences and no differences in patients who are managed medically. Women were more likely to be readmitted to the intensive care unit after CEA compared with men (1.9% vs 0.7%, respectively; $P = .01$); however, women had a similar duration of stay and discharge disposition (Table IV). There were no differences in discharge antiplatelet therapy and beta-blocker therapy, but women were less likely to be discharged on an angiotensin-converting enzyme inhibitor/angiotensin receptor blocker and a statin compared with men (Table IV).

CAS. A total of 945 individuals underwent CAS. Among those, 38.3% (n = 362) were women. Interventional radiologists performed the majority of CAS procedures (54.9%), followed by cardiologists (17.1%). The interval from admission to carotid intervention was similar among women and men (0.89 ± 1.9 days vs 0.9 ± 2.3 days, respectively; $P = .8$). An equal percentage of women and men underwent CAS for symptomatic carotid disease (60.1% vs 61.4%; $P = .7$).

There were no differences in the technical details of CAS with the majority performed under conscious sedation (85.2%). Embolic protection was similarly used in the majority of cases (women 89.7% and men 87.6%; $P = .32$).

Women had a higher in-hospital mortality after CAS compared with men (1.4% vs 0.7%; $P = .42$), but there were no differences between women and men in the composite outcome of postoperative stroke and mortality in asymptomatic (1.4% vs 2.2%; $P = .56$) or symptomatic (4.6% vs 2.5%; $P = .18$) carotid stenosis (Table III). This finding was also demonstrated in a multivariate analysis with no statistical difference seen in the odds of the composite outcome (OR, 0.74; 95% CI, 0.33-1.63). Sensitivity analysis demonstrated the same results (OR, 0.72; 95% CI, 0.33-1.58). Of note, given the small number of combined events (3.3% vs 2.4%) among women and

Table III. In-hospital outcomes for patients undergoing carotid interventions in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry (2010-2015)

	CEA (n = 2759)			CAS (n = 945)		
	Women (n = 1101)	Men (n = 1658)	*P*	Women (n = 362)	Men (n = 583)	*P* value
Stroke	13 (1.2)	20 (1.2)	.95	8 (2.2)	11 (1.9)	.73
In-hospital mortality	1 (0.1)	13 (0.8)	.01	5 (1.4)	4 (0.7)	.42
Composite outcome	14 (1.3)	30 (1.8)	.27	12 (3.3)	14 (2.4)	.40
Asymptomatic	5 (0.8)	1 (1.4)	.36	2 (1.4)	5 (2.2)	.56
Symptomatic	9 (1.8)	19 (2.2)	.58	10 (4.6)	9 (2.5)	.18
Reoperative intervention	19 (1.7)	35 (2.1)	.47	4 (1.1)	12 (2.1)	.27
Readmission to ICU	21 (1.9)	12 (0.7)	.01	5 (1.4)	4 (0.7)	.29
MI	6 (0.5)	6 (0.4)	.47	0	0	–
Tracheal intubation/tracheostomy	5 (0.5)	11 (0.7)	.48	3 (0.8)	3 (0.5)	.55
Postoperative cranial nerve injury	25 (2.3)	32 (1.9)	.54	0	0	–
Postoperative pneumonia	4 (0.4)	6 (0.4)	.99	2 (0.6)	11 (1.9)	.09
Urinary tract infection	3 (0.3)	3 (0.2)	.61	7 (1.9)	3 (0.5)	.04
Antibiotics for infection	9 (0.8)	19 (1.1)	.40	9 (2.5)	15 (2.6)	.93

CAS, Carotid stenting; *CEA*, carotid endarterectomy; *ICU*, intensive care unit; *MI*, myocardial infarction.
Values are presented as number (%).

Table IV. Discharge disposition and medications for patients undergoing carotid interventions in the Washington State Vascular-Interventional Surgical Care and Outcomes Assessment Program (VI-SCOAP) registry (2010 and 2015)

	CEA (n = 2759)			CAS (n = 945)		
	Women (n = 1101)	Men (n = 1658)	*P* value	Women (n = 362)	Men (n = 583)	*P* value
Hospital duration of stay	1.96 ± 11.2	1.98 ± 2.3	.83	2.4 ± 2.8	2.7 ± 3.6	.13
Discharge disposition			.14			.48
Home	1020 (92.6)	1523 (91.9)	–	312 (86.2)	488 (83.7)	–
Skilled nursing facility	39 (3.5)	58 (3.5)	–	22 (6.1)	38 (6.5)	–
Inpatient facility	8 (0.7)	9 (0.5)	–	3 (0.8)	6 (1)	–
Death	1 (0.1)	13 (0.8)	–	5 (1.4)	4 (0.7)	–
Not recorded	33 (3)	55 (3.3)	–	20 (5.5)	47 (8.1)	–
Discharge medications						
Antiplatelet therapy[a]	972 (88.4)	1459 (88.8)	.72	330 (93)	559 (96.5)	.01
Beta-blocker	522 (47.4)	813 (49.0)	.40	127 (35.1)	269 (46.1)	<.01
ACE inhibitor or ARB	517 (47.0)	862 (52.0)	.01	161 (44.5)	250 (42.9)	.63
Statin	803 (72.9)	1273 (76.8)	.02	256 (70.7)	466 (79.9)	<.01

ACE, Angiotensin-converting enzyme; *ARB*, angiotensin receptor blocker; *CAS*, carotid stenting; *CEA*, carotid endarterectomy.
Values are presented as mean ± standard deviation or number (%).
[a]Aspirin, clopidogrel, or both.

men undergoing CAS, respectively, the sample size needed to detect a statistically significant differences would be 10,948 CAS procedures.

Additional subgroup analysis was performed for patients aged 80 or older at the time of CAS. A total of 202 individuals underwent CAS (33.2% female; age range, 80-94 years; 65.3% for symptomatic carotid disease). Women with symptomatic carotid disease (n = 43) had a higher incidence of the composite outcome than men (n = 89; 11.6% vs 2.2%; *P* = .024).

DISCUSSION

In the Washington State VI-SCOAP participating hospitals, there were no statistically significant differences in in-hospital stroke and mortality among women and men undergoing carotid interventions. These findings are consistent with previously reported data.[8-12,19] Additionally, there were no differences in hospital duration of stay or discharge disposition among women and men. In a subgroup analysis, women undergoing CEA had a slightly higher intensive care unit readmission

after CEA and a lower in-hospital mortality compared with men. These differences were small and, although statistically significant, they are unlikely to be clinically relevant.

Our data did demonstrate that symptomatic carotid disease is associated with a higher in-hospital mortality compared with asymptomatic carotid stenosis. These findings are consistent with previous reports demonstrating higher rates of stroke and mortality after CEA and CAS in patients with preoperative neurologic symptoms related to carotid stenosis.[9,16,20,21]

Interestingly, the proportion of women undergoing CEA or CAS for asymptomatic carotid disease was similar. Based on previous studies demonstrating worse outcomes with CAS compared with CEA among women,[3,4] we expected a lower proportion of women undergoing CAS compared with CEA. A subanalysis within this group demonstrated that women age 80 or older with symptomatic carotid disease undergoing CAS experienced the worst outcomes and the highest postoperative stroke and mortality. This finding was primarily due to a higher rate of in-hospital mortality compared with men. These findings are similar to what has been previously demonstrated in the Carotid Revascularization Endarterectomy vs Stenting Trial lead in-phase trial the Stent-Protected Angioplasty vs Carotid Endarterectomy trial, and large administrated datasets.[22-24] These data reinforce the higher risk associated with CAS in patients who are octogenarians, especially women. This increased risk is likely related to the associated comorbid conditions and frailty associated with advanced age.

Interestingly, women were less likely to have documented CAD at the time of presentation for carotid interventions. This is unlikely related to the slightly younger age of presentation (70 years vs 71 years), because it is unlikely to be of clinical significance. It is possible that CAD is underdiagnosed in women rather than women having a lower incidence of CAD.[25] Failure to identify and treat CAD might predispose undiagnosed patients to higher rates of perioperative MI. Interestingly, in this patient cohort, there were no differences in postoperative MI between women and men. Women were as likely to be discharged on antiplatelet therapy and beta-blockers. Although the proportion of patients noted to have hyperlipidemia was similar among women and men, women were less likely to be started on a statin at the time of discharge, especially after CAS procedures. Careful medical management can further improve outcomes in all patients.

Another notable finding was that 53.2% of the carotid procedures were performed in symptomatic patients. Nationwide, the majority of carotid procedures are performed for asymptomatic carotid disease.[3,8,14,24] Although the results of the VI-SCOAP and previously analyzed administrative datasets are not directly comparable, such variances in carotid disease management could point toward regional differences in the management of asymptomatic carotid stenosis. Alternatively, this finding could be related to the way symptomatic and asymptomatic carotid diseases was abstracted in VI-SCOAP, thus leading to an overestimate of symptomatic cases. Future studies comparing national trends might offer insight into practice regional variation.

The study has several limitations. The cohort is predominantly Caucasian (90.1%), from the Pacific Northwest, and the findings cannot be generalized to a more diverse population. Because the data were obtained from a quality improvement registry, the choice of a carotid intervention offered was reflective of what is practiced at the institutional level rather than a standardized approach. Because the entry point to enrollment was the actual intervention (CEA or CAS), the difference in asymptomatic and symptomatic carotid disease between women and men could not be ascertained; those patients not offered a surgical intervention were not included. Additionally, given that the centers were deidentified at the time of data analysis, comparison of center volume with outcome differences was not possible. Given the low number of composite events, we did not assess clustering of outcomes by hospital. Moreover, the study is underpowered to detected differences based on the event rate, thus leading to a type II error given that the sample size necessary to demonstrate a statistically significant difference is more than 17,000 and 10,000 for CEA and CAS, respectively. Last, the outcomes are limited to the in-hospital stay and we were not able to compare late survival or long-term benefits of carotid interventions for women and men. Several studies have suggested that both sexes might have comparable long-term outcomes.[12,26]

CONCLUSIONS

In the Washington state VI-SCOAP registry, women and men had similar stroke and mortality after carotid interventions from 2010 to 2015. The notable exception to this finding was observed in a subcohort of women who were 80 years of age or older at the time of undergoing CAS for symptomatic carotid disease. These findings should be taken into account when risk stratifying patients for carotid interventions.

AUTHOR CONTRIBUTIONS

Conception and design: MM, SS
Analysis and interpretation: DN, GT, TH, SHS, DF, MM, SS, SK
Data collection: DF, MM
Writing the article: DN, SS
Critical revision of the article: DN, GT, TH, SHS, DF, MM, SS, SK
Final approval of the article: DN, GT, TH, SHS, DF, MM, SS, SK
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Overall responsibility: MM, SS

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