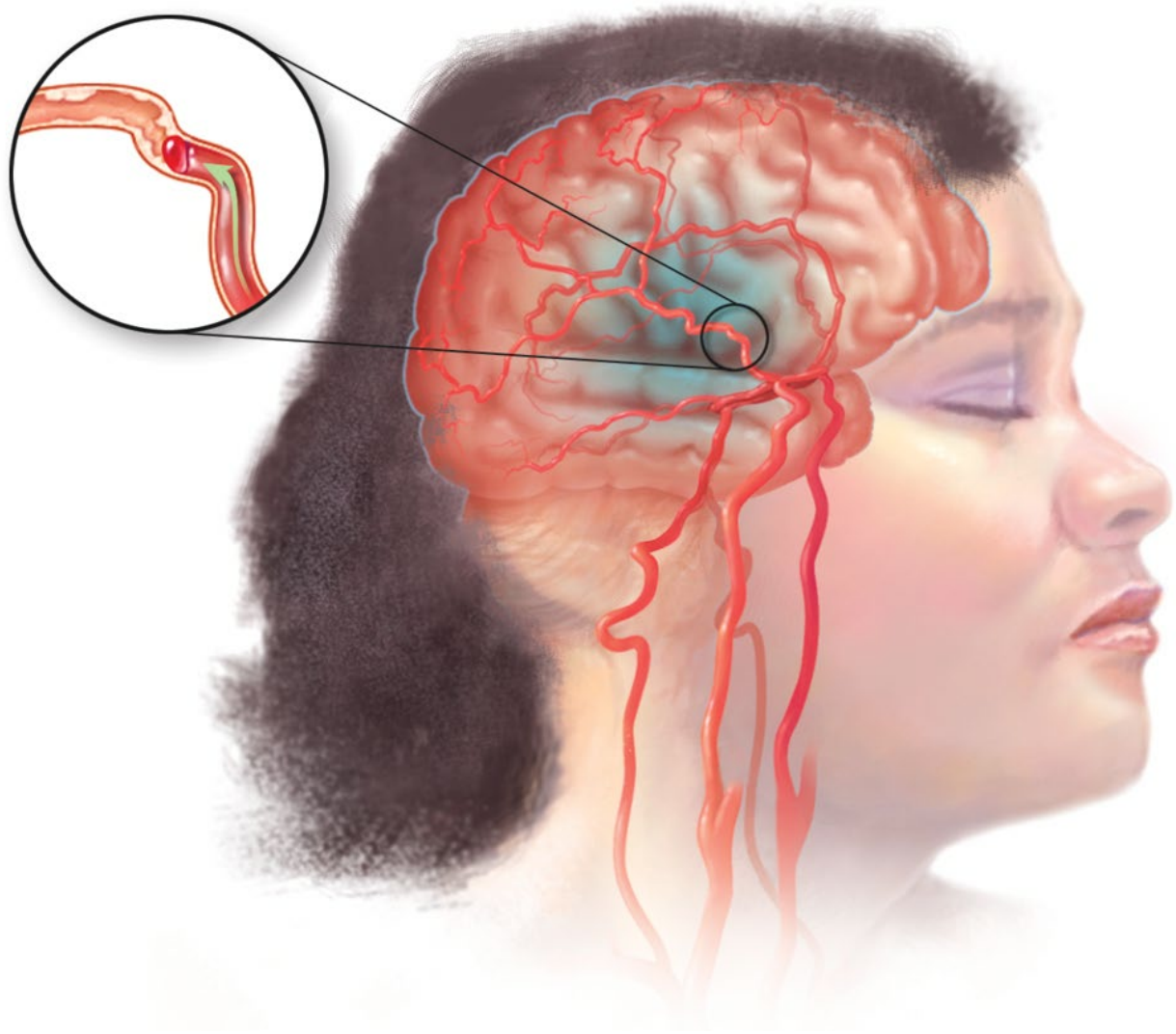
No sex-difference in outcomes after carotid revascularization in symptomatic patients: A two–stroke-center cohort

Camila Esquetini-Vernon, MD
Research Trainee
Division of Vascular and Endovascular Surgery
Mayo Clinic, Florida

BACKGROUND

- Carotid artery stenosis accounts for 20% of ischemic strokes.
- Sex differences in carotid anatomy and plaque features can influence outcomes after carotid revascularization.
- Guidelines do not provide sex-specific recommendations.
- Women are underrepresented in clinical trials limiting data and potentially leading to suboptimal management.



STUDY OBJECTIVES

- To compare outcomes between sexes in symptomatic patients undergoing CEA, TCAR, or TFCAS across two stroke centers.
- **Primary outcomes (30-day):** stroke/TIA, MI, death.
- **Secondary outcomes (mid-term):** stroke/TIA, MI, death, restenosis, reintervention.

METHODS

All patients who underwent carotid artery revascularization between 2015-2025 across two-stroke-centers.

Identification of symptomatic patients: ipsilateral neurologic symptoms within 6 months of the procedure.

Exclusion of asymptomatic patients, prior neck radiation and revascularization performed at an outside institution.

341 symptomatic patients: 238 males and 103 females.

BASELINE PATIENT DEMOGRAPHICS

- Age: 73.5±9.6 years.
- COPD was more prevalent in females.
- Other baseline demographics and comorbidities were comparable between sexes.

	Male (N=238)	Female (N=103)	p value
Age (years)			0.43
- Mean (SD)	73.5 (9.6)	73.2 (9.7)	
- Median (Q1, Q3)	75.2 (66.5, 80.7)	74.2 (66.4, 80.8)	
BMI (kg/m²)			0.81
- Mean (SD)	28.7 (5.3)	28.9 (7.6)	
- Median (Q1, Q3)	28.2 (25.5, 31.3)	28.0 (24.0, 31.4)	
Comorbidities			
Hypertension	197 (82.8%)	83 (80.6%)	0.63
Coronary artery disease	93 (39.1%)	29 (28.2%)	0.05
Atrial fibrillation	41 (17.2%)	19 (18.4%)	0.79
Peripheral artery disease	17 (7.1%)	6 (5.8%)	0.66
COPD	28 (11.8%)	21 (20.4%)	0.04
Hyperlipidemia	181 (76.1%)	80 (77.7%)	0.75
Diabetes mellitus	63 (26.6%)	31 (30.1%)	0.51
Current smoker	27 (11.3%)	15 (14.6%)	0.41
CKD stage			0.93
Stage 1	40 (17.1%)	16 (15.8%)	
Stage 2	110 (47.0%)	47 (46.5%)	
Stage 3a	51 (21.8%)	21 (20.8%)	
Stage 3b	25 (10.7%)	12 (11.9%)	
Stage 4	7 (3.0%)	5 (5.0%)	
Stage 5	1 (0.4%)	0 (0.0%)	

STROKE AT PRESENTATION

- Stroke severity was similar by sex.
- IV thrombolysis and mechanical thrombectomy did not differ by sex.
- Timing from thrombolysis to carotid intervention was similar.
- Functional status at discharge was comparable.

	Male N=125	Female N=59	p value
NIHSS at admission Mean (SD)	5.4 (6.6)	6.1 (6.9)	0.57
NIHSS at discharge Mean (SD)	2.1 (3.3)	3.8 (6.0)	0.14
mRS at discharge Mean (SD)	0.9 (1.2)	0.9 (1.2)	0.89
Thrombectomy, n (%)	19 (15.2%)	13 (22.0%)	0.25
TICI 2A, n (%)	0 (0.0%)	1 (7.7%)	0.57
TICI 2B, n (%)	6 (37.5%)	4 (30.8%)	
TICI 2C, n (%)	2 (12.5%)	3 (23.1%)	
TICI 3, n (%)	8 (50.0%)	5 (38.5%)	
Thrombolysis, n (%)	22 (17.6%)	7 (11.9%)	0.32
Thrombolytic agent: tNK, n (%)	11 (50.0%)	6 (85.7%)	0.09
Thrombolytic agent: tPA, n (%)	11 (50.0%)	1 (14.3%)	
Days from thrombectomy to surgery Mean (SD)	3.6 (4.3)	2.4 (2.8)	0.71
Days from thrombolysis to surgery Mean (SD)	5.4 (5.0)	4.0 (2.8)	0.35

IMAGING CHARACTERISTICS

- Stenosis severity on CTA was similar by sex.
- The ICA/CCA ratio was higher in females.
- MRI vulnerable plaque more common in males.

	Male (N=238)	Female (N=103)	p value
Stenosis on CT (%)			0.47
- Mean (SD)	74.1 (16.5)	74.8 (14.9)	
- Median (Q1, Q3)	75.0 (60.0, 90.0)	76.0 (70.0, 90.0)	
PSV (cm/s)			0.4
- Mean (SD)	219.1 (136.8)	260.4 (167.3)	
- Median (Q1, Q3)	186.0 (117.0, 300.8)	233.0 (120.0, 349.0)	
EDV (cm/s)			0.15
- Mean (SD)	66.1 (58.9)	74.0 (61.3)	
- Median (Q1, Q3)	46.0 (27.0, 87.0)	53.0 (27.8, 105.8)	
ICA/CCA ratio			0.02
- Mean (SD)	3.9 (3.5)	6.0 (5.6)	
- Median (Q1, Q3)	2.7 (1.8, 4.9)	4.1 (2.3, 7.2)	
MRI vulnerable features	38 (48.1%)	10 (27.0%)	0.03
Intraplaque hemorrhage	31 (39.2%)	9 (24.3%)	0.12
Ulceration	13 (16.5%)	2 (5.4%)	0.1
Lipid necrotic core	8 (10.1%)	2 (5.4%)	0.4
Inflammatory plaque	3 (3.8%)	1 (2.7%)	0.76
Thin fibrous cap	2 (2.5%)	0 (0.0%)	0.33

LIPID METRICS AND PERIOPERATIVE MEDICAL THERAPY

- Females had higher total cholesterol, HDL, and LDL.
- No other difference in pre-op nor post-op medication.

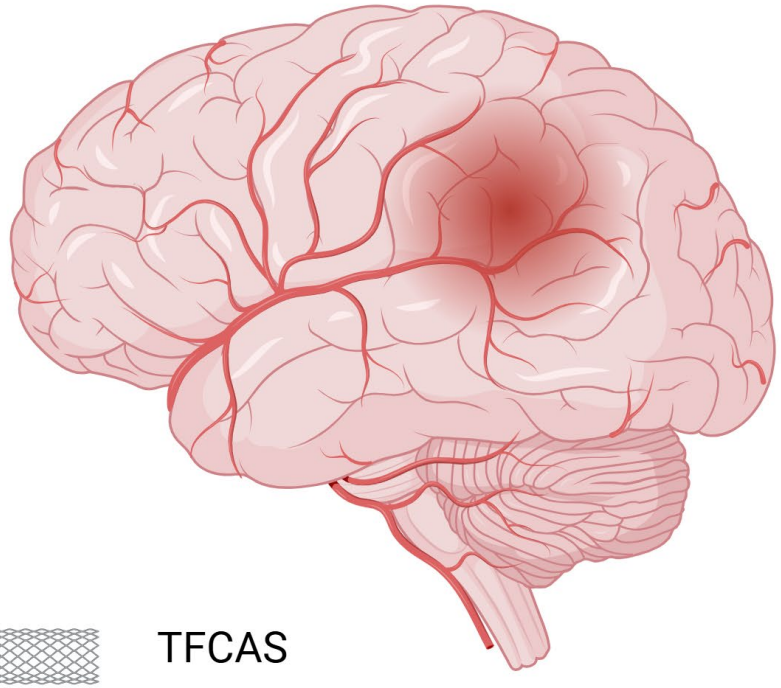
	Male (N=238)	Female (N=103)	p value
Total cholesterol (mg/dL)			< 0.01
- Mean (SD)	157.8 (43.5)	187.8 (59.5)	
- Median (Q1, Q3)	151.0 (127.8, 183.2)	174.0 (150.0, 221.0)	
HDL (mg/dL)			< 0.01
- Mean (SD)	48.2 (18.6)	56.3 (19.0)	
- Median (Q1, Q3)	45.0 (37.0, 54.0)	54.0 (41.0, 67.0)	
LDL (mg/dL)			< 0.01
- Mean (SD)	85.3 (36.7)	102.8 (46.8)	
- Median (Q1, Q3)	78.0 (57.0, 107.0)	91.0 (69.0, 132.2)	
Triglycerides (mg/dL)			0.32
- Mean (SD)	139.3 (99.3)	138.7 (97.5)	
- Median (Q1, Q3)	112.0 (83.5, 165.2)	120.0 (84.0, 164.0)	
Pre-op antithrombotic regimen			0.59
- Anticoagulation (AC)	9 (3.8%)	4 (3.9%)	
- Dual antiplatelet therapy (DAPT)	97 (40.8%)	39 (37.9%)	
- DAPT + AC	6 (2.5%)	2 (1.9%)	
- None	23 (9.7%)	16 (15.5%)	
- Single antiplatelet therapy (SAPT)	80 (33.6%)	36 (35.0%)	
- SAPT + AC	23 (9.7%)	6 (5.8%)	
Pre-op statin	193 (81.1%)	80 (77.7%)	0.47
Pre-op PCSK9 inhibitor	3 (1.3%)	2 (1.9%)	0.63
Pre-op ezetimibe	23 (9.7%)	16 (15.5%)	0.12
Pre-op estrogens	0 (0.0%)	3 (2.9%)	< 0.01
Pre-op antihypertensive	163 (68.5%)	69 (67.0%)	0.79
Discharge antithrombotic regimen			0.64
- Anticoagulation (AC)	5 (2.1%)	2 (1.9%)	
- Dual antiplatelet therapy (DAPT)	142 (59.7%)	61 (59.2%)	
- DAPT + AC	13 (5.5%)	2 (1.9%)	
- None	1 (0.4%)	0 (0.0%)	
- Single antiplatelet therapy (SAPT)	54 (22.7%)	29 (28.2%)	
- SAPT + AC	23 (9.7%)	9 (8.7%)	
Post-op statin	216 (90.8%)	89 (86.4%)	0.23
Post-op PCSK9 inhibitor	6 (2.5%)	2 (1.9%)	0.75
Post-op ezetimibe	24 (10.1%)	18 (17.5%)	0.06
Post-op estrogens	0 (0.0%)	6 (5.8%)	< 0.01

PERIOPERATIVE AND MID-TERM OUTCOMES BY SEX

- No sex-based differences at 30 days or mid term.
- Rates of restenosis and need for reintervention were similar by sex.

	Male (N=238)	Female (N=103)	p value
Cranial nerve injury	12 (5.1%)	2 (1.9%)	0.24
30-day outcomes			
Ipsilateral stroke	6 (2.5%)	4 (3.9%)	0.5
TIA	3 (1.3%)	2 (1.9%)	0.64
MI	1 (0.4%)	0 (0.0%)	1.00
Mortality	2 (0.8%)	3 (2.9%)	0.16
Composite	10 (4.2%)	8 (7.8%)	0.19
Mid-term outcomes			
Ipsilateral stroke	10 (4.2%)	5 (4.9%)	0.78
TIA	16 (6.7%)	6 (5.8%)	0.76
MI	4 (1.7%)	1 (1.0%)	1.00
Mortality	24 (10.1%)	13 (12.6%)	0.49
Composite	41 (17.1%)	22 (21.4%)	0.37
Restenosis	22 (9.2%)	12 (11.7%)	0.5
Reintervention	15 (6.3%)	10 (9.7%)	0.27
All-cause mortality	26 (10.9%)	19 (18.4%)	0.13

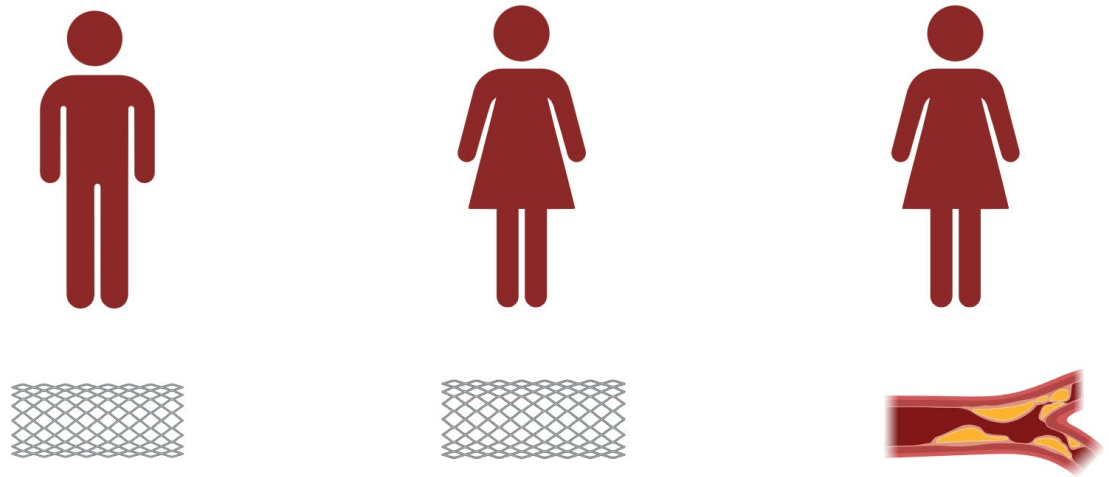
Ipsilateral 30-days strokes:



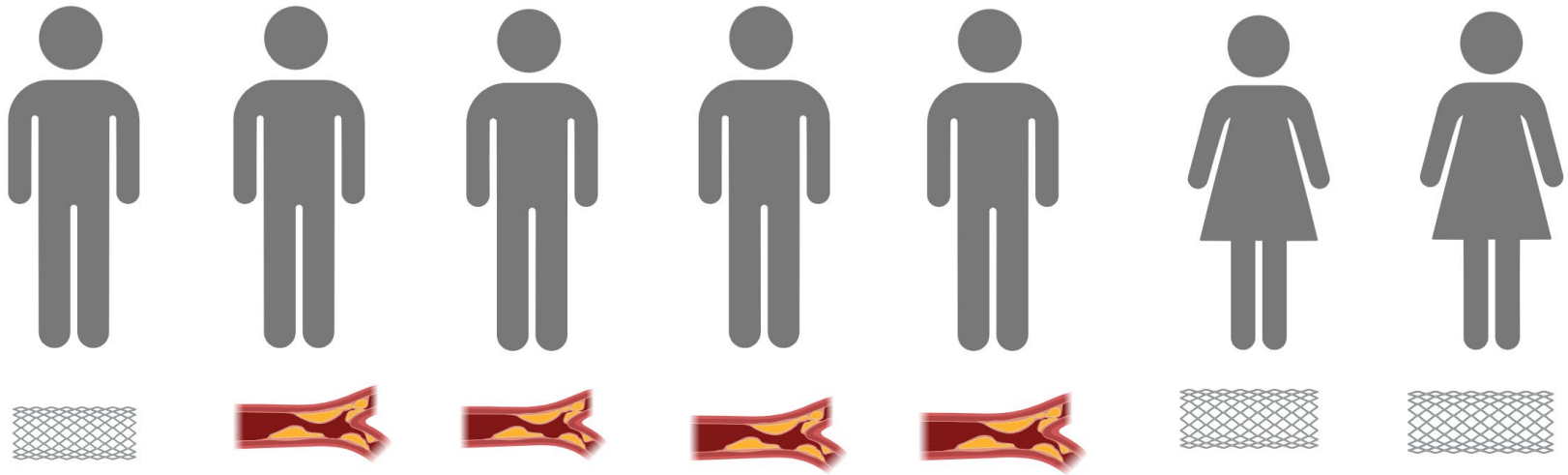
TFCAS

CEA

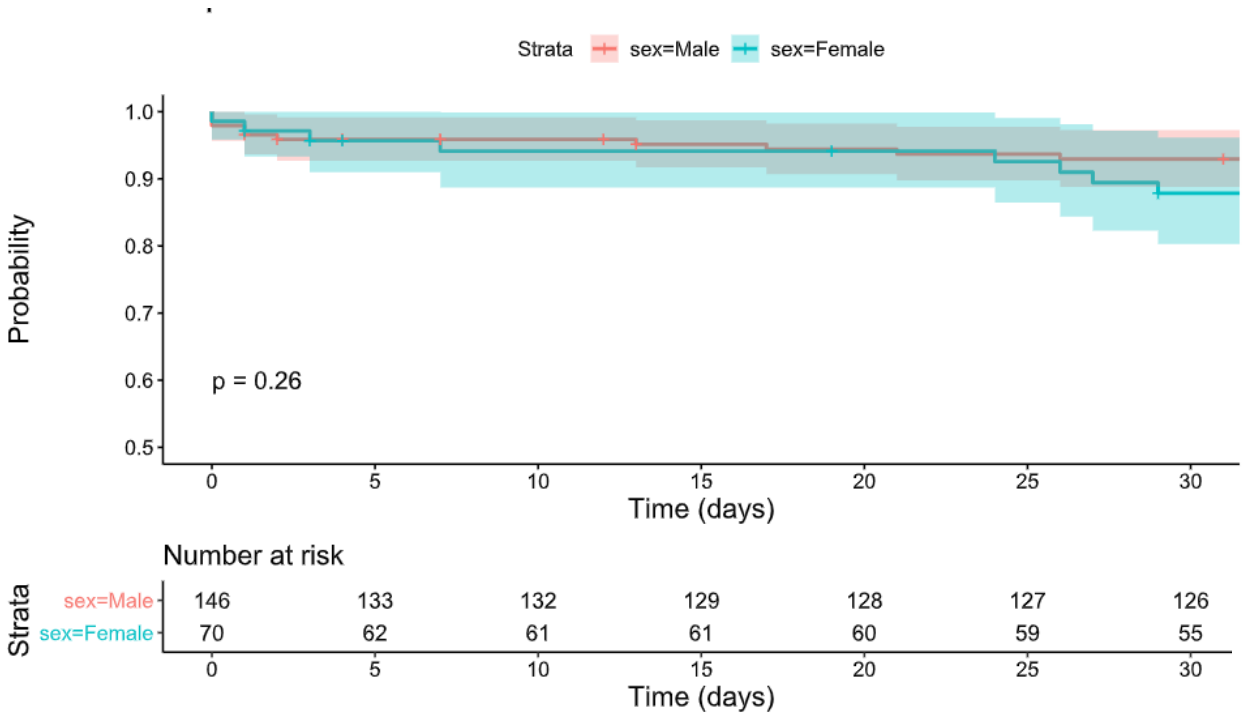
Hemorrhagic strokes



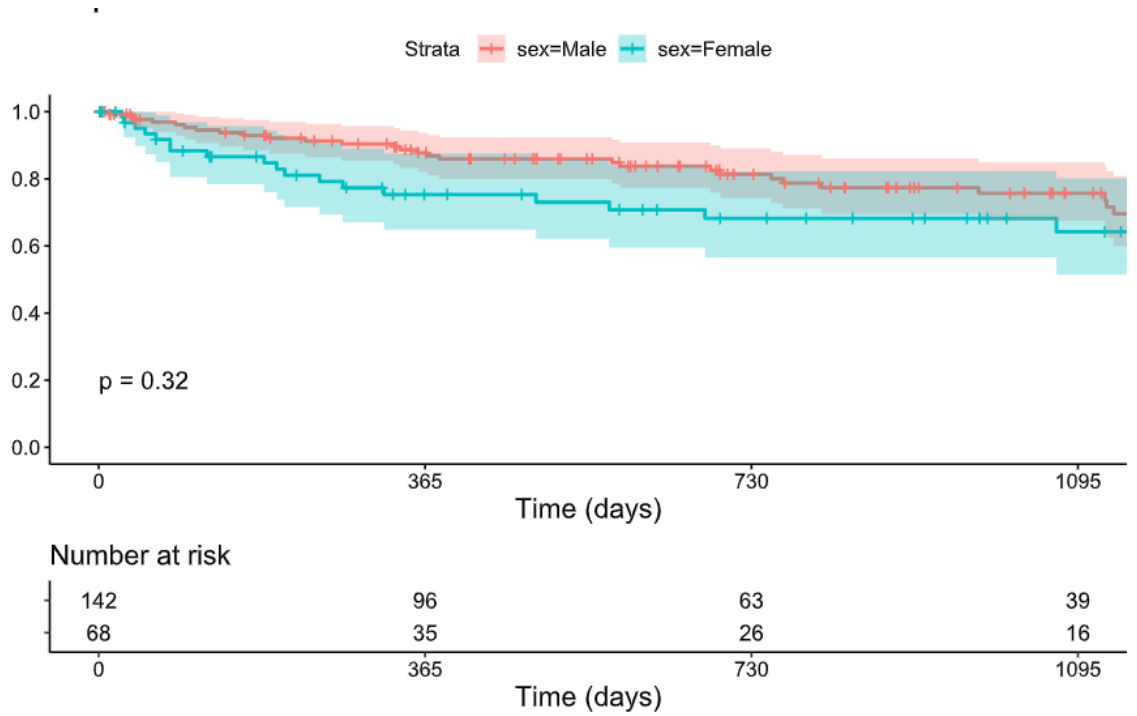
Ischemic strokes



30-DAY COMPOSITE OUTCOMES



MID-TERM COMPOSITE OUTCOMES



LIMITATIONS

- Retrospective design.
- Two–stroke-center study which may reflect practice patterns at specialized centers and may not generalize to lower-volume settings.
- Short follow-up period: mean of 2.4 ± 2.0 years, with a maximum of 7.8 years.

CONCLUSIONS

- Among symptomatic carotid artery patients, sex differences were not observed within 30-days of revascularization or mid-term follow-up.
- These findings support comparable results between sexes when treated at specialized, high-volume stroke centers.

Thank you

Camila Esquetini-Vernon, MD
Research Trainee
Mayo Clinic, Florida

Division of Vascular and Endovascular Surgery.

Houssam Farres, MD.
Young Erben, MD.
Christopher Jacobs, MD.
Adeeb Jlilati, MD.
Diego Sanchez, MD.
Ekin Inal, MD.
Camilo A. Polania Sandoval, MD.

@MAYOFL_VASC_RESEARCH